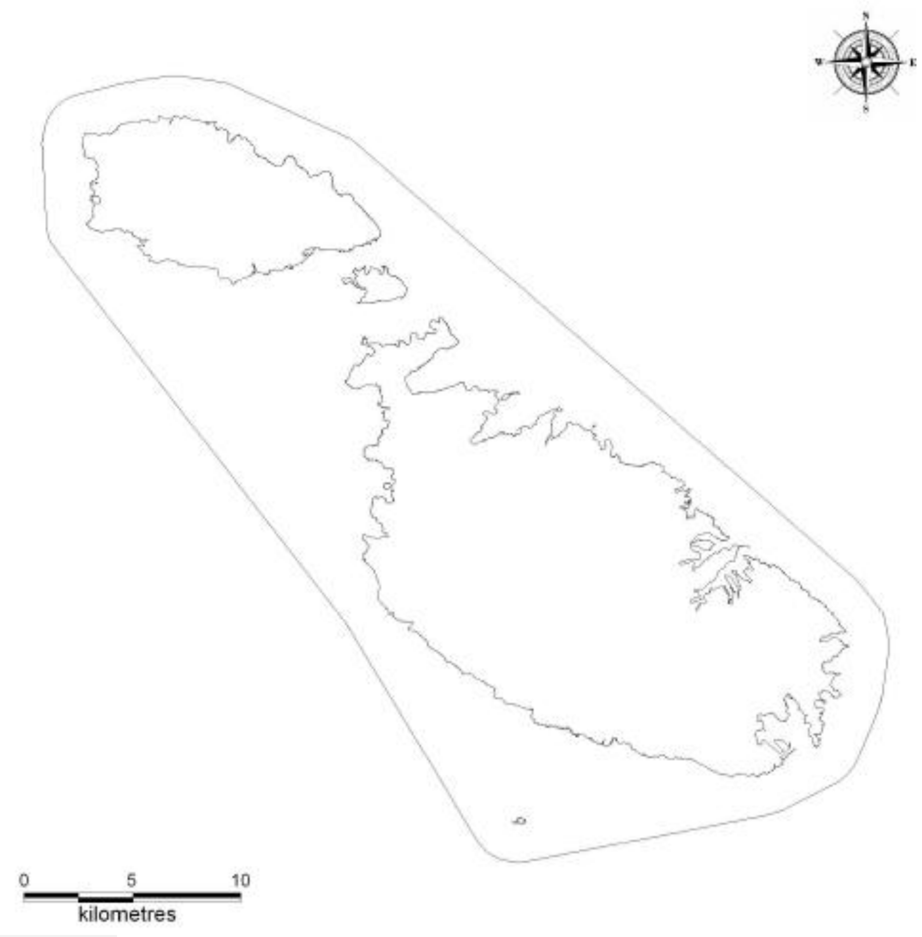
The 2nd Water Catchment Management Plan for the Malta Water Catchment District 2015 - 2021



Sustainable Energy and Water Conservation Unit
Environment and Resources Authority

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1.1 The Water Framework Directive

The 2nd Water Catchment Management Plan, continues to set out ways how to protect, improve and restore the water environment of Malta and Gozo. Waters are various and include surface waters (coastal waters and waters found in valleys, streams and springs) and groundwaters. All waters are linked through a hydrological system or water cycle. The natural area that binds all these waters together is known as a water catchment or river basin – the area of land within which all superficial water converges to a single central valley system during its flow into the sea.

The Water Framework Directive requires each Member State to regularly update its River Basin Management Plan for each River Basin District within its territory. A River Basin District, or Water Catchment District, means the area of land and sea, made up of one or more neighbouring river basins together with their associated groundwaters and coastal waters. Since there are no rivers in the Maltese islands, the River Basin Management Plan has been renamed the Water Catchment Management Plan (WCMP). Furthermore, due to the small size of the islands, the Water Catchment District is considered to encompass the three islands of Malta, Gozo and Comino. The 2nd Water Catchment Management Plan thus updates Malta's 1st WCMP issued in 2010, and continues to develop the Programme of Measures required to achieve the environmental objectives set under this 1st plan.

The purpose of the Water Framework Directive (WFD) is to set up a structure to protect all waters. This structure or framework should lead to the:

- prevention of the deterioration in the quality of aquatic ecosystems, their protection and the improvement of the ecological condition of all waters;
- promotion of sustainable water use based on a long-term protection of available water resources. This plan represents the first revision of the WCMP in a long term planning cycle which envisaged the undertaking of similar revisions on a six-yearly basis;
- reduction and progressive removal of hazardous pollutants and priority substances into the aquatic environment within a 20 year time frame for the date of adoption of the WFD;
- the progressive reduction in pollution of groundwater and the prevention of further pollution; and
- the mitigation of the effects of floods and droughts.

In achieving these purposes, the Directive would contribute to:

- the provision of the sufficient supply of good quality surface water for aquatic ecosystems and groundwater as needed for sustainable water use;
- a significant reduction in pollution of groundwater, inland surface waters, transitional and coastal waters;
- the restoration and protection of territorial and marine waters; and
- the achievement of objectives of other relevant international agreements, which aim to prevent and eliminate pollution of the marine environment.

The wider aim of the Water Framework Directive is the achievement of good status for all water bodies. This 2nd management plan thus undertakes an evaluation of the impact of the 1st WCMP with respect to the planned achievement of environmental objectives for 2015, and develops the measures necessary for the achievement of the environmental objectives planned for 2021. The 'good status' objectives of the WFD entails the achievement of good ecological status for surface waters up to one nautical mile from the coast; good chemical status for all territorial waters, good chemical and good qualitative status for groundwaters; and good ecological potential for heavily modified water bodies.

In order to reach these objectives the WFD proposes a general planning process at the river basin or water catchment scale. This process combines:
- the preparation of actions or measures needed to protect or improve the quality of our waters. These need to be implemented within the respective WFD cycle, which covers a period of 6 years. These measures are revised during each subsequent cycle,
- the progressive preparation of relevant planning documents that are updated during each planning cycle, and
- a consultation and participation process of the public and interested parties.

The different stages considered during the WFD planning process leading to the formulation of this 2nd Water Catchment Management Plan include the following:
- the characterisation of the water catchment district, which reviews the description of the natural hydrological and hydrogeological characteristics of the water catchment together with the water bodies found within; and updates the assessment of the main pressures and their impacts for each water body;
- the monitoring programme, where the monitoring networks established during the 1st planning period are reviewed with the aim of ensuring that the monitoring setup enables the reliable assessment of whether the environmental objectives that have been defined are being effectively achieved;
- the definition of the environmental objectives for each water body along with the development of a revised plan of measures required for the phased achievement of these objectives within the period 2016-2021;
- a review of the economic analysis of water use within the context of the catchment district, which is required to understand the tradeoffs between economic development, environmental protection and sustainability. An economic assessment is also needed in order to assess the most cost-effective combination of actions or measures needed to protect and improve the quality and quantity of our waters, and thus to consider significantly better environmental options that do not entail disproportionate costs; and
- an assessment of the foreseen impacts on the water catchment district due to extreme climatic events such as droughts and floods, in order to enable the development of a resilient and integrated water management framework which addresses these emerging challenges.

1.2 National Strategy for the implementation of the 2nd Water Catchment Management Plan

The Water Framework Directive (2000/60/EC) is transposed into national legislation as Legal Notice 194 of 2004 entitled 'The Water Policy Framework Regulations 2004'. These regulations define the Sustainable Energy and Water Conservation Unit (SEWCU) as the competent authority for groundwater and inland waters; with the exception of inland surface waters protected under the Malta Environment and Development Planning Act, Act X of 2010. Such inland surface waters are placed under the competency of the Malta Environment and Planning Authority (MEPA), which is also responsible for coastal and transitional waters.

The role of the competent authorities is to coordinate, prepare and produce the Water Catchment Management Plan and report to the European Commission on the implementation of this plan. In addition, to the pivotal role of these two agencies, the active involvement of stakeholders and the general public has been important for the revision of this management plan. In fact, the process leading to the revision of the Water Catchment Management Plan was backed with a relatively high number of direct meetings with stakeholders in which the development and implementation of water management measures were discussed. This engagement process will not stop with the publication of the plan, but will be a continuous process along the 2nd planning cycle, eventually leading to the 3rd revision of the management plan envisaged for 2021. The success of this catchment management plan depends fully on the cooperation of several different stakeholders and the public itself.

The Water Catchment Management Plan has legal value and a political aim: it gives administrative bodies, the local authorities and the general public, directions and objectives to be achieved in the field of water management. This plan's objectives have to be in line with other relevant environmental and sectoral policies in order to guarantee an integrated framework for water resource management. For this reason the Water Catchment Management Plan gives due consideration to the objectives of existing sectoral plans, polices and programmes which have a direct and/or indirect overlap with the water sector.

Since the first WFD cycle, there has also been a policy response towards integration of the WFD principles at a strategic level. In July 2015 the Strategic Plan for Environment and Development (SPED) replaced the 1990 Structure Plan for the Maltese Islands, and is based on an integrated planning system that regulates the sustainable use and management of land and sea resources. The Plan provides a strategic spatial policy framework for both the environment and development up to 2020, complimenting Government's social, economic and environmental objectives direction for the same period. It takes on board the WFD objectives and administrative units in its spatial policies.

The responsibility for the implementation of this Water Catchment Management Plan is shared between three major groups of players:
- targeted primary stakeholders such as government agencies and regulatory authorities that have a leading role in the implementation of the measures that were identified in the Programme of Measures. Primary stakeholders also have a communication role in facilitating communication through existing formal or informal networks down to secondary stakeholders and, in some cases, also to the general public;
- secondary stakeholders such as those agencies and bodies that would have a secondary role in implementing the measures or would be directly or indirectly influences by the measures and thus are likely to control their successful implementation; and
- representatives of the general public and opinion leaders who are considered instrumental in disseminating information and in raising awareness in the general public. This group is also expected to encourage the fostering of environmental stewardship.

Each citizen has a role to play in the successful implementation of this plan. It is acknowledged that it is therefore important that the general public becomes fully acquainted with it and is involved in its implementation whenever relevant.

2. Characterisation of the Water Catchment District of the Maltese Islands

2.1 Establishing the Water Catchment District

The Water Framework Directive establishes the river basin as the natural hydrological and geographical management unit for an integrated approach to water management. The Directive requires each Member State to identify individual river basin districts and prepare a River Basin Management Plan for each water district within its territory.

Malta has no large and permanent river systems. Inland surface water systems are small and linked to the dynamics of several dry river valleys, locally called *widien* and their associated catchments. Given their very small size, the Maltese islands were integrated into one water catchment district under Article 3 of the WFD. This water catchment district consists of all hydrological sub-catchments, coastal waters up to one nautical mile from the baseline and all groundwaters.

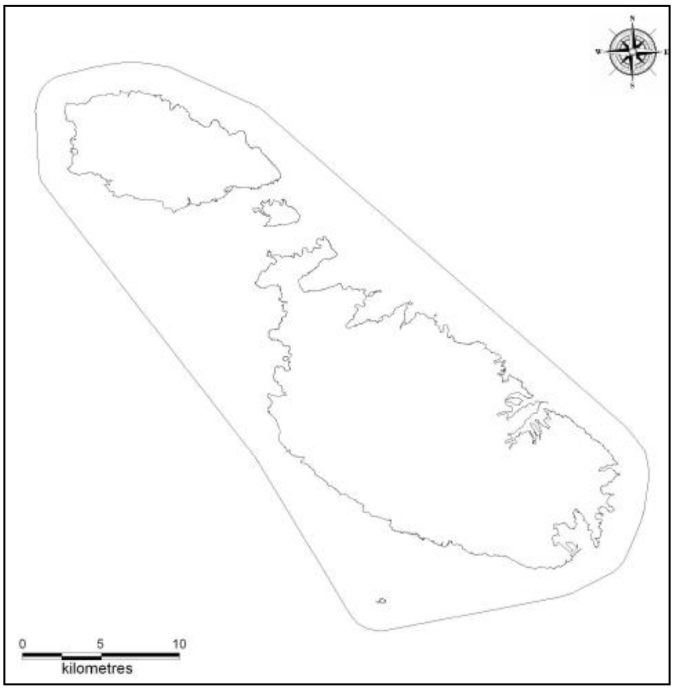


Figure 2.1: The Water Catchment District for the Maltese Islands

The basic unit of management with the water catchment district is the water body. All waters covered by the Directive are divided into water bodies, the boundaries of which encompass as much as possible a homogenous water environment and water type.

Water bodies for surface and groundwaters were initially identified in 2005 as part of the Initial Characterisation of water bodies required by the WFD, and revised during the formulation of the 1st catchment management plan. These designations were revisited during the preparation of the 2nd Water Catchment Management Plan and amended on the basis of technical information which has become available during the course of the implementation of the 1st catchment management cycle. The number of water bodies being designated or delineated in Malta for the 2nd WCMP in each category are shown in table 2.1 below.

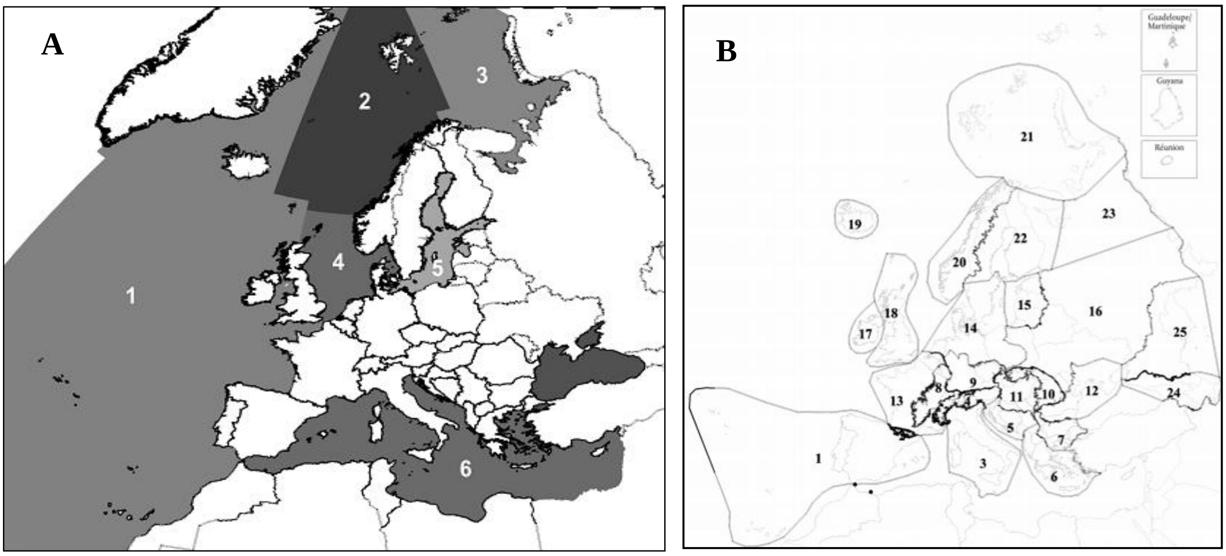
Water Body Type	Water categories				
	Surface waters				Groundwater
	Water Courses	Ponds	Transitional	Coastal	
Natural Waters	2	1	0	7	15
Heavily modified waters	1	1	5	2	Not applicable
Artificial waters	0	0	0	0	Not applicable

Table 2.1 Number of water bodies that have been delineated and/or designated by Malta for the implementation of the 2nd WCMP (by category)

2.2 Characterisation of surface waters

Surface Waters in the Maltese Water Catchment District fall into 4 different water categories: watercourses, pools, coastal and transitional waters. In the case of coastal water bodies, they are further differentiated according to type. The process of delineating water bodies and describing their type is called characterisation. The type or typology of water bodies is determined by a set of descriptors of the physical environment. The physical descriptors are given as:

- **System A:** Waters are first assigned to an Ecoregion as shown in Figure 2.1 a and b. Within each ecoregion the type is then described using physical characteristics. For instance in the case of coastal waters, different waters can be characterised by mean annual salinity and mean depth of waters;
- **System B:** uses a set of obligatory factors (longitude and latitude, tidal range and salinity) and optional physical descriptors (exposure to waves, mean water temperature range, current velocity, mixing characteristics, turbidity, retention time, mean substratum composition).



Key for Map A
1- Atlantic Ocean,
2- Norwegian Sea
3- Barents Sea
4- North Sea
5- Baltic Sea
6- Mediterranean Sea

Key for Map B
1-Iberic-Macaronesian
2- Pyrenees
3- Italy, Malta and Corsica
4- Alps
5- Dinaric western Balkan
6- Hellenic western Balkan
7- Eastern Balkan
8- Western highlands
9- Central highlands
10- The Carpathians
11- Hungarian lowlands
12- Pontic Province
13- Western plans
14- Central plans
15- Baltic province
16- Eastern plains
17- Ireland and N. Ireland
18- Great Britain

Figure 2.2: Ecoregion map for a) transitional and coastal waters; b) rivers and lakes *(Annex XI Map B 2000/60 EC)*

Typologies are the basis for WFD monitoring and assessment of **ecological status** (refer to Chapter 6). The purpose of assigning water bodies to a physical type is to ensure that valid comparisons of ecological status of water bodies can be made among water bodies that exhibit the same physical characteristics. Typology can therefore be said to be ecologically relevant, i.e. the physical characteristics that are used to define the typology of coastal waters must have local environmental relevance and be important determinants of the biological environment. This reflects the fact that the ecological character of coastal waters will vary according to their physical characteristics. It follows that the biological quality elements that define ecological status[1] are expected to exhibit different characteristics in water bodies of different typologies.

Establishing the typology is only a first part of the characterisation process. A further characterisation of water bodies involves that surface waters within the Maltese Water Catchment District are spilt into water bodies. Water bodies are the smallest management units within the Water Catchment District. The status of surface waters is determined at the water body level, and consequently the effectiveness of management measures to improve the status of waters is monitored at the water body level (Figure 2.2).

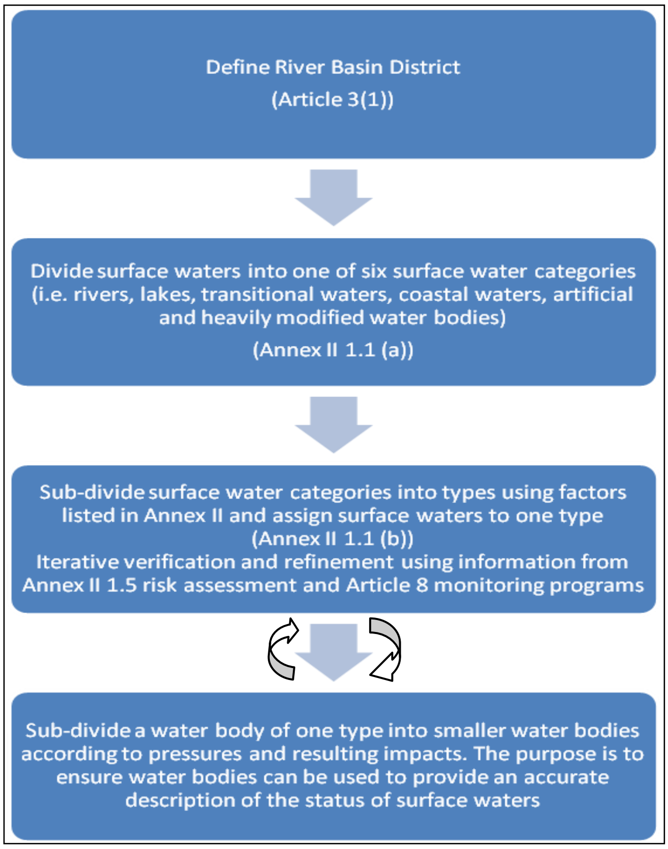


Figure 2.3: The hierarchical approach to the identification of typologies and water bodies *(Adapted from CIS Guidance Document No. 5)*

2.3 Characterisation of small waters - Inland surface and transitional waters

Within a territory of 316km^2 characterised by a southern Mediterranean climate, the inland surface and transitional waters of the Maltese Islands are very small streams, water courses or standing waters that flow or have fluctuating water levels throughout the year. The physical descriptors a set

[1] Biological quality elements are given in Annex V of the Directive

by the WFD described above (i.e. System A and System B) are insufficient to precisely characterise these unique waters. Malta is therefore attempting to use alternative means to characterise these waters where possible. This section gives an overview of the salient characteristics of these waters based on the limited monitoring data and few individual studies that have been carried out to date.

The characteristics of watercourses and small pools are closely linked to the hydrological dynamics of several valleys or 'widien' and their associated catchments as well as the strong Mediterranean biseasonal climatic element that dictates when water is present during the year. Some watercourses are further characterised by geology since springs that form from blue clay outcrops in perched groundwater systems rise to more frequent flows in the connected reaches of a water course. Such water courses are more common in the northern and north western parts of Malta where perched aquifers are present.

In addition to the climatic, hydrologic and geologic processes described above, coastal processes also play an important part in influencing the chemical and hydrological make-up of transitional waters. These various factors not only bring about seasonal and annual differences in the quantity of water to be found in these inland surface water systems, but also give rise to large fluctuations in the physical and chemical characteristics that may temporarily approach or even exceed the biological limits that organisms dependent on them can cope with.

Being unique in the species and habitats they offer, valley systems and other inland small water systems merit protection. They constitute important features in the landscape and provide significant ecosystem services such as flood protection, occasionally water for irrigation; and areas of recreational value. Inland surface and transitional waters often are of great ecological importance because they harbour a number of species and habitats of conservation value. Indeed, many inland waters have been scheduled as Areas of Ecological and/or Scientific Importance. They form part of Natura 2000 sites designated under the EU Habitats and Birds Directive and some have been designated under the Ramsar Convention on Wetlands. Refer to Chapter 4 for Protected Area related objectives.

Water Coruses

Freshwater pools

Transitional waters

Figure 2.4: Examples of inland surface waters and transitional waters in the Maltese Islands

Table 2.2 below lists these protected small inland surface and transitional waters, their water regime as presently known and their water depth range. The location of these waters in the Maltese Islands is presented in Figure 2.5 and Figure 2.6 as freshwaters and brackish waters.

Water Body Category	Water Body Name	Code	Water availability / regime*
Transitional waters	Is-Salini	MT TW 01	Water levels fluctuate between seasons Water depth range (max – min): 1.7m – 0.05m
	Il-Magħluq ta' Marsacala	MT TW02	Water levels fluctuate between seasons Water depth range (max – min): 1.4m – 1m
	Il-Ballut ta' Marsaxlokk	MT TW 03	Dries out completely after the wet season Water depth range (max – min): 0.3m – 0m
	Is-Simar	MT TW 04	Water levels fall substantially after the dry season
	L-Għadira	MT TW 05	Water levels fall substantially after the dry season
Water Courses	Wied tal-Baħrija	MT WC 01	Water present throughout the year, forming disconnected pools at the lower reaches as the dry season progresses
	Wied il-Luq	MT WC 02	Water present in the upper and middle reaches only after heavy downpours
	Wied il-Lunzjata	MT WC 03	Water present throughout the year, forming disconnected pools in the lower and upper reaches as the dry season progresses
Pools	Il-Qattara	MT SW 01	Perennial water pool, with fluctuations in water level from wet to dry season
	Għadira ta' Sarraflu	MT SW 02	Perennial water pool, with fluctuations in water level from wet to dry season

Table 2.2: Delineated protected Inland Surface and Transitional Waters
*Water availability / regime is based on one year hydromorphological observations and is subject to revision as more long-term data is collated

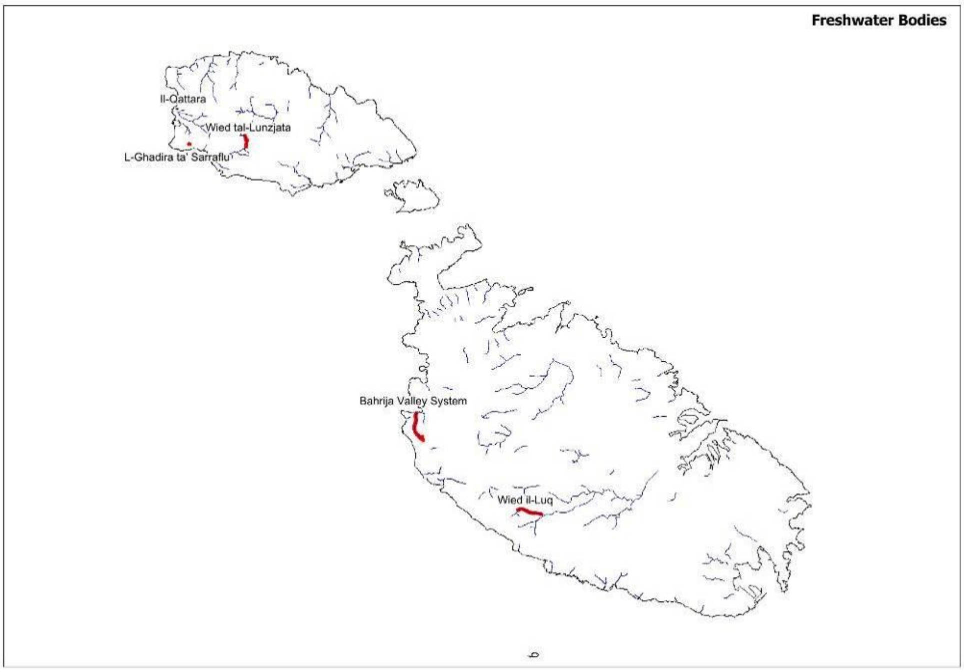


Figure 2.5: Small freshwaters in the Maltese Islands indicated by the red lines. The thin blue lines refer to the dry river valley systems considered to be of ecological significance in the Maltese Islands. Baħrija valley, Wied il-Luq and Wied Lunzjata (Gozo) are categorised as water courses. Il-Qattara and l-Għadira ta' Sarraflu (both located in Gozo) are freshwater pools.

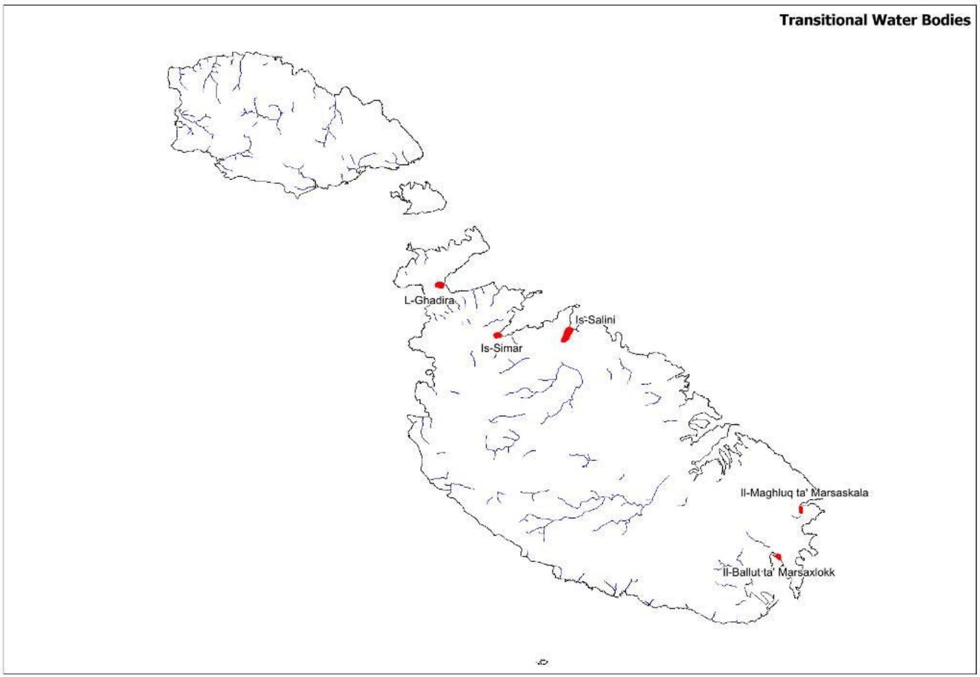


Figure 2.6: Transitional waters in the Maltese Islands are indicated by the red lines. The thin blue lines refer to the dry river valley systems considered to be of ecological significance in the Maltese Islands. Transitional waters are found at the mouths of dry valley systems

2.3.1 Characterisation of transitional waters

The delineation of the small transitional waters was based on the following criteria:

- Hydrographical characteristics - location of the water body at the mouths of valley catchments and in close proximity to the sea.
- Physico-chemical characteristics: mainly salinity and water temperature.

2.3.1.1 Hydrographical characteristics

The maps below (Figure 2.7 – 2.11) indicate the location of transitional waters at the mouths of major water catchments and in close proximity to the sea. Despite the fact that these transitional waters are brackish environments, their connection to the sea has been restricted over the years due to human modifications and road construction that curtail most of the sites. These sites are in fact considered to be greatly modified as all of them have been heavily engineered historically (refer to Chapter 6). Water circulation is considered to be very restricted in all of these waters, except for Salini where a direct connection to the marine environment is present.

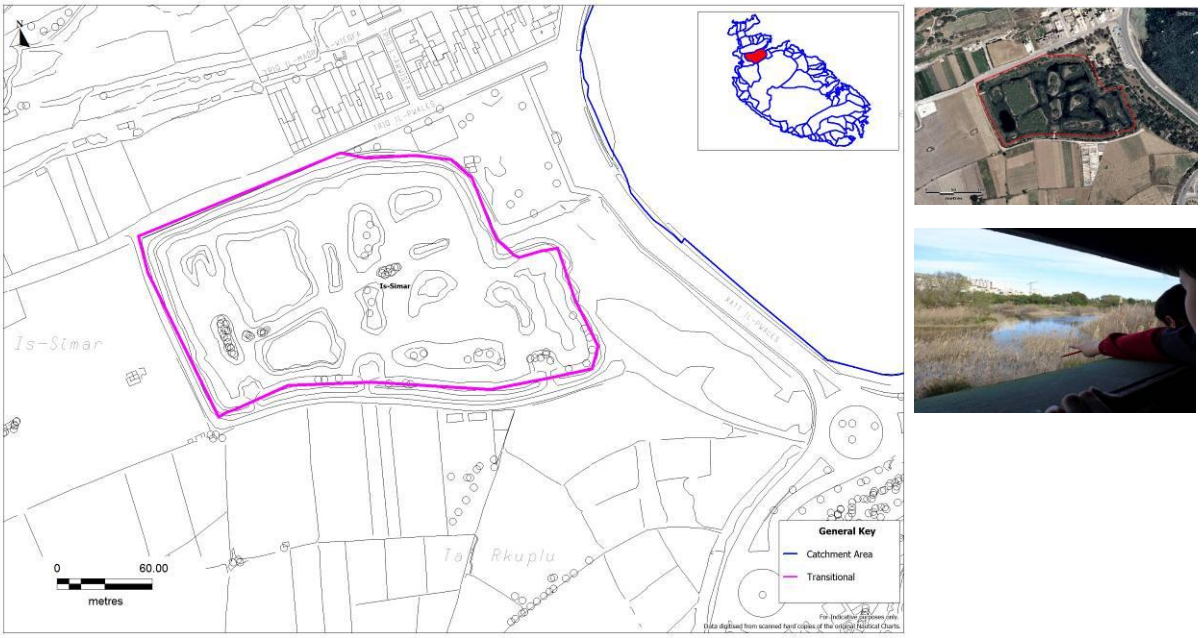


Figure 2.7: Is-Simar transitional water located at the mouth of the Pwales catchment: the green outline marks the boundary of the transitional water. *Top right:* an aerial view of the transitional water. *Bottom right* : The Simar transitional water is now a bird reserve

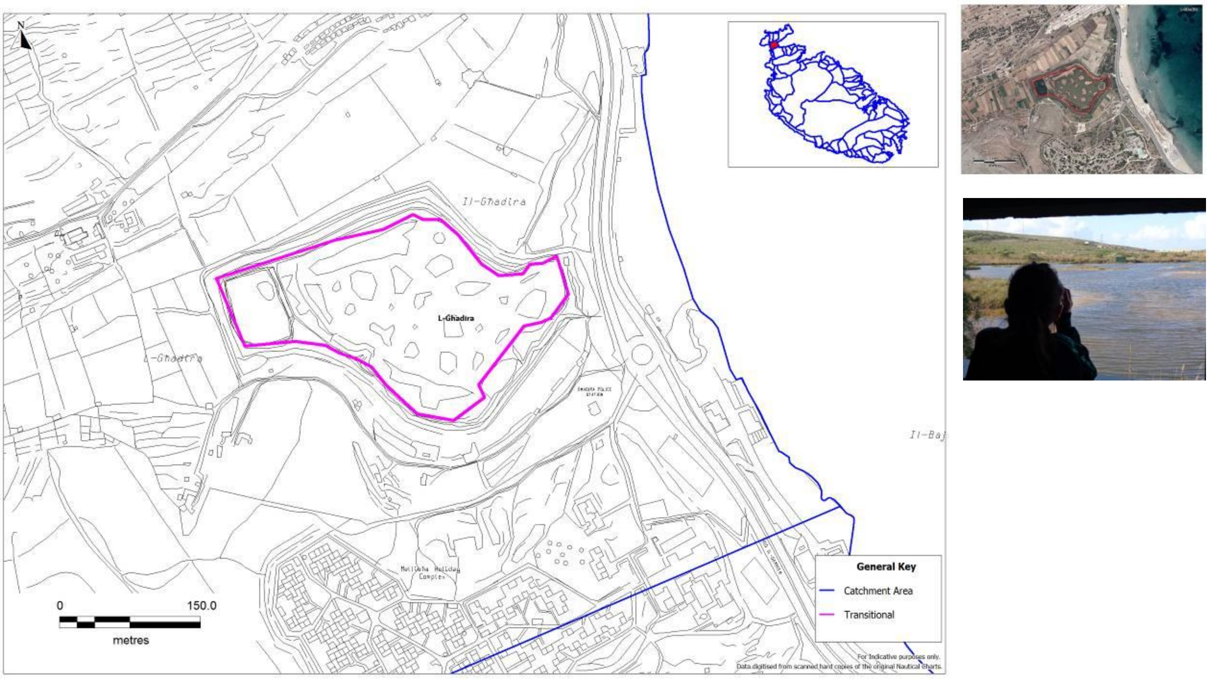


Figure 2.8: L-Għadira transitional water located at the mouth of a catchment area that stretches between Marfa and Mellieha ridges. The green outline marks the boundary of the transitional water. *Top right:* an aerial view of the transitional water, also a bird reserve. *Bottom right*: A view of the now artificial Ghadira reserve from a bird hide

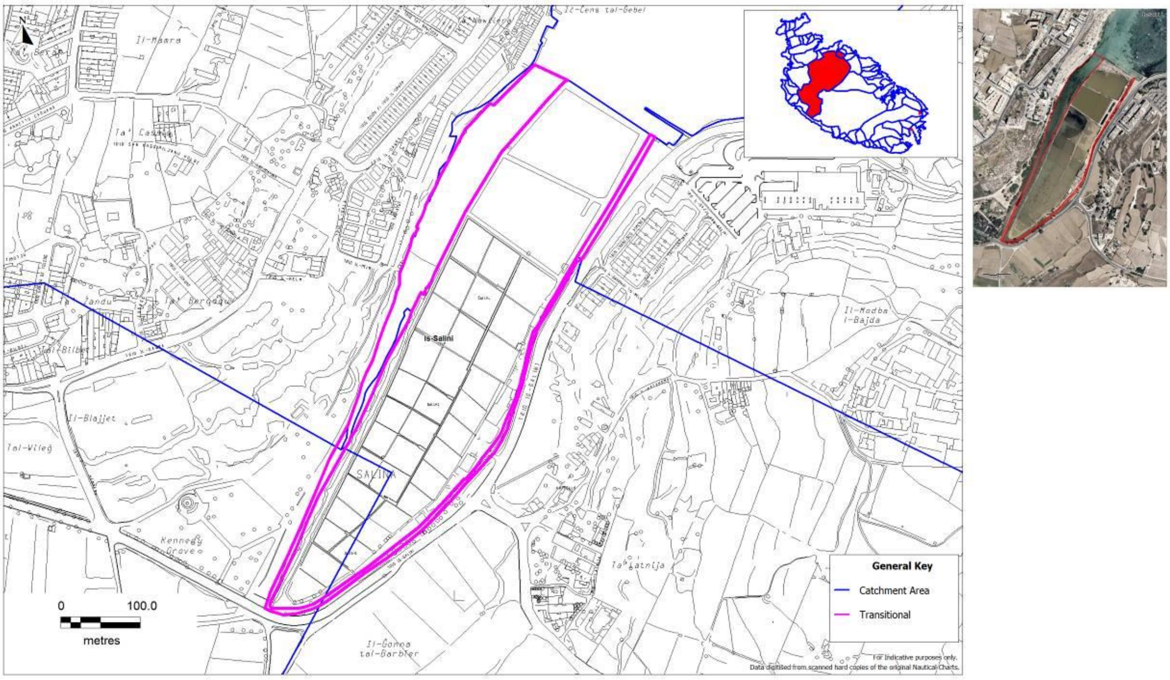


Figure 2.9: Is-Salini transitional water located at the mouth of il-Wied ta’ Għajn Riħana. The pink outline marks the boundary of the transitional water. *Top right:* an aerial view of the transitional water body

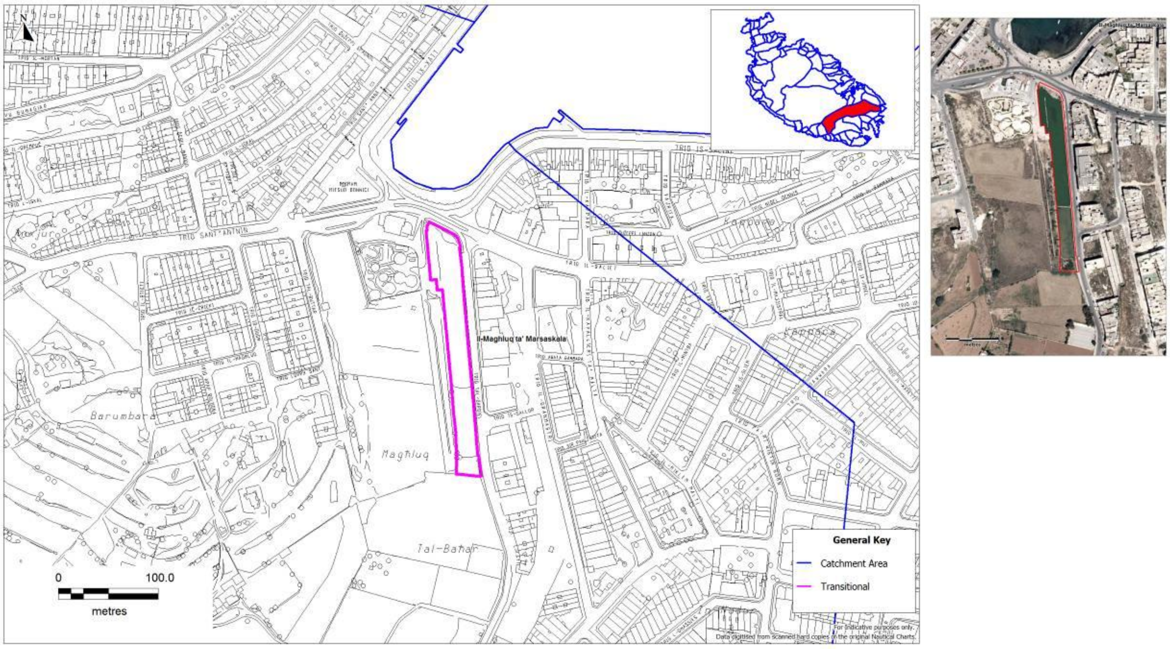


Figure 2.10: Il-Magħluq ta’ Marsakala transitional water located at the mouth of Il-Wied ta’ Sant Antnin, formerly a marshland. The pink outline marks the boundary of the transitional water. The rectangular outline is indicative of the now artificial sides of this modified water body. *Top right:* an aerial view of the transitional water body

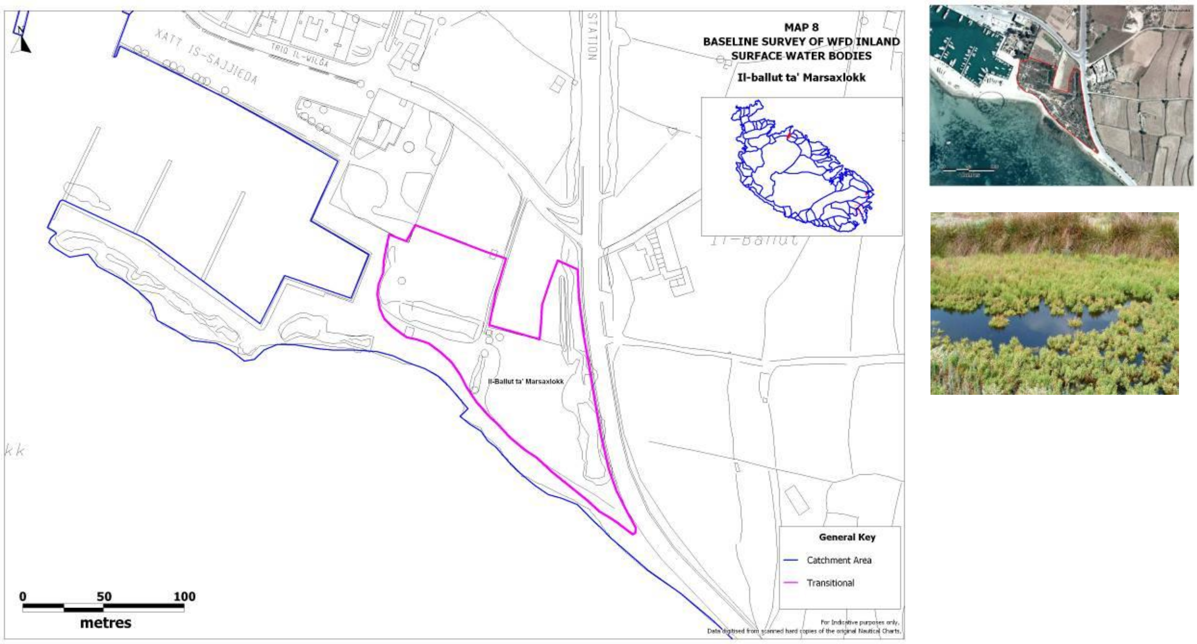


Figure 2.11: The location of Il-Magħluq ta' Marsaxlokk, also known as il-Ballut, is located at the mouth of a shallow *wied* that drains the land northeast of the coast. The pink outline marks the boundary of the transitional water.
Top right: an aerial view of the transitional water; *Bottom right*: Today the connection with the sea is no longer present and as a result it dries out towards the end of the rainy season. The photo indicates what the engineered marsh looks like during the wet season

2.3.1.2 Physico-chemical characteristics

The problem with the characterisation of transitional waters lies with the fact that they are extremely transient due to their intermediate location in the vicinity of the sea and at the mouths of hydrological catchments. Therefore limited data based on a single year is insufficient to determine typologies. This is most apparent for salinity. The monitoring of salinity in transitional waters over one year indicated that monthly values were insufficient to determine salinity-based typologies. As illustrated in Figure 2.12 below salinity levels fluctuated greatly from month to month in all transitional waters concerned.

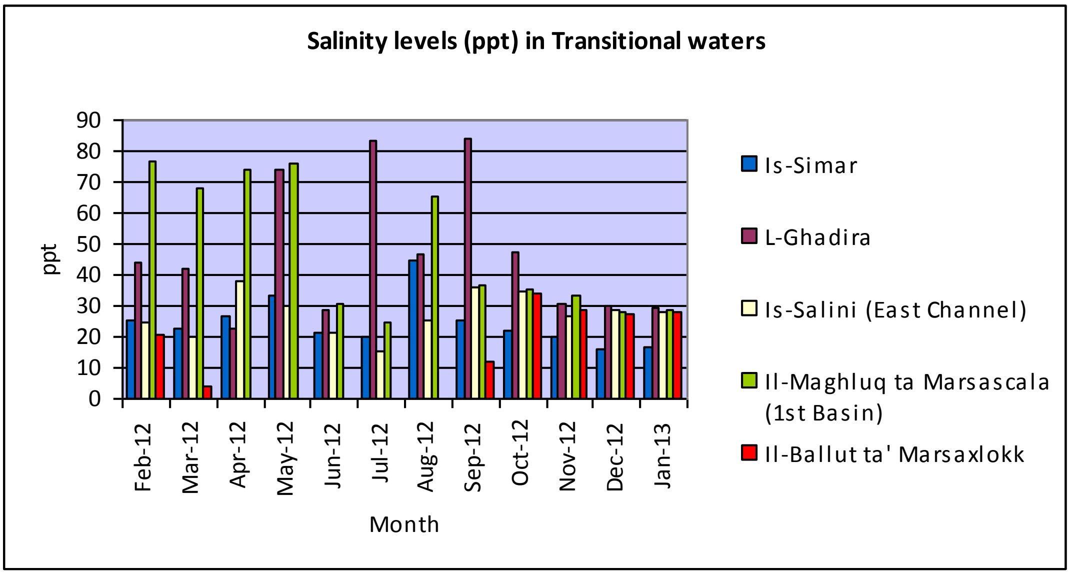


Figure 2.12: Salinity levels (ppt) in transitional waters
Note: Salinity values in il-Ballut ta' Marsaxlokk are missing due to the dry period where the basin dried up

In the case of dissolved oxygen in transitional waters very little can be determined since anoxic, hypoxic and saturated conditions, fluctuated constantly throughout the year. However anoxic and hypoxic conditions can be said to be more associated with the summer months when the change in temperature is significant. The lack of water flow and circulation in this water category also leads to less dissolved oxygen (refer to Figure 2.13).

PH levels on the other hand were consistent for all waters under this category (refer to Figure 2.14) and ranged from 6 - 9. It is possible that the alkalinity of the waters is related to limestone and the presence of carbonates. However slight dips in pH may also be caused by rainfall or contaminated runoff by sewage that may end up in the waters concerned. Monitoring results however indicate that pH levels are relatively healthy in these water systems.

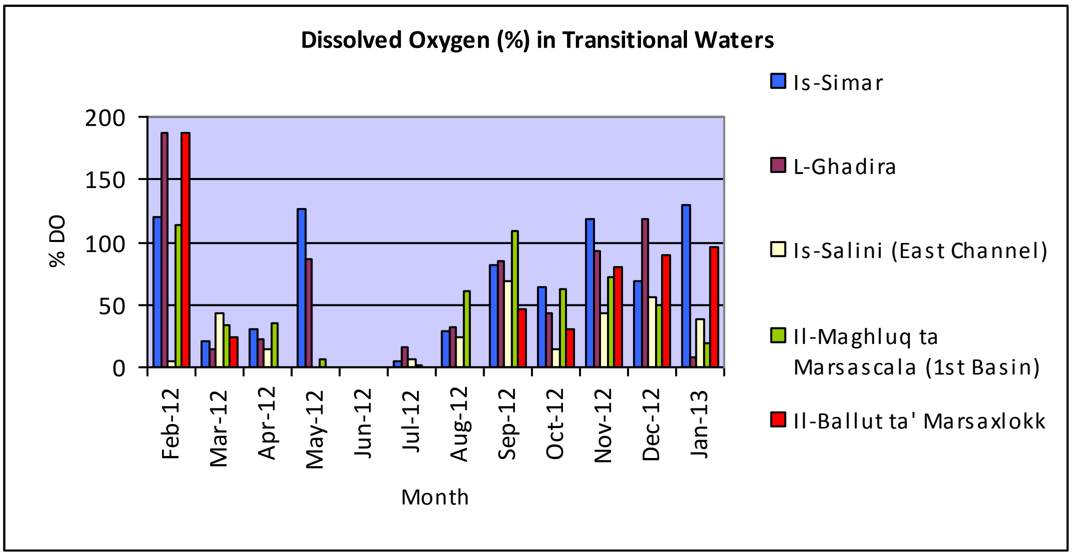


Figure 2.13: Dissolved oxygen levels in Transitional Waters during 2012/2013

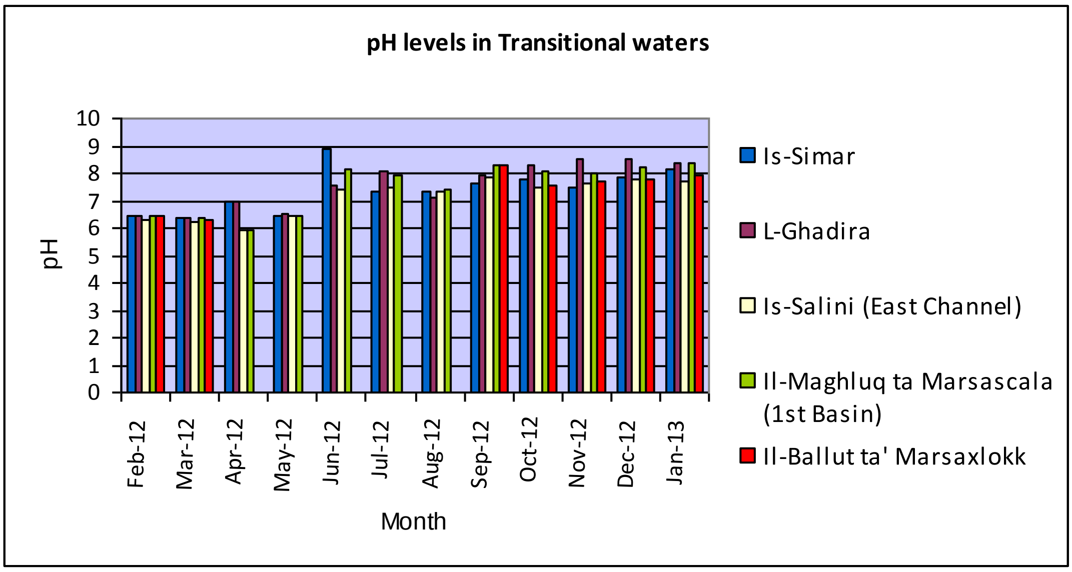


Figure 2.14: pH levels in Transitional Waters during 2012/2013

Water temperatures for these waters are presented in Figure 2.15. Temperatures are comparable between all transitional waters and clearly reflect the biseasonal climate of the Maltese Islands. As expected an inverse relationship between dissolved oxygen and temperature is clearly depicted.

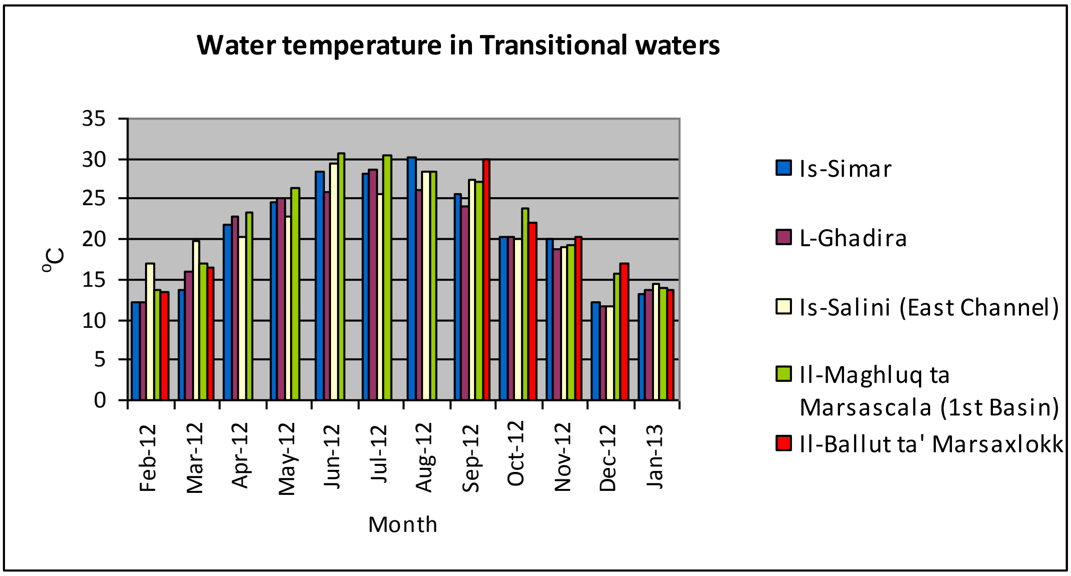


Figure 2.15: Water temperatures in Transitional Waters during 2012/2013

2.3.1.3 Trophic class

Nutrients such as nitrogen and phosphorus can be limiting factors in surface waters meaning that changes in their amounts can bring drastic changes in the biological community that depends on these nutrients. Increased nutrient concentrations may give rise to an increase in plant growth, and a reduction in oxygen levels. As a result the waters trophic index may increase too.

The nutrient levels that were obtained from the one year monitoring programme differed between early spring and the rest of the year. Spikes were commonly found during the spring /summer months of all water bodies ranging from 2 to 6mg/l (except for il-Ballut where water had completely dried out by the end of winter). Orthophosphates on the other hand were relatively high during late summer. It is generally noted that transitional waters are naturally eutrophic since they are at the receiving end of nutrient loadings from large catchment areas as well as from internal cycling processes between their sediment and water column because of their shallowness (Lucena-Moya et al., 2012)[2]. However nutrient levels were generally low for the remaining periods of the year indicating an oligotrophic nature. Chlorophyll a biomass values were also recorded below the detection limit of 0.3 µg/l. This one year of monitoring data indicates that most of the transitional waters are complex with trophic classes constantly changing depending on the time of the year.

2.3.1.4 Characteristics of Maltese transitional waters

The table below (Table 2.3) summarises the hydrological, hydromorphological and physico-chemical characteristics of all five transitional waters described above.

Water Category	Morphological parameters		Water quality parameter	
Transitional waters	**Geology**	Calcareous • Upper and Lower Coralline Limestone; • Middle Globigerina Limestone	**Temperature**	Summer range: 27 -29°C Winter range: 13 - 22°C
	Size	0.006 – 0.04 km^2	**Dissolved oxygen**	Varies significantly Not enough data over a sufficient timeframe to determine DO ranges

[2] Lucena-Moya, P., Gomez-Rodriguez, C., and Pardo I. 2012. Spatio-temporal variability in water chemistry of Mediterranean Coastal Lagoons and its management implications, in Wetlands 32, 1033:1045, April 2012.

	Depth	Average depth 0.4 - 1m	**pH**	6 - 8 > 8
	Water availability	Water is present all year round but levels drop considerably during early spring and summer. Il-Ballut was reported to dry out at early as April. Additional monitoring is required to characterise their water availability.	**Salinity**	Varies significantly Not enough data over a sufficient timeframe to determine salinity ranges
			Trophic class	Oligotrophic - mesotrophic

Table 2.3: Physical characteristics of the five transitional waters in the Maltese Islands

2.3.2 Characterisation of watercourses

2.3.2.1 Hydrological flows

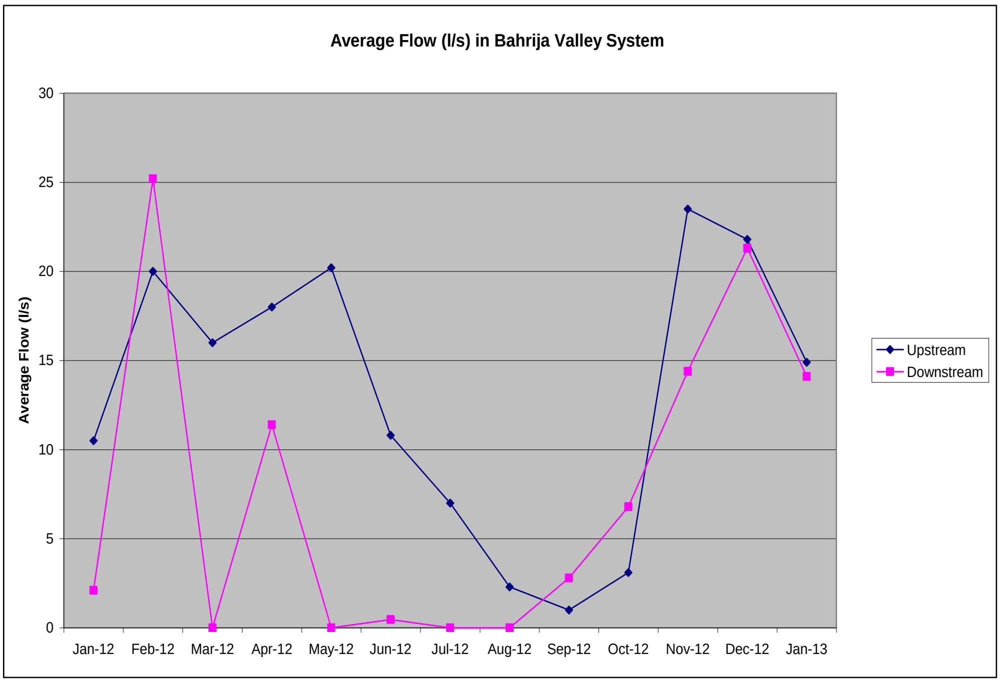
A single defining criterion used to characterise Maltese water courses is the **hydrological regime**. All three water courses are temporary. Temporary streams may be defined as bodies of freshwater that undergo a recurrent dry phase of varying length that is sometimes predictable in terms of both its time of onset and duration (Williams, 1996 in Sánchez-Montoya et al 2011[3]). Empirical evidence of observed water regimes in these water courses had pointed to this characteristic and was further confirmed by the one year baseline monitoring that was carried out in 2012/2013. It must be emphasised however, that one year monitoring data is insufficient to determine the hydrological regime and additional monitoring on a more frequent basis is required (refer to Chapters 5 and 9).

Temporary water courses is, however, too generic a term and insufficient to effectively capture the characteristics of the fluctuations in the hydrological regime. Such a term requires further subdivision in order to better explain the ecological status of these waters during different periods of the year. Temporary streams may be further divided into intermittent and ephemeral streams depending on their dry period condition. In the case of **intermittent streams**, the water flow disappears but water still continues to be present in the form of discontinued pools. In the case of **ephemeral streams**, water flows completely disappear and dry stream beds occur.

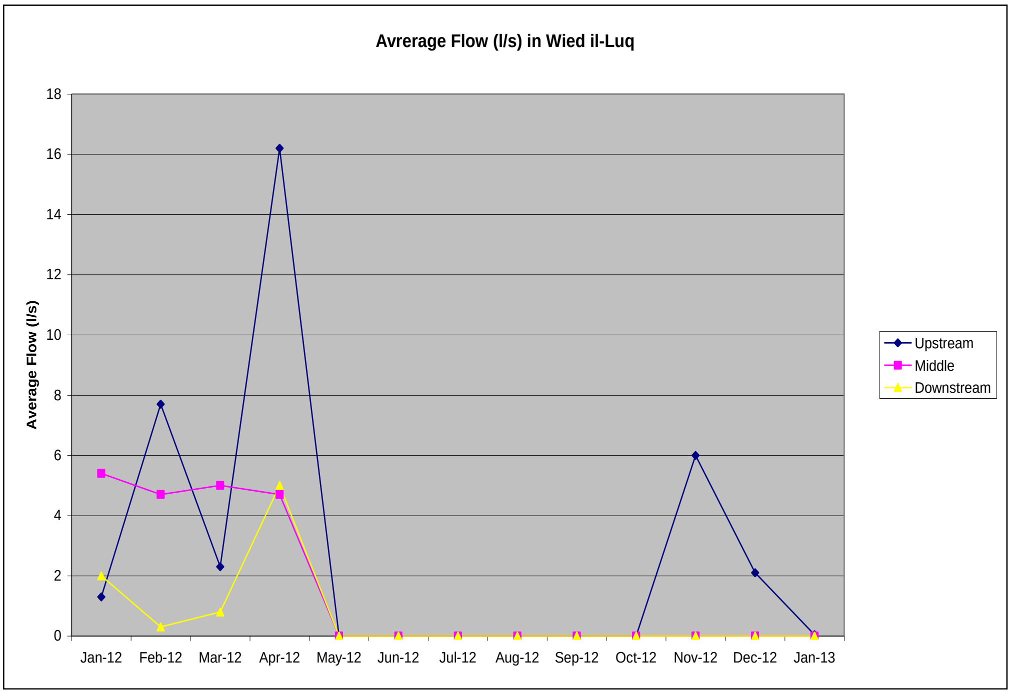
In temporary streams the main factors affecting the aquatic assemblages present; their function and structure, is their hydrological intermittency. The factors that need to be known are the frequency and duration of disturbance events and their predictability (Gasith and Resh, 1999)[4]. Flow stability and minimum flows are regarded to be important determinands for macroinvertebrate assemblages. In order to be in a better position to understand these factors Malta therefore needs to monitor the water flows in these watercourses continuously so that the predictability of such disturbance events is understood and can be taken into account in the status assessment (refer to Chapters 5).
At this point in time, with the current level of knowledge, Wied il-Baħrija and Wied il-Lunzjata have both been characterised to be intermittent streams. Given the highly engineered flow at Wied il-Luq (Buskett) the typology of this water course is less certain. The contribution of water supply infrastructure and engineered springs to the natural water flows in the watercourse channel need to be determined before this water course can be appropriately characterised in terms of its hydrological regime. Figures 2.16 a-c indicate the average flow that has been recorded in each of these waters over a period of one year.

[3] Williams, D.D. 1996. Environmental constraints in temporary freshwaters and their consequences for the insect fauna. *Journal of North American Benthological Society*, 15, 634 – 650 *in* Sánchez-Montoya, M.M., Gómez, R. Suárez, M.L., and Vidal-Abarca M.R. 2011. Ecological assessment of Mediterranean streams and the special case of temporary streams. River Ecosystems: Dynamics, Management and Conservation, 109-148.

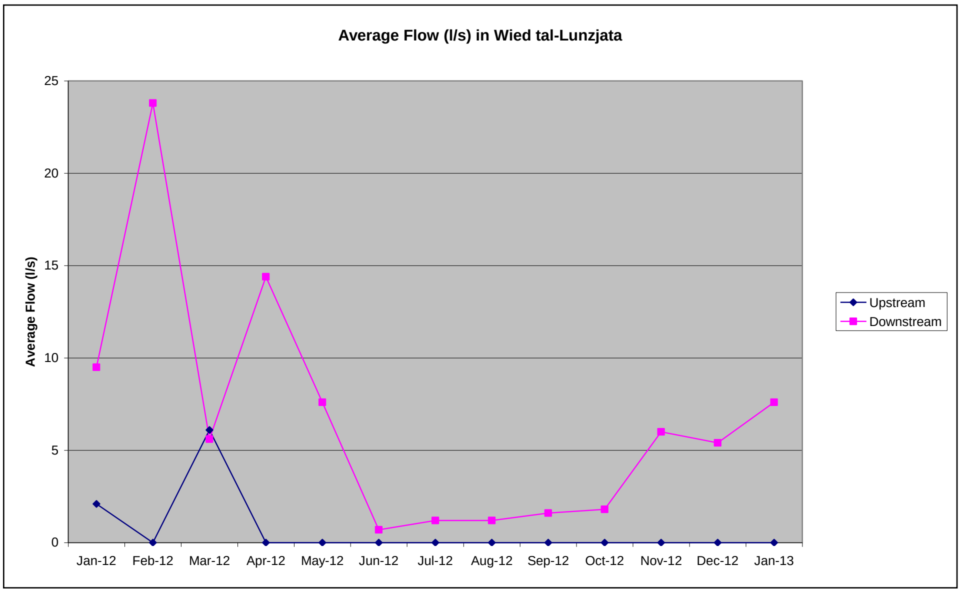
[4] Gasith, A. and Resh, V.H. 1999. Streams in the Mediterranean climate region: Abiotic influences and biotic responses to predictable seasonal events. *Annual review of Ecology and Systematics*, 30, 51-81



(a) Average flows at Baħrija Valley



(b) Average flows at Wied il-Luq



(c) Average flows at Wied Lunzjata

Figure 2.16 (a-c): Average flow (l/s) in all three watercourses - During the summer months flow decreases substantially, often reaching what are known as 'zero flow' regimes. Disconnected pools form in the lower reaches of the water course system.

As shall be seen in the next chapters (5 and 6) the hydrological complexity of these waters, coupled to the lack of historic data on water flows in the Maltese Islands, makes the biological, hydromorphological and physico-chemical evaluations for a holistic ecological assessment, as required by the Water Framework Directive, very difficult.

The boundaries of the water courses were delineated on the bases of the presence of water in the main channel. Since monitoring of the water regime in these water courses is very limited the boundaries can potentially change following additional monitoring. In the case of Wied il-Luq the water course does not lead to the sea but forms a small part of the larger Wied il-Kbir valley system. The reason is that this stretch of the valley system has been identified to be distinct from the remaining valley system as it contains water and is ecologically significant. The boundaries for each water course are shown in Figures 2.17-2.19.

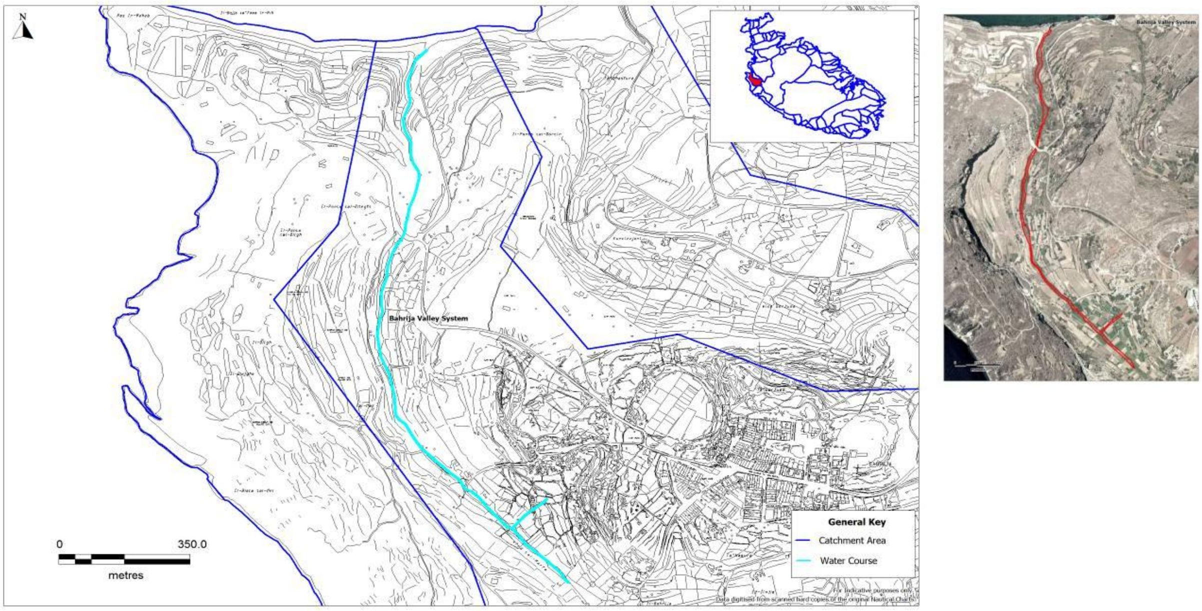


Figure 2.17: The location of Baħrija water course opening to Fomm ir-Riħ Bay on the northwest coast of Malta. The light blue line marks the boundary of Groundwater linkages here are strong and may account for the permanent, albeit diminished summer flow, throughout the year. *Top right:* an aerial view of the watercourse.

Figure 2.18: The location of the Wied il-Luq water course, as one of the main upper reach tributaries (along with Wied Girgenti and Wied Xagħra) of the larger Wied il-Kbir valley system that traverses Malta and ends up at Marsa (Southern Malta). Groundwater linkages here are likely and require further investigation.

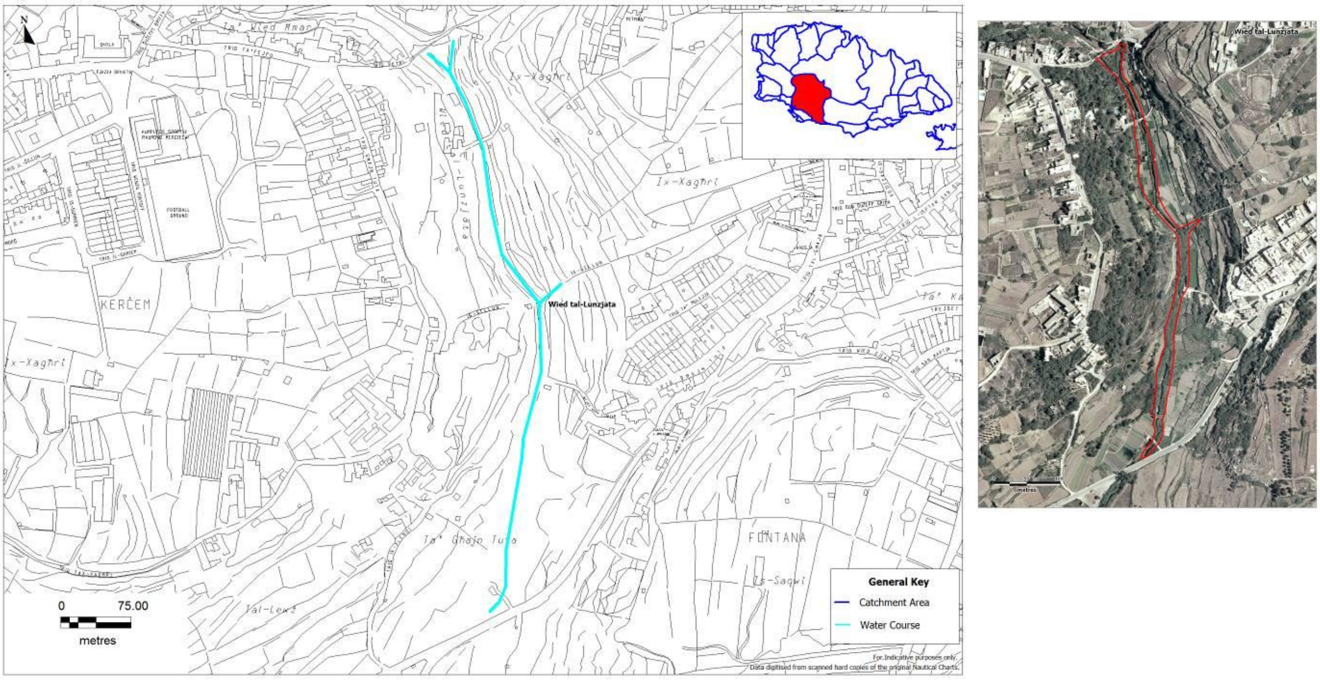


Figure 2.19: The boundary of the Wied Lunzjata water course located in the Xlendi valley system. The Xlendi system is well known for its dependence on springs. The Wied Lunzjata tributary was delineated on the basis of the flow of water that can be found here and the water dependent species that thrive on it.

2.3.2.2 Physico-chemical and nutrient characteristics

The intermittent hydrological regime of water courses described above is a key factor in controlling physico-chemical and nutrient characteristics. Alternating dry and humid conditions stimulate microbial activity and lead to nutrient pulses following precipitation – or rewetting (Ademollo *et al*., 2011). Given that the fluctuating low flow creates a mosaic of local environmental conditions, and biological processes, the chemical characteristics of these waters is constantly changing.

Low surface flow and longer water residence times lead to higher solute concentrations in water courses. Organic matter decomposition, nitrification and denitrification are affected by such changes in stream conditions. Therefore in the case of these water courses, nutrient levels may have a tendency to be higher in particular reaches of the watercourse or at particular time periods. In the case of the three watercourses nitrate levels were constantly high as indicated in figure 2.10. Any possible 'natural' fluctuation in nutrient levels is masked by the contribution of high nutrient levels by a number of potential sources such as agricultural activities and groundwater contributions. In fact nitrates alone were in the range of 110 – 200 mg/l in all three water bodies throughout the year.

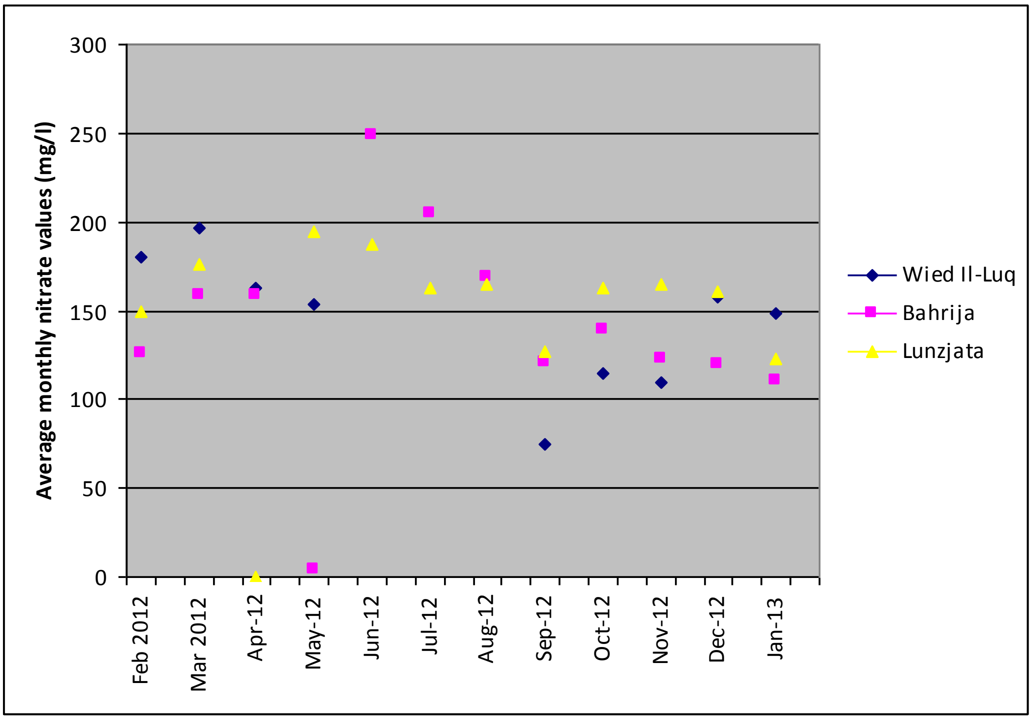


Figure 2.20: Average nitrate levels in the three water courses over a year. They are constantly high with two anomalies in April and May for Bahrija and Lunzjata water courses. These high levels further point to the link that exists between the surface water and groundwater systems, since nitrate levels in other freshwater systems, such as the pools were low.

Dissolved oxygen levels in each of the three water courses were comparable in those water course reaches where water was present all year round. Very low levels, as expected, coincided with high temperatures, however low levels in DO were also registered when there were increases in nitrate levels.

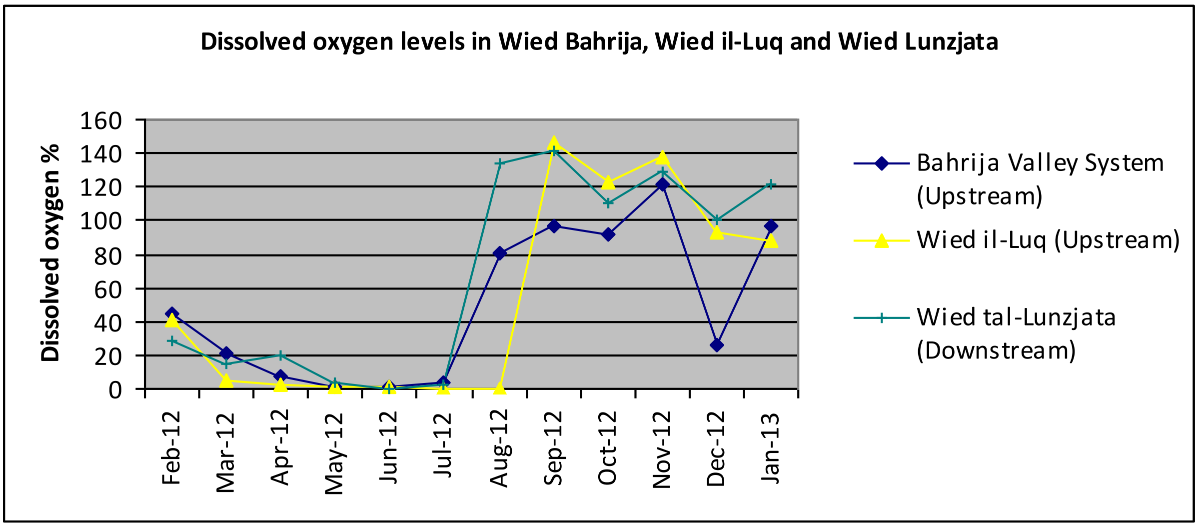


Figure 2.21: Dissolved oxygen levels in the three water courses.

2.3.2.3 Characteristics of Maltese Water Courses

Table 2.4 summarises the hydrological, hydromorphological and physico-chemical characteristics of all three water courses described above.

Water Category	Morphological parameter		Water quality parameter	
Water Courses	**Geology**	Calcareous	**Temperature**	< 13 °C >20°C
	Length of water course	0.6 km 1 - 1.7 km	**Dissolved oxygen %**	< 5% 5-20% 20-40% 80- 100%
	Depth of water channel	1 – 4 cm 5- 9 cm 10-25 cm	**pH**	5 - 6 >7
	Flow regime (wet period)	< 20 days per year > 100 days per year Irregular	**Salinity (ppt)**	< 1 1 - 2
	Water Supply	- Rainfall & groundwater - Rainfall and Water from engineered harvesting structures	**Trophic levels**	Eutrophic

Table 2.4: Physical characteristics of the three water courses in the Maltese Islands

In order to characterise the typology of these water courses the morphological parameters (geology, depth of water channel, and flow regime) and physico-chemical parameters (pH and Salinity) shall be used.

2.3.3 Characterisation of Pools

2.3.3.1 Hydrological regime

The presence of permanent freshwater pools in the Maltese Islands is very rare. Two permanent and extremely small pools are known to occur in the island of Gozo. These are the Ghadira ta' Sarraflu and the Qattara. They are described to be permanent due to the presence of water in these pools all year round. However they can be considered to be temporary due to the fact that they present significant variability in the length of their hydroperiod or the period during which the pools receive maximum waters. From the one year data collated the Ghadira ta' Sarraflu almost dried out completely during July. Additional data is required to be able to determine the various wetting stages of these two pools.

According to Keely and Zedler (1996) *in* Zacharias (2007)[5] a temporary pool may consist of four stages: (a) a wetting phase, (b) an aquatic phase, (c) a waterlogged terrestrial phase and (c) a drought phase. Although both pools never dry out, the graph presented in Figure 2.22, clearly indicates that both pools undergo different stages of wetting. These different stages influence the resultant aquatic flora and fauna that can be found within these pools at different times of the year (refer to Chapter 6).

[5] Zacharias, I. Dimitrou, E., Dekker, A. and Dorsman, E. 2007. Overview of temporary ponds in the Mediterranean region: Threats, management and conservation issues, in Journal of Environmental Biology, January 2007, 28 (1) 1-9.

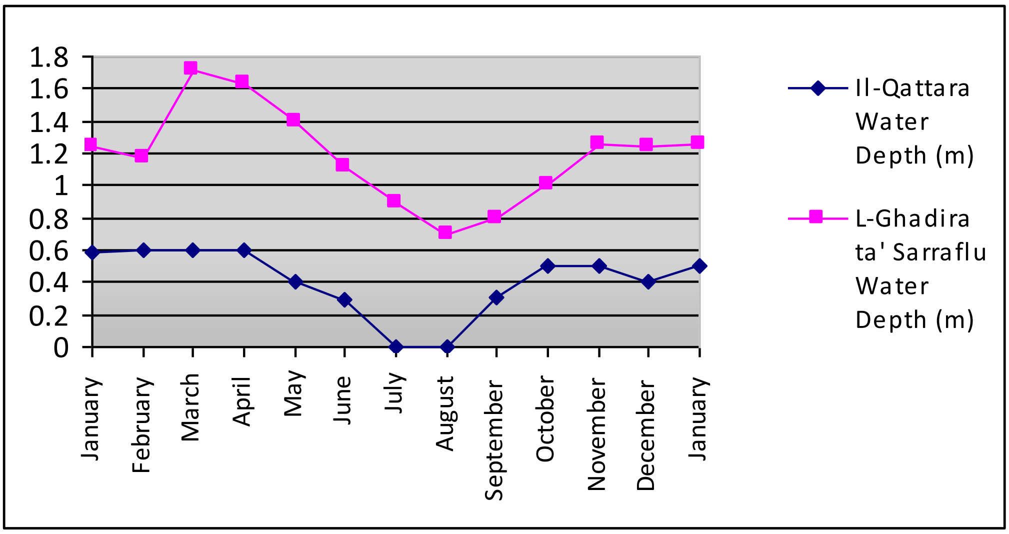


Figure 2.22: Water depths of the pools measured monthly from a central point between January 2012 and January 2013 in both freshwater pools

Water levels peak during the late winter months in both pools. They decline at the same rate in both pools as the summer season approaches, reaching their lowest levels (but never drying out completely), during July and August. Diversity of the pool biota in terms of species richness is dependent on the duration of the hydroperiod and on the diversity of vegetation colonising the substratum during the aquatic ecophase (Lanfranco, 1995[6]). Longer hydroperiods promote the accumulation of a larger subset of colonising species, while vegetational diversity increases habitat heterogeneity and hence faunal diversity (Lanfranco, 1995).

The freshwater inflow sources of the pools differ. In the case of the Qattara, which is located at the bottom of an escarpment and within a depression at the mouth of the valley Wied il-Kbir, the main inputs of water is through surface runoff as well as percolating water that comes from the surrounding Lower Coralline Limestone formation. Localised surface runoff flows contribute to the pool where it crosses the impermeable Blue Clay formation under high rainfall conditions (Refer to Figure 2.23 for the location and delineation boundary of the Qattara pool).

The sources of freshwater inflows into the Għadira ta' Sarraflu are less certain. One input is surface runoff that collects into a steep sided depression which was developed by subsidence of the surface layer of the Upper Globigerina Limestone layer. Erosion of the softer underlying Middle Globigerina Limestone layer underneath meant that the Upper Globigerina Limestone layer was pierced. As a result its sides overhang to form this depression. The indication of surface runoff as the only inflowing water source, however, is unlikely due to the location of the water body on high ground with very limited catchment area. Links with groundwater are not likely either due to the location of this water body above the Gozo Mean Sea Level Aquifer. Other likely freshwater inflows, possibly through percolating waters, need to be investigated further.

The outflows of both pools are mainly via evaporation as Figure 2.22 (water Depth graph) indicates. The possibility of infiltration for il-Qattara is highly unlikely given that is lies on the Blue Clay formation, whilst infiltration from the Għadira ta' Sarraflu is possible.

[6] Lanfranco S.1995. Temporary rainwater rockpools as repositories of biological diversity in the Maltese Islands - Presented at BIO'MES 95 scientific symposium; 7eme Rencontres de L'A.R.P.E.; Digne-les-Bains, France, October 1995.

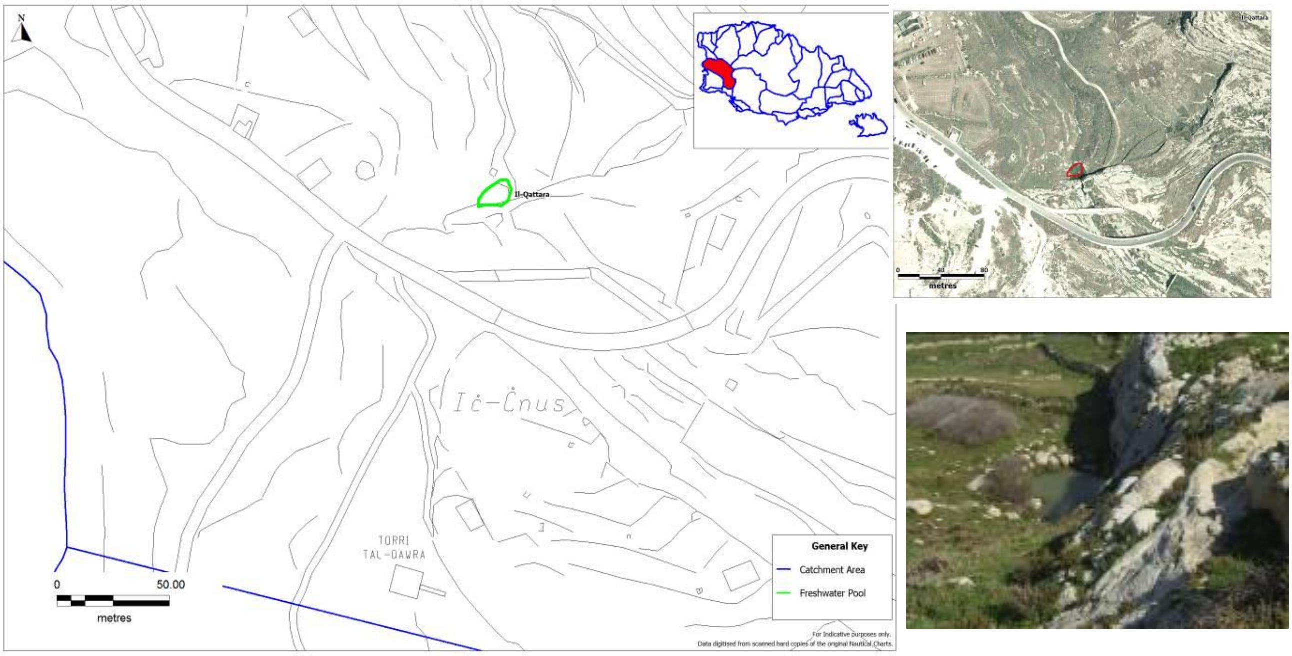


Figure 2.23: The location of the Qattara depression at the mouth of Wied il-Kbir, Dwejra in Gozo. *Top right:* An aerial view of the Qattara pool just beneath the road that leads to Dwejra. The area of the pool is approximately 100m^2

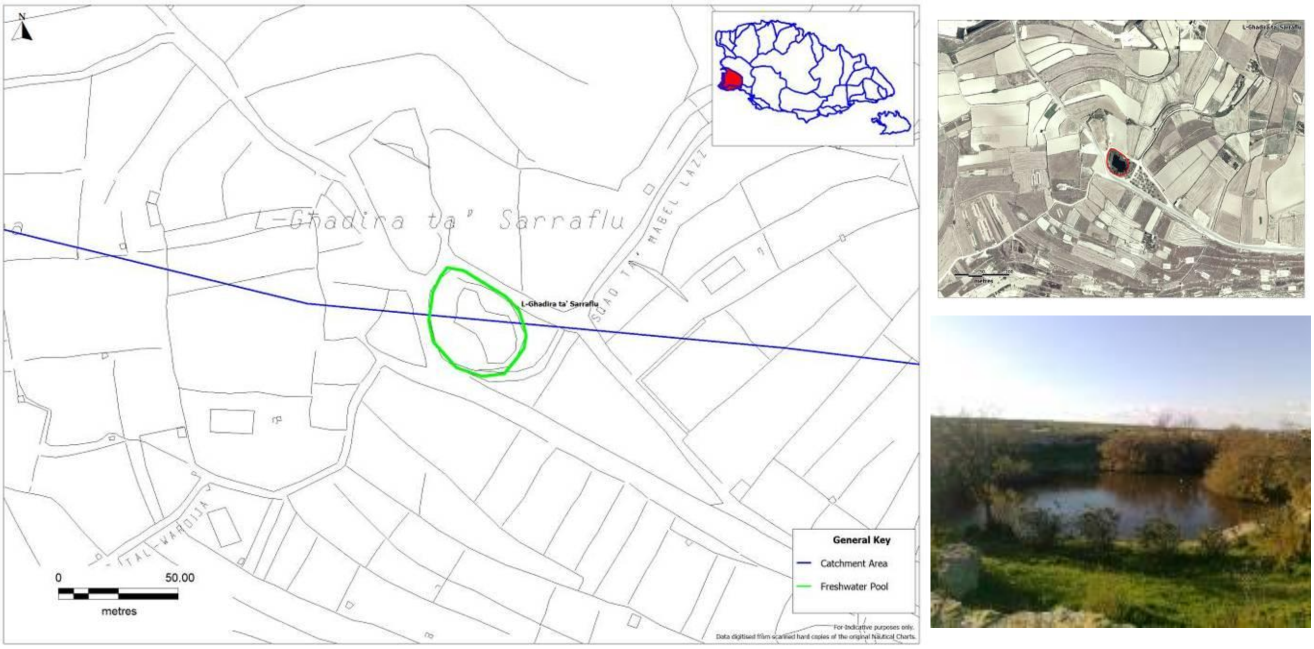


Figure 2.24: The Għadira ta' Sarraflu freshwater pool located on a cliff top on the Southwestern coast of Gozo. *Top right:* An aerial view of the pool. The area of the pool is approximately 1km^2

2.3.3.2 Physico-chemical observations

As stated previously, the physical and chemical characteristics fluctuate considerably in temporary waters. Establishing physico-chemical criteria in these waters is difficult because a considerable amount of monitoring data are required to refine indications about them and therefore, once again, the results have been interpreted in light of this premise.

Salinity can be an important factor in these temporary waters towards the end of the wet season when dissolved ions tend to accumulate due to evaporation. However the results indicated a reverse where salinity levels actually dropped during the dry season (Figure 2.25). A slight dip in salinity levels was recorded in these waters from October to January, most likely due to the increase in runoff contributions. Similar to the other water categories, not much can be determined from the one year monitoring.

Extreme changes in pH and levels of dissolved oxygen were also recorded in both water bodies. The acute changes in pH in these types of waters is explained by Zacharias *et al* (2007)[7] whereby the pH is largely controlled by the carbon dioxide-bicarbonate system and thus when waters experience photosynthetically–driven depletion of CO_2, the pH may rise 2-3 units with a few hours. Dissolved oxygen levels are known to fluctuate even on a diurnal basis and are often low. In the case of the both Qattara and Għadira ta' Sarraflu, anoxic conditions were present in the summer months of June and July. Dissolved oxygen levels improved during the rainy period. However diurnal changes in dissolved oxygen are known to occur in these waters since as light availability increases during the day, photosynthesis is inhibited by carbon dioxide limitation, and potentially oxygen availability is reduced as a result of photorespiration.

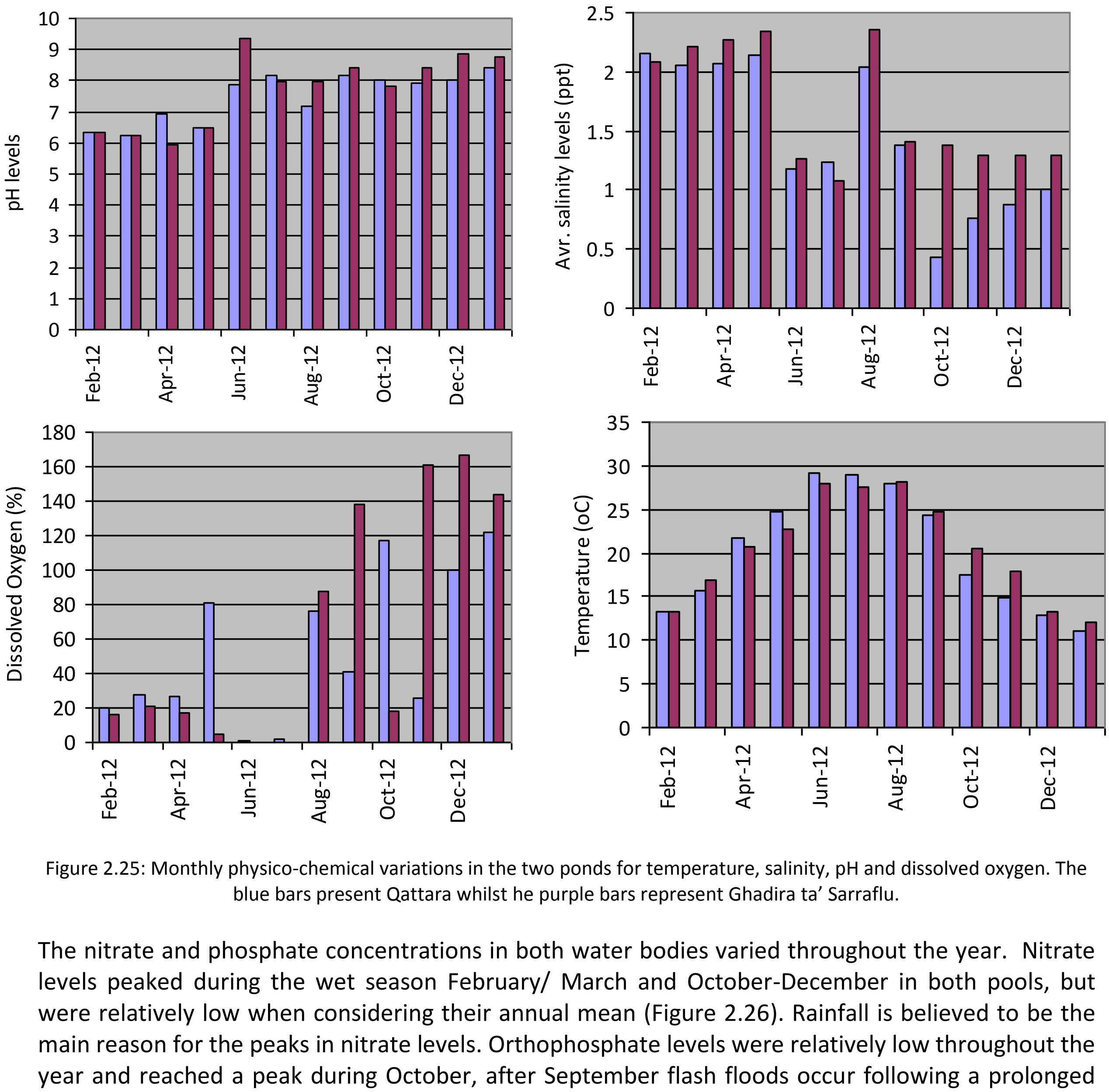
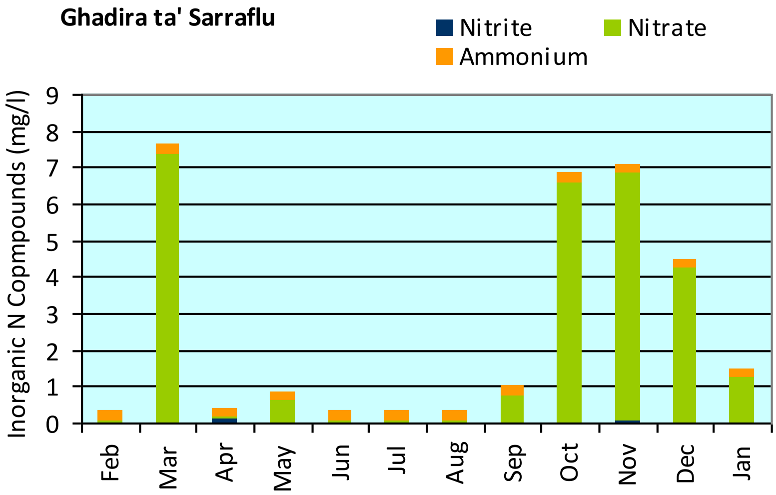


Figure 2.25: Monthly physico-chemical variations in the two ponds for temperature, salinity, pH and dissolved oxygen. The blue bars present Qattara whilst he purple bars represent Ghadira ta' Sarraflu.

The nitrate and phosphate concentrations in both water bodies varied throughout the year. Nitrate levels peaked during the wet season February/ March and October-December in both pools, but were relatively low when considering their annual mean (Figure 2.26). Rainfall is believed to be the main reason for the peaks in nitrate levels. Orthophosphate levels were relatively low throughout the year and reached a peak during October, after September flash floods occur following a prolonged dry season.

[7] Zacharias, I., Dimitriou, E., Dekker, A., and Dorsman,. E. 2007. Overview of temporary ponds in the Mediterranean region: Threats, management and conservation issues. Journal of Environmental Biology. January 2007, 28 (1) 1-9



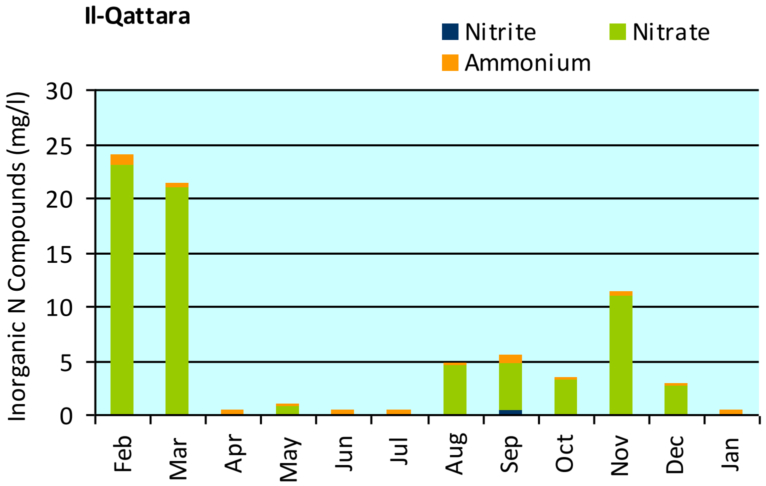


Figure 2.26: Average monthly nutrient values in the two ponds for inorganic nitrogen compounds.

Due to the fact that very little is known about the various stages of these pools at this point in time, the changes in the physico-chemical characteristics in relation to these changes, and their influence on the resulting ecological communities, are yet to be determined.

2.3.3.3 Characteristics of freshwater pools

The classification system being proposed for these waters considers the basic biotic and abiotic factors which determine the ecological regime of their habitats. These include water quality parameters and morphological parameters. Table 2.5 provides a typology system for the two pools based on the one year monitoring that was carried out at both sites during 2012-2013.

Water Category	Morphological parameter		Water quality parameter	
Water Courses	**Geology**	Calcareous	**Water Temperature**	< 15 °C 15–25°C >25°C
	Size	100m^2 1km^2	**Dissolved oxygen %**	< 5 % 5-10% 20-40% 80- 100% > 100%
	Water Depth	0.03 – 0.6 m 0.6 - 2m	**pH**	6-7 7-8 >9
	Inundation period / hydroperiod	Will be revised following additional data but indications are that both pools are inundated for a max of 30 days	**Salinity (ppt)**	< 2 > 2

		< 30 days / year > 30 days / year		
	Water Supply	• Rainfall • Rainfall and percolating water	**Trophic levels**	Oligotrophic Mesotrophic
	Period of flooding	Autumn (Sept/ Oct) Winter		

Table 2.5: Physical characteristics considered in for the typology of the two ponds in the Maltese Islands

In order to characterise the typology of these ponds the morphological parameters (geology, mean water depth, size (area of pond) and number of days that the pond is inundated as well as the period of flooding) and physico-chemical parameters (pH and Salinity) shall be used.

2.4 Characterisation of coastal waters

2.4.1 Introduction

The obligatory descriptors of System B described at the start of this Chapter for coastal waters are fairly consistent at the scale of the Maltese Islands. The size of the Maltese Islands would not sufficiently enable coastal water bodies to be differentiated according to their latitude or longitude. Salinity differences between water bodies are not significant either and the tidal range across the Maltese Islands, as elsewhere in the Mediterranean, is negligible. System B optional factors, on the other hand offer a good degree of variable factors which help to discern coastal water body characteristics and types. As recommended in the guidance document[8], these optional factors were considered: wave exposure, depth, followed by other factors until an ecologically relevant type of water body was achieved. Mixing characteristics, substratum type and current velocities were also considered to be relevant factors in the local scenario. The descriptors / factors that were considered relevant for the Maltese coastal waters and the corresponding ranges and descriptions are given in Table 2.6.

Exposure	A pan-European scale which should be used to assess exposure for the purposes of the WFD, as follows: **Extremely exposed** – open coastlines which face into prevailing winds and receive oceanic swell without any offshore breaks (such as islands or shallows) for more than 1000km and where deep water is close to the shore (50m depth contour within about 300m) **Very exposed** – open coasts which face into prevailing winds and receive oceanic swell without any offshore breaks such as islands, or shallows for at least several hundred kilometres. Shallow water less than 50m is not within about 300m of the shore. In some areas exposed sites may also be found along open coasts facing away from prevailing winds but where strong winds with a long fetch are frequent. **Exposed** – the prevailing wind is onshore (wind blowing towards the shore) although there is a degree of shelter because of extensive shallow areas offshore, offshore obstructions or a restricted window (<90 degrees) to

[8] The methodology used to define coastal typologies was based on the WFD CIS Guidance Document No.5: Transitional and Coastal Waters – Typology, Reference Conditions and Classification Systems.

	open water. These stretches of coast are not generally exposed to strong or regular swell. Coasts may also face away from prevailing winds if strong winds with a long fetch are frequent. **Moderately exposed** – these sites generally include open coasts facing away from prevailing winds and without a long fetch but where strong winds can be frequent. **Sheltered** – at these sites there is restricted fetch and/or open water. Coasts can face prevailing winds but with a short fetch e.g. 20km or extensive shallow areas offshore or may face away from the prevailing winds. **Very Sheltered** - these sites are unlikely to have a fetch greater than 20km (the exception being through a narrow channel) and may face away from prevailing winds of have obstructions such as reefs offshore or be fully enclosed.
Depth	Shallow <30m Intermediate 30-50m Deep >50m
Mixing	Permanently fully mixed Partially stratified Permanently stratified
Substratum	Hard (rock, boulders, cobble) Sand-gravel Mud Mixed sediments In many cases different seabed substrata will occur within one water body type. In such cases the dominant substratum type is selected.
Current velocity	For the Mediterranean (in relation to other eco-regions) weak currents are expected: ▪ <0.5 knots ▪ 0.5-1knot

Table 2.6 – System B Optional physical descriptors and corresponding ranges as relevant to coastal waters in the Maltese Islands

The physical characteristics of Maltese coastal waters are dictated by larger synoptic climatic features which take place at a Mediterranean scale. Being an enclosed sea the land and sea masses and the general topography of the Mediterranean basin influence pressure systems, winds, sea circulation, currents and sea surface temperatures.

The Mediterranean is influenced by temperature changes brought about by warmer seas in winter (when compared to land) and cooler sea in summer. Hence, during the winter the surface winds tend to flow from land towards the sea, and during the summer from the sea towards the land. In addition mountainous areas to the north and to the west of the basin mean that during winter, the mountain range to the north holds back much of the cold air from Europe or from Asia, while the mountains to the west resist the advance of polar front depressions, which can reach the Mediterranean only via the mountain gaps in southwest France and at the straits of Gibraltar, between Spain and Morocco. To the south there are no mountain barriers to prevent the dry dusty air from the Sahara, except the Atlas Mountains in Morocco.

Against this Mediterranean backdrop, the various System B optional factors selected to characterise Maltese coastal waters, were assessed. These included the assessment of exposure and depth based on prevailing winds, water depth and fetch[9], bathymetry and topography of the Mediterranean basin, water circulation, sea currents and resultant sea surface temperatures.

2.4.2 Assessment of Exposure and Depth

In order to understand the degree of exposure of the different coastal areas it is required to describe General circulation patterns of the Mediterranean sea, prevailing winds, water depths and the fetch of the coastal environment of the Maltese Islands.

2.4.2.1 Circulation

The Mediterranean Sea exhibits a complex thermohaline, wind, and water driven multi-scale circulation.[10] Different vertical water masses form as a result of mesoscale features and seasonal variability.

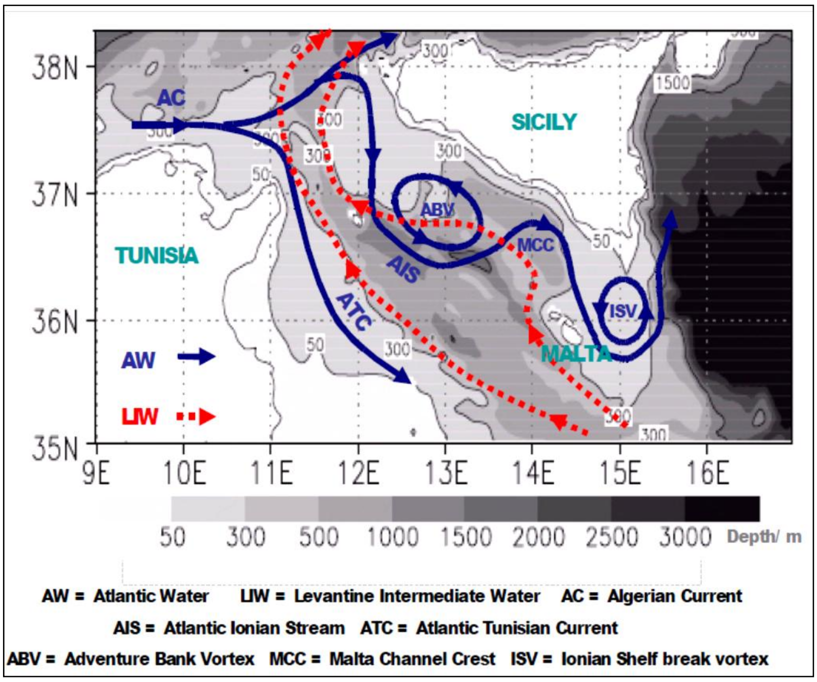


Figure 2.27: Schematic diagram of circulation in the Strait of Sicily
Source: Astraldi, Gasparini and Gervasio, 2001 [11]

The upper water mass (up to 100m depth) consists of a homogenous layer of cooler and fresh (less saline) Modified Atlantic Water (MAW; T= 15 to 17°C; S = 37.2 to 37.8). It becomes warmer and saltier as it spreads toward the eastern Mediterranean basin. The MAW is directed eastward by the unstable coastal boundary Algerian Current (AC). The latter is subject to significant mesoscale variability and a complex surface pattern due to the bottom topography. Looking at the schematic diagram (Figure 2.27 – blue stream), the MAW on approaching the Straits of Sicily splits in two energetic and meandering streams – the Atlantic Ionian Stream (AIS) and the Atlantic Tunisian Current (ATC).

[9] Fetch is defined as the distance of open water over which the wind blows. Generally long fetches result in stronger winds and rougher seas.

[10] Robinson, A.R., Leslie, W.G., Theocharis, A., and Lascaratos, A. (2001). Mediterranean Sea Circulation. 1689-1705 pp.

[11] Astraldi, M., Gasparini, G.P. and Gervasio, L. (2001). Dense Water Dynamics along the Strait of Sicily (Mediterranean Sea) *Journal of Physical Oceanography*, 31: 3457-3475 pp.

Figure 2.27 indicates how the former passes the region of the Straits of Sicily, and the latter flows southward along the Tunisian shelf break. The main AIS veers to the north-northeast, meandering around the Adventure Bank Vortex (ABV), The Malta Channel Crest (MCC) and Ionian Shelf Break Vortex (ISV). This bifurcation (and the opposite subsurface tongue of core Ionian water – explained further below) explains the warmer and saltier waters observed in the central part of the Strait, southwest of Malta. A second bifurcation of the main AIS occurs above the Ionian slope near (36.2N, 16E).[12]

Both AIS and ATC are characterised by a strong seasonal variability, in terms of path and hydrological features. The AIS circulation represents the main flow of the surface MAW and has a characteristic lower sub-surface temperature. During summer and autumn, the flow takes the consistency of a jet stream, gaining abruptly positive vorticity as it reaches the sharp shelf break to the east of Malta, and tending to deflect northward with an intense looping meander, forming the characteristic Ionian Shelf Break Vortex (ISV).

At an average depth of 200 to 280m, the layer of more saline Modified Levantine Intermediate Water (MLIW; T = 13.75 to 13.92 °C and S = 38.73 to 38.78 at the Straits of Sicily) moves in the opposite direction towards the west. Looking at Figure 2.27, the LIW (red stream in figure) enters the Sicily Channel from the Ionian. The LIW broadly rises above the Ionian slope. This leads to a northward boundary current along the slope which re-circulates parts of the LIW back into the Ionian Sea. The westward LIW passage is around Medina Bank, south of Malta where the sea bottom rises from a depth of over 2000m to a mean of around 400m with a salinity of about 38.74 to 38.75 psu and a temperature of about 14.0 to 14.1°C in autumn-winter. In the Sicilian Channel the LIW stream is strongly controlled by the topography. Once in the Strait, the westward advection continues along the Tunisian slope, with re-circulations around lenses and boundaries of local trenches. The LIW finally slides into the Tyrrhenian Sea, forming an eastward boundary current. The flux of LIW is not constant but subject to a seasonal variability and calculated to be 2–3 times higher in winter with respect to summer. The thickness of the LIW layer changes substantially with the seasons, wider in fall-winter and thicker in spring-summer. Its core depth varies seasonally with the LIW being deeper in winter, below 200 m, and closer to the surface in summer and autumn.

The layer of Ionian Water (IW; T= 15 to 16.5 °C, S = 37.8 to 38.4) resides as a subsurface layer (50-100 m depth) in the eastern extremity of the area, mainly south of Malta on the Malta shelf areas. The main IW pathways consist of a tongue in the central region of the Strait and of a meandering northward current along the Ionian slope (Figure 2.28). The core IW has two pathways: one enters 34.5N, 17E and follows the Ionian slope, the other starts at 34.5N, 14E and follows the Tunisian shelf, with a speed of about 5 cm/s. Southwest of Malta, this broad pathway bifurcates. The first branch goes east, flows south of Malta and then follows the Ionian slope northward, joining the first pathway. The second branch continues north, reaches the Maltese Channel Crest, is then entrained to the east and finally rises above the Maltese plateau within the AIS, mixing with MAW along the way.[13]

[12] Lermusiaux, P.F.J. and Robinson, A.R. (2001). Features of dominant mesoscale variability, circulation patterns and dynamics in the Strait of Sicily. *Deep-Sea Research I*, 1-45 pp.

[13] Lermusiaux, P.F.J. and Robinson, A.R. (2001). Features of dominant mesoscale variability, circulation patterns and dynamics in the Strait of Sicily. *Deep-Sea Research I*, 1-45 pp.

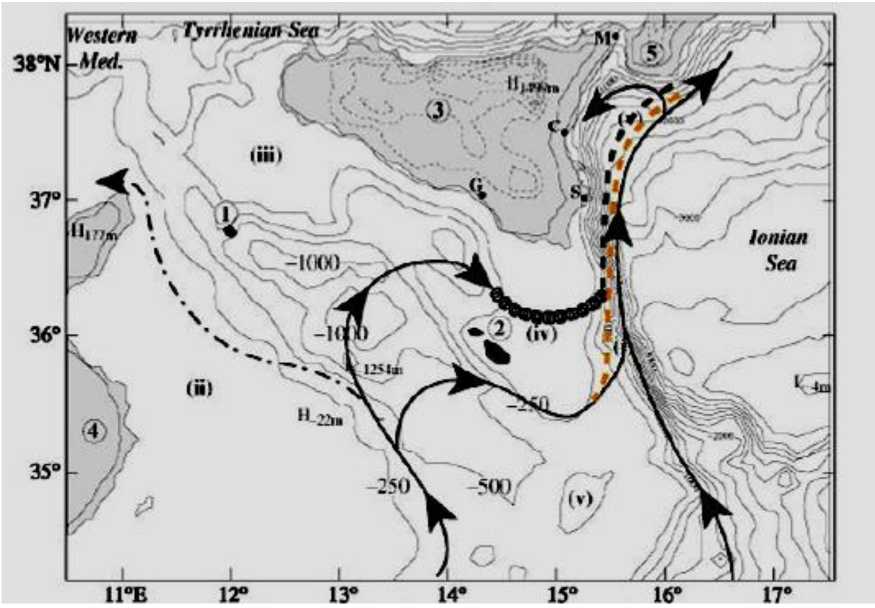


Figure 2.28: Ionian Water Pathways as per Lermusiaux and Robinson, 2001

The deeper Eastern Overflow Water (EOW) represents the water incident from the eastern Mediterranean overflowing over the south–central Mediterranean ridge into the Tyrrhenian Sea. It consists of LIW and Eastern Mediterranean Deep Water (EMDW) which is colder and fresher than the LIW. Below the LIW there is a significant volume of transient EMDW (tEMDW). In the Straits of Sicily area the tEMDW appears as a colder and fresher water mass with respect to the LIW, having a core characterised by a minimum temperature of 13.63°C and a salinity of 38.73.

2.4.2.2 Currents

Sea surface currents on the Malta shelf area are essentially characterised by the Atlantic Ionian Stream (AIS). This is directed towards the south-east along the Malta Channel with an average magnitude of 30 cm s^{-1}. The AIS is stronger in summer/autumn and weaker in winter/spring. In the eastern proximities of Malta, the AIS tends to swerve towards the south. This swerving is most evident in spring, summer and autumn. It gives rise to strong flows towards the south that subsequently veer towards the south-west (Figure 2.29). To the west, the presence of a quasi-permanent anticyclonic gyre drives water to the south and south-westerly directions. This circulation is most evident in spring and summer. Annual and seasonal average currents to the south-west of the Maltese Islands are relatively much weaker (10 cm s^{-1} on average) and carry a homogeneous directional spectrum (only a slightly higher frequency of occurrence towards the south-western sector).

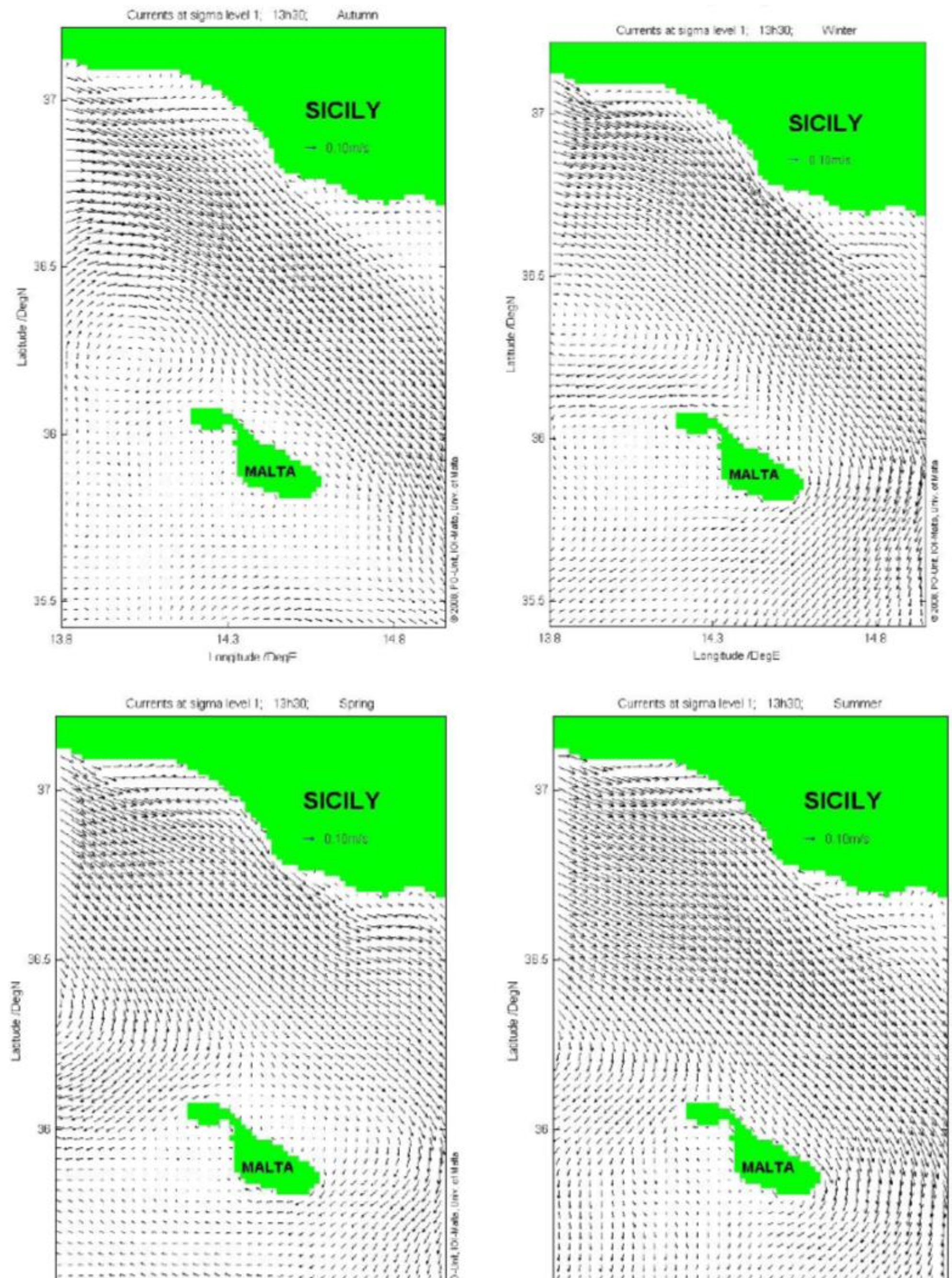


Figure 2.29: Climatological maps of seasonal sea currents
(Source: Alpha Briggs, 2008)[14]

For both the Modified Atlantic Water (MAW) and the Levantine Intermediate Water (LIW), the averaged kinetic variability has been observed two to four times higher in winter than in summer, in response to stronger wind stress and reduced stratification. The hydrographic properties of the MAW are also known to undergo significant seasonal variations, but those of the LIW are more constant (*vide* Lermusiaux and Robinson, 2001).[15]

[14] Source: Alpha Briggs (2008). Hydrographic Data Report. 102pp.

[15] Lermusiaux, P.F.J. and Robinson, A.R. (2001). Features of dominant mesoscale variability, circulation patterns and dynamics in the Strait of Sicily. *Deep-Sea Research I*, 1-45 pp.

2.4.2.3 Winds and waves

The Wind Rose below[16] (NSO, 2010) (Figure 2.30) indicates that the most common wind direction in the Maltese Islands is the North Westerly (Mistral). The mean value of wind speed over the islands in terms of strength and frequency is 8.5 knots (4.4 ms^{-1}) with the predominant wind speed below 10 knots (Alpha Briggs, 2008).

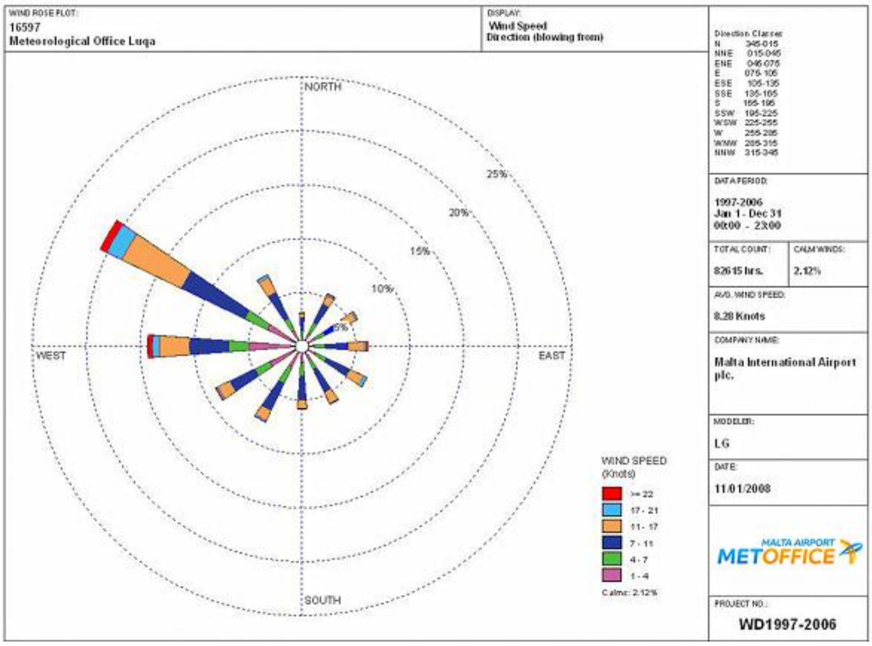


Figure 2.30: Wind rose for the Maltese Islands for the years 1997-2006
Source: Malta Airport Meteorological Office, 2006

The North-westerly (Mistral) blows on an average of approximately 21% of days in a year. The Mistral is often associated with lows that develop over Northern Italy and move towards east down the Adriatic (Figure 2.31). Due to the funnelling effect in the Sicilian strait the Mistral wind is the strongest and can often reach gale force.[17] Next in frequency is the wind blowing from the West followed by winds blowing from West Southwest (approx 9%), the South Southwest (8%) and North Northwest (7%). The other wind directions show no dominance. The North wind constitutes around 3% of the total days, making it the least dominant wind over the Maltese Islands.

Wind strengths may not necessarily be strongest from the most predominant directions. Wind rose plots show that the strongest winds originating in the north east, the south-east and east-south-east sectors are almost equally strong, albeit less frequent.

Winds in the Mediterranean Sea are characterised by the general circulation of depressions present in the Mediterranean during winter and transitional periods and by the presence of Azores high and north–east depressions during the warmer months (Figures 2.31 and 2.32). Winds from the north-east (Gregale) are often established during December to February. As the depression moves slowly towards the east along the Libyan coast and becomes established over Benghazi, the contrast with the high pressure over Europe triggers the very strong Gregale which leaps down from the Greek and Balkan mountains and blows with a long duration and a long fetch, piling up the sea all the way to the island of Djerba and the North African coast. This wind rises to gale force and is associated with heavy rain and poor visibility. Large energetic waves are also known to occur in the Malta Channel with wave heights reaching up to 6.5m occurring off Malta. These waves impinge orthogonally to the

[16] The Climate of Malta: statistics, trends and analysis, 1951-2010. Valletta: National Statistics Office, 2011viii, 45p.
[17] Alpha Briggs, October 2008 Hydrographic Data Report

northern coast of the Maltese Islands and can penetrate the otherwise sheltered ports and bays that stretch in parallel to their direction.

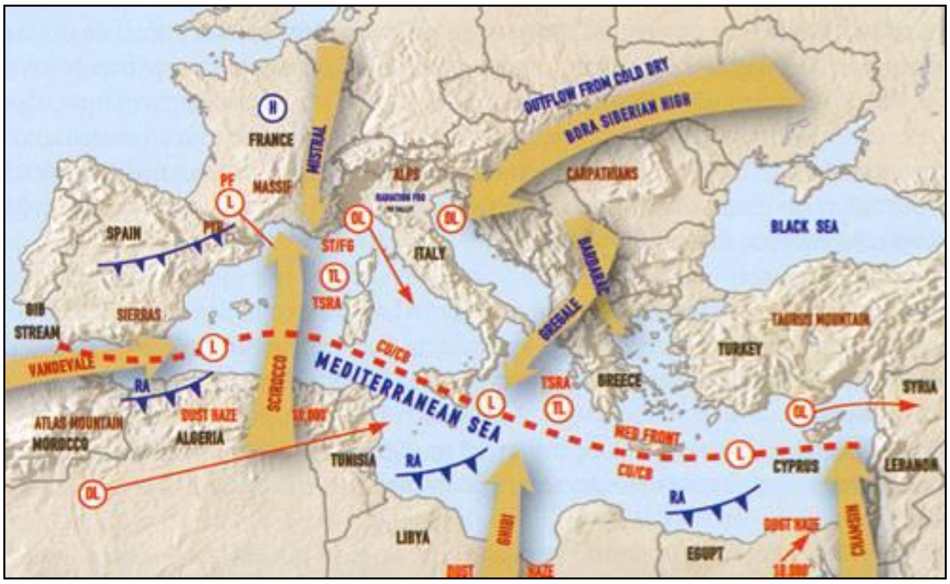


Figure 2.31: Mediterranean pressure systems and winds during the **winter** months
Source: http://www.aviamet.gr/cms.jsp?moduleId=018&extLang=LG

The south east winds occur when a depression over eastern Algeria and Tunisia together with a high over Greece or eastern areas of the Mediterranean, produce strong pressure gradients over the Ionian and Central Mediterranean leading to strong south-easterly (Scirocco) winds of continental tropical origin. These winds occur mainly towards late winter or in the April/May transition and can bring along Saharian dust that is deposited with rain.

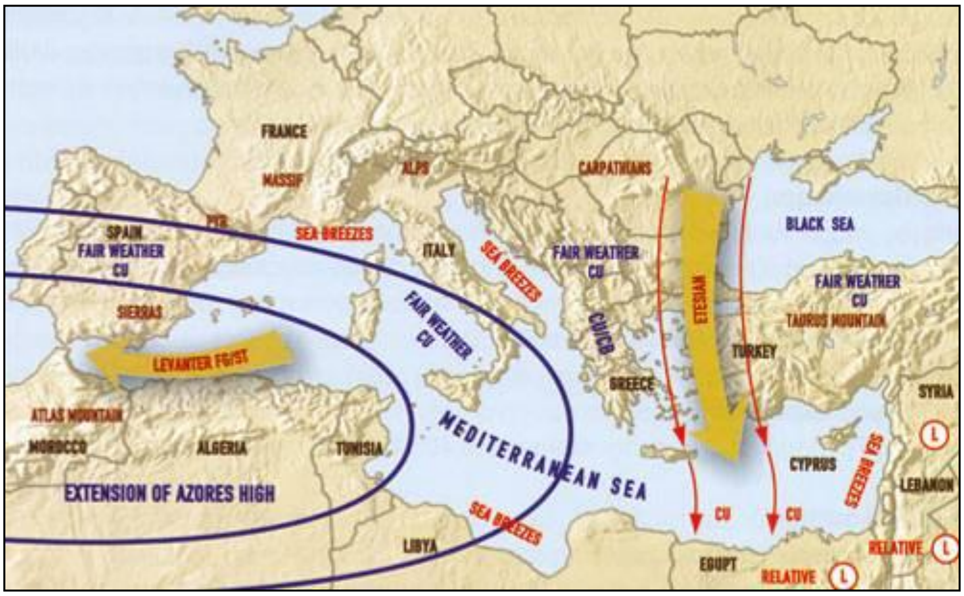


Figure 2.32: During the summer months the subtropical high of the Azores extends eastwards and enters the Mediterranean. Source: http://www.aviamet.gr/cms.jsp?moduleId=018&extLang=LG

Wind charts that depict wind speed on a seasonal and annual basis may be combined to present the annual average wind conditions in the marine environment, as presented in Figure 2.33 below. This diagram indicates that the wind climate in marine waters around the Maltese Islands is spatially homogenous with high wind strengths (7 ms^{-1}) reported to occur in the NW sector, speeds of 6ms^{-1} in the SW quadrant and weaker winds in the other quadrants (Alpha Briggs, 2008).

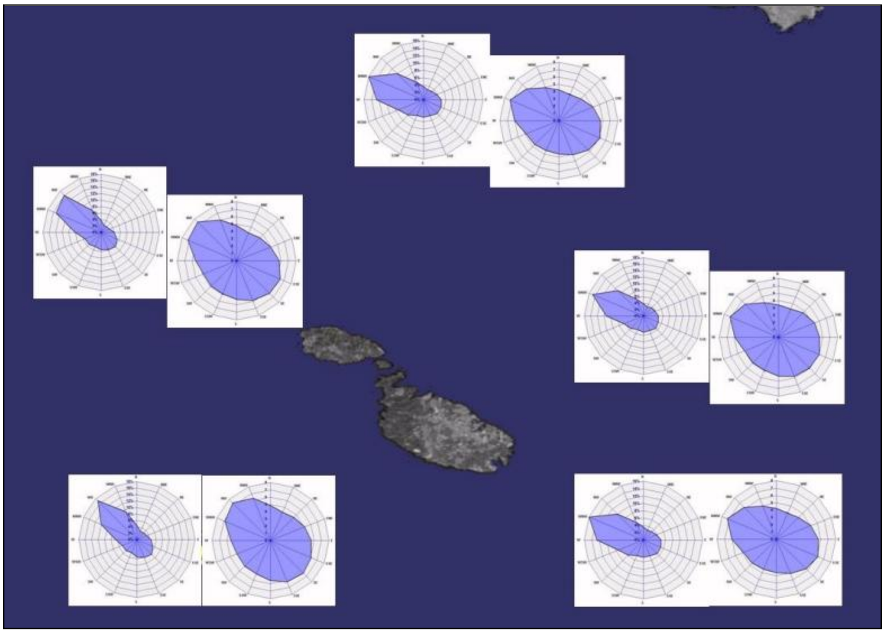


Figure 2.33: Annual average wind climate depicted by means of combined wind charts in Maltese marine waters. *Source: Alpha Briggs Hydrographical Data Report, October 2008*

Wave action is strongly linked to the prevailing wind conditions and fetch. In the Malta channel the wave field is typically most energetic in the area below 36.5°N due to the partial sheltering by the Sicilian coast (especially from Mistral and northerly winds). The strongest waves occur in the north, west and south west of the Maltese Islands. Wave incidence is predominantly from the North-north-west and the north.

The highest wave energy densities are experienced in January with wave heights able to reach 5m in open seas around the Maltese Islands[18]. August is the mildest month in terms of wave climate with over 60% of wave heights being in the lowest wave height band of 0-0.5m. The wave height distribution for June and July is similar to that of August.

2.4.2.4 Temperature

Sea temperature varies vertically according to the water masses that make up the water column. Variation is both by season and also inter-annually. In terms of season (Figure 2.34), during the summertime (graph for month 7), the nearshore well stratified surface layer (averages 20m in depth), above the cooler and relatively fresher Modified Atlantic Water (MAW), reaches temperatures between 20 and 27°C, due to solar heating. The near-bottom temperature is in contrast between 16°C and 19°C. The end of May usually leads to the first summer features. Approaching the winter season (*graph for month 1*), strong surface cooling and vertical mixing come into action. Winter mixing processes result in the homogenisation of the water column up to depths in excess of 100m with temperatures not exceeding 15°C. To the south the upper layer temperatures are around 2°C higher (homogeneous up to 60 m) mainly due to the advection of warmer water from the south. In early spring *(graph for month 4)* the presence of the fresh MAW starts to regain its evidence between Malta and Sicily, but its temperature in the upper layer remains greatly conditioned by surface forcing.

A transition stable water layer resides between 100m and 200m depth with an average temperature of 15.5°C. The characteristics of this layer are rather persistent throughout the year except that it is less thick in winter. The deeper water mass of Modified Levantine Intermediate Water (MLIW)

[18] Alpha Briggs, October 2008 Hydrographic Data Report

resides below 250m in winter and has a temperature decreasing with depth from 14.7°C to 14°C. This water mass is practically absent over the Malta shelf in areas with depths shallower than 100 m.[19]

In the area surrounding the Maltese Islands, various driving forces produce a very complex sea surface temperature (SST, at a depth of 5m) annual cycle, which varies significantly from year to year. The main driving forces include the progression of the Atlantic Ionian Stream (AIS) and its eastward extension, the upwellings south of Sicily and the warming and cooling of the shallow continental shelf.

Sea surface temperature readings for the year 2012 between the months of May and November are plotted in the graph below for a number of coastal water monitoring stations (Figure 2.35). As seen in the graph the SST increases on approaching summertime with readings peaking in the survey carried out at the end of August/ beginning of September. This reflects the surface heating (max reading is 29.15°C) that is normal for that time of year. The temperature starts to decrease on approaching the months of October and November.[20]

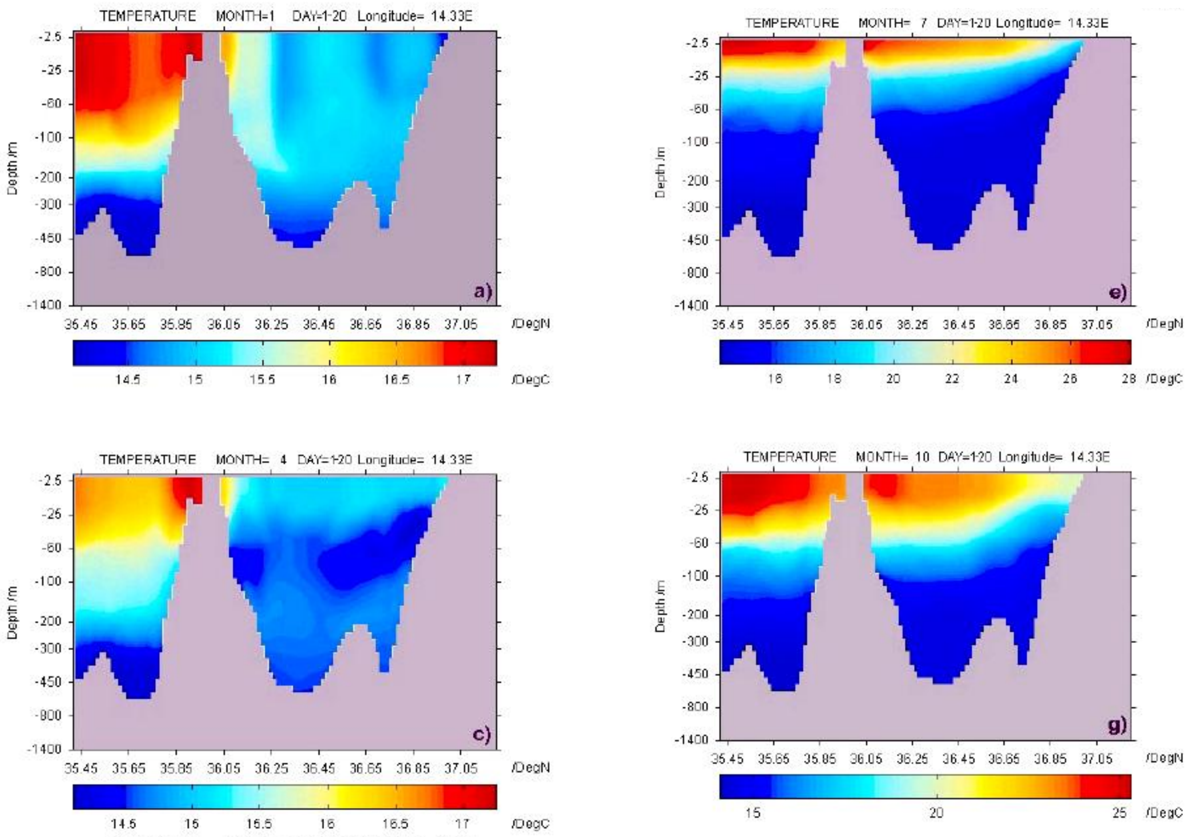


Figure 2.34: Meridional sections of temperature in months 1 (winter), 4 (spring), 7 (summer) and 10 (autumn) – The vertical section is taken along longitude 14°20′ E to coincide with the dividing line between Malta and Gozo (Source: Drago *et al.*, 2003)[21]

19 Sorgente, R., Drago, A. and Ribotti, A. (2003). Seasonal variability in the Central Mediterranean Sea circulation. *Annales Geophysicae*, 21, 299 - 322.

20 CIBM and Ambiente SC (2013). Development of Environmental Monitoring Strategy and Environmental Monitoring Baseline Surveys – Water Lot 3 – Surveys of Coastal Water – August 2012. ERDF156 - Developing national environmental monitoring infrastructure and capacity.

21 Drago, A.F., Sorgente, R., and Ribotti, A. (2003). A high resolution hydrodynamical 3D model of the Malta Shelf area. In *Annales Geophysicae*, 21: 323-344 pp.

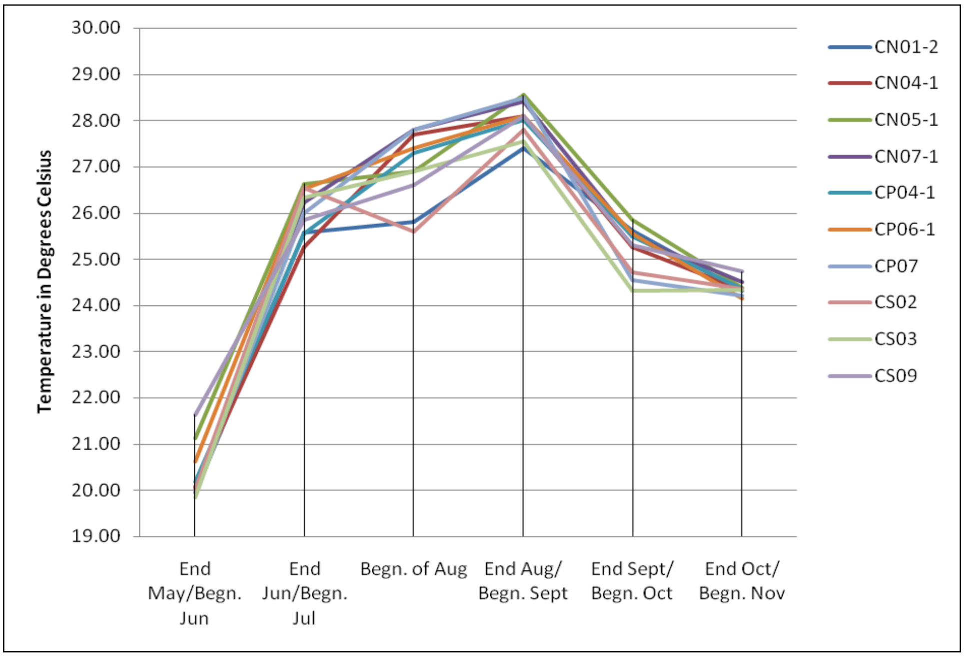


Figure 2.35: Sea Surface Temperature (°C) monitored at a number of WFD monitoring stations between May and November for the Year 2012

Malta's Second National Communication to the United Nations Framework Convention on Climate Change (UNFCCC) states that the mean SST in the coastal waters of the Maltese Islands has been steadily increasing at an average rate of close to +0.05°C per year since the late 70s. This is based on measurements made at a constant single point (in the open sea outside Delimara point) and at the same level of about 1 m below the sea surface, conducted for 28 consecutive years.[22]

2.4.2.5 Salinity

The Mediterranean Sea characteristically has a high salinity due to high evaporation rates and low river run-off. Surface Modified Atlantic Water (MAW) exhibits a strong seasonal variability in salinity as well as in the thickness of this layer. During the summertime (Figure 2.36, *graph for month 7*), sustained sea surface evaporation rates increase the salinity. The upper water layer in summer is characterised by a maximum salinity (reaching an average of 37.8 psu to the south). The underlying water has a lower salinity of the order of 37.4 psu, thus presenting, especially in the north, a salinity minimum with respect to the surface water. In mid-July the water of Atlantic origin appears as a well-defined subsurface core, centred along 36.6° N of latitude at an average depth of 20 to 60m. This core is gradually eroded as the winter season (*graph for month 1*) is approached, and strong surface cooling and vertical mixing come into action. A single homogeneous water mass is formed in the Malta Channel up to a depth of 100m.

A transition stable water layer resides between around 100m and 200m depth with an average salinity of 38.2 psu. This intermediate water is more saline than the overlying water masses and is the result of mixing of the Atlantic water with the deeper more dense water. The deeper water mass resides below 250m in winter and has a uniform salinity of around 38.75 psu. This water mass is identified as the MLIW and is practically absent over the Malta shelf areas with depths shallower than 100 m. It presents a maximum salinity in the western and southwestern approaches of Malta. The renewal time of the total MLIW in the channel has been estimated to be around 9 months, which is long enough to explain the fairly constant salinity over the annual cycle.

[22] Ministry for Resources and Rural Affairs & University of Malta 2010 The Second Communication of Malta to the UnitedNations Framework Convention on Climate Change; http://unfccc.int/resource/docs/natc/mlt_nc02.pdf

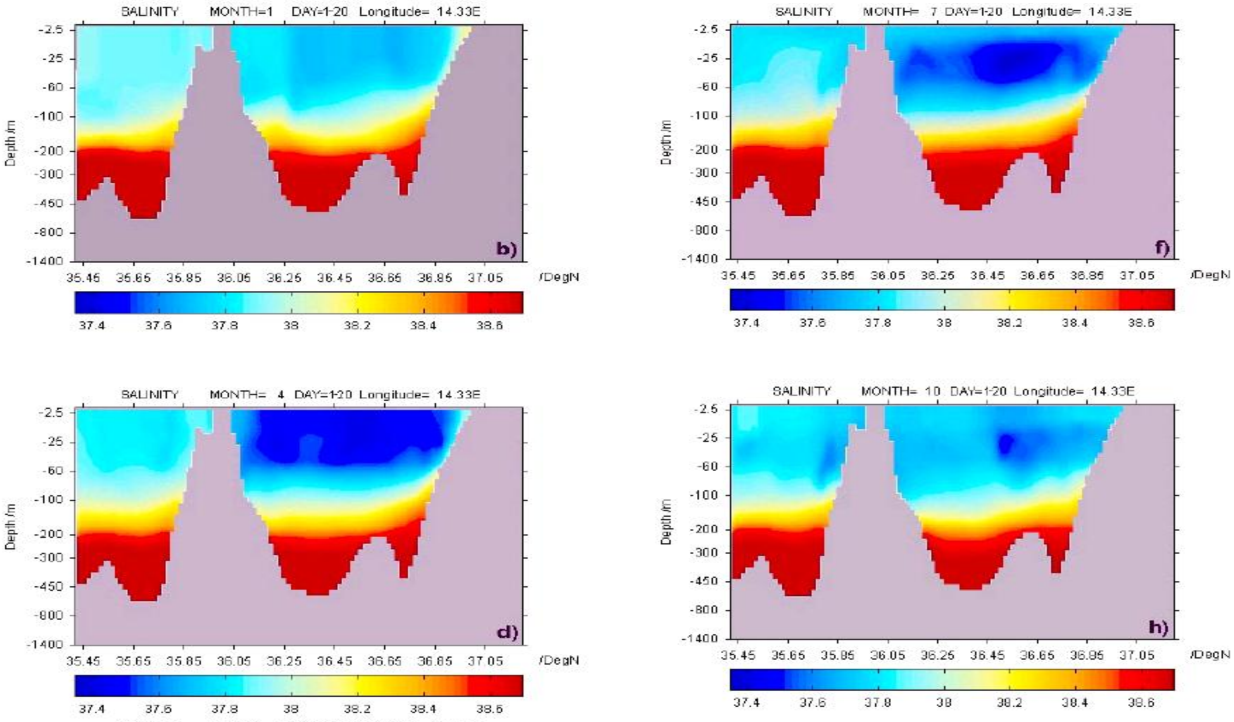


Figure 2.36: Meridional sections of salinity in months 1 (winter), 4 (spring), 7 (summer) and 10 (autumn) – The vertical section is taken along longitude 14°20′ E to coincide with the dividing line between Malta and Gozo (Source: Drago *et al*., 2003)[23].

Salinity readings (‰) readings for coastal monitoring station for the year 2012 between the months of May and November are plotted in the graph in Figure 2.37. As seen in the graph there is a sharp drop in salinity towards the end of June/beginning of July followed by a sharp increase with readings peaking round about summertime (end August/beginning of September) to coincide with the rise in temperature (and hence higher evapotranspiration). There is a gradual decrease on approaching the months of October and November.[24]

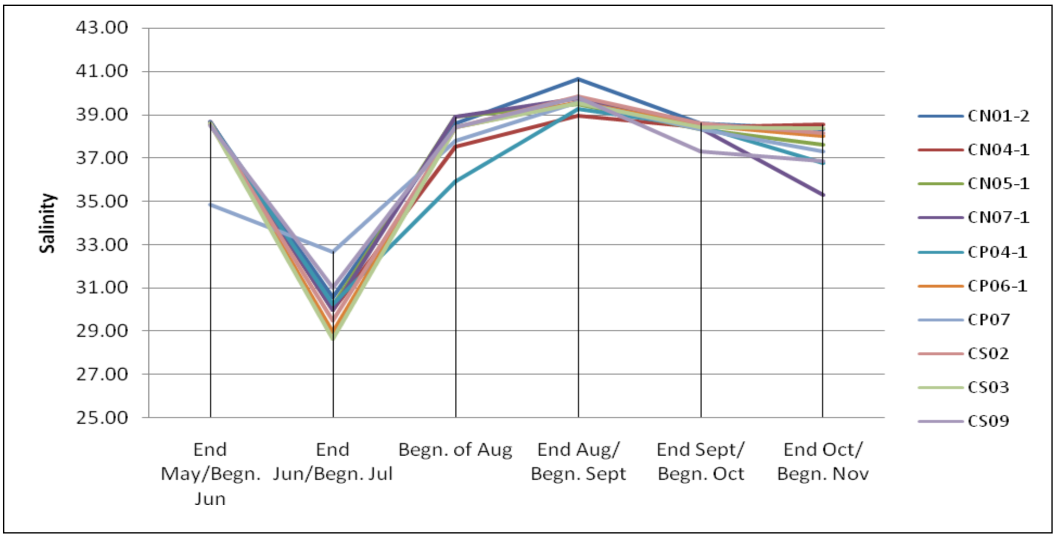


Figure 2.37: Salinity (‰) between May and November for the Year 2012

[23] Drago, A.F., Sorgente, R., and Ribotti, A. (2003). A high resolution hydrodynamical 3D model of the Malta Shelf area. In *Annales Geophysicae*, 21: 323-344 pp.

[24] CIBM and Ambiente SC (2013). Development of Environmental Monitoring Strategy and Environmental Monitoring Baseline Surveys – Water Lot 3 – Surveys of Coastal Water – August 2012. ERDF156 - Developing national environmental monitoring infrastructure and capacity.

2.4.2.6 Bathymetry

The bathymetry and topography of the Mediterranean plays an important role in determining the degree of exposure of the different coastal water stretches in the Maltese Islands. For purposes of assessing exposure a general description of the immediate depths of coastal waters around the Maltese Islands will suffice.

Figure 2.38 clearly illustrates the differences in depth between the Northern, and north eastern approaches of Malta to the western and south western approaches. The north and north eastern coastal stretches have shallow depths which gradually increase to the 100m depth as one progressively moves outwards. To the south the Maltese Islands are very close to the shelf break and therefore the bathymetry here is very steep. As the figure indicates, the 100m contour is very close to the coastline particularly in the North western parts of Gozo and Western coast of Malta.

It can therefore be concluded that **very exposed coastlines** in the Maltese Islands can be described to have a water depth that exceeds 50m very close to the shore (i.e. North western, western and south western stretches of coast). **Exposed coastlines** on the other hand, have a degree of protection from winds and waves due to shallow waters (<50m) that stretch for a significant distance offshore. For these coasts, the observed bathymetry within one nautical mile from the baseline (boundary of the water body) was of intermediate depth (predominantly 20-50 meters) and intermediate – deep (20->50m) – for the latter deep waters are present within the one nautical mile boundary.

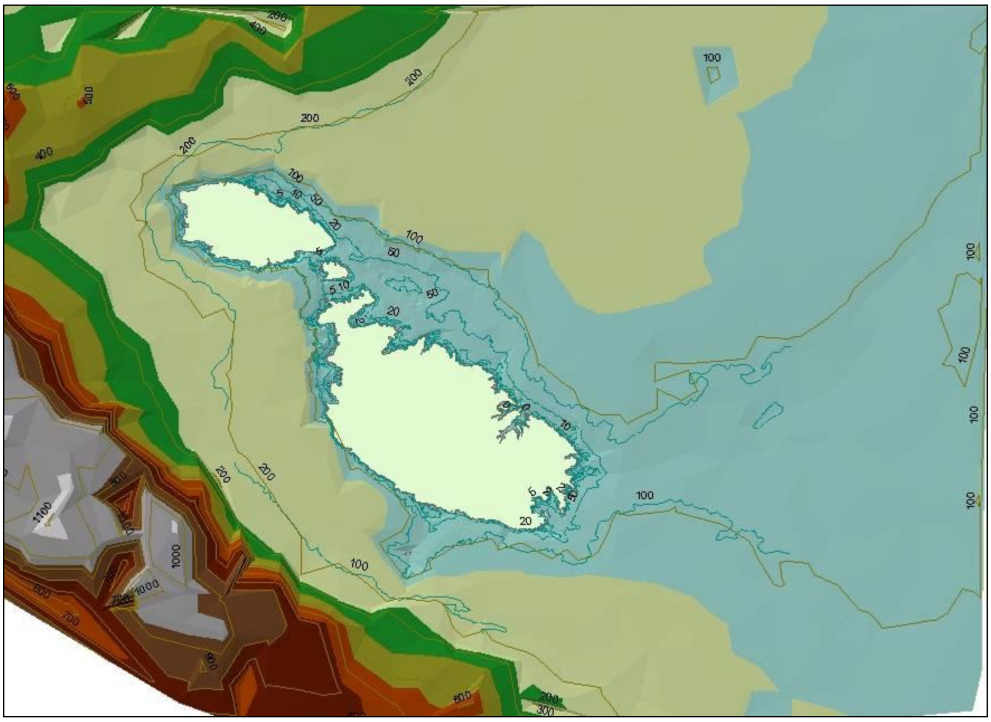


Figure 2.38: Water depths of coastal waters of the Maltese Islands

Source: MEPA mapping Unit

2.4.3 Definition of typologies

On the basis of the characteristics described above two exposure categories were defined for all coastal waters in the Maltese Islands: **very exposed** and **exposed**. Details for the degree of exposure of different water stretches are summarised in Table 2.7.

Very Exposed Coastlines		
Coastal stretch	**Wind**	**Water Depth and Fetch**
North West Gozo	Facing the prevailing wind, NW/Mistral	No breaks for several hundred kilometres and deep waters very close to the shore (50 meter contour line within 300m).
Southern coasts of Gozo (outside Comino Channel)	Sheltered from the prevailing north westerly winds, exposed to the west and south-west. As the wind rose (figure 2.17) indicates West is the second prevailing wind	There are no breaks for several hundreds of kilometres and there are no shallows within 300m from the shoreline.
Southern Malta,- south of Fomm ir-Riħ to Għar Lapsi	Sheltered from the prevailing north westerly winds, exposed to the west and south-west. As the wind rose (figure 2.17) indicates west is the second prevailing wind	There are no breaks for several hundreds of kilometres and there are no shallows within 300m from the shoreline.
Exposed Coastline		
Coastal stretch	**Wind**	**Water Depth and Fetch**
Western Coast Malta - Golden Bay/Fomm ir-Riħ and West side of Comino channel	Facing away from the prevailing North Westerlys but face the West, which is the second most prevailing wind and is very strong	Long fetch however shallows within 300 meters of the shoreline provide a degree of shelter
SE coast of Malta – Ports of Birżebbuġa and Marsaxlokk	This coast faces away from prevailing winds. South East winds are not very frequent but can be strong	There are no breaks for several hundred of kilometres (long fetch) and there is an extensive shallow area offshore (water depth is only 50m up to approximately 1 km from the shoreline).
North coast of Malta and Comino Channel	Exposed to the North and North East winds. These winds are frequent in the summer and can be very strong.	To the northeast there are no breaks for several hundred of kilometres, so there is strong wind present (NE although not very frequent can reach gale force) with a long fetch. However, there is some shelter provided compared to the southern coast of Malta due to a more extensive shallow area offshore (50m contour line reached between 500m-1km from the shoreline)
North coast of Gozo	Exposed to the North and North East winds that prevail in the summer months as much as the North Westerly.	To the north there is a significant break within 60 miles of the island (the island of Sicily) and further protection through shallows off the shoreline. However the coast is influenced by the North easterly winds as the north shores of Malta and hence can be considered to be exposed (and not moderately exposed).

Table 2.7: Summary of wave exposure classification of coastal waters around the Maltese Islands

On the basis of exposure and depth, 3 coastal water body types were identified under the first Water Catchment management Plan. These were:

- **Type I** – Very exposed, deep waters
- **Type II** – Exposed, intermediate
- **Type III** – Exposed, intermediate to deep waters

A fourth type to take into consideration the particular physical environmental conditions of the Comino Channel that may significantly influence its ecology was also maintained:

- **Type IV** – Exposed, intermediate to deep waters with channel mixing.

These typologies are being confirmed for the second WFD cycle. A map indicating these coastal water typologies is included below (refer to Figure 2.39).

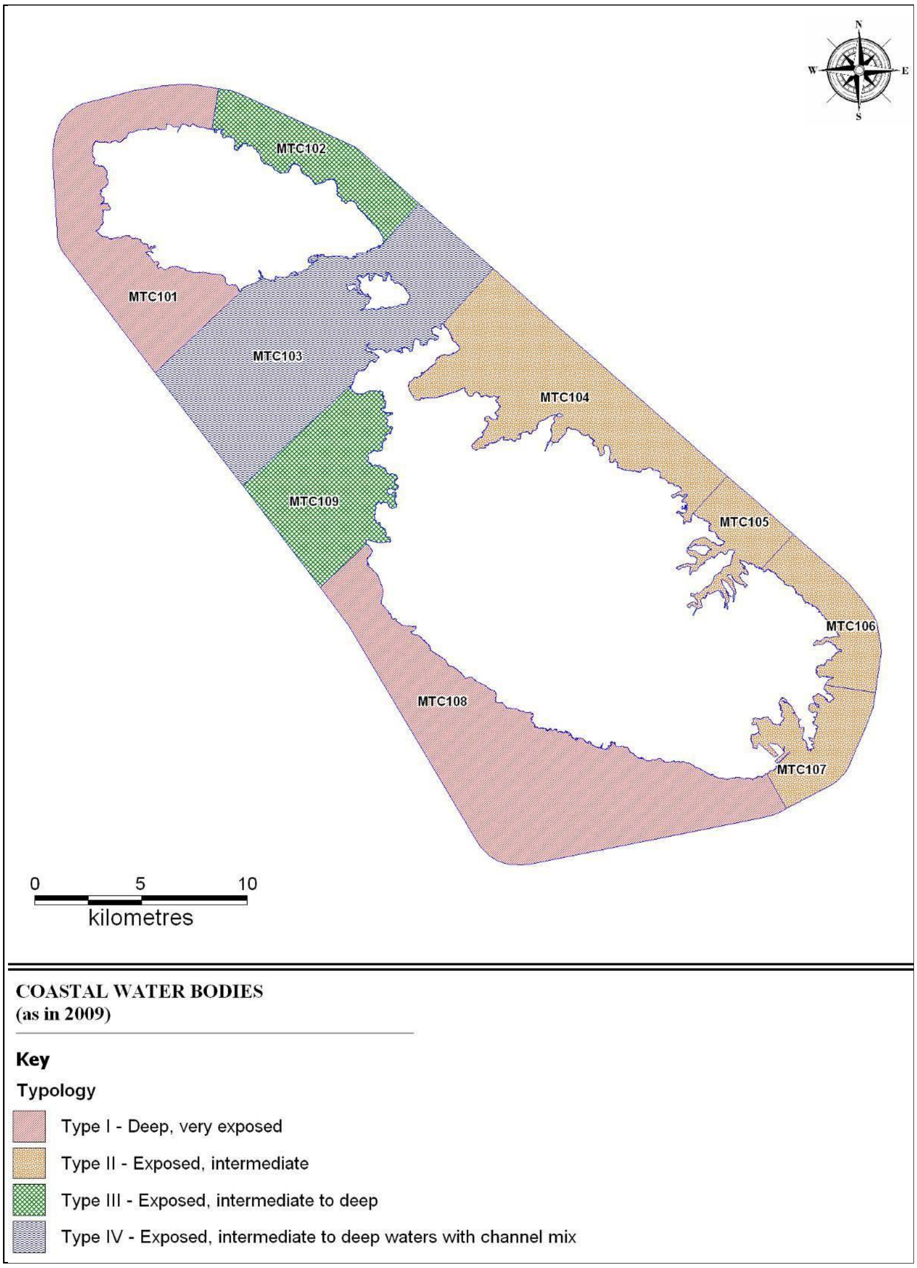


Figure 2.39: Typology of Maltese Coastal Waters

2.4.3.1 Checking the typology against Biological quality elements

Under the first WCMP the typology of coastal waters was not checked against biological data. According to the WFD in order for typology to be ecologically relevant, Malta needs to confirm that the physical characteristics used to define the typology of each water body are important determinants of the biological environment.

This exercise was made possible by the monitoring programme carried out in 2012/2013 whereby all biological quality elements (BQEs) were monitored. The determination of whether each biological quality element was found to exhibit different characteristics per established typology was not straightforward. The coastal waters exhibited more or less homogenous characteristics which did not help in distinguishing varying effects on BQEs.

In addition certain BQEs are more responsive to natural features that are not included in the SYSTEM B classification system. For instance the types of macroalgae found along the different stretches of coast were seen to respond most to the type of coast. There is an indication from the results that substratum inclination, exposure and coast type (whether decimetric, low or high coasts) play an important role in influencing the type of algal communities present. The relative abundance of the functional groups of algae varies between sheltered and exposed shores. Under these circumstances physical stress due to wave action may lead to a reduction or disappearance of macroalgae.

The profile of substratum can minimize the surface exposed to wave action and can be stressful in shallow habitats. Algae with major structural complexity of their thallus such as corticated and calcareous algae are more resistant to wave shear stress than algae with simpler shapes such as the filamentous species. Furthermore the presence of oblique or almost vertical surfaces may influence the colonisation of species by reducing the amount of sediment deposited and thereby favouring algal assemblage colonization.

These difficulties were also encountered in most cases by the Mediterranean Geographical Intercalibration Group who declared that Mediterranean typologies were not relevant for most BQEs (i.e. macroalgae, benthic invertebrates, sea grasses). During the early stages of the intercalibration work carried out by Mediterranean experts, attempts were made to distinguish water types based on relevant parameters that were deemed to influence the ecological significance of each biological quality element. These were mainly two – substrate composition and depth.

A Detrended Correspondence Analysis (DCA) was carried out using the datasets of a number of Mediterranean countries for all four coastal water types. In most of the cases the types do not differentiate from one another and it was therefore concluded that water types did not actually prove to be relevant for the Intercalibration exercise for most of the BQEs (except phytoplankton) "since the Mediterranean ecosystem is quite homogenous in comparison to Northern Seas" (MEDGIG Technical Report - Benthic Invertebrates, 2013).

In the case of phytoplankton the criterion adopted to identify typologies of coastal water bodies in the Mediterranean was seawater density, expressed as Sigma-t [25] annual mean values; whereby:

Type I : Sigma-t <25

Type II: 27>Sigma_t >25

Type III: Sigma-t >27

[25] Sigma_t is the measure of density of seawater at a given temperature.

This is because the Mediterranean Sea is known to have an East-West Gradient in Chlorophyll a distribution due to freshwater influence from the West (freshwater input through the Straits of Gibraltar coming from the Atlantic). The Western basin also has an additional gradient internal to the basin due to freshwater inputs from rivers discharging into the northern Mediterranean shores. The Eastern basin on the other hand is more nutrient deficient and can become ultra-oligotrophic as one moves further east along the Mediterranean Basin.

As a result of these differences, the following typologies were identified for the Mediterranean Member States:

- **Type 1** - Influenced by freshwater inputs (eg. France and Italy)
- **Type II-A** - Moderately influenced by Freshwater Inputs
- **Type III- W** - Continental Coast. Not affected by freshwater inputs. Western Basin
- **Type III-E** - Not affected by freshwater input. Eastern Basin
- **Type Island-W** - Mediterranean Island, not affected by freshwater Input, Western basin.

Since Malta is in the Eastern basin and not affected by freshwater input, Type III E would fit Malta's typology for this particular BQE.

Biological Quality Element	Common Intercalibration Type specified
Posidonia oceanica, Macro Algae, Benthic Invertebrates	Typology not relevant for Mediterranean Coastal Waters: Only one type for all of the Mediterranean region
Phytoplankton	Type 1 - Influenced by freshwater inputs Type 2A - Moderately influenced by freshwater inputs Type 3W - Western Basin - Not affected by freshwater inputs Type Island W – Mediterranean islands (western basin) not affected by freshwater inputs Type 3E - Eastern Basin Not affected by freshwater inputs

Table 2.8: Summary of Types defined for each Biological quality element at Mediterranean Level (MEDGIG).

2.5 Characterisation of the bodies of groundwater

The dynamics of groundwater flow in Maltese aquifers, from surface, into and through the unsaturated and saturated zones, call for a thorough analysis of the geological structure of the islands and the lithological variations which define the different geological formations. The physical characteristics of this hydrogeological framework can be then synthesised in a conceptual model of the respective groundwater body, where the mechanics of groundwater flow can be easily visualised and the interactions with external pressures are simplified to be clearly understood. Also the resulting effects of externalities on the physio-chemical characteristics of groundwater are explained through this conceptualisation process.

The representativity and reliability of the conceptual model of the aquifer system relies on a high quality characterisation process and a wide range of information and data, including but not limited to geology, hydrogeology water quality, land-use and other relevant data which will be assessed in the following sections.

2.5.1 Geological Baseline

The aquifer formations of the Maltese Islands are composed of fractured Oligo-Miocene carbonates of marine origin occasionally weathered and eroded by karstic action. Pliocene deposits are completely absent; whilst some sporadic Quaternary deposits occur in limited areas, mostly consisting of valley scree, raised beach deposits, sands and gravels of Pleistocene age.

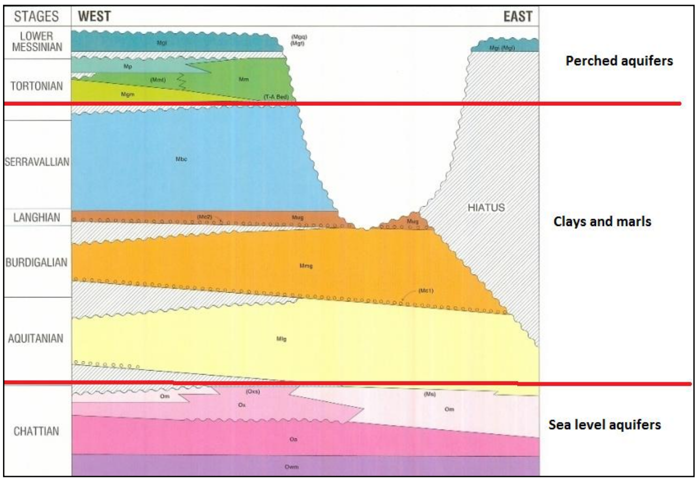


Figure 2.40: Schematic correlation chart showing lateral lithological variations and aquifer positions. (extract from OED map 1992)

The geological sequence of the islands is such that the geological formations occur in simple succession. Starting from the oldest in chronological order, the successions consist of:

a. The **Lower Coralline Limestone** (LCL) formation - a thick section of algal foraminiferal limestone divided into four distinct members (Pedley et al. 1978), all having a direct bearing on the infiltration processes through the unsaturated zone and on groundwater flow within the aquifer itself. The Lower Coralline is extremely heterogenous with frequent lateral passages from patch reef deposits to lagoonal and forereef facies such as the lateral transitions from the coarse grained biocalcarenites of the Xlendi Member to the finer compact yellow limestones of the Maghlaq member at the base of the Lower Coralline Limestone

Figure 2.41: Outcrops of Lower Coralline Limestone formation showing cross-bedding of the Xlendi Member

b. The **Globigerina Limestone** (GL) formation overlies the LCL formation and is predominantly composed of pelagic carbonate limestones, with abundant planktonic forams. It outcrops over large areas of central and southern Malta and Gozo, capping the underlying Mean Sea Level Aquifer system. It varies in thickness from 23m near Fort Chambray (Gozo) to 207 m around Marsaxlokk. On the basis of two laterally persistent phosphorite conglomerate hardgrounds, the Globigerina formation is subdivided into three members: the Lower, Middle and Upper Globigerina Limestone. The conglomerate hardgrounds are considered to be important pathways for surface infiltrations to the MSLA and also have a direct influence on mineralisation and qualitative aspects of groundwater.

Figure 2.42: Lower phosphorite conglomerate hardground between the Lower and Middle Globigerina

c. The **Blue Clay** (BC) formation consists of blue/grey pelagic marls interbedded with thick paler bands with a higher carbonate content (less than 30%) than the darker clay-rich bands. Kaolinite is the main clay mineral present within the formation, followed by chlorite, palygorskite, illite and smectite The maximum thickness of the Blue Clay is approximately 75 m, recorded at Xaghra (northern Gozo and on the western coast of Malta, North of Fomm ir-Rih Bay.

d. The **Upper Coralline Limestone** (UCL) formation is a shallow-water carbonate platform sequence, exhibiting complex facies deposited in very shallow marine environment from shallow subtidal to intertidal and supratidal. It reaches a maximum thickness of 104m at Comino and Mellieha. Four members of the Upper Coralline Limestone formation have been defined, all characterised by several lithological variations, laterally and vertically. These are: the Ghajn Melel Member (the oldest), Mtarfa Member, Tal-Pitkal Member and Gebel Imbark Member (the youngest).

The perched aquifers are mostly contained in the oldest two members of this formation namely, the Ghajn Mellel and the Mtarfa members. The perched groundwater bodies occur in several distinct units or structural blocks (geologically referred to as *horst and grabens*), bounded by normal faults and are relatively displaced in respect of each other. North-western Malta and southern and central Gozo are typical regions where these structures occur.

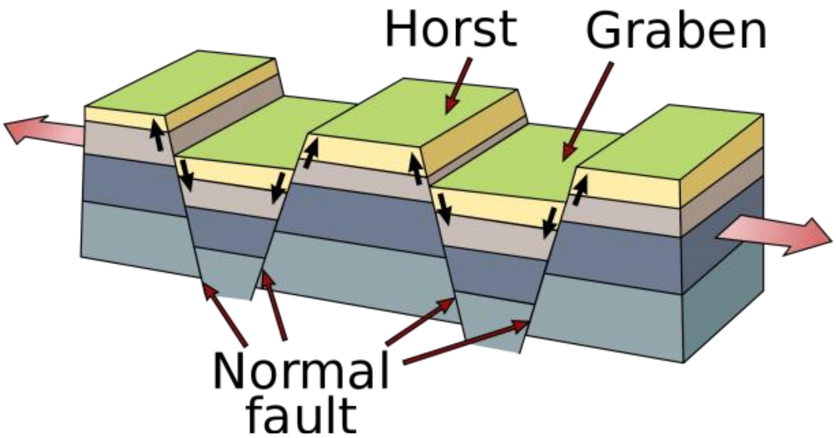


Figure 2.43: Schematised diagram of a horst-graben structure

Two distinct lithological facies can be observed within the formation with different hydrogeological characteristics; a highly porous reefal facies along the west coast and a lagoonal facies on the eastern part of the Upper Coralline Limestone, characterised exclusively by fracture permeability.

Figure 2.44: Upper Coralline Limestone Coral reef facies overlying algal succession

e. **Quaternary deposits**, mostly Pleistocene in age, are limited to slope scree, raised beach deposits, cliff breccias, cave and valley loams, sands and gravels. They are of limited hydrogeological importance except where valley fills occur at sea level, such as at the coastal end of the Pwales and Qammiegh aquifer systems.

2.5.2: Groundwater Bodies – Local Typology

The geological succession described above bears directly on the occurrence of groundwater bodies in the Maltese islands. It follows that two carbonate reservoirs lie horizontally stacked on top of each other, separated by a thick section of marls and clays. Under these conditions and depending on the physical features occurring in specific locations, the following typologies of groundwater bodies can be distinguished:

a. **Sea-level groundwater bodies** developed in the Lower Coralline Limestone formation and take the form of freshwater lenses floating over seawater and referred locally as mean-sea-level-aquifers (MSLAs). These are ubiquitous and occur extensively at sea level in Malta, Gozo and Comino.

b. **Unconfined (phreatic) perched groundwater bodies** sustained in the Upper Coralline Limestone formation perched over the Blue Clay formation. The perched aquifers overlie, in western Malta and in Gozo, the sea-level aquifers. Perched aquifers are completely absent in central and eastern Malta where the UCL and the clay aquitard have been completely eroded.

c. **Coastal groundwater bodies** occuring in depressed valley areas within the Upper Coralline Limestone formation where the clay lies below sea level and freshwater is laterally bounded at its contact with seawater. These small aquifer systems occur at Pwales, Mellieha and Marfa.

Groundwater Body Code	Groundwater Body Name
MT001	Malta Mean Sea Level
MT002	Rabat Dingli Perched
MT003	Mgarr-Wardija Perched
MT005	Pwales Coastal
MT006	Mizieb Mean Sea Level
MT008	Mellieha Perched
MT009	Mellieha Coastal
MT010	Marfa Coastal
MT012	Comino Mean Sea Level
MT013	Gozo Mean Sea Level
MT014	Ghajnsielem Perched
MT015	Nadur Perched
MT016	Xaghra Perched
MT017	Zebbug Perched
MT018	Victoria-Kercem Perched

Table 2.9: Groundwater Bodies in the Malta River Basin District

A physical characterisation for each groundwater body typology will be presented in the following sections.

Figure 2.45: Dingli, western Malta. Tertiary succession showing the two Coralline Limestone formations with Globigerina and Blue Clay in between

2.5.2.1: Lower Coralline Limestone Aquifer Systems

Conceptual Description of freshwater lens aquifers

The sea-level groundwater bodies in Malta and Gozo locally referred to as the Mean Sea Level Auifers (MSLAs) originate by virtue of density contrast between fresh and saline water[26]. As such these two liquids are in lateral and vertical contact, both in Malta and in Gozo. In shape, these aquifers can be compared to a lens of fresh water which is dynamically afloat on more saline water, having a convex piezometric surface and conversely a concave interface, both tapering towards the coast where there is virtually no distinct definition between the two surfaces.

[26] Density of freshwater ρ_w = 1.0kgm/m^3
Density of seawater ρ_s = 1.025kg/m^3

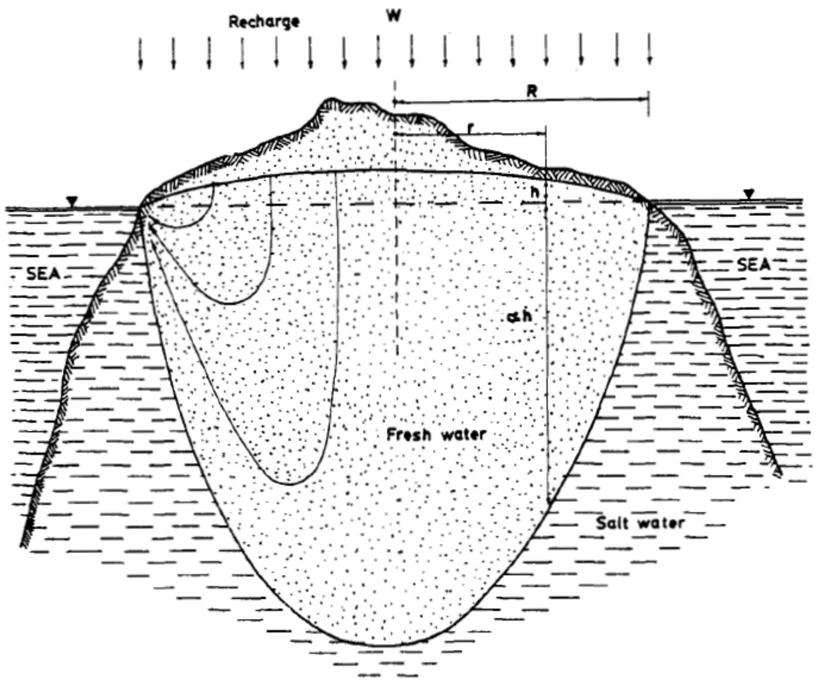


Figure 2.46: Freshwater lens under island natural conditions (UNESCO)
(vertical scale is exaggerated)

The lens sinks to a depth below sea level roughly 40 times its piezometric head at any point, following closely the Ghyben-Herzberg model, thus fading into pure seawater across a transition zone. The limits of the transition zone are commonly defined by the surfaces of 1% and 95% seawater content based on total dissolved solids or chloride content. The lens structure entails the development of a high storage capacity compared to the mean annual recharge. In fact, estimates from numerical models place the optimum storage capacity of the mean sea level aquifer systems in the Maltese islands at around 2 billion cubic meters, when the total mean annual recharge to the aquifer systems is estimated at around 50 million cubic meters per year.

The geometrical configuration of the lens has serious implications on the physio-chemical characteristics of groundwater. It implies that all the outer surface of the lens, excluding the piezometric surface, is in physical contact with seawater whilst the bulk of its mass and storage lie below sea level. Under such conditions therefore, the slightest amount of abstraction will destabilise the sensitive hydrodynamic balance at the salt/freshwater interface resulting in upconing (upward intrusion) of seawater. This condition together with the slow recharge process is a major constrain to the abstraction of freshwater from the Mean Sea Level Aquifer systems.

The structure of the lens also entails an outflow gradient towards the sea, physically reflected in a significant loss of freshwater reserves. An aerial survey using infra-red imagery has been recently commissioned with the aim of identifying natural groundwater outflow points in coastal areas. The identification of such natural outflow points will also permit an assessment of the importance of fracture flow in the hydrogeolgical context, and thus guide the development of more reliable groundwater models of the aquifer system. Results of this survey were corroborated by underwater inspections of identified outflow points carried out in 2015. Discharge plumes and upwellings of ground water were physically confirmed and documented in proximity of faults along the coastline. Under natural conditions therefore, these lenses lose a substantial portion of the freshwater content derived through natural recharge, by way of scattered diffusion and also through submarine springs.

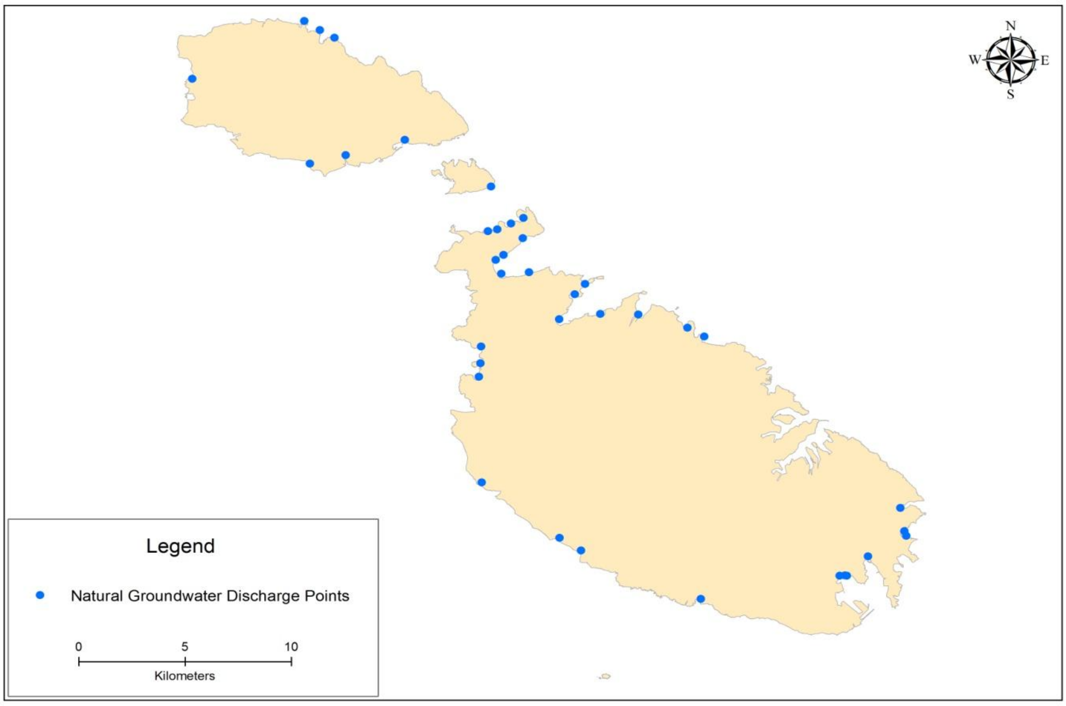


Figure 2.47: Identified natural groundwater discharge points in the Maltese islands

Also, it must be underlined that unlike other groundwater bodies which sit on a well-defined barrier and aquiclude, freshwater lenses in Malta and Gozo, do not have a true and proper physical barrier as a base-level to groundwater flow. The bottom of the lens is a virtual boundary between two fluids having different densities, where due to diffusion and hydrodynamic dispersion the interface is really a mixing or transition zone, the thickness of which depends on the hydrodynamic characteristics of the aquifer system. Variations in hydrostatic head as in the case of abstraction trigger a vertical upconing of seawater resulting in the localized intrusion of salinity in the freshwater body.

Malta MSLA Groundwater Body – MT001

In Malta the MSLA stretches over a surface area of 216.6 sq km and is capped by the Blue Clay beds for an area of 36 sq km on the north-western side of the island and to the north of the Victoria fault up to Pwales where the LCL lies in juxtaposition at sea level against the Blue Clay along the Ghajn Tuffieha/Tal Fekruna fault. Along the western coast of Malta, the Maghlaq fault forms a limited seal by the Blue Clay contact against the LCL, giving rise to a localised piezometric high as registered at Lapsi Road gauging borehole.

Figure 2.48: Maghlaq Fault – Lower Coralline Limestone on the right in juxtaposition against the Upper Coralline Limestone. Note the slickensided fault plane

Where the MSLA is capped by clay areas it is partially starved from its natural recharge which instead is intercepted by the Blue Clay and stored in the perched groundwater bodies. Percolation through the Blue Clay does however occur, in particular due to the presence of geological inconsistencies within the formation arising from patch reef formations and the occurrence of subsidence structures. Beyond the clay outcrops the MSLA also underlies the Globigerina Limestone except where the LCL outcrops at the surface forming outliers surrounded at the surface by younger Globigerina limestone. The latter functions as an aquitard, slowing downward percolation of surface recharge and increasing travel time of groundwater through the unsaturated zone, as a result of its low intrinsic permeability. These geological characteristics have a direct influence on the recharge processes from surface to the aquifer as well as on the residence time of groundwater within the aquifer itself.

The lens is very flat with its width being more than 100 times the depth of the interface. (L. Huismann 1972), implying a very low piezometric gradient particularly at the centre of the island. The highest potentiometric point of the water-table in recent years reached 3m as recorded at St. Katarina GBH.

Conceptual Model

The conceptual model developed for the Malta MSL aquifer assumes (Figure 2.49) that:

- the Lower Coralline Limestone is present across the whole island, although it is divided into horst and graben blocks north of the Pwales fault and parts are totally below sea level and are not aquifers;

- it is capped in the west part of the island by the overlying impermeable Blue Clay and the Greensand, and more extensively by less permeable strata in the Middle Globigerina Limestone;

- the water table is controlled by abstraction and is presently up to only 3 m above sea level in places. This means that here the aquifer is protected by the overlying strata, rather than being confined in a hydraulic sense. Abstraction also leads to saline upconing and an increase in salinity;

- the relatively low porosity means that the rate of downwards movement in the aquifer matrix will be greater than in the perched aquifers, but the unsaturated travel time will be long in the thicker parts of the aquifer. The limited detections of coliforms indicate that rapid transport from the surface to the aquifer is limited;

- CFC data shows that residence times in the saturated zone are in the range 15-40 years. Combined with the low estimates of transmissivity from pumping tests, this suggests that movement in enlarged solution features is limited;

- there are a number of possible mechanisms for recharge to the part of the aquifer capped by the Blue Clay, where the groundwater appears to be of similar age to the rest of the aquifer:

  – slow infiltration through the Blue Clay from the upper aquifer;

  – enhanced recharge at the edge of the Blue Clay or the Middle Globigerina;

  – rapid infiltration along faults or fractures.

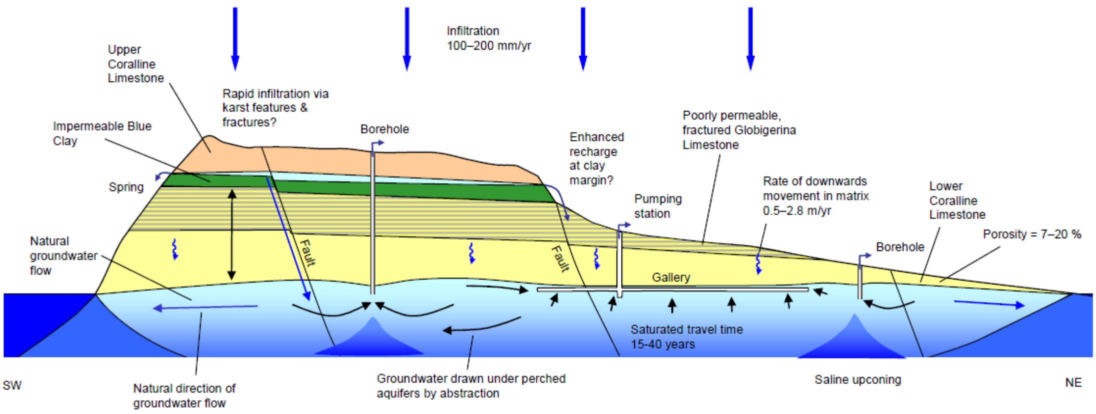


Figure 2.49: Conceptual Model of groundwater movement in the Malta Mean Sea Level Aquifer System

Gozo Mean Sea Level Groundwater Body – MT013
The Mean Sea Level groundwater body in the island of Gozo covers area of 50km^2 and occurs within the Lower Coralline Limestone. It is bounded to the south by the Ghajnsielem-Qala fault which bounds the northern limit of the Ghajnsielem syncline. Elsewhere the boundary is set by the coastline.

As with the sea-level groundwater body in Malta, the MSLA in Gozo occurs within the Lower Coralline Limestone formation which only outcrops in two locations and is mostly capped by the Globigerina Limestone formation and extensively by the Blue Clay and the perched aquifer systems sustained in the Upper Coralline Limestone. The MSLA is the main source of freshwater in Gozo and can, on its own can meet a significant proportion of the local demand.

The piezometric surface of the MSLA reaches a maximum height of 3m above sea level at Kercem and Nadur.

Recharge mechanisms are similar to the MSLA in Malta though here the aquifer is more extensively capped by thicker deposits of the Blue Clay and the Globigerina Limestone formations. The recharge area of the Mean Sea Level Aquifer in Gozo extends over 50km^2 and includes the exposed surfaces of the Lower Coralline Limestone, the Globigerina Limestone and the Blue Clay sloping towards the central regions.

Studies undertaken by the British Geological Survey (2008) using groundwater tracers showed that groundwater travel time in Gozo is older than in Malta. However, as the aquifer is more extensively capped than that in Malta, travel time through the unsaturated and saturated zone and can range from 35 to 60 years.

Conceptual Model
The conceptual model for the Gozo MSL aquifer assumes (Figure 2.49):
- the Lower Coralline Limestone aquifer is present across the whole island;
- it is extensively capped by the impermeable Blue Clay and the Greensand and by less permeable strata in the Middle Globigerina Limestone;
- the water table is controlled by abstraction and is presently only a few metres above sea level. This abstraction also leads to extensive saline upconing and an increase in salinity;
- the relatively low porosity means that the rate of downwards movement in the aquifer matrix will be greater than in the perched aquifers but the unsaturated travel time will be long in the thicker parts of the aquifer. The limited number of detections of coliforms indicates that rapid transport from the surface to the aquifer is limited except where the Lower Coralline Limestone is at outcrop;
- CFC data shows that the residence time in the saturated zone is in the range 30-60 years. Combined with the low estimates of transmissivity from pumping tests this suggests that movement in enlarged solution features may be limited.
- there are a number of possible mechanisms for recharge to the part of the aquifer capped by the Blue Clay. The single groundwater age from this part of the aquifer was in the older part of the range of the rest of the aquifer. Possible mechanisms include:
    – slow infiltration through the Blue Clay from the upper aquifers;
    – enhanced recharge at the edge of the Blue Clay;
    – rapid infiltration along faults or fractures.

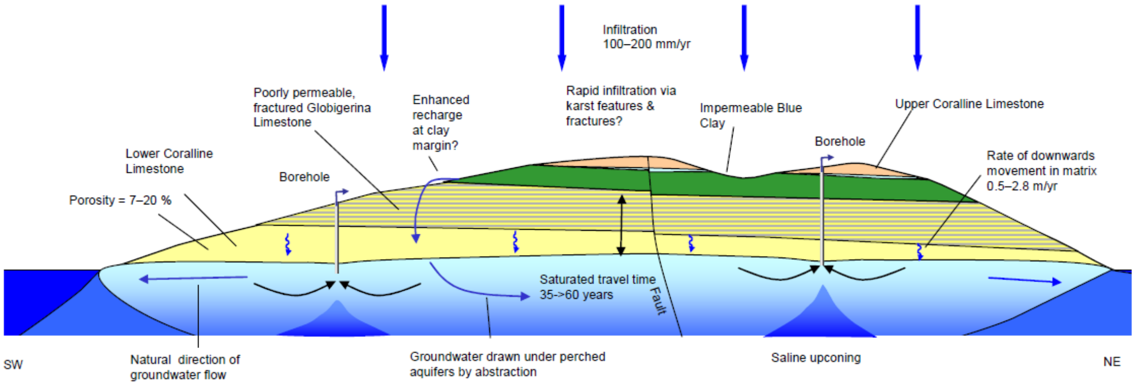


Figure 2.50: Conceptual Model of groundwater movement in the Gozo Mean Sea Level Aquifer System

Hydrogeological characteristics of the Lower Coralline Limestone aquifer systems

Groundwater bodies within the Lower Coralline Limestone are characterised by an irregular permeability typical of limestones of reefal origin where lateral variations in porosity and permeability are closely linked to sedimentary conditions. Primary porosity varies from 7% to 20% noting that most of the pores are weakly interconnected. Intrinsic permeabilities are therefore low. Results of permeability measurements on laboratory samples by previous authors are shown in the table below.

	Lower Coralline Limestone intrinsic permeability (m/s)
Robertson (1917)	1.2×10^{-7} 8.5×10^{-7} 2.9×10^{-8}
ATIGA (1972)	2.4×10^{-9} 6.9×10^{-7} 1.3×10^{-6} 2.3×10^{-6}
Bennett (1979)	1.2×10^{-7} 1.7×10^{-7}. 1.3×10^{-6} 9.2×10^{-6} 5.8×10^{-7} 1.1×10^{-7}

Table 2.10: Intrinsic Permeability in m/s of the Lower Coralline limestone

Effective porosity is entirely dependent on fracture permeability and weathering, and has been estimated (D.H.Martin 1972) to range between 10 - 15%. As fracture density increases in the proximity of faults, the permeability of the Lower Coralline formation is mostly of the secondary type, closely related to tectonic structures.

BRGM (1990) produced a series of hydraulic conductivity (permeability) values from pumping test and mapped the spatial distribution of hydraulic conductivity. Values range from 1.5×10^{-4} to 96×10^{-4} m/s.

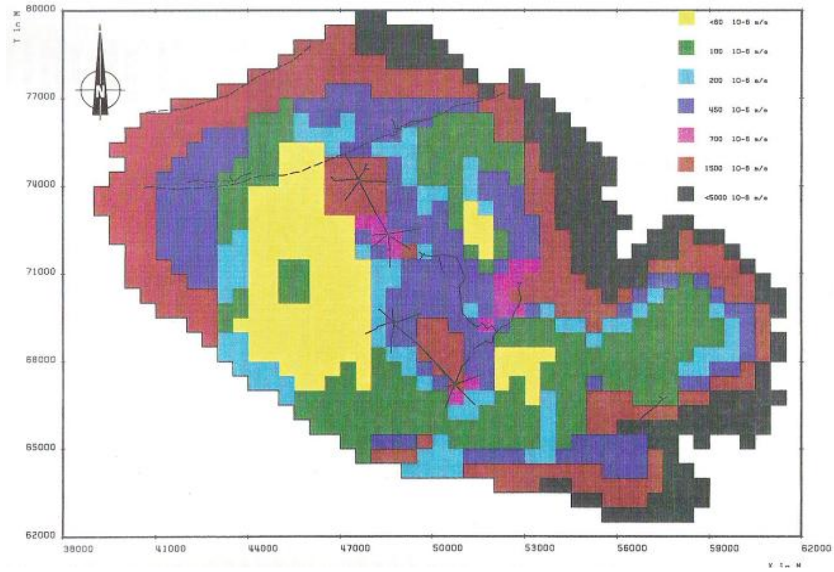


Figure 2.51: Permeability variations (m/s) in the LCL (BRGM 1992)

Modelled values of transmissivity also vary widely, from 10^{-4} and 10^{-3} m^2/sec, variations being the direct result of fracturing and lithological variations.

The Unsaturated Zone - Globigerina Limestone and Blue Clay barrier

The Globigerina Limestone formation is divided into three members; the Upper, Middle and Lower members. The Middle Globigerina is a marly limestone with a permeability which is likely to be lower than that of the Upper and Lower members. The Upper member consists of a tripartite sequence of limestone and marls. Various authors quote the intrinsic permeability for the entire Globigerina formation between 10^{-7} to 10^{-8} m/sec.

Laboratory testing by Costain and British Petroleum show the Globigerina limestone formation to have an intrinsic porosity of around 40% and low permeability. However in localised places where the Globigerina is fractured and lies at and around sea level, it can store groundwater becoming part of the MSLA. This is evident at one of the galleries of the Wied il-Kbir pumping station where freshwater is seen to be discharging through the fractured Globigerina at sea level

In view of these characteristics a hybrid flow pattern of surface recharge occurs through the Globigerina unsaturated zone which effectively acts as a physical barrier. Vertical percolation through the matrix is slow, taking longer in the thicker sections of the unsaturated zone. Exchange of solutes by diffusion between the porous (but impermeable) matrix and the faster flow through fractures and discontinuities is also expected to be slow (BGS 2008). This observation is strengthened further by rare *E. Coli.* contaminations registered in the deeper sections of the MSLAs underlying the Globigerina Limestone Formation.

Globigerina Limestone tests	**Intrinsic permeability (m/s)**
Robertson (1917)	3.45×10^{-8} 2.3×10^{-8} 1.15×10^{-8}
ATIGA (1972)	2.4×10^{-7} 2.5×10^{-7}
Bennett (1979)	2.9×10^{-7} 8.8×10^{-8} 3.1×10^{-7} 8.2×10^{-8}

Table 2.11: Intrinsic permeabilities on lab samples in m/s gathered from previous works.

The Blue Clays are practically impermeable wherever they are intact. Costain (1958) measured no effective porosity and permeability. As the clay is very plastic, fractures and fissures are slowly sealed up as the clay swells when absorbing water. However geological studies report several instances where subsidence structures and other geological structural inconsistencies were found to penetrate the clay allowing seepage of perched aquifer groundwater. Under such conditions the Blue Clay shows some vertical permeability channels which break its sealing characteristics. Permeability measurements on clay samples lifted from the Rabat-Dingli plateau measure 3.3 $x10^{-10}$m/sec

Figure 2.52: Blue Clay formation seated over top Globigerina

Recharge Mechanisms for the sea-level aquifer

The exclusive source of natural recharge is rainfall. As mentioned earlier the two prevailing pathways for recharge are fracture flow and matrix flow. Matrix permeability within the unsaturated zone is generally low, leading to a very slow transport of recharge through the unsaturated zone and into the aquifer system.

On the contrary, fracture permeability allows a faster recharge migration from the surface to the saturated zone. Outliers of the Lower Coralline Limestone are considered also as permeable areas allowing faster flow.

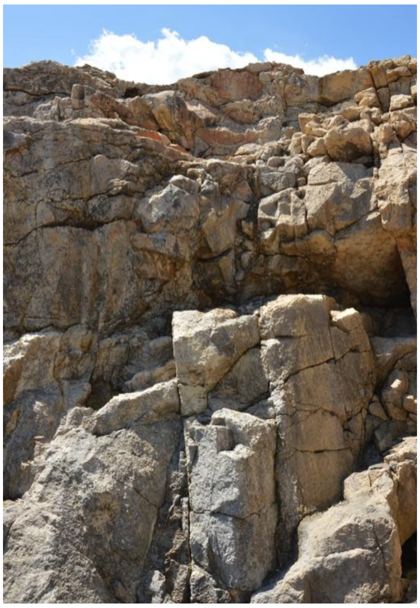


Figure 2.53: Lower Coralline in proximity of faults

Bedding planes, erosional surfaces and hiata are also important channels in the circulation patterns of groundwater. The karstic caves at Ghar Hasan are a typical example and develop at 80m above sea level along a bedding plane separating the Mara member from the Attard member. Karstic channels developed along bedding planes, were also recently recorded in an underground tunnel crossing the Lower Coralline Limestone at the boundary in question.

Figure 2.54: Weathered horizontal discontinuities with fine clay infill, resulting from dissolution in the LCL

Figure 2.55: Weathered sub vertical fracture zone with terra rossa and calcite concretions

Mineralisation of groundwater is also influenced by the spatial occurrence of these discontinuities which form extensive networks and constitute important pathways within the unsaturated zone.

Studies carried out during the first water catchment management cycle revealed a direct correlation between fluoride content in groundwater and the spatial occurrence of the phosphorite conglomerate beds in the Globigerina limestone formation. It has been recorded that the higher levels of fluoride content in the MSLA in Malta correspond to the area of the distribution of the Upper and Lower Phosphorite conglomerate beds (Scerri 2003). Furthermore as the phosphorite conglomerate beds are more developed in Gozo, the fluoride content in the MSLA there, is noticeably higher, sometimes exceeding 1.5mg/l in particular monitoring stations. It is believed that infiltrations through these sections of the unsaturated zone increase the possibilities of leaching of fluorapatite, a phosphate rich mineral which releases fluorides under specific conditions.

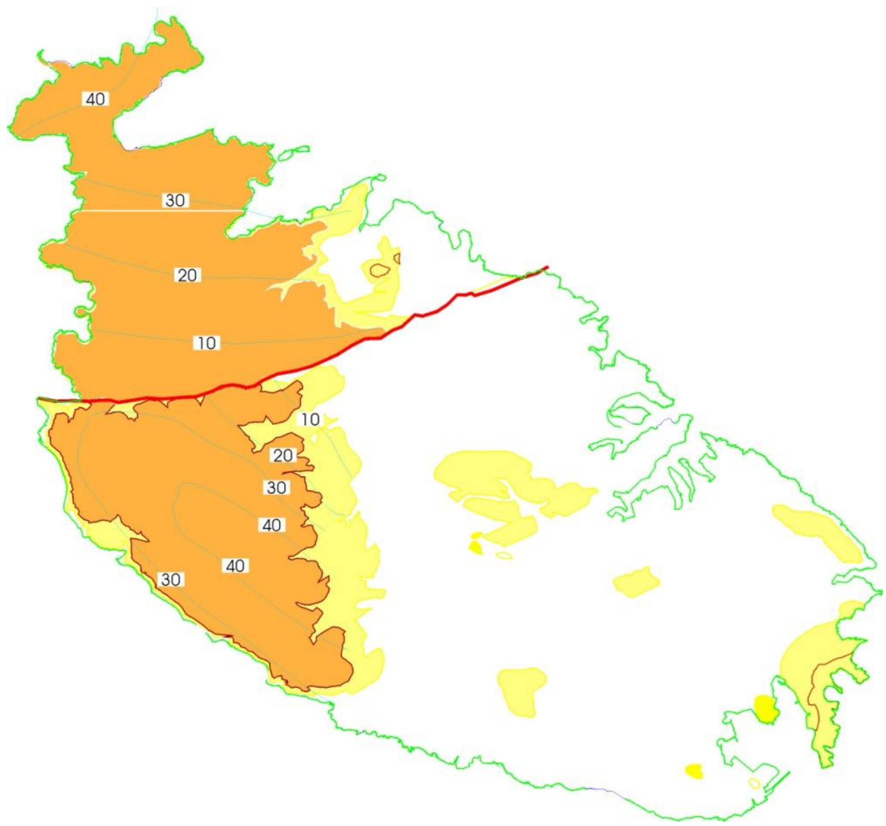


Figure 2.56: Isobath map of the phosphorite conglomerate

Fluorapatite is the only mineral that could possibly contribute to the presence of Fluoride in groundwater, since mineralogic and geochemical studies indicate that it is the only mineral present in the Maltese rock succession that contains Fluorine in substantial proportions.

Groundwater Residence Times

In the MSLAs in the Maltese islands the piezometric surface is close to sea level and the aquifer systems are overlain by a relatively thick unsaturated zone (average of 100m) when compared with the perched aquifers. As already mentioned the aquifer formation is extensively capped (and to a certain extent protected) by the Globigerina Limestone formation and by the Blue Clay formation in several areas with the exception of a few outliers in central and eastern Malta.

As for the Lower Coralline Limestone, limited detections of E.Coli suggest slow recharge from the surface through the unsaturated zone.

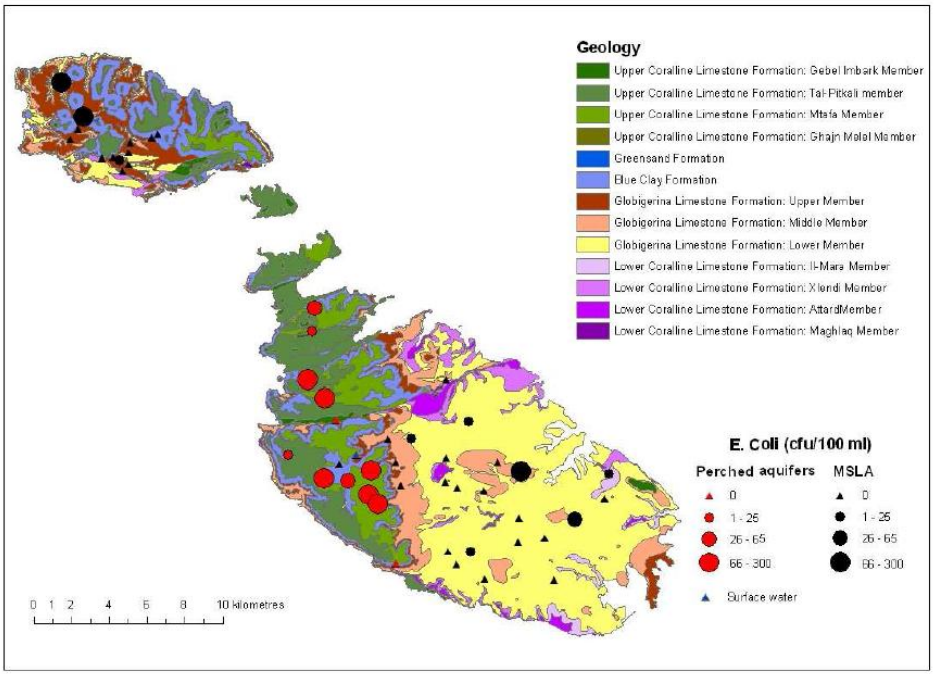


Figure 2.57: Presence of E-Coli in groundwater samples from the Mean Sea Level and Perched Aquifer systems

Tritium levels [27] of the MSLA in Malta range between 0.2 and 3.1 TU, with an average of 1.5 TU. These figures were interpreted during studies undertaken by the IAEA and the British Geological Survey as suggesting that the residence time within the MSLA is more than 40 years. This was supported by CFC data which suggest that saturated zone travel times are also in the range of 15-40 years

Groundwater tracers such as CFC-12 and SF6 can provide an estimate of the saturated zone travel time and the groundwater flow regime. Travel time in the unsaturated zone will be additional. The results obtained from a study on groundwater dating undertaken by the British Geological Survey are plotted in Figure 2.58 below, and show that groundwaters in Malta and Gozo have quite different histories. The age of the groundwater can be calculated using the concentration of each of the indicators separately. For Malta, groundwater in the Main Sea Level aquifer is, on average, between 15 and 40 years old. The two monitoring sites in the Malta MSL abstracting from beneath the perched aquifer gave groundwater ages in the same range as the other sites in the aquifer. The monitoring site under the perched site on Gozo was towards the lower end of the range.

Flow to boreholes appears to be by a number of mechanisms (Figure 2.58). The red line represents piston (matrix) flow through the saturated zone. Groundwater abstracted from certain monitoring points plots close to this line. The pink line is an exponential function representing the accretion of water of different ages along a flowline and is what would be anticipated (Figure 2.58). Groundwater from a number of monitoring stations plots along this line. The blue line represents simple mixing between old water which does not contain tracers and modern rainfall. Groundwater from other monitoring stations plots in this area.

All these models are gross simplifications of the flow mechanisms as the aquifer is almost certainly not of uniform thickness, there will be zones of considerably higher permeability than others and the points of recharge may vary due to less permeable younger strata. In addition further complication is likely through mixing within the well if the abstraction area is large (combining flow lines of differing ages). None-the-less, it does go someway to giving an indication as to how old the groundwater is in terms of a mean concentration of an 'average' packet of water.

[27] Backalowicz and Mangion (2003)

Results from Gozo show that the groundwater is generally much older (from 35 years old to pre-dating the introduction of CFCs in the 1940s). All the data points fall on the pink exponential line.

The results can also be interpreted in terms of the proportion of mixing of old and modern water. This would suggest that groundwater on Malta would be between 20 and 50% modern; whilst on Gozo groundwater is between 0 and 35% modern.

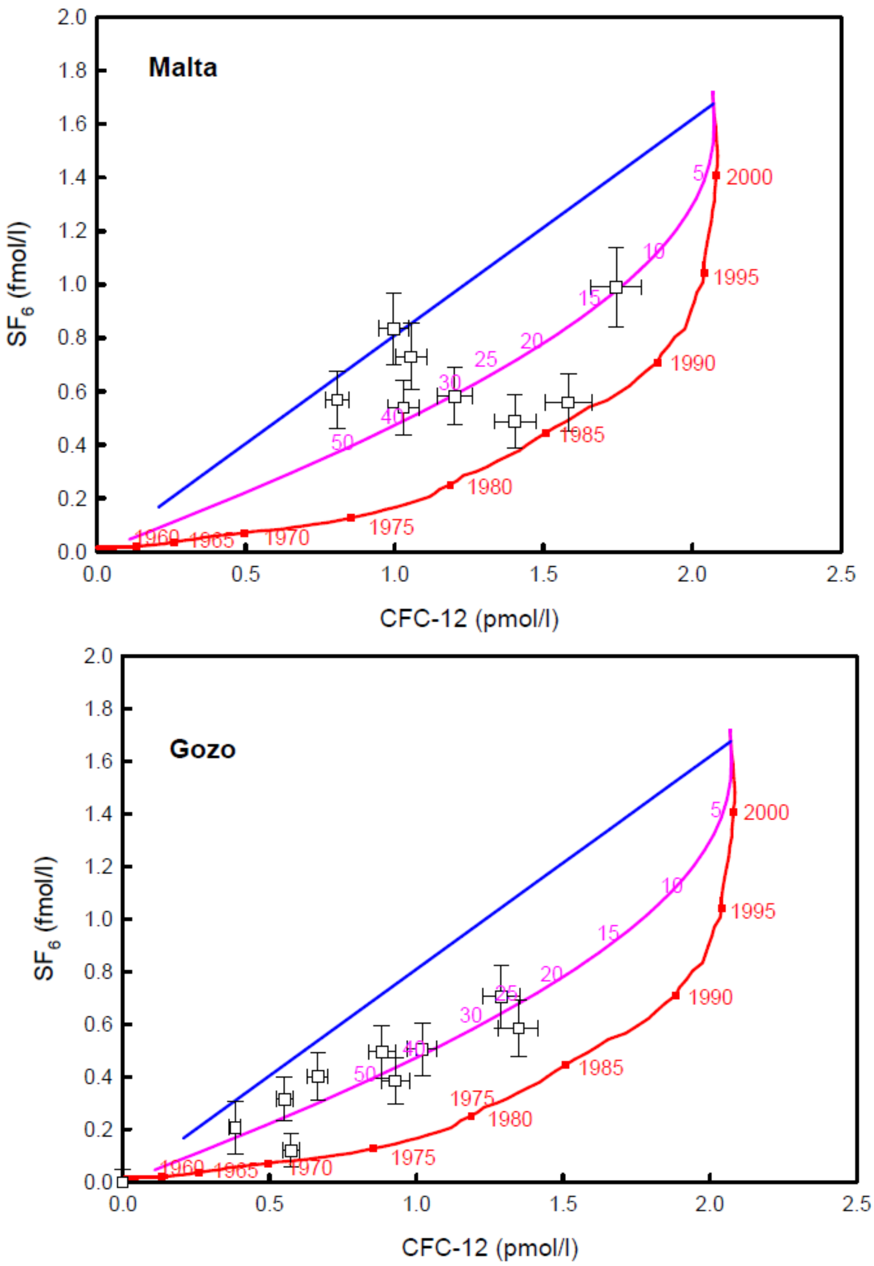


Figure 2.58: Estimation of groundwater age and flow mechanisms using a lumped model of SF_6 and CFC-12 concentrations for Malta and Gozo MSLAs.

2.5.2.2 Conceptual description of the Upper Coralline Limestone aquifer systems

The perched aquifer bodies are sustained in the Upper Coralline Limestone (UCL) Formation which is characterised by complex associations of geo-facies varying widely in porosity and permeability.

As described earlier two distinct facies can be identified within this formation having different hydrogeological characteristics. These are the reefal facies along the west coast and the lagoonal facies on the eastern flank of the UCL outcrops.


Figure 2.59: Upper Coralline Limestone Coral reef facies

Primary porosity ranges around 40% in both facies. Permeability is very low in the lagoonal facies and in the eastern part of the Rabat groundwater body fracture permeability prevails. A few springs (eg. Lunzjata) within this groundwater body discharge from a few well defined fractures and marginally from the rock matrix. The reefal facies are also characterised by a low primary permeability with some limited exceptions such as at the Mgarr and Ta'Falka water bodies where an effective porosity of 15% was established from pumping tests and attributed to the algal-reefal facies which characterise the reservoir in this locality.

The heterogeneous nature of the UCL weighs on the predictions of groundwater flow and on a clear understanding of the transfer of recharge through the unsaturated zone.

As the unsaturated zone is relatively thin and more weathered and karstic when compared to the Lower Coralline Limestone (LCL), travel time is faster than in the LCL. As such these groundwater bodies are highly vulnerable to surface pollution. Following heavy storms, several perched aquifer springs increase in flow by more than threefold. Although these events attest rapid infiltration from the surface through the unsaturated zone, the uninterrupted discharge from springs during summer confirms the importance of the slow-moving recharge component through rock matrix.

Three main groundwater body typologies developed within the Upper Coralline Limestone aquifer systems can be distinguished:

(i) Perched Aquifer systems where the Upper Coralline Limestone sits conformably over the Blue Clay in a monoclinal fashion. In such conditions the saturated zone is rather thin and irregular. Groundwater movement and spring discharge follows closely the gradient generated by the regional dip in the surface of the bounding Blue Clay formation. Typical examples of this typology include the Rabat-Dingli, the Mellieha, Nadur and Xaghra perched groundwater bodies.

(ii) Where the Upper Coralline Limestone forms synclinal structures (basins and troughs) over the clay, storage occurs to varying degrees within a thick saturated zone which reaches its maximum depth at the base of the syncline. Typical examples of this typology are the Mgarr-Wardija, Mizieb and Ghajnsielem Groundwater Bodies.

(iii) The Coastal Aquifer systems which occur where the Upper Coralline Limestone is downthrown to sea-level and is slightly tilted and in lateral contact with the sea giving rise to small coastal groundwater bodies such as at Mellieha Bay, Pwales and Marfa, Pwales; which are vulnerable to saline intrusion. Wells within these aquifers rarely have a saturated thickness above 1m and are mostly used for small scale irrigation.

Conceptual Model

The conceptual model for the perched aquifers assumes (Figure 2.60):

- these aquifers are present in the Upper Coralline Limestone in the western part of Malta. They are reported to be of limited saturated thickness;
- the high detection rate of coliforms suggests a short residence time; and
- the low permeability and high porosity means that the rate of downwards movement in the aquifer matrix will be slow and the travel time in the unsaturated zone will be long in the thicker parts of the aquifer.

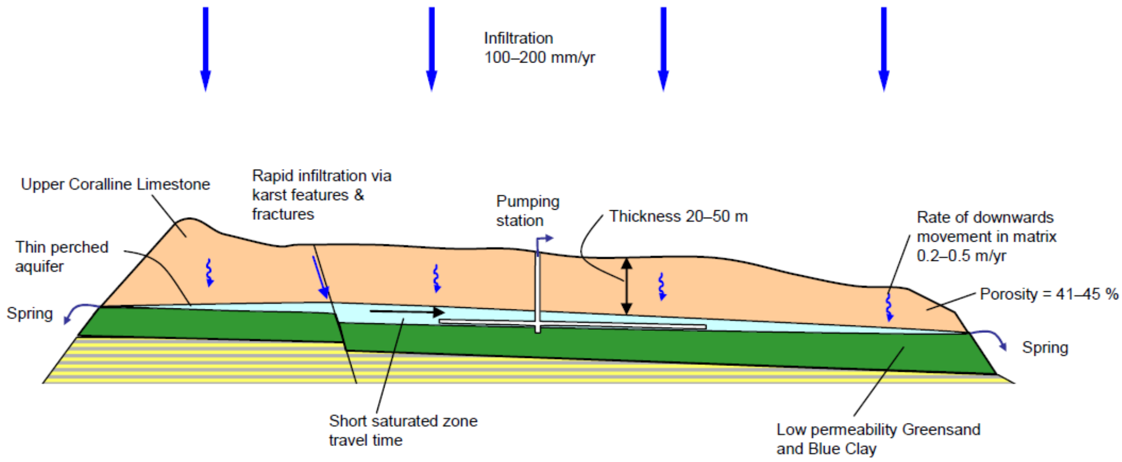


Figure 2.60: Conceptual Model of groundwater movement in the Perched Aquifer System

Upper Coralline Limestone Aquifer Systems (Malta)

(i) Rabat-Dingli Perched Groundwater Body – MT002

The Rabat Dingli Perched aquifer lies on a plateau which ranges in height from 150m to 244m above sea level. The plateau covers an area of approximately 22.6 sq. Km.

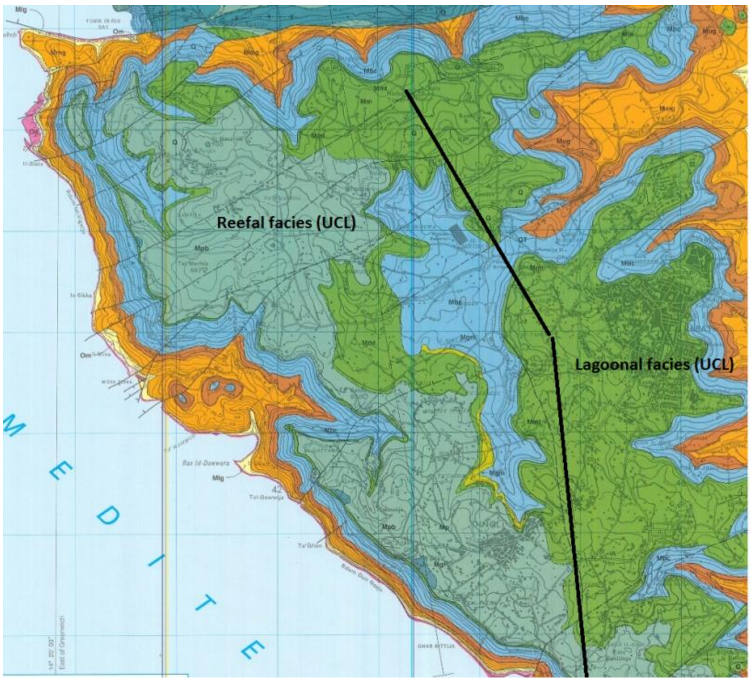


Figure 2.61: Rabat-Dingli Plateau showing regional separation between reefal and lagoonal facies of the Upper Coralline Limestone

The aquifer formation occurs on the upthrown side of the Victoria fault, within the Upper Coralline Limestone resting conformably over the Blue Clay beds, and reaching a maximum thickness of 52m (recorded in geological surveys undertaken in the 1950s by Costain Ltd). The formation outcrops over most of the Rabat Plateau but is extensively overlain by thin soils. Karstic features, namely sinkholes and dolines are also present.

Two distinct facies can be identified:

To the west of a line from Nadur tower to Tat-Targa to Rdum Dikkiena an algal mesophyllum reefal facies develops consisting of blue algal marls at the base followed by yellow algal marly limestone and white current bedded shelly foraminiferal limestone.

To the east of this line the Upper Coralline occurs in lagoonal facies, starting with yellow shelly limestone at the base, followed by cream barren fine grained limestone, often recrystallised, and white miliolid limestones at the top.

A number of subsidiary faults (strike faults) aligned ENE -WNW[28] run parallel to each other slightly obliquely to the Victoria fault and often hinging with a maximum throw in the west cutting the plateau in a series of blocks. These faults have an important hydrogeological significance in providing fast recharge pathways other than the slower ones through the rock matrix. Furthermore the faults cut the plateau in a number of tilted blocks. Erosion also played its part and has further subdivided the plateau in two sections west and east of Wied liemu where the Blue Clay outlier surfaces from Dingli to Fiddien. Several sinkholes occur, filled with terra rossa and surrounded by a rim of cavernous limestone. Most of these sinkholes are today utilised for arable agriculture.

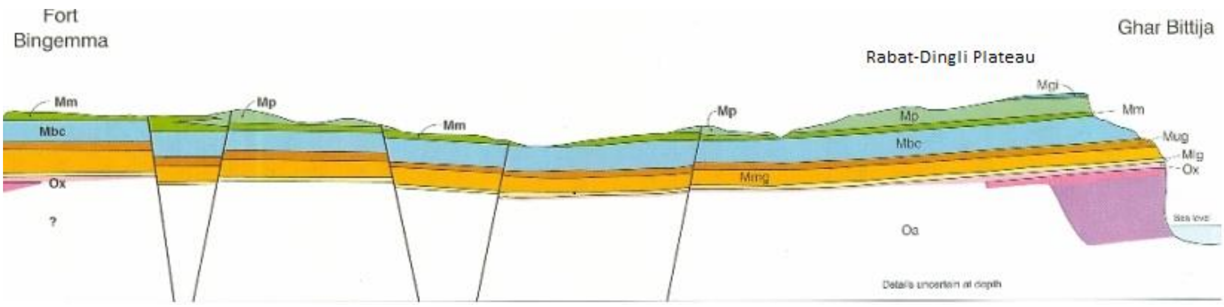


Figure 2.62: N-S section across Rabat-Dingli plateau

Boreholes and tube wells have a low rate of success in the hydrogeological conditions prevailing in this perched aquifer system, and yield is rather poor as a result of low transmissivity and groundwater flow conditions resulting from the thin saturated zone. Instead, radiating galleries from a central well are excavated along the surface of the Blue Clay formation to intersect fractures and fissures and thereon draining these pathways to a central connecting point. Most of these galleries were driven at the deepest dip level of the Blue Clay formation, parallel to the strike and perpendicular to the direction of flow. So designed, the gallery drains numerous slow infiltrations (through matrix and fissures) to a common discharge point where groundwater can be feasibly harvested and pumped.

The same technique has been followed by farmers in historical times. A wide (1.5m diameter) vertical shaft was often excavated by hand from surface to the top of the Blue Clay formation. From there, two or three radiating galleries were excavated outwards across fractured sections of the aquifer.

[28] 1958 Soil Mechanics Department Messrs Richard Costain Ltd; Report on the geological investigation of the Rabat/Dingli Plateau

Groundwater was then led into the central shaft which was, at the end, deepened by another 2m to create a storage cavity[29] and provide space for pumping gear, formerly wind driven.

(ii) Mgarr-Wardija Perched Groundwater body – MT003

The Wardija Ridge consists of an elevated strip of land stretching from the eastern to western coast between 91m and 137 m above sea level. It is located in north-western Malta and covers an area of 13.7 sq km. It is an upthrown block of Upper Coralline Limestone between two faults down-throwing outwards. To the north, the ridge lies adjacent to the depressed areas (troughs) of St Paul's Bay, whereas to the south it lies adjacent to the Rabat-Dingli perched groundwater body. The ridge is intersected by frequent subsidiary faulting which generate complex hydrogeological structures in the form of tilted blocks.

To the south of the ridge is a depressed stretch of land (graben) running east west between 75m and 90m above sea-level and bounded by two strike faults, downthrowing inwards. The major one is the Victoria fault bounding the area to the south. Within the graben, four synclinal structures straddle the depression between the southern border of the Mgarr complex and the downtrow side of the Victoria fault. These are: Fomm ir-Rih, Bingemma, Ghajn Qattus and Falka synclines all lying between Wardija Ridge and the Rabat Dingli plateau. The synclines are all long and narrow and aligned parallel to the Victoria fault.

The Upper Coralline Limestone is 50m thick on the ridge, reaching around 117m in the synclines. Within this groundwater body a number of karstic structures at Ta'Santi and Ta' Falka have been inferred by geophysical methods[30]. Red clays and boulders of recent origin were encountered during site investigations at Bingemma village for thicknesses varying between 15m to 45m

As with other locations, the UCL is extremely heterogenous and is characterised by varying permeability. Reefal facies prevail west of Mgarr village passing into the lagoonal facies towards the east. Outcrops are often heavily weathered and covered by soil, limestone fragments and occasional karstic features.

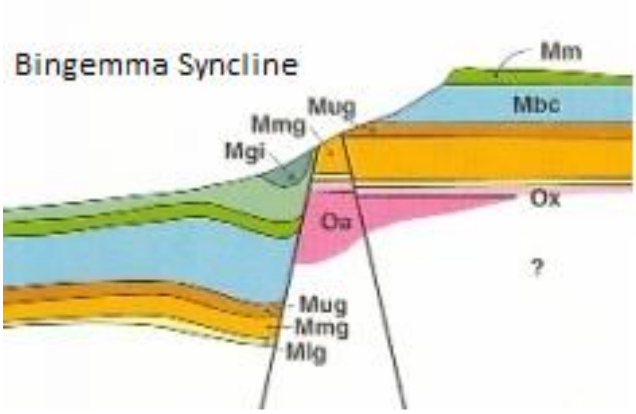


Figure 2.63: Section across Bingemma syncline showing direct contact between the UCL and the LCL on the upthrow side of the Victoria fault(OED 1992)

(iii) Pwales Coastal Groundwater Body – MT005

The Pwales area is one of the most fertile valleys in northern Malta where intensive agriculture is maintained by abundant irrigation water.

[29] Referred to as *hazna* in Maltese

[30] Richard Costain Ltd


Figure 2.64: Pwales Valley with its widespread agricultural landscape.

The water body occurs within a downthrown syncline of Upper Coralline Limestone which sits over clay at an altitude of 21m in the western side near Ghajn Tuffieha whilst it dips below sea-level to a depth of around 30m at the eastern side along Xemxija bay. Here the aquifer forms a small coastal aquifer heavily exploited for irrigation purposes. The valley receives, at several points, freshwater discharge from a number of springs discharging over the clay such as the Ballut springs, the springs of Wardija and Ghajn Nastas.

Structurally the valley is a narrow syncline dipping to the east between two faults bounding Wardija Ridge to the south and Baida Ridge to the north. The valley and flood plain is overlain by thick soils (hence its fertility) whereas the sides are covered with steeply dipping fanglomerates composed of limestone breccias cemented with iron rich concretions and with terra rossa.

Salinity intrusion processes differ from the MSLA. Whereas the MSLA is predominantly affected by vertical intrusion where up-coning of seawater intrudes the freshwater lens at the basal interface, at Pwales intrusion occurs in the form of a quasi-horizontal tongue of seawater spreading from east to west. The wells located at the western edge of the valley are least susceptible to seawater intrusion as the clay is elevated above sea-level.

(iv) Mizieb Mean Sea Level Groundwater body – MT006
Mizieb is the largest synclinal structure in northern Malta. The syncline occurs on the downthrow side of the Mizieb-Mistra fault that cuts across Mellieha ridge from west to east, dissecting the northern part of Malta into several ridges and valleys. The rim of the syncline is determined by the height of the clay on this side of the fault. The lowest point occurs at 14.9m above sea level on the southern flank at Bajda Ridge overhanging Pwales valley, and 15.2m on the eastern saddle leading to Mistra.

In close proximity to the fault the clay seal is breached along two stretches, namely:

a. one of 1.6km around Ciantar’s wine factory,
b. the other for 750m from the rain water course to the Mistra saddle.

Figure 2.65: Mistra, il-Blata.. Mizieb-Mistra Fault showing Upper Coralline Limestone in contact with Globigerina Limestone

The UCL reaches a maximum thickness of 97m with considerable variations in porosity and permeabilities. Reefal facies prevail along the western flank of the syncline passing to lagoonal facies in the east. Secondary permeability resulting from intense fracturing along the fault plane plays an important role in the groundwater flow of the Mizieb groundwater body. Furthermore groundwater is heavily conditioned by presence of karstic sink holes, several of which were discovered during site investigations. The most prominent sink holes were those discovered west of Ciantar's wine factory and at Dar, both concealed by surface deposits and soil cover. These sink holes with a diameter of 90m, extend through the UCL, penetrate and breach the clay to -40m below sea level bringing the saturated zone in direct contact with sea-water. Hence the groundwater body is highly susceptible to seawater intrusion.

(v) Mellieha Perched Groundwater body – MT008

At Mellieha Ridge the UCL outcrops for approximately 4 sq km and consists of a high massif between two strike faults; the Ras il-Griebeg fault and the Mizieb-Mistra faults. The ridge runs west east bounded by the aforementioned faults following the same direction. It is a tilted block over the clay beds which start at an altitude of 80m in the south falling to 55m in the north. Drainage is therefore northwards except for two synclines, one running south-east from Wied Ghajn Zejtuna the other south of Selmun tower where drainage is predominantly to the south.

The UCL has an average thickness of 60m and characterised at the peaks by grey hard semi crystalline limestone lying over coarse grained bioclastic limestones and patch reef deposits. This characteristic gave the plateau its repute for the occurrence of hard-stone mineral which has been extracted as an aggregate for concrete batching for the last 50 years. Karstic cavities are also found at Wied Ghajn Zejtuna and Ta'Randa partly filled with cemented limestone debris and terra rossa.


Figure 2.66: Operational Hard stone quarry in the Upper Coralline Limestone formation at Mellieha Ridge

As with other UCL areas porosity and permeability vary considerably. Laboratory measurements showed porosities ranging between 31 and 45% whereas permeabilities of samples were of the order of 10^{-6}m/sec. Fracturing and weathering play an important role on secondary permeability which is presumably high as attested by rapid response to rain events at tal-Madonna spring.

(vi) Mellieha Coastal Groundwater Body – MT009

The Mellieha coastal groundwater body lies on a depressed block of UCL bounded by two ridges, Marfa ridge to the north and Mellieha ridge to the south. The aquifer lies over the Blue Clay starting from 20m above sea level in the southern side of the block at il-Prajjet, dipping down to -15m near Ghadira. As such the Upper Coralline Limestone is in direct lateral contact with seawater.

The aquifer is split in two separate structures one at Qammiegh the other at Ghadira, both utilised extensively for agriculture. At Qammiegh, wells which are closer to the foot-slopes of Mellieha ridge receive recharge from springs hidden under the tallus and are thus less prone to saline intrusion.

(vii) Marfa Coastal Groundwater Body – MT010

This groundwater body occurs within the Upper Coralline Limestone forming Marfa Ridge at the northern extremity of the island of Malta. The ridge covers an area of around 6.5 sq km and slopes to the north from an altitude of 120m to sea level. The Upper Coralline limestone is underlain by the Blue clay which dips below sea level at the north side giving rise to a small coastal aquifer. This is exploited for irrigation by farmers through small hand-dug wells.

To the south of Wied Musa the UCL forms a small synclinal structure which is also tapped by a few wells for irrigation. These wells, unlike those further north, are not prone to saline intrusion.

Upper Coralline Aquifer Systems, Gozo

(i) Ghajnsielem Perched groundwater body – MT014

The Ghajnsielem syncline body lies in the south east of Gozo bounded by the Ghajnsielem-Qala fault to the north and the slopes from Qala to Mgarr, facing the north Comino channel, to the south. It occurs in a downthrown block of country where the bounding fault to the north varies considerably in its throw.

The aquifer lies within the UCL which reaches a maximum thickness of 87m and shows considerable variations in permeability and porosity. In general the formation is highly fractured and cavernous whilst the piezometric height varies from west to east. Within this groundwater body two synclinal structures occur:

- the first is a downthrown *trough* or graben produced by subsidence between two normal faults; the Ghajnsielem-Qala fault to the north and to the south by a subsidiary fault downthrowing to the north. The trough lies north of Ghajnsielem village and is crossed by the Victoria – Qala road. The floor of the trough is synclinal and corresponds with the top of the blue clays at - 0.6m below sea level. At the western flank of the trough clay levels rise to 46m above sea level whereas to the east the clay reaches 80m above sea level. The trough has been estimated to have a groundwater storage capacity[31] of 1.9Mm^3

- the second structure, to the west of the previous, takes the shape of a truncated *basin* as a result of the greater throw of the Qala-Ghajnsielem fault that also bounds this structure to the north. The southern boundary of the basin is formed by another fault throwing north and passing north of Ghajnsielem and close to the heliport. This structure is known as the *basin* where the lowest clay level is 30m above sea level. The *basin* has a storage capacity of 0.54Mm^3

The trough stretches from Cordina Street to Ghajnsielem village, ending at the toes of Nadur slopes near Wied Biljun. At the surface, the floor of the trough coincides with a strip of land extending, for 150m to the east of the first sharp bend in Tal-Palma Road. In this locality, the altitude is around 85m (retrieved from contoured topographical maps 1:25,000). While assuming the preserved thickness of the Upper Coralline limestone to be around 90m, the floor of the trough formed by the top of the Blue Clay lies around 0.6m below sea level. The rim of the trough and hence its storage limit may be taken at +50m AMSL this being further confirmed by the presence of clay levels at this depth, in wells found on the upthrow side of the southern fault.

The deepest clay level of the basin is 30m AMSL whilst its rim stands at an altitude of 60m. This configuration allows for an estimated storage of approximately 540,000m^3 assuming a 15% saturation of the UCL. Unlike the trough, the basin is not susceptible to seawater intrusion as its base is 30 metres higher than sea level.

(ii) Nadur Groundwater body – MT015

This groundwater body lies in the north-east of Gozo on a plateau of UCL bounded by the Ghajnsielem/Qala fault to the south and the coast to the north. It covers an area of 5.9 sq km. The UCL formation reaches a thickness of around 60m over the top of the Blue Clay. Softer and chronologically older beds of the Mtarfa Member outcrop over the south-eastern area while the younger and more compact members, the Pitkal and Gebel Imbark, are exposed on the highest parts of il-Qortin il-Kbir and il-Qortin tan-Nadur. Being more susceptible to mechanical degradation, areas in Mtarfa member generate a fertile and easily arable soil and are thus intensely cultivated ploughed regularly throughout the year.

The groundwater body occurs in the lowest member of a monoclinal block of UCL that dips to the north east over the Blue Clay. Around the northern margins of the UCL, several springs surface over the clayey slopes and small tunnels have been also drilled horizontally into the cliff face to intersect fissures and tap the aquifer close to its base level. Seepages over the clay surface are also frequent, though these are of minor intensity and are all preciously harvested for irrigation purposes.

Towards the northern extremities of the il-Qortin il-Kbir, the UCL, the edge of the plateau has collapsed in blocks of varying dimensions. Creeping movement and erosion of the underlying clay exposes the limestone formation to excessive stresses leading to block failure with time. Most of the blocks consequently rest in a *slumped-out* position over the clay tallus.

(iii) Xaghra Groundwater Body – MT016

[31] Richard Costain Ltd

The Xaghra plateau lies in central Gozo at an altitude ranging from 84m to 135m above sea level. The UCL at Xaghra covers an area of $3km^2$ and is approximately 33m thick. It is nowhere in contact with the sea.

The synonymous groundwater body is sustained with a monoclinal block of Upper Coralline dipping gently to the north over Blue Clay. Three major faults cross the block in a west-east direction, one dowthrowing north and crossing from Ta'Srug to Ta'Bullara, and the other two crossing the spur between ta'l'Ghezien and Ta Gajdoru downthrowing, north and south respectively. A small syncline is present at Ghajn Damma with an axial plane oriented west-east.

The Mtarfa member thins out to the east where it is completely absent. The Pitkal member in the area of Ghajn Hozna is underlain conformably by the Ghajn Mellel member that reaches a thickness of about 8m. As a result of the existing thin limestone cover the Xaghra perched aquifer is considered to be one of the most vulnerable to surface pollution, both urban and agricultural.

(iv) Zebbug Groundwater Body – MT017

This groundwater body occurs on a narrow plateau of UCL seated on Blue Clay and aligned in a north-south direction at an altitude of 160m above sea level. It is the least important groundwater body in Gozo, discharging from the Ghajn Mellel member through a number of natural springs. No public abstraction takes place from the Zebbug aquifer; around 90 small hand-dug wells are found mostly used for domestic purposes.

(v) Victoria-Kercem Groundwater body – MT018

This groundwater body is one of the smallest occurring within the UCL. It consists of a two downthrow blocks of Upper Coralline Limestone, well preserved and bounded by faults downthrowing inwards. Both blocks dip towards the valley of Wied il-Lunzjata where the Blue Clay is exposed and partly forms the footslopes underlying Rabat and Kercem. The two blocks cover an area of 1.7sq km and lie at an altitude between 80m and 105m above sea level. Both blocks dip towards the valley of Tal-Lunzjata where natural springs sustain water flow in the adjacent valley system.

Upper Coralline Aquifer Systems, Comino – MT012

(i) Comino Mean Sea Level Groundwater Body

The island of Comino is located between the two larger islands of Malta and Gozo. It is essentially an outcrop of the Upper Coralline Limestone formation. The highest areas of the island are composed of the Gebel Imbark Member of the Upper Coralline Limestone, whilst the Tal Pitkal Member outcrops over most of the island, except for the low lying Sta Marija valley where the Mtarfa Member outcrops. There are no main faults in the central parts of the island and the bedding planes are essentially horizontal. The Upper Coralline Limestone attains a maximum thickness of 80-100m. The island thus sustains a small mean sea level – freshwater lens groundwater body, sustained in the Upper Coralline Limestone formation.

3. Pressures and Impacts on our Water

Fresh and coastal water resources are subject to a wide range of activities which may give rise to water quality deterioration. If not appropriately managed, such activities or pressures can cause damage to the extent that various ecological services are placed at risk, and economic activity that relies of good water quality is lost. As a result excessive economic costs are incurred in order to reverse poor water status to an acceptable quality. Pressures can be categorised generally into:

- *qualitative pressures* related to chemical contamination;
- *quantitative pressures* which are related to abstraction of water for use;
- *changes to the hydrological or hydrographical regimes* brought about by hydromorphological alterations; and
- *biological pressures* by means of the introduction of new species which could potentially threat the functioning of ecosystems and displace local water dependent species.

This chapter describes the main pressures in the Maltese Water Catchment District. Together with the monitoring results included as part of Chapter 6 Status Assessment, this Chapter is an important tool in the management plan cycle as it identifies which pressures should be managed more; which pressures could be potential problems but too little information is available to fully understand their magnitude or significance; and which pressures are no longer deemed to be significant due to progress in measure implementation.

3.1 The spatial location of pressures in the Maltese Water Catchment District and beyond territorial waters

The purpose of this section is to present a spatial illustration of the major pressure sources, both national and transboundary, to our surface waters. The status of knowledge on the degree or significance of each pressure and their impacts is further discussed in the subsequent parts of this Chapter.

3.1.1 The geographic location and scale of land based pressures

Due to the physical topography of the Maltese water catchment district, several land based pressures are located on the North West to South East stretch of coast. This is because the islands naturally dip towards this direction and therefore the coast here is low lying and hence more accessible. As can be seen in Figure 3.1, major settlements and coastal development lie along this coastal stretch, on both islands of Malta and Gozo. Therefore it is expected that this coastal stretch would be more vulnerable to the various land based pressures and their impacts. The land based drivers of these pressures range from agricultural practices, tourism and recreational activities, industrial activities as well as waste management facilities and infrastructure development.

In addition due to the natural geological tilt of the Maltese water catchment district, dry valley catchments also contribute to transporting land-based contaminants to this part of the island. Valley systems are known to act as significant pathways in transporting land-based contaminants to any surface water category, water courses, pools, transitional waters and coastal waters. Dry valley catchments traverse the entire Maltese Islands, transporting contaminants from road networks and rural areas towards the North West to South East stretch of coast.

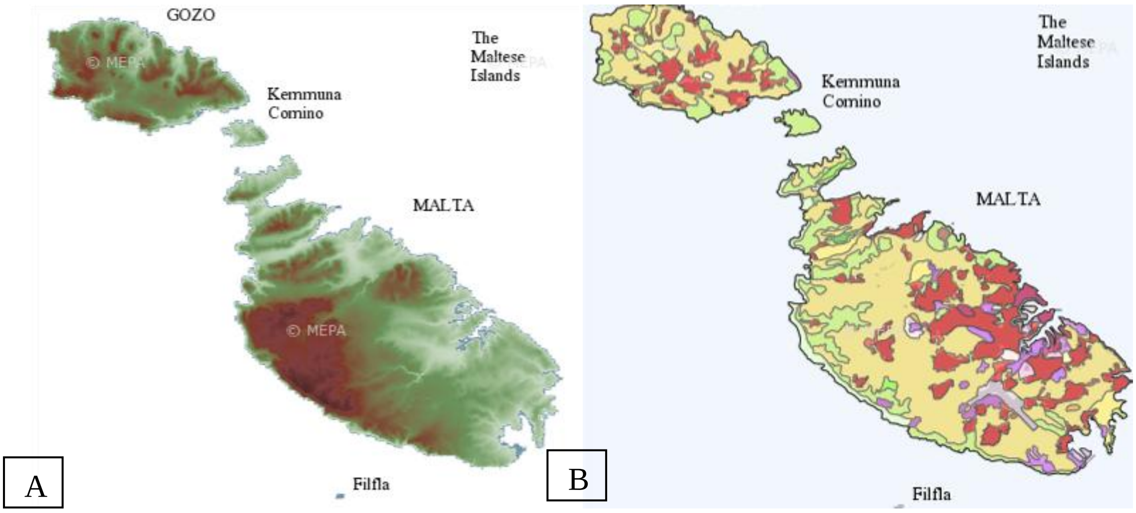


Figure 3.1: A – The natural topography of the Maltese Islands indicating that geological dip of the Maltese Islands towards the North West – South East stretch. B – Land cover of the Maltese Islands (Corine 2012) indicating the majority of settlement and human activity (indicated in red) located towards the more accessible stretch. This has a bearing on the vulnerability of the waters that lie along this part of the coastline. A more detailed map and legend is provided in Figure 3.3

Figure 3.2: Different uses of coastal stretches brought about by natural topographic feature, and therefore pressures - [A] Sliema coastline located in the north-western-south eastern coastal stretch of Malta, characterised by heavy development and low lying coast; [B] Coastal stretch characteristic of the opposite side of the Island, characterised by a rural environment, scattered tourism and recreational development and cliffs

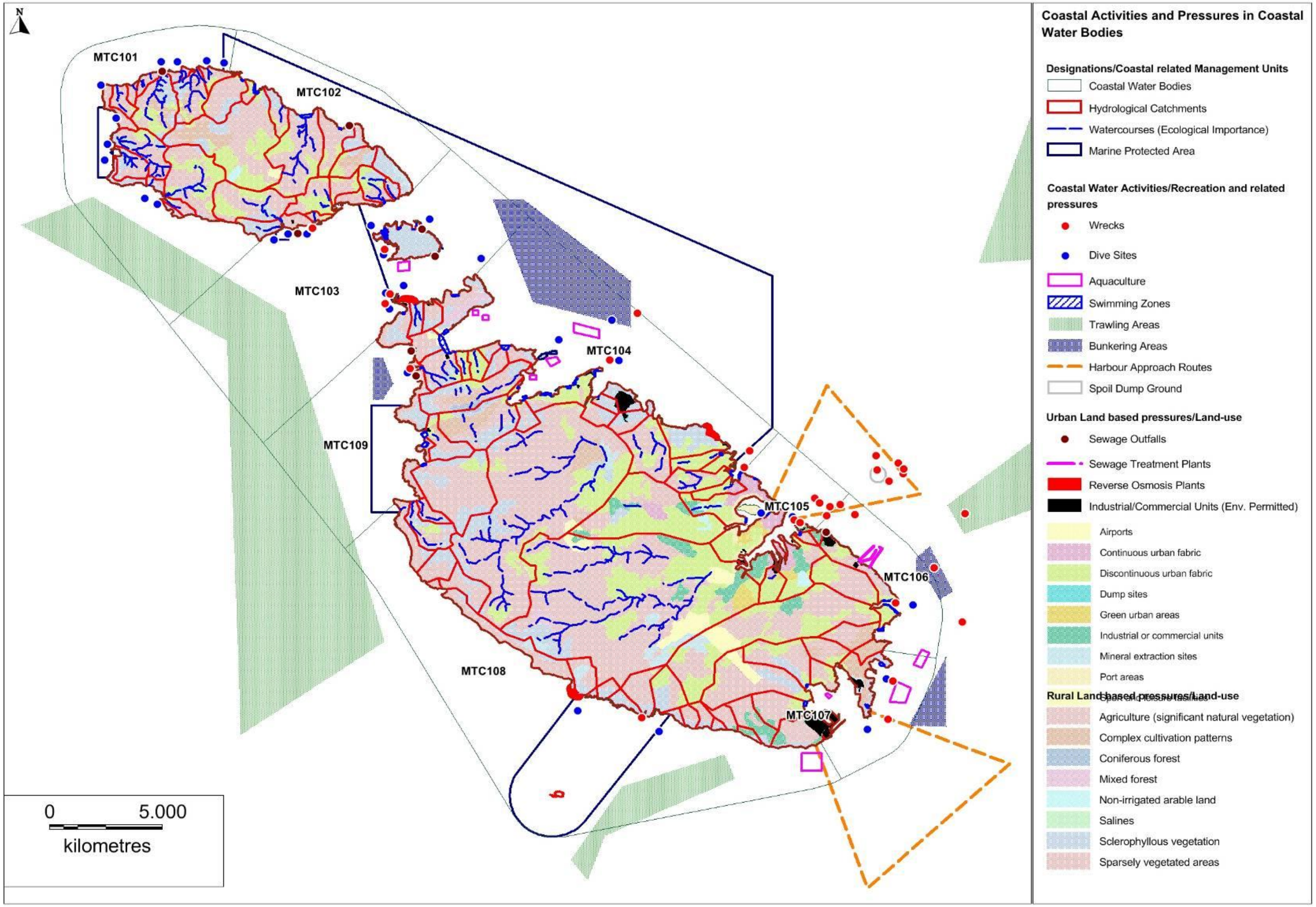


Figure 3.3: Coastal activities and pressures in the water catchment district and coastal water bodies

3.1.2 The geographic location of marine based pressures

Marine based pressures can either be generated from marine activities within Maltese territorial waters or from activities that are generated from outside Maltese territorial waters but which impact marine waters due to hydrographic transportation mechanisms.

3.1.2.1 Transboundary marine pressures

The Mediterranean is well known to be a major shipment hub in the world and according to a 2008 REMPEC study[32] Mediterranean shipping at that time accounted for 15 per cent of global shipping activity by number of calls and 10 per cent by vessel deadweight tonnes (DWT). Overall vessel activity within the Mediterranean has been rising steadily over the past 10 years and is projected to increase by a further 18 per cent over the next 10 years. Transits through the Mediterranean are expected to rise by 23 per cent. Increases in vessel activity were expected to be coupled with the deployment of ever larger vessels. Chemical tanker and container vessels were expected to show the highest rates of growth in respect of port callings within the Mediterranean since 2008 to date whilst increases in transits will be most pronounced in the product and crude tanker sector. Figure 3.4 indicates the major shipping routes in the Mediterranean.

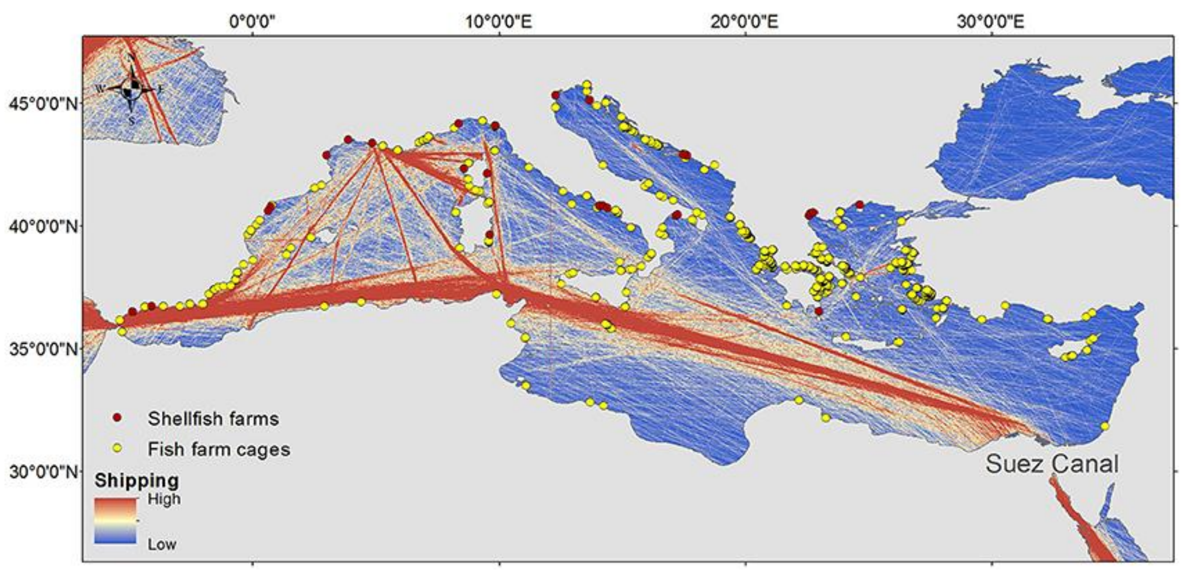


Figure 3.4: Extent of shipping in the Mediterranean sea - the colour of the marine area indicates the intensity of maritime activities – red is high whilst blue is low. *Source:* Halpern et al. (2008) [33]

Increased shipping brings about increased risks of oil pollution. A study by Ferraro et al (2009)[34] revealed that accidental oil / chemical pollution rarely occurs in the Mediterranean. However operational pollution is more common. The increase in maritime traffic within the basin may be exacerbating the problem. Satellite surveillance archives were used in this study to map out the potential extent of oil spills in the Mediterranean. It was found that the majority of spills are

[32] REMPEC 2008. Study of Maritime traffic flows in the Mediterranean Sea, Final Report – Unrestricted Version http://safemedproject.rempec.org/documents/safemed-l-documents/2.3-maritime-traffic-flows-study/view

[33] Halpern, B. S., Walbridge, S., Selkoe, K. A., Kappel, C. V., Micheli, F., D'Agrosa, C. 2008. A global map of human impact on marine ecosystems. Science 319, 948–952.

[34] Ferraro, G., yer-Roux, S., Muellenhoff, O., Pavliha, M., Svetak, J., Tarchi, D., and Topouzelis, K., 2009. Long term monitoring of oil spills in European Seas. International Journal of Remote Sensing 30(3): 627-645.

located beyond the 12 nautical mile limit of territorial waters. The authors of the study infer that this is' probably indicating deliberate intention to avoid risk of legal action.' The spill distribution in Figure 3.5 is highly correlated with the major shipping routes with concentrations appearing in the Ionian Sea, the Adriatic Sea, the Messina Strait, the Sicily Channel, the Ligurian Sea, the Gulf of Lion and east of Corsica.

In terms of seasonal variations, the majority of spills were detected during the summer months. This could be explained due to the fact that the mean wind speed is lower, thus determining a higher visibility of oil pollution. There are areas, however, that are well correlated with the increase in ferry traffic during the tourist season.

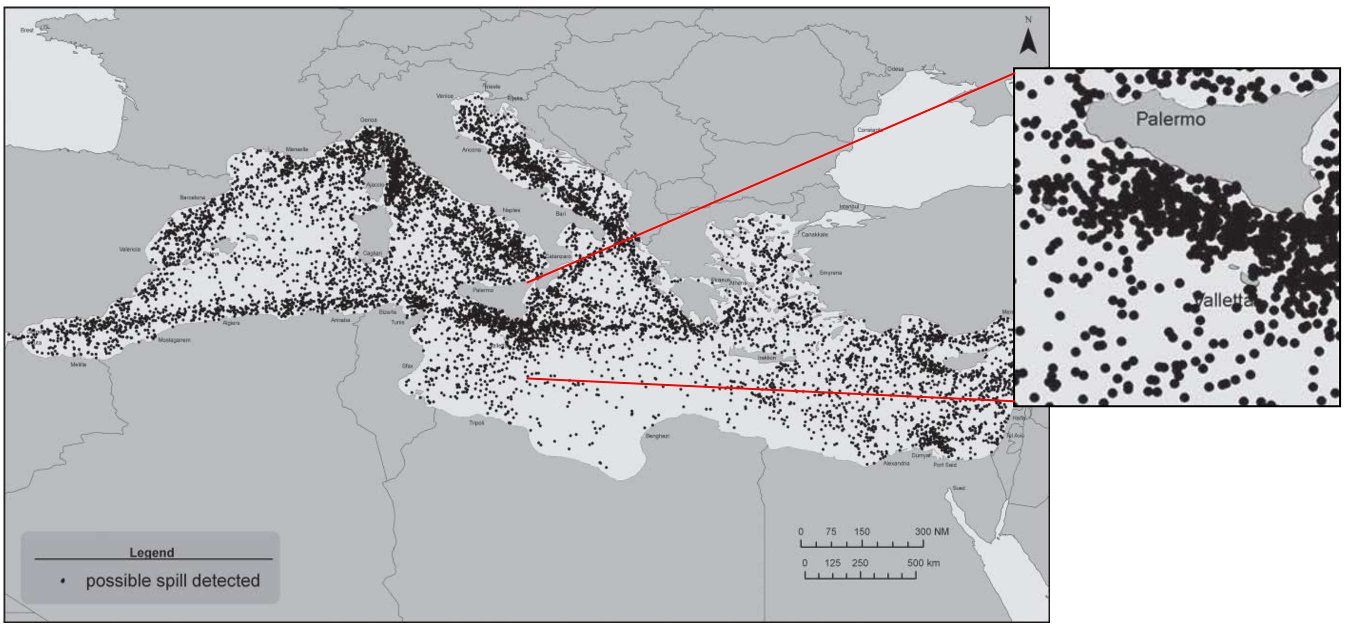


Figure 3.5: Possible oil spills detected in the Mediterranean offshore environment by satellite imaging (1999-2004), from both ships and offshore installations, as an indication of the scale of existing oil pollution. The insert is a zoom in on the Malta – Sicilian channel of the same map

Source: Ferraro et al. 2009. http://ec.europa.eu/environment/integration/research/newsalert/pdf/FB3_en.pdf

Another effective transboundary pathway is the atmosphere. The complex flow patterns of the Mediterranean region described under Chapter 2, contribute to the transportation of air pollutants over long distances. Very little has been studied with respect to the contribution of atmospheric deposition of contaminants into the Mediterranean marine environment. Nevertheless the few studies that exist indicate that atmospheric deposition is particularly acute in the Western Mediterranean Sea. This part of the Mediterranean is subject to particulate and dissolved atmospheric inputs, including inputs of anthropogenic origin from north eastern and Central Europe[35]. The region also receives pulsed Saharan dust from Northern Africa. As a result, trace metal concentrations in Mediterranean surface waters are higher than in the open ocean, for example the Atlantic Ocean.

[35] Heimburger, L.E. , Migon, C., Cossa, D. 2011. Impact of atmospheric deposition of anthropogenic and natural trace metals on Northwestern Mediterranean Surface waters: A box model assessment. In Environmental Pollution, June 2011, Vol. 159: 6, 1629-1634.

Seasonal cycles for the deposition of both lead and mercury have been studied in the Mediterranean region[36,37]. Both studies indicate that the highest concentrations of these two contaminants in air reach a maximum during the summer months. This is mainly attributed to the fact that the atmosphere is more heavily loaded with these metals during the dry season and the lack of rain precludes washout. Both studies indicate that the most efficient removal pathway of these contaminants from air is through the scavenging of particles by rain.

In the case of mercury, a Mediterranean Atmospheric Mercury Cycle System (MAMCS) project was performed between 1998 and 2000 to investigate the cycle of mercury in the Mediterranean atmosphere by combining field measurements with modelling. It was established that the Mediterranean sea is not only affected by mercury released in its vicinity but also from air masses enriched in mercury from regions of northern and north eastern Europe [5].

3.1.2.2 Local marine activities and their pressures

A number of more localised pressures exist in Maltese territorial waters. These activities have been discussed in detail in the MSFD Initial Assessment documentation accessible for download from the following webpage: http://www.mepa.org.mt/water-msfd-initial_assessment. The location of the marine based activities taking place in Maltese waters, are presented in subsequent sections of this chapter.

3.2 Definition of major qualitative pressures and impacts on inland surface, transitional and coastal waters

The Input of chemical contaminants to the surface water environment can result from both point and diffuse sources of emissions. A point source is defined as a single localised point of discharge of contaminated water or effluent containing one or more pollutant(s)[38]. Diffuse sources are defined as smaller or scattered sources from which pollutants may be released to land, air or water[39].

The status of several of these qualitative pressures to the coastal environment were assessed recently as part of Malta’s Initial Assessment on the State of Marine Waters that was required to be undertaken as part of the implementation of the Marine Strategy Framework Directive. A detailed account of each pressure descriptor is therefore accessible from the following link:

[36] Pirrone, N., Ferrara, R., Hedgecock, I.M., Kallos., G. Mamane, Y., Munthe, J., Pacyna, J.M., Pytharoulis, I., Sprovieri, F., Voudouri, A., and Wangberg, I. 2003. Dynamic processes of Mercury over the Mediterranean region: results from the Mediterranean Atmospheric mercury Cycle System (MAMCS) project in Atmospheric Environment, 37 Supplement no. 1, 21-39

[37] Remoudaki, E., Bergametti, G., and Buat-Ménard, P. 1991. Temporal variability of atmospheric lead concentrations and fluxes over the Northwestern Mediterranean Sea in Journal of Geophysical research, January 1991.Vol. 96: D1, 1043-1055

[38] European Commission. 2012. Common Implementation Strategy for the Water Framework Directive (2000/60/EC) Guidance Document No. 28. Technical Guidance for Preparation of an Inventory of Emissions, Discharges and Losses of Priority Substances and Priority Hazardous Substances; 69pp. Available online at: http://circa.europa.eu/Public/irc/env/wfd/library?l=/framework_directive/guidance_documents/guidance_document_2/_EN_1.0_&a=d (Accessed on 13th September 2012).

[39] Regulation (EC) No 166/2006 of the European Parliament and of the Council of 18 January 2006 concerning the establishment of a European Pollutant Release and Transfer Register and amending Council Directives 91/699/EEC and 96/61/EC. OJ L33, 4.2.2006, p.1-17

http://www.mepa.org.mt/water-msfd-initial_assessment. This section will provide an overview of the main qualitative pressures to inland surface, transitional and coastal waters, namely nutrient enrichment and contamination by hazardous substances or other substances of concern.

3.2.1 Defining Emissions, Discharges and Losses

Article 5 of the Environmental Quality Standards Directive 2008/105/EC requires Malta to establish an inventory of emissions, discharges and losses of chemical substances of toxicological concern to the surface water environment. In preparation of this Second Water Catchment Management Plan, this national water inventory was compiled as part of the review of pressures and impacts and is summarized in Section 3.3.3.

Whilst **emissions** refer to releases from point sources (e.g. treated wastewaters from industrial installations); **discharges** refer to releases from diffuse sources (e.g. pesticide runoff from agriculture land) and **losses** refer to the leaching of chemicals from consumer products (such as from products disposed of as waste in landfills). Table 3.1 summarises the main point and diffuse sources of pressures to the surface water environment.

Pathways are the means or routes by which specific substances can migrate or are transported from their sources to the water environment. In Malta's case these pathways can either be:

- *Land based* – via sub-catchment runoff, particularly through the dry valley catchment pathways that traverse the Maltese Islands; leaks from sewerage networks or from contaminated land;
- *Sea-based* – currents transport pollutants that end up in the sea from land sources and sea sources (including from neighboring countries); and
- *Air –based* - atmospheric deposition of contaminants that are emitted to air and deposited to the land or sea as dry deposition or wet deposition.

Pressure Type	Specific Sources
Diffuse Source Pollution	Fertiliser use in agricultural activities (via leaching, erosion, spills, direct drainage discharges)
	Plant Protection Products (incl. pesticides) use in agriculture related to undesired movement of such products in soil, water or air
	Urban development (including air deposition)
	Sea and land transport (including air deposition)
	Combustion activities (including air deposition)
	Litter
	Water run-off
	Discharges as a result of household and consumer product use
	Historic unmanaged landfills
	Historical pollution from sediments

	Historical pollution from contaminated land
	Transboundary inputs from neighbouring countries (via air and sea)
Point Source Pollution	Plant Protection Products – spills of PPP during transport, storage, filling, spraying, and cleaning management of residual spray and maintenance.
	Collection and transport of waste waters
	Aquaculture
	Manufacturing industries
	Energy generation

Table 3.1: Main point and diffuse sources of qualitative pressures to the surface water environment

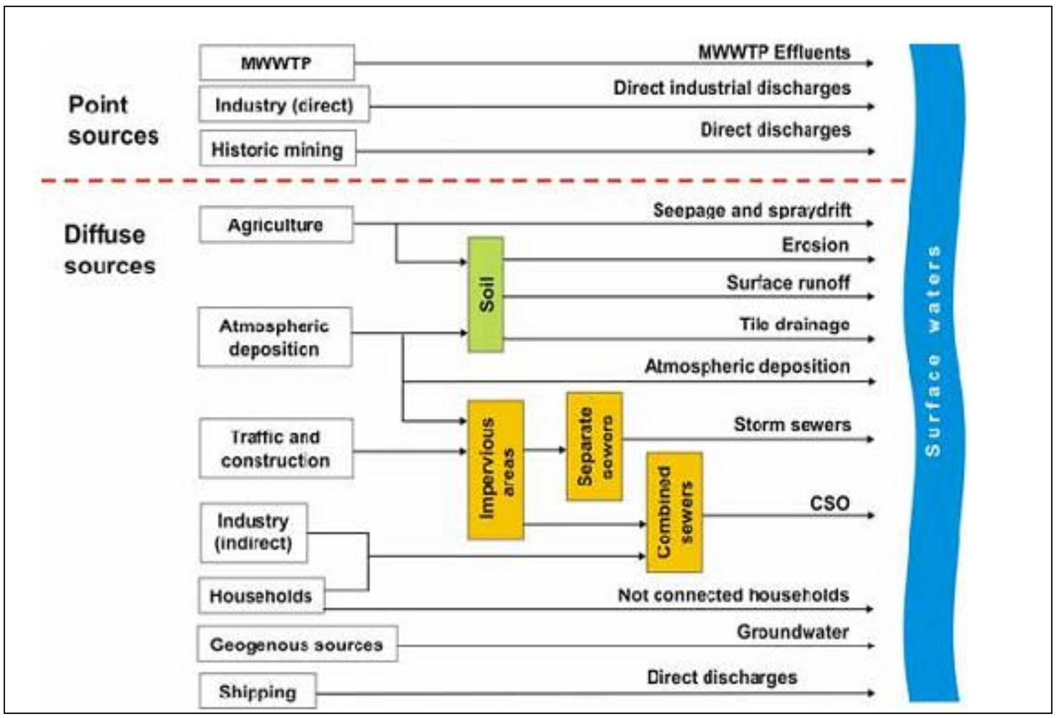


Figure 3.6: Sources and Emission pathways to be considered
Source: Fuchs et al., 2010 in CIS Guidance Document No. 28

3.2.2 Nutrient enrichment

Increased levels of nutrients in the water environment can bring about enhanced primary production or biomass production, algal blooms, and changes to the taxonomic composition of algae and plants. Enhanced primary productivity has effects on light climate, hence on biota, and increased fixation of carbon. The process of nutrient enrichment, especially compounds of nitrogen and/or phosphorous, leading to the effects described above, is termed 'Eutrophication'. The consequences of eutrophication are undesirable if they appreciably degrade ecosystem health and/or the sustainable provision of goods and services.

Increased levels of organic matter in the aquatic environment are also associated with negative effects. The decay of organic matter often leads to a stimulation of microbial decomposition and oxygen consumption, depleting bottom-water oxygen concentrations and potentially bringing about anoxic conditions especially in stratified water bodies. As a result, a reduction in benthic diversity may occur.

This section presents those pressures considered to be potential contributors to nutrient enrichment in Maltese inland surface, transitional and coastal waters.

3.2.2.1 Urban Wastewater Outfalls

Historically, discharges of untreated municipal and industrial wastewaters into coastal waters were the most visible form of pollution. The 2008 National Baseline Budget of 2008[40] had indicated that the majority of wastewaters reaching the marine environment from land-based operations were being discharged from sewage outfalls[41]. Today however, the discharge of untreated sewage into Maltese waters has been completely replaced by effluents treated to a secondary level. Sewage treatment plants at Ras il-Ħobż in Gozo and Iċ-Ċumnija in Malta have been discharging treated effluents from January 2008 and March 2009 respectively. The sewage treatment plant at Ta' Barkat (Northeastern coast of mainland Malta) has replaced the untreated sewage outfall at Wied Għammieq. It became operational in June 2011.

The treatment of all waste water discharged to the marine environment has significantly reduced the nutrient load contribution from waste water discharge. Table 3.2 provides an indication of the loads of nutrients and organic matter to the marine environment through discharge of sewage effluent in 2003, 2008 and 2011. Comparison of the total input calculated by the 2003 and 2008 baseline budgets may imply that, with the exception of suspended solids, there has been a general increase in the discharge of nutrients in Maltese waters in the period 2003-2008. However the differences between the two sets of data could also be attributed to more accurate and reliable data used for the 2008 Baseline study. The data clearly indicates a significant improvement in nutrient loads to the marine environment from the sewerage network in 2011. The treated effluent emanating from the plant is measured for COD (Chemical Oxygen Demand), BOD (Biological Oxygen Demand), TSS (Total Suspended Solids), NH_4-N (Ammonium-Nitrogen) and Total Nitrogen.

Although sewage effluents can reach the marine environment through sewage overflows (in emergency situations, particularly heavy rainfalls), such overflows are rigorously controlled by Malta's Water Services Corporation and the influx of raw sewage into the marine environment from sewage overflows is deemed to be localized and of short duration.

Nitrogen levels were not achieved as stipulated in Annex I of the Urban Waste Water Directive at the sensitive area located off Ċumnija, North of Malta[42]. This was due to the overload of the sewerage network with farmyard waste. This waste was meant to be disconnected from the sewerage network but failure to do so has hindered the proper removal of Nitrogen. An

[40] Axiak, 2009. Baseline Budget of Emissions/Releases for SAP targeted pollutants for Malta, 2008. As submitted to the United Nations Environment Programme, Coordinating Unit for the Mediterranean Action Plan. Environment Protection Directorate, Malta Environment and Planning Authority; 20pp.

[41] Axiak, 2009. Baseline Budget of Emissions/Releases for SAP targeted pollutants for Malta, 2008. As submitted to the United Nations Environment Programme, Coordinating Unit for the Mediterranean Action Plan. Environment Protection Directorate, Malta Environment and Planning Authority; 20pp.

[42] Malta's Article 15, 16 and 17 Urban Waste Water Treatment Directive Report 2012 and 2014.

alternative solution to handle farmyard waste is currently being investigated (refer to Chapter 7 and 9). An upgrading of the plant's aeration capacity is also being considered[43].

Nutrient Loads from waste water (kg/yr) according to the National Baseline Budgets			2011[44] Nutrient Loads from treated waste water (kg/yr) (from all 3 plants)	
	2003[45]	2008[46]		
COD5	6,642,782	12,716,356	COD	1,937,657
BOD5	5,645,203	20,639,546	BOD5	344,768
Total Nitrogen	944,993	2,260,669	Nitrates[47]	1,170,420
Total Phosphorous	107,851	372,014	Not applicable[48]	
Total suspended solids	6,695,434	6,322,209	Total Suspended Solids	664,341

Table 3.2: Waste water nutrient input loads to Maltese coastal waters in 2008 (untreated) and in 2011 (treated)

3.2.2.2 Aquaculture

Aquaculture activity in the Maltese Islands includes the cultivation of closed cultured species, such as sea bass and sea bream, as well as captured tuna fisheries. Being in close proximity to tuna migratory routes Malta has been the largest producer of tuna in the Mediterranean. In total there are 9 off-shore aquaculture sites in Malta. Most sites are located in open, exposed waters whilst the more sheltered sites are utilized for nursery production or broodstock holding. Conditions required for the location of tuna penning vary from those of sea bass and sea bream due to their feeding habits and practices. Tuna penning cages, in fact have to be sited at least 1km offshore in exposed waters that have strong currents and away from benthic habitats that are of ecological significance[49].

Marine-based fish farming is a source of contamination in the marine environment particularly through excess food and fish wastes. These nutrients are mainly released during the summer when light availability is high and thus the potential for phytoplankton blooms to occur in the vicinity of these farms is highly possible. Nevertheless, numerous studies[50], both local and international, have failed to detect significant changes in chlorophyll *a* or particulate organic carbon in the water column in proximity to the fish farm cages. This has been attributed to the dispersive nature of fish farming sites, whereby phytoplankton cells are not around long enough

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43 Malta's Article 15 report for 2012 concerning the implementation of Directive 91/271/EEC concerning Urban Waste Water Treatment

44 Data provided by the Water Services Corporation

45 Axiak, V. 2003. Baseline Budget of Emissions/Releases for SAP targeted pollutants for Malta. As submitted to the United Nations Environment Programme, coordinating unit for the Mediterranean Action Plan through the Environment Protection Directorate of the Malta Environment and Planning Authority. http://www.mepa.org.mt/file.aspx?f=3523

46 Axiak, 2009. Baseline Budget of Emissions/Releases for SAP targeted pollutants for Malta, 2008. As submitted to the United Nations Environment Programme, Coordinating Unit for the Mediterranean Action Plan. Environment Protection Directorate, Malta Environment and Planning Authority; 20pp.

47 Nitrates are being taken into consideration instead of 'Total Nitrogen', since the latter parameter is only available for the effluent discharged by the South Malta Sewage Treatment Plant. Total Nitrogen emitted from the South Malta Sewage Treatment Plant is 544,592kg in 2011 and 767,967kg in 2012 (based on E-PRTR data).

48 Data on 'Total Phosphorous' is only available for the effluent discharged by the South Malta Sewage Treatment Plant: 88,560kg in 2011 and 206, 762kg in 2012 (based on E-PRTR data).

49 Stirling Aquaculture and University of Stirling, 2012. An Aquaculture Strategy for Malta. Preparatory study and recommendations prepared for the Ministry of Resources and Rural Affairs, Government of Malta, Final Draft Report, March 2012, pp 133.

50 Holmer, M., Kupka Hansen, P., Karakassis, I., Borg, J.A. and Schembri, P.J. 2008. Monitoring of Environmental Impacts of Marine Aquaculture in M. Holmes et al. (eds.), Aquaculture in the Ecosystem, Springer, 2 47-85.

to capitalize on nutrients. During the past decade, there was an increasing shift towards tuna penning, accompanied by a drive to relocate such practices to offshore areas. A site designated for such purpose is located to the Southeast of mainland Malta.

Environmental monitoring of aquaculture activities in the Maltese Islands has been carried out since 1991 to date. Despite the fact that the negative impact to the benthic environment found directly beneath the fish cages is well known, very little impact has been observed in terms of water quality[51]. Yearly monitoring results have shown that aquaculture activities rarely have an impact on the nutrient quality of the water column *per se*[52]. Results for nutrient contamination of the sediment matrix are less conclusive. The impacts of aquaculture on marine quality vary on the type of farm, i.e. for closed cycle species (i.e. sea bass and sea bream) and tuna penning.
Figure 3.7 provides an indication of the input loads of total nitrogen, total phosphorous and total organic carbon from four fish farms operating in Maltese waters during the period 2007-2011. This data is reported for the purposes of the European Pollutant Release and Transfer Register (E-PRTR)[53]. An average of 319,038kg of total nitrogen, 53,010kg Total Phosphorous and 653,300kg Total Organic Carbon were released per year by the four offshore fish farms.

The National Baseline Budget report (2008) indicates that most of the wastewaters associated with tuna penning operations arise from ship-based sources where tuna processing and packaging takes place. Such wastewaters would be rich in organic contaminants and nutrients. Land-based aquaculture installations are on the other hand associated with wastewater effluents arising from net cleaning, defrosting and frozen bait, fish processing and packaging. However the significance of marine contamination from such discharges is considered low.

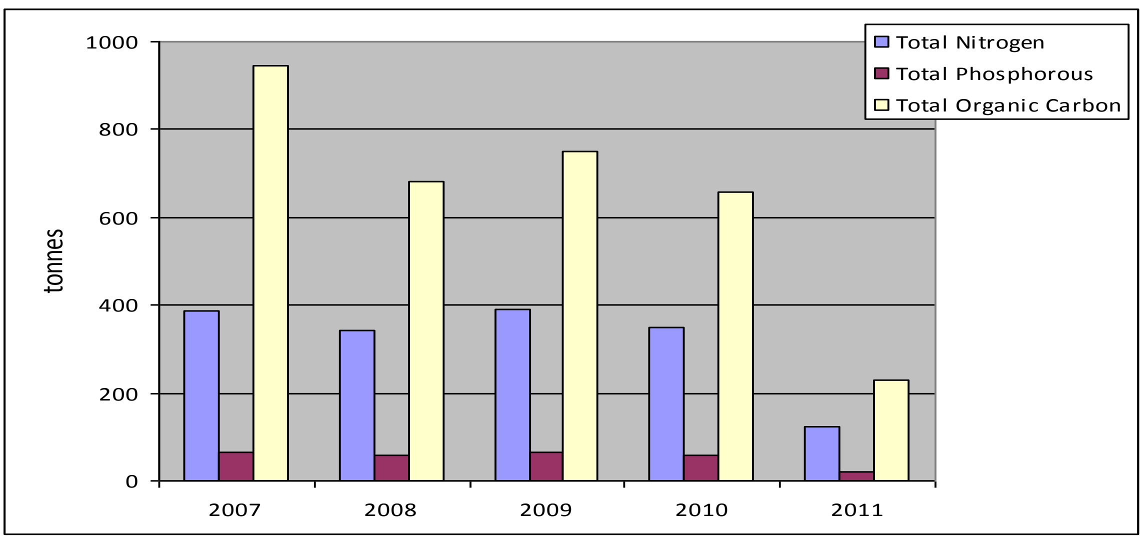

Figure 3.7: Loads of Total Nitrogen, Total Phosphorous and Total Organic Carbon per year as reported for the purposes of the E-PRTR by four fish farm cages operating in Maltese waters. During 2010, one fish farm was not operating

51 Borg, J.A. and Schembri, P.J. 2006. Environmental monitoring of aquaculture activities in the Maltese Islands. Presentation at seminar ' Aquaculture and the environment' organized by the Cleaner Technology Centre, Malta and the Regional Activity Centre for Cleaner Production (UNEP Mediterranean Action Plan); Valletta, Malta, 16 November 2007.

52 Ecoserv Monitoring reports Data submitted for Fish and Fish Ltd and Malta Fishfarming Limited Tuna penning monitoring data 2007-2010.

53 http://prtr.ec.europa.eu/FacilityLevels.aspx

3.2.2.3 Agricultural sources of nutrients and storm water runoff

Nutrient input from agricultural sources into the marine environment is mainly related to diffuse pollution from run-off. The several sub-hydrological catchments of the Maltese Islands and their individual valley systems transport nutrients from inland agricultural areas to the sea and contribute to the occasional nutrient enrichment incidences of sheltered inlets and bays around the Islands. Due to the diffuse nature of this source, it is very difficult to quantify the contribution of this source from agricultural activity. A rough approximation of agricultural nitrogen contribution discharged to the environment amounted to 163.7 tonnes during the first nitrate reporting cycle period (i.e. 2004-2007)[54].

The implementation of the Nitrates Directive has brought new controls to farmers, who have to abide to the Nitrates Action Programme. Measures within this programme relate to the storage, application and discharge of both inorganic and organic fertilizers on animal holdings and agricultural fields.

GIS based modelling of nutrient transfers from land to coastal waters in Malta was carried out in 2001 as part of a PhD dissertation[55]. The research developed an integrated approach for understanding coastal eutrophication processes and was based on numerical modelling of the production of land-based nutrients and their transport to coastal waters, using GIS and remote sensing. The effects of land cover upon nutrient export potential were evident from this study, with nutrient loadings being the highest for predominantly agricultural sub-catchments. Seasonal variations of chlorophyll-a in surface waters were also evident, although the concentrations were generally low with higher concentrations localised to the inner areas of coastal inlets and bays. Dye tracing was used to reveal water mixing and it resulted that slow rates of mixing were also limited to these innermost areas.

3.2.3 Emissions, discharges and losses of Chemical contaminants

Hazardous substances include chemical elements and compounds or groups of substances that are toxic, persistent and liable to bio-accumulate, and other substances or groups of substances which give rise to an equivalent level of concern[56]. Such substances can be broadly classified into two principal groups: synthetic substances and non-synthetic substances. Synthetic substances refer to man-made compounds such as pesticides, medicinal active ingredients and anti-fouling agents, where as non-synthetic substances include naturally occurring substances such as trace metals, aliphatic and aromatic hydrocarbons, as well as by-products of combustion activities.

Emission points of chemical contaminants arise from industrial (electricity generation, aquaculture, hotels, oil and fuel terminals, and shipyards), water-related infrastructure discharges (waste water treatment and desalination plants) and waste management facilities

[54] MEPA. 2008. Malta 1st Annex V Report of Council Directive 91/676/EEC of 12 December 1991 concerning the protection of waters against pollution caused by nitrates from agricultural sources.

[55] Tabone. Adami. E.2001. GIS Based Modelling of nutrient transfers from land to coastal waters for understanding eutrophication patterns, Thesis submitted for the Degree of Doctor of Philosophy, Darwin College, Cambridge, April 2001.

[56] Piha H. 2010. Marine Strategy Framework Directive Task Group 8 Report Contaminants and Pollution effects; 171pp. Available online at: http://www.ices.dk/projects/MSFD/TG8%20Report_Final_vII.pdf (Accessed on 13.09.12)

(landfills, marine spoil ground). Figure 3.8 indicates the location of these various point source discharges to the surface water environment.

3.2.3.1 Water Related Infrastructure

The sewerage system in Malta collects both domestic and industrial wastes, the latter regulated by Legal Notice 139 of 2002, as amended by Legal Notice 378 of 2005. Therefore hazardous substances generated by industries could end up in the marine environment through the sewerage network. With the exception of data reported under the obligations of the Urban Waste Water Treatment Directive, data with respect to loads of contaminants in treated effluents is lacking.

On the other hand, data on the composition of wastewater at key nodes on the wastewater collection and transmission network leading to the three sewage treatment plants currently in operation is available for the period 2008, 2009 and 2011. Such data indicates detectable concentration of contaminants listed in the Priority Substances Directive including the synthetic diuron and chlorpyrifos in 2008. Nickel and lead were the main Annex I non-synthetic contaminants detected in waste streams.

Discharges from municipal desalination plants and cumulative discharges from tourist resorts are also considered to be sources of hazardous substances, albeit of a localised nature and hence of low significance. There are three main desalination plants in Malta, operating at Lapsi (MTC 108), Ċirkewwa (MTC 103) and Pembroke (MTC 104), whereas brine discharges from hotels are restricted to the main tourist areas in Malta and Gozo.

Brine wastewaters, as well as membrane wash waters produced during back-flushing of the membranes are discharged directly into the sea. The main chemicals of concern which have been detected in desalination discharges are boron, and to a lesser extent, arsenic and nitrates. It is more likely that such chemicals or potential marine contaminants are originally found in the feed waters and are being concentrated in the discharged brine stream (Axiak and Delia, 2000)[57].

[57] Axiak & Delia. 2000. Assessing the Impact of Compliance with CD 76/464/EEC and other related Water Quality Directives with Reference to Marine Discharges in Malta. Commissioned Report for the Ministry for the Environment; 250 pp.

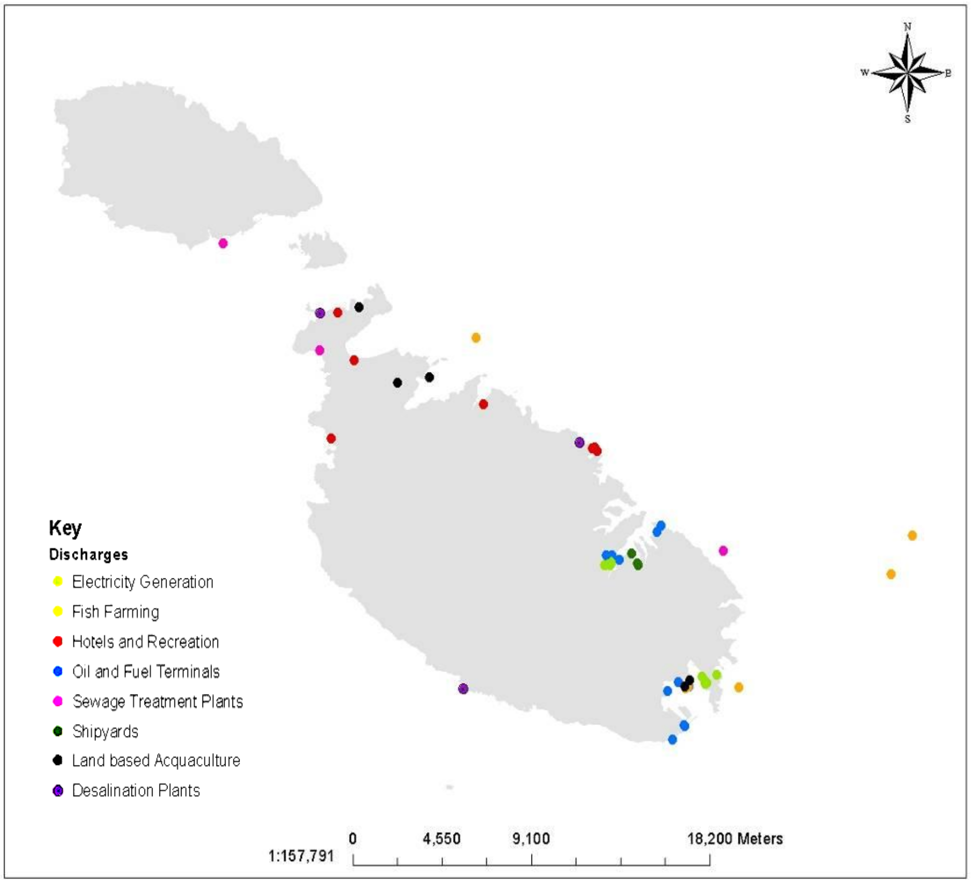

Figure 3.8: The location of point source emissions to the coastal water environment

3.2.3.2 Industrial Point Source Discharges

Most industries in Malta are located inland and are either connected to the municipal sewerage system or employ specific waste management practices to regulate discharges generated on site. The majority of the installations with direct discharges to the marine environment are located in harbour areas (coastal water bodies MTC105, MTC107). Such installations include oil storage and treatment facilities (oil and fuel supply terminals), as well as the power stations of Marsa (MTC 105) and Delimara (MTC 107). According to the National Diagnostic Analysis[58], cooling waters of power stations may contain traces of organotins, tetrachloroethylene, petroleum hydrocarbons and biocides. However reported emissions to water from the Marsa[59] and Delimara[60] Power Stations were respectively found to be in compliance with the contaminants discharge limits established in the operation permit of the installation. The aforementioned parameters are released in marine waters in minimal amounts.

Oil and fuel terminals are considered to be a potential source of chronic oil pollution. Wastewaters from such terminals are generally associated with dewatering of fuels during

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58 Axiak, V. 2004. National Diagnostic Analysis for Malta. As submitted to the United Nations Environment Programme, Coordinating Unit for the Mediterranean Action Plan through the Environment Protection Directorate of the Malta Environment and Planning Authority. http://www.mepa.org.mt/file.aspx?f=3524

59 Annual Environment Report 2011, Marsa Power Station; pp 47. Available online: https://www.mepa.org.mt/ippc-applications-installations-mps (Accessed on 22nd October 2012).

60 Annual Environment Report 2011, Delimara Power Station; pp 29. Available online: https://www.mepa.org.mt/ippc-applications-installations-dps (Accessed on 22nd October 2012).

storage or from oil-water separation of ballast waters, or rainwater runoff. The majority of the oil and fuel terminals are also located within harbour areas. The nature of the activities taking place at these terminals presents a risk of contamination of the marine waters, particularly by polycyclic aromatic hydrocarbons (PAHs), and traces of heavy metals[61]. Minor to moderate oil spills have been reported in inshore waters, resulting mostly from fuel terminals in the Grand Harbour area.

Shipyards located in the Grand Harbour area also constitute a source of contaminants in the marine environment. Until recently, the most important shipyard in Malta was the Malta Shipyards which was one of the largest ship repairing yards in the Mediterranean. Waste streams were mostly discharged directly to sea and were associated with organotins, hexachlorobutadiene, trichloromethane, dichloroethane, trichloroethylene, tetrachloroethylene, carbon tetrachloride, possible traces of polychlorinated biphenyls together with petroleum hydrocarbons and a range of heavy metals[62]. Activity at the Malta Shipyards was reduced significantly during the last decade. However the shipyards have been recently privatised and various activities related to yacht and ship repair, conversion and building of marine vessels, surface treatment of vessels and general engineering works are carried out.

3.2.3.3 Waste Management facilities - Landfills and the Spoil Ground

Until recently, mixed solid municipal waste was collected at three unmanaged land-based landfills at Magħtab, Qortin and Wied Fulija. These landfills could represent sources of contaminants through leaching in adjacent coastal water bodies MTC 104, MTC 102 and MTC 108 respectively. The NDA (2005)[63] suggests that the major impact exerted on the marine environment by the Magħtab landfill was that of contamination by heavy metals. However, Scott Wilson (2004)[64] concluded that overall these landfills did not pose a significant risk of contamination to the landfills' nearby water environment.

At present, municipal solid waste disposal is carried out at non-hazardous engineered waste facilities regulated through the Integrated Pollution Prevention and Control (IPPC) Regulations 2002, as amended by LN 230 of 2004, and the Waste Management (Landfill) Regulations 2002. As part of the permitting process of Ta' Żwejra and Għallis Non-Hazardous Landfills, four coastal monitoring stations have been designated for monitoring of contaminants in water and sediments in adjacent water body MTC 104. Monitoring in landfills encompasses various sectors this involves monitoring the set points for leachate, landfill gas, groundwater, surface water levels as well as coastal water set points in landfills are set and managed in order to provide for a high level of environmental protection. Points close to coastal waters, ground water

[61] Axiak, V. 2004. National Diagnostic Analysis for Malta. As submitted to the United Nations Environment Programme, Coordinating Unit for the Mediterranean Action Plan through the Environment Protection Directorate of the Malta Environment and Planning Authority. http://www.mepa.org.mt/file.aspx?f=3524

[62] Axiak, V. 2004. National Diagnostic Analysis for Malta. As submitted to the United Nations Environment Programme, Coordinating Unit for the Mediterranean Action Plan through the Environment Protection Directorate of the Malta Environment and Planning Authority. http://www.mepa.org.mt/file.aspx?f=3524

[63] Axiak, V. 2004. National Diagnostic Analysis for Malta. As submitted to the United Nations Environment Programme, Coordinating Unit for the Mediterranean Action Plan through the Environment Protection Directorate of the Malta Environment and Planning Authority. http://www.mepa.org.mt/file.aspx?f=3524

[64] Scott Wilson. 2004. Development of Rehabilitation Strategies, Magħtab, Qortin and Wied Fulija Landfills, Summary Report. Malta: WasteServ Malta Ltd.

monitoring, surface water monitoring also is carried out. Results[65] from the alleged impacted coastal monitoring points, close to the landfills' sites, at the water surface and bottom, during the years 2010 and 2011, have indicated concentrations in water well below Environmental Quality Standards as defined in the Priority Substances Directive for cadmium, lead, nickel and mercury in coastal waters. Chemical analysis of sediments from same sampling points and period, indicated concentrations of mercury, cadmium, lead, nickel, arsenic, chromium, copper and zinc below Environmental Quality Standards as proposed by Axiak (2003)[66] for non-industrial sites. Monitoring data from such sites from the permitting process to date does not show any concerning levels of pollutants are being emitted to surface waters. Releases of to air and water are also reported for each pollutant listed in Annex II of EC/2006.

Dumping of inert material at sea takes place at a designated national spoil ground off the Northeastern coast of Malta, consisting of a circular area with a radius of about 350m[67]. However, dumping at other unofficial offshore locations has been reported to occur. The potential chemical impact of the national spoil ground is to date unknown and a measure to increase knowledge in this regard has been developed (refer to Chapter 9). Nevertheless during the period 2007-2011, approximately 1 million tonnes of waste was disposed at sea. This waste constituted clean geological material originating from construction and demolition projects and dredged material. In 2010 grain was also disposed of at sea. [68]

3.2.3.4 Importation of Hazardous Substances

Importation data for hazardous substances can be useful to indicate the use of otherwise of certain chemical substances, over the years within the national territory. Such importation quantities do not necessarily represent loads of substances of potential releases to the environment. An exercise was carried out to review importation statistics data for the period 2004 to 2014 for the substances included in the Priority Substances Directive, as well as chemical substances of potential national concern to the marine environment. The importation quantities were made available by the National Statistics Office. Please refer to the findings of the National Inventory (Section 3.1.3 of this Chapter).

3.2.3.5 Storm Water

Storm water runoff within urban catchments is able to transport debris, litter, and traces of oil and sewage as well as particulate matter, such as soot from vehicular and industrial activities to the water environment. Input loads from diffuse land-based sources may ultimately end up leaching into Maltese fresh waters and coastal waters. Such sources encompass a wide spectrum of activities. These include hydrological sub-catchments discharging into coastal areas: storm water runoff, sewage overflows and industrial/agriculture/animal husbandry direct or indirect wastes.

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[65] Annual Environment Report 2011, Ghallis Non-Hazardous Waste Landfill; pp 47. Available online: https://www.mepa.org.mt/ippc-applications-installations-ghallisnh

[66] Axiak, V. 2003. Proposal for a National Marine Pollution Strategy to Control Direct Discharges into the Marine Environment. Final document submitted for consideration by the Environment Protection Directorate of the Malta Environment and Planning Authority; 96 pp. Available online at: http://www.mepa.org.mt/topics-water-monitoring

[67] Designated by Legal Notice 128 of 1997, as amended.

[68] Waste Management Plan for the Maltese Islands: A Resource Management Approach 2013-2020 Consultation Document October 2013.

Data on storm water quality is limited to a few studies limited to individual catchments in the Maltese Islands. This data gap is considered to be a significant water management issue and is being dealt with by means of a measure in this plan (refer to Chapter 9, measure KNO 3). A study carried out in 2010 to test stormwater runoff quality from an urban catchment, [69] focused on general physico chemical parameters and a number of additional substances in several monitoring points within the major Msida-Birkirkara water catchment area. These were Total Dissolved Solids and electrical conductivity, pH, Total hardness, calcium, magnesium, chlorides, nitrates, sulphates, Total Organic Carbon, boron, sodium and potassium. The analysis indicated that the quality of stormwater exhibits a higher concentration trend as one moves downstream, towards the end of the catchment, at Msida. The results also indicated that most of the water quality parameters increased in concentration after periods of dry weather due to the build up of contaminants in roads and surrounding areas.

3.2.3.6 Agriculture and Use of Plant Protection Products

The excessive use of pesticides in agriculture may also lead to the dispersion of pesticides into surface waters. Considering the fair share of pesticides listed in the Annex I, there is limited data in this regard. Pesticides pertaining to the group of 'Persistent Organic Pollutants' (POPs), namely aldrin, chlordane, DDT, dieldrin, endrin, heptachlor, hexachlorobenzene, mirex and toxaphene, were banned as from 2004 However there is no information on the possible existence of stockpiles of obsolete or banned pesticides in Malta[70]. On the other hand, concentrations of some of these pesticides in previous sewage outfalls were not detectable. Table 3.3 shows that use of chlorpyrifos in Malta was authorised till 2014, whereas although quinoxyfen and cypermethrin had authorization for usage, in 2013 there rights are under review.

EQS substance	Substance type	2010	2011	2012	2013	2014
Alachlor	herbicide/biocide	N.A	N.A	N.A	N.A	N.A
Atrazine	herbicide/biocide	N.A	N.A	N.A	N.A	N.A
Chlorfenvinphos	insecticide agricide	N.A	N.A	N.A	N.A	N.A
Chlorpyrifos (Chlorpyrifos-ethyl)	insecticide	**A**	**A**	**A**	**A**	**A**
Cyclodiene pesticides	insecticide	N.L	N.L	N.L	N.L	N.L
Aldrin	insecticide	N.A	N.A	N.A	N.A	N.A
Dieldrin	insecticide	N.A	N.A	N.A	N.A	N.A
Endrin	insecticide	N.A	N.A	N.A	N.A	N.A
Isodrin	insecticide	N.L	N.L	N.L	N.L	N.L
DDT total	insecticide	N.A	N.A	N.A	N.A	N.A
para-para-DDT	insecticide	N.L	N.L	N.L	N.L	N.L
Diuron	herbicide	N.A	N.A	N.A	N.A	N.A
Endosulfan	insecticide	N.A	N.A	N.A	N.A	N.A
Hexachlorobenzene	fungicide	N.A	N.A	N.A	N.A	N.A
Isoproturon	herbicide	N.A	N.A	N.A	N.A	N.A
Simazine	herbicide	N.A	N.A	N.A	N.A	N.A
Tributyltin compounds	anti-fouling agent	N.A	N.A	N.A	N.A	N.A

[69] Gatt, K. and Farrugia, E.S. 2012. Promoting the reuse of stormwater runoff in the Maltese Islands, Taylor and Francis, Urban Water Journal, 2012, 1-15.

[70] Axiak, V. 2004. National Diagnostic Analysis for Malta. As submitted to the United Nations Environment Programme, Coordinating Unit for the Mediterranean Action Plan through the Environment Protection Directorate of the Malta Environment and Planning Authority. http://www.mepa.org.mt/file.aspx?f=3524

Trifluralin	herbicide	N.A	N.A	N.A	N.A	N.A
Dicofol	pesticide	N.A	N.A	N.A	N.A	N.A
Quinoxyfen	pesticide/ fungicide	**A**	**A**	**A**	**A**	P
Aclonifen	herbicide	N.A	N.A	N.A	N.A	N.A
Bifenox	herbicide	N.A	N.A	N.A	N.A	N.A
Cybutryne/ Irgarol	antifouling biocide/algicide	N.L	N.L	N.L	N.L	N.L
Cypermethrin	insecticide/ biocide	**A**	**A**	**A**	**A**	P
Dichlorvos	insecticide/ biocide	N.A	N.A	N.A	N.A	N.A
Heptachlor and heptachlor epoxide	cyclodiene insecticide	N.A	N.A	N.A	N.A	N.A
Terbutryn	herbicide/biocide	N.A	N.A	N.A	N.A	N.A

Table 3.3: Showing the authorisation of pesticides in Malta throughout the years 2010 till 2014.

A implies authorisation, N.A implies not authorisation, N.L indicated that the biocide is not listed on the authorisation list therefore its use is ambiguous, P means pending

3.2.3.7 Sea based activities

Given its strategic location and strong tourism sector, shipping and recreational boating activity is extensive in the Maltese Islands. Discharges from ships and pleasure craft are a diffuse source of nutrient and other contaminant input and therefore to date it has been very difficult to quantify input loads of contaminants and nutrients from this sector. Nevertheless recent years have witnessed the coming into force of a number of legislative pieces (Port Reception Facilities for Ship-generated Waste and Cargo Residues Legal Notice and the Recreational Crafts Directive 2003/44/EC) with an aim to control sewage disposal and other wastes onboard the vessel and within ports and marinas.

Maritime activities also contribute to chronic and/or accidental release of contaminants into inshore and offshore maritime zones. Such activities include intense maritime traffic, harbour activities and yacht marinas, bunkering activities as well as intense leisure boating activities especially in summer. These activities in general lead to the diffuse release of hazardous substances such as tar, fuels, lubricating oils and biocides from the use of anti-fouling paints.
The National Diagnostic Analysis identifies various risks of oil pollution in the marine environment associated with the maritime transport sector, including:

- major or moderate accidents involving maritime traffic, including bunkering;
- illegal discharges of ballast waters by maritime traffic;
- operational and minor losses of fuel and diesel oils from small water craft

Nevertheless, to date, data on input loads from such activities is not available.

Dredging activities at sea may also lead to the potential release of historic contaminants and accumulated nutrients present in sediments. Such activities are mainly undertaken in inshore waters for the purposes of the maritime transport sector and are thus mainly restricted to harbour areas (Refer to Figure 3.9). Once again, no data is available with respect to type and amount of contaminants released into the marine environment through such activities.

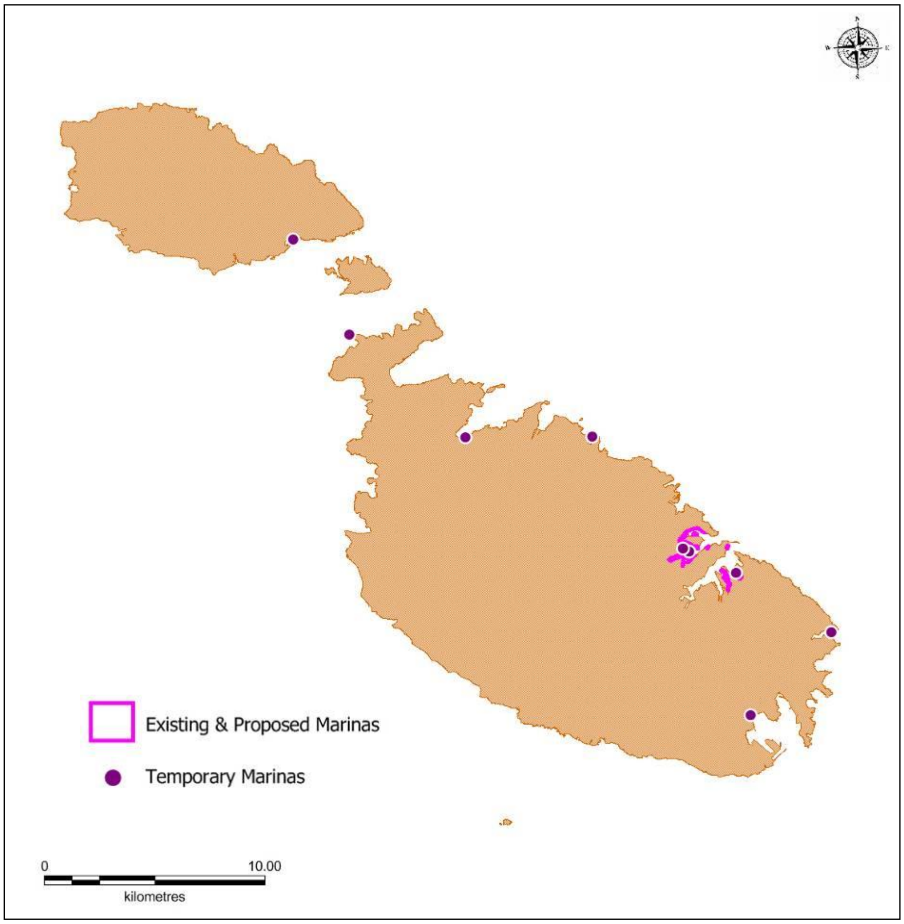

Figure 3.9: Potential additional sources of contaminant release in the marine environment from Marina activities

3.2.3.8 Transboundary Inputs

(i) Atmospheric Inputs

Inputs of contaminants into the marine environment can also result from atmospheric deposition. Such sources of contamination could occur through long-range atmospheric transport and deposition, as well as from land-based sources emitting to air. Parties, including Malta, to the Convention on Long-range Transboundary Air Pollution (CLRTAP) shall endeavour to limit and, as far as possible, gradually reduce and prevent air pollution including long-range transboundary air pollution[71]. The Convention encourages countries to develop policies and strategies to combat the discharge of air pollutants through exchanges of information, consultation, research and monitoring.

In accordance with CLRTAP and the European NEC Directive[72] obligations, a national inventory of emissions to air is compiled annually. These emissions are worked out by multiplying emission factors and activity statistics for each respective sector; partly also through the use of mathematical models. The national air inventory report for Malta published in March 2012 [73] includes a key category analysis, representing the most significant sources of emissions to air.

71 http://www.unece.org/env/lrtap/

72 Directive 2001/81/EC of the European Parliament and of the Council of 23 October 2001 on national emission ceilings for certain atmospheric pollutants. OJ L309, 27.11.2001, p22-30

73 MEPA. 2012. Informative Inventory Report for Malta, March 2012.

Hazardous substances which feature in the key category analysis are presented in Table 3.4 below.

Benzo(a)pyrene emissions to air resulted from road transport and other sources of fuel combustion. Emissions of chromium, lead, zinc and copper emissions to air have been reported solely from road transport tyre and brake wear. 5.32 tonnes of nickel emissions to air have been estimated to occur from public electricity production. Arsenic and cadmium have been reported to occur from road transport tyre and brake wear and public electricity production. Lastly, 0.1 tonnes of mercury have been estimated to be released to air from public electricity production and to a lesser extent from electrical and scientific equipment utilising mercury.

	Substance (kg)	2010 (Kg)	2011	2012
Heavy metals	Cadmium	40	20	20
	Mercury	11	5	5
	Arsenic	120	40	40
	Chromium	1300	1250	12500
	Lead	3400	5800	13000
	Nickel	6100	730	730
	Zinc	10270	10500	8530
	Copper	26800	26900	26900
Organic compounds	Benzo(a)pyrene	23	20	20
	Benzo (b) fluoranthene	20	20	120
	Benzo (k) fluoranthene	14	10	120
	Indeno (1,2,3-cd) pyrene	13	10	170
	HCB	0	0	0
	HCH	0	0	–
	PCBs	25	30	30

Table 3.4: Estimated Emissions to Air (Kg) from Key Category Sources in 2010-2012

The degree of atmospheric deposition of such substances in the marine environment has not been assessed to date. At this stage, this data is being included in this plan with a view to provide an indication of the type and levels of contaminants emitted to air, hence an indication of the potential for such contaminants to end up in the marine environment through deposition. The following substances of relevance to WFD include; lead, cadmium, mercury, nickel, polychlorinated dibenzo-p-dioxins (PCDD) and polychlorinated dibenzofurans (PCDF).

In addition perchlorate has been included for investigative purposes in the WFD monitoring programme for surface waters due to local research on perchlorate levels in air[74]. Fireworks are a possible source of perchlorate due to the use of potassium perchlorate in their manufacturing. Given that firework activity is widespread and frequent in the Maltese Islands particularly during the summer months, there is a need to establish levels of perchlorate in the water environment too.

[74] Vella, A.J., Aquilina, B., Delicata, F., and Farrugia, A. 2012. Perchlorates in Dust Fall: Evidence of environmental contamination by fireworks in Malta, 13th International Symposium on Fireworks, April 23-27, Valletta

(ii) Marine inputs
To date no data has been collected in this regard; marine inputs are to be investigated as part of this second plan (refer to Chapter 9 regarding the Programme of Measures).

3.3.3. National Inventory of Emissions, Discharges and Losses of Priority, Priority Hazardous Substances and other substances of concern to the Surface Water Environment

Any chemical substance identified to be of concern at European level is identified to be a priority substance. Any emissions, discharges and losses of these priority substances are kept under review by means of an inventory. Such an inventory also investigates those substances identified to be of national concern to the surface water environment.

The inventory targets those chemical substances of concern that are relevant at the Water Catchment level. For the purpose of compiling the water inventory for Malta, the surface water environment covers inland surface waters, transitional waters and coastal waters; with the latter extending to 12 nautical miles offshore, which corresponds with Malta's territorial sea boundary.

In the Maltese Islands, permitted discharges by means of the environmental permitting process are restricted to coastal waters. At present, the protection and improvement of the aquatic environment is targeted by implementing, among other things, specific measures to progressively reduce emissions of priority substances and of other chemicals and by phasing out in as much as possible the use of hazardous chemical substances. Provisions for emission control and cessation include obligations to comply with the best available technologies and also by limiting emissions of diffuse sources according to best environmental practice.

Beach profiles (refer to Chapter 4 of this plan) have been recently updated for all official bathing stations around the Maltese Islands. The data and information available in these documents was also used as part of the assessment of pressures and impacts impacting on the coastal environment.

The inventory builds upon previous baseline budgets of emissions, releases of targeted pollutants under the international obligations of the Barcelona Convention. In addition the most recent collected ambient monitoring data[75] [76] [77] on the concentration levels of chemicals in water, sediments and biota was also used to inform this report. This monitoring data will allow the identification of those chemical substances causing a failure of good chemical status at the water body level.

3.3.3.1 Methodology

The approach adopted for the compilation of the water inventory included an assessment of available ambient monitoring data collected to date and the use of E-PRTR emissions. Statistics on the import of chemical substances to the Maltese Island during the years 2008 until 2014 was also sourced.

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[75] Ambiente/CIBM 2013 – Baseline survey in coastal waters
[76] Ecoserv, 2012 – Baseline water survey in inland surface and transitional waters
[77] AAT, 2014 – Baseline sediment survey in inland surface and transitional waters

The DPSIR (Driver – Pressure - State – Impact – Response) approach has been adopted to assess the significance of the impacts at the water body level. Such an assessment included a review of the activities taking place at the water body level which may have impacted the water quality in terms of chemicals and ecology. A quantitative review of available monitoring data collected during the years 2012-2013 was also carried out. The quality of the data was also checked.

3.3.3.2 Assessment of the relevance of Priority Substances in surface waters

The relevance of the substances results, in part, from the available monitoring results on the pollution of Maltese waters. As part of the implementation of the WFD, MEPA carried out baseline surveys for the ten inland surface and transitional protected waters and all coastal water bodies. The surveys carried out during 2011-2013, included the collection of robust scientific data on the contaminants in inland surface, coastal waters and transitional waters. Prior to this project, baseline surveys for the water bodies were non-existent. Due to limited information on the production, application and emission situation the relevance of the pollutants listed in Annex I were only based on a single survey.

(a) Contaminants in coastal waters

The current level of pollution in Maltese waters was determined to be good for all parameters monitored in coastal waters, except for mercury which was ubiquitously detected in the water column from all the sampling stations. All measured mercury concentrations were found to exceed the annual average EQS of 0.05 µg/L. In the case of priority substances measured in sediments, the monitoring results show high concentrations of mercury, lead, copper and chromium in MTC 104 and MTC 106. Elevated levels of Polyaromatic Hydrocarbons (PAHs) in sediments were also measured in MTC 105. With regards to monitoring in biota, three parameters were measured hexachlorobenzene, hexachlorobutadiene. The analysis which was carried out solely in *Posidonia oceanica* indicated that the concentrations of such were lower than the detection limit.

(b) Contaminants in small inland surface and transitional waters

With regards to the limited monitoring which took place in 2011 in transitional waters, the assessment of pollutants showed all parameters for the most part were in line with EQS amounts. Nonetheless although not above the stipulated EQS, three pollutants were ubiquitously di(2-ethylhexyl)phthalate (DEHP), lead and nickel were found across the ten water bodies

Table 3.5 tallies the number of exceedances in the EQS for three parameters, DEHP, Lead and Nickel Where E indicates that was an Exceedance, E_O–Exceedance according to 2008 EQS directive and E_N – Exceedance according to the revised 2013 EQS directive, thus an exceedance in E_N also implies and exceedance by the E_O definition. Only on one occasion has the concentration for DEHP been exceeded, nonetheless its concentration was unanimously noted above detection limit levels in all the transition waters. For Nickel and Lead seem to be more problematic, since the EQS has been lowered to that of 1.2 µg/L from 7.2 µg/L for lead, and that of nickel from 20 µg/L to 4 µg/L.

	Substances which showed exceedances in EQS.		
Station	**DEHP**	**Lead**	**Nickel**
Is-Salini (station 1)		E_O	E_N
Il-Maghluq ta' Marsacala (station 2)		E_N	E_O
Il-Ballut ta' Marsaxlokk (station 3)		E_N, E_N	E_O, E_N
Bahrija Valley System (station 4)	E	E_O	
Wied il-Luq (station 5)			
Wied il-Lunzjata (station 6)		E_N	
Is-Simar Nature Reserve (station 7)			
L-Ghadira Nature Reserve (station 8)		E_N , E_N	
Il-Qattara (station 9)		E_N, E_N	E_N, E_N
L-Ghadira ta' Sarraflu (station 10)		E_N	E_N

Table 3.5: Number of exceedances in the EQS of DEHP, Lead, and Nickel in inland surface and transitional waters

With regards to the sediment analysis in inland surface and transitional waters DEHP was found in the water column of all the inland WBs. However it was only recorded in the sediments of one WB (il- Qattara) at levels that were not considered to be of ecotoxicological significance. Biota monitoring in inland surface and transitional waters was not carried out due to the limited and protected flora and fauna in the area.

The respective concentrations in all water body categories of the new substances that have been recently added to the priority substance list in 2013 (as stipulated by 2013/39/EC) are still unknown. In addition, explanations to the existing concentrations have yet to be assessed by long term monitoring data before anything conclusive can be established.

3.3.3.3 Importation Data for Hazardous Substances

Importation data for hazardous substances can be valuable to indicate the use as well as risk of such substances to reach surface waters. However, it must be noted that importation quantities do not necessarily represent loads of substances of potential releases to the environment. In so far the current inventory is looking into the usage of current priority substances and does not go beyond priority or priority hazardous substances.

Importation data can be provided by two means using either Harmonized System (HS) codes or through data collected via the REACH programme. Importation using HS codes was acquired through the National Statistics Office (NSO), as the local customs authority does not store importation data. In compiling this information, it was noted that the HS codes only correspond to the generic grouping of chemicals and not to specific substances, thus for the majority of the substances the importation could not be evaluated. The data compiled from the year 2008 to 2014 is shown in table 3.6 – 3.7. In so far, the available data confirms the importation of substances including benzene, dichloromethane, 1,2-dichloroethane, trichloromethane, pentachlorophenol.

Importation data acquired through the REACH has also been very limited. Although a number of EQS listed substances are on the list of substances of very high concern, the registration dossiers from the European Chemicals Agency (ECHA) database only list one EQS substance entry, that of nickel, for Malta. However it should be noted, that the list is not yet comprehensive and representative, as it could be the case that some substances that are currently being imported are missing from the registration list. One cannot exclude that *Substances of Very High Concern*

(SVHCs) are not being imported from the published ECHA list due to illegal importations and also because they might be imported in quantities less than 1 tonne.

Any substance identified as a Priority substance under the WFD should be automatically subject to a dossier by a member state/ ECHA, resulting in the substance being listed for further authorizations and restrictions under REACH. Any substance identified as a priority substance subject to an environmental quality standard (EQS) in surface water, must be restricted under REACH.

In addition to this, in Malta's National Action Plan for Sustainable Use of Pesticides 2013-2018, importation of plant protection products are proposed to be kept in store by the Malta Competition and Consumer Affairs Authority (MCCAA). Currently no importation data, however, is compiled by the MCCAA. With regards to the use of pesticides, some data is complied by the NSO; however data comes directly from importers.

Data compiled by the NSO on pesticide usage was carried out directly from importers. This raises some questions on the validity of the data. Additionally importation data on pesticides is also protected by confidentiality agreements that are in place. Such agreements indicate that only data related to those substances which have more than two importers can be disclosed to third parties. Thus, from these reports it is not possible to conclude the individual and respective chemical usage and possible storage in stock piles.

Heavy metal importation data compiled by NSO amounts in kg/year							
Substance	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**
Cadmium and its compounds	172	51	0	0	0	0	0
Lead and its compounds	7492	97,425	70,725	5501	44,883	9646	114,376
Mercury and its compounds	5198	28	39	14	213	20	24
Nickel and its compounds	33,239	18,317	7,762	11,038	18,063	20,537	18,449

Table 3.6: Heavy metal importation data supplied by the National Statisitics Office

Polyaromatic hydrocarbons importation data compiled by NSO amounts in kg/year							
Substance	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**
Benzo(a)pyrene	–	–	–	–	–	–	–
Benzo(b)fluoranthene	–	–	–	–	–	–	–
Benzo(g,h,i) perylene)	–	–	–	–	–	–	–
Benzo (k) fluoranthene	–	–	–	–	–	–	–
Indeno (1,2,3-cd)pyrene	–	–	–	–	–	–	–
Anthracene	–	–	–	–	–	–	–
Fluoranthene	–	–	–	–	–	–	–
Naphthalene	–	–	–	–	–	–	–

Table 3.7: Polyaromatic hydrocarbons importation data supplied by the National Statisitics Office

Chlorinated solvents importation data compiled by NSO amounts in kg/year							
Substance	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**
C10-13 Chloroalkanes	–	–	–	–	–	–	–
Carbon tetrachloride	0	95	0	0	0	0	0
1,2-dichloroethane	0	0	1826	18	0	0	0
Dichloromethane	3254	10,513	12,771	17,167	9,694	13,980	17,153
Trichloromethane	27	94	63	137	74	11	305
Tetrachloroethylene	13009	25301	22946	14086	9091	21584	14463
Trichloroethylene	4196	4	9	0	507	0	0

Table 3.8: Chlorinated solvents importation data supplied by the National Statisitics Office

Chlorinated compounds importation data compiled by NSO amounts in kg/year							
Substance	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**
Hexachlorobenzene	?	?	?	?	0	0	0
Hexachlorobutadiene	0	0	–	–	–	0	0
Pentachlorobenzene	?	?	?	?	–	–	–
Trichlorobenzenes	?	?	?	?	–	–	–
Pentachlorophenol	0	0	18,960	0	0	0	0

Table 3.9: Chlorinated compounds importation data supplied by the National Statisitics Office

Pesticides importation data compiled by NSO amounts in kg/year							
Substance	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**
Alachlor	–	–	–	–	–	–	–
Atrazine	0	0	0	0	0	0	0
Chlorfenvinphos	?	0	–	–	0	0	–
Chlorpyrifos (Chlorpyrifos-ethyl)	–	–	–	1,376	1,937	2,212	–
Aldrin	?	?	?	0	0	0	0
Dieldrin	?	?	?	0	0	0	0
Endrin	–	0	–	0	0	0	–
Isodrin	?	?	?	?	?	?	?
DDT total	?	?	?	?	0	0	0
Diuron	?	0	–	0	–	0	0
Endosulfan	–	–	0	–	0	0	–
Isoproturon	?	0	–	0	–	0	0
Simazine	0	0	0	0	0	0	0
Tributyltin compounds	?	?	?	?	0	0	0
Trifluralin	0	0	0	0	0	0	0
Dicofol	0	0	–	–	0	–	–
Quinoxyfen	–	–	–	–	–	–	–
Aclonifen	–	–	–	–	–	–	–
Bifenox	–	–	–	–	–	–	–
Cybutryne/ Irgarol	–	–	–	–	–	–	–
Cypermethrin	–	–	–	–	–	–	–
Dichlorvos	?	0	–	–	0	0	?
Heptachlor and heptachlor epoxide	0	0	0	0	0	0	0
Terbutryn	–	–	–	–	–	–	–

Table 3.10: Pesticides importation data supplied by the National Statisitics Office

Other priority substances importation data compiled by NSO amounts in kg/year							
Substance	2008	2009	2010	2011	2012	2013	2014
Benzene	1	11	13	0	0	0	0
Di(2-ethylhexyl)phthalate (DEHP)	?	?	?	?	?	?	?
Nonylphenols	–	0	–	0	–	0	0
4-nonylphenols	–	0	–	0	–	0	0
Octylphenols	–	0	–	0	–	0	0
Perflurooctane sulfonic acid and its derivatives (PFOS)	?	–	–	–	–	–	–
Dioxins and dioxin-like compounds	?	?	–	–	–	–	–
Hexabromocyclododecane (HBCDD)	?	?	?	?	?	?	?

Table 3.11: Other Priority substances importation data supplied by the National Statisitics Office

The data was collected by NSO

- *Indicates the data is inconclusive ad the HS cose is not specific to a particular substance, but of a category of substances.*

? *Indicates the data is unkown either due to the fact that the HS code in question was not in use or when the CAS number was searched through the ECIS/TARIC site the HS code was not found.*

Data for chlorpyrifos was supplemented through NSO but through importation data given directly from importers. HS codes which encompass a combined class of susbtances but in which there was no importation that year, the constitutent importation of those susbtances making up that class were also assumsed to be nil.

In cases were the HS code was not specified, and the importation data was not nil and thus where one could not discern the individual importation logistics was marked with '0'.

Metals importation data for the period 2004-2012 is presented as percentage contribution in Figure 3.10. Cadmium, mercury and chromium contributed to less than 1% of the total importation of metals within this period, with cadmium imports amounting to less than one tonne. Comparable quantities have been imported for tin, nickel and lead, followed by higher quantities of zinc. Titanium and copper contribute to almost 80% of the total imported metal quantities over the period 2004-2012.

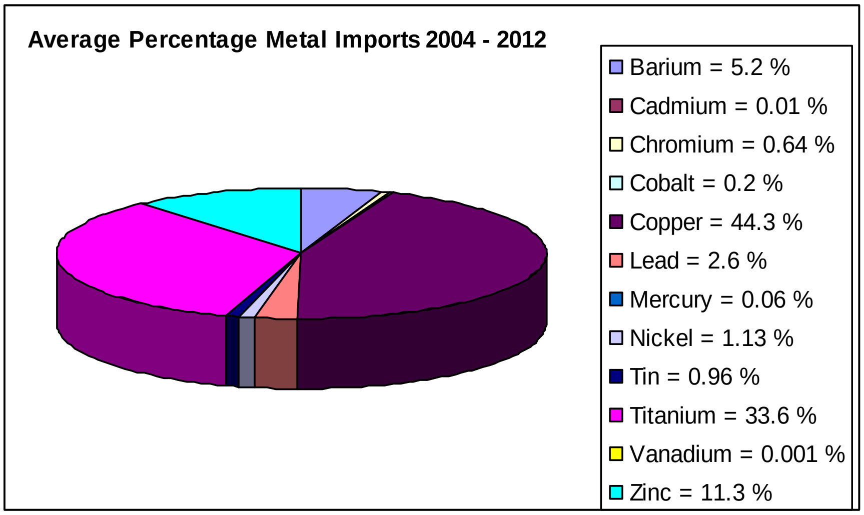

Figure 3.10: Metals importation data for the period 2004-2012

3.3.3.4 Permitted Facilities to Date

Due to its limited size Malta is not considered to have significant heavy industry, except for ship building. Most industries in Malta are located inland and are either connected to the municipal sewerage system or employ specific waste management practices to regulate discharges generated on site. The majority of the installations with direct discharges to the marine environment are located in harbour areas (coastal water bodies MTC105, MTC107). Under this authority, all industrial installations have to be classified and some require legal authorisation. Furthermore, some installations have a legal obligation to monitor their discharge effluents.

In Malta surface water permitted discharges are restricted only to discharges to coastal waters. At present, the greater protection and improvement of the aquatic environment is targeted by implementing, among other things, specific measures to progressively reduce emissions of priority substances and other chemicals. Provisions for emission control and cessation include obligations to comply through Emission Limited Values (ELVs) and also through limiting emissions of diffuse sources by implementation of 'best environmental practice'. Nonetheless MEPA's environmental permitting system has only recently been implemented and thus the industry census inventory is not complete and does not include all enterprises.

As a minimum requirement for the 1st inventory, point discharges of priority substances from industrial facilities and municipal wastewater plants (reported under the European Pollutant Release and Transfer Register (E-PRTR)) should be reported. The loads of the various parameters are listed in Table 3.12. The E-PRTR or equivalent national data represent the total annual emission released during normal operations and accidents. For E-PRTR, releases and transfers must however be reported only if the emissions of a facility are above the activity and pollutant thresholds set out in the E-PRTR Regulation. Therefore, sources may not need to report emissions if these are below a specified reporting threshold or reporting is not required for the specific activity undertaken at a facility. Consequently, point source emissions from smaller plants or from specific activities might not be included in the E-PRTR database.

Substance	2010	2011	2012	2013	Units
Total Nitrogen	325600	556000	999000	885000	Kg
Total Phosphorus	52400	96300	244000	196400	Kg
Total Organic Carbon	658800	150000	662300		Kg
Arsenic	316	0	316	1126	Kg
Cadmium	5.39	9.1	1055	230	Kg
Total Fluorides	4500	0	0		Kg
Benzene	0	216	0	–	Kg
Copper	545	2154	495	1272	Kg
Nickel	450	1630	30	2182	Kg
Chromium	0	567	228	572	Kg
Lead	149	190	214	48	Kg
Zinc	106	0	700	1700	Kg
Total Chlorides	0	28000000	55600000	6980000	Kg
Tributyltin compounds	0	66.4	0	–	Kg

Table 3.12: Total Loads based on E-PRTR data

3.3.3.5 E-PRTR Load Releases

Tables 3.13: below indicate the total loads of substances discharged per permitted EPRTR installation per Coastal Water Body.

Waterbody MTC 103/104		2010	2011	2012	2013	Units	Method
Aquaculture Facility - AJD Tuna Ltd	Total Nitrogen	234000	61000	231000	273000	Kg	calculated
	Total Phosphorus	37400	9760	37000	43700	Kg	calculated
	Total Organic Carbon	579000	150000	574000	669000	Kg	calculated

Waterbody MTC 105		2010	2011	2012	2013	Units	Method
Marsa Power Station	Arsenic	316	–	44	426	Kg	measured
	Cadmium	5.39	–	822	68	Kg	measured
	Total Fluorides	4500	0	0	–	Kg	measured
	Benzene	–	216	0	–	Kg	measured

	Copper	–	194	122	659	Kg	measured
	Nickel	0	1110	30	745	Kg	measured
	Chromium	–	–	75	250	Kg	measured
	Lead	–	–	214	48	Kg	measured
	Zinc	0	–	700	263	Kg	measured

Waterbody MTC 106		2010	2011	2012	2013	Units	Method
Ta' Barkat South Sewage Treatment Plant	Total Chlorides	0	5600000 0	5560000 0	6979700	Kg	calculated
	Total Nitrogen	0	991000	768000	525200	Kg	measured
	Total Phosphorus	0	161000	207000	138900	Kg	measured
Aquaculture Facility - Ta' Mattew Fishfarms Ltd	Total Organic Carbon	79800	54300	6080	7400	Kg	estimated
	Zinc	106	72	6.73	10	Kg	estimated
	Total Nitrogen	24700	16800	1880	2300	Kg	estimated
	Total phosphorus	4650	3170	354	400	Kg	estimated
Aquaculture Facility - Mare Blue Co. Ltd	Total Organic Carbon	0	0	88300	228000	Kg	estimated

Waterbody MTC 107		2010	2011	2012	2013	Units	Method
Delimara Power Station	Copper	545	1960	373	613	Kg	calculated
	Nickel	450	520	0	–	Kg	measured
	Lead	149	190	0	–	Kg	calculated
	Zinc	1940	8740	2130	11270	Kg	calculated
	Cadmium	0	9.1	233	162	Kg	measured
	Chromium	0	567	153	322	Kg	measured
	Tributyltin compounds	0	66.4	0	–	Kg	measured
	Arsenic	0	0	272	700	Kg	measured
Aquaculture Facility - Fish & Fish Ltd	Total Nitrogen	91600	0	0	84400	Kg	estimated
	Total Phosphorus	15000	6040	0	13800	Kg	estimated

Tables 3.13: above indicate the total loads of substances discharged per permitted EPRTR installation per Coastal Water Body

3.3.3.6 Assessment of criteria to select relevant substances of concern at Water Catchment District level.

The following criteria were used to establish which substances are of concern in the Maltese Catchment District based on the data that was analysed.

Criteria	Assessment of criteria
The substances that are causing failure of good status in at least one water body.	**Mercury** has been identified to be problematic in coastal waters. All other parameters were deemed to be in line with the EQS directive. No parameters were of concern with regards to inland surface waters.
The level of concentration for a substance is above half of the EQS in more than one water body.	In coastal waters, in view of the revised 2013/39/EU directive, it is likely that **lead** will also be above EQS limits. DEHP, nickel and lead were found ubiquitously in inland surface waters. There were not problematic in so far however, the levels of **nickel** are very close to the revised EQS directive values.
E-PRTR data show releases which might lead to future exceedances of the EQS.	The sum total of emissions of priority substances in relation to the effect on the resulting monitoring has not yet been investigated. As data collection with both E-PRTR as well as monitoring data has only recently been started, it is premature to quantify the cause and effect relationship between the two.
Known sources and activities causing inputs in the Maltese Water Catchment District exist which might lead to concentrations of substances that may be of concern.	Further assessment is needed in this regard.

Table 3.14: substances of concern in the Maltese Catchment District

3.3.3.7 Conclusion and Data Gaps

This section sets out the latest assessment of the potential chemical pressures on the water environment and assesses the progress made towards achieving the water quality objectives of the Water Framework Directive in 2015. The assessments made in this inventory are considered to be draft and preliminary; containing a considerable degree of uncertainty due to an incomplete dataset of information and it is therefore subject to modification in the light of data. The reliability of our assessment will evidently depend very much on the accuracy of the information supplied to the present consultant/s. The inventory is thus considered as a continuous exercise, better estimates will be made available and refined continually in subsequent evaluations when more data is compiled and analysed.

Nonetheless a number of data deficiencies and methodological improvements were noted which will be improved upon on in the future. For instance, limited data flow records exist for some point sources and water monitoring data is not yet available from all the permitted sites to date. The E-PRTR data reporting is also above a set threshold, and hence there may be additional emissions at lower levels which are not being reported as part of this exercise. It is expected that the quality of the inventory is improved as more monitoring data becomes available in the future.

(i) Data acquisition

One of the main constraints in the compilation of this inventory was accessibility to the required data. For the inventory to fulfill its full scope more data still needs to be compiled and made available. The data can be updated in a more quantitative and qualitative manner. It is understood that in order for the inventory to be detailed and representative of the emissions, discharges and losses that are taking place can be very resource intensive. There is a need for coherent coordination between government agencies and authorities to achieve this. Critical and integral parts of the major data discrepancies could be tackled through the set-up of a single shared environmental database. This would facilitate information exchange, aggregation, cross-checking and verification of the data collected. In addition the compilation of this inventory should be an annual process; it is good practice to set up a management process involving a management plan at the beginning of each cycle and an evaluation at the closure of the cycle, providing proposals for improvements.

Moreover it is good practice for the inventory to be transparent, consistent, comparable, complete and accurate. It is good practice to implement quality assurance/quality control (QA/QC) and verification procedures as an integral part in the inventory management approach to accomplish this goal. It is a prerequisite that all calculations leading to emission estimates should be fully reproducible. Adequate documentation and archiving of the inventory compilation process is therefore crucial. One issue was that certain data could not be reported as it was subject to confidentiality agreements of commercial information. Confidentiality data should not be made publicly available but it should not necessarily limit the inventory compilers access to it. Formalising the inventory tasks and co-operation between the many institutes and stakeholders thus needs to be carried out.

(ii) Improvements to achieve the full scope of this inventory
Pollutant load estimations are a fundamental part in the development of many river basin management plans. Establishing the link between a given pollutant and the source causing the problem usually involves a mass balance analysis. This essentially involves quantitative accounting of the sources and losses through the environments of the pollutant in question. This however could not be extrapolated due a lack of knowledge on the hydrography as well as lack of thorough knowledge on the use of the priority substances. Unless this data is collected, it is impossible to understand these relations. Further improvements are expected to me made with long term monitoring programmes in place.

When it comes to diffuse sources, additional GIS-based deterministic models may be developed to explicitly predict and address all inputs of the relevant substances into the environment. The systematic use of models would allow the estimation of emissions from sources not within the E-PRTR register. To conclude an improved inventory is expected to be published as more data becomes available.

3.4 Hydromorphological alterations to the coastal environment

Hydromorphological pressures are physical developments or alterations that bring about morphological alterations in the depth, width, quantity, structure and substrate of an inland surface water or coastal water body. Hydromorphological alterations to a water body can take place through coastal engineering works, dredging, channel modifications, and beach replenishment. Such alterations can bring about irreversible changes to the water body through the smothering of benthic environments, the removal of substrate, changes in water currents; changes in water circulation and residence times as well as changes in water flow regimes in protected water courses and streams. Such alterations also bring about changes to the physico-chemical characteristics of a water body, such as changes in temperature, dissolved oxygen and turbidity. These physical changes in turn impact ecological systems.

The following marine and land based activities give rise to hydromorphological changes to the surface water environment:

Localised hydromorphological changes within the water body	Activities with a potential of bringing about significant alterations to the hydromorphological characteristics of a water body
The laying of underwater pipelines and cables including power cables, telecommunication cables, Gas pipelines, water distribution and sewerage pipelines.	Capital and maintenance dredging on a large scale or at a scale which will impact the waterbody.
	Extensive dredging
Localised dredging activities associated with the operations of ports or construction of small scale developments	Extensive Land reclamation
	Large scale coastal engineering works or coastal engineering works within enclosed / sheltered bays
Controlled anchoring	Extensive anchoring activities
Scuttling of vessels	Disposal of waste at sea Dumping of rubble within watercourses
Aquaculture	
Small scale coastal engineering works (small jetties, slipways and minor extensions to quays, or coastal platforms, temporary pontoon installation)	Coastal defense structures - Construction of breakwaters
	Beach replenishment or reclamation

Table 3.15: Hydromorphological changes to the surface water environment

The mitigation of hydromorphological impacts on surface waters is mainly introduced by means of regulatory controls in the form of planning permit conditions that are stipulated during the construction and operational phases of development. During the first WFD cycle Malta has strived to integrate the requirements related to mitigation of hydromorphological impacts brought about by various developments into the planning permit process by assessing applications for development consent on a case by case basis. A guidance document was also drafted to indicate how the WFD requirements concerning hydromorphological pressures, amongst other pressures, are being streamlined into the development planning process. This guidance document will be refined and extended in scope during the second cycle to cover additional pressures that have been identified by the Marine Strategy Framework Directive (refer to Chapter 9).

In the case of hydromorphological alterations to coastal waters, the majority of related development activity takes place within harbour areas in coastal water bodies MTC 105 (Grand harbour and il-Port ta' Marsamxett) and MTC 107 (Il-Port ta' Marsaxlokk and Pretty Bay). These coastal waters have historically been subject to hydromorphological alterations. However in addition to their historical modifications, these water bodies are also considered to be two very important hubs of economic activity in the Maltese Islands and recent economic developments during the last few decades have enhanced their economic role. Table 3.16 summarises the hydromorphological alterations that have taken place in these two coastal waters and indicates why these two waters have been designated as Malta's heavily modified water bodies. The designation process and definition of good ecological potential in these waters is explained further in Chapter 6.

Heavily Modified Coastal water body	Activities that have brought about intense hydromorphological modifications to these waters
MTC 105 The Grand Harbour and Il-Port ta' Marsamxett  Source: Malta Tourism Authority	**Historic National heritage –**fortifications built during the 16th Century; Bighi hospital, Lazaretto quarantine hospital, Shipyard activity since the 1500s; historic quays and docks **More recent development** – Cruise liner terminal; waterfront development; dockyard (dock 1) rehabilitation development; yacht marinas
MTC 107 Il-Port ta' Marsaxlokk and Malta Freeport  Source: www.skyscrapercity.com	**Historic National heritage –**fortifications built both during the 16th Century and the British period **More recent development** – Marsaxlokk is a fishing port (fish landing facilities and hardstanding facilities) ; Malta Freeport built in 1988 which is continuously growing; Tank storage; Delimara power station and Ħas-Saptan fuelling Dolphin; Birzebbuga key to handle light fuel oils

Table 3.16: Hydromorphological alterations to coastal water bodies MTC 105 and MTC 107

Other smaller scale hydromorphological alterations take place along the accessible coastal stretch of MTC 104 which extends from Sliema up to Mellieħa. As indicated in Figure 3.11, the majority of coastal development and the associated extent of artificial coast are located in the heavily modified harbour areas and coastal water body MTC 104. Given the nature of economic activity along this stretch of coast, hydromorphological pressures are foreseen to increase here.
In recent years, interest has been shown in developing renewable energy structures such as offshore wind farms and land reclamation indicating that hydromorphological impacts may be extended offshore. To date no concrete plans for land reclamation have been submitted to the Malta Environment and Planning Authority for development consent, whilst studies related to the installation of an offshore wind farm have concluded that this would be infeasible.

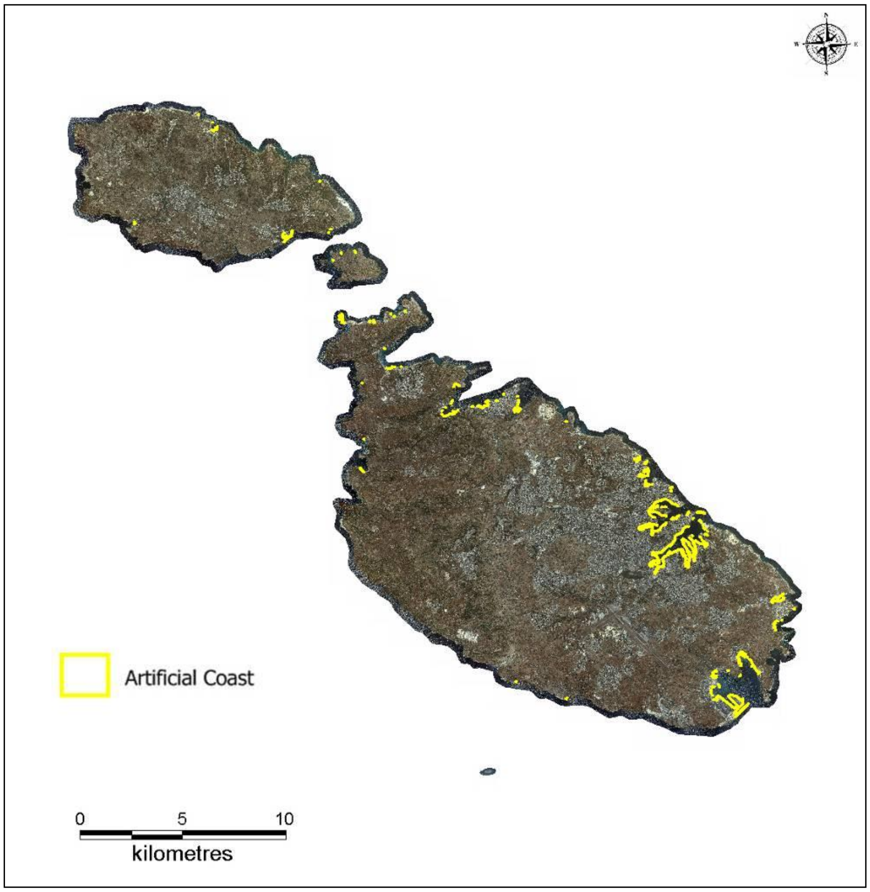

Figure 3.11: Extent of artificial coast in the Maltese Water Catchment District

3.5 Biological pressures

Biological pressures refer to the introduction of non indigenous species into waters, by intentional or unintentional means. Inland surface waters, transitional waters and coastal waters are subject to the introduction of species that live outside their native distributional range. Not all introduced non native species necessarily pose a threat to local species, but there are some that are invasive.

The International Union for the Conservation of Nature (IUCN) defines '*invasive* alien species'(IAS) as those alien species which become established in natural or semi-natural ecosystems or habitats and become an agent of change, increasing in abundance and distribution and threatening native biological diversity (IUCN, revised 2012)[78]. IAS are introduced outside their natural range by human action, either direct or indirect, and can cause harm to biodiversity or ecosystem services by competing with and on some occasions replacing native species, and causing complex changes within the structure and function of the new hosting ecosystem. Invasive species often owe their success in colonizing new ecosystems to certain characteristics that make them more difficult to control and such as the capacity to thrive in different environments and tolerate a wide range of environmental conditions, high growth and reproduction rates, a lack of natural predators and an ability to exploit a variety of food sources.

[78] Otero, M., Cebrian, E., Francour, P., Galil, B., Savini, D. 2013. Monitoring Marine Invasive Species in Mediterranean Marine Protected Areas (MPAs): A strategy and practical guide for managers. Malaga, Spain: IUCN. 136 pages

The EU adopted a regulation (Regulation 1143 of 2014) on invasive alien species (IAS) which entered into force on the 1st January 2015 to address the problem of invasive alien species comprehensively by means of prevention, early detection and rapid eradication and management. A list of invasive alien species of Union concern has been drawn up by the Commission, the scientific community and Member States. In order for a particular species to be included in this list the potential of the species to establish viable populations as well as cause significant adverse impacts on biodiversity, the economy and human health need to be considered, amongst other criteria.

This list is subject to review every 6 years. To date no marine species have been identified. No freshwater species of significant concern to the Maltese Islands has been included on the list either. Nevertheless at national level work is ongoing to strengthening the legal regime. Management of existing IAS is prioritised within protected areas as part of the management framework for the protected areas while action is also done on an ad hoc basis in other areas as deemed required.

Malta's National Biodiversity Strategy and Action Plan (2012-2020) adopted on 12 December 2012, includes the national target that states: "*By 2020, measures are in place to prevent, in so far as practical, the introduction and establishment of new invasive non-native species, while those that are established are identified and prioritised for eradication or control, where feasible*." This target is accompanied by four measures on IAS requiring: a national information and early warning system for prevention and contingency planning for inadvertent introductions; the drawing up of a national strategy complemented by national policy guidance; the safeguarding of endemic species and areas of conservation value and their prioritisation for IAS management; and finally national codes of best practice addressing those activities/sectors that can aid the introduction and spread of IAS.

Progress towards the implementation of the target and actions has been reviewed as part of Malta's reporting obligations to the Convention on Biological Diversity. Work on the development of the strategy and codes has also commenced. The MEPA "Guidelines on Managing Major Plant Invaders and Restoring Native Plant Communities within Terrestrial Settings in the Maltese Islands" were published in March 2013.[79] The Guidelines have been drawn up to assist the planning and implementation of management programmes, aimed at counteracting the spread of existing plant invaders; and to assist in the design and implementation of native plant reintroductions or reinforcements, aimed at reinstating native plant communities to a favourable conservation status.

3.5.1 Non indigenous species in inland surface waters

There are a number of non indigenous species in protected watercourses and pools. Not all are invasive however, whilst others have been naturalised. The common water hyacinth or floating water hyacinth (*Eichornia crassipes*), for instance has been found naturalised at Wied il-Lunzjata. This species is fast growing and can colonise shallow temporary ponds, wetlands and marshes, slow flowing waters, and reservoirs. Water hyacinth infestations in freshwater ecosystems prevent sunlight and oxygen from reaching the water column and submerged plants. Shading and crowding of native aquatic plants results in the reduction on native biodiversity.

[79] Guidelines are downloadable from https://www.mepa.org.mt/guidelines-alienplants

The *Arundo donax* is also known to be a non indigenous invasive species in watercourses competing directly with riparian species for already limited water resources. The *Arundo donax*, or giant reed is known to consume large quantities of water and also results in changes to the morphology of streams and rivers. [80]

In the case of freshwater pools of Qattara and Ghadira ta' Sarraflu the deliberate release of alien species has meant that native water dependent species now have to compete for limited water resources. For example, the Levant water frog (*Pelophylax bedriagae*) which has been released at Għadira ta' Sarraflu via the pet and aquarium trade has in fact established a population in this pool and competes with the Siculo-Maltese endemic painted frog (*Discoglossus pictus pictus*, Maltese: Żrinġ). This alien amphibian has been documented to prey on Odonata species, i.e. dragonflies and damselflies; especially on their eggs and juveniles (nymph stage). *P. bedriagae* has also been observed predating on the larval and juvenile stages of the painted frog.[81]

Alien freshwater fish that have been released into watercourses and freshwater pools include the *Gambusia affinis* or mosquitofish and the *Carassius auratus*, commonly known as the goldfish. The mosquitofish (Gambusia sp.) has been deliberately released in reservoirs for the control of mosquitoes and has become subsequently naturalised and common at l-Għadira ta' Sarraflu and in several reservoirs in Malta and Gozo.

The *Mauremys caspica* (striped necked terrapin) was probably introduced for aquaria and has been released in freshwater ponds, including the Qattara and reservoirs, though it is localised and found in low numbers.

Molluscs have also been introduced in freshwater environments. These freshwater molluscs comprise the *Physa acuta* (Bladder snail) and the *Helisoma duryi* (Seminole rams-hole).

Notwithstanding the fact that work on the drafting of the National strategy for the prevention and mitigation of the impact of invasive alien species has commences in line with the requirements of Malta's National Biodiversity Strategy Action Plan; a number of measures to control invasive alien species in the small freshwater habitats have been defined in respective Natura 2000 plans and this Water Catchment Management Plan (refer to Chapter 9).

3.5.2 Non indigenous species in coastal waters

Marine invasive species are regarded as one of the main causes of biodiversity loss in the Mediterranean Sea[82] as they cause major ecosystem displacement and threat the structure and function of various habitats. They may enter the Mediterranean basin due to deliberate or accidental introduction by means of human induced activity through various vectors or pathways such as through the Atlantic and the Suez Canal (refer to Table 3.14 for examples of fish species); via maritime shipping activity particularly through hull fouling and ballast water discharge; as well as via the mariculture industry by means of contaminants and escapees. Estimates of the number of NIS present in the Mediterranean region vary from 573 species

[80] Giessow, J., Casanova., J., Leclerc, R., MacArthur, R., Fleming, G., and Giessow, J. 2011. Arundo donax (giant reed): Distribution and Impact Report, March 2011, California Invasive Plant Council.

[81] Schembri, P.J. 2010. A tale of two frogs, in the Gozo Observer no.22, June 2010

[82] Galil, B., 2007. Loss or gain? Invasive aliens and biodiversity in the Mediterranean Sea. Marine Pollution Bulletin 55, 314–322.

(Galil, 2009) to 986 species, 249 of which are associated with the Central Mediterranean region (Zenetos et al., 2012)[50].

Species	Distribution	First entrance in the Mediterranean	North Spain	Tunisia	Sicily	North Italy	France	% of all records
Atlantic Species								
Parablennius pilicornis (Ringneck Blenny)	Continuous	Ca. 1960	1986	Ca. 1970	1982	2003	2006	?
Pomadasys incisus (Bastard Grunt)	Continuous	Before 1840	Ca. 1900	1893	?	1991	2006-2011	50-70% since 2006
Lampris guttatus (Opah/ Moonfish)	Continuous	Before 1800	?	2008	1979	1807	1826	60% since 2008
Kyphosus sectatrix (Bermuda sea chub)	Patchy	Before 1840	1996	2003	1883	1903	2006	70% since 2006
Pisodonophis semicinctus (Saddled snake eel)	Patchy	Ca 1950	?	1991	1997	1996	1980	60% since 1997
Lessepsian Species (Suez Canal)								
Siganus luridus (Rabbit fish)	Patchy	1956	no	1970	2003	no	2008	?
Fistularia commersonii (Cornetfish)	Patchy	2000	2007	2003	2002	2004	2007	?

Table 3.17: Atlantic and Lessepsian fish species (from the Suez Canal) in the Mediterranean (Source: Otero et al., 2013)[49]

Climate Change is also expected to have an impact on invasive species interactions in the Mediterranean. Taking onto account the uncertainties that come with scientific projections, coastal sea temperatures in the Mediterranean are expected to increase by at least 1-2.5^{o}C [83] by the end of the 21st Century. Detailed projections of the potential impacts of climate change to surface waters are provided in Chapter 12 of this plan. Climate change will therefore likely assist the spread of alien species that may out-compete native ones. Since the majority of alien species are thermophilic (warmth-loving) that originated in tropical seas of the Indo-Pacific, warming sea temperatures will favour the introduction of more Red Sea species in the Eastern Mediterranean, and their rapid spread towards the western basin. Any species of Atlantic origin would likewise spread eastwards.

[83] Otero, M., Cebrian, E., Francour, P., Galil, B., Savini, D. 2013. Monitoring Marine Invasive Species in Mediterranean Marine Protected Areas (MPAs): A strategy and practical guide for managers. Malaga, Spain: IUCN. 136 pages

More than 5% of the marine species in the Mediterranean are now considered non-native species[84] (Zenetos et al., 2012). According to the latest regional reviews, 13.5% of those species are classed as being invasive in nature, with macrophytes (macroalgae and seagrasses) the dominant group in the western Mediterranean and Adriatic Sea, and polychaetes, crustaceans, molluscs and fish in the eastern and central Mediterranean (Zenetos et al., 2012). The vast majority of alien species occur in the eastern Mediterranean; some are located exclusively in the south-eastern basin, others are restricted to the western basin, while others have colonized the entire Mediterranean.

A recent updated review of marine alien species and other 'newcomers' recorded from Maltese waters was published in March 2015[85]. This review indicates that a total of 31 species have been added to a former inventory compiled in 2007. The total number of alien species (including alien, range expansion species and Cryptogenic[86]) in Maltese waters amounts to 73.

Nationally marine molluscs are the predominant taxonomic group representing marine NIS recorded in Maltese waters[53]. This taxonomic group amounts to 21 documented species, followed by Actinopterygii (15 species), followed by Crustacea (8 species) and Rhodophyta (7 species). A comprehensive inventory of non-indigenous species found in Maltese marine waters can be found in Evans et al (2015) review of non-indigenous species[53]. This same report identified shipping to be the most common introductory pathway for alien species, followed by secondary dispersal from elsewhere in the Mediterranean. The report indicates that there has been an increasing trend in the number of alien species in Maltese waters.

The spatial distribution of non indigenous species is unknown however a number of locations where 39 species have been recorded have been mapped in the MSFD initial assessment report (Figure 3.12)[87]. An assessment of the spatial distribution was also carried out in this report. It was evident that harbour areas and bays were the main points of entry for NIS due to shipping, fishing and aquaculture activities. The locations with the highest number of documented records of species occurrence are Marsaxlokk Bay and Birzebbuġa Bay (MTC 107).

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84 Zenetos A., S. Gofas, C. Morri, A. Rosso, D. Violanti, E.García Raso, M.E. Cinar, A. Almogi-Labin, A.S Ates, E. Azzurro, E. Ballesteros, C. N. Bianchi, M. Bilecenoglu, M. C. Gambi, A. Giangrande, C. Gravili, O. Hyams-Kaphzan, P.K. Karachle, S. Katsanevakis, L. Livej, F. Mastrototato, F. Mineur, M. A. Pancucci, A. Ramos Esplá, C. Salas, G. San Martín, A. Sfriso, N. Streftaris, M. Verlaque, 2012. Alien species in the Mediterranean Sea by 2012. A contribution to the application of European Union's Marine Strategy Framework Directive (MSFD). Part 2. Introduction trends and pathways. Mediterranean Marine Science, 13/2, 328-352.

85 Evans, J., Barbara, J. and Schembri, P.J. 2015. Updated review of marine alien species and other 'newcomers' recorded from the Maltese Islands (Central Mediterranean), Mediterranean Marine Sceince, 16/1: 225-244

86 These three categories are defined by Evans et al., 2015 as follows:
Alien: Species that may survive and reproduce outside their historically known geographically occupied area as a result of deliberate or accidental introduction by humans.
Range expansion: Species that have arrived in an area in recent decades by natural dispersal from a native neighboring area.
Cryptogenic: Species that are not demonstrably native or introduced and whose origin is therefore uncertain - including species whose native geographic distribution is unknown, and species for which uncertainty exists as to whether their introduction was induced anthropogenically or not.

87 MSFD Initial Assessment, 2012. Non Indigenous Species Report accessible from MEPA website: http://www.mepa.org.mt/water-msfd-initial_assessment

It is also to be noted (as Figure 3.4 indicated) that the Maltese Islands are located on the main shipping routes across the Mediterranean and therefore a large number of commercial and leisure vessels call at the Maltese Islands or pass very close by. The MSFD initial assessment also identifies staging posts for drilling platforms to be potential sources of non indigenous species.
The extent of knowledge of the impacts of non indigenous species on biodiversity and economic activity in the Maltese Islands is very limited. Table 3.15 summarises what potential impacts have been gauged to date from the limited studies carried out in the Maltese Islands focusing on a number of specific species, as presented in Malta's MSFD initial Assessment.

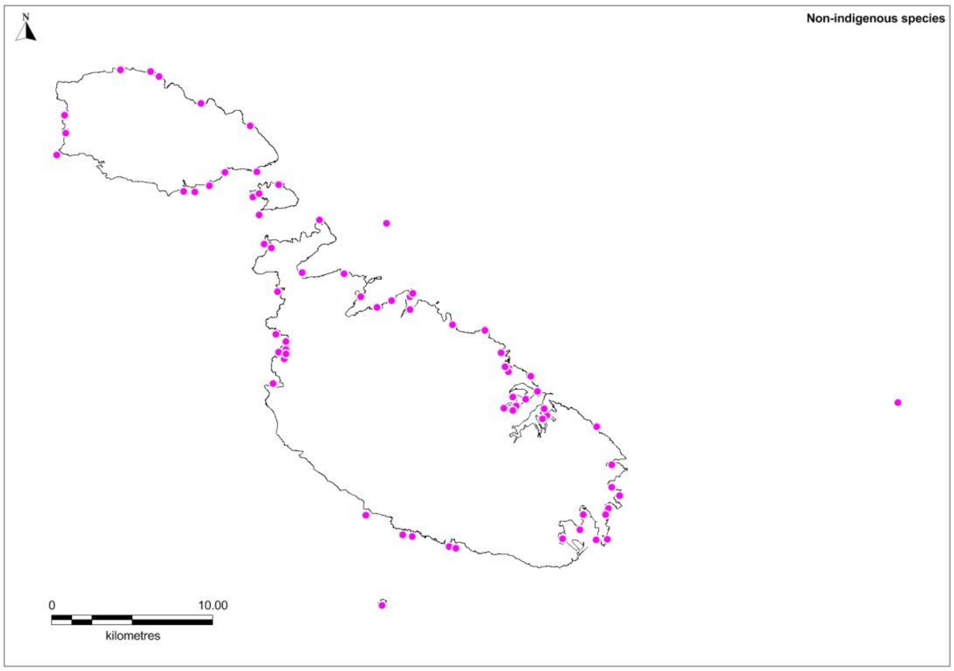

Figure 3.12: The spatial distribution of non-indigenous species is unknown however a number of locations where 39 species have been recorded give an indication of widespread distribution

Functional group	Invasive species studied	Potential impact
macrophytes	Green alga *Caulerpa cylindracea* Formerly known as *Caulerpa racemosa var. cylindracea* but the tax-onomy has been updated as per AlgaeBase	**Impact of *C. racemosa* –** First Maltese record: 1997 Camilleri (2005)[88] reports on findings of a study undertaken to assess the impact of C. cylindracea on phytobenthic/macroalgal communities at Tad-Debbra (Marsaxlokk). One of the observations was the lower percentage composition of Posidonia oceanica where C. cylindracea was present in comparison to areas where C. cylindracea was absent. Another study carried out by Mifsud & Lanfranco (2007)[89] indicated that prolific expansion of this species in several habitats is reported, however degraded localities seem to favour the expansion of this green alga. Despite the fact that additional studies are required local experts can indicate with confidence that *C. racemosa* generally colonises areas which

[88] Camilleri, C. 2005. Caulerpa racemosa impact on phytobenthic/ macroalgal communities at Tad-Debbra (Marsaxlokk). Abstract of M/Sc. Dissertation In Dandria, D. (ed). Biological Abstract 2005. Department of Biology, University of Malta

[89] Mifsud, C. & Lanfranco, E. 2007. *Caulerpa racemosa* (Chlorophyta, Caulerpales) in the Maltese Islands (Central Mediterranean). Proceedings of the 3rd Mediterranean Symposium on Marine Vegetation (Marseilles, 27-29 March 2007). p. 285-287.

Functional group	Invasive species studied	Potential impact
	(www.algaebase.org) [58] Red alga *Womersleyella setacea* are of most concern.	are not occupied by Posidonia oceanica, particularly in areas where P. oceanica meadows are patchy or reticulate. **Impact of *W. Setacea* –** First Maltese record : 1994 W. setacea is also widespread in the Maltese Islands where it inhabits a variety of substrates in the lower infralittoral and circalittoral. This rhodophyte permeates substrates by its fine creeping filaments and changes the physical structure of sediments. It also reduces species numbers and diversity by trapping sediments which prevent the development of other species. In the North East of Malta, *W. setacea* has been observed binding mäerl thalli and restricting the movement of such rhodoliths by currents (Rizzo, 2001).[90]
Invertebrates	*Rhopilema nomadica* (Nomad jellyfish) *Percnon gibbesi* (Sally lightfoot crab)	***Rhopilema nomadica* -** First Maltese record : 2004 First sited in Maltese waters in 2004. It is described to be a voracious planktotrophic jellyfish species[91], which can form very large swarms (as seen in the easternmost parts of the Mediterranean Sea) and can decimate plankton resources. This species is not only a health concern in view of the painful stings it can inflict on bathers, but can also adversely affect tourism, fisheries (e.g. via net clogging) and coastal installations (by blocking intake pipes of cooling systems). Nationally it is thus far a casual introduction. ***Percnon gibbesi* -** First Maltese record : 2001 This species was first reported from Malta in 2001 [92]and has become well established in certain areas (e.g. Sliema, Tigne, Munxar Point and Filfla). The species' distribution is controlled by habitat type and availability, with boulder fields being the observed preferred habitat locally (as seen in Għajn Tuffieha, Ramla tal-Mixquqa, Imġiebah, Paradise Bay, Marsascala, Daħlet Qorrot and Ħondoq ir-Rummien). In a study carried out by Sciberras and Schembri (2007)[93] *P. gibbesi* was observed to coexist with other crabs *Pachygrapsus marmoratus* and *Eriphia verrucosa*. Both are native species that occur in the same habitats frequented by *P. gibbesi*. *P. gibbesi* was observed to occasionally interact with *P. marmoratus* when the two approached to within circa 15cm. Based on these observations competition by the alien species for resources, mainly space, with the native *P.* marmoratus was suggested. Laboratory studies however indicated that *P. marmoratus* shows a competitive advantage over *P. gibbesi* and that it is unlikely to be excluded from its natural habitat by the alien species. Overall, if this species continues to increase in number it could compete with other marine invertebrates

[90] Rizzo, M. 2001. An investigation of potential anthropogenic impacts on a mäerl ground off North-Eastern Malta. Unpublished M.Sc. dissertation. Department of Biology, University of Malta, ix + 308pp.

[91] Deidun., Arrigo, A., Piraino, S. 2011. The westernmost record of *Rhopilema nomadica* (Galil, 1990), in the Mediterranean off the Maltese Islands. Aquatic invasions Vol 6, Suuplement 1: 99-103

[92] Borg J.J. & Attard-Montalto J. 2002. The grapsid crab *Percnon gibbesi* (Milne Edwards, 1853) (Crustacea, Decapoda, Brachyura), a new addition to the marine fauna of Malta; Cent. Medit. Nat., 3: 159-160.

[93] Sciberras, M. & Schembri, P.J. 2007b. Observations on the alien crab Percnon gibbesi (Decapoda, Brachyura, Grapsidae) from the Maltese islands; Rapp. Comm. int. Mer Medit., 38: 594.

Sciberras, M. & Schembri, P.J. 2008. Biology and interspecific interactions of the alien crab Percnon gibbesi in the Maltese Islands; Marine Biology Research; 4: 321-332.

Functional group	Invasive species studied	Potential impact
		having the same habitat and it could also graze on rare algae. Its ecological impact would be deemed high considering its feeding mode of systematically cleaning rocks of vegetation.
Fish	*Alepes djedaba* (Shrimp scad) *Sphyraena chysotaenia* (Yellowstripe barracuda)	***Alepes djedaba* -** First Maltese record : 1961 This species is a very fast and active predator, preying on small to medium sized demersal fish. It may be competing with other native species, and hence its potential impact is considered to be high. It is known from all around the Maltese shores and is recorded from all local habitats. Although single records were made when species was first introduced, its numbers have increased in following years. Currently there is no impact by this alien species on public health or economic activity. ***Sphyraena chrysotaenia* -** First Maltese record : 1993 *Sphyraena chrysotaenia*, although currently rare, is established and is most likely on the increase. It frequents the pelagic and demersal zone of inshore waters, and occurs in bays, creeks and inlets as well as open waters. It preys on small pelagic fish and competition with other demersal predators (e.g. *Sphyraena sphyraena* (European Barracuda) and *Seriola dumerilli (Greater amberjack*) may result should it continue to increase.

Table 3.18: Impacts of some examples of invasive species studied in Maltese coastal and marine waters

3.6 Analysis of Anthropogenic Pressures and Impacts on Groundwater Resources

3.6.1 Quantitative Pressures on Groundwater

The total population of the Maltese Islands was recorded at 421,364[94] as at the end of 2012, an increase of 21.9 per cent when compared to the 1985 figure. For the same period a growth in the influx of foreign residents was also registered resulting in an increase in the share of foreign residents of the total population, from 1.4 per cent in 1985 to 5.3 per cent by the end of 2012.

The rate of increase in the population decreased in recent years, compared to the sharp increase observed at the start of the 20th century. Nonetheless, the Maltese population is expected to grow annually by 0.43% until 2030, after which it will be expected to decline slowly

In a European Union context, Malta remains the country with the smallest population, placing behind Luxembourg and Cyprus, the only countries with less than a million inhabitants.

As opposed to population size, Malta by far ranked first among all EU Member States in terms of population density, with an average 1,325 persons per square kilometre, compared with the EU average of 117 persons per square kilometre. The second most densely populated country within the EU was the Netherlands, with 495 persons per square kilometre.

[94] NSO demographic review 2005-2012

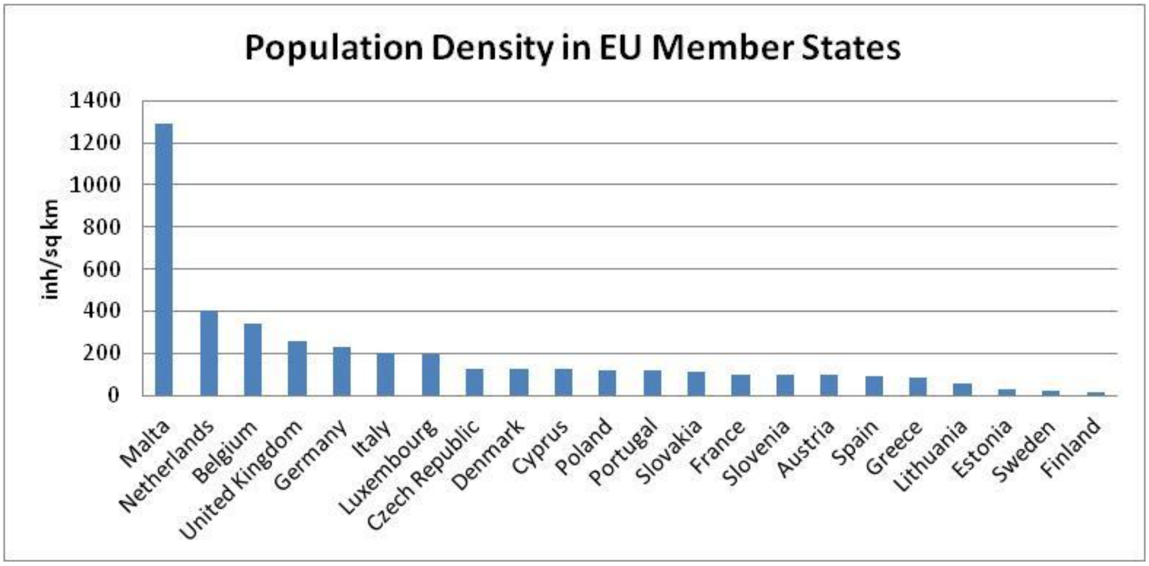

Figure 3.13: Comparative analysis of population density in EU Member States

The high population density and the natural shortage of water resources are also a determining factor in ensuring that the Maltese islands have by far the lowest natural freshwater availability per person per year of all the EU Member States. In fact, freshwater availability per capita is estimated to stand between the 80 and 120m^3 mark, way below the 500m^3 which the UN, through the Falkenmark Index, considers as the limit for the manageable capability to ensure the basic water needs required for the sustained development of the country.

Mean Annual per Capita availability of Naturally Renewable Freshwater Resources	**Classification**
>1600m^3	Sufficient Availability
1000 - 1600m^3	Water Stress
500 – 1000m^3	Chronic Water Scarcity
<500m^3	Below the manageable capability

Table 3.19: UN Falkenmark Water Scarcity Index

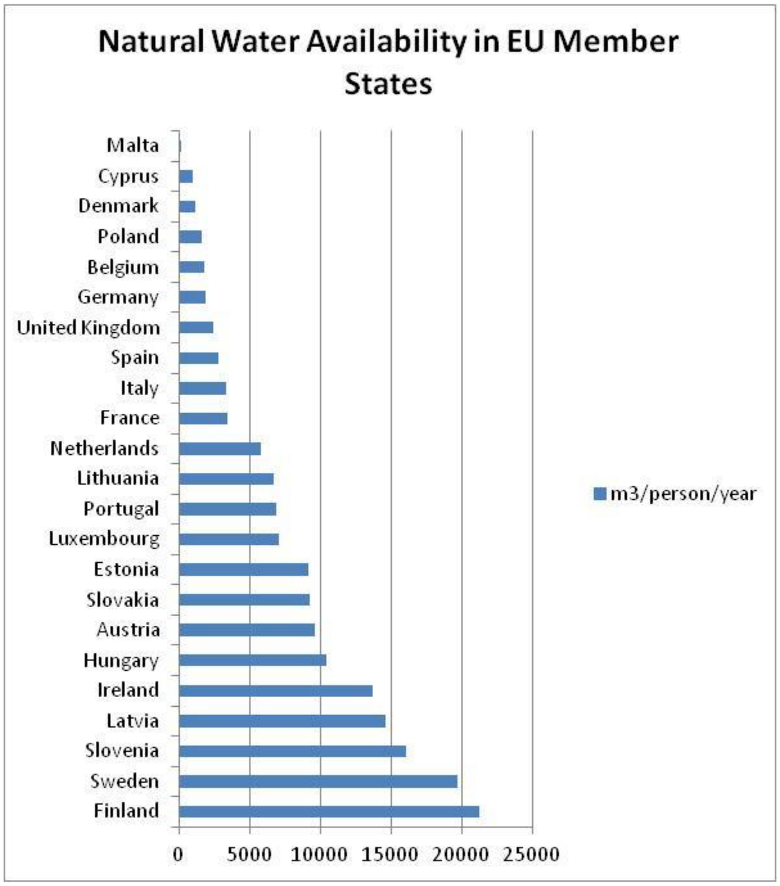

Figure 3.14: Comparative analysis of natural freshwater availability in EU Member States

Following EU membership, the Maltese economic development has been mainly focused on tourism, light industry, financial services and the ICT industry. Around 1.7 million tourists visit Malta annually, the figure being targeted to increase in coming years. When the length of the tourists' visits is taken into consideration, this translates to around a mean of 37,000 additional population each day (ranging from a minimum of 19,000 during the low season to 75,000 during the high season), the water needs of whom need also to be addressed.

During the last three years (2012-2015) an average growth rate in the Gross Domestic Product of 2.76% was registered projecting Malta as one of the one of the fastest-growing economies in the EU. The World Economic Forum (WEF) in its recently published Global Competitiveness Index Report ranked Malta 51st out of 139 countries. The index is an internationally recognised tool that benchmarks the drivers of competitiveness and prosperity in an economy.

These figures confirm the need for reliable services, of which water supply is one of the most essential to sustain economic growth. In a country where resources are scarce it is therefore logical to expect competition between different sectors all claiming individual priority based on various factors. It is here where good governance comes in and plays an important role, to manage resources in an integrated manner where economic factors are balanced with environmental and social considerations.

Water Demand

The total water demand of the Maltese islands has been estimated to reach 62 million m^3 in 2014, increasing from the 48 million m^3 estimated in 2009 at the launch of the 1st Water Catchment Management planning cycle. This change should be considered with due caution given that it is mainly arises from the increases registered in the 'modelled' agricultural sector, and also reflects the fact that in 2009, 680mm of rainfall were registered contributing to a lower irrigation demand, compared to 2014 when the annual rainfall was below the mean, thereby more irrigation water would have been required by the sector.

The demand of the various water using sectors in the Maltese islands is increasingly being addressed through the conjunctive use of four main water resources, namely:
- groundwater aquifer systems,
- harvesting of rainwater runoff,
- desalinated sea-water, and
- treated wastewater.

Increased efficient use, recycling/reuse of water resources and supply substitution through the use of alternative resources are the management tools most broadly used. These are used to ensure that the national water demand is kept at efficient-use levels, and that the supply base available is sufficient to meet this demand whilst ensuring the protection of status of groundwater resources.

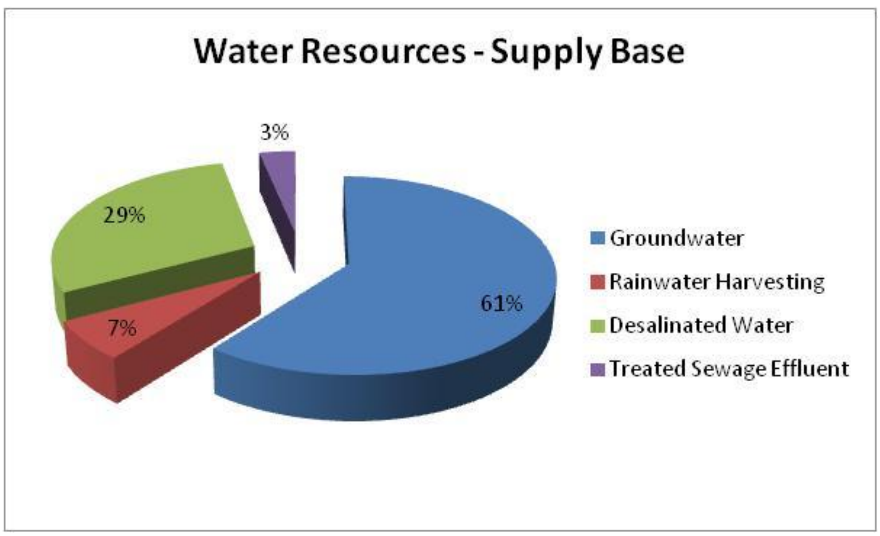

Figure 3.15: National Water Resources Supply Base (2014)

Water demand assessments have been undertaken for the main water using sectors over the period 2003-2013, where:

(i) the **domestic sector** shows a mildly increasing trend, where increased demands are mainly assumed to be sourced from alternative water resources to the municipal water supply network. This since the water consumption of this sector from the municipal network was fairly stable during the period under consideration;

(ii) the **agricultural sector** shows an increasing trend in its water demand. Given the absence of historical direct water consumption data for this sector, its water demand has been estimated through the use of FAO's CROPWAT model which takes into account the yearly climate (on a 10-

day time-step) and the land-used for agricultural purposes. The increase in demand indicated by this model could thus reflect the increasing trend in irrigated land-area as reported by the National Statistics Office;
(iii) the **commercial sector** (industrial, commercial and tourism) which is assumed to have a stable water demand over the period under consideration. The water demand of this sector is addressed by both public (WSC) and private (tankers and self-production) water supply sources, and significant data gaps still exist with regards to the volumes being supplied by private operators; and
(iv) the **other sectors**, which mainly reflect the demand of the public (government) entities, is assumed to be entirely dependent on the municipal water supply. Based on consumption metering data, the demand of this sector is assumed to be stable over the period under consideration.

Sector	Water Resources
Domestic	Groundwater, Desalinated Water, Rainwater Harvesting
Agricultural	Groundwater, Rainwater Harvesting, Treated Sewage Effluents
Commercial	Groundwater, Desalinated Water, Rainwater Harvesting, Treated Sewage Effluents
Others	Groundwater, Desalinated Water, Rainwater Harvesting

Table 3.20: Sectoral Use of Water Resources

During the course of the implementation of the 2nd Water Catchment Management Plan, econometric studies to better assess the trends in the water demands of these sectors are planned to be undertaken. Furthermore, the demand of the agricultural sector will also be assessed through the use of remote sensing data. These studies should be sufficient to significantly reduce the level of uncertainty in the demand values presented, and enable an increase in the reliability of the status assessments required for the 3rd WCMP.

This water demand assessment concluded that during the period under consideration the national water demand showed an increasing trend, mainly reflecting the increasing trends from the modelled demand of the agricultural sector.

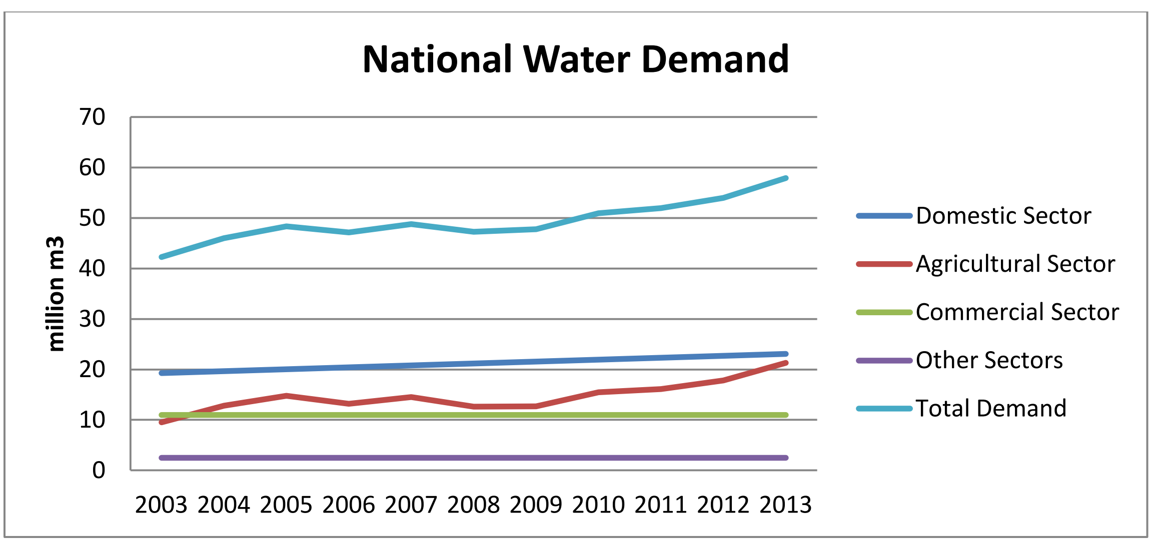

Figure 3.16: Trends in the National Water Demand between 2003 and 2013

Groundwater Abstraction

Groundwater abstraction, from all the groundwater bodies in the Maltese Water Catchment District, in 2014 was estimated to reach around 38 million m^3, or 61% of the total national water demand. The sector with the highest dependence on groundwater resources was the agricultural sector which accounted for almost half of the total groundwater abstraction in the Maltese islands. Groundwater abstraction by the Water Services Corporation accounts for around 37% of the total estimated groundwater abstraction.

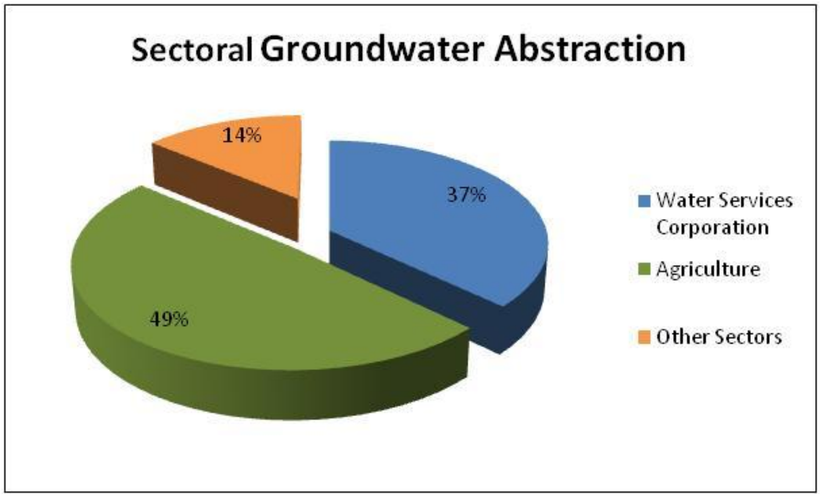

Figure 3.17: Classification of sectoral groundwater abstraction (2014)

It is noted that the analysis of the spatial distribution groundwater demand, showed that groundwater abstraction tends to have a regional dimension, with the perched aquifer systems being important groundwater sources to sustain the traditional irrigated land-areas of the Maltese islands, whilst abstraction of groundwater by the Water Services Corporation gains more relevance in the sea-level aquifer systems.

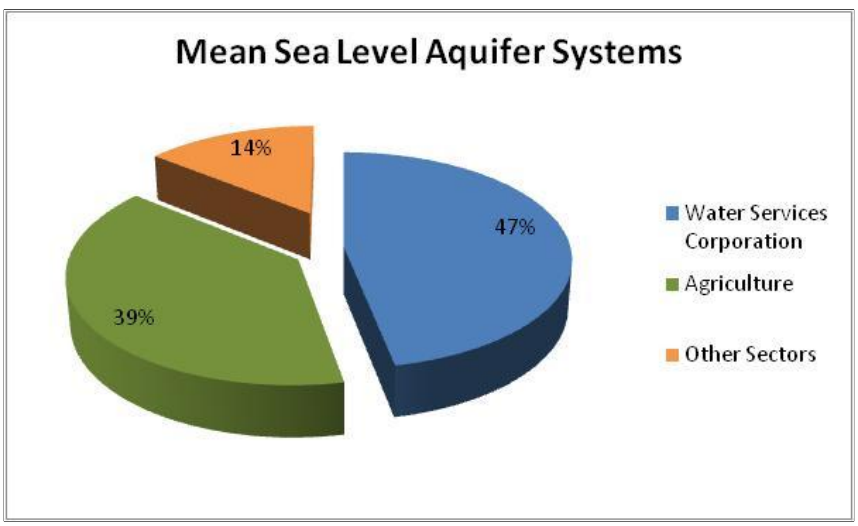

Figure 3.18: Comparative analysis of sectoral groundwater abstraction from the Mean Sea Level Aquifer systems (2014)

In fact, whilst public abstraction accounts for around 47% of all abstraction from the Mean Sea Level Aquifer systems, it accounts for only 8% of the abstraction of groundwater from the Perched Aquifer systems.

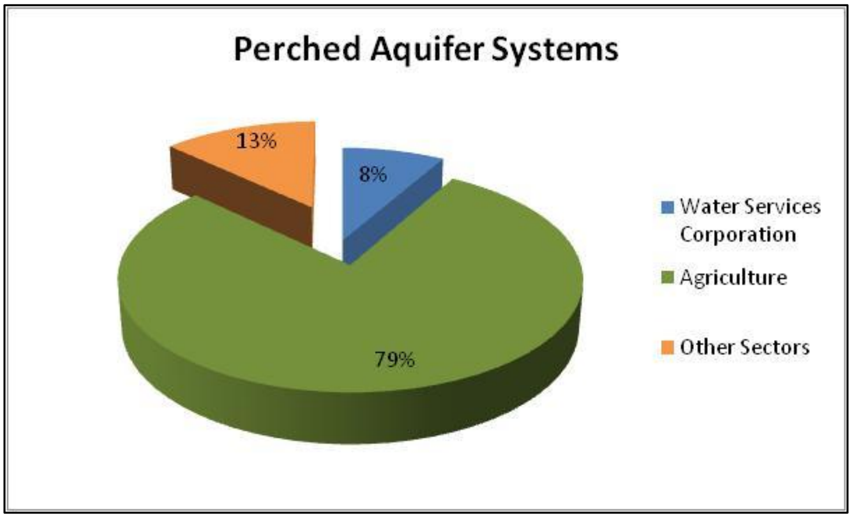

Figure 3.19: Comparative analysis of sectoral groundwater abstraction from the Perched Aquifer systems (2014)
The 'other sectors' includes the estimated abstraction from the old low-yield hand-dug wells (spieri) used by households

The groundwater abstraction assessment undertaken as part of the quantitative status assessment under the 2nd WCMP, indicates that cumulatively the sea-level aquifer systems are being overabstracted, whilst the perched aquifer systems show an overall positive balance.

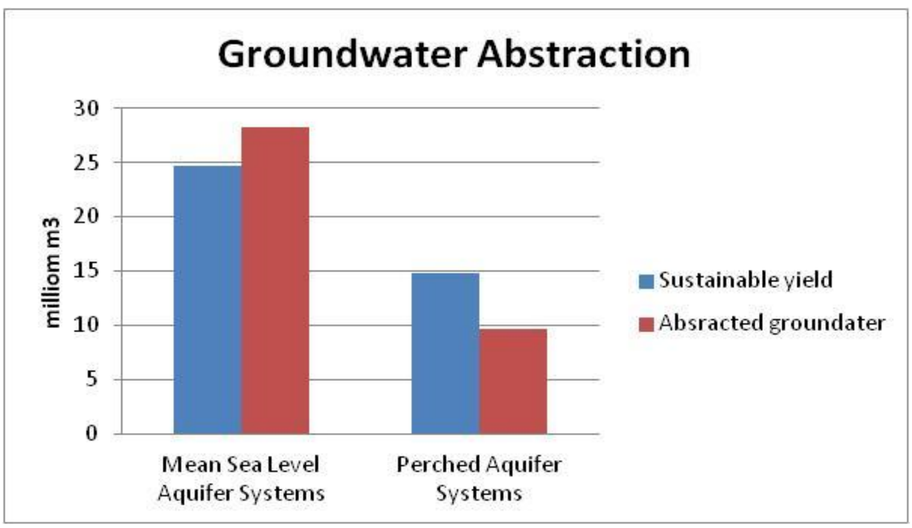

Figure 3.20: Comparative analysis of groundwater abstraction and sustainable yield for the two main aquifer typologies (2014)

Groundwater abstraction therefore remains a significant pressure for the two main mean sea-level aquifer systems in the Maltese islands, which still suffer from over abstraction of groundwater and the related impacts of sea-water intrusion.

Water Exploitation Index

The Water Exploitation Index (WEI+) is a commonly used indicator at EU level to gauge water stress. It has been defined as the percentage of the annual freshwater abstraction (both from surface and groundwater) over the long-term available freshwater resources.

When computed over the period 2007 to 2014, the WEI+ index ranges between 46% and 103%. whilst WEI+ calculations on a 'long term annual average' basis for the Malta Water Catchment District yield levels of 78%, thereby confirming the water stressed nature of the catchment district. These levels should also be considered from the perspective that the EU considers a level of 40% WEI+ as indicating conditions of high water stress.

Parameter	LTAA	2014	Comments
Precipitation (hm3)	174	159	
Actual Evapotranspiration (hm3)	109	100	assumed at 63% of total precipitation in both cases
Renewable Water Resources (hm3)	65	59	
Natural Subsurface Discharge (hm3)	24	24	assumed at 50% of the long term annual recharge to the MSLA systems
Unrecoverable Surface Runoff (hm3)	4	4	estimated at 25% of total surface runoff generated (initial estimate)
Actual available Water Resources (hm3)	37	31	
Total Abstraction / Utilisation (hm3)	38	42	
Returned Water (hm3)	12	12	return from municipal supply leakages and irrigation
WEI+	78%	97%	

Table 3.21: Estimation of WEI+ (LLTA and 2014) for the Maltese Islands

Indirect quantitative pressures

The Maltese islands present a semi-arid Mediterranean climate, with long dry summers and mild wet winters. To express the severity of water stress in any location *dryness* indices are commonly utilised. These delineate areas affected by water stress according to different levels (Pereira 2009). UNEP (1997) developed an *aridity index* which is the ratio of the annual precipitation to the annual potential evapotranspiration computed by the Pennman-Montheit relationship.

This index is defined by the following equation:

$AI_{UNEP} = P/PET$

Threshold values of the different zones under this Aridity Index are classified in ascending order as shown in Table 3.x below:

Classification	Aridity Index (AI)
Hyperarid	<0.05
Arid	0.05 to 0.2
Semi-arid	0.2 to 0.5
Dry sub humid	0.5 to 0.65

Table 3.22: Classification of the Aridity Index

Evapotranspiration is considered as a major component of the water cycle and is dependent on a number of climatic factors, including amongst others, rainfall, air temperature and solar radiation. The *Potential* Evapotranspiration computed for a time-series of climatic data of the Maltese islands covering the years between 1922 and 1998, using the Penman-Montheit method, stood at 1391mm when the annual average rainfall for the same period was recorded at 547mm. Based on these values and applying the UNEP aridity index formula, the Aridity Index (AI) for Malta is 0.39 thereby classifying the islands as being under *semi-arid* conditions.

This situation of natural water scarcity, is expected to be further affected by the onset of climate change. Current climate change projections for the central Mediterranean region indicate that the major challenges to Malta's groundwater resources will most probably arise due to:

(i) Increasing temperatures
Air temperature is one of the most relevant climatic parameters and significant and consistent changes from the norm area among the first signals of a changing climate. Prolonged extreme temperature events over the Maltese islands may be due to heat waves, droughts or unusually cold spells. An analysis of the mean, maximum and minimum ambient temperature measured at Luqa Airport, which is Malta's climate reference point was undertaken in 2011[95]. The anomaly exhibited by the mean annual temperate from the climate norm of 1961-1990 is shown in figure 3.x below. The 3-year moving line average shows a rise in the anomaly after 1981 where the highest anomaly of +1.2°C was reached in 2001.

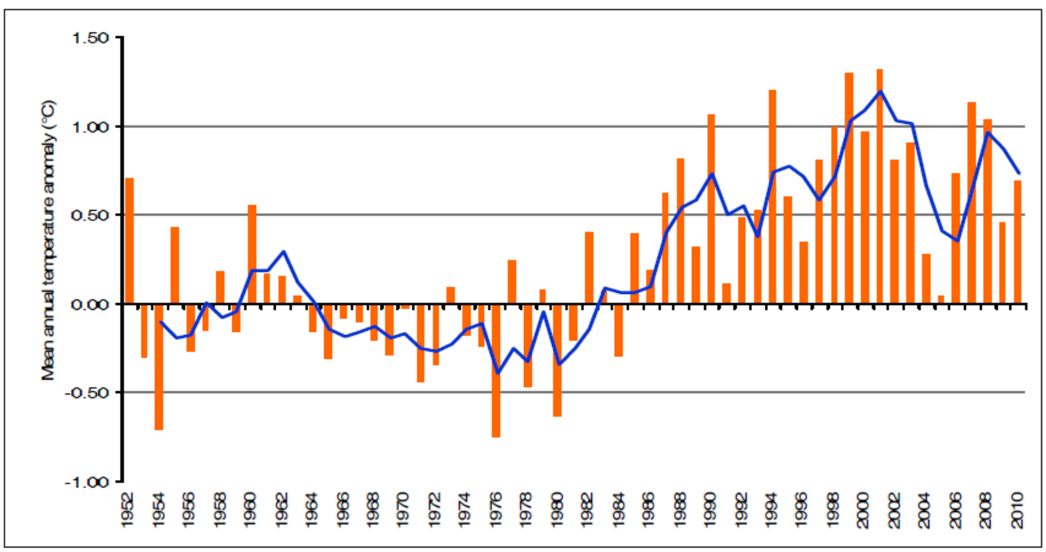

Figure 3.21: Annual mean air temperature anomaly for the period 1951-2010
(3-year running average shown in blue)

Using a linear regression model, the rate of change is defined by the slope of the regression line, which in this case is 1.1°C since 1951. The Mann-Kendall test confirmed that the positive trend observed is significant with a 99 per cent confidence level.

[95] The Climate of Malta: statistics, trends and analysis 1951-2010, Dr Charles Galdies, National Statistics Office, Malta.

This local rate of change is greater that what the International Panel on Climate Change (IPCC) reports for the global, but 100-year liner tend (1906-2005) of 0.7°C ± 0.2°C (IPPC 2007). The global linear warming trend observed from 1956-2005 is nearly twice that for the period 1906-2005(IPPC, 2007), which makes it slightly higher that the local rate of change.

This statistical assessment of local data concludes that relatively little change in the frequency of extreme temperatures is expected, but conditions will be such that an increased hot weather and previous record high temperatures will be exceeded far more often. The average temperature of 18.5°C given by the data distribution for the period 1951-1980, is markedly different from that of the most recent period of 1981-2010, during which the temperature distribution has increase to an average of 19.2°C.

Increasing temperatures will invariably be expected to result in higher water demand, mainly from the agricultural, landscaping and recreational sectors, increasing also the quantitative pressures on groundwater resources.

(ii) Changes in rainfall depth

Locally, periods of rainfall can range from minutes to hours (such as the case of strong showers), while rain shortages range from weeks to even months. Extremes of rapid and strong rainfall often result in uncontrolled street surface runoff in downstream built-up areas within valley systems with potentially damaging consequences.

An analysis of local rainfall data similar to that of temperature (Galdies, 2011) was undertaken. The observations are based on data collected by the Malta MetOffice during the period between 1951 and 2010.

Figure 3.x shows the total annual rainfall anomaly for the period 1951 – 2010. The Mann-Kendal test did not confirm a trend at the 99 per cent confidence level, while significance testing indicated that there is no significant difference at the 95 per cent confidence level between the mean of the periods 1995-2010 and 1951-1994.

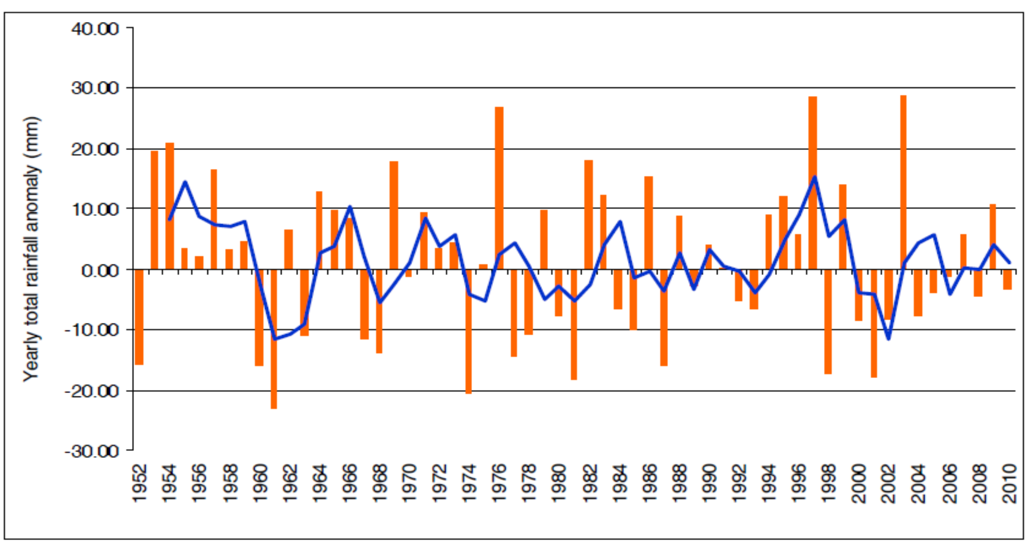

Figure 3.22: Annual total rainfall anomaly for the period 1951-2010
(3-year running average shown in blue)

An eventual potential reduction in the mean annual precipitation would be expected to result in lower infiltration (recharge) rates to groundwater, although consideration will need to be given to the temporal variation and intensity of rainfall events.

(iii) Changes in rainfall patterns

The analysis also focused on the departure of the total amount of rainfall recorded in 24 hours from the climate norm. The results of the analysis are shown in figure 3.x below. The data shows no significant trends a the 99 per cent confidence level, and no statistical difference at the 95 per cent confidence level between the means of the periods 1995-2010 and 1951-1994.

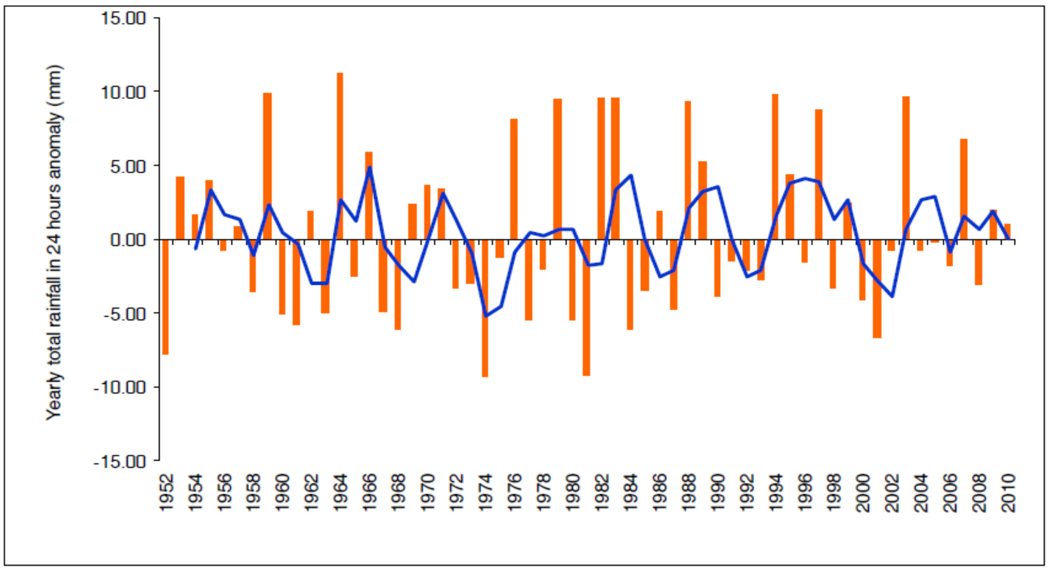

Figure 3.23: Annual total rainfall in 24 hours for the period 1951-2010
(3-year running average shown in blue)

Reconnaissance Drought Index (RDI)

In view of the relatively high evapotranspiration rates experienced in the Malta Water Catchment District, an assessment of drought indices undertaken during the development of the 2nd WCMP recommended the use of the Reconnaissance Drought Index (RDI) instead of the more mainstream Standard Precipitation Index (SPI) which does not fully consider the impact of evapotranspiration losses to the effective rainfall. The Reconnaissance Drought Index (RDI) in fact is calculated using an equation which requires both rainfall and potential evapotranspiration data, and is therefore more suited to regions where natural losses due to evapotranspiration are significant.

The RDI defines the occurring climatic conditions according to the below statistical classification:

State	Criterion
Extremely Wet	RDI ≤2.0
Very Wet	1.5 ≤ RDI < 2
Moderately Wet	1.0 ≤ RDI < 1.5
Near Normal	-1.0 ≤ RDI < 1
Moderately Dry	-1.5 ≤ RDI < -1.0
Very Dry	-2.0 ≤ RDI < -1.5
Extremely Dry	RDI < -2.0

Table 3.23: Criteria for the classification of climatic status according to the RDI index

A first assessment on the use of the RDI for the Maltese Water Catchment District was undertaken under the EU funded PRODIM Project, using climatic data from 1947-2005. These studies have shown a trend towards an increased number of dry years and therefore towards less water availability.

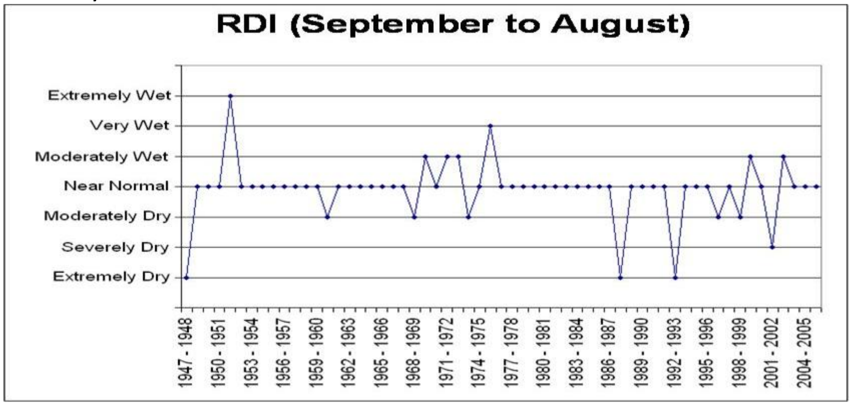

Figure 3.24: Application of the Reconnaissance Drought Index to the Malta Water Catchment District (1947-2005)

The ensuing long-term scenario of reduced water availability is expected to have two main effects:
(i) an increased water demand in response to a reduced natural water availability, particularly by those sectors which are heavily dependent on the natural water supply; and
(ii) reduced recharge to groundwater arising from the decreased availability of superficial water.

Both these two effects will therefore be expected to result in an increase on the pressures on groundwater, which is the only naturally renewable water resource of the islands.

Urban Land-use

The impermeabilisation of land-use has a direct impact on natural recharge. Aquifers in Malta and Gozo are all unconfined and the only possible source of recharge is through surface infiltrations. Once the ground terrain is sealed, the recharge process will stall. Within this scenario, the beneficial effect of annual recharge on the quantitative status of the MSLA, is impaired as a result of the high urban density and the natural "smallness" of the archipelago.

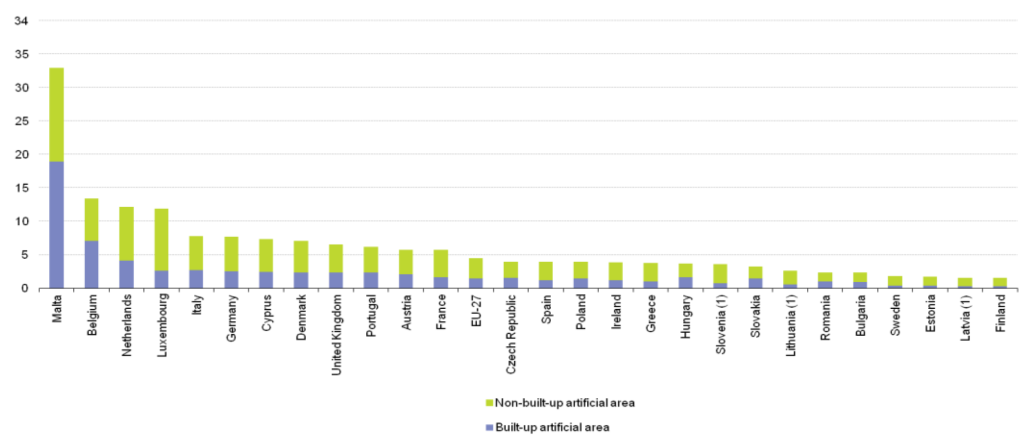

Figure 3.25: EU Member States share of non-built-up artificial land and built-up artificial areas

Eurostat (Lucas survey) classified in 2012 the land-cover of the 27 member states in two categories namely, built-up areas and artificial non-built-up areas. Malta features as the Member state with the highest percentage of built-up areas in relation to territory size.

The extent of urban landcover in the Maltese islands has increased from 4% in 1956 to 22% in 1997, where it has stabilised in subsequent years due to the main development being constrained within zoned development areas. No major increases over these levels are expected in the short to medium term.

3.6.2 Qualitative Pressures on Groundwater

Saline Intrusions

Seawater intrusion in the mean sea level aquifer systems occurs as a direct and unavoidable consequence of groundwater abstraction. Regional intrusion, which is the most important type of intrusion at a water body scale, occurs as a result of groundwater overabstraction and although having a qualitative impact, needs to be tackled through quantitative measures, namely by restoring the balance between the mean annual recharge and abstraction. Regional intrusion is a slow process which take a relatively long time to manifest itself, since it involves the displacement of significant volumes of water. Its effects, however will be felt in the long term.

Localized intrusion beneath abstraction wells, technically referred to as 'saline upconing' is a spatially limited phenomenon which occurs beneath groundwater abstraction wells where the freshwater-saltwater interface responds to the drawdown in the piezometric surface resulting from groundwater abstraction. This form of abstraction results in the salinisation of abstracted groundwater, but if carefully managed does not impact the regional status of the aquifer system. This mainly due to the fact that this type of intrusion is extremely limited in extent to the area beneath active 'high-yield' wells. Modelling undertaken on the Mean Sea Level Aquifer system in Malta, where the Dupuit-Forscheimer well discharge equation was applied under the hydgeological conditions prevailing in this aquifer system and at the maximum abstraction rates experienced at public groundwater abstraction stations indicated a maximum extent of the cone of depression around each abstraction source being defined by the 300m radius around the well. Given that upconing is a direct response to the depression in the piezometric surface, the maximum extent of the upconing (experienced at the freshwater-saltwater interface) will not exceed this 300m radius. The impact of the upconing phenomenon will decrease exponentially along the distance to the bottom of the well. Furthermore, being a fast-response process, the effects of upconing will stop in relatively short period following the ceasing of abstraction, and is not considered to have any significant long-term impacts.

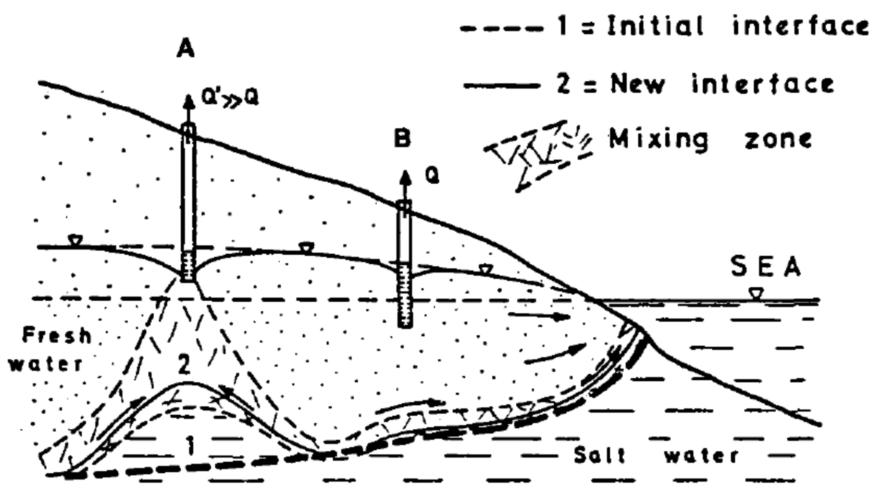

Figure 3.26: Schematic representation of saltwater upconing beneath a high-yield groundwater abstraction station (UNESCO)

The perched aquifer systems are also impacted by indirect intrusion of salinity mainly through the aerial deposition of salts due to the proximity of the aquifer systems to the sea, and the use of (higher salinity) water derived from the sea-level aquifer systems on their surface catchment areas. In fact, out of eight perched groundwater bodies, three exhibit a mean Electrical Conductivity content which exceeded the groundwater threshold value established for this sea-water intrusion indicator parameter for these groundwater bodies (2014 monitoring data).

Agricultural Practices

Arable agricultural practices are one of the main land-use activities of the Maltese islands, effectively covering around 47% of the total land surface of the islands. These activities are generally associated with diffuse pollution emerging from the use of agri-chemicals such as fertilizers and pesticides. Whilst pesticide pollution in groundwater has to date not been detected in groundwater chemical analysis in the Maltese islands, on the other hand nitrate is one of the major pollutants, responsible for the poor status conditions of groundwater bodies.

Studies undertaken by the British Geological Survey performed a detailed analysis of the ratio of stable isotopes of nitrogen in groundwater nitrate, 15N/14N reported as δ15N values, both in Malta and Gozo. Stable isotope ratios of nitrate and oxygen are important tools to understand the geochemical origin and evolution of nitrate. The δ15N and δ18O values reflect the original sources of nitrogen (e.g. fertilizer, animal waste, etc.) and oxygen (water, O_2), as modified by any subsequent chemical transformation such as denitrification.

Groundwaters from all three aquifer types – the perched and MSL aquifers on Malta, and the MSL aquifer on Gozo – displayed very similar ranges of δ15N and δ18O values, and could not therefore be distinguished from one another which suggest a similar source of nitrates in the three aquifers whilst the difference relate to a different hydrology.

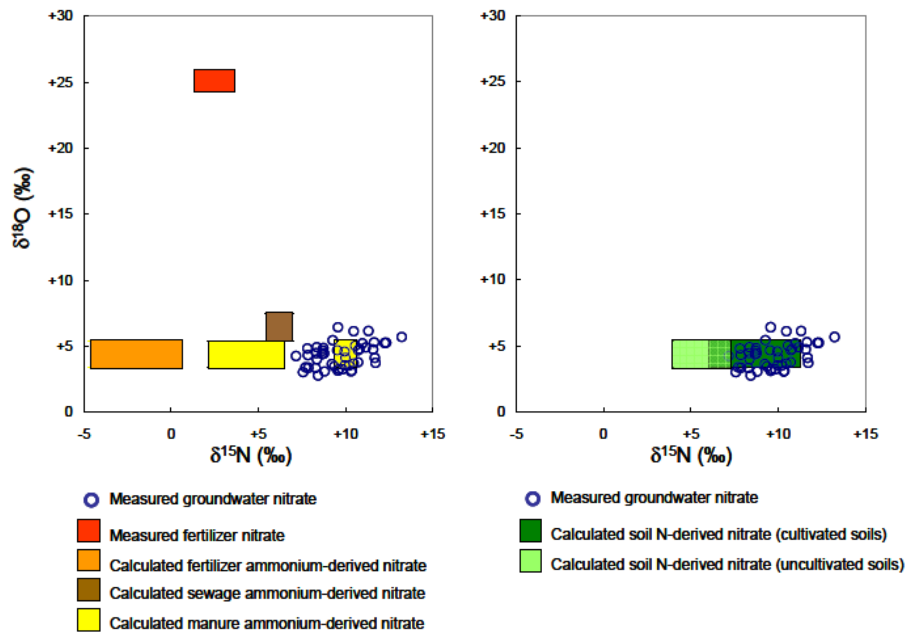

Figure 3.27: Results from N-isotope investigations indicate arable agriculture and animal manure as the main sources of nitrate pollution in groundwater

The study concluded that values of organic nitrogen in cultivated soils coincide closely with those of nitrate in the groundwater. Overall, the δ15N and δ18O figures indicate that nitrates in groundwater are mainly being derived by leaching of nitrate formed by nitrification in soils. Nonetheless derivation from stored animal wastes could not be discounted. In the case of a soil nitrate source the isotope data did not rule out inorganic fertilizers and/or animal wastes as the *original* source of the nitrogen. The study showed that the nitrate derivation process in groundwater was the result of nitrogen from inorganic fertilisers and/or animal wastes is assimilated into the soil organic nitrogen pool and takes on the isotope signature of this pool during its residence period in cultivars before nitrification and leaching into the underlying groundwater.

In this respect it is also noted that whilst the study indicates the main source of Nitrate contamination in the aquifer systems, the presence and potential contribution of other potential sources of Nitrate contamination present in the catchment district cannot and should not be discounted. Efforts should thus be continued towards the upgrading of waste storage areas in animal husbandry activities and the upgrading of the municipal sewage systems to reduce leakages. It is noted that such upgrading measures were implemented by both sectors during the course of the 1st Water Catchment Management Plan.

Commercial and Industrial Installations

Industrial and IPPC facilities, landfilling facilities, fuel stations and waste recycling yards are present within the Maltese urban context. Though strongly regulated, these are potential sources for point-form pollution of the Mean Sea Level and Perched Aquifer systems in both Malta and Gozo. Planning controls are in place for such applications which require the adoption of pollution prevention measures. In the case of fuel storage installations, the controls require double skinned reservoirs fitted with proper alarm devices which can alert in a timely manner any accidental leakage of fuels.

Groundwater monitoring results do not indicate any qualitative impacts from these potential pollution sources.

Anthropogenic Contaminants
Urban land-use and associated activities also present a potential risk of pollution to groundwater. Transfer of pollutants can occur through processes such as the flushing of contaminants by rainwater runoff to permeable recharge areas and/or the leaching of pollutants from leakages in the public sewerage system. Pollutants such as heavy metals, oils and solvents, personal care products and pharmaceuticals can all potentially be present in polluted water streams from such areas.

The presence of such contaminants in groundwater has not been detected to date in either the Surveillance or the Operational Monitoring Exercises undertaken during the course of the 1st Water Catchment Management Plan. This notwithstanding Malta aims to actively participate during the course of the 2nd WCMP in a pan-European initiative under the Common Implementation Strategy of the Water Framework Directive aimed at assessing the content of indicators of such contaminants in groundwater.

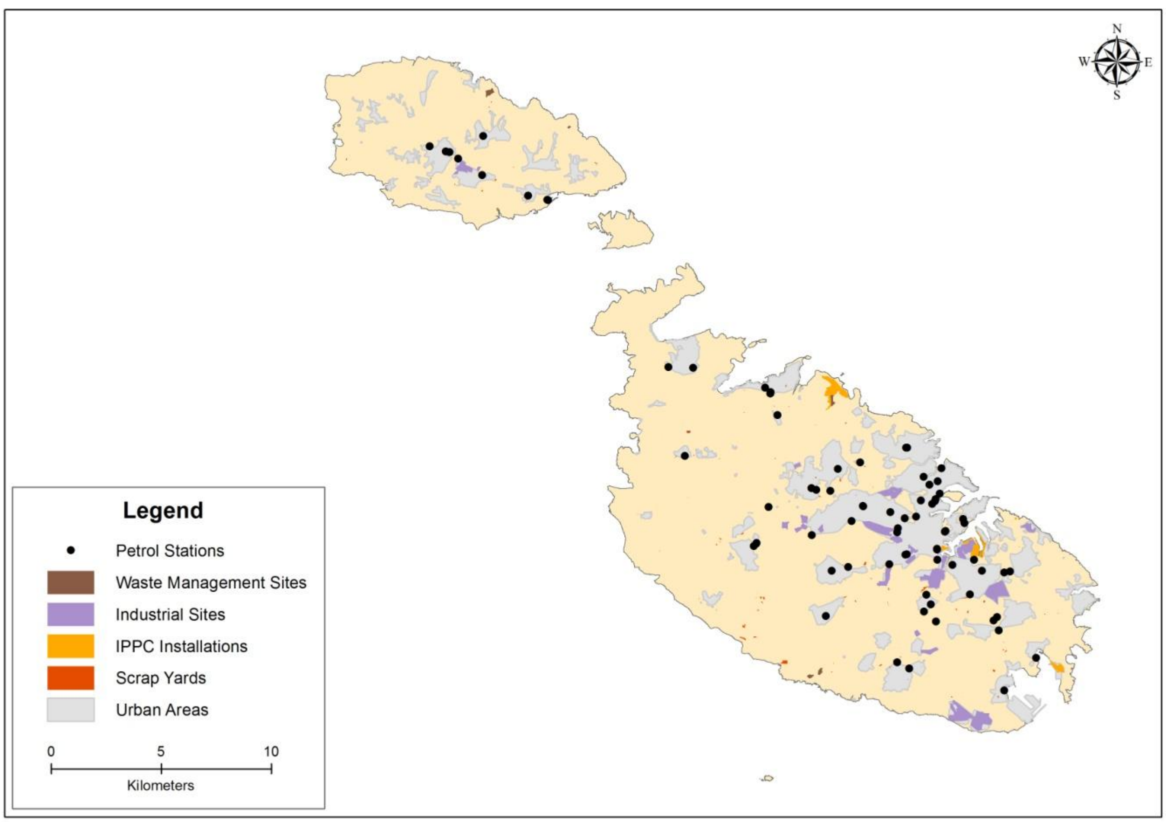

Figure 3.28: Commercial and Industrial Installations in the Maltese islands

3.6.3 Summary Information

Identification of 'At Risk' Bodies of Groundwater

GWB Code	GWB Name	Risk Review 2009	Risk Review 2015	Significant Pressures			
				Point Source Pollution	Diffuse Source Pollution	Water Abstraction	Sea-Water Intrusion
MT001	Malta Mean Sea Level	At Risk	At Risk	x	x	x	x
MT002	Rabat-Dingli Perched	At Risk	At Risk	x	x	x	
MT003	Mgarr-Wardija Perched	At Risk	At Risk	x	x	x	
MT005	Pwales Coastal	At Risk	At Risk		x	x	x
MT006	Mizieb Mean Sea Level	Not at Risk	Not at Risk		x	x	x
MT008	Mellieha Perched	At Risk	At Risk		x		
MT009	Mellieha Coastal	At Risk	At Risk		x		x
MT010	Marfa Coastal	At Risk	At Risk		x		x
MT012	Comino Mean Sea Level	Not at Risk	Not at Risk		x		x
MT013	Gozo Mean Sea Level	At Risk	At Risk	x	x	x	x
MT014	Ghajnsielem Perched	At Risk	At Risk		x	x	
MT015	Nadur Perched	At Risk	At Risk		x		
MT016	Xaghra Perched	At Risk	At Risk		x		
MT017	Zebbug Perched	At Risk	At Risk		x		
MT018	Victoria-Kercem Perched	At Risk	At Risk		x		

Classification of Risk

GWB Code	GWB Name	Risk due to Nitrate Contamination	Risk due to Sea Water Intrusion	At Risk Objectives			
				Quantitative Status	Qualitative Status	Use (Drinking Water)	Associated SW Bodies
MT001	Malta Mean Sea Level	x	x	x	x	x	
MT002	Rabat-Dingli Perched	x			x		x
MT003	Mgarr-Wardija Perched	x			x	x	
MT005	Pwales Coastal	x	x		x		
MT006	Mizieb Mean Sea Level						
MT008	Mellieha Perched	x			x		
MT009	Mellieha Coastal	x	x		x		
MT010	Marfa Coastal	x	x		x		
MT012	Comino Mean Sea Level						
MT013	Gozo Mean Sea Level	x	x	x	x	x	
MT014	Ghajnsielem Perched	x			x		
MT015	Nadur Perched	x			x		
MT016	Xaghra Perched	x			x		
MT017	Zebbug Perched	x			x		
MT018	Victoria-Kercem Perched	x			x		x

4. Protected Areas

4.1 Introduction

The register of protected areas is a list of sites lying within the Maltese Catchment District which require special designation for the protection of the surface water and groundwater or for the conservation of habitats and species directly dependent on water.

A full list of areas under this registry, applicable to the Maltese Islands, is as follows:

- Areas designated for the protection of habitats and/ or species where the maintenance or improvement of the status of water is an important factor in their protection.
- Bodies of water designated as recreational waters, including areas designated as bathing waters under the Bathing Water Directive.
- Nutrient-Sensitive areas, including areas designated as vulnerable zones under the Nitrates Directive and areas designated as sensitive areas under the Urban Waste Water Directive.
- Areas designated for the abstraction of water intended for human consumption.

This register includes the details of all protected sites, their location, a description of European Union legislation and National legislation under which they have been designated and their current status as at end 2013.

Measures have been identified (see Chapter 9) for the further protection of these sites, building on what was already carried out under Malta's first Catchment Management Plan issued in 2011. In addition, Natura 2000 management plans have also been developed in the case of areas designated for the protection of habitats and species. Where the maintenance or improvement of the status of water is an important factor in habitats and/ or species protection, these management plans have synergized water and habitat requirements by means of individual operational objectives and related measures.

These management plans envisage implementation of operational objectives for the individual sites over five years. The management actions identified in such plans have been synergized with the requirements of the Water Framework Directive requirements and therefore all integrated measures of this process shall be included in the upcoming water catchment management plan due at the end of 2015.

Under the WFD, all protected areas are required to meet any water related standards and objectives according to the timeframes set in the upcoming Water Catchment Management Plan, unless otherwise specified in the Community legislation under which the individual protected areas have been established.

4.2 Areas designated for the protection of habitats and species where the maintenance or improvement of the status of water is an important factor in their protection.

These areas incorporate terrestrial and marine areas of ecological significance that depend on good quality surface waters. Terrestrial ecosystems also require adequate water flow regimes and where a connection to groundwater exists, good quality groundwater also needs to be ensured. Figure 1.1 indicates all terrestrial and marine protected sites which host habitats and/or species that are dependent on water bodies.

Terrestrial and marine sites have either been designated as protected areas under the Habitats Directive or Birds Directive or under National legislation. The Habitats Directive (Council Directive 92/43/EEC of 21 May 1992 on the conservation of natural habitats and of wild fauna and flora) was transposed into Maltese legislation through the **Flora, Fauna and Natural Habitats Protection Regulations, 2006** (Legal Notice 311 of 2006, as amended). These regulations provide for the implementation of related nature Multilateral European Agreements, such as the Convention on Biological Diversity and the Bern Convention. Natura 2000 sites have been designated; including a number of WFD protected areas such as Baħrija Valley system, Wied il-Luq, Il-Ballut l/o M'Xlokk. Five marine Special Areas of Conservation have also been designated, covering stretches off Rdum Majjiesa to Ras ir-Raħeb, Dwejra, Mġarr ix-Xini, a large stretch of coast along the north east of the Islands and an area between Għar Lapsi and Filfla. These Marine Protected Areas provide protection for over 80% of Posidonia beds found in the Maltese Islands.

The Birds Directive (Council Directive 79/409/EEC of 2nd April 1979, implemented locally through the **Conservation of Wild Birds Regulations, 2006** (LN79/06, as amended) and related Regulations. SPAs (Special Protection Areas) have been designated through various subsidiary legislation, and include a number of areas like Ghadira l/o Mellieha and is-Simar l/o St. Paul's Bay which are also Water Framework Directive protected areas and wetlands of international importance under the **Ramsar Convention.**

Some protected areas included in this registry have been protected solely under national legislation under **Government Notice 288/1995** (Section 46 of the Development Planning Act 1992).

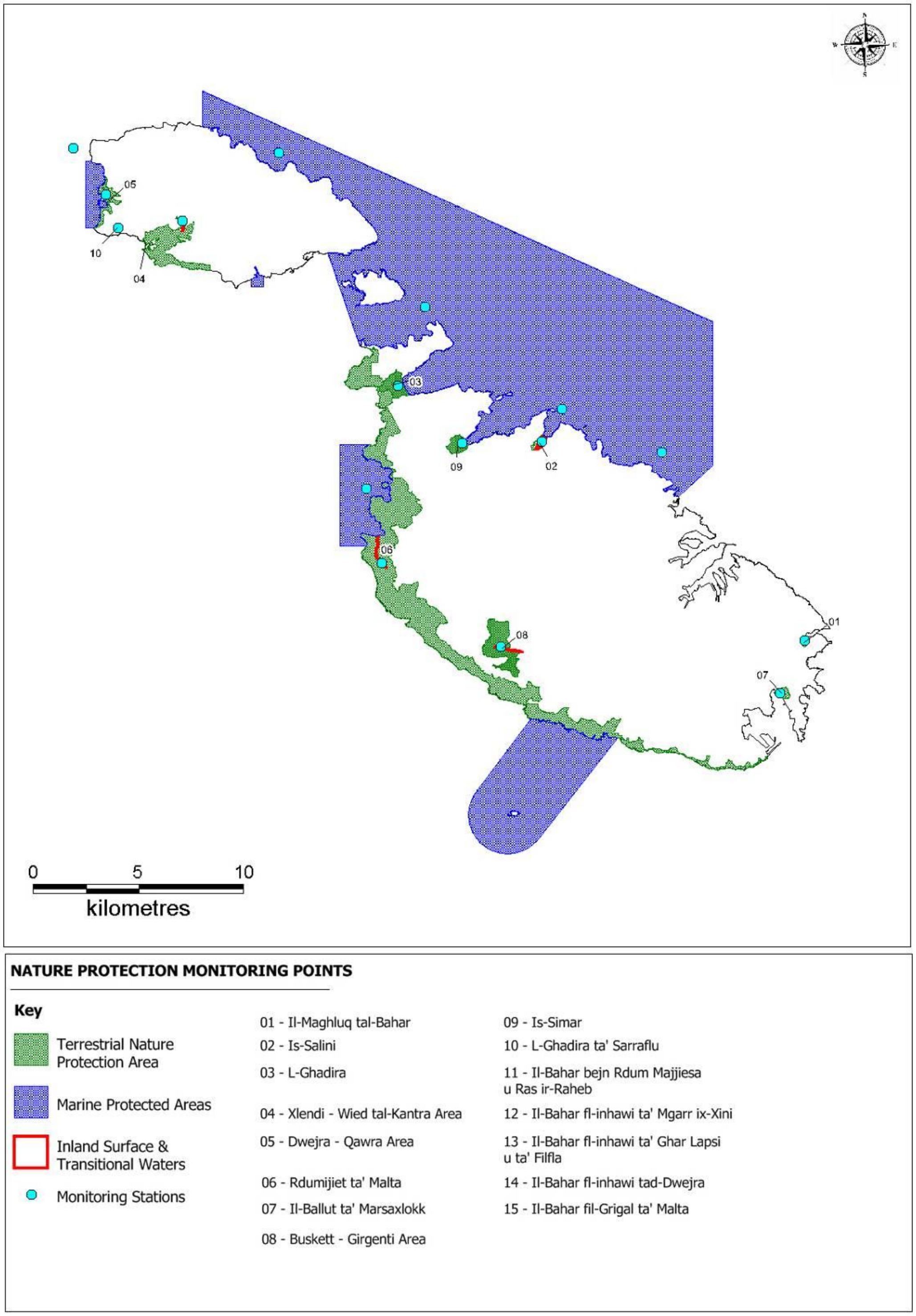

Figure 4.1: Map of the Maltese Islands indicating the location of terrestrial and marine protected areas dependent on the quality of surface waters. The location of monitoring stations located within these sites indicates monitoring carried out during the first WFD monitoring cycle (2012-2013)

4.2.1 Water Courses of ecological significance (areas 05, 07 and 09 in Figure 1.1)

1. Wied il-Luq

Wied il-Luq forms part of the larger Buskett/Girgenti Natura 2000 site. This Natura 2000 site is part of a large valley system and hosts several habitat types. The watercourse environments located within this Natura 2000 site are characterised by riparian habitats composed of *Salix alba, Salix pedicellata, Populus alba,* and *Fraxinus angustifolia, Ulmus minor* and *Ulmus canescens.* Due to the limited cover of this habitat type, the species associated with this habitat type are rare to very rare and threatened.

Natura 2000 area:	L-Inhawi tal-Buskett u tal-Girgenti
SAC Code:	MT0000018
Longitude:	14.4031
Latitude:	35.8581
Area of SAC [ha]:	244.71
Area of sub-catchment:	14.36 km^2
Length of watercourse:	1.36 km

(i) The Hydrological Catchment

Wied il-Luq is one of the tributary valleys feeding the Wied il-Kbir system, which is the largest valley system on the island. The valley system includes Wied tal-Girgenti, Wied l-Isqof and Wied Inċita. These tributaries meet at Wied Ħesri and flow down to the Qormi / Marsa Area.

The upper part of Wied il-Luq is carved into the Blue Clay layer, the middle part is carved into the Upper Coralline Limestone and the downstream section is carved into the Middle Globigerina Limestone.

Water flow at Wied il-Luq is perennial depending to a large extent on the amount of rainfall at the start of the rainy season in September. An additional and more significant water source is the Ta’ Sala spring water which, since the time of the Knights, has been diverted into reservoirs and used for landscaping purposes. The **Ta' Sala Spring** is the only known contributing source to Wied il-Luq. It used to discharge as a public supply spring with its outlet in the opening or cave like structure that can be seen near the huge tent at Buskett. The outflow of this spring has been diverted into a canal system to water the gardens during the Knights period. The British replaced the canal system and connected the outflow of the spring to increase the flow to the Wignacourt Aqueduct system. Today the water from the reservoir is used to water orchards at Buskett and is extracted by the Landscaping Consortium (the ELC). Any overflow from the reservoir that is located towards the middle reach of Wied il-Luq is then allowed to flow into the water course.

Based on one year monitoring, the wet period gives rise to a stream having an average water depth of 3cm and average width of 12cm at the uppermost reaches of the watercourse system. After April the stream would have dried out completely. Due to the fact that water that is found in the middle reaches of the valley comes from the overflow of the reservoir that was constructed to divert water from the Ta’ Sala spring for irrigation purposes; the natural water flow regime of Wied il-Luq has not been determined as yet and it will be necessary to establish the water flow requirements for the habitats and species that thrive in this valley in order to ensure an ecological flow.

Figure 4.2: Wied il-Luq water course after heavy rains
Photo credit: MEPA

(ii) Historical Hydromorphological alterations

Wied il-Luq forms part of the Buskett semi-natural woodland that was extensively modified since the times of the Knights of St. John in the 1500s. Gardens and woodlands were planted and the water was engineered to allow for irrigation works, reservoirs, fountains and fish tanks. Wied il-Luq was also extensively modified. Its banks were reinforced with dry stone walls, ashlar walls and supporting buttresses.

(iii) Water Dependent Habitat types

92A0 Salix Alba and *Populus alba galleries:* One of the most important features at this Natura 2000 site is the native *Populetum albae riparian* woodland at Wied il-Luq consisting of *Populus alba, Fraxinus angustifolia* (only site where this is known), *Ulmus minor* and *Quercus robur.*

(iv) Water Dependent Species

There are no water dependent Annex II species dependent on the watercourse itself. However there are a large number of species which are endemic or restricted to the freshwater environment which is rare in the Maltese Islands. These include plant species such as the *Carex divulsa* (Grey Sedge / Sogħda mifruda) and *Calystegia x lucana* (Leblieb bagħal); snails such as the *Physa acuta* (tadpole or bladder snail) and amphibians such as the *Discoglossus pictus pictus,* Malta's only native amphibian (Maltese painted frog/ Iż-Żrinġ) (Figure 4.3). This area is also important for Lepidoptera (butterflies, moths and skippers) and flatworms. Species restricted to the freshwater spring habitat in the Maltese Islands include: the Vetch *Vicia bithynica*, the pondweed *Potamogeton pectinatus* and the Butcher's Broom *Ruscus hypophyllum*.

Figure 4.3: *Discoglossus pictus pictus,* Malta's only native amphibian (Maltese painted frog/ Iż-Żrinġ)
Photo Credit: MEPA

Natura 2000 management plans identify measures which give priority to Annex I habitats and Annex II species. Other important species which are not included under these Annexes are protected through horizontal measures which support the protection of these species or restoration of habitats on which they depend. In some cases specific action plans targeting the conservation of particular species may also be drawn up depending on the vulnerability of the species.

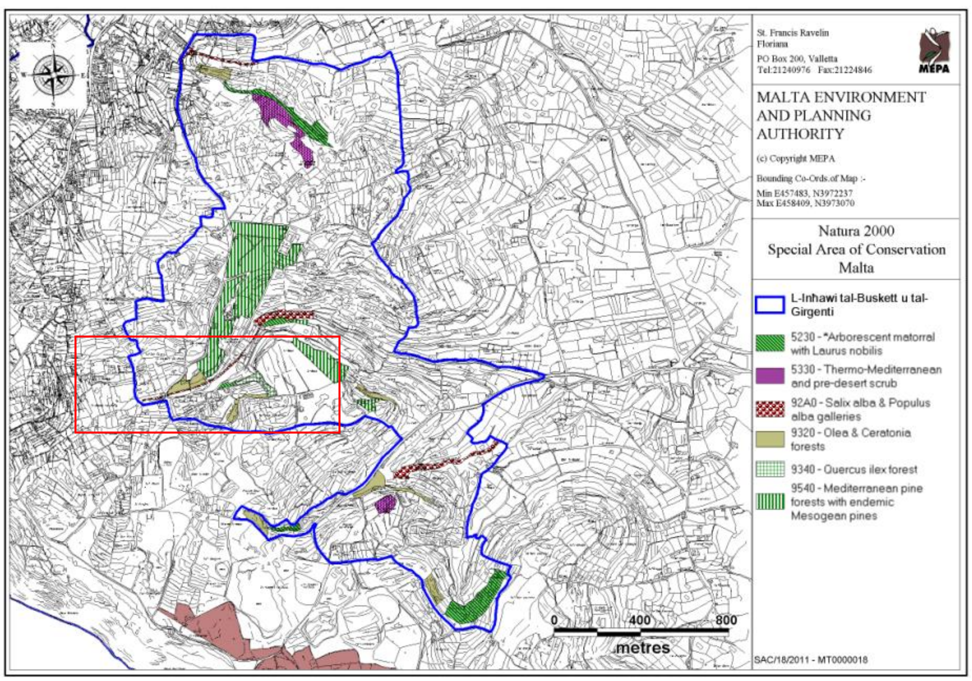

Figure 4.4: Location of Wied il-Luq water course and *Salix alba* and *Populus alba* galleries indicated by the red box in the Buskett Special Area of Conservation
Source: MEPA Natura 2000 data form

2. Wied tal-Baħrija

Wied tal-Baħrija is a watercourse of high conservation value which forms part of a larger SAC of International importance. The watercourse is also part of a Tree Protected Area, in accordance with the provisions of the Trees and Woodlands Protection Regulations (2011) as per Government Notice 473 of 2011.

Natura 2000 area:	Rdumijiet ta' Malta: Ras il-Pellegrin sax-Xaqqa
SAC Code:	MT0000026
Longitude:	14.3572
Latitude:	35.8689
Area of SAC [ha]:	378.45
Area of catchment:	2.44 km^2
Length of watercourse:	1.74 km

(i) The Hydrological Catchment

Wied tal-Baħrija arises from Wied Rini on the western coast of Malta. The valley is incised to the level of the Globigerina Limestone and opens in Fomm ir-rih Bay on the western coast of Malta. The upper parts of the valley are composed of Upper Coralline Limestone and a thin discontinuous layer of greensand. The valley then passes over the Blue Clay layer and concludes on top of the Middle Globigerina Limestone.

The valley system is typified by perennial or near-perennial springs ('għejun', singular 'għajn', in Maltese). Therefore the existence of this watercourse is largely dependent on the presence of the perched aquifer and seepage from the Blue Clay and Upper Coralline Limestone junction as 'high level springs'. The springs originate from the Rabat-Dingli plateau such that the upper reaches of the watercourse are almost never completely dry. The lower reaches of the valley is characterised by a series of disconnected pools. Such pools dry out completely during the summer months of July and August.

(ii) Water Dependent Habitat types

There is one main water dependent Annex I habitats of particular importance to this valley system - the *Salix alba* and *Populus alba* galleries (92A0). This habitat is one of rarest and most vulnerable habitats in Malta. Similar to the salt meadows its existence depends on the supply of a permanent spring of water. As in the case of Wied il-Luq, the habitat at Wied tal-Baħrija is threatened from water abstraction, the planting of Eucalyptus trees and competition with the Giant Reed (*Arundo donax*) that has overtaken the valley bed (see Figure 4.5).

(iii) Water Dependent Species

There are no Annex II water dependent flora and fauna species at Il-Wied tal-Baħrija. However there are a number of invertebrates that are specifically dependent on the freshwater environment at Baħrija.

These include 2 species of longhorn grasshopper (*Conocephalus conocephalus* and *Homorocoryphus nitidulus*), the freshwater amphipod (*Echinogammarus pungens*), the small water beetle (*Halipus lineaticollis*), a species of damselfly (*Ischnura genei*), dragonflies

(*Orthetrum brunneum*) and freshwater snails (*Lymnaea truncatula*). The endemic freshwater crab (*Potamon fluviatile ssp. Lanfrancoi*) is also found at the Wied tal-Baħrija.

Natura 2000 management plans identify measures which give priority to Annex I habitats and Annex II species. Other important species which are not included under these Annexes are protected through horizontal measures which support the protection of these species or restoration of habitats on which they depend. In some cases specific action plans targeting the conservation of particular species may also be drawn up depending on the vulnerability of the species.

Figure 4.5: The *Arundo donax* taking up large extents of the watercourse.
Photo credit: AIS environmental, 2014

3. Wied tal-Lunzjata

Wied tal-Lunzjata forms the upper part of Wied Xlendi and its diverse habitats attract a large and diverse avifauna. In fact this area serves as a staging post for a number of migratory birds. Wied tal-Lunzjata is one of the few remaining valleys of the Maltese Islands with a permanent freshwater supply. Various species that are associated with this freshwater habitat are found in the valley bed, and these are very rare and/or endemic and/or found only in a few other localities or are restricted to Wied ix-Xlendi valley system.

Natura 2000 area:	**Xlendi Wied tal-Kantra Area**
SAC Code:	**MT0000020**
Longitude:	**14.2147**
Latitude:	**36.0314**
Area of SAC [ha]:	**296.3**
Area of catchment:	**6.18 km2**
Length of watercourse:	**0.645 km**

(i) The Hydrological Catchment

Wied il-Lunzjata is the upper portion of an extensive valley system that comprises Wied il-Lunzjata, Wied tax-Xlendi and numerous other tributaries. The system’s headwaters are at Ta’

Wied Ħmar at Kerċem, and the lower reaches of the valley exits on the coast within il-Bajja tax-Xlendi that is now built up. The Valley bed in the upper reaches lies below the spring line at the Upper Coralline Limestone and Blue Clay interface. This means that the upper part of the valley system is fed by springs originating from the perched aquifer of the Kercem-Rabat Plateau.

Figure 4.6: Wied Lunzjata and surrounding agricultural land
Source: AIS Environmental, 2014

(ii) Water Dependent Habitat and Water Dependent Species[96]

No Annex I water dependent habitats or Annex II species have been identified at Wied Lunzjata. Nevertheless Wied tal-Lunzjata's diverse habitats and availability of water all year round attracts a large and diverse avifauna, including crakes, rails, egrets and herons that are associated with thick reed growth along the stream bed; as well as harriers and honey buzzards, and flycatchers, warblers, chats, thrushes, finches and buntings that are attracted to the dense vegetation cover mostly provided by carob trees.

Plant species include *Phragmites australis, Apium nodiflorum*, the rare *Apium graveolens, Ranunculus muricatus, Mentha pulegium* and *Rumex spp*. A small number of individual *Populus alba** trees are found further downstream.

Important fauna dependent on water include the only known Maltese population of *Haemopis sanguisuga (*Horse leech*)*; the best population of the Maltese freshwater crab *Potamon fluviatile lanfrancoi* (Figure 4.7) in Gozo; the only population of *Planorbis moquini (*a freshwater snail*)*; very good populations of the otherwise rare *Physa acuta (*another freshwater snail*)*; the

[96] Species names with an asterix indicates that they are referred to in Article 4 of Directive 2009/147/EC and listed in Annex II of Directive 92/43/EEC

endangered *Pseudamnicola melitensis (*a brackish water snail endemic to Malta*)* and *Mercuria cf. similis* (freshwater snail which may be present as an endemic form); and a small population of *Pisidium* pea-mussels that are otherwise known from another two localities in the Maltese Islands. Furthermore, the valley system also provides adequate breeding ground for *Discoglossus pictus pictus (*the Maltese painted frog*)* (MEPA, Natura 2000 Data form).

Figure 4.7: The *Potamon fluviatile lanfrancoi* (Maltese Freshwater crab)
Source: MEPA Photo Bank, 2010

4.2.2. Standing Waters of ecological significance

1. Il-Qattara

Il-Qattara is a tiny permanent freshwater pool located on the west coast of Gozo, near the Dwejra inland sea (Figure 4.8). The pool is on the periphery of the Qawra solution subsidence structure. The original pool is said to have been modified since large stones have been placed around its perimeter. In the 1940s and 1950s the pool was used as a water source for animals brought to the valley depression to graze by herders. Today the pool is no longer used for such purposes but has been subject to the introduction of alien species such as the Goldfish (*Carassius sp.)* and the Western Mosquito fish (*Gambusia affinis*).

Natura 2000 area:	**L-Inhawi tad-Dwejra u tal-Qawra**
SAC Code:	**MT0000019**
Longitude:	**14.1939**
Latitude:	**36.0489**
Area of SAC [ha]:	**86.93**
Area of water body:	**0.0001 km2**

(i) The Hydrological Catchment

The pool at Qattara is located on the Blue Clay formation and immediately adjacent to a Lower Coralline Limestone outcrop. The freshwater pool is replenished by surface water runoff that culminates at the area of the pool from the nearby valley system and also by percolating water within the surrounding Lower Coralline Limestone.

(ii) Water Dependent Habitats and Species

As a result of the perennial supply of water, the habitats, flora and fauna of the area are quite atypical from the rest of the larger SAC. The ledges of the pool lying just below the linear seepage of the freshwater that percolates the Lower Coralline Limestone formation support an assemblage of species which are typical of shady, humid habitats, such as the maidenhair fern (*Adiantum capillus-veneris)*; the brooklime (*Samolus valerandi*); the moss (*Eucladium verticillatum)*; and the endemic Żigland t'Għawdex *Hyoseris frutescens*, which is usually found in more xeric habitats (MEPA 2012, Natura 2000 Standard Data form).

The freshwater pool is dominated by the endemic Maltese horned pond-weed, *Zannichellia melitensis*; and the charophyte, *Chara globularis*; and a number of vascular plants which are only partially submerged; characterizing the Habitats Directive Annex I habitat of Hard oligo-mesotrophic waters with benthic vegetation of *Chara spp*.

The banks of the pool are characterised by various wetland species, including the galingale, *Cyperus longus*; the round-headed club-rush, *Scirpoides holoschoenus*; the otherwise critically endangered wild celery, *Apium graveolens*; the clustered dock, *Rumex conglomeratus*; the pennyroyal, *Mentha pulegium*; the slender centaury, *Centaurium tenuiflorum*; a single individual of the very rare white willow, *Salix alba* (a planted species); various grasses and leguminous plants; and a small *Nerio-Tamaricetea* community, based upon *Tamarix africana* (MEPA 2012, Natura 2000 Standard Data form).

Figure 4.8: The very small Qattara pool located in the Dwejra area, Gozo
Source: MEPA Photo bank 2007

The perennial supply of water also houses an array of threatened species, including a number of species confined to this locality like the critically endangered beetles *Augyles maritimus* associated with muddy edges of Il-Qattara, and Aulacochthebius exaratus. Other important species include the beetles *Ochthebius celatus, Octhebius dilatatus, Potamonectes cerisyi* and *Siagona europaea*; the amphipod *Orchestria gammarellus*; the freshwater spire-snail *Mercuria* cf. *similis*; and the dwarf pond-snail, *Lymnaea truncatula*; all of which are threatened due to the lack of their habitat and consequently have a very restricted distribution in the Maltese Islands. The Painted Frog, *Discoglossus pictus pictus* is also known from this area.

The availability of freshwater during the summer months also attracts birds such as the spectacled warbler (*Sylvia conspicillata)*; the corn bunting (*Miliaria calandra*); the short-toed lark (*Calandrella brachydactyla)*; and the blue rock-thrush (*Monticola solitarius*); which breed in the Dwejra area.

2. L-Għadira ta' Sarraflu

The Għadira ta' Sarraflu is a freshwater pool located on the cliffs located along the southwestern coast of Gozo. It does not fall within the NATURA 2000 network but has been designated as a Special Area of Conservation of National Importance and an area of Ecological and Scientific Importance by GN 112 of 2007 and GN 288 of 1995.

Longitude:	**14.3461**
Latitude:	**35.9719**
Area of water body:	**0.044 km2**

(i) The Hydrological Catchment

The pool of freshwater collects within a steep-sided depression created by the subsidence of the surface of Upper Globigerina Limestone due to subsequent accelerated erosion of the underlying softer Middle Globigerina Limestone. The pool is permanent.

Figure 4.9: The Għadira ta' Sarraflu pool located in a subsidence depression.

(ii) Water Dependent Habitats

The habitat that depends on the water environment at the Għadira ta' Sarraflu is the Southern Riparian galleries and thickets (*Nerio-tamaricetea and Securinegion tinctoriae*).

(iii) Water Dependent Species

The pool is inhabited by the native painted frog, *Discoglussus pictus pictus*. However similar to Il-Qattara, a number of introduced alien species can be found competing with the native species, such as the Bedriaga's frog *Rana bedriagae,* terrapins, Goldfish *Carassius sp.,* and mosquito fish *Gambusia sp.*

The margins of the pool are dominated by the African Tamarisk (*Tamarix africana)* which has self-regenerated since its plantation.

4.2.3 Heavily modified Marshlands of ecological significance

1. Is-Salini

This site is one of the last remaining salt marshes in the Maltese Islands. The area incorporates the salt marsh, saltpans, and a canal (Refer to figure 3.1) which skirts the saltpans on either side. This canal, known as Tas-Sokkorsu, provides freshwater to the marsh. The site supports a number of endemic flora and fauna, as well as a considerably large number of rare, endangered and locally threatened species.

Natura 2000 area:	**Is-Salini**
SAC Code:	**MT0000007**
Longitude:	**14.4225**
Latitude:	**35.9469**
Area of SAC [ha]:	**23.67**
Area of water body:	**0.028 km2**

(i) The Hydrological Catchment

The hydrological catchment that drains into is-Salini comprises 14 interlinked watercourse tributaries which extend more than 11 kilometres to the west, across Dingli, Rabat, Naxxar, and St Paul's Bay. The catchment is one of the main water catchments in Malta covering a total area of 40km^{2,} traversing the north central stretch of the main island. The sub-catchments are all scheduled areas of High Landscape Value. The drainage system has three main branches:

- Wied Qannotta draining Wardija Ridge
- Għajn Rihana and its tributaries
- Wied il-Għasel comprising of six valleys draining the northeastern part of the Rabat-Dingli plateau.

(ii) Historical Hydromorphological alterations

Is-Salini, following the dredging and reclamation of the marshes at Marsa in the 19th century, became the largest marshland in the Maltese Islands. In the past, it used to be more extensive but was reduced due to reclamation of the upper stream area of Burmarrad for health (malaria/Anopheles is now extinct from the Maltese Islands) and agricultural aspects. Other parts were later developed, such as the Ta' Mattew area where a freshwater stream was known to occur supporting a population of the brackish water snail *Melanoides tuberculata*.

Construction in the area had completely obliterated this stream and the snail is now extinct. Some parts of the marshland was also afforested and turned into a recreational area (Kennedy Grove).

Figure 4.10: Is-Salini Salt pans, coastal Lagoon and salt marsh
Source: MEPA Photobank, 2010

(iii) Water Dependent Habitats

The following Annex I water dependent habitats are found at Is-Salini:

1150* – Coastal lagoons
1310 – Salicornia and other annuals colonising mud and sand
1410 – Mediterranean salt meadows
1420 – Mediterranean and thermo-Atlantic halophilous scrubs
92D0 – Southern riparian galleries and thickets.

Figure 4.11: Is-Sokkorsu water canal encircles the salini salt panels and provides a marshland habitat.
Source: MEPA Photobank, 2010

(iv) Water Dependent Species

The Salini area is also ecologically important for the endemic fauna it supports. Most of these are typical of salt marsh areas and some have only been recorded at this site. A number of endemics reported from this locality are the Maltese Top Snail (*Trochoidea spratti*) and *Muticaria macrostoma*, both locally protected.

One particular species of importance is the native Killifish (*Aphanius fasciatus*), a small euryhaline fish. (Refer to Figure 4.12). The Salini population of Aphanius is the only naturally known occurring species in the Maltese Islands. The populations at Għadira and Simar, two other protected areas under this registry were introduced. The Marsa populations were eradicated when the marshland was dredged and reclaimed. Therefore the population at Salini is considered to be very important since it represents one of the only 2 autochthonous populations of the species.

The life cycle of this species does not include dispersal phases and therefore gene flow between different populations is very limited (Deidun *et al*., 2002). As a result, the species presents a high degree of morphological and genetic differentiation between different populations.

Figure 4.12: The native Killifish (*Aphanius Fasciatus)*
Source: MEPA Photobank, 2010

Another species of importance is the Eurasian Reed Warbler (*Acrocephalus scirpaceus*). This species is a common autumn migrant and nests in the *Phragmites australis* reedbed, its preferred nesting habitat. It is a scarce breeding visitor but is also known to nest at the Simar Wetland Reserve.

2. IL-Magħluq ta' Marsaskala

The il-Magħluq ta' Marsakala represents one of the few extant marshland communities in the Maltese Islands. The site is characterised by two brackish pools, originally utilized as fishponds until the mid-20th century. The site is rich in rare, threatened/ or endemic species. The site is also home to the rare *Miktoniscus melitensis*, a woodlouse known from soil samples from this area and L-Għallis.

Natura 2000 area:	**Il-Magħluq tal-Baħar ta' Marsaskala**
SAC Code:	**MT0000023**
Longitude:	**14.5625**
Latitude:	**35.8622**
Area of SAC [ha]:	**4.42**
Area of water body:	**0.006 km2**

(i) The Hydrological Catchment and hydromorphological alterations

Originally il-Magħluq tal-Baħar was a saline marshland that developed at the mouth of the Wied ta' Sant Antnin. It is possible that in the early 17th Century the marsh was excavated to create a series of fishponds to store fish brought in by fishers or before sale. These fishponds have limestone block walls.

The fishponds receive water from valley runoff and also from the sea. The connection between the ponds and the sea was restricted when a road was constructed skirting the head of Marsascala Bay. Today the connection between the sea and the ponds are two narrow culverts running under the road. Lack of circulation often results due to the fact that the culverts are often blocked by accumulated silt and debris, severely restricting water flow for long periods of time leading to hypoxic and sometimes even anoxic conditions.

The surrounding catchment is urbanized, particularly the eastern side (Figure 4.13). The western edges are agricultural and only a few patches of marshland occur at the back of the ponds. In 1977 there were unsuccessful attempts to regenerate the marshland vegetation. Two smaller pools were in fact excavated at the back of the ponds, further modifying this already heavily modified environment.

Figure 4.13: An aerial photo of the Magħluq ta' Marsaxlokk (red box) indicating fishponds and road skirting Marsascala Bay, limiting the water body's connection to the sea.

(iii) Water Dependent Habitats

The following Annex I water dependent habitats are found at Il-Magħluq tal-baħar:

1150* – Coastal lagoons
1410 – Mediterranean salt meadows

(iv) Water Dependent Species

The site is typified by populations of the locally very rare beaked tassel-pondweed, *Ruppia maritima* whilst the banks of the ponds and the northern part of the area support one of the only two Juncetalia maritime communities of the Maltese Islands typified by the sea rush, *Juncus maritimus*, a vulnerable species on a national scale (Figure 4.14). The vulnerable water snail, *Hydrobia ventrosa* and a small population of the endangered Killifish, *Aphanius fasciatus** are also found in this water body.

Figure 4.14: The sea rush, *Juncus maritimus*, a vulnerable species on a national scale found at Il-Magħluq
Source: MEPA Photobank 2009

3. Il-Ballut ta' Marsaxlokk

The Ballut ta' Marsaxlokk is one of the few remaining salt marshes in the Maltese Islands. This marsh is important for a number of invertebrates associated with saline marshlands, including beetles and gastropods, some of which have a restricted distribution in the Maltese Islands. It is also important because the plant communities here show a remarkable difference from those found in the northern part of the island, suggesting a restricted distribution of the biota found in the area.

Natura 2000 area:	**Il-Ballut ta' Marsaxlokk**
SAC Code:	**MT0000014**
Longitude:	**14.5511**
Latitude:	**35.8406**
Area of SAC [ha]:	**23.3**
Area of water body:	**0.012 km2**

(i) The Hydrological Catchment and historical alterations

Il-Ballut ta' Marsaxlokk was originally a series of fishponds which were dredged to make way for a quay in the 1950s. It eventually developed into a marshland owing to the presence of a seasonal watercourse which develops after the rains and drains the land northeast of the coast, bringing freshwater into the marsh.

The mouth of this *wied* was developed into fishponds. These were later abandoned in the late 19th Century and in the 1950s were dredged to make way for a quay. In the early 1990s habitat engineering works were undertaken to create a marshland habitat. The area with the remaining pools was excavated and deepened and some agricultural land adjacent to the pool area was excavated to create more pools. Culverts were also laid connecting the marsh to the sea.

This setup allows for the ponds to fill up with water and experience cycles of alternating hypohaline and hyperhaline conditions depending on the season. In recent years the pools dry up immediately after the wet season ends, implying that direct connection with the sea has been lost due to blocked culverts.

Figure 4.15: The dried-up marshland of il-Ballut ta' Marsaxlokk located in the vicinity of the sea.

Apart from anthropogenic engineering works which affect the marshland, coastal erosion is also altering the water body. Erosion is mostly dominant in the narrow strip of beach that separates the marshland from the sea. Aerial photos of the marshland and beach over the past decade reveal a progressive retreating marsh. A human-made embankment to protect the marshland from direct sea water intrusion started in 1991 by the Society for the Study and Conservation of Nature in collaboration with the then Environment Protection Department. Whilst it is evident that in some parts, wave action may result in the deposition of sediments and suspension, in other areas wave action has eroded the same human embankment as the aerial snap shots over time indicate below (figure 4.16)

Figure 4.16: Coastal erosion at il-Ballut ta' Marsaxlokk over the last decades
Source: MEPA map server (1994, 2004, 2008 and 2012) and Google Map (2014)

(iii) Water Dependent Habitats and Species

The following Annex I water dependent habitats (Figure 4.17) are found at Il-Ballut ta' Marsaxlokk:

1310 – *Salicornia* and other annuals colonising mud and sand
1410 – Mediterranean salt meadows
1420 – Mediterranean and thermo-Atlantic halophilous scrubs

Figure 4.17: The lagoon when it is filled with water during the wet months.

The various habitat types listed above harbour a number of marshland and brackish water species, some of which are known only from this site or from very few other localities in the Maltese Islands. There are no Annex II species but a number of invertebrate species listed in the Red Data Book (RDB) have been recorded on site (Standard Data Form, 2012), which are of conservation importance.

Flora found in this saline marshland include the Sea Rush *Juncus maritimus* (which is only found here and at Marsascala; the Sea-side Sea-lavender *Limonium virgatum*, and the Glasswort *Salicornia ramosissima*. A population of the Sea Purslane *Halimione portulacoides* was transplanted here in a rescue operation as the original site where this species occurred is now built over, while seeds of the endangered Long-bracted Sedge *Carex extensa* have been planted. Tamarisk (*Tamarix africana*) and *Atriplex halimus* shrubs were planted on the embankment in order to stabilise it, and Lesser Reed (*Phragmites australis)* now grows along the embankment.

The woodlouse *Armadilloniscus littoralis*, the flies *Nemotelus brachystomus* and *Aphaniosoma grisescens*, and the beetle *Brachygluta simplex hipponensis* are presently known only from this site, while the beetles *Tachys dimidiatus,* *Bembidion normannum mediterraneum*, *Dichirotrichus obsoletus* and *Cyclodinus minutus*, the earwig *Labidura riparia*, the False scorpion Garypsus beauvoisi and the cricket *Tartarogryllus burdigalensis* have a restricted distribution in the Maltese Islands.

This marsh is also an important site for brackish water snails; it is one of only two localities for the Spire-snail *Hydrobia acuta*, while three other species of brackish water snails (*Paludinella littorina, Ovatella firminii* and *Auriculinella bidentata*) have been recorded from this marsh and the associated pools in the past, but may now be extinct from this locality.

4. Is-Simar

Is-Simar is a coastal wetland representing one of the few saline marshlands left in the Maltese Islands. The wetland was a former natural coastal wetland which formed at the mouth of Wied il-Pwales but was artificially recreated into a bird reserve by engineering works. It is important as it provides an adequate habitat for the killifish, *Aphanius fasciatus* (Annex II, Habitats Directive) which is locally restricted to a few places and threatened. Apart from the legal designation in GN 170 of 2006 as an area of Ecological and Scientific Importance, the site was also declared a Nature Reserve in 1991 and a Wetland of International Importance under the Ramsar Convention in 1996.

Natura 2000 area:	**Is-Simar (limiti ta' San Pawl il-Bahar)**
SAC Code:	**MT0000006**
Longitude:	**14.3794**
Latitude:	**35.9464**
Area of SAC [ha]:	**58.38**
Area of water body:	**0.032 km2**

(i) The Hydrological Catchment and historical alterations

Is-Simar receives runoff from the Pwales valley and the surrounding high ground. It was once also connected to the sea at St. Paul's Bay, however marine input is now limited due to the construction of a coast road that skirted the head of St. Paul's Bay. Today the only connection to the sea is via a drainage canal which passes underneath the road. This reduced connection to the sea has altered the dynamics of the ecosystem and established lagoon conditions and fluctuating physicochemical conditions such as salinity, temperature, Dissolved oxygen and pH. The water depth, based on one year data, varies from 1.35m during the wet season to 0.8m during the dry summer months.

The Simar was formerly a natural coastal wetland that formed at the mouth of the Wied il-Pwales. It was later engineered into a bird reserve. Until the 1980s the Simar site was neglected and through silting from surrounding agricultural land, the marshland was reduced to a small saline wetland. In 1992 the former Environment Protection Department together with an NGO initiated excavation works to create an artificial permanent lagoon with different water depths and islands (figure 4.18), becoming an important bird reserve.

Figure: 4.18: The lagoon and bird reserve of Is-Simar with several islands and varying water depths.

(ii) Water Dependent Habitats and species

The following Annex I water dependent habitats are found at Simar:

1150 Coastal Lagoons

3170 Mediterranean temporary ponds

Figure 4.19: A bird hide near one of the pools at the Simar Bird reserve.

Is-Simar wetland provides an adequate habitat for the killifish, *Aphanius fasciatus* (Annex II, Habitats Directive) which is locally restricted to a few places and threatened. It is to be noted, however, that *Aphanius fasciatus* never occurred naturally at Is-Simar and the population there was established from that at L-Ghadira, itself a mixed population.

Small areas bordering the wetland were planted with rare riparian species, mostly typical of the *Populion albae* community. In addition, the wetland area provides adequate habitat for a number of migratory bird species: especially rails, bitterns, moorhens and warblers that are associated with reeds. Is-Simar is one of the few places in the Maltese Islands where such migrating birds can stop to rest and feed.

5. L-Għadira

The area constitutes a wetland with a brackish water pool that becomes increasingly saline in summer but does not dry out. The wetland present provides an adequate habitat for the Killifish, *Aphanius fasciatus,* and is a breeding and a resting retreat for migratory birds, especially waders, rails, bitterns, moorhens and reed-associated warblers.

Natura 2000 area:	**L-Inħawi tal-Għadira**
SAC Code:	**MT0000015**
Longitude:	**14.3461**
Latitude:	**35.9719**
Area of SAC [ha]:	**97.74**
Area of water body:	**0.044 km2**

(i) The Hydrological Catchment and historical alterations

The Għadira water body has been heavily modified over the years. Today Għadira is a bird reserve which includes two interconnected pools surrounded by saline marshland and other non-wetland habitats, including plantations and a remnant sand dune. The area is enclosed within an artificially constructed ditch and embankment.

Għadira was not always a permanent water body. Prior to the engineering works, a pool of water used to form in the centre of the Għadira marsh during the wet season by accumulated rainwater from the surrounding high ground and also partly from incursion of seawater directly from Mellieha bay. During the dry season the pool would evaporate and leave salt deposits in the soil. In the mid-16th Century this characteristic permitted the natural marshy depression to be used for the manufacture of salt by collecting the crystallized salt. In the mid-19th Century, under British rule, Għadira was turned into a game reserve and from the mid-20th Century until the 1960s the Government leased the land to private individuals for bird shooting. In the mid-1960s the coast road was constructed bypassing the marshy area and in 1978, after a campaign to declare the area protected due to its importance as a stopover point for migrating birds, the area was declared a Bird Sanctuary (Ecoserv, 2008).

In 1978 the marsh was converted into an engineered bird reserve and in 1980 the habitat engineering work began. This consisted of creating a deep central pool that would retain water all year round and a smaller pool adjacent to it on the side of the marsh furthest from the sea. A ditch and embankment to contain the pools and bird reserve were also constructed. Small islands were also constructed (Figure 4.19).

Figure 4.20: The two artificially engineered pools of the Ghadira bird reserve together with artificial islands constructed in the late 1970s.

The hydromorphological modifications carried out at Ghadira brought about significant changes to the hydrological regime of the area. Permanent pools were formed with a fluctuating water level, affecting the previous biota of the marsh. Some species were eliminated such as the alga *Vauchria* (Ecoserv, 2008). Other populations declined (such as the macrophyte, *Ruppia drepanesis*). Other species started to appear (such as the green algae*, Cladophora*). *Cladophora* depletes oxygen supply in the water exacerbating the eutrophication process during late spring and summer.

(ii) Water Dependent Habitats and Species

The following Annex I water dependent habitats are found at Għadira:
1150 Coastal Lagoons
1310 Salicornia and other annuals colonising mud and sand
1410 Mediterranean salt meadows
1420 Mediterranean and thermo-Atlantic halophilous scrubs

Apart from the Annex II *Aphanius Fasciatus* which can be found at Ghadira, the bird reserve is rich in macrofaunal species. According to a study (Barbara and Schembri, 2005) carried out in 2005 a total of 121 macrofaunal species were identified from the pool edges and the pool water. Barbara & Schembri (2005) found that the community structure had changed considerably since the Reserve was studied 19 years previously (Borg *et al*, 1990); some species such as the gastropod *Ovatella myosotis* were not found, other species such as the isopod *Sphaeroma sp*. and the gastropod *Truncatella subcylindrica* were represented by very few specimens, and there were new additions to the macrofaunal community, for example the palaemonid shrimp *Palaemonetes antennarius.*

Biota of conservation importance occurring within the Għadira bird reserve includes the Lesser Tassel-pondweed *Ruppia drepanensis*, the Long-horned grasshopper *Odontura stenoxipha*, and a number of wasps and beetles.

Some flora were transplanted within the boundaries of L-Għadira as a rescue operation; these include the Sea Purslane *Halimione portulacoides*, an unidentified species of Sea Lavender *Limonium sp.,* both of which rescued from Ras ic-Cagħaq in Delimara prior to the construction of the Delimara Power Station, and the Long-bracted Sedge *Carex extensa*, transferred to the reserve from the saline marshland at Il-Ħofra near to l-Għadira.

4.2.4. Marine Protected Areas (areas 12-16 in Figure 4.1 above)

1. Marine zone between Rdum Majjiesa to Ras-Raħeb

The site is designated as a Special Area of Conservation - Candidate Site of International Importance via Government Notice 112 of 2007, as declared through the provisions of the Flora, Fauna and Natural Habitats Regulations of 2006 (Legal Notice 311 of 2006).

Natura 2000 area:	**Zona fil-Baħar Bejn Rdum Majjiesa u Ras ir-Raħeb**
SAC Code:	**MT0000101**
Longitude:	**14.3267**
Latitude:	**35.9247**
Area of MPA [ha]:	**848.72**
Habitats for which site was designated:	**Posidonia oceanica, Reefs, Sand banks and caves**
WFD Coastal waterbody:	**MTC 109**

(i) Habitat types and related species dependent on water

The site hosts representatives of the main marine habitat types occurring in the Maltese Islands, with the associated biotic assemblages including species and ecosystems of conservation importance. Meadows of the seagrass *Posidonia oceanica* dominate large areas of the seabed within the 50 metre bathymetric region. These meadows are found on bedrock and on sand, where some areas produce thick matte walls allowing for colonisation by an array of photophilic algae. *Posidonia oceanica* meadows support a large variety of organisms of conservation interest, such as the bivalve *Pinna nobilis* (noble pen shell), species of economic importance, such as *Octopus vulgaris*, as well as a number of demersal fish species.[97]

The seagrass *Cymodocea nodosa* is also abundant at the site. Its meadows are among the most extensive around the Maltese Islands. C. *nodosa* forms a major association with the biocoenosis of fine sands, but has also been recorded on Blue Clay and Globigerina bedrock covered by thin layers of silt.

Phaeophytes (brown algae) cover a high percentage of the hard substrata in the site, with the most common species being *Cystoseira spinosa var. tenuior*, particularly in the shallower depths. At depths greater than 15 meters, associations of *Dictyopteris polypodioides, Cystoseira squarrosa* and *Sargassum vulgare* become more dominant.

The variety of marine habitats found provide important feeding, breeding and nursing grounds for many fish species, including demersal and predatory types. The rocky reefs and drop-offs attract shoals of large fish, such as *Sphyraena sphyraena* (Barracuda) and *Seriola dumerili (*Greater amberjack*)*; as well as solitary species like the *Epinephelus marginatus* (Dusky grouper) and *Dasyatis spp.* (Stingray).

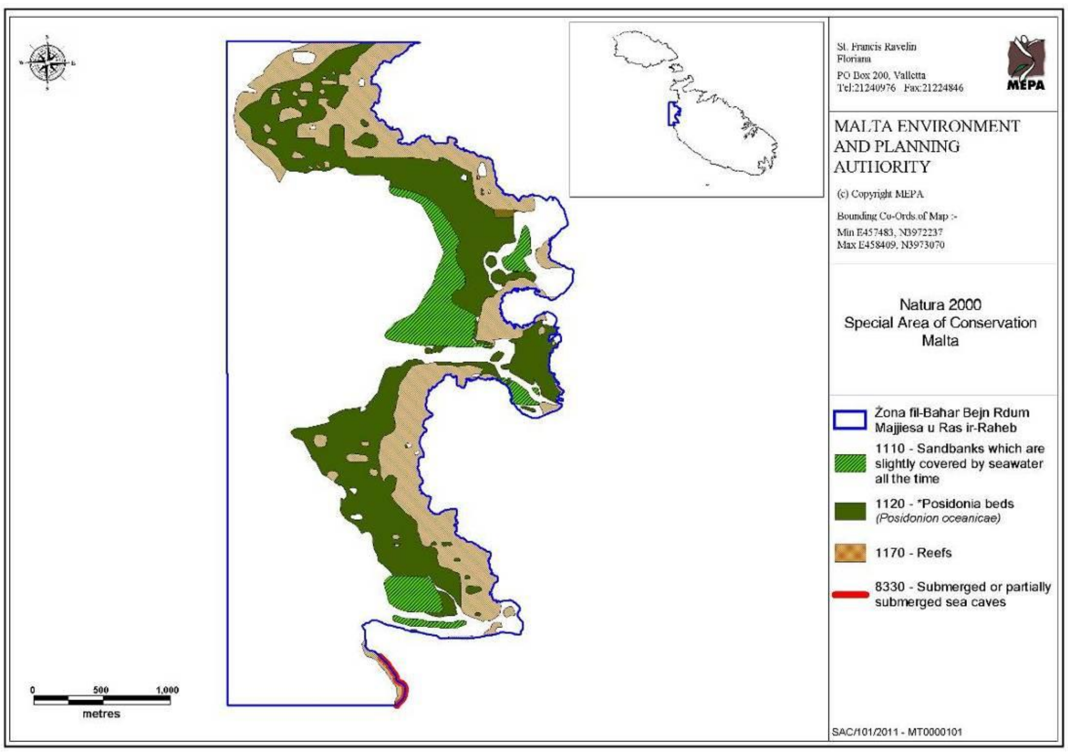

Figure 4.21 Marine Protected Area extending from Rdum Majjiesa to Ras ir-Raħeb.
Source: MEPA 2012, Natura 2000 Standard Data form

[97] http://www.mepa.org.mt/impnatareas-pas-int-n2k-dsmap

(ii) Ecological quality status of waters as monitored under the WFD

Monitoring of the biological quality elements (BQEs) established under Water Framework Directive at the WFD surveillance monitoring site (CS09) resulted in a **high quality status** for all elements. These BQEs include macroalgae, *Posidonia oceanica*, benthic invertebrates and phytoplankton.

2. Marine area at Mġarr ix-Xini

The site is designated as a Special Area of Conservation of International Importance via Government Notice 851 of 2010, as declared through the provisions of the Flora, Fauna and Natural Habitats Regulations of 2006 (Legal Notice 311 of 2006).

Natura 2000 area:	**Zona fil-Baħar fl-Inħawi ta' Mġarr ix-Xini (Għawdex)**
SAC Code:	**MT0000104**
Longitude:	**14.2733**
Latitude:	**36.0186**
Area of MPA [ha]:	**30.56**
Habitats for which site was designated:	***Posidonia oceanica***
WFD Coastal waterbody:	**MTC 103**

(i) Habitat types dependent on water

The *Posidonia oceanica* present within this site comprises small patches with average shoot densities. The shoots have an average of 5 leaves and heavy epiphytic growth. In the mouth of the inlet the *Posidonia* sp. has a shoot density approximately three times as that of other patches found within this site, and an average of 6 leaves per shoot. None of the *Posidonia* patches appear to possess a well developed matte. The *Posidonia* sp. meadows present within this site are semi-isolated since there is little continuity with meadows present in other coastal areas.

The biotopes present in the inlet and beyond its mouth are typical of ones found along the southwestern coast of the Maltese Islands where the prevailing bottom type is steeply sloping rock or consists of submarine cliffs with extensive forests of photophilic algae. Small populations of important fauna can be found, including populations of *Centrostephanus longispinus* (hatpin urchin) and *Scyllarides latus* (Mediterranean slipper lobster). The site also hosts the hermit crab and the gastropod *Phallium undulatum* at a shallower level than the normal depth at which they are generally found.

A significant area of reefs is occupied by an association with *Flabellia petiolata* and *Peyssonnelia squamaria*. Other important associations include that with *Dictyopteris polypodioides.*

(ii) Ecological quality status of waters as monitored under the WFD

Given the designation of the MPA was concluded after the adoption of Malta’s first Water Catchment Management Plan, monitoring of the biological quality elements (BQEs) established under the Water Framework Directive was not carried out within this area during the first Water Catchment Management Plan cycle. Monitoring has been considered for inclusion under the second plan.

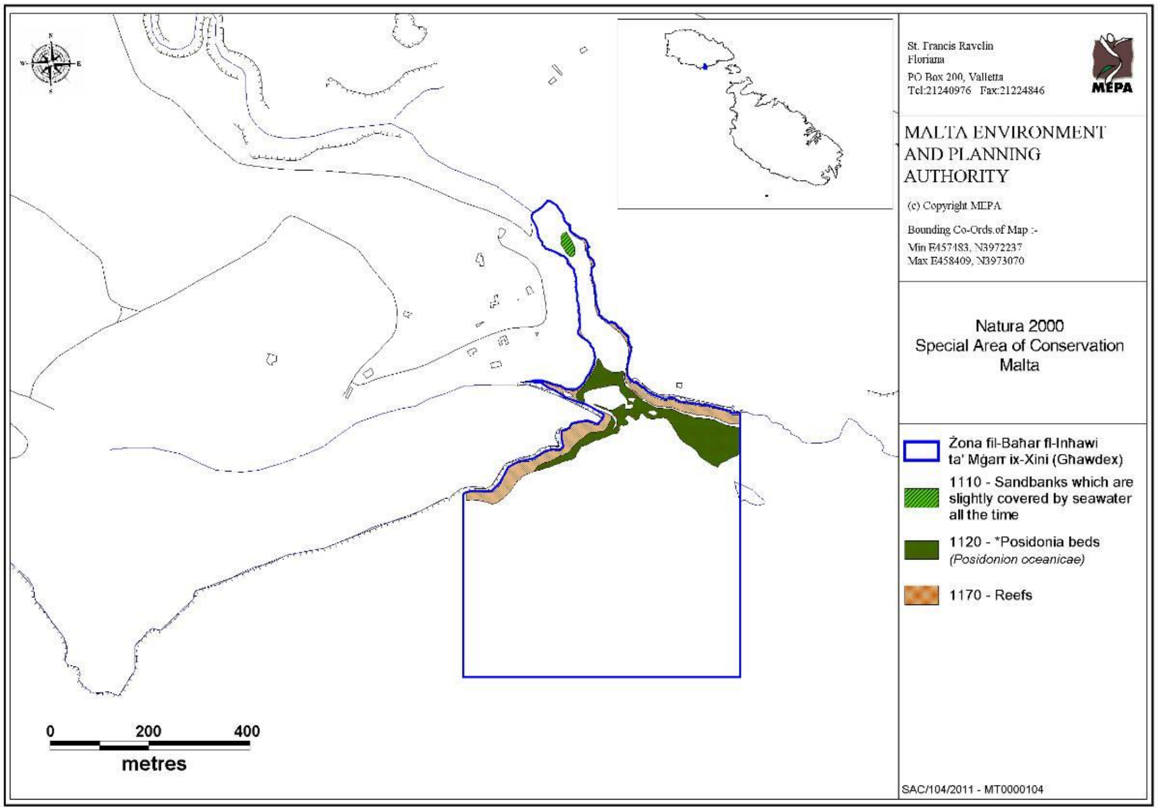

Figure 4.22: Marine area at Mġarr ix-Xini

Source: MEPA 2012, Natura 2000 Standard Data form

3. Marine zone between Għar Lapsi and Filfla

The site is designated as a Special Area of Conservation of International Importance via Government Notice 851 of 2010, as declared through the provisions of the Flora, Fauna and Natural Habitats Regulations of 2006 (Legal Notice 311 of 2006).

This marine site is afforded some degree of protection also under the Malta Maritime Act (Cap. 352): Government Notice 173 of 1990 (issued under the auspices of Legal Notice 117 of 1975 – Berthing Regulations) refers to an area of one nautical mile radius around Filfla. Unless authorised, no vessel or boat or other craft, may be berthed, moored or anchored and no person may swim or carry out any kind of activity connected with underwater diving or sea sport. This does not apply to activities connected with fishing carried out directly from a vessel, boat or any other craft.

Natura 2000 area:	**Żona fil-Baħar fl-Inħawi ta' Għar Lapsi u ta' Filfla**
SAC Code:	**MT0000102**
Longitude:	**14.4217**
Latitude:	**35.8008**
Area of MPA [ha]:	**2450.51**
Habitats for which site was designated:	***Posidonia oceanica* beds**
WFD Coastal waterbody:	**MTC 108**

The marine area around Filfla has been shortlisted by the Structure Plan for the Maltese Islands as a candidate Marine Protected Area (MPA). The islet itself is a strict nature reserve and a Natura 2000 site (MT0000016), whereas both the islet and its surrounding marine area are considered as an Important Bird Area (IBA) of EU Importance by BirdLife Malta. (The islet of Filfla is also considered a Global Important Bird Area by BirdLife International.)

Despite the fact that most of the marine species recorded on site are common around the rest of the Maltese Islands; the site's location, the relatively high species richness and the relatively unpolluted waters of the site justify its protection. Indeed, this site hosts a rich and diverse biota, reflecting a heterogenous bottom.

(i) Habitat types dependent on water

Considering the *Posidonia* beds, from a survey carried out in 2002, it was discovered that in the Għar Lapsi area, the Posidonia bed's rhizome primary production values are amongst the higher values for the Mediterranean Sea. The high quality of the meadows was reconfirmed by the 2012/ 2013 WFD monitoring exercise carried out.

Furthermore, the general environmental conditions of the site were classified as normal and higher abnormal. The reefs that exist to the south of the island of Malta are in a very good status. Associations with *Cystoseira, Flabellia* and *Peyssonnelia* are relatively abundant in the area very close to Filfla.

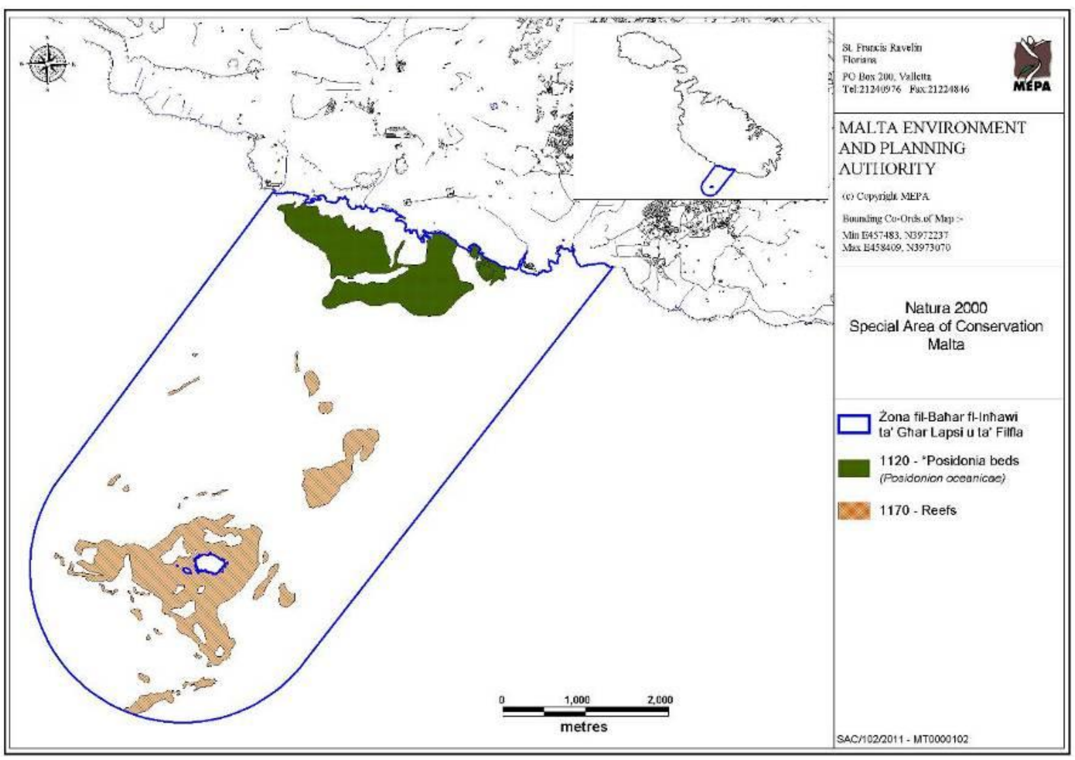

Figure 4.23: Marine Zone between Għar Lapsi and the islet of Filfla

Source: MEPA 2012, Natura 2000 Standard Data form

(ii) Ecological quality status of waters as monitored under the WFD

Monitoring of the biological quality elements (BQEs) established under Water Framework Directive at the WFD surveillance monitoring site (CS08) resulted in a **high quality status** for all elements. These BQEs include macroalgae, benthic invertebrates and phytoplankton. *Posidonia oceanica* was not monitored at monitoring point CS 08 due to the fact that no meadows grow at this point. However a national monitoring point located just off Għar Lapsi indicated that the status of the *Posidonia* meadows was **high**.

4. Marine area at Dwejra, Gozo

The site is designated as a Special Area of Conservation of International Importance via Government Notice 851 of 2010, as declared through the provisions of the Flora, Fauna and Natural Habitats Regulations of 2006 (Legal Notice 311 of 2006).

Natura 2000 area:	**Zona fil-Bahar fl-Inhawi tad-Dwejra (Ghawdex)**
SAC Code:	**MT0000103**
Longitude:	**14.1861**
Latitude:	**36.0525**
Area of MPA [ha]:	**228.61**
Habitats for which site was designated:	**Posidonia oceanica, caves and reefs**
WFD Coastal waterbody:	**MTC 101**

(i) Habitat types dependent on water

There is an extensive, though non-continuous, bed of *Posidonia oceanica* meadows within the area of 'Il-Bajja tad-Dwejra' (Dwejra Bay) where the sea-grass strands are dense and healthy. Small patches of the sea-grass also occur on bedrock in other parts of the area. The Posidonia oceanica meadows within this site are considered to be isolated since there is little or no continuity with meadows present in other coastal areas due to the prevailing deep water off most of the eastern coast of Gozo (Posidonia does not grow in deep waters).

A baseline survey on the extent and character of *Posidonia oceanica (L.) Delile* Meadows in the territorial waters of Malta was carried out in 2002. Following examination of various parameters during this Posidonia Baseline Survey, the meadow and the general environmental conditions have been classified as normal within this site. The *Posidonia* baseline survey used the Pergent *et al*. (1995)[98] system to provide an indication of 'status' of *Posidonia* meadows. The system proposed by Pergent *et al*. uses certain parameters associated with *Posidonia* meadows as indicators of water quality similar to the PREI index (e.g. depth, density, epiphytic coverage etc…) The parameters measured for *Posidonia* meadows in this area in accordance with Pergent *et al*. (1995) during the *Posidonia* Baseline Survey (in 2002) indicate that the meadows were considered 'normal', implying a healthy status/good condition".

[98] Pergent-Martini, C. and Pergent, G. 1994. Lepidochronological analysis in the Mediterranean seagrass *Posidonia oceanica*: State of the art and future developments. Oceanologica acta, 17(6): 673-681

Pergent, G., Pergent-Martini, C. and Boudouresque, C. F. 1995. Utilisation de l'herbier a Posidonia oceanica comme indicateur biologique de la qualite' du milieu littoral en Mediterrane: etat des connaissances. Mesogee. 54: 3-27.

In a more recent Dwejra survey carried out in 2004 stated the following in relation to *Posidonia* meadows at Dwejra: *There is an extensive but non-continuous bed within Il-Bajja tad-Dwejra area where the stands are dense and healthy. Small patches of the seagrass also occur on bedrock in other parts of the area. The P. oceanica meadows in the Dwejra/Qawra area are considered to be isolated since there is little or no continuity with meadows present in other coastal areas due to the deep water present off most of the western coast of Gozo*. Therefore the 2004 survey, while indicating a small decrease in the coverage of *Posidonia* meadows, is also confirming the healthy status/good condition of such meadows within this area.

Marine invertebrates associated with the *Posidonia oceanica* meadows include numerous species of molluscs, polychaetes, crustaceans and echinoderms that seek refuge in the leaf canopy and root-rhizome layers, hence being quite inconspicuous. Additionally, several species of sponges, corals, sea urchins, sea stars, crabs and anemones occur within this site. Of particular note is the existence of small populations of *Pinna nobilis, Centrostephanus longispinus* and *Scyllarides latus*, and *Epinephelus marginatus* which is frequently encountered by divers.

(ii) Ecological quality status of waters as monitored under the WFD

Monitoring of the biological quality elements (BQEs) established under Water Framework Directive at the national monitoring station (CN01-1) resulted in a **high quality status** for all elements. These BQEs include macroalgae, benthic invertebrates *Posidonia oceanica* and phytoplankton.

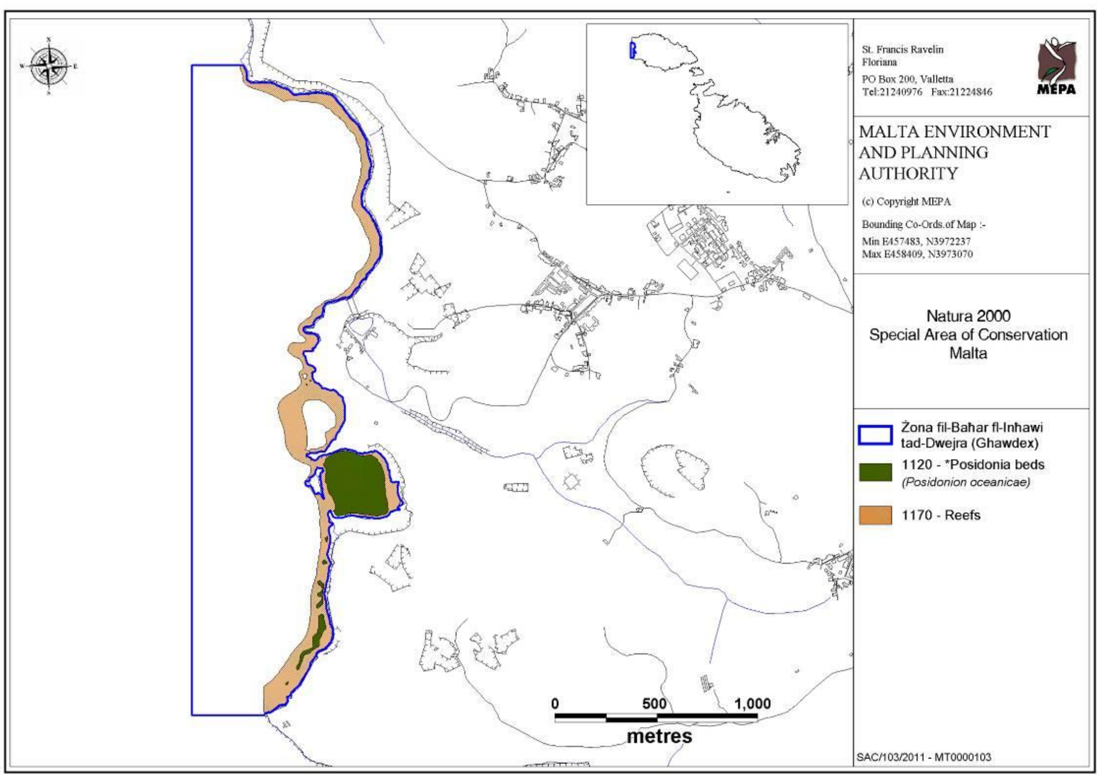

Figure 4.24: Marine Area at Dwejra

Source: MEPA 2012, Natura 2000 Standard Data form

5 Marine area in the North East of Malta

The site is designated as a Special Area of Conservation of International Importance via Government Notice 851 of 2010, as declared through the provisions of the Flora, Fauna and Natural Habitats Regulations of 2006 (Legal Notice 311 of 2006).

Natura 2000 area:	Żona fil-Baħar fil-Grigal ta' Malta
SAC Code:	MT0000105
Longitude:	14.3911
Latitude:	36.0139
Area of MPA [ha]:	15519.4
Habitats for which site was designated:	*Posidonia oceanica* beds, sand banks, caves and reefs
WFD Coastal waterbody:	MTC 102, 103, 104

(i) Habitat types dependent on water

This area hosts the largest variety of *Posidonia* sp. sub-types when considering the marine sites selected to form part of the Natura 2000 Network, with the representativity of each being considered superior. The subtypes present in this site are the following:

- *Posidonia* sp. settled on matte, whose meadows are normally continuous and having a high density;
- *Posidonia* sp. settled on rock, showing a reticulate distribution of dense strands;
- *Posidonia* sp. settled on sand, with continuous beds generally showing low densities and variable percentage cover;
- Mosaic morphology, intermixed between *Posidonia* sp., *Cymodocea nodosa* and coarse sand, showing a reticulate structure;
- Ecomorphosis of 'barrier reef' *Posidonia* sp. meadows. The *Posidonia* sp. meadows within this site are also known for a high degree of connectivity, as well as percentage coverage.

From the data available through the *Posidonia* Baseline Survey carried out in 2002, it is evident that *Posidonia* meadows in various parts of this site are very abundant and healthy. This was reconfirmed by the 2012/ 2013 WFD monitoring exercise carried out. They are dense and show a high degree of shoot density, particularly in White Tower Bay, which appears to host probably the highest shoot density in the Mediterranean. The site is also known for the deepest records where *Posidonia* sp. grows, namely off the south coast of Comino. However, in some areas within this site, such as at Mistra Bay and at Mellieha Bay, the beds are showing signs of regression as a result of anthropogenic activities.

Reefs have been identified within this site, occurring on hardbeds and rocks. The following subtypes occur within this site: -

- reefs with associations of *Dictyopteris polypodioides*; -
- reefs with associations of *Halopteris scoparis* and *Padina pavonica*; -
- reefs with associations of *Flabellia petiolata* and *Peyssonnellia squamaria*; -and
- reefs with associations of *Cystoseira* spp.

Amongst the important habitats within this site is the mäerl bed off which is characterised by five species of coralline algae: *Lithothamnion minervae*, *Phymatolithon calcareum*, *Lithothamnion corallioides, Lithophyllum racemus* and *Mesophyllum alternans*
Lithothamnion minervae was the most abundant rhodolith-forming species present at this mäerl bed. *Lithothamnion corallioides* and *Phymatolithon calcareum* are listed in Annex V to the Habitats Directive.

Gibbula nivosa, which is considered as the only endemic marine mollusc of Malta, and is listed as having a vulnerable status and a restricted distribution within Maltese waters, is also present within this site. *Gibbula nivosa* has been found on *Posidonia oceanica* leaves and under stones.

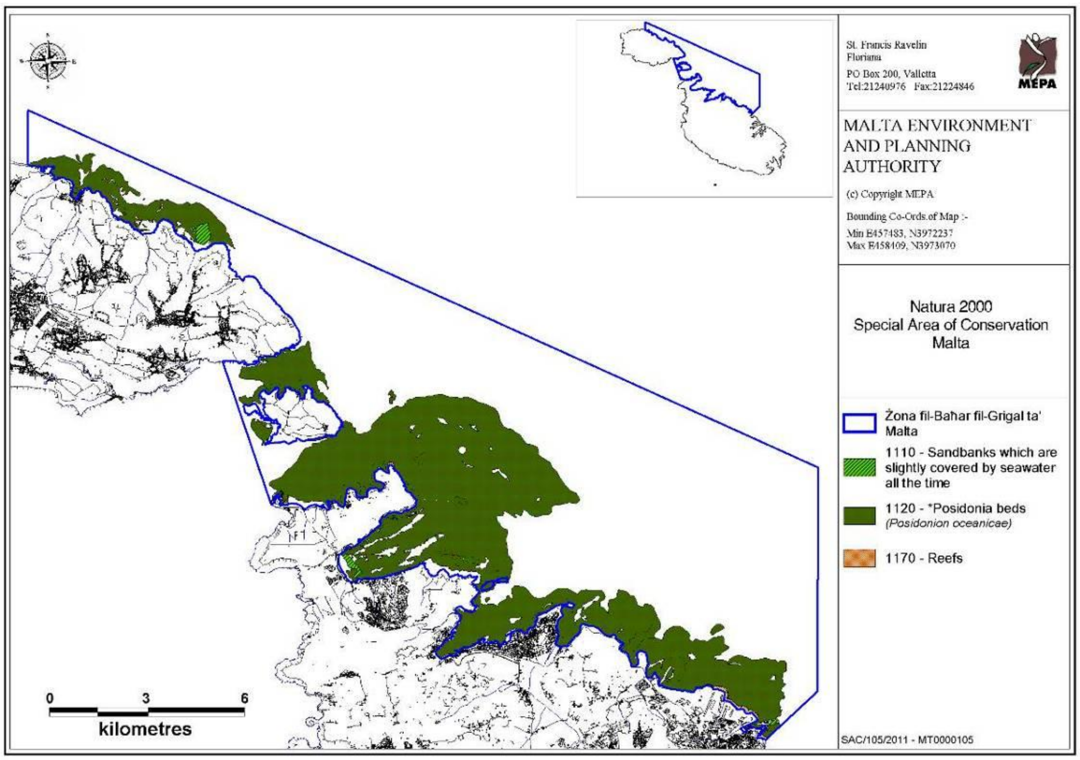

Figure 4.25: Marine area in the North East of Malta
Source: MEPA 2012, Natura 2000 Standard Data form

(ii) Ecological quality status of waters as monitored under the WFD

This extensive Marine Protected Area covers stretches of three coastal water bodies designated under the Water Framework Directive. Three WFD surveillance sites along the stretch provide an indication of the ecological status of this Marine Protected Area. Despite the high incidence of coastal activities in this stretch of coast, the ecological status of the water resulted to be mainly of high status. Monitoring stations (CS02 – located off Ramla l-Hamra) and (CS 03 – located in the Comino channel) both resulted in a high quality status for all BQEs. The ecological status of the biological quality elements at the third monitoring station (CP04-2) located off Qawra point resulted to be of high status except for phytoplankton. This BQE was of good status (Refer to Chapter 6).

4.3 Bodies of water designated as recreational waters, including areas designated as bathing waters under the Bathing Water Directive

A requirement of the Bathing Water Directive 2006/7/EC is to achieve specific mandatory water quality standards for the protection of bathers. The objective for Bathing Water protected areas is to achieve a bathing water class of at least 'sufficient' by the end of 2015.

The Bathing Water Directive has been transposed into Maltese legislation through the **Management of Bathing Water Quality Regulations, 2008** (LN125/08, as amended). In total there are 36 coastal bathing areas around the Maltese Islands, where water quality[99] is monitored and classified in accordance with the requirements of the Bathing Water Quality Directive. The total number of monitoring points for bathing waters is 86 and their location is shown in table 4.1.

Apart from these designated bathing areas, Transport Malta has also defined 26 swimming zones around the Maltese Islands. The purpose of these swimming zones is to guarantee the safety of bathers. Not all identified swimmer zones are within the bathing area identified by the EHD. TM has identified a number of swimmer zones also in harbour areas where bathing in such areas is not recommended.

Figure 4.27: Għajn Tuffieha Bathing Area (MTC 109)

The bathing water quality monitoring programme

The bathing water monitoring programme is carried out by the Health Inspectorate Services within the Environmental Health Directorate (EHD). As part of the management programme, environmental health officers carry out routine site-inspections so as to check for any sources of pollution. Any public complaints are investigated and in case of doubt extra samples are

[99] Water Quality under the Bathing Water Directive refers to microbiological quality whereby two parameters are measured. These are Escherichia coli and Intestinal enterococci counts.

collected and sent for analysis at the public health laboratory. In the case that visual evidence of pollution is noted, the effected site is temporarily closed for bathing.

During the bathing season, the EHD issues a weekly report with the classification for each bathing area based on the Escherichia coli and Intestinal enterococci counts. A star rating weekly report using the new sign and symbols as per Commission Implementation Decision 2011/321/EU is also issued on a regular basis. . The raw data is posted on a weekly basis on the EHD webpage.[100]

Copies of these reports are sent by e-mail to all those who requested to be on the Directorate mailing list and to all local councils. All bathing areas monitored are clearly identified by fixed information signs, in 5 languages, indicating the site code and stating that the area is monitored by the EHD on a regular basis. If there is a need to temporarily close any of these areas, a temporarily closure sign is attached at the same site and the information is again provided in 5 languages.

Current status of Bathing Water protected sites

Bathing water quality has improved significantly over the years (Refer to Figure 4.26 for classification of bathing water status from 2005 - 2014). All protected bathing areas have achieved the objectives of the revised Bathing Water Directive 2006/7/EC whereby **excellent water quality** was reported at all sites over the 23 week monitoring period during 2014.

Furthermore, 29 bathing water profiles[101] have also been developed by the Environmental Health Directorate, whereby any pressures with a potential of impacting the quality of these waters are indicated through the continuous monitoring of microbiological quality parameters at these sites. Details of these Bathing site profiles are provided in table 4.6 below.

Each bathing water profile provides a general description of the bathing waters and surrounding areas, a location of the bathing area and the monitoring points; a land-use map and the water quality classification over 4 years (2009-2012). An update is also published for all 29 bathing water profiles following the publication of the Commission Bathing Water Report. Thus since the development of these bathing water profiles 2 up-dates have been published i.e. covering data for 2010-2013 and 2011-2014. Existing pressures for each site are also described and mitigation measures identified. Contact information in the case of a pollution incident within a bathing area is provided for each bathing profile.

[100] http://health.gov.mt/en/environmental/Pages/Health-Inspectorate/Environmental-Health-Risk-Management/Bathing-Water-Programme.aspx

[101] https://ehealth.gov.mt/healthportal/public_health/environmental-health/health_inspectorate/env._hlt._risk_management/bathing_water_profiles_report.aspx

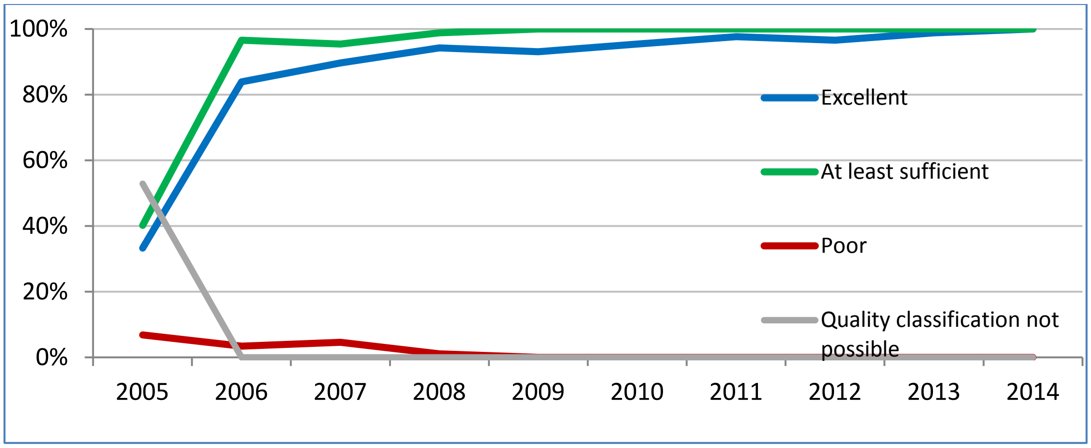

Figure 4.27: Bathing water quality in the Maltese Islands 2005 – 2014

Source: European Environment Agency, 2015

Bathing water profile	WFD water Body	Site
Profile 1	MTC 106	Xgħajra (2 Bathing water sites)
Profile 2	MTC 106,107	Marsascala (3 bathings sites) , St. Thomas Bay (2 bathing sites)
Profile 3	MTC 107	Birzebbuġia (7 bathing sites)
Profile 4	MTC 108	Żurrieq (consisting of 1 bathing site)
Profile 5	MTC 108	Għar Lapsi (consisting of 1 bathing site)
Profile 6	MTC 104	Baħar ic-Cagħaq (consisting of 1 bathing site)
Profile 7	MTC 104	Pembroke (1 bathing site)
Profile 8	MTC 104	St. George's Bay – St. Julian's (2 sites), St. Julian's (1 site)
Profile 9	MTC 104	Spinola Bay (2 sites); Balluta Bay (2 sites), Sliema front (2 sites)
Profile 10	MTC 104	Sliema (4 bathing sites)
Profile 11	MTC 109	Ġnejna (1 bathing site)
Profile 12	MTC 109	Għajn Tuffieha (2 sites); Golden Bay (2 sites)
Profile 13	MTC 109	Anchor Bay (1 site)
Profile 14	MTC 103	Ċirkewwa (2 sites)
Profile 15	MTC 103	Armier and Little Armier (2 bathing water sites)
Profile 16	MTC 104	Mellieħa Bay (5 bathing water sites)
Profile 17	MTC 104	Mistra Bay (2 sites); and - St. Paul's Bay (3 sites)
Profile 18	MTC 104	St. Paul's Bay (4 sites)
Profile 19	MTC 104	Buġibba (3 sites)
Profile 20	MTC 104	Qawra (4 sites); Salini (1site)
Profile 21	MTC 103	Southern Gozo (3 sites)
Profile 22	MTC 101	Xlendi (4 sites)
Profile 23	MTC 101	Dwejra (1 site)
Profile 24	MTC 102	Marsalforn (2 sites)
Profile 25	MTC 102	Marsalforn (4 sites)
Profile 26	MTC 102	Ramla (2 sites), San Blas (1 site); Daħlet Qorrot, Nadur Area
Profile 27	MTC 103	Ħondoq ir-Rummien and Żewwieqa Bay, South East Gozo (2 sites)
Profile 28	MTC 103	Blue Lagoon Comino (1 site)
Profile 29	MTC 103	San Niklaw, and Santa Marija Bay Comino (2 bathing water sites)

Table 4.1: A list of the 29 Bathing Water Profiles together with their respective WFD coastal water monitoring bodies

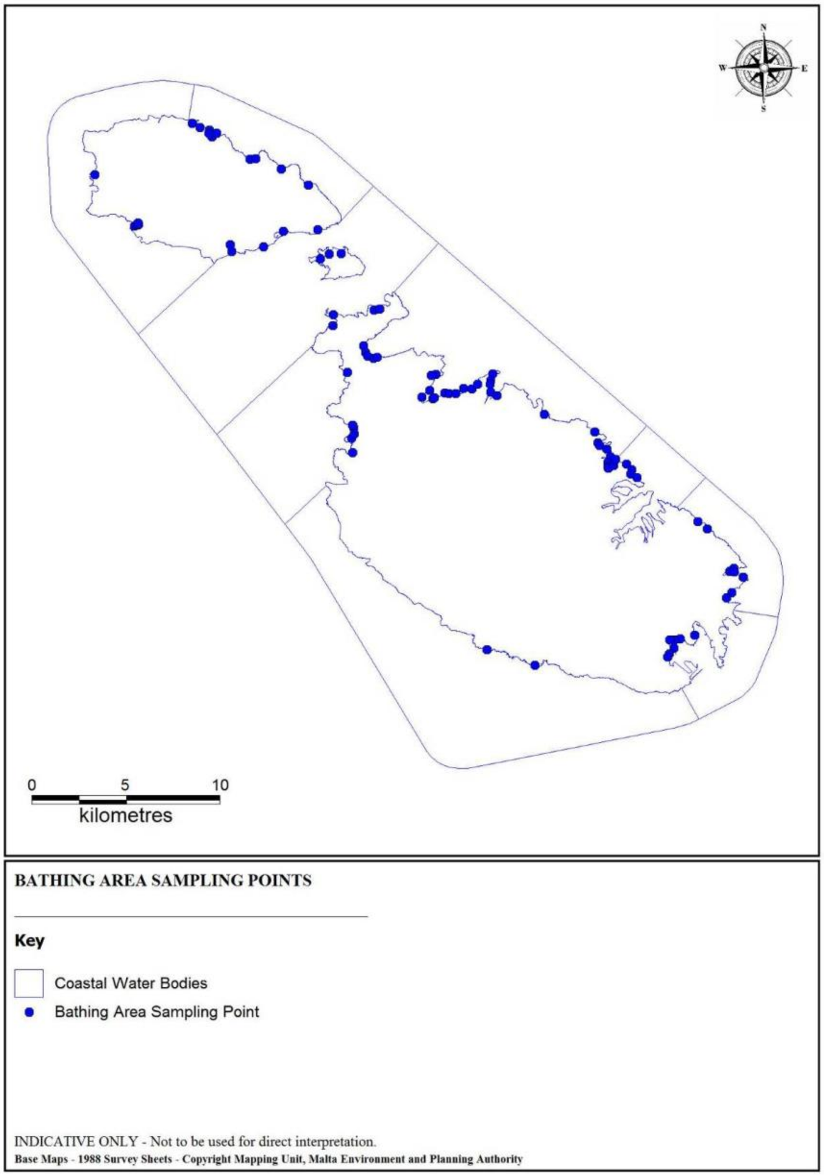

Figure 4.28: The 87 bathing area monitoring points in the Maltese Islands as monitored by the Environmental Health Directorate during the bathing season

4.4 Nutrient sensitive areas, including areas designated as vulnerable zones under Directive 91/676/EEC and areas designated as sensitive areas under Directive 91/271/EEC

There are two types of nutrient-sensitive protected areas, reflecting the two major sources of nutrients in the water environment – sewage and agricultural fertilisers.

1. **Areas that have been designated under the Urban Waste Water Treatment Directive (91/271/EEC)**

The general objective of the Urban Waste Water Treatment Directive is to protect the environment from the adverse effects of sewage discharges from urban and industrial conglomerates. The Urban Waste Water Directive was transposed through the Urban Waste Water Treatment Regulations, 2001 (LN340/01).

Sensitive areas are those waters which are considered vulnerable to eutrophication if they are receiving areas for Urban waste water discharges and fall under any of the following categories:

- Freshwater bodies, estuaries and coastal waters which are eutrophic or which may become eutrophic if protective action is not taken;
- Surface freshwaters intended for the abstraction of drinking water which contain or are likely to contain more than 50 mg/l of nitrates;
- Areas where further treatment is necessary to comply with other Council Directives such as the Directives on fish waters, on bathing waters, on shellfish waters, on the conservation of wild birds and natural habitats, etc.

The emission standards for discharges to a UWWTD designated Nutrient Sensitive Protected Area must be achieved within seven years of the designation of that area. The first set of UWWTD nutrient sensitive sites of the Maltese Islands were designated through Legal Notice 120/2005 'Urban Waste Water Treatment (Amendment) Regulations, 2001.' These are listed in table 4.2 below and their location is mapped in Figure 4.27.

Implementation of the Urban Waste Water Treatment Directive in Malta

All agglomerations in the Maltese Islands meet the requirements stipulated for collection systems. These collection systems are subject to continuous improvements and extensions to replace or supplement old parts of the sewerage network to serve the ever growing urbanisation and development needs.

All waste water is now being treated at three waste water treatment plants located at Mgarr ix-Xini, Gozo; Malta North; and more recently Malta South, at Ta' Barkat. The sludge generated by the treatment plants is being aerobically or anaerobically stabilised, dewatered and disposed to landfill. The treated waste water is currently being discharged directly to sea or via a pipe diffuser but there are plans and ongoing projects that are investigating the full reuse potential of this effluent.

The Highly Polished Reclaimed Water Master Plan for the Maltese Islands commissioned in 2012 will involve the installation of equipment aimed at further polishing the treated effluent generated at the UWWTPs that is currently being discharged to sea. It is envisaged that a large proportion of the reclaimed water will be used for secondary water purposes; whilst the possibility of artificial recharge is currently being studied with the Sustainable Energy and Water Conservation Unit within the Ministry for Energy and Health (Energy).

Related WFD water body	Monitoring Point	Urban Waste Water Sensitive Area Name
MTC 107	CN 07-2	Marsaxlokk Bay
MTC 106	CN 06-1	Marsakala Bay/Wied il-Għajn Bay
MTC 105	CN 05-1, CN 05-2	Marsamxetto and the Grand harbour
MTC 109	CS09, CN 09-1	Qammieh Point till Ras ir-Raħeb
MTC 103	CN 03-2	Mġarr Harbour
MTC 101	CN 03-1	Mġarr Ix-Xini
MTC 101	CN 01-2	Xlendi Bay
MTC 102	CN 02-1	Marsalforn Bay

Table 4.2: UWWTD Sensitive Areas as designated in 2005 and corresponding WFD Coastal water bodies together with the national Monitoring station codes used to assess nutrient status in nutrient sensitive areas

UWW Sensitive site	Sampling site	Notes on drivers/sources of nutrient pressures	WFD Physico-chemical quality	Status of WFD Biological quality element *			
			Nutrient concentrations in coastal water (based on one year data 2012-2013)	Macro-algae	*P. oceanica*	Benthic invertebrates	Phyto-plankton
Xlendi Bay	CN01-2	Exposed to diffuse sources of pollution rather than urban waste water discharge	Fluctuation in nutrients monitored in seawater. Nitrates peaked during spring season.	H	H	H	G
Marsalforn Bay	CN02-1	Exposed to diffuse sources rather and not specific to an UWWTP	Fluctuations in nutrient concentrations, often being below limit of detection. Nitrates peaked during Spring and late Summer after the first rains.		H	H	G
Mgarr Ix-Xini	CN03-1	Situated very close to the wastewater outfall of Ras il-Ħobz	Fluctuations in nutrient concentrations, often being below limit of detection. Nitrates peaked during Spring and late Summer after the first rains.	G	G	H	H
Mgarr Harbour	CN03-2	Monitoring station located in harbour where diffuse pressures come into play	Nutrient concentrations always low or below detection limit. One time nitrate peak during Spring 2013.	G		H	M
Marsamxett	CN05-1	Monitoring station located in harbour where diffuse pressures come into play	Peaks in nutrient concentrations associated with the winter season.	G		H	P
Marsascala	CN06-1	Located within a sheltered bay, exposed to diffuse sources and not solely to UWW discharges / downwind of South Treatment plant discharge	Nitrate peaks during spring and throughout winter.	H	G		M
Marsaxlokk	CN07-2	Subject to diffuse sources – agriculture and storm water runoff	Nutrient concentrations on average low or below detection limit. One time nitrate peak during Spring 2013.	M	M		M
	CP07	WFD Operational monitoring point	Nutrient concentrations on average low or below detection limit. One time nitrate peak during Spring 2013.	H	G	H	G
Qammieh point to Ras ir-Raheb	CN09-1	Located in the vicinity of the UWWTP at Cumnija	Nutrient concentrations generally low except for one time peak in Winter	M	G	H	G

Table 4.3: Status of Biological Quality elements in previous designated sensitive areas as monitored under the WFD

UWW Sensitive site	Designation of sensitive area under the Urban Waste Water Directive
Xlendi Bay	Removed from Sensitive area designation since it is no longer a receiving area in terms of Urban waste water discharges. Monitoring of nutrient contamination will be maintained as part of the Nitrates Directive monitoring framework.
Marsalforn Bay	Removed from Sensitive area designation since it is no longer a receiving area in terms of Urban waste water discharges
Mgarr Ix-Xini	Nutrient status indicates that the area is still vulnerable to nutrient enrichment occasionally however the site is not a direct receiving area of treated waste water
Mgarr Harbour	Removed from Sensitive area designation since it is no longer a receiving area in terms of Urban waste water discharges
Marsamxett	Removed from Sensitive area designation since it is no longer a receiving area in terms of Urban waste water discharges
Marsascala	Given that the sheltered bay is potentially affected by several sources of nutrient input (eg. agriculture, leisure boating and stormwater runoff), and the site is no longer a direct receiving area of urban waste water discharges, the site is no longer designated as a sensitive area under the UWWTD. The bay is however located within a sheltered bay, situated downstream of the prevalent currents from the discharge point at Ta' Barkat Urban Waste Water Treatment Plant. First comprehensive monitoring of three biological quality elements within the bay indicate that phytoplankton is of moderate status (based on very short term data), though macroalgae and *Posidonia oceanica* grasses are of high to good status. Monitoring of nutrient status will be maintained as part of the Water Framework Directive monitoring strategy.
Marsaxlokk	Removed from Sensitive area designation since it is no longer a receiving area in terms of Urban waste water discharges. Monitoring of nutrient contamination will be maintained as part of the Nitrates Directive monitoring framework.
Qammieh point to Ras ir-Raheb	Located in the vicinity of the UWWTP at Ċumnija. Monitoring results indicate vulnerability of site and therefore the site is to be maintained as a sensitive area until further monitoring indicates marked improvement (taking 2013/13 monitoring conditions as a baseline).

Table 4.4: Revision of Urban Waste Water Sensitive Areas

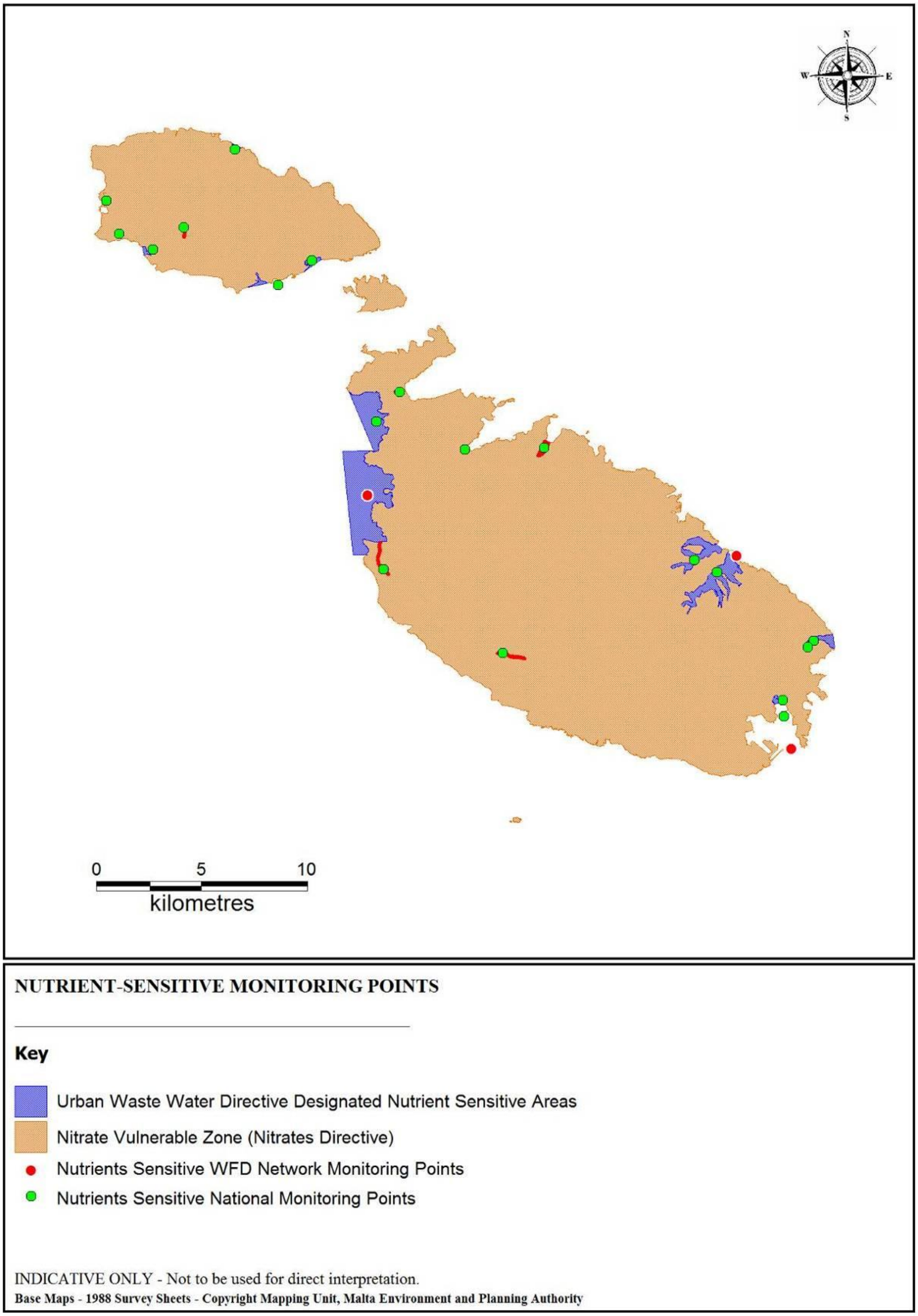

Figure 4.29: Monitoring points for nutrient sensitive areas as monitored under the first WFD Cycle.

4.5 Areas that have been designated under the Nitrates Directive (91/676/EEC)

Increased levels of nutrients in the water environment can bring about enhanced primary production or biomass production, algal blooms waters, and changes to the taxonomic composition of algae and plants. Enhanced primary productivity has effects on light climate, hence on biota, and increased fixation of carbon. The process of nutrient enrichment, especially compounds of nitrogen and/or phosphorous, leading to the effects described above, is termed 'Eutrophication'[102].

The general objectives of the Nitrates Directive is to reduce water pollution caused by nitrates from agricultural sources and prevent any further quality deterioration in these waters. The Nitrate Directive requires Member States to implement action programmes within 2 years of designating a Nitrate Vulnerable Zone (NVZ). Malta has designated the whole territory of Malta and Gozo as being nitrate vulnerable.

Following transposition through the **Protection of Waters against Pollution Caused by Nitrates from Agricultural Sources Regulations** (LN343/01; as amended) a key milestone in the implementation of the Nitrates Directive in the last few years was the development of the Nitrate Action Programme which was given legal effect by the **Nitrates Action Programme Regulations** (LN321/11, as amended). The aim of the Regulations is to implement the Nitrates Action Programme and to ensure compliance with the Nitrates Directive.

The current status of the Nitrate Vulnerable Zone and receiving waters is explained in both Chapter 2 and 6 of this plan.

4.6 Areas designated for the abstraction of water intended for human consumption

The Water Framework Directive identifies as 'protected areas' those bodies of water which are utilised for the abstraction of water intended for human consumption. In the Malta Water Catchment District the bodies of water used for such purpose are:

- Malta Mean Sea Level groundwater body
- Mgarr Perched groundwater body
- Mizieb Mean Sea Level groundwater body
- Gozo Mean Sea Level groundwater body

102 Definition extracted from Ferreira, J.G.; Andersen, J.H.; Borja, A.; Bricker, S.B.; Camp, J. ; Cardoso da Silva, M.; Garces, E.; Heiskanen, A.S.; Humborg, C.; Ignatiades, L.; Lancelot, C.; Menesguen, A.; Tett, P.; Hoepffner, N. & Claussen, U. Marine Strategy Framework Directive Task Group 5 report on Eutrophication. Joint Report Prepared under the Administrative Arrangement between JRC and DG ENV (no 31210 ² 2009/2010), the Memorandum of Understanding between the European Commission and ICES managed by DG MARE and JRC's own institutional funding; Editor: N. Zampoukas.

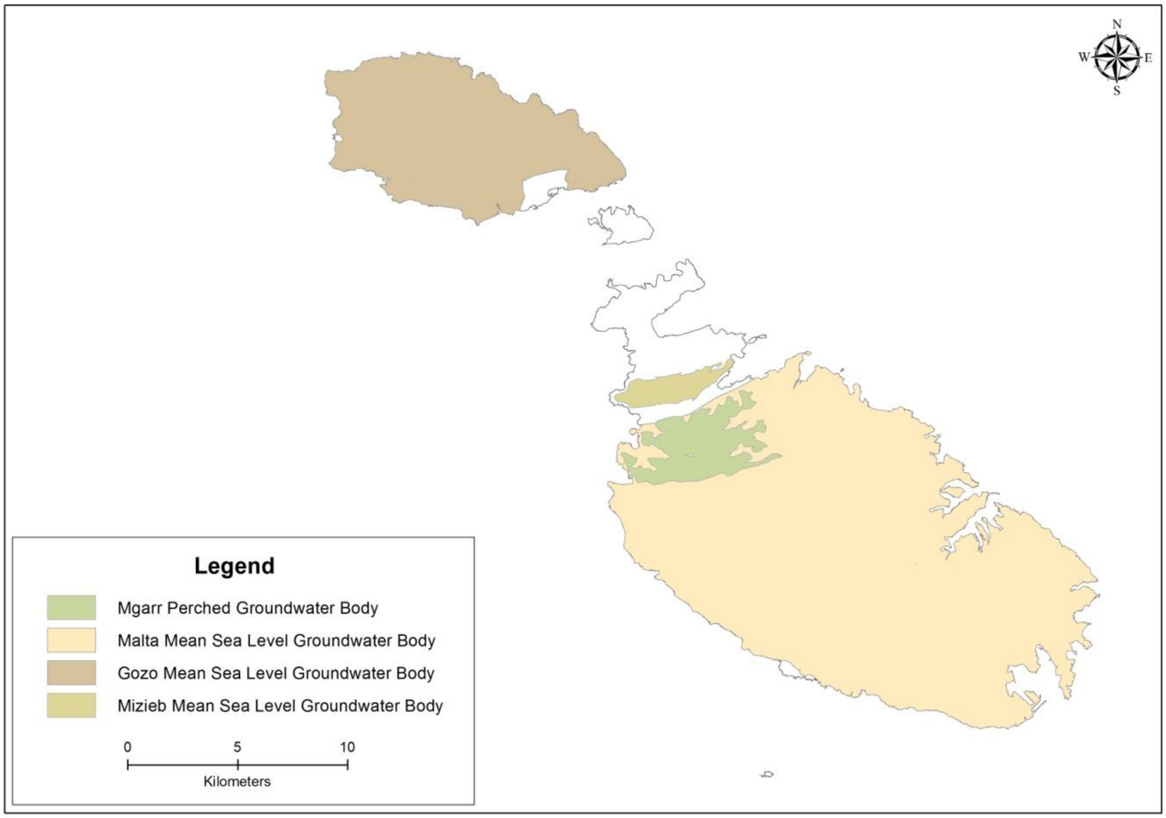

Fig 4.30: Groundwater bodies used for the abstraction of water intended for human consumption

Within these bodies of groundwater, safeguard zones have been established in which planning controls have been enacted. These safeguard zones have been established on the basis of the zone of influence (drawdown cone in the piezometric surface of the aquifer) around public groundwater abstraction sources, determined according to the Dupuit-Forchheimer well discharge equation.

The Dupuit-Forchhiemer equation is expressed as:

$$Q = \frac{\pi K(H^2 - h^2)}{\ln\left(\frac{R}{r}\right)}$$

where:
Q = groundwater abstraction rate
K = permeability of the aquifer formation
H = saturated thickness of the aquifer system
h = saturated thickness at the abstraction point
R = radius of influence
r = radius of the abstraction point

The calculation of this zone of influence therefore takes into consideration:
- the representative hydrodynamic properties of the aquifer system (coralline carbonate formation), and
- the highest groundwater abstraction rates operated by the Water Services Corporation, the public utility entrusted with the production of water for human consumption.

Under these conditions, the maximum zone of influence can be defined by the 300m radius around each groundwater abstraction source.

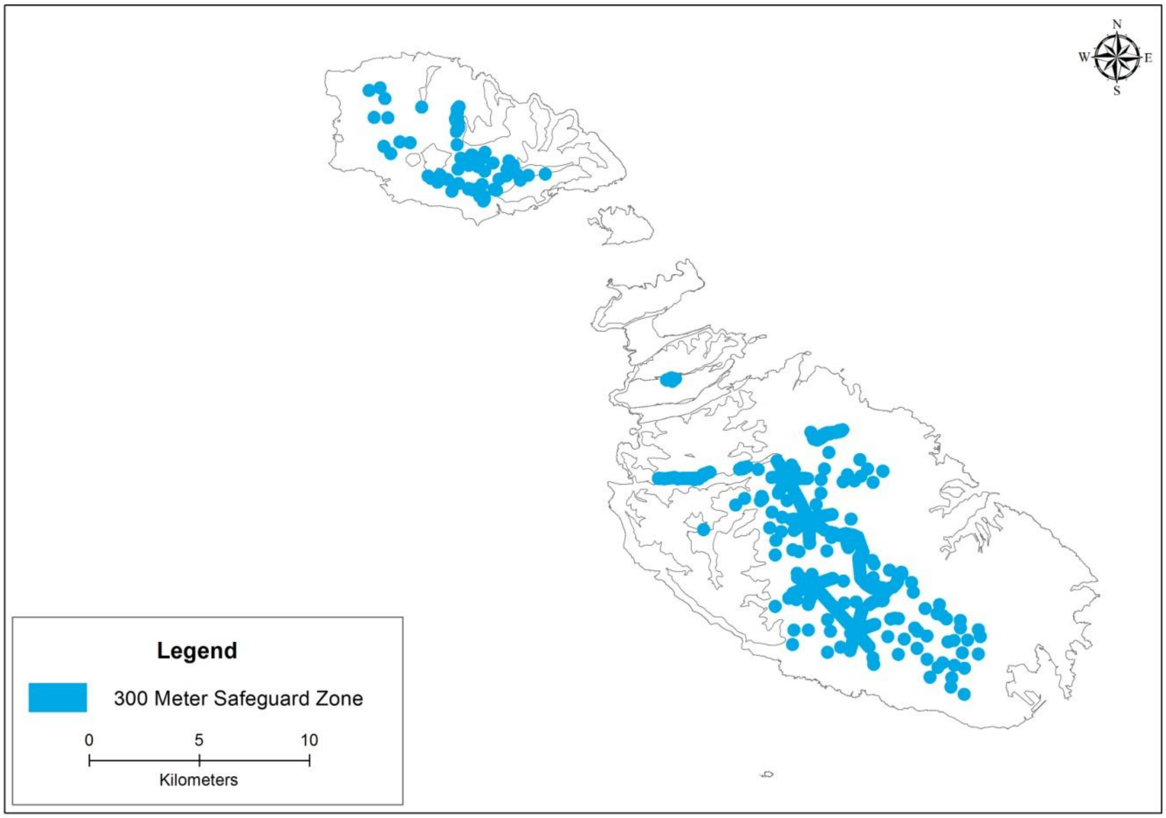

Figure 4.31: 300m groundwater safeguard zone around public groundwater abstraction stations

Three safeguard zones have been defined under national planning policies, marked by the 100m, 200m and 300m radius from public groundwater abstraction sources. Furthermore, a wider safeguard area merging together all the 300m safeguard areas has also been established. Planning controls have been established for each zone by the Planning Authority (MEPA) which include:

- the development of potentially highly polluting activities such as cattle farms and pig farms is not allowed within the 300m safeguard zone;
- the development of activities with a lower polluting potential such as poultry and sheep farms is not allowed within the 200m safeguard zone;
- all developments located within the 300m merged safeguard zones are required to implement additional pollution protection measures such as the additional lining of waste management facilities to limit accidental discharges.

The delineation of these zones is publicly available on the MAPSERVER of the Planning and Development Authority (www.mepa.org.mt/mapserver).

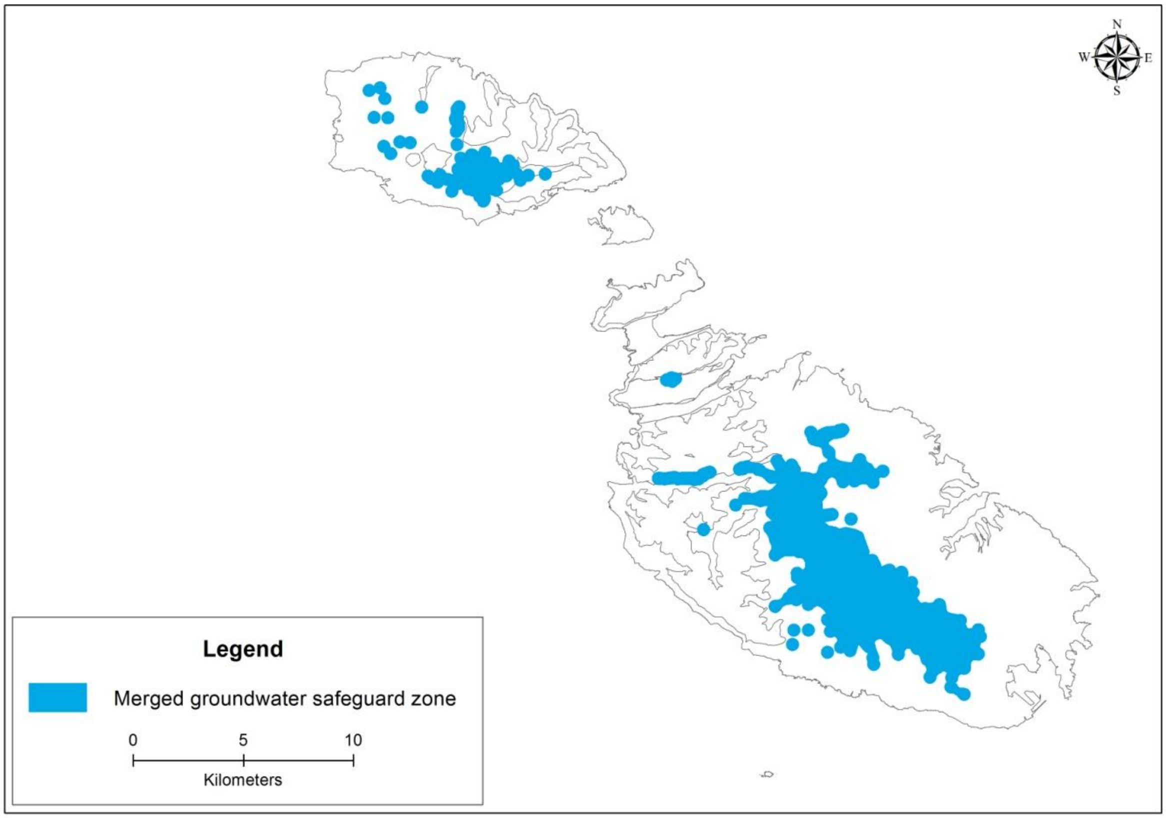

Fig 4.32: Groundwater safeguard zone established by merging the 300m zones of influence

It is further noted that from a land-use perspective the 100m, 200m, 300m and merged safeguard zones cover 4%, 10%, 18% and 23% respectively of the surface catchment area of the four groundwater bodies utilised for the abstraction of water intended for human consumption within the Malta Water Catchment District. Groundwater protection control policies are therefore applied to a significant proportion of the catchment area of these bodies of groundwater.

5. WFD Monitoring Networks

5.1 Evaluation of the Monitoring Programme for inland surface, transitional waters and related protected waters carried out during the 1st RBMP

Before the first WFD cycle, the monitoring of inland surface waters was limited only to occasional student dissertations and basic physico-chemical monitoring in the Ramsar protected sites (Simar and Ghadira) managed by the environmental NGO Birdlife. Therefore monitoring these waters under the first WCMP is considered to be the starting point for the Maltese Islands in our attempt to understand the complex dynamics these small waters. This one year monitoring is considered to provide a snap shot of the environmental characteristics of these waters. It has identified potential water quality and quantity issues and also additional data gaps related to the lack of knowledge on pressure and impact interactions with water dependent species and habitats. The monitoring programme also exposed the limited level of knowledge at a Mediterranean scale especially where water levels and water flows are highly dynamic and change drastically over a timeframe of just a few days.

5.1.1 Evaluation of monitoring strategy and resultant programme

The first monitoring efforts carried out in the inland surface and transitional waters served to highlight the practical problem areas when adapting classification methods used in other Member States, to the Maltese Islands. This lead to a revision of the monitoring programmes required to be in place for these waters. It is to be noted that the revision of the monitoring programmes is an iterative process and will be improved upon as more knowledge is gained from the execution of one monitoring programme to the next.

(i) Ecological Quality Monitoring Programme evaluation for Transitional Waters

The attempt to define ecological status in this water category was based on one critical biological quality element (benthic invertebrates) together with supporting physico-chemical and hydromorphological parameters. No classification methods were identified for the other relevant biological quality elements (i.e. macrophytes, phytobenthos, fish and phytoplankton). The second monitoring programme shall therefore consider indices that have been developed by Mediterranean Member States for macrophytes so that the classification of ecological status in these waters is improved.

TRANSITIONAL WATERS			
Biological Quality Elements			
BQE	**Available Med GIG method**	**Method applied to Maltese waters**	**Shortcomings and future monitoring recommendations**
Benthic Invertebrates	Not completed	Standard indices recommended for transitional water bodies, like M-Ambi and BITS index could not be applied due to atypical features of such water bodies in Malta. The Shannon-Weiner index was applied since it was claimed to be less sensitive to problems encountered in the local context and could provide an insight into the extent of the assemblages.	Monitoring results indicate that the Shannon-Weiner index is affected by fluctuations in physico-chemical parameters, particularly salinity and therefore a multi-index approach may need to be looked into.

Macrophytes and phytobenthos	France- *Exclame*, Greece – *EEI-c,* Italy – MaQI	Macrophytes and phytobenthos were assessed through detailed walk-over surveys. No assessment methods were applied.	Recommend applicability of the **MaQI – Macrophyte Quality Index** used in Italy be tested to assess status
Phytoplankton	Not completed	Composition and abundance of phytoplanktonic assemblage investigated using method UNI EN 15204:2006 by cell enumeration.	
Fish	No results	Killifish (*Aphanius fasciatus*) sampled using baited minnow traps and the number of fish, size of each specimen and gender was recorded. Visual observations of fish abundance were also noted.	Since no fish communities exist within these systems, the BQE 'Fish' as per WFD requirements cannot be assessed. Nevertheless monitoring of Killifish will be maintained and an additional fish species, the Grey Mullet, will also be assessed during the next monitoring programme.
Physico-chemical parameters			
Nutrients (eutrophication)	NA	The Trophic Index (TRIX) was applied to assess eutrophication	This method is commonly used for coastal lagoons but is unsuitable for shallow water systems where phytoplankton is not the only component of the primary producer community responding to increasing nutrient concentrations. The importance of sedimentary processes in shallow water systems is important with respect to mobilization of nutrient deposits and detection of secondary effects of eutrophication. Alternative indices therefore need to be looked into.
Hydromorphological Quality Elements			
Depth variation	NA	Water levels were taken per basin or channel per month but actual shape of the basin was not calculated	Any hydrological modifications brought about by dredging or accumulated sediment cannot be assessed due to this shortcoming.
Hydrological budget	NA	The possibility of a connection to a groundwater body was assessed	The actual hydrological budget in terms of freshwater inputs, exchanges with the sea, meteorological variables and water residence time were not assessed. Possible practical methodologies need to be identified.

Table 5.1: Applied methods together with identified related gaps and shortcomings and some recommendations in Transitional Waters

(ii) Ecological Quality Monitoring programme evaluation for Watercourses

The attempt to define ecological status in watercourses was also based on one critical biological quality element (benthic invertebrates) together with supporting physico-chemical and hydromorphological parameters. The method used during the first monitoring programme however, was found to be inadequate (refer to Table 5.2). In addition no classification methods were identified for macrophytes and phytobenthos. It was therefore acknowledged that the second monitoring programmes should consider a new method for benthic invertebrate assessment as well as new indices that have been developed by Mediterranean Member States for macrophytes so that the classification of ecological status in these waters is improved.

WATER COURSES			
Biological Quality Elements			
Quality Element	**Available Med GIG method for type RM5* (Temporary streams)**	**Method applied to Maltese waters**	**Shortcomings and any future monitoring recommendations**
Benthic Invertebrates	Cyprus - STAR ICMi method, Italy – MacrOper, Portugal – IptIN, IptIS), Spain – IMMi-T and IBMWP Slovenia – Ecological status ass system for rivers using benthic invertebrates	The **Extended Biotic Index** Method - has the advantage of providing the quality class of a given water body on the basis of the retrieved macro invertebrate assemblage	Method is highly influenced by presence/absence of sensitive indicator groups which are widespread in Alpine or mountain rivers but tend to rarefy downwards towards sea level. EBI calculated from these sites is therefore expected to be lower than the corresponding values from a given continental river, regardless of the actual pollution level. Several research papers on Mediterranean temporary streams recommend the use of the **ICMi** method or **IBMWP** method and should be investigated further. Morais et al (2004) also explored additional matrices used in a temporary stream context that should be investigated. *Morais. M., Pinto. P., Guilherme. .P., Rosado, J. and Antunes, I. 2004. Assessment of temporary streams: the robustness of metric and multimetric indices under different hydrological conditions in Hydrobiologia 516: 229-249*
Macrophytes and phytobenthos	The MMI method (developed by Cyprus) has recently been adopted. For **Phytobenthos:** Cyprus, Portugal and Spain - IPS, Italy – ICMi and Slovenia (national assessment method)	Macrophytes and phytobenthos were assessed through detailed walk-over surveys. No assessment methodology was applied.	Consultants recommend that during the upcoming monitoring programme the **IBMR Method - Biological Macrophytes Index for Rivers** used in Italy is applied to assess the status of Macrophytes. Recent attempts by Cyprus indicate that the **MMI** method (Multimetric Macrophyte Index method) developed by Cyprus is more appropriate for temporary streams. Although this method was considered to be unsuitable for purposes of status classification under Intercalibration, it was deemed to be a more useful tool to gauge the status of temporary waters.
Physico-chemical Quality Elements			
Nutrients (eutrophication)	NA	The Trophic Index (TRIX) was applied to assess eutrophication	This method is commonly used for coastal lagoons but is unsuitable for shallow water systems where phytoplankton is not the only component of the primary producer community responding to increasing nutrient concentrations. Also it is not known whether such an index can be applied to a temporary freshwater context.
! IMPORTANT NOTE – Physico-chemical parameters are subject to spatial and temporal variability in all aquatic ecosystems, rivers and streams. However the grade of variability increases when one analyses temporary streams. Therefore appropriate considerations had to be included in the design of the Monitoring programme where the spatial and temporal variability in solubility concentrations, mainly nutrients, come into play.			
Hydromorphological Quality Elements			
Quantity and dynamics of water flow	NA	Water flow readings taken once per month	Due to high variability of Mediterranean stream environments frequency and method is insufficient to construct sufficient flow regime data. In-situ flow meters are needed
Connection to groundwater	NA	The possibility of a connection to a groundwater body was assessed	Analysis was qualitative. No actual groundwater table heights or surface water discharge estimates were investigated. Link between high nitrate values and groundwater also needs to be investigated.

Water stream continuity	NA	Continuity was assessed in terms of water flow, presence/absence	Water stream continuity needs to be assessed in terms of infrastructural developments along the channel which may lead to hydromorphological interference. Guidance with respect to most appropriate mapping techniques to report changes in watercourse continuity is needed.
Water course depth and width variation	NA	Wetted perimeter of water course mapped	Standard procedure for mapping wetted perimeter in continuously changing water regimes such as these water courses is required.
Structure and substrate of the channel bed	NA	Qualitative description of structure and substrate of channel bed was carried out.	Cross sections and particle size of substrate is lacking and needs to be considered.
Structure of the Riparian Zone	NA	No method was applied during the first monitoring cycle	It has been identified that the Riparian Quality Index (Del Tanago and de Jalon (2011)) is used since this Quality Index would be useful for both the HD assessment of Conservation Status and the WFD assessment.

Table 5.2: Applied methods together with identified related gaps and shortcomings and some recommendations in water courses

(iii) Ecological Quality Monitoring programme evaluation for Standing Waters

Similar to the case of transitional waters and watercourses, the attempt to define ecological status for standing waters was based on benthic invertebrates together with supporting physico-chemical and hydromorphological parameters. The method applied for benthic invertebrates was the Chandler biotic score. The Spanish have also developed a new method (Qualitat de l'Aigua d'Ecosistemes Lenítics Soms) for shallow lentic water systems that may also be applicable to Malta and will be trial tested in the upcoming cycle.

No classification methods were identified for macrophytes and phytobenthos and therefore the applicability of the Aquatic flora Spanish assessment method will also be tested in this second cycle.

STANDING WATERS			
Biological Quality Elements			
Quality Element	**Available Med GIG method**	**Method applied to Maltese waters**	**Shortcomings, gap and any future monitoring recommendations**
Benthic Invertebrates	Only two common types of lakes were identified related to deep and large reservoirs of a calcareous or siliceous character	**Chandler Biotic Score (CBS)** chosen for its ease of application in many different contexts (saline, brackish and freshwater) as well as for its relative robustness when applied to slow-flowing or standing water systems, where other indices are inadequate.	In the case of the Ghadira and Simar, key-species based indices are affected by the lack of indicators since at these two sites indicator species are likely replaced with salt-tolerant organisms, generally not considered among the ecological quality standards (because the standards have been developed in relation to a strict freshwater context). Ghadira and Simar have however been removed from this water category. Pools: To test the Spanish method developed for lentic shallow systems which was applied in temporary and permanent freshwaters and also in brackish waters[103]

[103] Boix, D., S. Gascon, J. Sala, M. Martinoy, J. Gifre & X.D. Quintana, 2005. A new index of water quality assessment in Mediterranean wetlands based on crustacean and insect assemblages: the case of Catalunya (NE Iberian peninsula). Aquatic Conservation-Marine and Freshwater Ecosystems 15:635-651.

Macrophytes and phytobenthos	not completed	Macrophytes and phytobenthos were assessed through detailed walk-over surveys. No assessment methods were applied.	The applicability of the **Aquatic Flora Spanish Assessment Method** will be tested.
Phytoplankton	not completed	Composition and abundance of phytoplanktonic assemblage have been investigated using method UNI EN 15204:2006 by cell enumeration.	Considered to be adequate and will be retained in second cycle.
Physico-chemical Quality Elements			
Nutrients (eutrophication)	NA	The Trophic Index (TRIX) was applied to assess eutrophication	This method is commonly used for coastal lagoons but is unsuitable for shallow water systems where phytoplankton is not the only component of the primary producer community responding to increasing nutrient concentrations. Also it is not known whether such an index would apply to a freshwater context. Alternative indices therefore need to be looked into.
Hydromorphological Quality Elements			
Quantity and dynamics of water flow	NA	Water level readings taken once per month	There is limited or negligent flow in these pools and therefore water level was considered sufficient. In the case of Qattara, inputs of water through percolating water may need to be assessed.
Residence time	NA	Not investigated	Not considered to be cost-effective. Water levels and evaporation rates need to be assessed in lieu of water residence time.
Connection to groundwater	NA	The possibility of a connection to a groundwater body was assessed	Analysis was qualitative. No quantitative assessment is deemed necessary given that none of the pools are connected directly to groundwater
Pool depth variation	NA	Pool depth calculated at one water level point – due to small size.	Seasonal pool volume change should be monitored
Quantity, structure and substrate of pool bed	NA	Substrate qualitatively described on the basis of geological observations/sediment monitoring.	Considered sufficient for Malta. Any chemical contamination in sediments is monitored via the priority substances monitoring programme
Structure of the pool perimeter/shore	NA	Qualitative description of structure and substrate of channel bed was carried out. Particle size also measured (under chemical monitoring exercise)	No gaps identified here.

Table 5.3: Applied methods together with identified related gaps and shortcomings and some recommendations in standing waters

Survey guidelines are availble: Agencia Catalana de l'Aigua, 2006. ECOZO Protocol d'avaluacio de l'estat ecològic de les zones humides, Agencia Catalana de l'Aigua, Barcelona.

(iv) Chemical Status water monitoring programme evaluation
Chemical water quality monitoring was carried out in the water and sediment matrix during two different periods. Water column monitoring was carried out for three consecutive winter months during late 2011 and early 2012, whilst the sediment matrix monitoring was carried out in the spring May/ June 2013.

- <u>Changes to monitoring contaminants in the water column</u>

Whilst the frequency for a good number of contaminants that were monitored during the first cycle will remain the same under the second cycle, the frequency of monitoring of a small number of contaminants found to be occurring above detection limits in at least one of the inland surface or transitional water bodies will increase to every two months (i.e. 6 times a year) (Refer to section 5.4.2 for a detailed parameter list).
An additional parameter, perchlorates, was also added given that it was identified to represent a potential environmental risk by other studies (Vella *et al.,* 2012)[104] and therefore identified to be a potential contaminant of concern.

- <u>Changes to monitoring contaminants in the sediment matrix</u>

Similar to the monitoring of contaminants in the water column, the frequency of monitoring in the sediment matrix will increase for 34 of the 70 parameters (refer to section 5.4.2 for a detailed parameter list) that were monitored during 2013.

- <u>Monitoring contaminants in biota</u>

Monitoring of particular chemical contaminants in biota was not carried out during the first WFD cycle and will not be carried out during the second cycle either. The Environmental Quality Standards Directive introduces the requirement that Member States are to consider the establishment of environmental quality standards in biota, apart from water and sediment so as to ensure sufficient protection against indirect effects and secondary poisoning from contaminants. Such requirements are very difficult to apply in a local context particularly since our waters are very small and are very transient and dynamic.

Furthermore Member States should not use species that are endangered or that require special protection, as is the case with all the 10 inland surface and transitional waters. This presents a problem since in order to obtain a required degree of validity of any biomonitoring data, a considerable amount of biota species need to be sampled. In addition it would be very difficult to identify a suitable species due to availability of the species in terms of numbers and type. Biota monitoring in these sites is therefore considered to be impractical in inland surface and transitional waters.

5.2 Inland surface water and transitional water Monitoring Network Implementation Strategy for the 2nd RBMP

An inland surface and transitional water monitoring programme for the second cycle was developed with the following objectives in mind:

(i) To help in establishing a good understanding of the complex chemical, ecological and hydromorphological cycles these unique waters go through on an inter-annual, inter-seasonal and intra-annual basis,
(ii) Contribute to our first attempts to establish a better understanding of the long-term trends brought about by natural conditions,

[104] Vella, A.J., Aquilina, B., Delicata, F., and Farrugia, A. 2012. Perchlorates in dust fall: Evidence of Environmental contamination by fireworks in Malta. 13th International symposium on Fireworks. April 23-27, 2012. Valletta , Malta

(iii) Contribute to our first attempt to start to understand the long-term changes resulting from widespread human activity,
(iv) Assist in our attempts to find the best way possible to assess the status of these waters so that decision makers can decide whether they are indeed at risk of poor quality or deterioration,
(v) Keep track of the effectiveness of any management actions that are implemented over time,
(vi) Investigate further in cases where monitoring results may point to problematic areas or exceedances in contaminants, particularly when the sources or reason for the exceedance is unknown,
(vii) to form a basis of information that would be used to ascertain the magnitude and impacts of any accidental pollution events that may occur in the future.

5.2.1 Ecological Status Monitoring Programme and implementation strategy

As an outcome of the first baseline monitoring Malta will need to sustain frequent monitoring in order to address the significant gap of knowledge that exists on the various inland surface and transitional water ecological communities. The monitoring programmes described below are therefore seen to be transitory since they are part of a longer process of continuous refinement of methods to assess the ecological status of these small and unique waters. It would be impractical for Malta to establish a fixed monitoring programme at this stage that is to be repeated year in year out throughout the duration of this second Cycle. Therefore what is presented here is a monitoring programme intended to take forward the baseline studies that have already been carried out, with a purpose to continue to develop better assessment methods. This monitoring programme will have to be revised every 2 years during the upcoming cycle so as to accommodate changes that would be needed as additional data and knowledge is acquired.

5.2.1.1 Transitional Waters

5.2.1.1.1. Biological Quality Elements

As indicated in the table related to the ecological status of Transitional waters presented above (Table 5.1), there are 4 biological quality elements that are usually considered under the WFD as part of the assessment of ecological status. Whilst all four biological quality elements are found in our transitional waters, very little is known about the efficacy of these BQEs in assessing the ecological status of this water category.

(i) Fish

During 2012 and 2013 a single fish species was sampled, that being the *Aphanius fasciatus* (Killifish). They were sampled using baited minnow traps, which were left overnight at four of the transitional waters where this species is known to occur (L-Ghadira, Is-Simar, Il-Maghluq ta' Marsacala and Is-Salini). This is the only autochthonous fish species known to occur in these waters.

Due to the fact that there are no well developed fish communities in our heavily modified transitional wetlands, the Killifish and Mullet are the only species that can be monitored. These however cannot be assessed using methods that have been developed to fulfil requirements of the WFD. Therefore for the second WCMP cycle Malta will maintain Killifish abundance monitoring.

The following parameters will be measured in situ:

- Number of fish sampled
- Size of each individual sampled
- Gender of each individual sampled

(ii) Benthic invertebrates
During the first baseline studies the Shannon Weiner index was used. Results indicated (refer to Chapter 6 for detailed results) that the use of this simple diversity index may not be adequate given that the complex natural regime of these transitional waters is not yet understood. These results have been echoed at a larger Mediterranean scale. There have been attempts by Mediterranean states to apply a number of assessment methods to assess benthic invertebrates present within these waters as appropriate bio-indicators of water status. Indeed a number of methods have been developed and have successfully been intercalibrated in a coastal water context. However the results of the transitional water intercalibration process has been less successful, the reasons being that transitional waters in the Mediterranean are extremely heterogeneous and there is a complete lack of reference conditions available to allow for the application of approved coastal water methods to a transitional water environment. It has been acknowledged[105] that further work is needed at a Mediterranean scale to develop a biotic index that is able to work under different conditions and under different pressures.

Considering that the application of the simple Shannon-Weiner Diversity index alone was unsuitable to Malta's circumstances, there would be a need to test phase multiple indices that have been developed in a transitional water context in order to come up with a more flexible method. In the upcoming monitoring programme, Malta will therefore take the following approach in an attempt to come closer to a viable method that is suitable to assessing the status of waters based on benthic invertebrates. This would entail:

(a) The carrying out of additional long-term monitoring of physico-chemical, hydrological and biological parameters that would lead to a better understanding of the various dynamics of these transitional systems,
(b) Based on the long-term monitoring records, identify periods that are considered to be naturally stable'. Distinguish these from anthropogenic disturbance occurrences.
(c) Establish virtual reference conditions according to the best and worse status found in the available data set for a particular 'pre-defined' period in a particular water body. This is because each water body is unique even within the same 'water category'. This would mean that status class boundaries would be set for particular water bodies and change according to the natural regime present in the water body and would not be static throughout the year. In order for these virtual conditions to be set, long-term monitoring is a requirement and therefore it is not expected that these virtual conditions could be set within the timeframe of this second cycle.

(iii) Macrophytes and phytobenthos
No assessment methods were attempted during the first baseline surveys. Detailed walk-over surveys enabled the presence of each species found on the banks of / within water bodies to be recorded. Observations pertaining to the most dominant or typical species found were also noted. The level of species sensitivity in relation to their legal protection status and inclusion in the Red data book of the Maltese Islands was also noted. The dominant habitats were mapped. However no percentage coverage or abundance of particular species was recorded.

Three national MEDGIG methods have been developed by France, Greece and Italy[106] to assess the status of these particular Biological Quality elements at a Mediterranean scale. All methods classify

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[105] Ponti, M. et al. 2008. Quality Assessment of Mediterranean and Black Sea transitional waters: Comparing responses of benthic biotic indices *in* 'Aquatic Conservation: Marine and Freshwater ecosystems' 18:S62-S75, John Wiley and Sons, Ltd.

[106] *France* - Exclame (Macrophytes quality of transitional waters bodies; Qualité des macrophytes des masses d'eau de transition). *Greece* - EEI-c (Ecological Evaluation Index – continuous form) classifies macrophytes species in five functional

species in two or more sensitivity groups and assess the coverage of these groups compared to the area studied. All three methods differ in the number of sensitivity groups and the combination rule to obtain the global Ecological Quality Ratio that is needed to determine the status.

During the second monitoring phase Malta will be taking a closer look at the applicability of these intercalibrated methods. Malta takes particular note that all three assessment methods developed by the other Mediterranean states include:
• Abundance metrics, mostly expressed as relative coverage of species belonging to groups of different sensitivity, and
• Disturbance sensitive taxa metrics expressed as coverage of species belonging to groups of different sensitivity.

Malta will therefore carry out the upcoming monitoring phase in 2016 taking these two metrics into account.

(iv) Phytoplankton
In the context of our transitional waters this particular Biological quality element is considered to be a tricky one to assess. This is due to a number of reasons all of which are described below and which have influenced the design of the next monitoring phase required to be carried out by Malta. The difficulties in the development of a phytoplankton community composition indicator compliant with the requirements of the WFD are by no means limited to the Maltese Islands. Experience of neighbouring countries in the Mediterranean region has also highlighted this difficulty and to date no intercalibrated method for transitional waters exists.

The first difficulty is the paucity of high quality data that is well representative of the temporal and spatial variability of phytoplankton assemblages in these highly dynamic transitional water environments. Apart from the fact that Malta has just started monitoring phytoplankton assemblages in these waters, the actual sampling frequency may be insufficient to cover the high temporal variability of this particular BQE in our transitional waters. The high variability in the physico-chemical and hydrological characteristics of these waters also has to be considered in the equation. Insufficient spatial and temporal data coverage will not allow for these factors to be taken into account.

Moreover transitional waters are naturally stressed systems as they are at the receiving end of runoff from their catchments and therefore it is difficult to distinguish between natural and anthropogenic stress. It is important that the indicators used to assess status should be able to successfully reflect the effect of anthropogenic pressures on the water environment. Therefore the metric used as an indicator of pressure should be responsive to stressors, have a low natural variability so as to provide a response that can be distinguished from natural variation. Physico-chemical fluctuations, such as salinity and even hydrological changes, as in the case of Ballut ta' Marsaxlokk, can mask the response of a selected indicator to the pressure.

The following standards for sampling phytoplankton have been set by Annex V, Section 1.3.6 of the WFD and will therefore have to be adhered too where appropriate:

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groups that fall in two ecological status groups (ESG I & II). ESG I includes late successional species of two functional groups while ESG II includes opportunistic species of three functional groups.
Italy - R-MaQI (Macrophyte Quality Index- Rapid version) classifies macroalgae in three sensitivity groups and Angiosperms in four sensitivity groups. According to the relative coverage of the different groups and based on a key. A number ranging from 0 to 1 is attributed corresponding to a quality class. The index is composed by continuous metrics (e.g. percentage of sensitive species, macroalgal relative abundance and seagrass and macroalgal total coverage).

- EN 15204:2006 Water quality – Guidance standard on the enumeration of phytoplankton using inverted microscopy (Utermöhl technique)
- ISO 10260:1992 Water quality- Measurement of biochemical parameters – Spectrometric determination of the chlorophyll-a concentration

In upcoming monitoring efforts, Malta is attempting to reconcile adequate sampling effort and analytical effort at reasonable costs to build up the data required to deal with the issues highlighted above. Malta can only use phytoplankton as a status-setting BQE at a later stage when sufficient long-term data that adequately covers a spatial and temporal span has been collected. The location of the sampling of each biological quality element is provided in table 5.5 below.

	Transitional Water Biological Quality Elements			
	Fish	**Macroalgae and angiosperms**	**Benthic Invertebrates**	**Phytoplankton**
Metric	Abundance of killifish	Abundance, Disturbance sensitive taxa Possible methods: • Italy - MaQI –- Macrophyte Quality Index • Greece - EEI-c – Ecological Evaluation Index France- Exclame	Species richness and diversity	Chlorophyll a *(The same parameter indicative of biomass considered in the Intercalibration Exercise for Mediterranean Sea GIG for coastal waters (and other GIG))*
Surveyed component	4 water bodies (Salini, Simar, Maghluq ta' Marsascala, Ghadira)	All available species in soft-bottom sediment in water of all 5 transitional water bodies 1 – 2 sampling sites at the deepest part of the water body	Soft bottom sediment of all 5 water bodies	Water column of all 5 water bodies 1 – 2 sampling sites at the deepest part of the water body
Sampling device	minnow traps / visual observations new WFD standards may also be applicable	Visual observations? (depending on method adopted)	Collected by means of a Peterson grab, sieved in 0.5 mm mesh.	Water sampling dark stained glass bottles.
Sampling frequency	Seasonal (4 times a year)	beginning of summer or late Spring	End of spring (when water is present)	Monthly (when water is present)
Sampling process	Baited Minnow traps are left overnight	The vegetation of the entire transect is mapped. Angiosperms are identified to species level and macroalgae to the lowest possible taxonomic level and enough to classify them in the relevant sensitivity group. The relative coverage of each species/taxa/group is calculated. Single plants are taken to validate correct identification.	Samples manually checked under a microscope and all organisms detected, individually sorted and identified in a matrix.	Water samples fixed by adding Lugol solution in a 1:250ml ratio upon collection. At the laboratory the enumeration of phytoplankton using inverted microscopy (Utermőhl technique) EN 15204:2006

Standard Methods			• EN ISO 19493:2007 Water quality — Guidance on marine biological surveys of hard-substrate communities • EN ISO 16665:2013 Water quality — Guidelines for quantitative sampling and sample processing of marine soft-bottom macro-fauna	• ISO 10260:1992 Water quality — Measurement of biochemical parameters — Spectrometric determination of the chlorophyll-a concentration. • EN 15204:2006 Water quality - Guidance standard on the enumeration of phytoplankton using inverted microscopy (Utermöhl technique). • EN 15972:2011 Water quality - Guidance on quantitative and qualitative investigations of marine phytoplankton.

Table 5.4: Tabulated monitoring programme for Biological Quality Elements found in Transitional waters during the first monitoring year (2016) of the second WCMP cycle

Standards for monitoring of biological quality elements in transitional waters

Apart from the individual standards per quality element that have already been mentioned, the generic standard EN ISO 5667 -3: 2012 (Water quality – Sampling- Part 3: Preservation and handling of samples) required for use with any of the specific methods indicated in the table above will be conformed to. Any relevant standards included under the revised Annex V, Section 1.3.6 will be adhered to where practicable.

Biological Quality Element	Transitional water body – coordinates for station				
	Salini	**Simar**	**Għadira (Mellieħa)**	**Il-Ballut ta' Marsaxlokk**	**Il-Magħluq ta' Marsacala**
Fish	West Channel 448035.32 3978573.49 East Channel 448192.76 3978485.62	Inner Basin 444177.49 3978267.57 Outer Basin 444346.78 3978272.97	Inner Basin 441035.641 3980982.75 Outer Basin 441233.27 3981008.49	Largest pool 459351.05 3966373.93	Inner Basin 3968792.73 460491.58 Outer Basin 460544.68 3968988.20
Macrophytes and Phytobenthos	2 transects covering 10% of both basins	2 transects covering 10% of both basins	2 transects covering 10% of both basins	1 transect covering 10% water body	2 transects covering 10% of both basins
Benthic Invertebrates	West Channel 448035.32 3978573.49 East Channel 448192.76 3978485.62	Inner Basin 444177.49 3978267.57 Outer Basin 444346.78	Inner Basin 441035.641 3980982.75 Outer Basin 441233.27	Largest pool 459351.05 3966373.93	Inner Basin 3968792.73 460491.58 Outer Basin 460544.68

		3978272.97	3981008.49		3968988.20
Phytoplankton	West Channel / East Channel 448035.32 3978573.49 Or 448192.76 3978485.62	Outer Basin 444346.78 3978272.97	Outer Basin 441233.27 3981008.49	Largest pool 459351.05 3966373.93	Inner Basin 3968792.73 460491.58 Outer Basin 460544.68 3968988.20

Table 5.5: Location of monitoring stations for biological quality elements in each water body[107]

5.2.1.1.2 Supporting Monitoring Programme for Physico-Chemical Quality elements in Transitional Waters during each year of the second WCMP cycle.

Temporal fluctuations in the physico-chemical make-up of transitional waters are expected to be large due to their position between marine and freshwater ecosystems. These variations are often accentuated in Mediterranean systems due to seasonal variations in weather conditions and the unpredictable character of disturbances. Therefore when designing a monitoring programme for these waters, the temporal variation element cannot be overlooked. The monitoring frequencies and methods for each physico-chemical parameter are provided in table 5.6 below.

	Transitional Water Supporting Physico-chemical Quality Elements		
	Unit	**Sampling device**	**Sampling frequency**
Temperature	° C	Multi-parametric probe	Monthly every year
Salinity / Electrical conductivity[2]	ppt or psu µS/cm	Van Dorn plastic sampling containers or niskin bottles	Monthly every year
pH		Multi-parametric probe	Monthly every year
O2 Saturation, Dissolved Oxygen concentration	% saturation	Multi-parametric probe[1]	Monthly every year
Turbidity[3]	NTU	Nephelometer or turbidity meter	Monthly every year
Biological Oxygen Demand (BOD_5)	mg/l	Homogenized, unfiltered, undecanted sample. Determination of dissolved oxygen before and after five-day incubation at 20°C ± 1°C, in complete darkness, Addition of a nitrification inhibitor.	Monthly every year
Nutrients Total Nitrogen, Total Phosphorous Dissolved Nitrates, Dissolved Nitrites, Orthophosphates, Ammonium ions	N µmol/L, µg/L P µmol/L, µg/L NO_3-N µmol/L NO_2-N µmol/L PO_4-P µmol/L NH_4-N µmol/L	Van Dorn plastic sampling containers or niskin bottles	Monthly every year
Chlorophyll *a*[4]	µg/l	Dark-glass containers	Monthly every year

Table 5.6: Sampling frequencies and sampling methods for physico-chemical parameters

1 *Correction for salinity is required in transitional waters. Keep times taken for DO sampling and temperature readings per site constant*

2 *If a multi-parametric method is selected to asses the residence time of water in a particular transitional water body then the frequency and spatial coverage of electrical conductivity has to increase.*

3 *A turbidity meter or Nephelometer should be used rather than a secchi–disk due to shallow waters*

4 *Standard applicable to Chlorophyll analysis is ISO Standard ISO 10260:1992 Water Quality – Measurement of biochemical parameters – Spectrometric determination of the chlorophyll-a concentration needs to be applied;*

107 Location is provided in coordinate system ED 50 - Longitude and Latitude

In order to ensure quality of the analytical methods that are to be used to monitor nutrients the following limits of detection (LOD) and limits of quantification (LOQ) have been set (refer to table 5.8). In general the Limit of detection is taken to be the lowest concentration of an analyte in a sample that can be detected, but not necessarily quantified, under the stated conditions of a test. The LOQ is the lowest concentration of an analyte in a sample that can be determined with acceptable precision and accuracy under the stated conditions of the test.

Parameter	Limit of Detection		Limit of Quantification	
	µmol	µg	µmol	µg
Dissolved nitrates	0.01µmol-N/L	0.14µg N/L	0.03µmol-N/L	0.46µg N/L
Dissolved nitrites	0.01µmol-N/L	0.14µg N/L	0.05µmol-N/L	0.7µg N/L
Ammonium ions	0.01µmol-N/L	0.14µg N/L	0.03µmol-N/L	0.46µg N/L
Dissolved phosphates	0.005µmol-P/L	0.15µg P/L	0.01µmol-P/L	0.31µg P/L
Total Nitrogen	0.1µmol-N/L	1.4µg N/L	0.17µmol-N/L	2.4µg N/L
Total Phosphorous	0.01µmol-P/L	0.3µg P/L	0.02µmol-P/L	0.62µg P/L
Chlorophyll a		0.05µg/L		0.1µg /L

Table 5.7: Limits of Detection and Limits of Quantification to be used for sample analysis

Replicate samples for each physico chemical parameter will be taken at the identified monitoring stations listed in Table 5.8.

Physico-chemical Quality Element	Transitional water body – coordinates for station				
	Salini	**Simar**	**Għadira (Mellieħa)**	**Il-Ballut ta' Marsaxlokk**	**Il-Magħluq ta' Marsacala**
All physico-chemical parameters *Temperature; Salinity /Electrical conductivity; pH; O2 Saturation, DO; Turbidity; Nutrients, Chl-a)*	West Channel 447975.86 3978460.21 East Channel 447824.40 3977992.13	Inner Basin 444188.48 3978237.83 Outer Basin 444376.77 3978237.83	Inner Basin 441040.60 3980967.71 Outer Basin 441256.79 3980994.35	Largest pool 459376.53 3966341.84 And 459301.22 3966418.66	Inner Basin 460561.40 3968816.32 Outer Basin 460546.46 3968971.61

Table 5.8: Location of monitoring stations for physico-chemical quality elements in each water body
Location is provided in coordinate system ED 50 - Longitude and Latitude

The figures 5.1a - 5.1e indicate the location of monitoring stations for ecological status classification per transitional water.

Figure 5.1a: Monitoring stations for biological, physico-chemical and hydromorphological elements at Salini

Figure 5.1b: Monitoring stations for biological, physico-chemical and hydromorphological elements at S-Simar

Figure 5.1c: Monitoring stations for biological, physico-chemical and hydromorphological elements at Għadira.

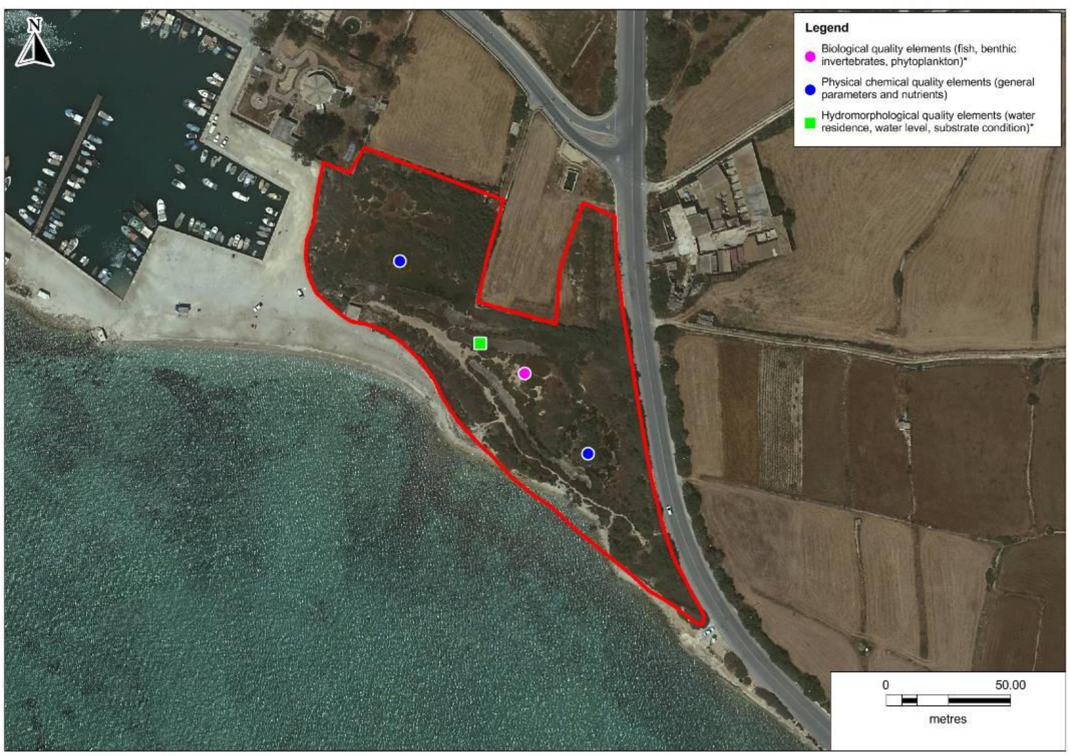

Figure 5.1d: Monitoring stations for biological, physico-chemical and hydromorphological elements at il-Ballut ta' Marsaxlokk

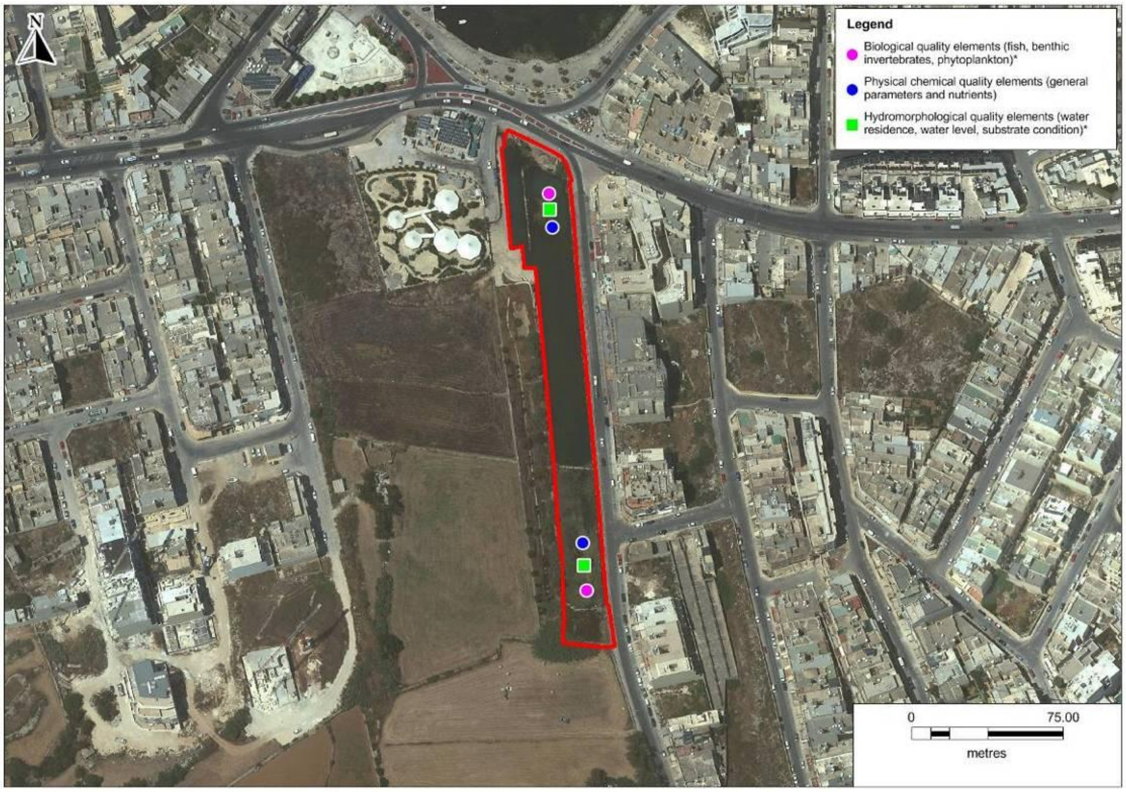

Figure 5.1e: Monitoring stations for biological, physico-chemical and hydromorphological elements at il-Magħluq ta' Marsaskala

5.2.1.1.3 Supporting Monitoring Programme for Hydromorphological Quality elements in Transitional Waters during the first year

The choice of hydromorphological parameters that were included under this monitoring programme were selected on the basis of the role they play in supporting the biological quality elements that have to be protected or restored in a transitional water environment. For instance the dominant controls on phytoplankton result from physical and chemical processes which are under the direct control of hydromorphological processes. Thus, the main physico-chemical factors of greatest importance – namely light availability, nutrients and salinity are determined by hydrographic elements such as residence time, freshwater flows and morphological features (depth variation, shape, substratum type etc.) The same applies to the other biological quality elements. Details for each monitoring parameter are provided in table 5.9 whilst the monitoring locations are provided in table 5.10.

Transitional Water Supporting hydromorphological Quality Elements	Measured parameter indicative of the QE	Sampling device	Sampling frequency
depth variation	bathymetric survey and a continuous recording of the water levels (in Metres)	Grid bathymetric mapping of **0.5m x 0.5m/ 1m x 1m** for larger water bodies Installation of a gauge*	Once every 6 years to establish morphological characteristics (establish changes in sediment transportation) and the continuous recording of water levels
Morphological conditions_ Quantity, structure, and substrate of the bed and condition of the water body edges	Grain size , Organic content, Vegetation cover and vegetation composition	Dependent on water depth: - On foot – corer - Boat – with Van Veen or Smith-McIntyre dredger Vegetation cover monitored by field surveys	Once every 6 years

Table 5.9: Detailed monitoring features for each hydromorphological parameter

* *The gauge should be read approximately the same time. The frequency of gauge readings should increase when it rains and should be read within 12 hours to 24 hours of a substantive rainfall event. Gauge readings should be taken after a rainfall event to help show the interaction between the transitional water and its sub-catchment.*

Hydromorphological Quality Elements	Transitional water body – coordinates for station				
	Salini	**Simar**	**Għadira (Mellieħa)**	**Il-Ballut ta' Marsaxlokk**	**Il-Magħluq ta' Marsacala**
Depth Variation	Coverage of area of water body	Coverage of area of both basins	Coverage of area of both basins	Coverage of area of water body	Coverage of area of both basins
Water levels	one point: 448003.52 3978526.36	Inner Basin 444180.52 3978254.11 Outer Basin 444359.65 3978260.33	Inner Basin 441037.55 3980975.02 Outer Basin 441244.82 3981001.09	459333.34 3966385.99	Inner Basin 460561.88 3968805.20 Outer Basin 460545.04 3968980.40
Morphological conditions_ Quantity, structure and substrate of the bed	On the same transects useed to monitor macroalgae and angiosperms	On the same transects useed to monitor macroalgae and angiosperms	On the same transects useed to monitor macroalgae and angiosperms	On the same transects useed to monitor macroalgae and angiosperms	On the same transects useed to monitor macroalgae and angiosperms
Structure and condition of the water body edges	Fringe perimeter of both water channels	Fringe perimeter of both basins	Fringe perimeter of both basins	Fringe perimeter of external circumference / islands	Fringe perimeter of both basins

Table 5.10: Location of monitoring stations for hydromorphological quality elements in each water body

Water Courses

5.2.1.2.1 Biological Quality Elements

The monitoring programme designed for water courses has to consider the fact that water courses in Malta not only change from *lotic* to *lentic* systems, but are also discontinuous with parts of the reach drying out a few days after the last episode of heavy rain. This makes the choice of WFD Biological Quality Elements to assess ecological status extremely limited, amounting to the following parameters – benthic invertebrates and macrophytes and phytobenthos.

(i) Macro invertebrates

As confirmed by the baseline results (refer to Chapter 6) the macroinvertebrate community found in temporary watercourses are greatly influenced by hydromorphological parameters of flow stability and minimum flows. This has been confirmed by studies carried out in Spain.[108] Monitoring methods applied to these water bodies therefore need to be detailed enough to take into account the shifts in macroinvertebrate assemblages, together with changes in the hydrological regime. Buffagni *et al* (2009)[109] reported that an increase in lentic conditions is associated with a decrease in the quality metrics value when assessing macroinvertebrates. Such a finding must be considered when setting reference values for temporary and intermittent streams since the "natural" low value may be mistaken for anthropogenic disturbances and lead to an underestimation of the ecological quality.

The monitoring programme for benthic invertebrates in watercourses is therefore closely linked to that of hydromorphology. The water flows within the 3 water courses need to be classified into hydrological groups depending on their flow regime. Spain for instance, has come up with a classification system based on monthly and annual flow statistics.

Nationally the lack of consistent long-term monitoring data poses a problem since Malta cannot construct a clear understanding of the benthic assemblages present in relation to changes in the water regime present. Based on the Spanish system, described by Belmar et al. (2013) and Sanchez-Montoya et al (2011)[110], Malta will have to collect this necessary information monthly on a yearly basis. Indicator taxa present at each stage of a changing 'hydrological regime' need to be noted in order for Malta to be able to build up a robust enough baseline that in turn would help in assessing the status of this particular BQE.

Macroinvertebrate abundance data at family, genus and species level is required. Since the flow classification regime of the 3 water courses is presently not known, Malta will need to monitor macroinvertebrate abundance data at sufficient temporal and spatial frequencies to allow correlation with flow regime. The plan to monitor these elements would be similar to that established for transitional waters and would entail:

(a) The carrying out of additional long-term monitoring of physico-chemical, hydrological and biological parameters that would lead to a better understanding of the various dynamics of these intermittent water courses. Physico-chemical parameters would need to be monitored even within disconnected pools form along the water course since pools undergoing expansion and contraction processes could affect the physico-chemical make-up of the water, and subsequently the composition of the macro-invertebrate assemblages.

(b) Based on the long-term monitoring records, identify periods that are considered to be naturally stable' for each hydrological class. Distinguish these from anthropogenic disturbance occurrences.

(c) Attempt to classify different hydrological regimes of the same watercourse using methods that have been developed strictly for temporary streams in the Mediterranean region. The monitoring method described in table 5.12 below relates to the STAR ICMi method which has been adapted to local circumstances.

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[108] Belmar. O. et al. 2013. The influence of natural flow regime on macroinvertebrate assemblages in a semiarid Mediterranean Basin; *in* Ecohydrology, Volume 6, Issue 3, pages 363–379, June 2013

[109] Buffagni, A., Armanini, D.G. and Erba, S.2009. Does the lentic-lotic character of rivers affect invertebrate metrics used in the assessment of ecological quality? *In* Journal of Limnology, 68, p. 92-1

[110] Sanchez-Montoya, M.M., Gomez, R., and Suarez, M.L and Vidal-Abarca, M.R. 2001. Ecological Assessment of Mediterranean Streams and the Special Case of Temporary Streams, *in* River Ecosystems : Dynamics, Management and Conservation, Chapter 2, p. 109-148

(d) Establish virtual reference conditions according to the best and worse status found in the available data set for a particular hydrological (water-regime type) period in a particular water body i.e. High flow, low flow, disconnected pools etc. This would mean that status class boundaries would be established on flow characteristics of a particular stretch of water course rather than on one whole stretch. In order for these virtual conditions to be set, long-term monitoring is a requirement and therefore it is not expected that these virtual conditions could be set within the timeframe of this second cycle.

(ii) Macrophytes

During the MEDGIG intercalibration process progress has been made with respect to the assessment of macrophytes and phytobenthos in Mediterranean temporary streams. Mediterranean temporary rivers revealed large structural and functional differences and the method developed for temporary streams was not intercalibrated.[111]

MEDGIG experts compared the floristic composition and the functional guilds using data collated from temporary waters and the permanent rivers, and used the classification for reference and impaired sites. A consistent lower species diversity and cover of aquatic macrophytes was found in temporary rivers than in permanent rivers, accompanied by rather similar species richness across the Mediterranean Basin (around ten species per site). With increasing flow intermittency, a significant increasing number of hygrophyte species (plants which grow wholly in water), and lower ratio of hydrophytes /helophytes (plants that grow in waterlogged conditions / plants that grow in marshland and which bud under water) was also observed. The number of pteridophytes, mosses and liverworts (including supra-aquatic bryophytes) species was however found to be similar between permanent and temporary river types, and these patterns remain the same in reference and impaired sites, albeit the differences resulting from pressures.

Several Mediterranean Member States make use of the IBMR method (Biological Macrophytes index for Rivers). However it is very likely that this method cannot be applied to Malta as revealed by Cyprus' experience and their failure to adopt such a method[112]. When Cyprus attempted to apply this method to their own temporary waters, the statistical regression analysis carried out indicated that the method could not be correlated with the pressures (i.e. against a pressure gradient). As a result Cyprus developed its own national method – the MMI method (the Multimetric Macrophyte Index) [113], which helped to provide a better indication of status in temporary waters, but which was still found to be unsuitable for status classification (Communication with Cyprus, 2015).

Given that Malta did not adopt any particular monitoring methods in the first cycle, it will need to refine the monitoring of macrophytes during the upcoming cycle in order to better understand how this BQE can be used to assess status. The details for the monitoring programme intended to be carried out for this BQE during the first year is provided in Table 5.12 below.

(iii) Phytobenthos

In the case of phytobenthos monitoring reference is being made to diatom monitoring. In the case of the first monitoring carried out in 2012/2013 Malta did not monitor diatoms in water course environments.

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[111] Intercalibration Technical report 2012 – Mediterranean River GIG - Macrophytes

[112] Papastergiadou E., P Manolaki, P. 2011. MEDGIG report: R-M5 IC River types of Cyprus. Developing as assessment system of R-M5 river types for Cyprus. Patras University, Greece, 21 pp (not published).

[113] In addition to the Intercalibration technical report 2012 for macrophytes, reference should also be made to Aguiar, F.C., Segurado, P., Dorflinger, G., Ferreira, J., Germ., M., Manolaki, P., Minciardi, M.R., Munni, A., Papastergiadou, E., and Ferreira, M.T. 2014. Comparability of river quality assessment using macrophytes: A multi-step procedure to overcome biogeographical differences In *Science of the Total Environment* 476-477 (2014) 757-767.

Since temporary waters are considered under the MEDGIG, the methods that have been adopted for diatom assessment in this water typology will be tested by Malta in the upcoming cycle. These include the Specific Pollution-sensitivity Index (IPS) that has been developed by Cyprus and similar methods developed by Spain and Portugal which have also been used in a temporary water setting. The details for the monitoring methods to be carried out are provided in Table 5.12 below.

	Water courses Biological Quality Elements		
	Macrophytes	**Phytobenthos (Diatoms)**	**Macro Invertebrates**
Metric	Taxonomic composition and relative abundance; vascular plants, bryophytes and macroalgae	IPS method - Relative abundance of each species (Benthic diatoms), - Pollution sensitivity of each species A list of sensitive and tolerant species can be found in Delgado et al. 2012[114] - Indicator value or stenoecy degree of each species (3 classes)	Metrics in accordance with STAR ICMi intercalibration method List of biological metrics: - ASPT - Log10(sel_EPTD), i.e. [Log10 (sum of Heptageniidae, Ephemeridae, Leptophlebiidae, Brachycentridae, Goeridae, Polycentropodidae, Limnephilidae, Odontoceridae, Dolichopodidae, Stratyomidae, Dixidae, Empididae, Athericidae, Nemouridae)] - 1-GOLD, i.e. 1-[Relative abundance of Gastropoda, Oligochaeta, Diptera)] - Total number of Families - Number of EPT families [Sum of Ephemeroptera, Plecoptera, Trichoptera - Shannon-Wiener diversity index Weighted average metric scores are combined.
Surveyed component	Species found within water channel and immediately adjacent to channel (riparian zone) along the entire stretch of the watercourse,	Preferably hard substrate - Area in water course channel containing stones (selected by expert judgement). If natural hard substrate is not available artificial hard substrate are sampled e.g. walls of the side of a channel	Multi-habitat sampling designed for sampling major habitats in proportion to their presence within a sampling reach is carried out. Sampling area selected is based on expert judgement and includes representation of different stretches.
Sampling device	Visual observations through walking and wading (use of an Aquascop in cases where dense reed beds make visual observation of submerged vegetation difficult).	Toothbrush	Surber or Hess sampler (0.25 x 0.25m) 500µm mesh size of sampler
Sampling frequency	One survey during early spring (the driest the year the earlier the start of the survey month).	One sample per year during the winter months (February – April)	once a year /in Spring (February / March)
Sampling process	The vegetation of the entire watercourse stretch is identified. **Level of taxonomical identification (**Genus, Species/species groups): *Specification of level of determination:* Phanerogams,	5 random stones should be selected and removed from the water. The upper surface of each stone is scraped to collect epilithic diatoms using a toothbrush. The material which is scraped is preserved in a plastic bottle using Lugol solution.	A sample consists of 16 sampling units taken from all habitat types at the sampling site with a share of at least 5 % coverage. A 'sampling unit' is a stationary sampling performed by positioning the surber sampler and disturbing the substrate in a quadratic area that equals the frame-size

114 Delgado, C., Pardo, I., Garcia, L. 2012. Diatom communities as indicators of ecological status in Mediterranean temporary streams (Balaeric Islands), Spain. In Ecological Indicators 15 (2012) 131 - 139

	pteridophytes, lichens, bryophytes and Characea algae: species level Macroscopic algae (filamentous, gelatinous, thallose): genus level, Bacterial tufts: genus level **Record of abundance:** *Determination of abundance:* Percent coverage *Abundance is related to:* Area *Unit of the record of abundance:* percent cover *Other relation of abundance:* abundance classes are required by the standard, but the percent of cover is required for WFD networks survey.	**Sample treatment:** 400 valves Sample is divided (sub-sampling) and organisms of a sub-sample are identified. **Level of taxonomical identification:** *Level:* Genus, Species/species groups **Record of abundance:** *Determination of abundance:* Individual counts, Relative abundance *Abundance is related to:* Area *Unit of the record of abundance:* Number of valves *Other record of abundance:* 100 cm^2	upstream of the net (0.25 x 0.25 m). Sediments must be disturbed to a depth of 10cm (where possible) depending on substrate compactness. **Sample treatment:** Sample is subsampled until at least 700 individuals are analysed. If sample is < 700 individuals, no sub-sampling is performed. Sample is divided (sub-sampling) and organisms of a sub-sample are identified. **Level of taxonomical identification:** *Level:* Family, Genus, species **2.15 Record of abundance:** *Determination of abundance:* Individual counts *Abundance is related to:* Area *Unit of the record of abundance:* Number of individuals per one m^2
Sampling standards	• EN 14184:2014 Water quality - Guidance for the surveying of aquatic macrophytes in running waters).	• EN 15708: 2009 Water quality - Guidance standard for the surveying, sampling and laboratory analysis of phytobenthos in shallow running water. • EN 13946:2014 Water quality - Guidance for the routine sampling and preparation of benthic diatoms from rivers and lakes • EN 14407:2014 Water quality - Guidance for the identification and enumeration of benthic diatom samples from rivers and lakes.	• EN 15196:2006 Water quality — Guidance on sampling and processing of the pupal exuviae of Chironomidae (order Diptera) for ecological assessment. • EN ISO 10870:2012 Water quality - Guidelines for the selection of sampling methods and devices for benthic macroinvertebrates in fresh waters. • EN 16150:2012 Water quality — Guidance on pro rata multi-habitat sampling of benthic macro-invertebrates from wadeable rivers.

Table 5.11: Tabulated monitoring programme for Biological Quality Elements found in watercourses during the first (and in some cases second) monitoring year (2016) of the second WCMP cycle

Biological Quality Element	Water Courses – coordinates for station		
	Wied tal-Baħrija	**Wied il-Luq**	**Wied Lunzjata**
Macrophytes	**Along a stretch (Upstream)** 440459.02 3972574.70 **(Middle section)** 440164.83 3973077.50 **Lower reach** 440250.41 3973791.56	**Along a stretch (Upstream) -** 445898.00 3968637.83 **(Middle section)** 446540.42 3968454.48 **Lower reach** 447022.59 3968389.28	**Along a stretch (Upstream) -** 430937.56 3988922.88 **(Middle section)** 431031.17 3988672.22 **Lower reach** 430996.27 3988389.81
Phytobenthos	To be indicated by field monitors (representative of upper and lower reaches)	To be indicated by field monitors (representative of upper and lower reaches)	To be indicated by field monitors (representative of upper and lower reaches)
Benthic Invertebrates	To be advised by field monitor depending on habitats present	To be advised by field monitor depending on habitats present	To be advised by field monitor depending on habitats present

Table 5.12: Location of monitoring stations for biological quality elements in each water body

Figure 5.2a - 5.2c represent location of monitoring stations for ecological status classification per watercourse.

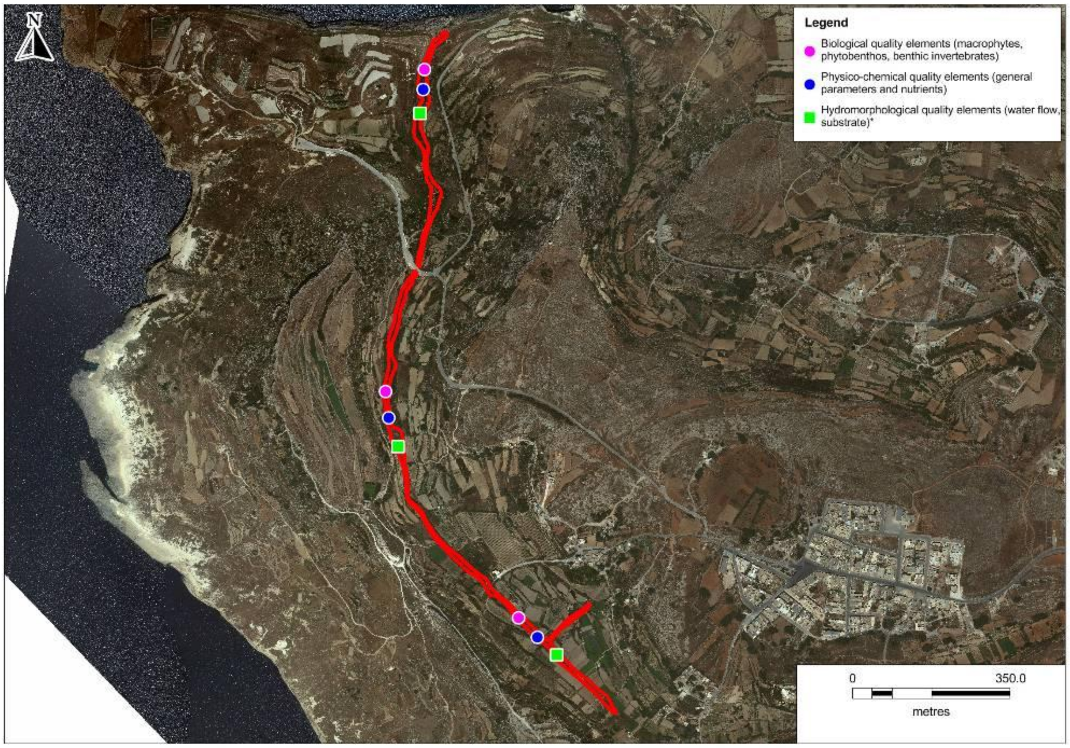

Figure 5.2a: Monitoring stations at Bahrija

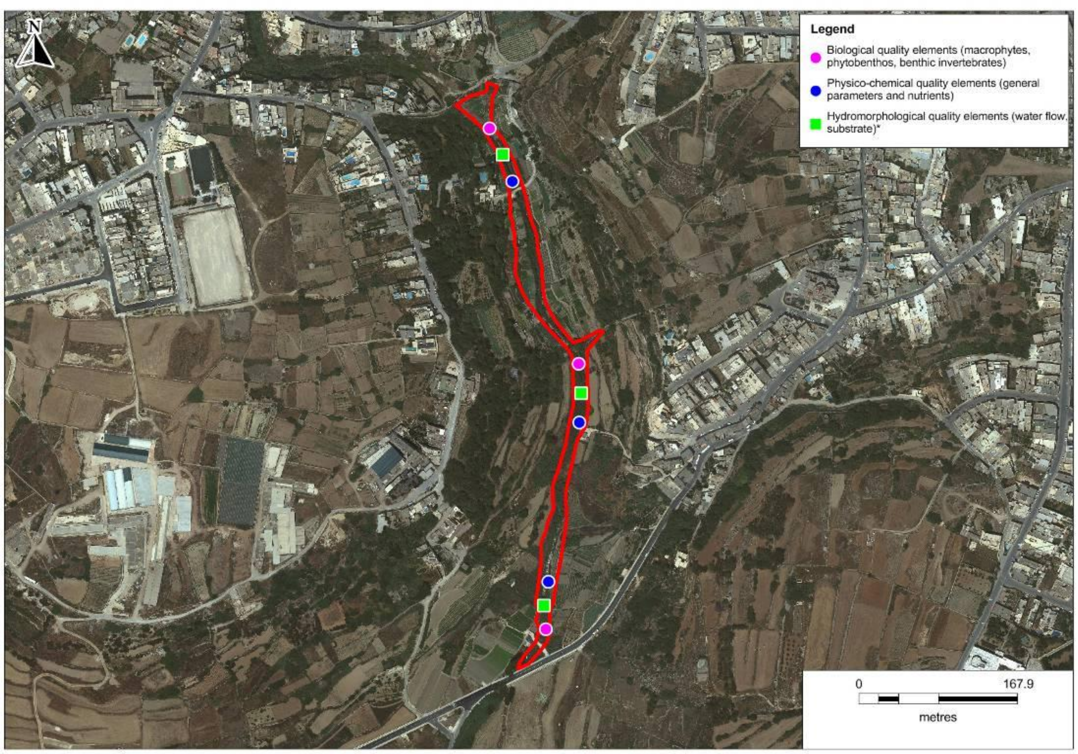

Figure 5.2b: Monitoring stations at Wied Lunzjata

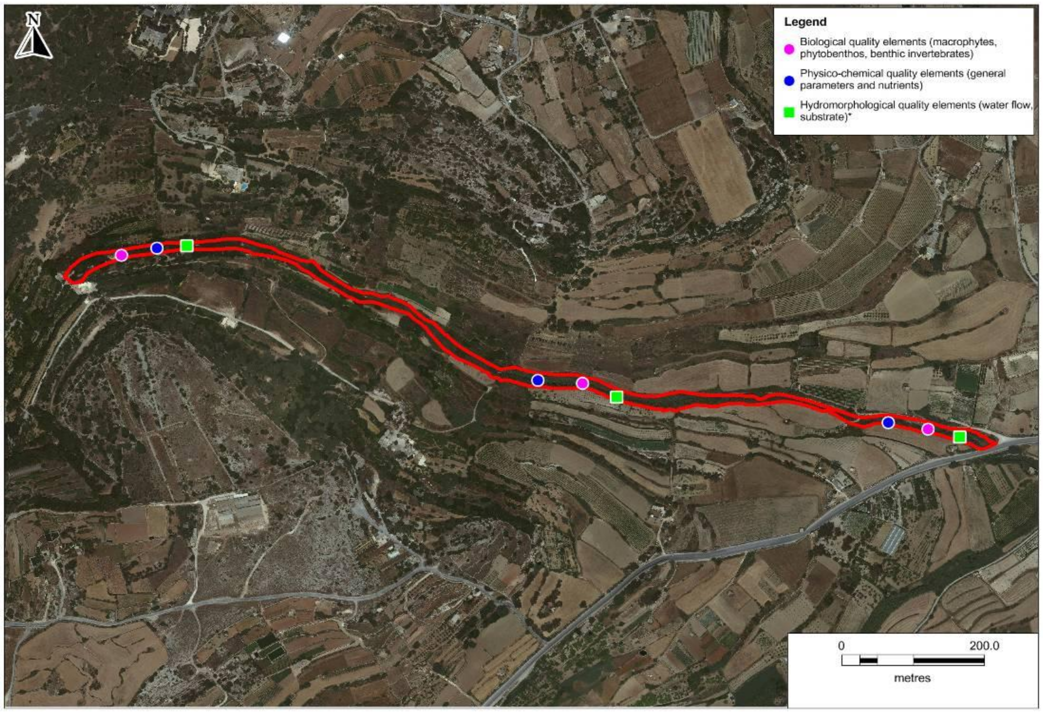

Figure 5.2c: Monitoring stations at Wied il-Luq

5.2.1.2.2 Supporting Monitoring Programme for Physico-Chemical Quality elements in Water Courses

Being temporary, the establishment of physico-chemical criteria in streams is difficult because a considerable amount of monitoring data is required to reach conclusions with adequate scientific certainty. Natural spatial and temporal variability in solute concentrations exist in temporary streams.

Fluctuating low flows create a mosaic of local environmental conditions, influencing advection, water residence time, oxidising and reducing conditions, sediment-water interactions and biological processes (such as nitrification and denitrification). Besides biotic factors, low surface flows and spatial intermittency reinforce the effect of abiotic heterogeneity that affects solute availability. This is because advection in temporary streams is lower (less flow) and therefore opportunities for biotic and abiotic interactions are more plentiful.

Considering these complex conditions the monitoring programme for the second WFD cycle has been devised as presented in Table 5.14 below.

	Water courses - Supporting Physico-chemical Quality Elements		
	Unit	**Sampling device**	**Sampling frequency**
Temperature	^{o} C	Multi-parametric probe	monthly
Salinity / Electrical conductivity	ppt or psu µS/cm	Van Dorn plastic sampling containers or niskin bottles	monthly
pH		Multi-parametric probe	monthly
O2 Saturation, Dissolved Oxygen concentration	% saturation mg/L	Multi-parametric probe	monthly
Turbidity[1]	NTU	Nephelometer or turbidity meter	monthly

Nutrients[2] Total Nitrogen, Total Phosphorous Dissolved Nitrates, Dissolved Nitrites, Orthophosphates, Ammonium ions	N mg/L P mg/l NO_3-N mg/l NO_2-N mg/l PO_4-P mg/l NH_4-N mg/l	Van Dorn plastic sampling containers or niskin bottles	monthly
BOD_5	mg/l	Homogenised, unfiltered, undecanted sample. Determination of dissolved oxygen before and after 5-day incubation at 20°C ± 1°C, in complete darkness. Addition of a nitrification inhibitor.	monthly
Chlorophyll a[2]	µg/l	Dark-glass containers	monthly

Table 5.13: Sampling of physico-chemical parameters in water courses.

[1] A turbidity meter or Nephelometer should be used rather than a secchi–disk due to shallow waters

[2] Standard applicable to Chlorophyll analysis is ISO Standard ISO 10260:1992 Water Quality – Measurement of biochemical parameters – Spectrometric determination of the chlorophyll-a concentration needs to be applied;

Benchmark levels for physico-chemical parameters in water courses

In the absence of water quality boundaries set for physico-chemical parameters Malta will use the following benchmarks as established by the MEDGIG for guidance purposes (refer to Table 5.15) during the first monitoring year. It is therefore necessary that the limits of detection and limits of quantification of the analytical methods used for these parameters are set at adequate levels.

Parameter	Benchmark value
DO (mg/L)	6.39 – 13.70
O_2 (%)	60.34 – 127.92
NH_4-N (mg/L)	0.09
NO_3-N (mg/L)	1.15
PO_4-P (mg/L)	0.06
Total P (mg/L)	0.07

Table 5.14: Benchmark values for physico-chemical parameters
Reference: MEDGIG 2012 Phytobenthos Intercalibration report

Replicate samples for each physico chemical parameter will be taken at the identified monitoring stations listed in Table 5.16.

Physico-chemical Quality Element	Wied tal-Baħrija	Wied il-Luq	Wied Lunzjata
All physico-chemical parameters *(including Temperature; Salinity / Electrical conductivity; pH; O2 Saturation, DO; Turbidity; Nutrients and Chlorophyll a)*	**Along a stretch (Upstream) -** 440499.78 3972532.78 **(Middle section)** 440171.76 3973018.66 **Lower reach** 440247.61 3973746.46	**Along a stretch (Upstream) -** 445947.38 3968648.18 **(Middle section)** 446478.77 3968458.68 **Lower reach** 446967.18 3968398.12	**Along a stretch (Upstream) -** 430961.10 3988866.66 **(Middle section)** To confirm with mapping (431031.78 3988609.75) **Lower reach** 430999.24 3988440.35

Table 5.15: Location of monitoring stations for physico-chemical quality elements in each water body

5.2.1.2.3 Supporting Monitoring Programme for Hydromorphological Quality elements in Water Courses

As indicated by the previous discussion on Biological Quality Elements, hydromorphological elements play a very significant role in influencing the conditions necessary to sustain various BQEs. The main influential hydromorphological elements in terms of Biological status in a temporary water course setting, as highlighted above, are water regime and continuity. These are largely depending on climatic factors but also connectivity with groundwater and the use of such a resource.

Due to the paucity of data related to these important supporting elements, Malta will monitor hydromorphological elements on a twice monthly basis (i.e. twice every month for every year). This frequency is required In order to gather sufficient data to support the ongoing attempt Malta has embarked on to better understand the water related requirements of habitats and species and ecological flows.

The relevant standard for assessing hydromorphological features of rivers (EN 14614:2004) as identified by the WFD may not be applicable to the Maltese Islands. Nevertheless it may be adapted to local circumstances.

Water course Supporting hydromorphological Quality Elements	Measured parameter indicative of the QE	Sampling device	Sampling frequency
Quantity and dynamics of water flow	In situ measurements of water flow; Meteorological variables	In-situ flow gauging stations*	continuous
Connection to groundwater	Water table height, Spring discharges	Groundwater height from boreholes in vicinity, gauges from springs discharging to surface waters or diverted to reservoirs in order to assess connection	Seasonal studies (i.e. 4 times) for one year
Water stream continuity	Continuity of watercourse with respect to the longitudinal and lateral artificial infrastructure in the watercourse bed and its banks	Field surveys - mapping	once every 6 years
Water course depth and width variation	Depth of water and width changes (wetted perimeter) including depth and width of disconnected pools	Field surveys – mapping (topographic survey)	once every 6 years
Structure and substrate of the channel bed	Water course cross section (length and width of actual water channel), particle size change across different reaches	Field surveys – mapping for cross-section of water course, sieve mesh (starting from 0.01 mm mesh size)	Every 3 years for cross-section; Detailed particle size analysis for 12 months for one year

Structure of riparian zone	Based on the Riparian Quality Index (RQI) proposed by Gonzales del Tanago and Garcia de Jalon (2011) the following attributes need to be assessed and score given according to status: 1. Dimensions of land with riparian vegetation 2. Longitudinal continuity and coverage of riparian corridor 3. Composition and structure of riparian vegetation 4. Age diversity and natural regenration 5. Bank conditions 6. Floods and lateral connectivity 7. Substratum ad vertical connectivity	Field surveys - Reaches ranging between 600m to 800m. Data inputting on the RQI forms for each reach under assessement.	Twice a year one in summer and one in winter for one year per WFD cycle.

Table 5.16: Detailed monitoring features for each hydromorphologicalparameter

* *The gauge should be read approximately the same time. The frequency of gauge readings should increase when it rains and should be read within 12 hours to 24 hours of a substantive rainfall event. Gauge readings should increase after a rainfall event to estimate flow duration curves.*

Hydromorphological Quality Elements	**Water Courses – coordinates for monitoring stations**		
	Wied tal-Baħrija	**Wied il-Luq**	**Wied Lunzjata**
Quantity and dynamics of water flow	**Along a stretch (Upstream) -** 440543.00 3972494.25 **(Middle section)** 3973693.63 3972954.85 **Lower reach** 440241.36 3973693.62	**Along a stretch (Upstream) -** 445989.21 3968651.40 **(Middle section)** 446587.94 3968435.38 **Lower reach** 447066.32 3968378.17	**Along a stretch (Upstream) -** 430951.00 3988894.71 **(Middle section)** To confirm with mapping 431034.02 3988641.16 **Lower reach** 430994.75 3988414.55
Connection to groundwater	Analysis of water abstraction in the area related to springs	Not required	Analysis of water abstraction in the area related to springs
Water stream continuity	Along the whole stretch of water course	Along the whole stretch of water course	Along the whole stretch of water course
Water course depth and width variation	Along the whole stretch of water course	Along the whole stretch of water course	Along the whole stretch of water course
Structure and substrate of the channel bed	**Along a stretch (Upstream) -** 440543.00 3972494.25 **(Middle section)** 3973693.63 3972954.85 **Lower reach** 440241.36 3973693.62	**Along a stretch (Upstream) -** 445989.21 3968651.40 **(Middle section)** 446587.94 3968435.38 **Lower reach** 447066.32 3968378.17	**Along a stretch (Upstream) -** 430951.00 3988894.71 **(Middle section)** To confirm with mapping 431034.02 3988641.16 **Lower reach** 430994.75 3988414.55

Table 5.17: Location of monitoring points for hydromorphological parameters in water courses

5.2.1.3 Standing Waters - Pools

Fresh water pools in the Maltese Islands are very rare and undergo cyclical changes in their water regime, and corresponding physico-chemical make-up as the biseasonal climate of the Maltese Islands takes its course. The pools occur in hollows (kamenitzas) on karstified limestone substrata which solutional erosion of rock by percolation of water (Lanfranco, 1995)[115]. Freshwater derived from precipitation and runoff accumulates in such solution hollows forming the pool environment. In the Maltese Islands the largest pools, Il-Qattara and the Ghadira ta' Sarraflu, both in Gozo, are the best known examples of a freshwater pool environment and are included in this monitoring programme.

Keely and Zedler (1996) in Zacharias *et al*., 2007[116], characterise the temporary Mediterranean pool in 4 stages:

1. A wetting phase
2. An aquatic or inundation phase
3. A waterlogged terrestrial phase
4. A drought phase

5.2.1.3.1 Biological Quality Elements

The residence time of freshwater in the pools is characterised by a typically autumnal cycle with the alternation of an aquatic phase and a desiccated phase. When the pools are filled with water a diverse macro and microplanktonic resident biota is present and as they dry a flora of terrestrial macrophytes may colonise the substratum (Lanfranco, 1995).

The fluctuating nature of the pool habitat restricts colonisation and several groups that are generally regarded as being typical of freshwaters have not been recorded from local pools (Lanfranco, 1995). These include gastropods, bivalves, oligochaetes and malacostracans. The absence of these groups is a consequence of their inability to survive the inherent instability of the habitat which places the constraint of a prolonged period of desiccation on the biota.

The resident biota therefore comprises organisms with short life-cycles and rapid attainment of reproductive capability. These features are known to be biotic adaptations of organisms colonising lentic waters in arid and semi-arid regions. The fauna of both Qattara and Ghadira ta' Sarraflu is lacking in both numbers and species variety. According to Lanfranco (1995) lowered species richness is a consequence of two principal factors:

1. The generally small size of pools on karstic terrain in the Maltese Islands, limiting habitat heterogeneity and hence placing an upper limit to the number of available niches.
2. The insular nature of the Maltese habitat, representing a small target for potential sources of colonisation (such as wind-borne propagules). Diversity of the pool biota in terms of species richness is furthermore dependent on the duration of hydroperiod and on the diversity of vegetation colonising the substratum during the aquatic phase. In general, longer hydroperiods promote the accumulation of a larger subset of the pool of colonising species, while vegetational diversity increases habitat heterogeneity and hence faunal diversity.

The resident biota of pools in the Maltese Islands is dominated by microcrustaceans (Branchiopoda, podocopid Ostracoda, cyclopoid Copepoda) and chlorophytic algae (Chlorophyceae, Zygnemataceae, Characeae). Semi-transient biota that occupy the pool environment as larval stages include insects

[115] Lanfranco S. 1995. Temporary rainwater rockpools as repositories of biological diversity in the Maltese Islands - Presented at BIO'MES 95 scientific symposium; 7eme Rencontres de L'A.R.P.E.; Digne-les-Bains, France (in press). October 1995.

[116] Zacharia, I., Dimitriou, E., Dekker., A, Dorsman, E. 2007. Overview of temporary ponds in the Mediterranean region: Threats, management and conservation issues in Journal of Environmental Biology, 28(1) 1-9

(Chironomidae, Culiciidae, Ephemeroptera, Odonata) and tadpoles. Several adult insects visit the pools for brief periods. All microcrustaceans recorded from local pools are widely distributed throughout the Mediterranean littoral[117].

	Biological Quality Elements – Freshwater Pools		
	Phytoplankton	**Macrophytes and Phytobenthos**	**Macro Invertebrates**
Metric	**Indicators of phytoplankton biomass**: (1) Chlorophyll-a concentration (µg/L) (2) Total biovolume (mm^3/L) = (average cell biovolume of taxon * number of individuals) **Composition**[118] : (1) IGA (Index Des Grups Algals) (2) Percentage cyanobacteria (%)	Macrophytes: vascular species, carophytes, bryophytes and filamentosus algae have to be determined at species level; Aquatic flora Spanish assessment method Phytobenthos sampling: Diatoms have to be determined at species level[119]	Relative abundance of microcrustaceans (based on the Spanish Water Quality of Lentic Shallow Water Ecosystems method)
Surveyed component	Water column – depth of pool	Multi-habitat sampling within water body and along pool perimeter (refer to aquatic flora assessment method – Spain)	Multi-habitat sampling within water body and along pool perimeter
Sampling device	Water sampling dark stained glass bottles.	Bathyscope – visual observations	Invertebrate sampling using a 20 cm diameter dip-net (250µm mesh size). Within each pool three sweeps per visit is carried out. Each sweep consists of 20 dip-net pushes in rapid sequence.
Sampling frequency	5 times a year (1 winter, 1 spring, 2 samplings between june and September and 1 Autumn) for three years	Spring (February/March for 3 years	Spring (February/March for 3 years
Sampling process	**Sample treatment:** Samples have to be integrated samples from the euphotic zone (in Malta waters this would correspond to the entire depth of the shallow pool). **Biovolume and composition:** 1. EN15204. 2006. Water quality – Guidance standard on the enumeration of phytoplankton using inverted microscopy	**Sample treatment:** na **Level of taxonomical identification:** *Level:* Species/species groups *Specification of level of determination:* *Macrophytes sampling:* All the groups of species: vascular species, carophytes, bryophytes and filamentosus algae have to be	**Sample treatment:** Samples are to be preserved in 4% lugol solution The first sweep is used to estimate the index based on relative abundance of microcrustaceans, whereas all sweeps were used to calculate the index based on taxon richness. The sample is divided (sub-sampling) and organisms of a sub-sample are

[117] Lanfranco S. 1995. Temporary rainwater rockpools as repositories of biological diversity in the Maltese Islands - Presented at BIO'MES 95 scientific symposium; 7eme Rencontres de L'A.R.P.E.; Digne-les-Bains, France (in press). October 1995.

[118] **Indicators of phytoplankton composition:**
(1) % Cyanobacteria biovolume = (cyanobacteria biovolume * 100) / total biovolume
(2) Catalan index – refer to Hoyos *et.al*., 2014. JRC technical report, Mediterranean lake phytoplankton assessment methods.

[119] **Metrics related to assessment of pressures:**
Metrics which assess eutrophication pressures: InDia (diatoms Index), Coverage of eutrophication species of macrophytes;
Metrics which assess hydromorphological pressures: Presence/absence of hydrophytes, Macrophytes richness, Total coverage of hydrophytes, Total coverage of helophytes, Total coverage of macrophytes (hydrophytes+helophytes);
Metrics which assess introduction of exotic macrophytes species: Coverage of exotic macrophytes species

	(Utermöhl technique). 2. CEN TC 230/WG 2/TG 3: 'Phytoplankton biovolume determination using inverted microscopy Utermöhl technique'. **Level of taxonomical identification:** *Level:* Genus, Species/species groups *Specification of level of determination:* If identification to the species level is not possible or doubtful, identification remains at the genus level. **Record of abundance:** *Determination of abundance:* Individual counts *Abundance is related to:* Volume *Unit of the record of abundance:* Number of individuals per ml **Quantification of biomass:** Chlorophyll-a concentration, Utermöhl technique	determined to species level; *Phytobenthos sampling:* Diatoms have to be determined to species level **Record of abundance:** na	identified. **Level of taxonomical identification:** *Level:* Genus, Family *Specification of level of determination:* Crustaceans and adults of coleoptera and heteroptera, to genus level. Family level for insects' larval, pupae and nymph stadia. **Record of abundance:** *Determination of abundance:* Relative abundance *Abundance is related to:* Volume *Unit of the record of abundance:* Number of individuals per CPUE (captures per unit effort (CPUE=1 dip net)) *Other relation of abundance:* relative abundance for species with sensitivity coefficient and presence of the rest (for the assessment of taxa richness) *Other record of abundance:* relative abundance measured as captures per unit effort (CPUE=1 dip net)
Relevant standards	• ISO 10260:1992 Water quality — Measurement of biochemical parameters. — Spectrometric determination of the chlorophyll-a concentration. • EN 15204:2006 Water quality - Guidance standard on the enumeration of phytoplankton using inverted microscopy (Utermöhl technique). • EN 16695:2015 Water quality - Guidance on the estimation of phytoplankton biovolume. • EN 16698:2015 Water quality - Guidance on quantitative and qualitative sampling of phytoplankton from inland waters.	• EN 13946:2014 Water quality - Guidance for the routine sampling and preparation of benthic diatoms from rivers and lakes. • EN 14407:2014 Water quality - Guidance for the identification and enumeration of benthic diatom samples from rivers and lakes. • EN 15460:2007 Water quality - Guidance standard for the surveying of macrophytes in lakes.	• EN 15196:2006 Water quality — Guidance on sampling and processing of the pupal exuviae of Chironomidae (order Diptera) for ecological assessment. • EN ISO 10870:2012 Water quality - Guidelines for the selection of sampling methods and devices for benthic macroinvertebrates in fresh waters.

Table 5.18: Tabulated monitoring programme for Biological Quality Elements found in standing waters (pools) during the first monitoring year (2016) of the second WCMP cycle

Biological Quality Element	Pools – coordinates for monitoring stations	
	IL- Qattara	**L-Ghadira ta' Sarraflu**
Phytoplankton	**One point :** 427317.95, 3990104.23	**One point :** 427896.08, 3988515.05
Macrophytes, Phytobenthos Benthic Invert	Perimeter of pool and one point in water body	Perimeter of pool and one point in water body

Table 5.19: Location of monitoring stations for biological quality elements in each water body

Figures 5.3a and 5.3b represent location of monitoring stations for all parameters in both pools.

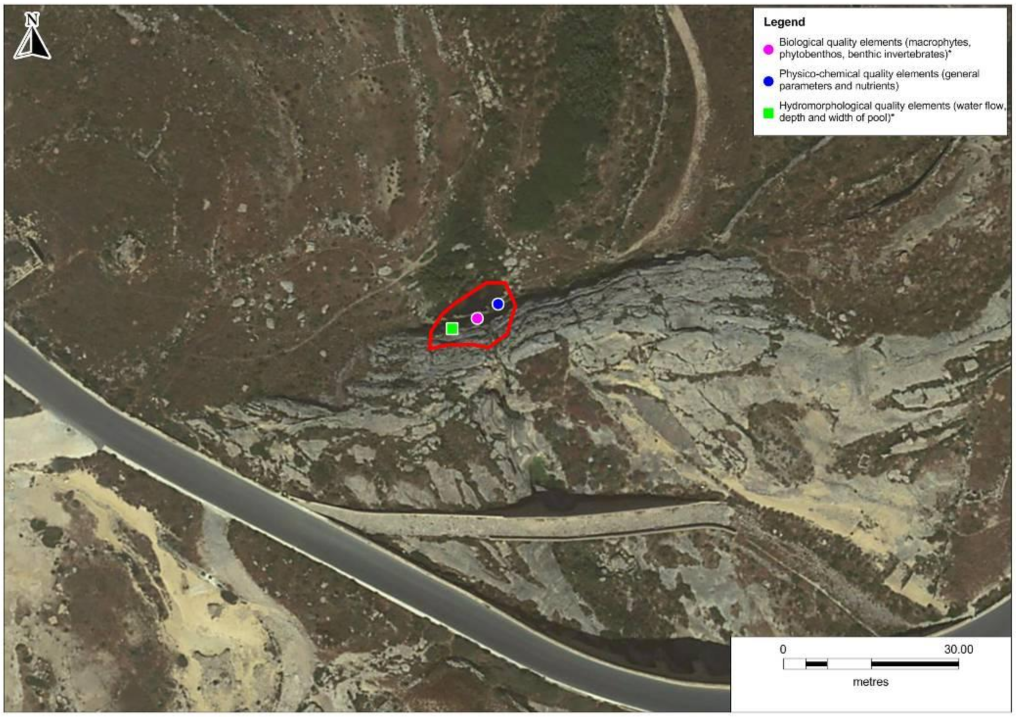

Figure 5.3a: Monitoring stations at Il-Qattara

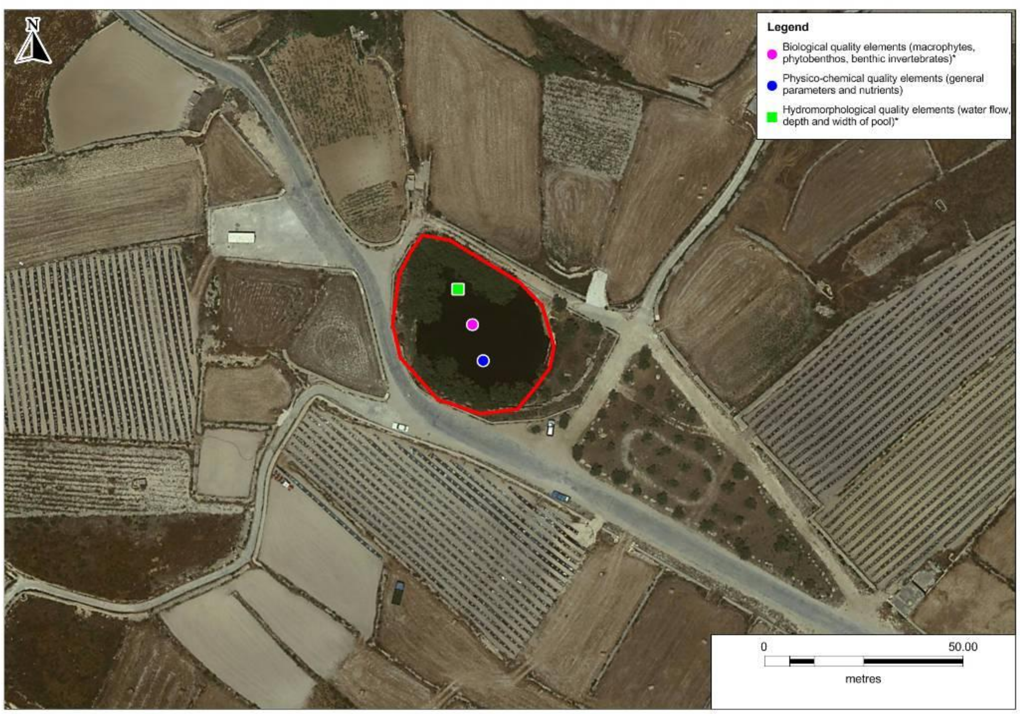

Figure 5.3b: Monitoring stations at l-Ghadira ta' Sarraflu

5.2.1.3.2 Supporting Monitoring Programme for Physico-Chemical Quality elements in pools during each year of the second WCMP cycle.

The physico-chemical parameters of these two pools vary considerably on a diurnal basis. Their instability in terms of physico-chemical characteristics may approach and sometimes exceed the biological limits that biological organisms can endure. Salinity for instance can become a significant influential factor towards the end of the wet season and waters also undergo extreme fluctuations in pH, levels of dissolved carbon dioxide and oxygen. Extreme changes in temperature may also be recorded low due to the relatively high surface to volume ratio of these shallow depressions.

The two pools will be monitored on a monthly basis to gauge the differences as a result of the biseasonal climate and the various stages of the hydrological regime described above. The sampling frequency and device used per parameter is provided in Table 5.21 below.

	Water courses - Supporting Physico-chemical Quality Elements		
	Unit	**Sampling device**	**Sampling frequency**
Temperature	^{o} C	Multi-parametric probe	monthly
Salinity / Electrical conductivity	ppt or psu µS/cm	Van Dorn plastic sampling containers or niskin bottles	monthly
pH		Multi-parametric probe	monthly
O2 Saturation, Dissolved Oxygen concentration	% saturation mg/L	Multi-parametric probe	monthly
Turbidity[1]	NTU	Nephelometer or turbidity meter	monthly
Nutrients[2] Total Nitrogen, Total Phosphorous Dissolved Nitrates, Dissolved Nitrites, Orthophosphates, Ammonium ions	N mg/L P mg/l NO_3-N mg/l NO_2-N mg/l PO_4-P mg/l NH_4-N mg/l	Van Dorn plastic sampling containers or niskin bottles	monthly
BOD_5	mg/l	Homogenised, unfiltered, undecanted sample. Determination of dissolved oxygen before and after 5-day incubation at 20^{o}C $\pm$ 1^{o}C, in complete darkness. Addition of a nitrification inhibitor.	monthly
Chlorophyll a[2]	µg/l	Dark-glass containers	monthly

Table 5.20: Monitoring programme of physico-chemical parameters for Qattara and Ghadira ta' Sarraflu

[1] A turbidity meter or Nephelometer should be used rather than a secchi–disk due to shallow waters

[2] Standard applicable to Chlorophyll analysis is ISO Standard ISO 10260:1992 Water Quality – Measurement of biochemical parameters – Spectrometric determination of the chlorophyll-a concentration needs to be applied.

Due to the very small size of the pools the physico-chemical parameters will be monitored at one point in each pool as follows:

Il- Qattara	L-Ghadira ta' Sarraflu
One point : 427321.52, 3990106.69	**One point :** 427902.36, 3988496.83

5.2.1.3.3 Supporting Monitoring Programme for Hydromorphological Quality elements in freshwater pools

As highlighted by the four different hydrological stages mentioned above, these pools present a significant variability regarding the length of their hydroperiod (the period during which pools are flooded) and the initiation of their inundation period. The substrates permeability and slop at sub-catchment scale determines the amount of water reaching the pond via surface runoff and in the case of il-Qattara, percolating water. This affects the length of the hydroperiod and the ecological systems that thrive therein. The hydromorphological parameters indicative of these criteria will be monitored according to the programme below (table 5.22).

Pool Supporting hydromorphological Quality Elements	Measured parameter indicative of the QE	Sampling device	Sampling frequency
Pond depth and width variation	depth and width pool	Field surveys - mapping	once every 6 years
Structure and substrate of the pond bed	pool cross section	Field surveys – mapping for cross-section of pool	once every 6 years
Structure of the pond perimeter and the pond perimeter	Length, vegetation present, species present, bank features (including slope)	Visual observations	Once every 6 years

Table 5.21: Hydromorphological parameter monitoring in ponds

5.2.2 Chemical Water Quality Monitoring Programme and implementation strategy for inland surface and transitional waters

5.2.2.1 Water Quality monitoring

The monitoring of the 47 substances that were monitored in water during the first cycle will be repeated (Table 5.23). The complete list of chemicals in water, together with their Limits of Detection (LODs) and Limits of Quantification (LOQs) are provided in Table 5.24 below. In addition perchlorate will be monitored in the water column as part of the investigative monitoring programme.

Whilst the majority of the substances listed in the table will be monitored once every 3 years, increased frequency of monitoring was identified to be applicable to the following parameters:

- Dichloromethane,
- Di(2-ethylhexyl)phthalate
- Fluoranthene
- Lead
- Mercury
- Nickel
- Trichloromethane

Monitoring Programme for chemicals		Units
Frequency:	Once a year, every 3 years monitoring of all 47 chemicals listed in table 5.23 plus perchlorates 6 times a year monitoring of 7 of the 47 chemicals (marked in red in table 5.23)	
Sampling depth:	50 cm depth	cm
No. of samples:	2 replicates	
Supporting parameters:	<u>Supporting physico-chemical parameters:</u> Temperature Salinity pH Water hardness Total suspended solids Total organic carbon <u>Supporting hydromorphological parameters:</u> water depth water flow	 ºC ppm ppm/ mg/L mg/L % m m/s

Table 5.22: Monitoring frequencies and supporting parameters for chemicals

Parameter	Analytical Methodology	Units	Limit of Detection	Limit of Quantification
Alachlor	EPA 3510C 1996 + EPA 8270D 2007	µg/l	0.001	0.005
Anthracene	APAT CNR IRSA 5080 Man 29 2003	µg/l	0.001	0.005
Atrazine	EPA 3510C 1996 + EPA 8270D 2007	µg/l	0.001	0.005
Benzene	EPA 5030C 2003 + EPA 8260C 2006	µg/l	0.01	0.1
Brominated diphenylethers	EPA 1614 2007	µg/l	0.0001	0.1
Cadmium	APAT CNR IRSA 3020 Man 29 2003	µg/l	0.01	2
Carbon tetrachloride	EPA 5030C 2003 + EPA 8260C 2006	µg/l	0.01	0.1
Chloroalkanes, C10-13	EPA 3510C 1996 + EPA 8270D 2007	µg/l	0.01	0.1
Chlorfenvinphos	APAT CNR IRSA 5100 Man 29 2003	µg/l	0.01	0.05
Chlorpyrifos	APAT CNR IRSA 5100 Man 29 2003	µg/l	0.01	0.05
Endrin	EPA 3510C 1996 + EPA 8270D 2007	µg/l	0.001	0.005
Isodrin	EPA 3510C 1996 + EPA 8270D 2007	µg/l	0.001	0.005
Aldrin	EPA 3510C 1996 + EPA 8270D 2007	µg/l	0.001	0.005
Dieldrin	EPA 3510C 1996 + EPA 8270D 2007	µg/l	0.001	0.005
DDT Total	EPA 3510C 1996 + EPA 8270D 2007	µg/l	0.001	0.005
Para-para-DDT	EPA 3510C 1996 + EPA 8270D 2007	µg/l	0.001	0.005
1,2- Dichloroethane	EPA 5030C 2003 + EPA 8260C 2006	µg/l	0.001	0.1
Dichloromethane	EPA 5030C 2003 + EPA 8260C 2006	µg/l	0.01	0.1
Di(2-ethylhexyl)phthalate	EPA 3510C 1996 + EPA 8270D 2007	µg/l	0.01	0.1
Diuron	APAT CNR IRSA 5050 Man 29 2003	µg/l	0.1	0.1
Endosulfane	EPA 3510C 1996 + EPA 8270D 2007	µg/l	0.001	0.005
Fluoranthene (PHC)	APAT CNR IRSA 5080 Man 29 2003	µg/l	0.001	0.005
Hexachlorobenzene	EPA 3510C 1996 + EPA 8270D 2007	µg/l	0.001	0.005
Hexachlorobutadiene	EPA 5030C 2003 + EPA 8260C 2006	µg/l	0.01	0.1
Hexachlorocyclohexane	EPA 3510C 1996 + EPA 8270D 2007	µg/l	0.001	0.005
Isoproturon	APAT CNR IRSA 5050 Man 29 2003	µg/l	0.1	0.1
Lead	UNI EN ISO 17294-02:2005	µg/l	0.1	3
Mercury	UNI EN ISO 17294-02:2005	µg/l	0.05	1
Naphthalene	APAT CNR IRSA 5080 Man 29 2003	µg/l	0.001	0.005
Nickel	UNI EN ISO 17294-02:2005	µg/l	0.1	3
Nonylphenols	APHA Standard Methods for the Examination of Water and Wastewater, ed 21st 2005, 6410 B	µg/l	0.01	0.05
4-nonylphenol	APHA Standard Methods for the Examination of Water and Wastewater, ed 21st 2005, 6410 B	µg/l	0.01	0.05
Octylphenols	APHA Standard Methods for the Examination of Water and Wastewater, ed 21st 2005, 6410 B	µg/l	0.01	0.05
Pentachlorobenzene	EPA 3510C 1996 + EPA 8270D 2007	µg/l	0.001	0.05
Pentachlorophenol	APHA Standard Methods for the Examination of Water and Wastewater, ed 21st 2005, 6410 B	µg/l	0.001	0.01
Polyaromatic hydrocarbons		µg/l		
Benzo(a)pyrene	APAT CNR IRSA 5080 Man 29 2003	µg/l	0.001	0.005
Benzo(b)fluoranthene	APAT CNR IRSA 5080 Man 29 2003	µg/l	0.001	0.005

Benzo(g.h.i)perylene	APAT CNR IRSA 5080 Man 29 2003	µg/l	0.001	0.005
Benzo(k)fluoranthene	APAT CNR IRSA 5080 Man 29 2003	µg/l	0.001	0.005
Indeno(1,2,3-cd)pyrene	APAT CNR IRSA 5080 Man 29 2003	µg/l	0.001	0.005
Simazine	APAT CNR IRSA 5060 Man 29 2003	µg/l	0.01	0.05
Tetrachloroethylene	EPA 5030C 2003 + EPA 8260C 2006	µg/l	0.01	0.1
Trichloroethylene	EPA 5030C 2003 + EPA 8260C 2006	µg/l	0.01	0.1
Tributyltin compounds	UNI EN ISO 17353:2006	µg/l	0.0002	0.1
Trichlorobenzene	EPA 3510C 1996 + EPA 8270D 2007	µg/l	0.001	0.05
Trichloromethane	EPA 5030C 2003 + EPA 8260C 2006	µg/l	0.01	0.1
Trifluralin	EPA 3510C 1996 + EPA 8270D 2007	µg/l	0.001	0.05

Table 5.23: List of chemical parameters already analysed in the water column during 2011/2012, their analytical methodology, their limits of detection and limits of quantification. The monitoring of these substances will be repeated

Supplementary monitoring in the water column

Malta will be monitoring **perchlorate** and the newly identified priority substances in water as from 2018. These new substances were added to the priority substances list during 2013 when the 2008 list was revised by the European Community.

In the case of perchlorate, which is naturally occurring but also manufactured and commonly used as an oxidizer in munitions, fireworks, airbag initiators for vehicles, matches and fertilisers; will be monitored at all 10 inland surface and transitional sites as part of Malta's investigative monitoring.

Parameter	Analytical Methodology	Units	Limit of Detection	Limit of Quantification
Perchlorate	Liquid-chromatography-mass spectrometry EPA 331.0	µg/l	0.013	0.10

These additional new substances to be monitored <u>in water</u> are as follows:

Parameter		LOQ
Plant protection products		
Aclonifen	Aclonifen is an herbicide used in plant protection products.	0.01µg/l
Bifenox	Bifenox is an herbicide used as a control of broad leaved weeds in post-emergence applications in winter cereals.	0.01µg/l (indicated to be insufficient)[120]
Cypermethrin	Cypermethrin is a pyrethroid insecticide.	0.001 µg/l (indicated to be insufficient)
Dicofol	Dicofol is an organochlorine pesticide (arcaricide; miticide) that is chemically related to DDT, and used for controlling mites that damage cotton, fruit trees and vegetables.	0.005 µg/l
Heptachlor and heptachlorepoxide	Heptachlor is an insecticide which is banned and not used anymore in the EU. Heptachlorepoxide is its degradation product.	LOQ of 7 pg/l of EPA method 1699 is not sufficient

[120] Indicated to be insufficient by the JRC 2012 Technical Report on Analytical methods for new proposed Priority substances of the European WFD

Quinoxyfen	Quinoxyfen is a fungicide often used to control powdery mildew infections on grapes.	0.002 µg/l
Industrial chemicals		
Perfluorooctane sulfonic acid and its derivatives (PFOS)	PFOS (CAS no. 1763-23-1) is a perfluoroalkyl substance which was used (in Europe) in providing grease, oil and water resistance to materials such as textiles, carpets, paper and in general coatings. Other smaller volume uses are in chromium plating, photolithography, photography, and in hydraulic fluids for aviation. PFOS has also been used in fire fighting foams. Production of PFOS (or its derivatives) has been phased out.	0.002 ng/l of the ISO method 25101 (not sufficient)
Biocidal products		
Dichlorvos	Dichlorvos is an organophosphorous insecticide.	European Standard EN 12918 reaches a LOQ of 0.01 µg/l (insufficient)
Cybutryne	Cybutryne (= Irgarol) is an effective triazine herbicidal biocide (or algicide) mainly used as an antifouling agent in paints for boats and vessels. It is applied at marine as well as at inland freshwater sites in mainland Europe (may not be applicable to Malta).	0.001µg/l
Terbutryn	Terbutryn is a triazine herbicide or algicide.	80 pg/l

Table 5.24 New priority substances to be monitored in inland surface and transitional waters

New priority substances that that will not be monitored in the water matrix in inland surface waters

- **Hexabromocyclodecane (HBCDD)**

Hexabromocyclododecane (HBCDD) is a high production volume chemical used as a flame retardant, mainly within the polymer and textile industry. No analytical standard methods are available for HBCDD in water. However, scientific literature shows (refer to JRC 2012 report) that biota analysis at 1/3 of the EQS (0.3 × EQS = 50.1 µg/kg) should be possible. Given that no biota will be monitored in Inland surface and transitional waters, this parameter cannot be monitored.

- **Dioxin and dioxin –like PCBs**

Dioxins and dioxin-like compounds comprise Polychlorinated dibenzo-p-dioxins (PCDDs), Polychlorinated dibenzofurans (PCDFs), Polychlorinated biphenyls (PCBs) (twelve of them have "dioxin-like" properties). There are 75 PCDDs, and seven of them are specifically toxic. There are 135 PCDF congeners, and ten of them have "dioxin-like" properties. Dioxins occur as by-products in the manufacture of some organochlorines, in the incineration of chlorine-containing substances such as PVC (polyvinyl chloride), in the chlorine bleaching of paper, and from natural sources such as volcanoes and forest fires. These substances need to be monitored in the biota matrix hence given that no biota will be monitored in Inland surface and transitional waters, this parameter will be monitored in sediment.

5.2.2.1 Sediment Quality Monitoring

The monitoring of the 70 substances that were monitored in the sediment matrix during the first cycle will be repeated. Details of their monitoring programme are provided in Table 5.23 below. The complete list of chemicals in sediment, together with their Limits of Detection (LODs) and Limits of Quantification (LOQs) are provided in table 5.27 below.

Whilst the majority of the substances listed in the table will be monitored once every 3 years, increased frequency of monitoring (i.e. every 2 months) was identified to be applicable to 34 of the 70 parameters. These are indicated in red in table 5.26 below.

A number of the new substances that were added to the Priority substances list during 2013 when the 2008 list was revised by the European Community will have to also be monitored in sediment due to their propensity to partition to sediment. These substances will be monitored once during the first monitoring year and have been included in table 5.27 as well.

Summary of monitoring Programme for chemicals		Units
Frequency:	Once a year, every 3 years monitoring of all 70 chemicals listed in table 5.26 6 times a year monitoring of 34 of the 70 parameters as marked in red in the table 5.26 below	
Sampling depth	Up to 10 cm depth	cm
No. of samples	2 replicates	
Supporting parameters:	Supporting physico-chemical parameters: Total Organic Carbon Grain size	 % µm

Table 5.25: Monitoring programme for Chemical status in the sediment matrix in inland surface and transitional waters

Parameter	Analytical Methodology	Units	Detection Limits
Total Organic Carbon	UNI EN 13137:2002	%	0.01
Total Phosphorous	CNR IRSA 9 Q 64 Vol 3 1985	%	0.01
Total Nitrogen	CNR IRSA 6 Q 64 Vol 3 1985	%	0.01
Anthracene	EPA 3541 1994 + EPA 3630C 1996 + EPA 8270D 2007	mg/kg	0.01
Brominated diphenylether (Referreing to Congener numbers 28,47,99, 100, 153, 154)	EPA 1614:2007 + EPA 3545:2007	ng/Kg	100
Cadmium and its compounds	UNI EN ISO 13657: 2004 + APAT CNR IRSA 3020 Man 29 2003	mg/kg	0.1
C10-13 Chloroalkanes	EPA 3541 1994 + EPA 3630C 1996 + EPA 8270D 2007	mg/kg	0.1
Di(2-ethylhexyl)-phthalate (DEHP)	EPA 3541 1994 + EPA 3630C 1996 + EPA 8270D 2007	mg/kg	0.01
Fluoranthene	EPA 3541 1994 + EPA 3630C 1996 + EPA 8270D 2007	mg/kg	0.01
Hexachloro-benzene	EPA 3541 1994 + EPA 3630C 1996+ EPA 8081B 2007	mg/kg	0.001
Hexachloro-butadiene	EPA 5021A 2003 + EPA 8260C 2006	mg/kg	0.01
Hexachloro-cyclohexane	EPA 3541 1994 + EPA 3630C 1996+ EPA 8081B 2007	mg/kg	0.001
Lead and its compounds	UNI EN ISO 13657: 2004 + APAT CNR IRSA 3020 Man 29 2003	mg/kg	0.1
Mercury and its compounds	EPA 3051A 2007 + EPA 6010C 2007	mg/kg	0.1
Pentachloro-benzene	EPA 3541 1994 + EPA 3620C 2007 + EPA 8270D 2007	mg/kg	0.01
Polyaromatic hydrocarbons (PAH):			
Benzo(a)pyrene	EPA 3541 1994 + EPA 3630C 1996 + EPA 8270D 2007	mg/kg	0.01
Benzo(b)fluor-anthene	EPA 3541 1994 + EPA 3630C 1996 + EPA 8270D 2007	mg/kg	0.01
Benzo(k)fluor-anthene	EPA 3541 1994 + EPA 3630C 1996 + EPA 8270D 2007	mg/kg	0.01
Benzo(g,h,i)-perylene	EPA 3541 1994 + EPA 3630C 1996 + EPA 8270D 2007	mg/kg	0.01

Indeno(1,2,3-cd)-pyrene	EPA 3541 1994 + EPA 3630C 1996 + EPA 8270D 2007	mg/kg	0.01
Tributyltin compounds (Tributyltin-cation)	ICRAM App. 1 2001 - 2003	mg/kg	0.1
Dicofol	EPA 3541 1994 + EPA 3630C 1996+ EPA 8081B 2007	mg/kg	0.01
Perfluorooctane sulfonic acid and its derivatives (PFOS)	EPA 537 2009	mg/kg	0.01
Quinoxyfen	EPA 3541 1994 + EPA 3630C 1996+ EPA 8081B 2007	mg/kg	0.01
Dioxin and dioxin-like compounds *	EPA 1613B 1994 + EPA 3545 A 2007	ng/kg	0.1
Hexabromocyclodecane (HBCDD) **	EPA 3541 1994 + EPA 3630C 1996+ EPA 8081B2007	mg/kg	0.01
Heptachlor and heptachlor epoxide	EPA 3541 1994 + EPA 3630C 1996+ EPA 8081B 2007	mg/kg	0.001
Nickel and its compounds	UNI EN ISO 13657: 2004 + APAT CNR IRSA 3020 Man 29 2003	mg/kg	0.1
Chromium	UNI EN ISO 13657: 2004 + APAT CNR IRSA 3020 Man 29 2003	mg/kg	0.1
Copper	UNI EN ISO 13657: 2004 + APAT CNR IRSA 3020 Man 29 2003	mg/kg	0.1
Zinc	UNI EN ISO 13657: 2004 + APAT CNR IRSA 3020 Man 29 2003	mg/kg	0.1
Manganese	UNI EN ISO 13657: 2004 + APAT CNR IRSA 3020 Man 29 2003	mg/kg	0.1
Barium	UNI EN ISO 13657: 2004 + APAT CNR IRSA 3020 Man 29 2003	mg/kg	0.1
Boron	UNI EN ISO 13657: 2004 + APAT CNR IRSA 3020 Man 29 2003	mg/kg	0.1
Beryllium	UNI EN ISO 13657: 2004 + APAT CNR IRSA 3020 Man 29 2003	mg/kg	0.1
Cobalt	UNI EN ISO 13657: 2004 + APAT CNR IRSA 3020 Man 29 2003	mg/kg	0.1
Fluorides	CNR IRSA 14 Q 64 Vol 3 1996	mg/kg	0.1
Malathion	EPA 3541 1994 + EPA 3630C 1996 + EPA 8141 2007	mg/kg	0.01

Table 5.26: List of chemical parameters to be analysed in the sediment matrix, their analytical methodology and their limits of detection

* Compounds included in the parameter 21 'Dioxin and dioxin-like compounds"
** Congener compounds included in the parameter 22 'Hexabromocyclodecane (HBCDD)'

'Dioxin and dioxin-like compounds"

Parameter	Analytical Methodology	Units	Detection Limits
Polychlorinated dibenzo-p-dioxins (PCDDs) I-TEQ			
2,3,7,8-T4CDD	EPA 1613B 1994 + EPA 3545 A 2007	ng/kg	1
1,2,3,7,8-P5CDD	EPA 1613B 1994 + EPA 3545 A 2007	ng/kg	5
1,2,3,4,7,8-H6CDD	EPA 1613B 1994 + EPA 3545 A 2007	ng/kg	5
1,2,3,6,7,8-H6CDD	EPA 1613B 1994 + EPA 3545 A 2007	ng/kg	5
1,2,3,7,8,9-H6CDD	EPA 1613B 1994 + EPA 3545 A 2007	ng/kg	5
1,2,3,4,6,7,8-H7CDD	EPA 1613B 1994 + EPA 3545 A 2007	ng/kg	5
1,2,3,4,6,7,8,9-O8CDD	EPA 1613B 1994 + EPA 3545 A 2007	ng/kg	10
Polychlorinated dibenzofurans (PCDFs) I-TEQ			
2,3,7,8-T4CDF	EPA 1613B 1994 + EPA 3545 A 2007	ng/kg	1
1,2,3,7,8-P5CDF	EPA 1613B 1994 + EPA 3545 A 2007	ng/kg	5
2,3,4,7,8-P5CDF	EPA 1613B 1994 + EPA 3545 A 2007	ng/kg	5

1,2,3,4,7,8-H6CDF	EPA 1613B 1994 + EPA 3545 A 2007	ng/kg	5
1,2,3,6,7,8-H6CDF	EPA 1613B 1994 + EPA 3545 A 2007	ng/kg	5
1,2,3,7,8,9-H6CDF	EPA 1613B 1994 + EPA 3545 A 2007	ng/kg	5
2,3,4,6,7,8-H6CDF	EPA 1613B 1994 + EPA 3545 A 2007	ng/kg	5
1,2,3,4,6,7,8-H7CDF	EPA 1613B 1994 + EPA 3545 A 2007	ng/kg	5
1,2,3,4,7,8,9-H7CDF	EPA 1613B 1994 + EPA 3545 A 2007	ng/kg	5
1,2,3,4,6,7,8,9-O8CDF	EPA 1613B 1994 + EPA 3545 A 2007	ng/kg	10
Dioxin-like polychlorinated biphenyls (PCB-DL) WHO-TEQ			
3,3’,4,4’-T4CB (PCB 77)	EPA 3545A 2007 + EPA 1668B 2008	ng/Kg	20
3,3’,4’,5-T4CB (PCB 81)	EPA 3545A 2007 + EPA 1668B 2008	ng/Kg	20
2,3,3',4,4'-P5CB (PCB 105)	EPA 3545A 2007 + EPA 1668B 2008	ng/Kg	20
2,3,4,4',5-P5CB (PCB 114)	EPA 3545A 2007 + EPA 1668B 2008	ng/Kg	20
2,3',4,4',5-P5CB (PCB 118)	EPA 3545A 2007 + EPA 1668B 2008	ng/Kg	20
2,3',4,4',5'-P5CB (PCB 123)	EPA 3545A 2007 + EPA 1668B 2008	ng/Kg	20
3,3’,4,4’,5-P5CB (PCB 126)	EPA 3545A 2007 + EPA 1668B 2008	ng/Kg	20
2,3,3',4,4',5-H6CB (PCB 156)	EPA 3545A 2007 + EPA 1668B 2008	ng/Kg	20
2,3,3',4,4',5'- 6CB (PCB 157)	EPA 3545A 2007 + EPA 1668B 2008	ng/Kg	20
2,3',4,4',5,5'-H6CB (PCB 167)	EPA 3545A 2007 + EPA 1668B 2008	ng/Kg	20
3,3’,4,4’,5,5’-H6CB (PCB 169)	EPA 3545A 2007 + EPA 1668B 2008	ng/Kg	20
2,3,3',4,4',5,5'-H7CB (PCB 189)	EPA 3545A 2007 + EPA 1668B 2008	ng/Kg	20

5.3 Evaluation of the Monitoring Programme for coastal waters and related marine protected waters carried out during the 1st RBMP

5.3.1 Evaluation of monitoring strategy and resultant programme

The monitoring programme for coastal waters under the first WCMP was supplemented by a number of national monitoring sites due to the fact that the level of knowledge on the quality of national coastal waters was limited. Therefore the first monitoring programme featured WFD surveillance and operational monitoring sites sited in areas deemed to be most representative of the whole water body. These were supplemented with additional monitoring stations located in areas considered to be most representative of point and diffuse pressures. No investigative monitoring programmes were instigated during the first cycle due to the fact that the first comprehensive monitoring programme was yet to be carried out.

(i) Changes to Biological quality parameters and supporting parameter monitoring

Since this was Malta’s first experience with monitoring particular biological quality elements according to methods adopted by other Mediterranean Member States, there were some additional changes to the location of a number of monitoring stations in order to respect the method employed. This first comprehensive monitoring allowed Malta to refine its monitoring strategy and monitoring programme for the second WFD cycle accordingly. It also enabled Malta to embark on the delayed intercalibration exercise, needed to ensure that the methods used to classify ecological status were comparable to those of other Mediterranean Member States.

The attempt to intercalibrate the biological quality monitoring data collected was carried out during 2014 and start of 2015. Such a process brought about a further revision of the monitoring strategy that had been defined and the corresponding monitoring programme. The revisions made were in the monitoring frequency of particular parameters; the supporting parameters covered; the depth of monitoring samples particularly where benthic invertebrate monitoring and phytoplankton are concerned; as well as changes in the distance of monitoring from the shore. Detailed changes are to the coastal water monitoring programmes are summarised in table 5.28 below.

(ii) Changes to Chemical Status monitoring

Scientific knowledge on the fate and effects of pollutants in water has evolved significantly over recent years. More is known about which compartment of the water environment (i.e. whether the water column, sediment or biota) a substance is likely to be found in, and therefore where its concentration is most likely to be measurable. For instance some hydrophobic (water fearing) substances accumulate in biota and are hardly detectable in water even using the most advanced analytical techniques. For such substances the European Commission has set EQS in biota rather than in water or sediment. This has lead to a revision in the chemical monitoring component of the WFD monitoring programme.

In addition, with the revision of the Environmental Quality Standards Directive 2008/105/EC, additional substances have been added to the list of chemical substances and will be monitored as from 2018. These include Dicofol, Perfluorooctane sulfonic acid and its derivatives (PFOS), Quinoxyfen, Dioxins and dioxin-like compounds, Aclonifen, Bifenox, Cybutryne, Cypermethrin, Dichlorvos, Terbutryn, Hexabromocyclododecane (HBCDD), Heptachlor and Heptachlor epoxide.

Feature in first monitoring strategy / programme	Characteristic	Finding	Revision (included in second Monitoring programme)
Changes to Biological quality element monitoring			
Monitoring of Phytoplankton	Phytoplankton: Most taxonomic data on phytoplankton available was generated in the late 60s and late 70s and data on trends is not available. There is insufficient data to establish trends of phytoplankton biomass.	Sufficient coverage of chlorophyll a has only just started to be monitored around the Maltese Islands. Vertical profiles of phytoplankton have not been monitored.	Vertical profiles of phytoplankton monitoring have been considered in monitoring programme
		Not all of Malta's plankton sampling took place in the nearshore zone (i.e. 500m-1500m from the shore) as required for WFD monitoring. In order to make use of the 2012-2013 monitoring data Malta would need to establish a relationship between inshore/nearshore and offshore samples in order to estimate the nearshore equivalent of nearshore sites. However, transect data is not available for Malta and as a consequence this exercise could not be carried out.	Malta has taken this into consideration in the design of the coastal/marine monitoring programme. In addition to this Malta will need to collect Chlorophyll *a* data during winter since this was not carried out during the first baseline. Malta will be collecting monthly samples of Chlorophyll a during at least 1 year at a suitable number of stations.
Monitoring of benthic habitats	Benthic habitats	The benthic samples were not collected at the monitoring stations used for other parameters. 2012-2013 samples were collected from a water depth of 50m	Malta will adopt the correct sampling procedure to study marine benthos in sublittoral waters. In the upcoming monitoring programme Malta has to collect most samples from the 8-12 m depth range. Malta is to follow the procedure that has been outlined by the consultants in the case that sandy sediment is not found within the stipulated depth range, agreed to at MEDGIG level.
		Essential data on sediment grain size was not monitored	This requirement has been included in the coastal / marine monitoring programme

Changes to Hydromorphological element monitoring			
Monitoring of hydromorphological elements		Although a number of research initiatives have increased our knowledge on the physical features of our marine (incl.coastal) waters, there is still a lack of temporal and spatial data coverage of data related to currents, water circulation, water mixing and residence times. This is often due to the fact that monitoring equipment is prohibitively expensive	Assessment of baseline with respect to hydrographical conditions characterising Maltese waters has been included in the monitoring programme. Such baseline data includes *inter alia* data on currents, including current velocity and wave exposure. Before Malta can establish a better understanding of the mixing characteristics and residence time, the baseline data will first need to be collated.
Changes to Chemical status monitoring			
Monitoring of contaminants in biota	In the case of the analysis for certain chemicals in biota, the marine seagrass *Posidonia oceanica* was confirmed as a suitable bio-indicator for Maltese coastal waters up to 40m depth.	For biota sampling at greater depths, the necessity to rely on alternative biological species was considered important and parallel sampling of a different bio-indicator was recommended. In addition the new EQS Directive 2013/39/EU calls on MS to monitor certain substances (such as dioxins and dioxin like compounds) in fish, crustaceans and molluscs.	Monitoring programmes have been amended to include a wider spectrum of biota species that needs to be monitored. Monitoring in Posidonia rhizomes will be also be maintained to establish trends.

Table 5.27: Specific changes to various quality elements included in the second coastal water monitoring programme

(iii) Monitoring of pollutants of national concern (also known as River Basin specific contaminants)

During the first WCMP Malta had identified a preliminary list of non-priority specific pollutants that are equivalent to river basin specific pollutants. These included the following 10 contaminants

1. Copper,
2. Chromium,
3. Manganese,
4. Zinc,
5. Barium,
6. Beryllium,
7. Boron,
8. Cobalt,
9. Fluorides and
10. Malathion.

In selecting these pollutants, Malta considered list II families of the former Council Directive 76/464/EEC of 4 May 1976 on pollution caused by certain dangerous substances discharged into the aquatic environment of the Community[121] and the group of substances included as Annex I of the Dangerous Substances Directive; substances indicated as relevant for the Strategic Action Programme to address pollution from Land-based Activities as per requirements under the revised Protocol for the protection of the Mediterranean Sea against Pollution from Land-based sources and Activities (LBS Protocol). Substances were identified on the basis of the level of importation of the chemicals or class of chemicals by the National Statistics Office for the period 2000-2004 and on the level of occurrence in local

[121] This Directive has since been repealed

discharges and/or environment of the respective chemicals. All substances identified as having significant loads in the LBS Protocol National Baseline Budget (NBB) were also identified as being of national concern / River Basin Specific Pollutants.

The first Monitoring results of these contaminants in the sediment matrix together with the development of the inventory of water discharges enabled Malta to revise this list as follows:

- **Copper, Chromium, Manganese , Zinc** and **Barium** are national pollutants of concern
- **Boron** levels in seawater as measured by means of the Watch list pilot, are similar to background levels in the Mediterranean**.** In the harbour of Marsaxlokk, however, it could be a potential pollutant of concern. Further investigative monitoring may therefore be needed here.
- **Beryllium** and **fluorides** were also only detected in small quantities in the Marsaxlokk harbour and therefore further investigative monitoring for these parameters is not being ruled out at this stage.
- **Cobalt and Malathion** were not detected in any samples and thus are being considered to be retracted.

5.3.3 Monitoring of priority substances and other chemicals of national concern during the first WCMP cycle.

A number of priority substances established in Directive 2008/105/EC together with other national pollutants of concern were measured in the water, sediment and biota matrix. A complete list of these substances, together with their respective Limits of Quantification, Limits of Detection, the matrix in which they were measured, and the method applied are provided in Table 5.29 , Table 5.30 and 5.31 below.

Parameter	Methods*	LOQ	LOD	Unit
Polyaromatic Hydrocarbons (Total) *	EPA 3510C 1996 + EPA 3640A 1994 + EPA 8270D 2007	0,0125	0,003	µg/L
Benzo (a) pyrene	EPA 3510C 1996 + EPA 3640A 1994 + EPA 8270D 2007	0,005	0,001	µg/L
Benzo (b) fluoranthene	EPA 3510C 1996 + EPA 3640A 1994 + EPA 8270D 2007	0,005	0,002	µg/L
Benzo (g, h,i) perylene	EPA 3510C 1996 + EPA 3640A 1994 + EPA 8270D 2007	0,005	0,001	µg/L
Benzo (k) fluoranthene	EPA 3510C 1996 + EPA 3640A 1994 + EPA 8270D 2007	0,005	0,002	µg/L
Indeno (1,2,3 - c, d) pyrene	EPA 3510C 1996 + EPA 3640A 1994 + EPA 8270D 2007	0,005	0,001	µg/L
Cadmium	EPA 3015A 2007 + EPA 6020A 2007	0,45	0,2	µg/L
Lead	EPA 3015A 2007 + EPA 6020A 2007	0,2	0,01	µg/L
Mercury	EPA 3015A 2007 + EPA 6020A 2007	0,05	0,02	µg/L
Nickel	EPA 3015A 2007 + EPA 6020A 2007	0,2	0,01	µg/L
Benzene	EPA 5021A 2003 + EPA 8260C 2006	0,1	0,01	µg/L
Tetrachloromethane	EPA 5021A 2003 + EPA 8260C 2006	0,1	0,01	µg/L
1,2 - Dichloroethane	EPA 5021A 2003 + EPA 8260C 2006	0,1	0,01	µg/L
Dichloromethane	EPA 5021A 2003 + EPA 8260C 2006	0,1	0,01	µg/L
Tetrachloroethene	EPA 5021A 2003 + EPA 8260C 2006	0,1	0,01	µg/L
Trichloroethene	EPA 5021A 2003 + EPA 8260C 2006	0,1	0,01	µg/L
Trichloromethane	EPA 5021A 2003 + EPA 8260C 2006	0,1	0,01	µg/L
Anthracene	EPA 3510C 1996 + EPA 3640A 1994 + EPA 8270D 2007	0,005	0,001	µg/L
Fluoranthene	EPA 3510C 1996 + EPA 3640A 1994 + EPA 8270D 2007	0,005	0,001	µg/L
Alachlor	EPA 3510C 1996 + EPA 3640A 1994 + EPA 8270D 2007	0,005	0,001	µg/L
Chlorpyrifos	EPA 3510C 1996 + EPA 3640A 1994 + EPA 8270D 2007	0,005	0,001	µg/L
Endrin	EPA 3510C 1996 + EPA 3640A 1994 + EPA 8270D 2007	0,005	0,001	µg/L

Isodrin	EPA 3510C 1996 + EPA 3640A 1994 + EPA 8270D 2007	0,005	0,001	µg/L
Aldrin	EPA 3510C 1996 + EPA 3640A 1994 + EPA 8270D 2007	0,005	0,001	µg/L
Dieldrin	EPA 3510C 1996 + EPA 3640A 1994 + EPA 8270D 2007	0,005	0,001	µg/L
DDT	EPA 3510C 1996 + EPA 3640A 1994 + EPA 8270D 2007	0,005	0,001	µg/L
Endosulfan (**)	EPA 3510C 1996 + EPA 3640A 1994 + EPA 8270D 2007	0,005	0,001	µg/L
Hexachlorobenzene	EPA 3510C 1996 + EPA 3640A 1994 + EPA 8270D 2007	0,005	0,001	µg/L
Hexachlorobutadiene	EPA 5021A 2003 + EPA 8260C 2006	0,005	0,001	µg/L
Hexachlorocyclohexane (***)	EPA 3510C 1996 + EPA 3640A 1994 + EPA 8270D 2007	0,005	0,001	µg/L
Tributyltin	UNI EN ISO 17353:2006	1	0,05	µg/L
Trifluralin	EPA 3510C 1996 + EPA 3640A 1994 + EPA 8270D 2007	0,005	0,001	µg/L
Diuron	EPA 3510C 1996 + EPA 3640A 1994 + EPA 8270D 2007	0,005	0,001	µg/L
Chloroalkanes (C10 - C13)	EPA 3510C 1996 + EPA 3640A 1994 + EPA 8015D 2003	1	0,4	µg/L
Chlorfenvinphos	EPA 3510C 1996 + EPA 3640A 1994 + EPA 8270D 2007	0,005	0,001	µg/L
Brominated diphenylethers	EPA 3510C 1996 + EPA 3640A 1994 + EPA 8270D 2007	0,005	0,001	µg/L
Di(2-ethylhexyl)phthalate	EPA 3510C 1996 + EPA 3640A 1994 + EPA 8270D 2007	0,005	0,001	µg/L
Nonylphenols	EPA 3510C 1996 + EPA 3640A 1994 + EPA 8270D 2007	0,005	0,001	µg/L
4-para-Nonylphenols	EPA 3510C 1996 + EPA 3640A 1994 + EPA 8270D 2007	0,005	0,001	µg/L
Octylphenols	EPA 3510C 1996 + EPA 3640A 1994 + EPA 8270D 2007	0,005	0,001	µg/L
Trichlorobenzene	EPA 3510C 1996 + EPA 3640A 1994 + EPA 8270D 2007	0,005	0,001	µg/L
Pentachlorobenzene	EPA 3510C 1996 + EPA 3640A 1994 + EPA 8270D 2007	0,005	0,001	µg/L
Atrazine	EPA 3510C 1996 + EPA 3640A 1994 + EPA 8270D 2007	0,005	0,001	µg/L
Isoprotun	EPA 3510C 1996 + EPA 3640A 1994 + EPA 8270D 2007	0,5	0,1	µg/L
Naphthalene	EPA 3510C 1996 + EPA 3640A 1994 + EPA 8270D 2007	0,005	0,001	µg/L
Pentachlorophenol	EPA 3510C 1996 + EPA 3640A 1994 + EPA 8270D 2007	0,005	0,001	µg/L
Simazine	EPA 3510C 1996 + EPA 3640A 1994 + EPA 8270D 2007	0,005	0,001	µg/L

Table 5.28: Methods of analysis, LODs and LOQs for contaminants measured in the Water Matrix

*Analytical methods are indicative of methods that were used but are subject to change according to the Competent Authorities' requirements.

Parameter	Methods *	LOQ	LOD	Unit
Cadmium	EPA 3051A 2007 + EPA 6020A 2007	0,02	0,01	mg/Kg
Nickel	EPA 3051A 2007 + EPA 6020A 2007	0,02	0,01	mg/Kg
Lead	EPA 3051A 2007 + EPA 6020A 2007	0,02	0,01	mg/Kg
Mercury	EPA 3051A 2007 + EPA 6020A 2007	0,01	0,005	mg/Kg
Copper	EPA 3051A 2007 + EPA 6020A 2007	0,02	0,01	mg/Kg
Chromium	EPA 3051A 2007 + EPA 6020A 2007	0,02	0,01	mg/Kg
Cobalt	EPA 3051A 2007 + EPA 6020A 2007	0,02	0,01	mg/Kg
Manganese	EPA 3051A 2007 + EPA 6020A 2007	0,02	0,01	mg/Kg
Zinc	EPA 3051A 2007 + EPA 6020A 2007	0,02	0,01	mg/Kg
Barium	EPA 3051A 2007 + EPA 6020A 2007	0,02	0,01	mg/Kg
Beryllium	EPA 3051A 2007 + EPA 6020A 2007	0,02	0,01	mg/Kg
Boron	EPA 3051A 2007 + EPA 6020A 2007	0,02	0,01	mg/Kg
Fluorides	EPA 300.0 1993	0,2	0,1	mg/Kg
Hydrocarbons Total	EPA 3545A 2007 + EPA 3620C 2007 + EPA 8015C 2007	5	1	mg/Kg
Polyaromatic Hydrocarbons (Total)(*)	EPA 3545A 2007 + EPA 3640A 1994 + EPA 8270D 2007	0,0005	0,00025	mg/Kg
Indeno (1,2,3 - c, d) pyrene	EPA 3545A 2007 + EPA 3640A 1994 + EPA 8270D 2007	0,0002	0,0001	mg/Kg
Benzo (a) pyrene	EPA 3545A 2007 + EPA 3640A 1994 + EPA 8270D 2007	0,0002	0,0001	mg/Kg
Benzo (b) fluoranthene	EPA 3545A 2007 + EPA 3640A 1994 + EPA 8270D 2007	0,0002	0,0001	mg/Kg
Benzo (g, h,i) perylene	EPA 3545A 2007 + EPA 3640A 1994 + EPA 8270D 2007	0,0002	0,0001	mg/Kg

Benzo (k) fluoranthene	EPA 3545A 2007 + EPA 3640A 1994 + EPA 8270D 2007	0,0002	0,0001	mg/Kg
PHC (=Total Hydrocarbons)	EPA 3545A 2007 + EPA 3620C 2007 + EPA 8015D 2007	5	1	mg/Kg
Malathion	EPA 3545A 2007 + EPA 3640A 1994 + EPA 8270D 2007	0,0002	0,0001	mg/Kg
DDT	EPA 3545A 2007 + EPA 3640A 1994 + EPA 8270D 2007	0,0002	0,0001	mg/Kg
Diuron	EPA 3545A 2007 + EPA 3640A 1994 + EPA 8270D 2007	0,002	0,001	mg/Kg
Endosulfan(**)	EPA 3545A 2007 + EPA 3620C 2007 + EPA 8270D 2007	0,0002	0,0001	mg/Kg
Endrin	EPA 3545A 2007 + EPA 3640A 1994 + EPA 8270D 2007	0,0002	0,0001	mg/Kg
Hexachlorobenzene	EPA 3545A 2007 + EPA 3640A 1994 + EPA 8270D 2007	0,0002	0,0001	mg/Kg
Hexachlorobutadiene	EPA 5021A 2003 + EPA 8260C 2006	0,005	0,004	mg/Kg
Hexachlorocyclohexane (***)	EPA 3545A 2007 + EPA 3640A 1994 + EPA 8270D 2007	0,0002	0,0001	mg/Kg
Pentachlorobenzene	EPA 3545A 2007 + EPA 3640A 1994 + EPA 8270D 2007	0,0002	0,0001	mg/Kg
Brominated diphenylethers	EPA 3545A 2007 + EPA 3640A 1994 + EPA 8270D 2007	0,005	0,002	mg/Kg
Chloroalkanes (C10 - C13)	EPA 3545A 2007 + EPA 3640A 1994 + EPA 8270D 2007	0,01	0,005	mg/Kg
Di(2-ethylhexyl)phthalate	EPA 3545A 2007 + EPA 3640A 1994 + EPA 8270D 2007	0,0002	0,0001	mg/Kg
Tributyltin	Method ICRAM	0,0002	0,0001	mg/Kg
Fluoranthene	EPA 3545A 2007 + EPA 3640A 1994 + EPA 8270D 2007	0,0002	0,0001	mg/Kg
Naphthalene	EPA 3545A 2007 + EPA 3640A 1994 + EPA 8270D 2007	0,0002	0,0001	mg/Kg
Anthracene	EPA 3545A 2007 + EPA 3640A 1994 + EPA 8270D 2007	0,0002	0,0001	mg/Kg

Table 5.29: Methods of analysis, LODs and LOQs for contaminants measured in Sediment

*Analytical methods are indicative of methods that were used but are subject to change according to the Competent Authorities' requirements.

Parameter	LOD	LOQ	Unit
Mercury	< 0,002	< 0,005	mg/kg
Hexachlorobenzene	< 0,0001	< 0,0005	mg/kg
Hexachlorobutadiene	< 0,005	< 0,01	mg/kg

Table 5.30: Methods of analysis, LODs and LOQs for contaminants measured in Biota

5.4 Coastal water Monitoring Network Implementation Strategy for the 2nd WCMP

The WFD monitoring strategy and related programme for coastal waters has been incorporated into that of the Marine Strategy Framework Directive and Barcelona Convention, as well as other water related directives, strategies or conventions. This has enabled the appropriate streamlining of all monitoring efforts into one coherent national monitoring strategy. A full list of the links to additional Conventions and Directives per monitoring programme is provided below.

Each monitoring programme identifies

- the related legislative requirements,
- the Competent Authorities responsible for the monitoring programme and the data,
- the spatial extent of the monitoring network,

- the required monitoring parameters per theme and supporting parameters, the respective monitoring stations and relevant coordinates and frequency of monitoring
- Links to other related monitoring processes/programmes
- An explanation of how the monitoring will feed into the assessment of status
- Relevant pressures and/or activities that may affect marine elements covered by the monitoring factsheets;
- Quality Assurance and Control of the methods applied and analysis
- Any additional gaps and research needs that would need to be implemented over and above the monitoring programme in a phased manner.

5.4.1 Ecological quality monitoring

The relevant detailed monitoring programmes related to the various quality elements assessed for ecological Status consist of four. For Biological quality parameter monitoring reference is made to the monitoring factsheets of **Benthic Habitats** (covering Angiosperms, benthic invertebrates and macroalgae) and **Water column** (covering phytoplankton). These are accessible from the following webpage: http://www.mepa.org.mt/water-msfd. A summary of these monitoring programmes are provided in sections 5.6.1.1 and 5.6.1.2 below.

The monitoring factsheets entitled '**Eutrophication**' (including physico-chemical parameters) and '**Hydrographical changes'** (including hydromorphological parameters) deal with additional elements needed to be monitored in order to support the biological quality elements. Other physicochemical parameters have been integrated in the monitoring programmes dealing with all biological quality elements. These are accessible from the following webpage: http://www.mepa.org.mt/water-msfd
A summary of these monitoring programmes are provided in sections 5.6.1.3 and 5.6.1.4 respectively.

5.4.1.1 Monitoring programme for benthic habitats

The following relevant habitats under the Joint MSFD-WFD monitoring programme will be monitored by means on the benthic habitat monitoring programme:

MSFD habitat classification	Depth	Topography
Littoral rock and biogenic reef	0m	Coastal Waters
Shallow sublittoral rock and biogenic reef	0m – 50m	

5.4.1.1.1 Monitoring parameters for benthic habitats and applicable monitoring methodologies

The monitoring parameters for selected benthic habitats relevant to the WFD are listed in Table 5.32. Habitats to be monitored were selected on the basis of availability of baseline data and listings in policies that emanate form EU law (i.e. water related directives and EU Biodiversity Strategy) and regional conventions, such as the Barcelona Convention and the Protocol for Specially protected Areas and Biological Diversity in the Mediterranean. Habitat types and parameters to be monitored are subject to revision as further knowledge and baseline data becomes available, on the basis of a risk-based approach.

Habitat	Indicator	Parameter	Methodology to be applied
Littoral and shallow sublittoral rock: Hard beds associated with communities of photophilic algae (*Cystoseira* belts)	Habitat Distributional Range	Grid map outlining the lateral extent of habitat	The range and extent of macroalgal assemblages characterised by *Cystoseira* spp. are determined through the application of the CARLIT[122] methodology as described in Ballesteros *et al.* 2007[123]. The length of coastline occupied by macroalgal assemblages dominated by *Cystoseira* spp. is recorded. Range and extent are also recorded on a 1kmX1km grid
	Habitat Extent	Length of coastline occupied by habitat type (km)	
	Habitat condition: Condition of the typical species and communities	List of habitat-typical species	The CARLIT methodology is applied by means of a small boat, navigated as close as possible to the rocky shoreline at selected sampling stations. Macroalgae present in the littoral and upper-sublittoral zones (to a maximum depth of 0.5m) along the Maltese coastline are identified and recorded as per categories listed in the Monitoring factsheet on appropriate maps. The rocky shoreline is partitioned into sections of habitat categories which are assigned sensitivity levels reflecting the vulnerability/resistance of communities to environmental stress related to water quality. Geomorphological factors which are likely to influence the presence / abundance of macroalgae communities are defined. Each sector of the coast is thus characterized by the community category and the different geomorphological features.
		Density of *Cystoseira* spp. per length of coastline	
	Habitat condition: Relative abundance	CARLIT index (based on assigned sensitivity of macroalgal community and length of coastline occupied by the community)	
Organogenic trottoirs with *Lithophyllum* spp, including facies with vermetids (trottoir with vermetids)	Habitat Distributional Range	Grid map outlining the lateral extent of habitat	Application of the CARLIT methodology for the purposes of determining range and extent of macroalgal assemblages is applied to determine the range and extent of organogenic trottoirs with *Lithophyllum* spp. and trottoirs with *Dendropoma* spp. The length of coastline occupied by organogenic trottoirs is recorded.
	Habitat Extent	Length of coastline occupied by habitat type (km)	

122 'CARtography of LITtoral and upper-sublittoral rocky communities'

123 Ballesteros E., Torras X., Pinedo S., Garcia M., Mangialajo L., de Torres M. (2007). A new methodology based on littoral community cartography dominated by macroalgae for the implementation of the European Water Framework Directive. Marine Pollution Bulletin 55: 172-180.

Habitat	Indicator	Parameter	Methodology to be applied
Organogenic trottoir with *Lithophyllum* sp.	Habitat Condition: Condition of the typical species and communities	% cover of live *Lithophyllum* species	0.2mX0.2m quadrats are randomly deployed along stretches of coastline identified to host *Lithophyllum* spp. concretions. Percentage cover of live and dead *Lithophyllum* spp. is determined through visual estimations.
Posidonia beds	Habitat Distribution: Range	Grid map outlining the lateral extent of habitat in question	Determined through the application of remote seabed mapping techniques. Range and extent are recorded on a 1kmX1km grid as per Assessment and reporting under Article 17 of the Habitats Directive: Explanatory notes & Guidelines for the period 2007-2012. The bathymetric range of this habitat type is determined through the application of the PREI index as described in Gobert et al 2009[124]
	Habitat Extent	Area covered by habitat type (km^2)	
	Habitat condition: Condition of the typical species and communities	Shoot Density [PREI index]	The PREI Index is applied at specific monitoring stations. This technique requires SCUBA divers working on monitoring stations at constant depths (at 15 $\pm$ 1m depth) and on fixed points at the lower limit of the meadow. At each station, three $400m^2$ areas each being 10m apart are investigated as replicates.
		Shoot Surface Area [PREI index]	
		Ratio between epiphytic biomass and leaf biomass [PREI index]	
		depth of the lower limit [PREI index]	
		type of this limit (regressive, progressive or stable) [PREI index]	
		% live *Posidonia*: dead matte	
Shallow sublittoral sediment	Habitat Condition: Presence of particularly sensitive and/or tolerant species	Number of species (S)	Two replicate samples are collected from monitoring stations on shallow sublittoral sediment by means of a 0.025m2 Van Veen grab. Samples are washed through a 0.5mm mesh sieve and then fixed in buffered formalin-seawater solution (8%). Sediment grain size is determined through granulometric analysis; Total Organic Carbon is also measured for the sediment samples. Organisms are sorted out and classified to the lowest taxonomic level possible. The abundance of each taxon is expressed as number of individuals. % abundance of
		Species Richness	
		Abundance (Individuals/m^2)	
		Diversity index (H') (Shannon Wiener)	
		BENTIX index determined in line with methodologies outlined in Simboura and Zenetos (2002)[125]	

[124] Gobert, S., Sartoretto, S., Rico-Raimondino, V., Andral, B., Chery, A., Lejeune, P., & Boissery, P. (2009). Assessment of the ecological status of Mediterranean French coastal waters as required by the Water Framework Directive using the *Posidonia oceanica* Rapid Easy Index: PREI. Marine Pollution Bulletin, 58(11), 1727-1733.

[125] Simboura, N. and Zenetos, A. 2002. Benthid indicators to use in Ecological Quality classification of Mediterranean soft bottom ecosystems, including a new Biotic Index *in* Mediterranean Marine Science, Vol 3/2. 2002, 77-111.

Habitat	Indicator	Parameter	Methodology to be applied
			benthic invertebrates within each ecological group is determined.

Table 5.31: Indicators and parameters to be monitored per selected habitat

When considering all the various elements of the coastal water monitoring programmes together, the following supporting parameters will be monitored to assist in data analysis and interpretation of results:

Parameter	Unit
Nutrients	
Dissolved Oxygen	% saturation
Water Turbidity	Secchi depths, NTU
Near bottom temperature	°C
Salinity	psu
Organic matter in sediment (in relation to assessment of benthic invertebrates)	%
ph	
Granulometric analysis of sediment in relation to assessment of benthic invertebrates (sediment grain size)	
Hydrodynamics Data including seabed structure, substrata, composition, topography, bathymetry, current direction/wave exposure	

Table 5.32: Supporting parameters to be monitored together with benthic habitats

Additional Information that will be recorded includes:

- time of the day,
- weather conditions,
- sampling depth,
- an estimate of the volume of sediment collected and
- a visual description of the sediment collected (depth of oxygenated layer and smell).

5.4.1.1.2 Monitoring network

(i) Monitoring stations established for Hard beds associated with communities of photophilic algae (Cystoseira belts)

The CARLIT methodology is applied along the whole stretch of Malta's coastline. Data interpretation for the purpose of status assessment is carried out on the basis of the water bodies.

(ii) *Posidonia oceanica*

The distribution and extent of *Posidonia* beds are assessed at a National scale. Assessment of the condition of *Posidonia* beds will be undertaken at monitoring stations listed in Table 5.34 and shown in Figure 5.4. Monitoring stations are subject to revision following the initial monitoring cycles.

Mon. Site Ref. Code	Monitoring Network	Coordinates (Full UTM ED50)	
		Longitude	Latitude
CP04-1	Operational	453769,71	3977836,62
CP04-2	Operational	449013,07	3979914,24
CP06-1	Operational	461078,41	3971492,15
CP06-2	Operational	460522,84	3970960,01
CP07	Operational - Harbour	459771,77	3964111,98
CS02	Sur + Reference Site	435571,14	3992063,13
CS03	Sur + Reference Site	442502,54	3984741,51
CS09	Sur + Protected area	439697,26	3976129,46
CN01-1	Protected Area	426700,89	3990134,58
CN01-2	Op – Diffuse Sources	429492,88	3987775,43
CN02-1	Op – Diffuse sources	433397,15	3992518,78
CN03-1	Op – Sewage Outfall	435420,03	3986084,12
CN03-3	Op - Harbour	440130,02	3983083,45
CN03-6	Op – Minor Sewage Outfall	441540,34	3985079,15
CN04-1	Op - diffuse sources	442596,44	3981355,59
CN04-3	Op - bunkering site	445500,41	3984462,78
CN04-4	Op - diffuse sources	444937,85	3978614,21
CN04-5	Nitrates Directive	454162,08	3976206,21
CN04-6	Nitrates Directive	454528,54	3975162,74
CN06-1	Op - diffuse sources	460815,92	3969206,43
CN07-1	Op - Thermal effluent	460712,08	3966044,50
CN07-2	Op – Harbour	459413,96	3965607,40
CN07-3	Op – Harbour	458110,28	3965070,20
CN08-1	Op – Desalination Plant	447163,40	3965389,58
CN09-1	Op – Sewage Outfall	440099,89	3979621,63
MPA MSFD 1	Mgarr ix-Xini MPA	434555,04	3986240,65

Table 5.33: Monitoring Stations for assessment of the condition of *Posidonia* beds

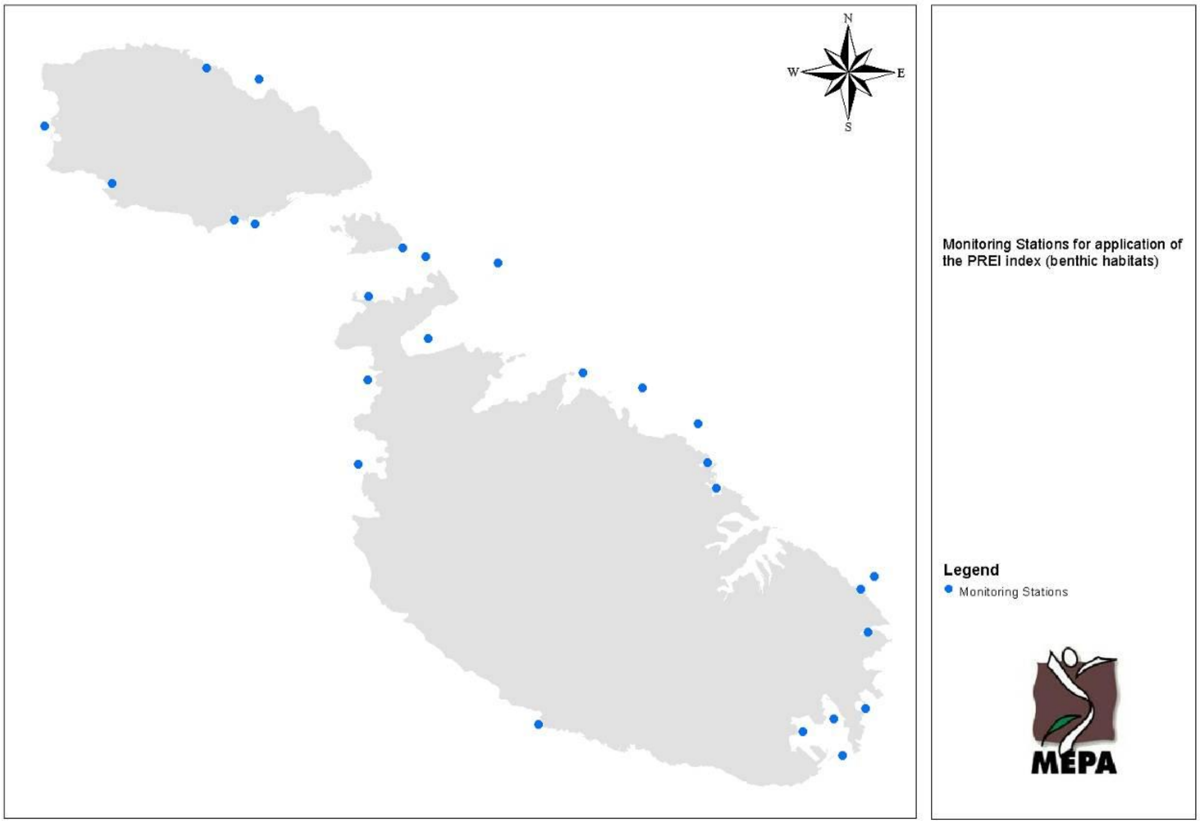

Figure 5.4: Monitoring stations for the application of the PREI index

(iii) Shallow Sublittoral Sediment

Malta's first intercalibration process revealed that the initial monitoring stations for benthic invertebrates were not sufficient for purposes of intercalibration. Monitoring stations for the purpose of assessing benthic invertebrates will therefore need to be revisited and identified through a pilot survey. Stations characterised by sediment within the 8-12m depth range are to be selected and georeferenced. Should stations within this depth range be mostly characterised by seagrasses or rocky bottoms, alternative stations are selected within the 6m – 15m depth range or at a maximum depth of 18m. The latter depth range should only be used as a last resort. Implementation of the monitoring programme will therefore be undertaken following completion of this exercise and identification of the monitoring stations.

5.4.1.2 Monitoring programme for Phytoplankton

Water column habitats are generally referred to as 'pelagic' habitats which include the water column and all the organisms that inhabit it. In accordance with UNEP/RAC/SPA (2013)[126,] two zones of pelagic habitats are identified:

- the neritic zone – also known as coastal zone - which is the portion of the ocean lying above the continental shelf (i.e., extending from the low tide mark to the location corresponding to the continental shelf break - around a depth of 200 m); and
- the oceanic zone – also termed the open ocean or open sea - which extends away from the coast beyond the shelf break.

[126] UNEP(DEPI)/MED WG.382/11: Towards the identification and Reference List of Pelagic Habitat Types in the Mediterranean Sea.

The WFD component of this monitoring programme focuses on the former zone. Water column habitats are largely dependent on movements of the water masses and the complex interactions between biological and physical processes. For this reason, water column habitats can be classified differently at different times of the year. In the case of Malta such classification would depend on the hydrodynamics in the area, which are mainly dictated by the general flow in the Sicilian Channel, and thermal stratification of the water column that characterises the Mediterranean basin.

5.4.1.2.1 Monitoring parameters for phytoplankton and applicable monitoring methodologies

(i) Monitoring parameters

Parameter	Unit
Phytoplankton abundance	cells per litre
Phytoplankton biomass (chlorophyll-a)	µg/L
Phytoplankton composition[127]	
Percentage abundance of known opportunistic/blooming/non-indigenous species[128]	
Species shifts: Diatom to flagellate ratio	

Table 5.34: Monitoring parameters for phytoplankton

When considering all the various elements of the coastal water monitoring programmes together, the following supporting parameters will be monitored to assist in data analysis and interpretation of results:

Parameter	Unit
Nutrients	
Dissolved Oxygen	% saturation
Water Transparency/Turbidity	Secchi depths, NTU
Temperature	°C
Salinity	psu
pH	
Hydrodynamics Data	

Table: 5.35: Supporting parameters

(ii) Applicable methodologies

Water sampling will take place at the monitoring stations at surface and sub-surface depth (between 1m and 5m from surface[129]) and along specified transects at three depths: surface, medium depth and bottom, using the methodology that is in line with the 'Eutrophication Monitoring Strategy of MEDPOL'[130].

127 This parameter can be used to determine the diatom:flagellate ratio

128 Ferreria et al. (2010) distinguish three types of harmful blooms: (i) those due to toxic algae (e.g. Alexandrium, Dinophysis and Pseudonitzschia) which can poison fish and shellfish even at low algal abundance; (ii) potentially toxic algae (e.g. Pseudonitzschia); and (iii) high-biomass blooms that cause problems mainly because of the high biomass itself. High-biomass blooms are sometimes called "red tides" but may in fact be brown, green or white discolourations of the sea. Some organisms (e.g. Alexandrium) occur in more than one category. Links between HABs and nutrient enrichment have been much debated. HABs should be treated as part of the undesirable consequences of eutrophication only if their frequency or amplitude increases in correspondence with increased nutrient input.

129 When vertical distribution of phytoplankton populations is to be studied, samples from deeper waters and at a number of depths would need to be collected. During the first cycle of monitoring the samples are taken at surface and sub-surface depth, e.g. between 1 and 5 m from surface pending further knowledge on the vertical distribution patterns of phytoplankton and their relationship with environmental status.

130 UNEP(DEC)/MED WG. 231/14

Replicate samples are collected using Van-Dorn vertical all-plastic sampler or Niskin bottles[131.] The volume collected is normally about 5L, which will sufficiently provide sub-samples for the different parameters that would need to be analysed from each location. For chlorophyll-a analysis, samples are collected in dark glass containers and filtered either immediately on board the vessel, or else in the laboratory within 8 hours from collection.

Samples are appropriately preserved: those intended for identification of major phytoplankton groups are preserved in Lugol's Iodine, while samples intended for detailed species identification are preserved using both Lugol's Iodine and formalin (2 aliquots).

(iii) Sample Analysis

The following elements will be analysed for Phytoplankton samples:

- *Full species composition and abundance*: involving concentration of samples followed by enumeration and identification to genus or species level on an inverted optical microscope.
- *Total Abundance of major groups*: identification of individuals down to the major groups: diatoms, dinoflagellates, and other phytoplankton[132]. Diatom to flagellate ratios are also to be determined.
- *Percentage abundance of known opportunistic/blooming/non-indigenous species*: Species that are known to be opportunistic or have a tendency to bloom or that are known to be non-indigenous are specifically counted and their percentage abundance is calculated from the total abundance.
- *Biomass (Chlorophyll a)*: chemical determination of chlorophyll *a* concentration through spectrophotometry (SPFT)

(iv) Standards for sampling

Adherence to methodological standards as listed below will be ensured. Monitoring methodologies should primarily be in line with those stipulated in UNEP/MAP/MED POL (2005)[133].

- EN 15204:2006: Water Quality – Guidance standard on the enumeration of phytoplankton using inverted microscopy (Utermöhl Technique)
- EN 15972:2011: Water Quality – Guidance on quantitative and qualitative investigations of marine phytoplankton
- ISO 10260:1992: Water Quality – Measurement of biochemical parameters – Spectrometric determination of the chlorophyll-a concentration

[131] Phytoplankton nets, which are useful in collecting samples over a relatively large area to assess the different species of phytoplankton that are present, may be used in offshore stations (only) to collect semi-quantitative data to be combined with quantitative data from samples collected in Niskin bottles. A conical net of diameter 20 – 30 cm, having a mesh size of 100µm or smaller (30 – 80 µm), is deployed at a specific depth between 1 and 5m from surface. The towing speed should be relatively constant between 1 and 2 knots and horizontal tows should be of 5-10 minutes duration. The net is rinsed thoroughly between hauls so as to remove any species that might have adhered to its sides.

[132] Due to their small size and lack of protruding structures that aid identification, phytoplankton other than diatoms and dinoflagellates often require more strenuous and sophisticated methods for their identification and enumeration, with preliminary filtration of samples, specialised concentration techniques and the combination of light and electron microscopical observations for satisfactory identification. Focus will thus be on the processing of samples for diatom and dinoflagellate identification, with the remaining specimens being categorised under 'other flagellates'

133 UNEP/MAP/MED POL (2005). Sampling and Analysis Techniques for the Eutrophication Monitoring Strategy of MED POL. MAP Technical Reports Series No. 163. UNEP/MAP, Athens, 2005

5.4.1.1.2 Monitoring network for phytoplankton

The monitoring network for phytoplankton consists of four types of networks:

a) inshore monitoring stations (refer to Table 3.37 and Figure 5.5)
b) nearshore (500m-1500m) for chlorophyll *a* only to enable intercalibration of chlorophyll-a (refer to Table 3.37)
c) monitoring nine of the inshore monitoring stations at a distance of 6 nm from the baseline where the breadth of the territorial waters is measured with a view to provide data between the 1nm and the 12 nm extent of Malta's territorial waters (Table 3.38).
d) Transects – sampling along a transect perpendicular to the coastline will be carried out for 4 additional monitoring stations in order to assess the horizontal and vertical distribution of phytoplankton (Table 3.39).

Monitoring stations shall be updated after the first monitoring year also on the basis of further knowledge on phytoplankton in inshore and offshore waters.

Mon. Site Ref. Code	Monitoring Network	Coordinates (Full UTM ED50)	
		Longitude	Latitude
Operational Monitoring Stations			
CP04-1	Operational	453769,71	3977836,62
CP04-2	Operational	449013,07	3979914,24
CP05	Operational - Harbour	457169,68	3973252,05
CP06-1	Operational	461078,41	3971492,15
CP06-2	Operational	460522,84	3970960,01
CP07	Operational - Harbour	459771,77	3964111,98
Surveillance Monitoring Stations			
CS01	Surveillance	425781,39	3992303,97
CS02	Sur + Reference Site	435571,14	3992063,13
CS03	Sur + Reference Site	442502,54	3984741,51
CS08	Surveillance	453654,59	3962794,34
CS09	Sur + Protected area	439697,26	3976129,46
National Monitoring Stations			
CN01-1	Protected Area	426700,89	3990134,58
CN01-2	Op – Diffuse Sources	429492,88	3987775,43
CN02-1	Op – Diffuse sources	433397,15	3992518,78
CN03-1	Op – Sewage Outfall	435420,03	3986084,12
CN03-2	Op - Harbour	437057,14	3987236,76
CN03-3	Op – Harbour	440130,02	3983083,45
CN03-6	Op – Minor Sewage Outfall	441540,34	3985079,15
CN04-1	Op - diffuse sources	442596,44	3981355,59
CN04-3	Op - bunkering site	445500,41	3984462,78
CN04-5	Nitrates Directive	454162,08	3976206,21
CN04-6	Nitrates Directive	454528,54	3975162,74
CN05-1	Op – Harbour	455167,45	3973034,62
CN06-1	Op - diffuse sources	460815,92	3969206,43
CN07-1	Op - Thermal effluent	460712,08	3966044,50
CN07-2	Op – Harbour	459413,96	3965607,40
CN07-3	Op – Harbour	458110,28	3965070,20
CN08-1	Op – Desalination Plant	447163,40	3965389,58
CN09-1	Op – Sewage Outfall	440099,89	3979621,63

Table 5.36: Inshore monitoring stations

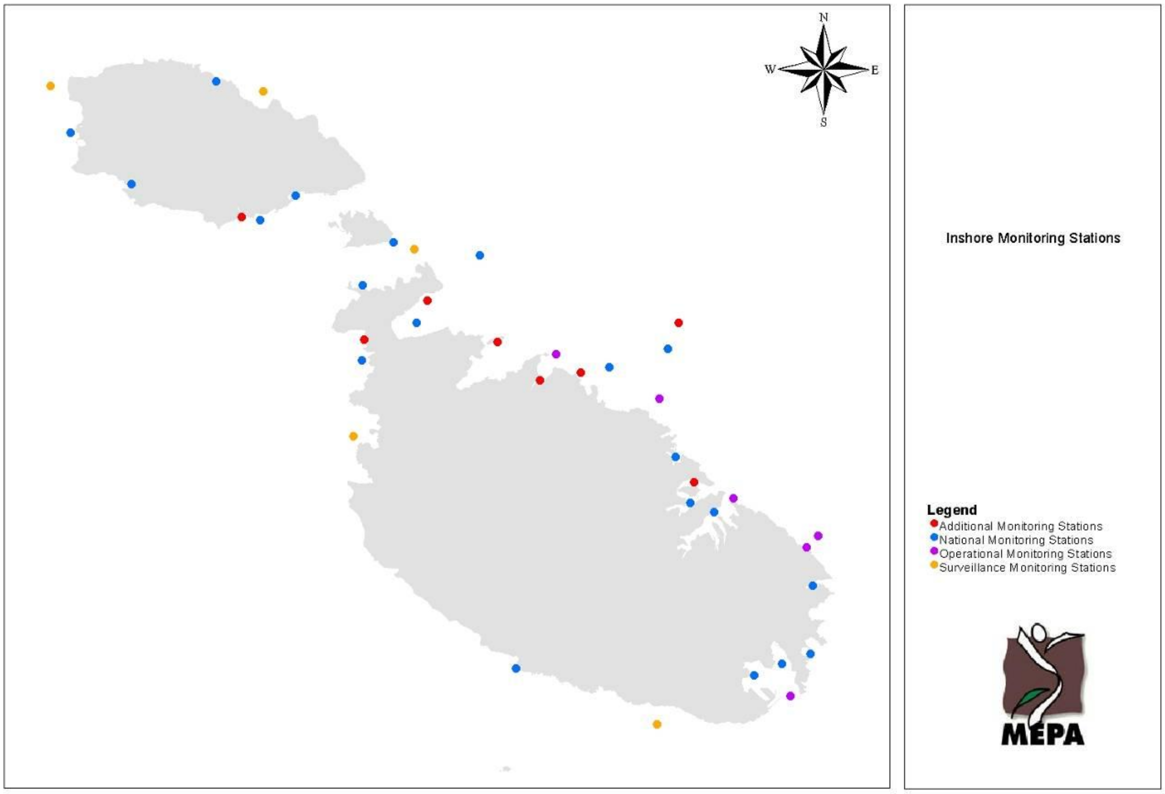

Figure 5.5: Inshore monitoring stations

Mon. Site Ref. Code	Monitoring Network	Coordinates (Full UTM ED50)	
		Longitude	Latitude
CP04-2	Operational	449013,07	3979914,24
CP05	Operational - Harbour	457169,68	3973252,05
CP06-2	Operational	460522,84	3970960,01
CP07	Operational - Harbour	459771,77	3964111,98
CN01-1	Protected Area	426700,89	3990134,58
CN03-1	Op – Sewage Outfall	435420,03	3986084,12
CN03-6	Op-Minor Sewage Outfall	441540,34	3985079,15
CN09-1	Op – Sewage Outfall	440099,89	3979621,63

Table 5.37: Additional nearshore stations for monitoring of chlorophyll-a

Mon. Site Ref. Code	Monitoring Network	Coordinates (Full UTM ED50)	
		Longitude	Latitude
CS01	Surveillance	425781,39	3992303,97
CS02	Sur + Reference Site	435571,14	3992063,13
CS03	Sur + Reference Site	442502,54	3984741,51
CP04-1	Operational	453769,71	3977836,62
CP05	Operational - Harbour	457169,68	3973252,05
CP06-1	Operational	461078,41	3971492,15
CP07	Operational - Harbour	459771,77	3964111,98
CS08	Surveillance	453654,59	3962794,34
CS09	Sur + Protected area	439697,26	3976129,46
Bunkering Area 2		463215,69	3970468,46

Mon. Site Ref. Code	Monitoring Network	Coordinates (Full UTM ED50)	
		Longitude	Latitude
Bunkering Area 3		480042,40	3971974,31
Bunkering Area 4		463310,71	3964577,20
Bunkering Area 6		439080,51	3978830,25
Waiting Area		470247,20	3967047,73

Table 5.38: Monitoring Stations to be sampled at a distance of 6 nautical miles from the baselines where the breadth of the territorial waters is measured and additional monitoring stations in bunkering areas[134]

Mon. Site Ref. Code	Monitoring Network	Coordinates (Full UTM ED50)	
		Longitude	Latitude
CN01-2	Op – Diffuse Sources (Xlendi)	429492,88	3987775,43
CN05-2	Op – Harbour (Grand Harbour)	456279,18	3972594,26
CN07-2	Op – Harbour (Marsaxlokk)	459413,96	3965607,40
	Innermost part of Salini	448260,79	3978712,49

Table 5.39: Monitoring stations to be supplemented by monitoring stations along a transect

5.4.1.1.3. Monitoring frequency

The monitoring frequency for the monitoring parameters on phytoplankton and zooplankton are listed in 5.40. To address the temporal variability of plankton populations, a minimal sampling frequency of a survey per season is essential. However, given the lack of available data on local populations, monthly sampling is resorted to for at least the first monitoring year. Monitoring frequency, monitoring stations and parameters to be monitored in each station are subject to revisions following the results of the first monitoring year.

		First Monitoring Year	Subsequent years
Chlorophyll-a	Inshore monitoring stations	monthly	To be determined following the first monitoring year
	Additional near shore stations	monthly	
	Stations at 6 nautical miles; bunkering areas, bunkering areas	6-monthly	
	transects	3-monthly	
phytoplankton composition and abundance	Inshore monitoring stations	3-monthly	
	Stations at 6 nautical miles; bunkering areas, bunkering areas	6-monthly	
	transects	3-monthly	

Table 5.40: Monitoring Frequency

[134] Bunkering Area 1 is covered by monitoring station CN04-3 hence not included in this table

5.4.1.3 Monitoring programme for physico-chemical parameters

5.4.1.3.1 Monitoring parameters for supporting physico-chemical parameters and applicable monitoring methodologies

Parameter	Unit	Methodology
i. Nutrient Concentrations in seawater		
Dissolved Nitrates (NO_3-N)	NO_3-N µmol/L, µg/L	Water sampling will take place at monitoring stations at surface and at one sub-surface depth (between 1 and 5m from surface) for analysis of nutrients, chlorophyll-a levels and phytoplankton profiles. Water samples collected along specified transects will take place at three depths: surface, medium depth and bottom as required by the 'Eutrophication Monitoring Strategy of MEDPOL'[135]. Nutrient ratios are to be determined for each sample, by determining the atomic elemental ratio of total nitrogen to total phosphorous to silicates.
Dissolved Nitrites (NO_2-N)	NO_2-N µmol/L, µg/L	
Ammonium ions (NH_4-N)	NH_4-N µmol/L, µg/L	
Dissolved Phosphates (PO_4-P)	PO_4-P µmol/L, µg/L	
Silicate (SiO_2)	SiO_2 µmol/L	
Total Nitrogen	N µmol/L, µg/L	
Total Phosphorous	P µmol/L, µg/L	
N:P:Si ratio		
(ii) Phytoplankton[136]		
Chlorophyll-a	µg/L	The applicable methodologies for phytoplankton have been included in section 5.6.1.2 above.
Phytoplankton abundance	cells per litre	
Phytoplankton composition[137]		
(iii) Other physico-chemical parameters		
Temperature	°C	Multiparametric probes are used for *in situ* measurements of the following physical parameters (Salinity , Temperature, Turbidity (through Transmissometer or Optical Black-Scatter System[138]), Dissolved Oxygen; pH) Depth profiles of these parameters are recorded. Secchi depths are measured to provide an indication of transparency. Measurement of physical parameters are undertaken under the same meteo-marine conditions throughout the monitoring years; Measurements of salinity and pH are also repeated in the laboratory.
Salinity	psu	
pH		
Water Transparency	Secchi depths, NTU	
Dissolved Oxygen	% saturation	
(iv) Organic matter in sediment		
Total Organic Carbon	% weight	Sediment samples are collected using van veen grabs. Sub-samples are labelled and frozen. 5g of the sediment sub-samples are weighted and analysed for organic carbon in accordance with Walkley & Black method (Buchanan, 1984)[139]. Samples are pre-treated with acid prior to the analysis to remove any inorganic carbon.

Table 5.41: Monitoring parameters for supporting physico-chemical parameters

135 UNEP(DEC)/MED WG. 231/14

136 Refer to Section 5.6.1.2

137 This parameter can be used to determine the diatom:flagellate ratio

138 The OBS is the preferred instrument in areas where the total suspended material concentration in the water column exceeds ~200 ppm, whereas a transmissometer usually is the more effective instrument in locations with low total suspended material concentration

139 Buchanan J.B. (1984). Sediment analysis. In: N.A. Holme & A.D. McIntyre [eds] Methods for the study of marine benthos; pp. 41-65. Oxford: Blackwell Scientific Publications

Limits of Detection and/or Limits of Quantification to be applied for nutrient and chlorophyll-a analysis are listed in the table below.

Parameter	Limit of Detection		Limit of Quantification	
	µmol	µg	µmol	µg
Dissolved nitrates	0.01µmol-N/L	0.14µg N/L	0.03µmol-N/L	0.46µg N/L
Dissolved nitrites	0.01µmol-N/L	0.14µg N/L	0.05µmol-N/L	0.7µg N/L
Ammonium ions	0.01µmol-N/L	0.14µg N/L	0.03µmol-N/L	0.46µg N/L
Dissolved phosphates	0.005µmol-P/L	0.15µg P/L	0.01µmol-P/L	0.31µg P/L
Total Nitrogen	0.1µmol-N/L	1.4µg N/L	0.17µmol-N/L	2.4µg N/L
Total Phosphorous	0.01µmol-P/L	0.3µg P/L	0.02µmol-P/L	0.62µg P/L
Dissolved silicates	0.01µmol-Si/L	0.28µg Si/L	0.02µmol-Si/L	0.56µg Si/L
Chlorophyll a		0.05µg/L		0.1µg /L

Table 5.42: Limits of Detection and Limits of Quantification to be used in sample analysis

5.4.1.3.2 Monitoring network for supporting physico-chemical parameters in coastal waters

Inshore monitoring stations for assessing nutrient and organic matter enrichment are listed in Table 5.43.

Monitoring stations and parameters to be monitored within each station shall be updated after the first monitoring year on the basis of a risk-based approach following further knowledge on:

- the status of each station in terms of nutrient and organic enrichment;
- links between activities and impacts on the marine environment;
- links between nutrient and organic enrichment and the status of water column habitat types.

In accordance with the 'Eutrophication Monitoring Strategy of MEDPOL'[140] sampling along a transect perpendicular to the coastline should be sought for the purposes of applying the TRIX index, and to assess the vertical and horizontal profiles of phytoplankton. For this purpose green highlighted monitoring stations listed in Table 5.43 will be supplemented by adjacent monitoring stations along a transect. As per MEDPOL's eutrophication monitoring strategy, three stations should be sampled for each transect in accordance with bottom typology (*vide* UNEP(DEC)/MED/WG.231/14).

Mon. Site Ref. Code	Monitoring Network	Coordinates (Full UTM ED50)		Nutrients	Total Organic carbon (sediment)	Phytoplankton	Other[141]	*Posidonia oceanica*[142]
Operational Monitoring Stations (highlighted yellow refer to additional near shore monitoring of nutrients and chlorophyll whilst Highlighted green stations refer to supplementary monitoring along a transect								
CP04-1	Operational	453769,71	3977836,62	×	×	×	×	×
CP04-2	Operational	449013,07	3979914,24	×	×	×	×	×

[140] UNEP(DEC)/MED WG.231/14

[141] Other parameters refer to salinity, temperature, turbidity, Dissolved Oxygen, pH

[142] Monitoring of *Posidonia oceanica* depends on the presence of this community at the monitoring station; In this regard, sampling regime at each monitoring station can be updated following the first monitoring episodes.

Mon. Site Ref. Code	Monitoring Network	Coordinates (Full UTM ED50)		Nutrients	Total Organic carbon (sediment)	Phytoplankton	Other[141]	*Posidonia oceanica*[142]
CP05	Operational - Harbour	457169,68	3973252,05	×	×	×	×	N/A
CP06-1	Operational	461078,41	3971492,15	×	×	×	×	×
CP06-2	Operational	460522,84	3970960,01	×	×	×	×	×
CP07	Operational - Harbour	459771,77	3964111,98	×	×	×	×	×
Surveillance Monitoring Stations								
CS01	Surveillance	425781,39	3992303,97	×	×	×	×	N/A
CS02	Sur + Reference Site	435571,14	3992063,13	×	×	×	×	×
CS03	Sur + Reference Site	442502,54	3984741,51	×	×	×	×	×
CS08	Surveillance	453654,59	3962794,34	×	×	×	×	N/A
CS09	Sur + Protected area	439697,26	3976129,46	×	×	×	×	×
National Monitoring Stations								
CN01-1	Protected Area	426700,89	3990134,58	×	×	×	×	×
CN01-2	Op – Diffuse Sources	429492,88	3987775,43	×	N/A	×	×	×
CN02-1	Op – Diffuse sources	433397,15	3992518,78	×	×	×	×	×
CN03-1	Op – Sewage Outfall	435420,03	3986084,12	×	×	×	×	×
CN03-2	Op - Harbour	437057,14	3987236,76	×	×	×	×	N/A
CN03-3	Op-Harbour	440130,02	3983083,45	×	×	×	×	×
CN03-6	Op-Minor Sewage Outfall	441540,34	3985079,15	×	×	×	×	×
CN04-1	Op - diffuse sources	442596,44	3981355,59	×	×	×	×	×
CN04-3[143]	Op - bunkering site	445500,41	3984462,78	×	×	×	×	×
CN 04-4	Op-diffuse sources	444937,85	3978614,21					×
CN04-5	Nitrates Directive	454162,08	3976206,21	×	×	×	×	×
CN04-6	Nitrates Directive	454528,54	3975162,74	×	×	×	×	×
CN05-1	Op - Harbour	455167,45	3973034,62	×	×	×	×	N/A
CN05-2[144]	Op - Harbour	456279,18	3972594,26	×	N/A	×	×	N/A
CN06-1	Op - diffuse sources	460815,92	3969206,43	×	×	×	×	×
CN07-1	Op - Thermal effluent	460712,08	3966044,50	×	×	×	×	×
CN07-2	Op – Harbour	459413,96	3965607,40	×	N/A	×	×	×
CN07-3	Op – Harbour	458110,28	3965070,20	×	×	×	×	×
CN08-1	Op – Desalination Plant	447163,40	3965389,58	×	×	×	×	×
CN09-1	Op – Sewage Outfall	440099,89	3979621,63	×	×	×	×	×
	Mgarr ix-Xini	434555,04	3986240,65					×
	Inner most part of Salini	448260,79	3978712,49	×	×	×	×	
Monitoring stations to be sampled at a distance of 6 nautical miles from baseline and additional monitoring stations in bunkering areas for monitoring of dissolved nitrates and phytoplankton parameters								
CS01	Surveillance	425781,39	3992303,97	×		×	×	
CS02	Sur + Reference Site	435571,14	3992063,13	×		×	×	

[143] Nutrients were not assessed within this station during the first WFD monitoring surveys. Station retained for monitoring to be representative of bunkering sites.

[144] Nutrients were not assessed within this station during the first WFD monitoring surveys. Station retained for monitoring to be representative of harbour areas.

Mon. Site Ref. Code	Monitoring Network	Coordinates (Full UTM ED50)		Nutrients	Total Organic carbon (sediment)	Phytoplankton	Other [141]	*Posidonia oceanica* [142]
CS03	Sur + Reference Site	442502,54	3984741,51	×		×	×	
CP04-1	Operational	453769,71	3977836,62	×		×	×	
CP05	Operational - harbour	457169,68	3973252,05	×		×	×	
CP06-1	Operational	461078,41	3971492,15	×		×	×	
CP07	Operational-harbour	459771,77	3964111,98	×		×	×	
CS08	Surveillance	453654,59	3962794,34	×		×	×	
CS09	Sur + Protected area	439697,26	3976129,46	×		×	×	
	Bunkering area 2	463215,69	3970468,46	×		×	×	
	Bunkering area 3	480042,40	3971974,31	×		×	×	
	Bunkering area 4	463310,71	3964577,20	×		×	×	
	Bunkering area 6	439080,51	3978830,25	×		×	×	
	Waiting area	470247,20	3967047,73	×		×	×	

Table 5.43: Monitoring Stations (Yellow highlighted stations indicate near shore stations for monitoring of nutrients and chlorophyll-*a*; whilst green refers to supplementary monitoring of nutrients and phytoplankton)

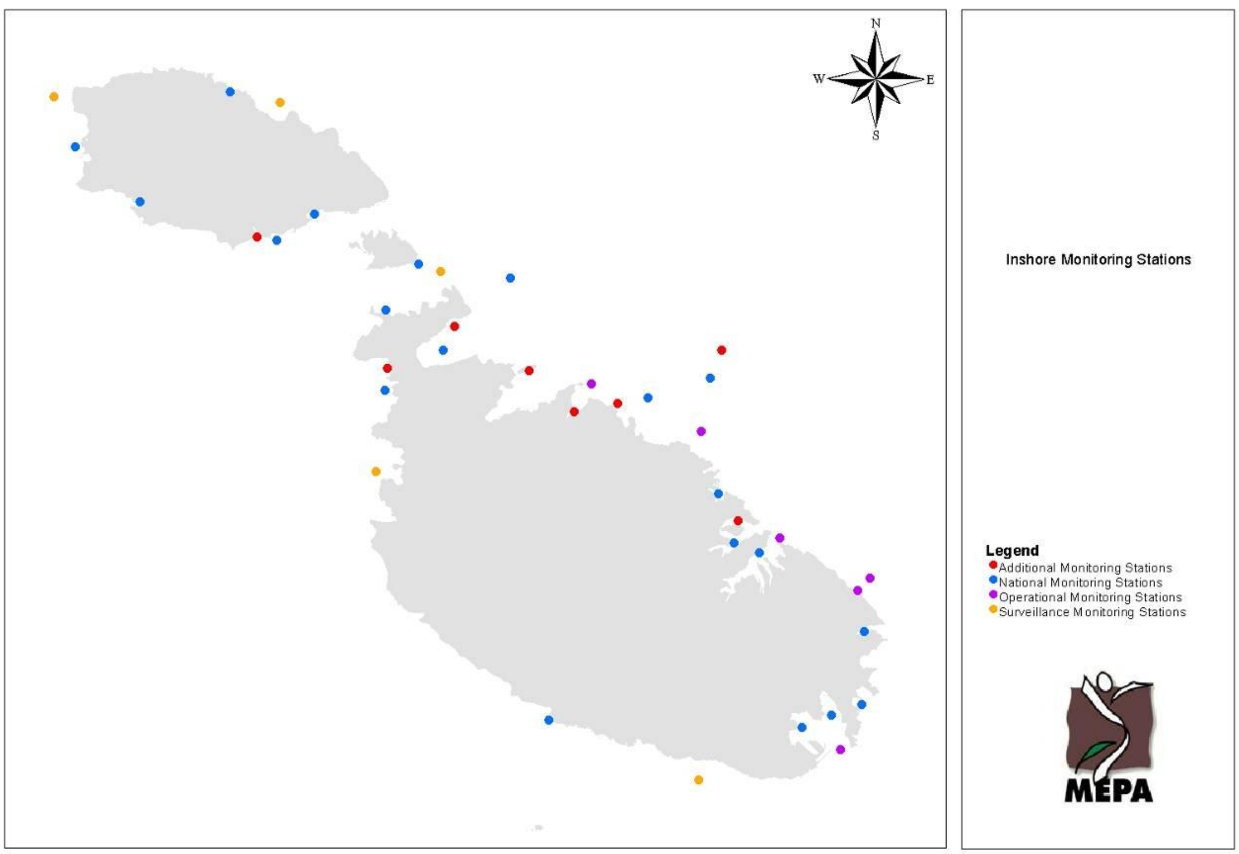

Figure 5.6: Monitoring stations for supporting physico-chemical parameters

5.4.1.1.3 Monitoring frequencies

Monitoring for the purposes of 'nutrient and organic matter enrichment' should apply a risk-based approach and should be flexible on the choice of parameters to be monitored, the frequency of monitoring as well as the location of monitoring stations.

Monitoring frequency for the first monitoring year and, where possible, subsequent years is indicated in Table 5.44. For the first monitoring year, all parameters listed and their respective monitoring stations/transects will be assessed. Subsequently, the parameters to be monitored, the location of monitoring stations and the frequency of monitoring will be revised on the basis of the data generated during the first monitoring year. In particular, monitoring frequency for monitoring stations with good status in terms of nutrient and organic matter enrichment will be reduced in subsequent years.

		First Monitoring Year	Subsequent years
Nutrient concentrations (and other parameters)	**Inshore Monitoring stations**	Every 3 months (except for CN05-1 for which monthly monitoring will be carried out)	To be determined following the first monitoring year.
	Nearshore stations	3-monthly (first monitoring year)	
	Transects	3-monthly	
Nitrates	**Stations at 6 nautical miles; bunkering areas**	6-monthly	
Organic Matter (sediment)	**Inshore monitoring stations**	yearly	To be determined following the first monitoring year.
Other physico-chemical parameters	**Inshore Monitoring stations**	monthly	To be determined following the first monitoring year.
	Nearshore stations	Monthly	
	Transects	3-monthly	
	Stations at 6 nautical miles; bunkering areas	6-monthly	

Table 5.44: Monitoring Frequency

5.4.1.4 Monitoring programme for Hydromorphological Characteristics

5.4.1.4.1 Monitoring Parameters and methodologies

Monitoring parameters listed in this section constitute the 'core parameters' for collecting hydrographical data and physical characteristics of the seabed for the purpose of providing background information against which changes in hydrographical conditions can be assessed. These parameters are not direct indicators, but their monitoring is required for the purpose of assessing changes in hydrographical conditions and/or extent of areas affected by permanent alterations as required by policy indicators. The monitoring parameters and their methodologies are included under Table 5.45.

The monitoring methodologies outlined are applicable to 'state monitoring' of core hydrographic and physical parameters of the coastal/marine environment and physical characteristics of the seabed. Such monitoring will be carried out for the definition of 'baseline' conditions and may not need to be carried out on a continuous basis once such conditions are known/modelled.

Monitoring methodologies for assessing changes in hydromorphology associated new developments are not covered by this monitoring. Such monitoring would need to be undertaken through a risk-based approach that considers individual projects and expected impacts on a case-by-case basis.

Parameter	Methodology
Hydrographical parameters	
Current velocity	Depth profiles of current direction and velocity are recorded through the use of current meters - Acoustic Doppler Current Profiler (ADCP); The ADCP is deployed from vessels at monitoring stations for spot measurements of current profiles. Fixed moorings[145] equipped with Acoustic Doppler Current Profiler (ADCP) are also set at strategic location/s to provide continuous measurements of surface and subsurface currents.
Wave exposure	Automated wave buoy/s [146] are deployed at strategic location/s to measure wave height and direction, meteo conditions and physico-chemical parameters in the surface and water column on a continuous basis.
Physical Characteristics of the seabed and coastline	
Seabed topography and bathymetry	Seabed topography and bathymetry up to the 1 nautical mile boundary from the baselines where the breadth of the territorial waters is measured were mapped by means of side-scan sonar in 2012[147]. Within this context, further assessment/monitoring of seabed topography and bathymetry are not deemed necessary in the short term with the exception of specific localities which may be subject to regular changes in topography and bathymetry. In the longer-term, the topography and bathymetry of coastal waters within the 1 nautical mile boundary would need to be re-assessed by means of echosoundings [side-scan sonars (SSS) or multibeam echo-sounders (MBES)[148]] in selected localities known to have been subject to bathymetry / morphological changes post-2012.
Substrate Composition	Substrate composition has been partly assessed by ground truthing of side-scan sonar plots in 2012[149]. Additional assessments of substrate composition will be undertaken as deemed necessary following an analysis of the information compiled by ERDF 156[150] and EMODnet Geology. Assessment of substrate composition over wide areas will be undertaken by the use of side-scan sonars (SSS) or multibeam echo-sounders (MBES). Ground truthing of SSS/MBES plots and/or assessment of substrate composition in localised areas will be carried out through grab sampling using a 0.1m^2 Van Veen grab at specific locations, followed by sieve analysis (or gradation test) of the samples. A typical sieve analysis involves a nested column of sieves with wire mesh cloth (screen). The amount of material retained in each sieve is then weighed. The sediment is classified in line with the classification system as adopted for the purpose of EMODnet Geology.
Physico-chemical parameters[151]	
	Details on methodologies to be applied to sampling and analysis of supporting physico-parameters are described under Section 5.6.1.4 above.

Table 5.45: Hydrographic parameters and suggested methodologies

[145] Drago, A., Cordina, G., Borg, S., Deidun, A.; Delitala, A. & the Marine Group of Experts (2009), *The support of Operational Oceanography for a more effective maritime sector in the Maltese Islands,* Report for the NET.MARI.MED (Network for supporting Marine Affairs in the Mediterranean) Archimed Interreg project.

[146] This monitoring is subject to available funds. Any physico-chemical parameters monitored depend on acquired equipment.

[147] ERDF 156 - Development of Environmental Monitoring Strategy and Environmental Monitoring Baseline Surveys (Lot 2) Contracts Ref. No – CT3024/2011 Activities 1 – 4

[148] A major advantage of MBES over SSS is that MBES generate quantitative bathymetric data that are much more amenable to classification and image processing, but the narrow beam width (ideal for quantitative analysis) makes them less useful for detection of small objects (<1 m)

[149] ERDF 156 - Development of Environmental Monitoring Strategy and Environmental Monitoring Baseline Surveys (Lot 2) Contracts Ref. No – CT3024/2011 Activities 1 – 4

[150] ERDF 156 - Development of Environmental Monitoring Strategy and Environmental Monitoring Baseline Surveys (Lot 2) Contracts Ref. No – CT3024/2011 Activities 1 – 4

151 The list of physico-chemical parameters for monitoring of hydrographical conditions reflects the list of parameters to be monitored for the purposes of nutrient enrichment.

Additional supporting parameters include the following Information that is to be recorded in the field:

- date and time,
- sampling depth and
- meteo-marine conditions, mainly rainfall, wind speed, wind direction.

Satellite data on sea surface temperatures and chlorophyll concentrations can also used to support the implementation of this monitoring programme. Drago *et al.* (2009)[152] indicate that such satellite data is already supported by the local Meteorological Office.

5.4.1.4.2. Monitoring network for supporting hydromorphological parameters in coastal waters Hydrographical and Physico-chemical parameters

(i) Spot measurements

Monitoring stations for spot measurements of current direction and velocity and of physical parameters (temperature, salinity, turbidity, dissolved oxygen, pH and nutrients) are listed in Table 5.46.

For the purpose of nutrient enrichment, nine of the inshore stations will also be sampled at a distance of 6 nautical miles from the baselines where the breadth of the territorial waters is measured with a view to provide data between the 1nm and the 12nm extent of Malta's territorial waters. These stations, which can also be used for the purpose of spot measurements, are also listed in the table below.

Mon. Site Ref. Code	Monitoring Network	Coordinates (Full UTM ED50)	
		Longitude	Latitude
Operational Monitoring Stations			
CP04-1	Operational	453769,71	3977836,62
CP04-2	Operational	449013,07	3979914,24
CP05	Operational - Harbour	457169,68	3973252,05
CP06-1	Operational	461078,41	3971492,15
CP06-2	Operational	460522,84	3970960,01
CP07	Operational - Harbour	459771,77	3964111,98
Surveillance Monitoring Stations			
CS01	Surveillance	425781,39	3992303,97
CS02	Sur + Reference Site	435571,14	3992063,13
CS03	Sur + Reference Site	442502,54	3984741,51
CS08	Surveillance	453654,59	3962794,34
CS09	Sur + Protected area	439697,26	3976129,46
National Monitoring Stations			
CN01-1	Protected Area	426700,89	3990134,58
CN02-1	Op – Diffuse sources	433397,15	3992518,78
CN03-1	Op – Sewage Outfall	435420,03	3986084,12
CN03-2	Op - Harbour	437057,14	3987236,76
CN03-3	Op – Harbour	440130,02	3983083,45

152 Drago, A., Cordina, G., Borg, S., Deidun, A.; Delitala, A. & the Marine Group of Experts (2009), *The support of Operational Oceanography for a more effective maritime sector in the Maltese Islands,* Report for the NET.MARI.MED (Network for supporting Marine Affairs in the Mediterranean) Archimed Interreg project.

Mon. Site Ref. Code	Monitoring Network	Coordinates (Full UTM ED50)	
		Longitude	Latitude
CN03-6	Op – Minor Sewage Outfall	441540,34	3985079,15
CN04-1	Op - diffuse sources	442596,44	3981355,59
CN04-3	Op - bunkering site	445500,41	3984462,78
CN04-5	Nitrates Directive	454162,08	3976206,21
CN04-6	Nitrates Directive	454528,54	3975162,74
CN05-1	Op – Harbour	455167,45	3973034,62
CN06-1	Op - diffuse sources	460815,92	3969206,43
CN07-1	Op - Thermal effluent	460712,08	3966044,50
CN07-3	Op – Harbour	458110,28	3965070,20
CN08-1	Op – Desalination Plant	447163,40	3965389,58
CN09-1	Op – Sewage Outfall	440099,89	3979621,63
Additional near shore stations			
CP04-2	Operational	449013,07	3979914,24
CP05	Operational-harbour	457169,68	3973252,05
CP06-2	Operational	460522,84	3970960,01
CP07	Operational-harbour	459771,77	3964111,98
CN01-1	Protected Area	426700,89	3990134,58
CN03-1	Operational-sewage outfall	435420,03	3986084,12
CN03-6	Op-Minor sewage outfall	441540,34	3985079,15
CN09-1	Op-Sewage outfall	440099,89	3979621,63
Monitoring stations in territorial waters (6 nm from baseline)			
CS01	Surveillance	425781,39	3992303,97
CS02	Sur + Reference Site	435571,14	3992063,13
CS03	Sur + Reference Site	442502,54	3984741,51
CP04-1	Operational	453769,71	3977836,62
CP05	Operational - Harbour	457169,68	3973252,05
CP06-1	Operational	461078,41	3971492,15
CP07	Operational - Harbour	459771,77	3964111,98
CS08	Surveillance	453654,59	3962794,34
CS09	Sur + Protected area	439697,26	3976129,46
Bunkering Area 2		463215,69	3970468,46
Bunkering Area 3		480042,40	3971974,31
Bunkering Area 4		463310,71	3964577,20
Bunkering Area 6		439080,51	3978830,25
Waiting Area		470247,20	3967047,73

Table 5.46: Monitoring Stations for spot measurements and physico-chemicalarameters

(ii) Fixed Stations: Continuous current profiling and wave measurements

During the first monitoring year, the location of automated wave buoys and fixed moorings will be determined on the basis of the station positions as proposed by Drago *et al*. (2009) and extracted in the figure below (Figure 5.7). Deployment of a minimum number of one automated buoy and one fixed station shall be sought and is subject to the availability of funds. Deployment of additional buoys and/or moored stations will be assessed on the basis of cost-effectiveness.

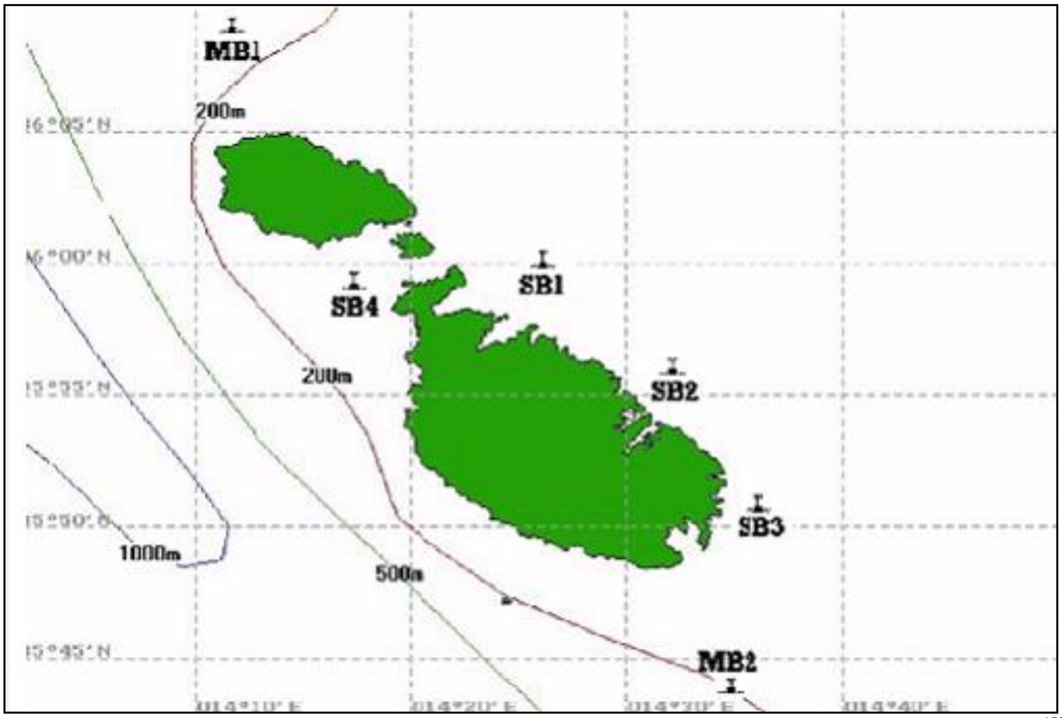

Figure 5.47: Proposed location of automated buoys and secondary buoys as proposed by Drago *et al* (2009)[153]

Seabed topography and bathymetry
Monitoring for seabed topography and bathymetry will be restricted to the 1 nautical mile and the spoil ground located beyond this boundary, off the Northeastern coast of mainland Malta. The Areas/localities to be subject to this monitoring shall be determined following an assessment of potential changes in these aspects within specific localities through time.

(i) Substrate Composition
Additional monitoring of substrate composition will be restricted to the 1 nautical mile boundary. The location of additional grab samples, if deemed necessary for the purpose of ground truthing or further assessment of substrate composition, will be determined following an analysis of the SSS plots[154] and the outcome of the EMODnet project which is using existing data published and unpublished to provide a seabed substrate GIS layer.

5.4.1.4.3 Monitoring frequency
Monitoring frequency for the first monitoring year is indicated hereunder. The monitoring frequency is subject to revision following the initial monitoring episodes and is indicated in table 5.47.

[153] Drago, A., Cordina, G., Borg, S., Deidun, A.; Delitala, A. & the Marine Group of Experts (2009), *The support of Operational Oceanography for a more effective maritime sector in the Maltese Islands,* Report for the NET.MARI.MED (Network for supporting Marine Affairs in the Mediterranean) Archimed Interreg project.

[154] Data from the side scan sonar surveys was not available at the time of compiling this document.

Characteristics	Parameters	Monitoring Stations	Monitoring Frequency (first monitoring year)
Hydrographical parameters[155]	Currents (spot measurements)	Inshore and near shore stations	Monthly
		6 nautical miles & bunkering areas	6-monthly
	Currents (at fixed stations)		Continually
	Wave exposure		Continually
Physico-chemical parameters[156]	Salinity; Temperature; Oxygen; Turbidity; pH; Nutrients	Inshore and near shore stations	Monthly
		6 nautical miles & bunkering areas	6-monthly
Physical Characteristics of the seabed	Seabed topography and bathymetry		Monitoring frequency depends on necessity to monitor potential alterations to seabed topography, bathymetry and substrate types
	Seabed substrate composition		

Table 5.47: Monitoring frequency for hydrographical, physico-chemical and physical parameters of the seabed

5.4.2 Chemical quality monitoring in coastal waters

A detailed monitoring programme for chemical quality monitoring is provided in the monitoring factsheet entitled 'contaminants', accessible from the following webpage http://www.mepa.org.mt/water-msfd. A summary of this monitoring is provided in section 5.4.2.1 below. In addition to this monitoring programme for contaminants a supplementary monitoring programme dealing with new emerging substances is included under section 5.4.2.2.

5.4.2.1 Contaminant monitoring in water, sediments and biota

5.4.2.1.1 Monitoring parameters and methodology

Lists of contaminants to be monitored in water, sediment and biota are compiled in Table 5.48 – Table 5.52 on the basis of the following:

i. Selection of contaminants to be monitored is based on the results attained in the baseline monitoring survey carried out in 2012. In general, chemicals which were consistently found below the Limits of Detection and which are not known to be discharged are not included;
ii. Substances for which Member States shall apply the biota EQS in line with Article 2 of Directive 2013/39/EU and substances for which Member States shall take measures aimed at ensuring that such concentrations do not significantly increase in sediment and/or relevant biota (as per Article 2 (6) of the Directive) are included in the relevant environmental media;
iii. Substances for which programmes and measures should be prepared for monitoring as agreed by MEDPOL Focal Points[157] are included. Monitoring of such substances should be subject to regional agreement. The preferred environmental medium in which monitoring should take place still needs to be determined;
iv. a phased approach should be applied in line with Article 2 of Directive 2013/39/EU amending Article 3 of Directive 2008/105/EC by defining:
    - stricter EQS for some substances to be applied by December 2015
    - new substances for which Member States shall establish and submit a supplementary monitoring programme by 22 December 2018

155 Monitoring frequency to be adjusted in line with the monitoring frequency adopted for the purposes of physico-chemical parameters.
156 Monitoring frequency to be adjusted once the seasonal cycle is identified through monitoring data
157 These were agreed to at their meeting held in France in November 2009 (as indicated in UNEP(DEPI)/MEDIG.21/5)

These lists should be considered as provisional, to be confirmed or updated following the initial monitoring year/s. Other contaminants which may pose risks to the marine environment and to its resources should be included, as soon as new information or verifications are available. This includes chemicals that may be identified from time to time by the EU Commission, in agreement with Member States, regarding the Watch List mechanism as required by Article 8b of Directive 2013/39/EU. Reduction of parameters from the list to be analysed could be affected after analysis of data.

A. Contaminants in Water

Number (2013/39/EU)	Substances	WFD & EQS Directive 2013/39/EU	MSFD regionally agreed contaminants	River Basin Specific Pollutants (WFD)	LBS protocol (Article 8) & MEDPOL	Euratom Treaty	REACH	Other substances of concern
Priority monitoring								
Non-Synthetics								
4	Benzene	×						
15	Fluoranthene	× [158]						
20	Lead and its compounds	× [159]					×	
21	Mercury and its compounds	×			× [160]			
22	Naphtalene	× [161]						
23	Nickel and its compounds	× [162]						
28	Benzo(a)pyrene	×						
28	Benzo(b)fluoranthene	×						
28	Benzo(g,h,i)perylene	×						
28	Benzo(k)fluoranthene	×						
28	Indeno(1,2,3-c,d)pyrene	×						
	Barium			×				
	Chromium and its compounds			×			×	
	Copper			×				
	Manganese			×				
	Zinc			×				
Synthetics								
10	1,2-Dichloroethane	×					×	
11	Dichloromethane	×						
32	Trichloromethane	×						
Monitoring in selected stations								
Non-Synthetics								
	Beryllium			×				
	Boron			×				
	Fluorides			×				

158 Stricter EQS to be applied by December 2015
159 Stricter EQS to be applied by December 2015
160 Listed in Annex I to the LBS Protocol and in UNEP(DEPI)/MED IG.21/9
161 Stricter EQS to be applied by December 2015
162 Stricter EQS to be applied by December 2015

Number (2013/39/EU)	Substances	WFD & EQS Directive 2013/39/EU	MSFD regionally agreed contaminants	River Basin Specific Pollutants (WFD)	LBS protocol (Article 8) & MEDPOL	Euratom Treaty	REACH	Other substances of concern
Synthetics								
	Carbamezepine & its metabolite (10,11-Dihydro-10,11-dihydroxycarbamazepine)							×
Euratom Treaty Monitoring								
	^{137}Caesium					×		×
	^{60}Cobalt					×		
	^{40}Potassium					×		
Supplementary monitoring to be established by 2018								
Synthetics								
34	Dicofol	×						
35	Perfluorooctane sulfonic acid & derivatives	×					×	
36	Quinoxyfen	×						
37	Dioxins[163]	×						
	Polychlorinated biphenyls (PCBs)				×[164]			
	Polychlorinated dibenzodioxins (PCDDs)				×[165]			
	Polychlorinated dibenzo furans (PCDFs)				×[166]			
38	Aclonifen	×						
39	Bifenox	×						
40	Cybutryne	×						
41	Cypermethrine	×						
42	Dichlorvos	×						
43	Hexabromocyclododecane	×					×	
44	Heptachlor & Heptachlor epoxide	×						
45	Terbutryn	×						

Table 5.48: List of non-synthetic and synthetic contaminants to be monitored in the water column

163 Directive 2013/39/EU establishes EQS for dioxins in biota based on the sum of PCDD+PCDF+PCB-DL. Monitoring of these individual substances is being discussed as part of the MEDPOL process and are hence listed as part of the 'dioxin' group. Although dioxins are non-synthetic substances, they are being listed as synthetic, in view of their man-made production.

164 Listed in UNEP(DEPI)/MED IG.21/5; organohalogen compounds are also listed in Annex I to the LBS Protocol

165 Listed in UNEP(DEPI)/MED IG.21/5; organohalogen compounds are also listed in Annex I to the LBS Protocol

166 Listed in UNEP(DEPI)/MED IG.21/5; organohalogen compounds are also listed in Annex I to the LBS Protocol

B. Contaminants in sediment

Number (2013/39/EU)	Substances	WFD & EQS Directive 2013/39/EU	MSFD regionally agreed contaminants	River Basin Specific Pollutants (WFD)	LBS protocol (Article 8) & MEDPOL	REACH	Other substances of concern
				Priority monitoring			
				Non-Synthetics			
2	Anthracene	×[167]					
6	Cadmium and its compounds	×	×		×[168]	×	
15	Fluoranthene	×[169]					
20	Lead and its compounds	×[170]	×		×[171]	×	
21	Mercury and its compounds	×	×		×[172]		
22	Naphtalene						
23	Nickel and its compounds						
28	Polyaromatic hydrocarbons	×[173]	×		×[174]		
28	Benzo(a)pyrene	×					
	Barium			×			×
	Chromium and its compounds			×	×[175]	×	×
	Copper			×	×[176]		×
	Manganese			×			×
	Zinc			×	×[177]		×
				Synthetics			
5	Brominated diphenylethers	×[178]				×	
7	C10-C13 Chloroalkanes	×				×	
12	Di(2-ethylhexyl)phthalate	×			×[179]	×	
16	Hexachlorobenzene	×			×[180]		

167 Stricter EQS to be applied by December 2015
168 Mandatory by MEDPOL PHASE III
169 Stricter EQS to be applied by December 2015
170 Stricter EQS to be applied by December 2015
171 Recommended by MEDPOL PHASE III
172 Mandatory by MEDPOL PHASE III
173 Stricter EQS to be applied by December 2015
174 Recommended by MEDPOL PHASE III
175 Recommended by MEDPOL PHASE III
176 Recommended by MEDPOL PHASE III
177 Recommended by MEDPOL PHASE III
178 Stricter EQS to be applied by December 2015
179 Listed in UNEP(DEPI)/MEDIG.21/9
180 Listed in UNEP(DEPI)/MEDIG.21/9

Number (2013/39/EU)	Substances	WFD & EQS Directive 2013/39/EU	MSFD regionally agreed contaminants	River Basin Specific Pollutants (WFD)	LBS protocol (Article 8) & MEDPOL	REACH	Other substances of concern
17	Hexachlorobutadiene	×					
18	Hexachlorocyclohexane	×			×[181]		
26	Pentachlorobenzene	×[182]					
30	Tributyltin	×	×				
	Perchlorate[183]						×
	Polychlorinated biphenyls		×				×
Monitoring in selected stations							
Non-Synthetics							
	Arsenic[184]					×	×
	Beryllium			×			×
	Boron			×			
	Fluorides			×			×
	Total Petroleum hydrocarbons						×
Synthetics							
	Carbamezepine & its metabolite (10,11-Dihydro-10,11-dihydroxycarbamazepine)						×
Supplementary monitoring to be established by 2018							
Synthetics							
34	Dicofol	×					
35	Perfluoroctane sulfonic acid & derivatives (PFOS)	×				×	
36	Quinoxyfen	×					
41	Cypermethrin						×
43	Hexabromocyclododecane	×				×	
44	Heptachlor & Heptachlor epoxide	×					

Table 5.49: List of non-synthetics and synthetic substances to be monitored in sediment

181 Listed in UNEP(DEPI)/MEDIG.21/9

182 According to Article 2(6) of Directive2013/39/EU, Member States are required to arrange for the long-term trend analysis of concentrations of those priority substances that tends to accumulate in sediment and/or biota, including this substance, on the basis of monitoring of surface water status…Member States shall take measures aimed at ensuring that such concentrations do not significantly increase in sediment and/or relevant biota

183 Although perchlorate is a naturally occurring substance, it is being included with the synthetics due to the fact that it is manufactured for the purposes of pyrotechnics, which is a possible route through which this substance is being introduced into the marine environment.

184 Monitoring of 'Arsenic' in sediments should be carried out in sediments in receiving waters of urban waste water discharges and off Delimara power stations

C. Watch list substances

There are a number of emerging substances that have been identified to be of potential significant risk at European Union level, however for which there is insufficient monitoring data available at Union level to conclude on the actual risk posed by these substances. Those toxic substances that are used in many European Member States and discharged to the aquatic environment but are rarely monitored are considered for inclusion in this list. During early 2015 the European Commission, together with Member States, agreed on the first Watch list of substances. Malta shall monitor these substances (listed below) in the water column throughout late 2015/ 2016 for **12 consecutive months** at **one** coastal water monitoring station. The substances consist of estrogenic hormones, pharmaceuticals, pesticides and chemicals used in sun-screen products.

Name of watch list substance/group of substances	**CAS number**
Diclofenac	15307-86-5
17-Beta-estradiol (E2) and Estrone (E1)	50-28-2, 53-16-7
17-Alpha-ethylestradiol (EE2)	57-63-6
2,6-Ditert-butyl-4-methylphenol	128-37-0
2-Ethylhexyl 4-methoxycinnamate	5466-77-3
Macrolide antibiotics	
Erythromycin	114-07-8
Clarithromycin	81103-11-9
Azithromycin	83905-01-5
Methiocarb	2032-65-7
Neonicotinoids	
Imidacloprid	105827-78-9/138261-41-3
Thiacloprid	111988-49-9
Thiamethoxam	153719-23-4
Clothianidin	210880-92-5
Acetamiprid	135410-20-7
Oxadiazon	19666-30-9
Tri-allate	2303-17-5

Table 5.50: Watch list substances to be monitored in water/ sediment

The monitoring data of these substances, collected at a European Union scale, will then support a review exercise that would then determine the actual risk that these substances pose. Once a substance is deemed to be of significant risk it is then considered for inclusion in the official priority substance list. An EQS will then have to be set for each of the newly listed substances and each substance would also be subject to an impact assessment. Malta will then monitor each newly listed substance continuously as part of the chemical status monitoring in consequent cycles.

D. Contaminants in biota

Number (2013/39/EU)	Substances	WFD & EQS Directive 2013/39/EU	MSFD regionally agreed contaminants	River Basin Specific Pollutants (WFD)	LBS protocol (Article 8) & MEDPOL	REACH	Other substances of concern	EC 1881/2006
Priority monitoring								
Non-Synthetics								
6	Cadmium and its compounds		x		x[185]	x		x
20	*Lead*[186] and its compounds		x		x[187]	x		x
21	Mercury and its compounds	x	x		x[188]			x
28	Benzo(a)pyrene[189]	x	x					x
Synthetics								
16	Hexachlorobenzene	x			x[190]			
17	Hexachlorobutadiene	x						
30	Tributyltin		x				x	
37	Dioxins[191] (including PCBs)	x[192]	x					x
Supplementary monitoring to be established by 2018								
Synthetics								
34	Dicofol	x[193]						
35	Perfluorooctane sulfonic acid and	x[194]				x		
43	Hexabromocyclododecane	x[195]				x		
44	Heptachlor	x[196]						

Table 5.51: List of synthetics and non-synthetics to be monitored in biota

Species to be used for monitoring of contaminants in biota and seafood are listed in 5.52.

185 Mandatory by MEDPOL PHASE III

186 Lead should only be considered as priority monitoring in fish/crustacea/molluscs, since it is a requirement of EC Regulation 1881 of 2006 with a view to facilitate links between monitoring of contaminants in biota and contaminants in foodstuff.

187 Recommended by MEDPOL PHASE III

188 Mandatory by MEDPOL PHASE III

189 In line with Directive 2013/39/EC, for the group of priority substances of polyaromatic hydrocarbons (PAHs), the biota EQS and corresponding AA-EQS in water refer to the concentration of benzo(a)pyrene, on the toxicity of which they are based. Benzo(a)pyrene can be considered as a marker for the other PAHs, hence only benzo(a)pyrene needs to be monitored for comparison with the biota EQS or the corresponding AA-EQS in water.

190 Listed in UNEP(DEPI)/MED IG.21/5

191 Dioxins should be considered as priority monitoring only in fish/crustacea/molluscs, since it is a requirement of EC Regulation 1881 of 2006 to facilitate links between monitoring of contaminants in biota and contaminants in foodstuff. According to Directive 2013/39/EU, monitoring for dioxins should be subject to supplementary monitoring by 2018. This Directive establishes EQS for dioxins in biota based on the sum of PCDD+PCDF+PCB-DL. Monitoring of these individual substances is being discussed as part of the MEDPOL process.

192 New substance with effect from 22 December 2018 + Member States to apply biota EQS

193 New substance with effect from 22 December 2018 + Member States to apply biota EQS

194 New substance with effect from 22 December 2018 + Member States to apply biota EQS

195 New substance with effect from 22 December 2018 + Member States to apply biota EQS

196 New substance with effect from 22 December 2018 + Member States to apply biota EQS

	Retail Samples (*Thunnus thynnus, Xiphias gladius* and/or *Coryphaena hippurus*)	*Posidonia oceanica*	*Fish and Crustacea*	
			Mullus barbatus & *Merluccius merluccius*	*Aristaeomorpha foliacea* & *Parapenaeus longirostris*
Fluoranthene				×
Benzo(a)pyrene				×
Lead	×		×	
Cadmium	×		×	
Mercury	×	×	×	
Hexachlorobenzene		×	×	
Hexachlorobutadiene		×	×	
Dioxins (incl. dioxin-like & non-dioxin like			×	
Tributyltin			×	

Table 5.52: Monitoring of contaminants in biota

Standards related to monitoring contaminants in different environmental media

Sampling methodologies and analysis of samples shall be carried out in line with MEDPOL and WFD technical specifications for chemical analysis and monitoring of water status as per Directive 2009/90/EC, better known as the Quality Assurance and Quality Control Directive (QAQC), which have been transposed in regulation 10 of Legal Notice 24 of 2011. This schedule provides definitions related to water monitoring aspects, choice of methods of analysis, minimum performance criteria for the methods of analysis, calculation of and presentation of mean values, as well as quality assurance and control recommendations.

Article 4 of the QAQC Directive stipulates that during execution of the monitoring of contaminants one would need to ensure that the minimum performance criteria for all methods of analysis applied are based on an uncertainty of measurement of 50 % or below (k = 2) estimated at the level of relevant environmental quality standards and a limit of quantification equal or below a value of 30 % of the relevant environmental quality standards.

The following standards/guidelines will also be followed:

- EN ISO 5667-3: 2012 including guideline procedures for sampling programmes and techniques, preservation and handling of different types of water and sediments, bio-testing of samples and other general techniques.
- CEN standard EN 13804: Foodstuffs – Determination of trace elements – Performance criteria, general considerations and sample preparation.
- EN ISO/IEC 17025:2005: General requirements for the competence of testing and calibration laboratories

Supporting parameters

Tables 5.53 and 5.54 list the supporting parameters that will be monitored together with contaminants in each matrix.

Parameter	Unit	Related Monitoring Factsheet
Dissolved Nitrates (NO_3-N)	NO_3-N µmol/L, µg/L	Eutrophication
Dissolved Nitrites (NO_2-N)	NO_2-N µmol/L, µg/L	
Ammonium ions (NH_4-N)	NH_4-N µmol/L, µg/L	
Dissolved Phosphates (PO_4-P)	PO_4-P µmol/L, µg/L	
Silicate (SiO_2)	SiO_2 µmol/L	
Total Nitrogen	N µmol/L, µg/L	
Total Phosphorous	P µmol/L, µg/L	
Total Organic Carbon	%weight	
Dissolved Oxygen	% saturation	
Water Turbidity	Secchi depths, NTU	
Chlorophyll-a	µg/L	
Temperature	°C	
Salinity	psu	
pH		
Water hardness ($CaCO_3$/sum of Ca and Mg concentrations) – for analysis of Cd only		N/A
Sediment grain size through granulometric analysis		
Hydrodynamics Data		Hydrographical Changes

Table 5.53: Concentration of contaminants in water and sediment

Bioparameters	Related Monitoring Factsheet
Length	Commercial fish
Sex	
Maturity	
Individual Weight	
Age	

Table 5.54: Concentration of contaminants in biota (fish, crustaceans, molluscs)

5.4.2.1.2 Monitoring methodologies

This section briefly outlines methodologies for monitoring contaminants in water, sediment and biota.

a. Priority monitoring and monitoring in selected stations: water

- Water samples are collected using Niskin Bottles/Van Dorn samplers at surface and 2m depth at monitoring stations;
- Samples are appropriately preserved and stored in agreement with the accredited laboratory performing the chemical analyses.

b. Watch list substances

The following indicative analytical methods will be adhered to when monitoring watch list substances in water (except for 2-ethylhexyl 4-methoxycinnamate that will also be monitored in sediment)

Name of substance/group of substances	Indicative analytical method[197]	Maximum acceptable method detection limit (ng/l)
Diclofenac	Solid-phase extraction – Liquid chromatography (tandem) triple quadruple mass spectrometry	10
17-Beta-estradiol (E2) and Estrone (E1)	Solid-phase extraction – Liquid chromatography (tandem) triple quadruple mass spectrometry	0.4
17-Alpha-ethylestradiol (EE2)	Large-volume Solid-phase extraction – Liquid chromatography (tandem) triple quadruple mass spectrometry	0.035
2,6-Ditert-butyl-4-methylphenol	Solid-phase extraction - Gas chromatography-mass spectrometry	3160
2-Ethylhexyl 4-methoxycinnamate	Solid-phase extraction – Liquid chromatography (tandem) triple quadruple mass spectrometry or Gas chromatography-mass spectrometry	6000
Macrolide antibiotics Erythromycin Clarithromycin Azithromycin	Solid-phase extraction – Liquid chromatography (tandem) triple quadruple mass spectrometry	90
Methiocarb	Solid-phase extraction – Liquid chromatography (tandem) triple quadruple mass spectrometry or Gas chromatography-mass spectrometry	10
Neonicotinoids Imidacloprid Thiacloprid Thiamethoxam Clothianidin Acetamiprid	Solid-phase extraction – Liquid chromatography (tandem) triple quadruple mass spectrometry	9
Oxadiazon	Liquid liquid extraction / Solid-phase extraction - Gas chromatography-mass spectrometry	88
Tri-allate	Liquid liquid extraction / Solid-phase extraction - Gas chromatography-mass spectrometry or Liquid chromatography (tandem) triple quadruple mass spectrometry	670

Table 5.55:Watch list substances to be monitored in water/sediment

b. Priority monitoring and monitoring in selected stations: sediment
  - Two replicate samples of the first 3cm superficial sediments are collected using box corers or Van Veen grabs;
  - Sediment samples are stored in acid-washed containers. For mercury, samples must be stored in acid-washed borosilicate glass or quartz containers.
  - Records of the colour, appearance and any particular smells of each sample are kept;
  - Subsamples of sediment to be collected immediately after sampling and subject to granulometric analysis and analysis of Total Organic Carbon.
  - Correlation analysis would need to be carried out on the reported levels of contaminants in superficial sediments, and the granulometric statistics and total organic carbon content of the sediments. Subsequently, if need be, reported levels of contaminants should be recorded both as raw, and as levels corrected for organic content, and particle size.

[197] Commission Implementing Decision (EU) 2015/495 of 20 March 2015 establishing a watch list of substances for Union wide monitoring in the field of water policy pursuant to Directive 2008/105/EC of the European Parliament and of the Council

c. Priority Monitoring in Biota

(i) Retail Samples of pelagic fish

Priority monitoring for contaminants in foodstuff involves routine monitoring pursuant to EC regulation 1881 of 2006 (as amended by 1259/2011) and Council Regulation 3954 of 1987.

- Collection of retail samples of *Thunnus thynnus*, *Xiphias gladius* and *Coryphaena hippurus* from local suppliers/markets depending on availability; Samples to be randomly selected although samples should originate from Malta[198];
- Samples to be analysed in accordance with Commission Regulation 1883/2006[199] and Commission Regulation 333/2007[200]
- Record keeping as follows:
  - number of contaminants that exceed set limits
  - species for which levels are exceeded
  - number of events when regulatory limits are exceeded, source location, species concerned, absolute levels of contaminants

(ii) Posidonia oceanica (applicable to waters up to 40m depth)

- A fixed number of *Posidonia oceanica* (L.) Delile[201] shoots are collected at each monitoring station.
- Shoots are preserved at -20°C and kept frozen.
- Seagrass shoots are dissected in order to separate rhizomes from leaves and foliar basal parts and analysed for contaminants in line with standard methodologies.

(iii) Fish & Crustacea

- Analysis of contaminants in fish and crustacea (other than retail samples) is performed on specimens collected by the Mediterranean International Bottom Trawl Surveys (MEDITS). Sub-samples of *Mullus barbatus* and *Parapenaeus longirostris* from catch areas within the shallow depth strata and sub-samples of *Merluccius merluccius* and *Aristaeomorpha foliacea*[202] from deeper catch areas are used for this purpose.
- Two specimens of marketable size of the selected species of per selected haul are retained.
- Muscle tissue of fish and crustacean tissue excluding head and thorax are analysed for contaminants.

5.4.2.1.3 Monitoring Network for contaminants in all coastal water matrices

Monitoring stations listed in this section shall be updated after the first monitoring year on the basis of a risk-based approach following further knowledge on the status of each station in terms of contaminants.

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198 Reference made to EC Regulation No. 104/2000: Improvements in the traceability of retail samples are expected in the medium-term.

199 laying down methods of sampling and analysis for the official control of levels of dioxins and dioxin-like PCBs in certain foodstuffs

200 laying down methods of sampling and analysis for the official control of the levels of lead, cadmium, mercury, inorganic tin, 3-MCPD and benzo(a)pyrene in foodstuffs

201 The marine angiosperm *Posidonia oceanica* (L.) Delile is selected as a bioindicator for detection of chemical pollutants, in view of both the natural features of the organism (benthic, long-living, widespread) and its distribution (coastal areas which are generally exposed to anthropogenic impacts), which make this organism both prone to bioaccumulation and easy to be retrieved in impacted zones. It is widely known that *P. oceanica* accumulates a number of xenobiotic contaminants which can be subsequently transferred to the upper levels of the trophic chain.

202 Selection of species would facilitate link between monitoring of contaminants in biota with monitoring of contaminants in foodstuff since the species selected are also consumed in Malta - hence the need to collect samples from catch areas. The choice of *A. foliacea* and *P. longirostris* is based on the requirements of the Priority Substances Directive which indicates that for Fluoranthene and PAHs, the biota EQS refers to crustaceans and molluscs. Such species would also cater for the requirements of EC Regulation 1881 of 2006.

1. Priority monitoring in water and sediment

Inshore monitoring stations for 'priority monitoring' contaminants are included under Table 5.56. The same list of substances are monitored in water (only) sampled in four offshore stations as listed in Table 5.57 and shown in Figure 5.8.

Mon. Site Ref. Code	Monitoring Network	Coordinates (Full UTM ED50)	
		Longitude	Latitude
Operational Monitoring Stations			
CP04-1	Operational	453769,71	3977836,62
CP04-2	Operational	449013,07	3979914,24
CP05	Operational - Harbour	457169,68	3973252,05
CP06-1	Operational	461078,41	3971492,15
CP06-2	Operational	460522,84	3970960,01
CP07	Operational - Harbour	459771,77	3964111,98
Surveillance Monitoring Stations			
CS01	Surveillance	425781,39	3992303,97
CS02	Sur + Reference Site	435571,14	3992063,13
CS03	Sur + Reference Site	442502,54	3984741,51
CS08	Surveillance	453654,59	3962794,34
CS09	Sur + Protected area	439697,26	3976129,46
National Monitoring Stations of relevance to 'Contaminants'			
CN01-2	Op – Diffuse Sources	429492,88	3987775,43
CN02-1	Op – Diffuse sources	433397,15	3992518,78
CN03-1	Op – Sewage Outfall	435420,03	3986084,12
CN03-2	Op - Harbour	437057,14	3987236,76
CN04-1	Op - diffuse sources	442596,44	3981355,59
CN04-3[203]	Op - bunkering site	445500,41	3984462,78
CN04-4	Op - diffuse sources	444937,85	3978614,21
CN05-1	Op - Harbour	455167,45	3973034,62
CN05-2	Op - Harbour	456279,18	3972594,26
CN06-1	Op - diffuse sources	460815,92	3969206,43
CN07-1	Op - Thermal effluent	460712,08	3966044,50
CN07-2	Op – Harbour	459413,96	3965607,40
CN07-3	Op – Harbour	458110,28	3965070,20
CN08-1	Op – Desalination Plants	447163,40	3965389,58
CN09-1	Op – Sewage Outfall	440099,89	3979621,63

Table 5.56: Inshore Monitoring Stations (water and sediment)

Offshore Monitoring stations	Coordinates (Full UTM ED50)	
	Longitude	Longitude
Malta North	378799.33 4	4028101.37
Malta East	530961.17 3	3976110.62
Malta South	473775.46 3	3904926.63
Malta West	375854.66 3	3951016.29

Table 5.57: Offshore monitoring stations (water sampling)

203 This station shall also be used to specifically monitor PHCs and PAHs in sediment of bunkering areas since the station is representing Bunkering Area 1

Figure 5.8: Offshore monitoring stations (Water sampling)

2. Monitoring in selected stations

Bunkering/waiting areas

Petroleum hydrocarbons and Polyaromatic hydrocarbons are monitored in sediment sampled in bunkering/waiting areas as listed in Table 5.58 and shown in Figure 5.9.

Monitoring of PHCs & PAHs in bunkering/waiting areas (sediment only)		
Bunkering Area 2	463215,69	3970468,46
Bunkering Area 3	480042,40	3971974,31
Bunkering Area 4	463310,71	3964577,20
Bunkering Area 6	439080,51	3978830,25
Waiting Area	470247,20	3967047,73

Table 5.58: Monitoring of Petroleum hydrocarbons and Polyaromatic hydrocarbons in bunkering sites (sediment only)[204]

204 Note that Bunkering Area 1 is already represented by monitoring station CN04-3 in Table

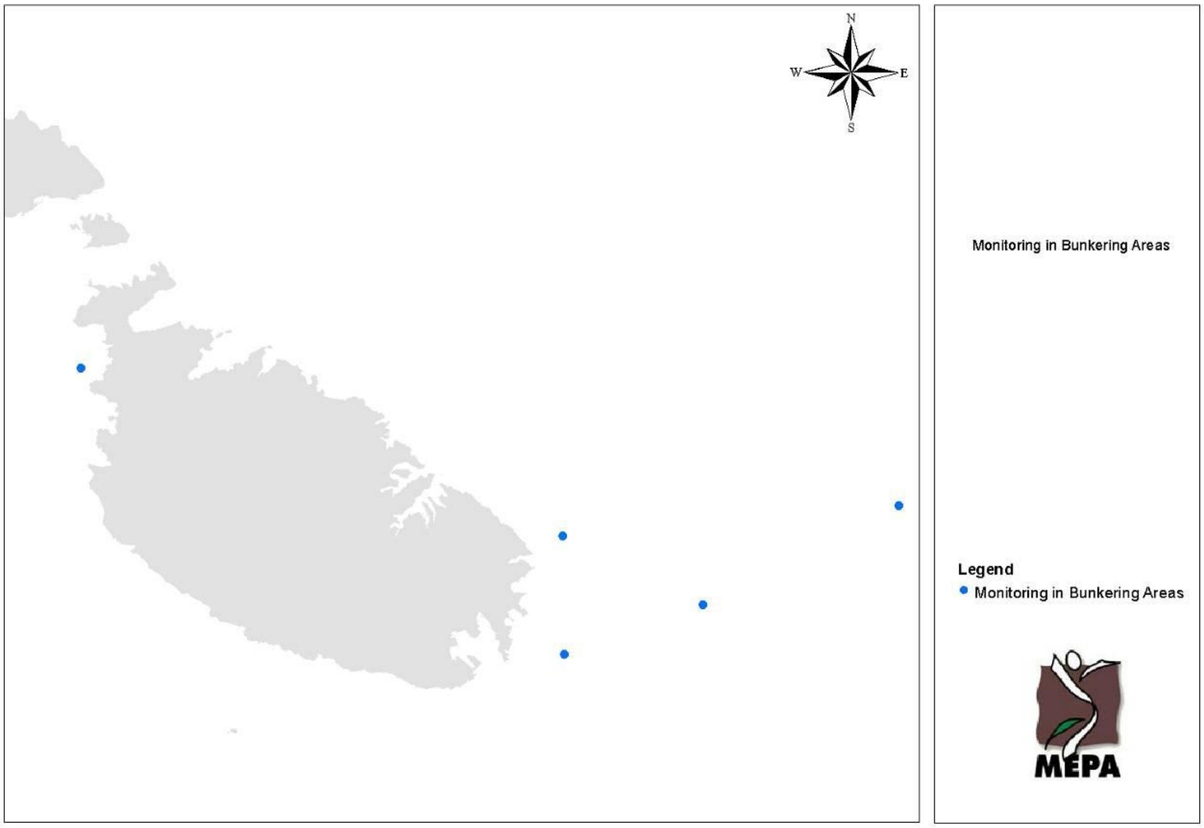


Figure 5.9: Monitoring in bunkering areas (sediment)

3. Areas subject to discharge of urban waste water

The presence of arsenic in sediment and carbamezepine and its metabolite in water and sediment will be determined through one-off monitoring within areas subject to discharge of urban waste water are indicated in Table and 5.60, and shown in Figure 5.10.

Mon. Site Ref. Code	Monitoring Network	Coordinates (Full UTM ED50)	
		Longitude	Latitude
CP06-1	Operational – sewage outfall	461078,41	3971492,15
CP06-2	Operational – sewage outfall	460522,84	3970960,01
CP07	Operational - Harbour	459771,77	3964111,98
CN03-1	Op – Sewage Outfall	435420,03	3986084,12
CN07-1	Op - Thermal effluent	460712,08	3966044,50
CN09-1	Op – Sewage Outfall	440099,89	3979621,63

Table 5.59: One-off monitoring for Arsenic in sediment

Mon. Site Ref. Code	Monitoring Network	Coordinates (Full UTM ED50)	
		Longitude	Latitude
CP06-1	Operational – sewage outfall	461078,41	3971492,15
CP06-2	Operational – sewage outfall	460522,84	3970960,01
CN03-1	Op – Sewage Outfall	435420,03	3986084,12
CN07-1	Op - Thermal effluent	460712,08	3966044,50
CN09-1	Op – Sewage Outfall	440099,89	3979621,63

Table 5.60: One-off monitoring for Carbamezepine & its metabolite (10,11-Dihydro-10,11- dihydroxycarbamazepine) in water & sediment

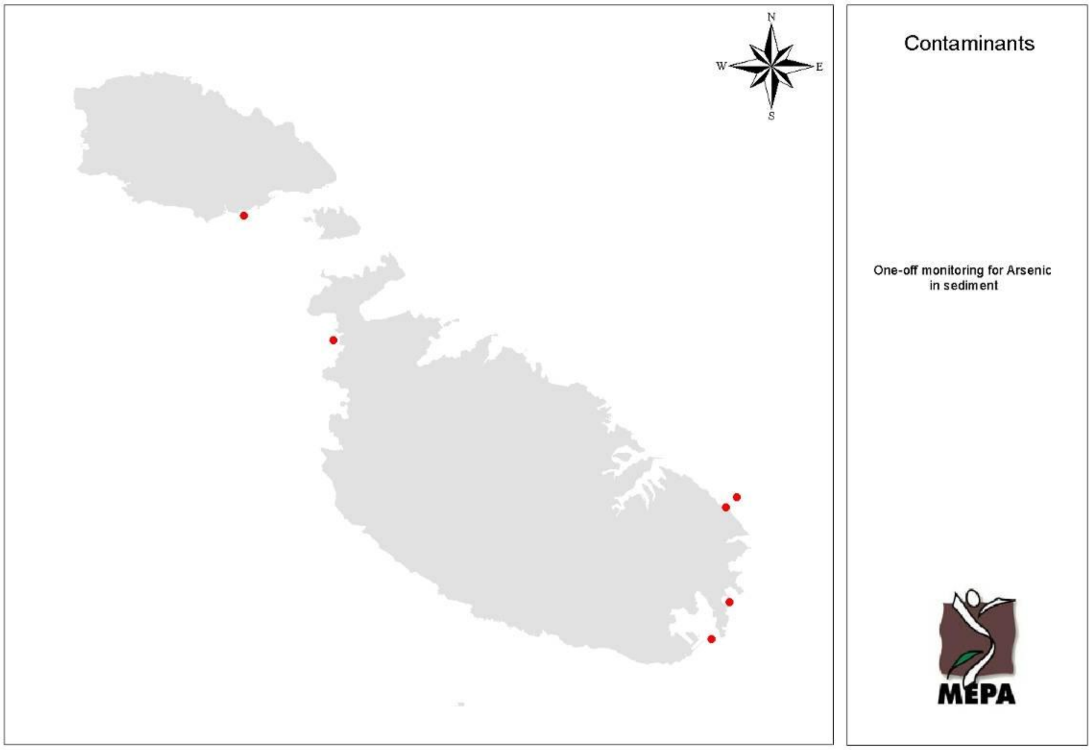


Figure 5.10: Monitoring Stations for one-off monitoring of Arsenic and Carbamezepine & its metabolite (10,11-Dihydro-10,11-dihydroxycarbamazepine)

4. Monitoring contaminants in sediment in Harbour areas

Monitoring of Water catchment Specific Pollutants Beryllium, Boron and Fluorides will be carried out in Marsaxlokk harbour and one reference area as per Table 5.61.

Mon. Site Ref. Code	Monitoring Network	Coordinates (Full UTM ED50)	
		Longitude	Latitude
CS09	Sur + Protected area	439697,26	3976129,46
CN07-2	Op – Harbour	459413,96	3965607,40
CN07-3	Op – Harbour	458110,28	3965070,20

Table 5.61: Monitoring for Beryllium, Boron and Fluorides in water & sediment

5. Monitoring contaminants in Posidonia oceanica

Monitoring stations for monitoring of contaminants in *Posidonia oceanica* are listed in Table 5.62 and shown on Figure 5.11. Monitoring stations shall be updated after the first monitoring year on the basis of a risk-based approach following further knowledge on the status of each station in terms of contaminants.

Mon. Site Ref. Code	Monitoring Network	Coordinates (Full UTM ED50)	
		Longitude	Latitude
Operational Monitoring Stations			
CP04-1	Operational	453769,71	3977836,62
CP06-1	Operational	461078,41	3971492,15
CP06-2	Operational	460522,84	3970960,01
CP07	Operational - Harbour	459771,77	3964111,98
Surveillance Monitoring Stations			
CS02	Sur + Reference Site	435571,14	3992063,13
CS03	Sur + Reference Site	442502,54	3984741,51
CS09	Sur + Protected area	439697,26	3976129,46
National Monitoring Stations of relevance to 'Contaminants'			
CN01-2	Op – Diffuse Sources	429492,88	3987775,43
CN03-1	Op – Sewage Outfall	435420,03	3986084,12
CN03-3	Op – Harbour	440130,02	3983083,45
CN03-6	Op – Minor Sewage Outfall	441540,34	3985079,15
CN04-1	Op - diffuse sources	442596,44	3981355,59
CN04-3	Op - bunkering site	445500,41	3984462,78
CN04-4	Op - diffuse sources	444937,85	3978614,21
CN04-6	Nitrates Directive	454528,54	3975162,74
CN06-1	Op - diffuse sources	460815,92	3969206,43
CN07-1	Op - Thermal effluent	460712,08	3966044,50
CN08-1	Op – Desalination Plants	447163,40	3965389,58

Table 5.62: Monitoring Stations (*Posidonia oceanica*)

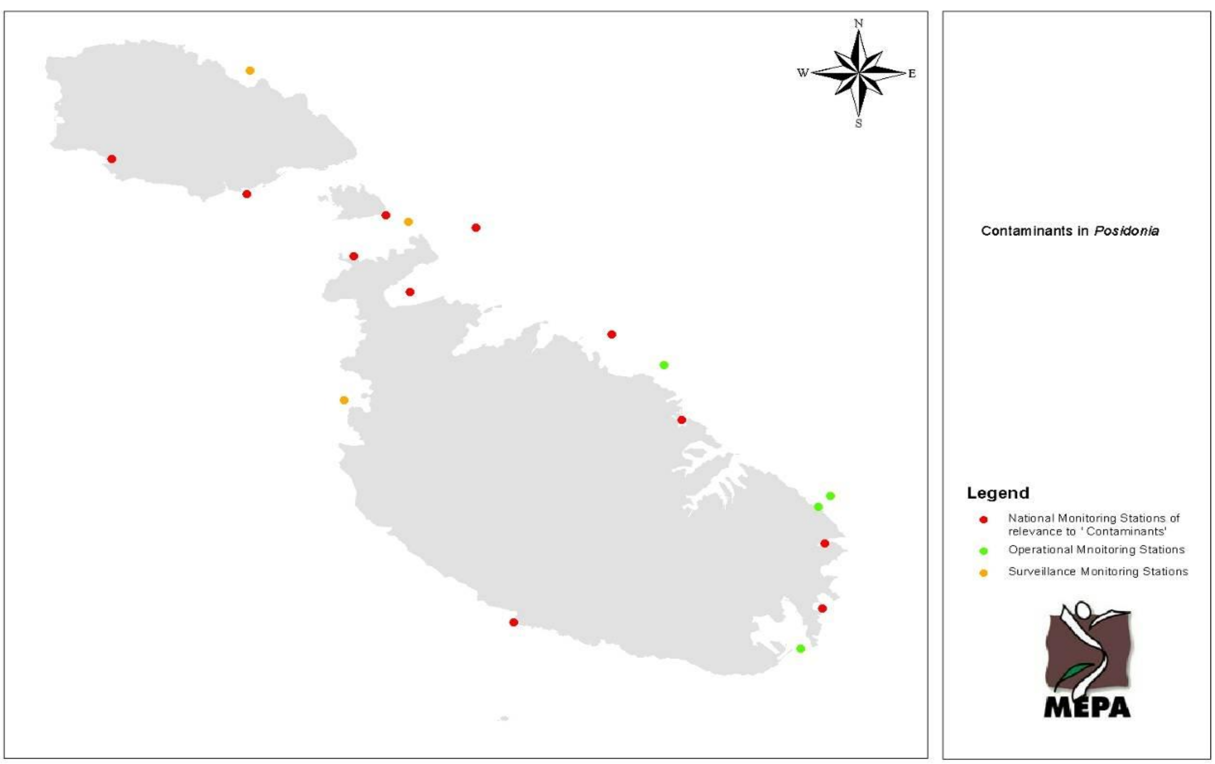


Figure 5.11: Monitoring Stations (*Posidonia*)

6. Monitoring contaminants in Fish & Crustacea

MEDITS[205] stations located within or in the vicinity of (within 1.5 NM) catch areas as represented by trawling zones are indicated in Table 5.63 together with the species sampled in such hauls to be subject to analysis of contaminants.

MEDITS Haul	Mean Depth (m)	Specimens to be collected depending on availability	Coordinates (start & end)	
			Longitude	Latitude
49	83	*Mullus barbatus*	35.8770	14.9377
			35.8755	14.9078
55	125	*Mullus barbatus* *Parapenaeus longirostris*	35.9958	14.7113
			36.0183	14.7222
54	127	*Mullus barbatus* *Parapenaeus longirostris*	36.1097	14.7272
			36.0903	14.7078
5	187	*Mullus barbatus* *Parapenaeus longirostris*	35.9543	14.2607
			35.9632	14.2318
79	203	*Mullus barbatus* *Parapenaeus longirostris*	36.1602	14.4338
			36.1828	14.4478
76	335	*Merluccius merluccius* *Parapenaeus longirostris*	36.4140	14.4165
			36.3707	14.4470
10[206]	345	*Merluccius merluccius* *Parapenaeus longirostris*	36.1948	14.0110
			36.2155	14.0675
70	441	*Merluccius merluccius* *Aristaeomorpha foliacea*	36.4750	14.3452
			36.4360	14.3847
74[207]	471	*Merluccius merluccius* *Aristaeomorpha foliacea*	36.1288	14.0868
			36.1587	14.1480
7[208]	606	*Aristaeomorpha foliacea*	36.0805	13.9863
			36.1242	13.9343
8[209]	640	*Aristaeomorpha foliacea*	36.1090	13.9632
			36.1433	13.9190

Table 5.63: Selected MEDITS hauls within or in the vicinity of catch areas and species to be collected depending on presence in haul.

205 The *MEDITS* survey programme (International bottom trawl survey in the Mediterranean) intends to produce basic information on benthic and demersal species in term of population distribution as well as demographic structure, on the continental shelves and along the upper slopes at a global scale in the Mediterranean Sea, through systematic bottom trawl surveys. (http://www.sibm.it/SITO%20MEDITS/principaleprogramme.htm)

206 Within 1.5 nautical mile of trawling zone

207 Within 1.5 nautical mile of trawling zone

208 Within 1.5 nautical mile of trawling zone

209 Within 1.5 nautical mile of trawling zone

5.4.2.1.4 Monitoring parameters and methodology

	Environmental Medium	Monitoring Stations/ features/ parameters	First Monitoring Year	Subsequent years
Priority Monitoring	Water	Inshore stations	Monthly	Monthly, every 3 years (subject to revision)
		Offshore stations	6-monthly (summer and winter)	To be determined following the first monitoring year
	Sediment	Inshore stations	Yearly	To be determined following the first monitoring year
Petroleum hydrocarbons & Polyaromatic hydrocarbons	Sediment	Bunkering sites	Yearly	To be determined following the first monitoring year
Arsenic & Carbamezepine	Water	Selected stations	One-off	To be determined depending on presence of substance or otherwise
	Sediment			
Water Catchment Specific Pollutants: Boron, Beryllium & Fluorides	Water	Selected stations	Monthly	To be determined depending on presence of substance or otherwise
	Sediment		Yearly	

Table 5.64: Monitoring Frequency for contaminants in water and sediment

Monitoring Stations/ features/ parameters	First Monitoring Year	Subsequent years
Retail samples	2-yearly	
Posidonia oceanica	Yearly	To be determined
Fish & Crustacea	Yearly	To be determined

Table 5.65: Monitoring Frequency for contaminants in water and sediment

5.5 Groundwater Monitoring Networks

Article 8 of the Water Framework Directive defines a requirement for the establishment of programmes for the monitoring of groundwater. These monitoring programmes are intended to provide the necessary information to enable the Environmental Objectives (Article 4 of the WFD) to be met, and in particular the assessment of groundwater quantitative status, chemical status and the identification of significant, long-term trends in natural conditions and trends resulting from human activity in groundwater bodies.

5.5.1 Background

During the implementation of the 1st Water Catchment Management Plan groundwater bodies were grouped for monitoring purposes, based on their hydrogeological characteristics, catchment typologies and risk assessments outcoming from the Article 5 characterisation analysis. This following a conceptual assessment in which it was determined that the monitoring information obtained would provide for a reliable assessment of the status of each water body in the group and the confirmation of any significant upward trend in pollutant concentration.

Following, a review of the Article 5 Characterisation assessment, undertaken in preparation to the 2nd Water Catchment Management Plan, the 'risk' classification established under the 1st WCMP for all bodies of groundwater within the Malta Water Catchment District was confirmed. In as much, the grouping of groundwater bodies undertaken for the purpose of the implementation of the 1st WCMP monitoring network development, which was based on the hydrogeological characteristics of the groundwater bodies was confirmed. This in line with the requirements of the Water Framework Directive which allows grouping of only those water bodies which are sufficiently similar in terms of aquifer characteristics, pathway susceptibilities, pressures and confidence in their risk assessment.

In as much, the seven groundwater body groupings established during the 1st WCMP were confirmed and adopted for the implementation period of the 2nd WCMP. These are:

Group Code	Component GWB Code	Name of Component Bodies of Groundwater
MT0_G01	MT001	Malta Mean Sea Level
MT0_G02	MT002	Rabat-Dingli Perched
MT0_G03	MT003, MT006, MT014	Mgarr/Wardija Perched, Mizieb Mean Sea Level, Ghajnsielem Perched
MT0_G04	MT005, MT009, MT010	Pwales Coastal, Mellieha Coastal, Marfa Coastal
MT0_G05	MT008, MT015, MT016	Mellieha Perched, Nadur Perched, Xaghra Perched
MT0_G06	MT017, MT018	Zebbug Perched, Victoria/Kercem Perched
MT0_G07	MT012, MT013	Kemmuna Mean Sea Level, Gozo Mean Sea Level

Table 5.66: Grouping of groundwater bodies based on their characteristics

The Water Framework Directive requires the establishment of a monitoring network which is representative of each groundwater body. The amount of monitoring required thus needs to be proportional to the difficulty in judging the status of the groundwater body, the presence of adverse trends and the implications of errors in such judgements, in particular with regard to the setting up of programmes of measures.

Consequently, during the 1st WCMP, different approaches for establishing monitoring networks were adopted in the Malta Water Catchment District, in order to take into consideration the relative importance of the groundwater bodies with particular reference to those water bodies which sustain freshwater ecosystems and those which are utilised as sources of 'water intended for human consumption'. The main conclusions of this analysis are outlined hereunder:

(i) In the Lower Coralline Limestone aquifer groundwater bodies a monitoring density of one site per sixteen square kilometres was established. This to allow for detailed investigations on spatial variations in the quality of these water bodies and also to permit the future undertaking of Electrical Conductivity profile analysis to eventually develop 3D qualitative models of the aquifer systems; and

(ii) In the Upper Coralline Limestone groundwater bodies a minimum threshold of three monitoring points for each groundwater body grouping, with at least one monitoring point in each body of groundwater was established. Due account was taken of subsurface groundwater flow conditions in order to ensure that the selected monitoring sites are representative of the comprehensive status of the body of groundwater. An additional, 'qualitative status' monitoring point was established in the case of the Rabat-Dingli and Victoria-Kercem perched groundwater bodies to provide effective coverage to the surface water systems that this groundwater body sustains.

The monitoring network established and operated during the 1st WCMP is presented in the table below:

Group Code	Total Number of Monitoring Sites	Quantitative Monitoring Sites	Qualitative Monitoring		Protected Area Monitoring Sites
			Surveillance Monitoring Sites	Operational Monitoring Sites	
MT0_G01	110	29	14	14	67
MT0_G02	5	-	5	5	-
MT0_G03	11	1	5	5	5
MT0_G04	3	-	3	3	-
MT0_G05	3	-	3	3	-
MT0_G06	3	-	3	3	-
MT0_G07	62	12	7	7	43

Table 5.67: Establishment of Monitoring Networks

The monitoring networks which have been developed during the course of the implementation of the 1st Water Catchment Management Plan, and the plans aimed at further developing these networks during the course of the 2nd WCMP implementation period will be outlined in the remaining sections of this chapter.

5.5.2 Quantitative Monitoring

The Water Framework Directive identifies 'water level' as the main metric for determining groundwater quantitative status. The quantitative monitoring network adopted under the 1st WCMP in Malta was based on the measurements of 'groundwater levels in gauging boreholes', as the basic parameter for measuring quantitative status.

Use of existing groundwater-level monitoring networks operated by the Water Services Corporation was therefore made. These stations are essentially groundwater boreholes dedicated for the measurement of water level in the mean sea level aquifer systems, which since the late 1990's have been upgraded with automated water level monitoring equipment. The equipment in use in these stations is based on water level float encoders, fitted with data loggers. It is noted that some of these monitoring stations have been in operation since the 1940's, when manual readings of water level were taken.

Figure 5.12: Borehole Water Level Monitoring Instrumentation – Float Encoders

The water level monitoring stations in operation during the 1st WCMP amounted to 42 and covered all the sea-level aquifer systems.

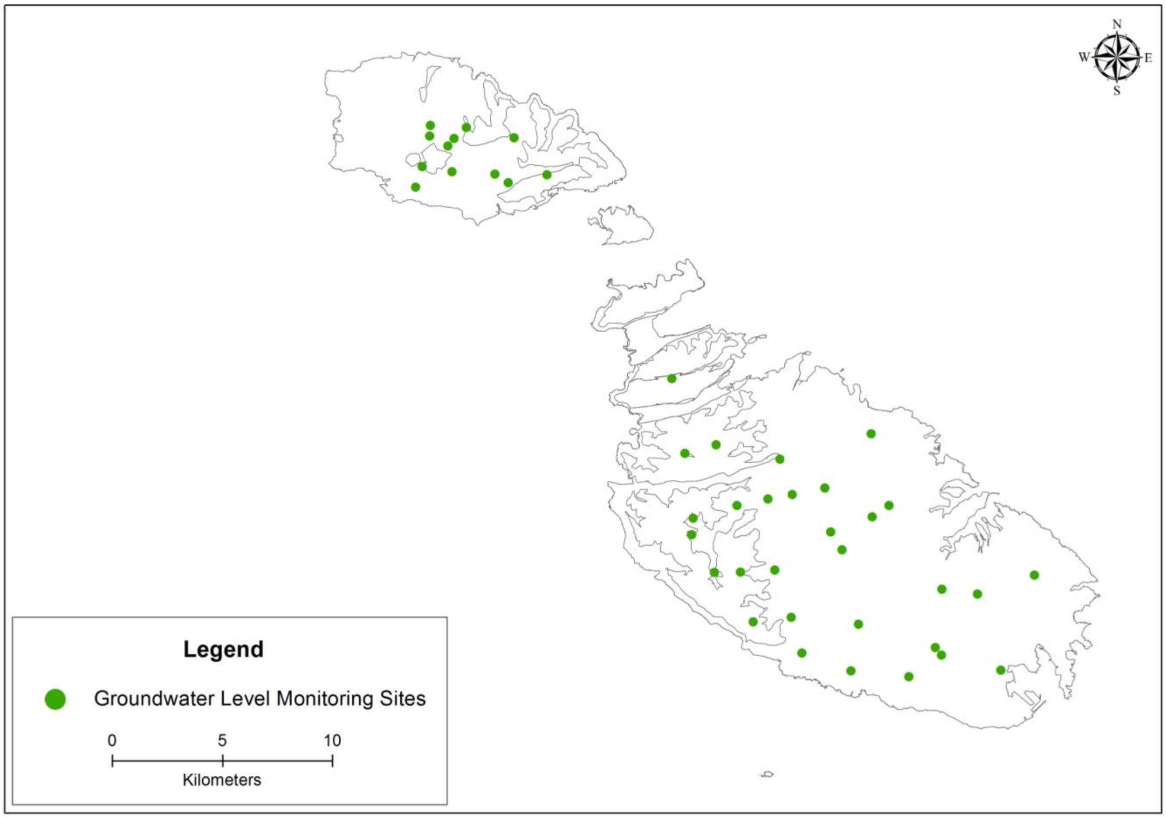


Figure 5.13: Groundwater Quantitative Status monitoring network

The water level monitoring probes collect water level data automatically at fixed intervals, in the case of some probes as low as 1 hour, which are collected in a data logger. Water level data is then regularly downloaded by technical personnel, and used to produce water level temporal distribution plots.

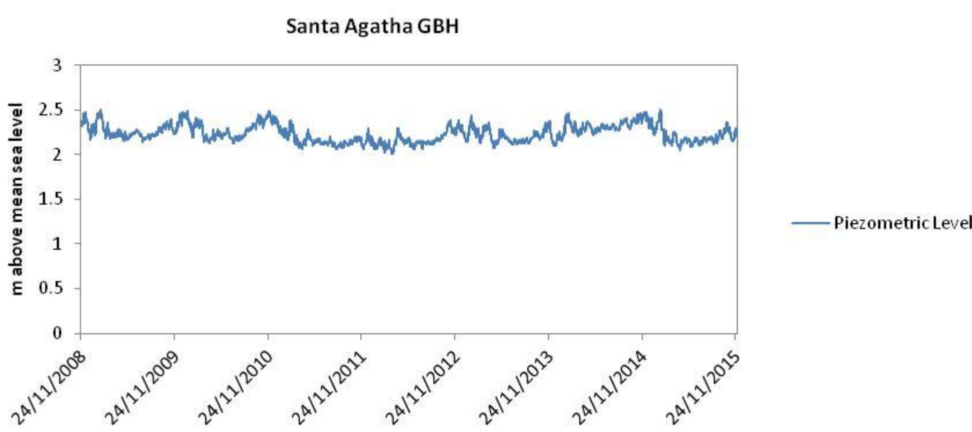


Figure 5.14: Water Level Readings at Sant'Agatha Gauging Borehole (South Malta) during the 1st WCMP period

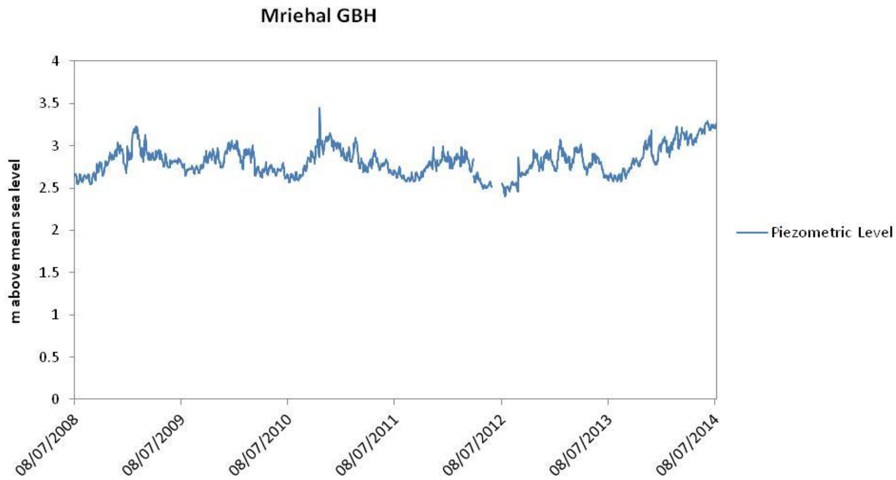


Figure 5.15: Water Level Readings at Mriehel Gauging Borehole (Central Malta) during the 1st WCMP period

In addition, to water level measurements, initial conductivity well profiles have been undertaken in the Mean Sea Level Aquifer systems. These profiles are undertaken by measuring the Electrical Conductivity down the borehole at fixed depth intervals. Conductivity profiles are the best monitoring technique for sea-level floating lens aquifers as the Malta and Gozo Mean Sea Level Aquifer systems, since they provide an opportunity of undertaking a combined quantitative and qualitative scan throughout the whole length of the freshwater lens. In as much, profiles can monitor the level of the freshwater (piezometric) surface, but more importantly can also monitor changes in the transition zone between freshwater and saltwater, the lower boundary of the freshwater aquifer system. As outlined in the Ghyben-Herzberg principle, changes in the position of the piezometric surface are amplified by around 40 times in the position of the freshwater- saltwater interface. Therefore, conductivity profiling presents an opportunity for optimising the monitoring of the sea-level aquifer systems, since the thickness of the Transition Zone is an important factor for the determination of the effective quantitative status of these water bodies.

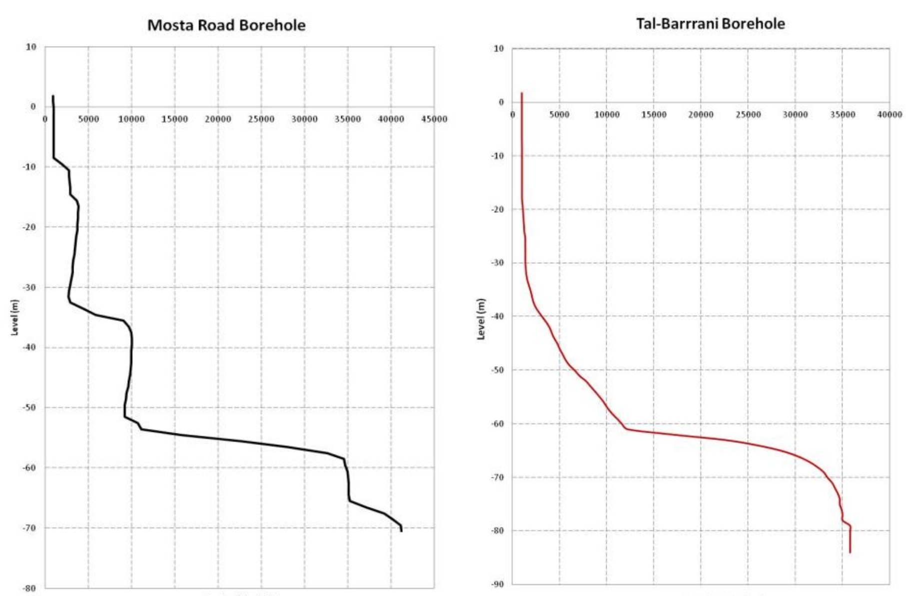


Figure 5.16: Profiles of Electrical Conductivity along deep gauging boreholes
at Mosta Road (Malta Central) and Tal Barrani (Malta South)

Following these initial results, plans are being developed (as part of the comprehensive upgrading of the hydrological monitoring framework) to progressively upgrade the quantitative monitoring stations in the mean sea level aquifer systems to enable the undertaking of conductivity profiles. This process will start during the course of the 2nd WCMP. The eventual use of this monitoring capability, based on the characteristics of these sea-level aquifer systems, will provide further information on which to more reliably base future status assessments for these sea-level aquifer systems. It is noted that this monitoring network will enable the correlation of piezometric level data with aquifer thickness data and thus enable a more reliable direct assessment of the quantitative status of the groundwater body.

Furthermore, during the implementation of the 1st WCMP the use of alternative water level gauging equipment was tested as part of an assessment on the potential optimisation of the monitoring capacity. This equipment included pressure based piezometric level measurement instrumentation which can also provide readings of electrical conductivity at the monitoring level. The feasibility of the adoption of this alternative water level gauging technology is still being assessed.

Figure 5.17: Borehole Water Level Monitoring Instrumentation – Pressure Probes

The main challenges faced during the implementation of the 1st WCMP monitoring requirements mainly relate to the monitoring of the quantitative status metric, i.e. groundwater level, in the perched (upper coralline limestone) aquifer systems. This was mainly due to the hydrogeological properties of these systems which presents an extremely thin unsaturated zone (and therefore low standing water levels), which does not permit the installation of traditional water level metering equipment.

Pilot initiatives were thus undertaken to test the feasibility of using 'groundwater flow' measurements in spring channels as an alternative metric for assessing quantitative status. The main challenges faced in this regard related to the size of the spring channels, which rarely exceed 10cms x 5cms in cross-section (rectangular). The identification of channel water flow monitoring equipment which can be fitted in these micro-channels proved difficult. In order to address this situation, manual monitoring points (flow measuring points over V-notches) will be progressively installed at the identified springs whilst the testing of equipment which can take continuous automated readings of water flow in these channels will be continued to enable the eventual identification of the best water-flow measurement equipment which can be installed in these stations.

Efforts to install an effective monitoring framework will therefore be renewed during the 2nd water catchment planning cycle with the planned introduction of water flow measurements in spring channels.

Figure 5.18: Typical spring channels in the perched aquifer system, showing the nature of groundwater flow in these aquifer systems, and the difficulties associated with the installation of water level and water flow monitoring instrumentation

The upgrading of existing and the introduction of new quantitative (water level, conductivity profiling and water flow) monitoring stations will form part of a more comprehensive project focussing on the optimisation of the national hydrological monitoring capability which will be proposed for financing under Priority Axis 10 of the Cohesion Funds for Malta 2014-2020.

5.5.3 Qualitative Monitoring

The qualitative groundwater monitoring strategy adopted in Malta envisages a six-year cycle starting with a 'Surveillance' monitoring exercise which is then complemented by five years of 'Operational' monitoring. Surveillance monitoring is required to support the validation of the risk assessments undertaken during the review of the WFD Article 5 Characterisation. This monitoring exercise, which is undertaken once every six-years, entails a full qualitative analysis of the status of the groundwater body. Moreover, this monitoring programme will also identify those parameters for which more detailed (operational) monitoring is required to enable the assessment for long term trends in natural conditions and in pollutant concentrations resulting from human activity.

Operational monitoring is carried out during the five-year periods between Surveillance Monitoring, and can be considered as a specific monitoring exercise focused on assessing the specific identified risks to the achievement of the Directive's objectives. This monitoring exercise is carried out twice every year during the five-year period between the Surveillance Monitoring exercises, and is specifically modelled for each body of groundwater following an analysis of the results of the Surveillance Monitoring programme and the pressures and impacts assessment undertaken in the lead up to the formulation of the respective Water Catchment Management Plan.

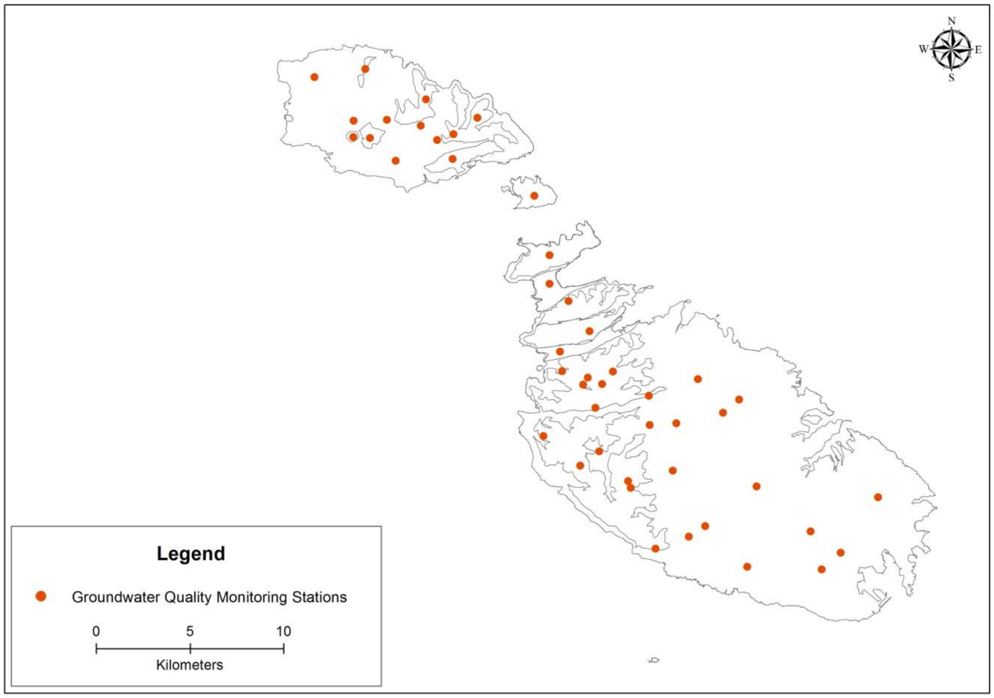


Figure 5.19: Groundwater Qualitative Monitoring Network

The Operational Monitoring strategy established under the 1st WCMP was based on the results of the 1st Surveillance Monitoring exercise, and focused on:
- the core determinands outlined in the Groundwter Directive,
- a suite of selected determinands, the presence of which at levels which pose a risk to the achievement of 'good status' had been encountered during the surveillance monitoring exercise, and
- those determinands for which the pressures and impacts assessment had indicated the presence of a potential risk of pollution to groundwater.

Following an analysis of the results of the 2nd Surveillance Monitoring (2015) programme, no need was identified for the inclusion of further parameters in the Operational Monitoring strategy for the 2nd WCMP. In as much the only change to be made in the Operational Monitoring strategy during the 2nd WCMP implementation period will entail the inclusion of the new core determinands (Nitrites and Phosphate) introduced in the amendments to the Groundwater Directive (2015).

Groundwater Body Group Code	Selected Monitoring Determinands for the Operational Monitoring exercise
MT0_G01	NO3, TPest, ECond, Na, Cl, B, F, Pb, Cu, Zn, As, F, SO4, NH4, NO2, PO4
MT0_G02	NO3, TPest, ECond, Pb, Cu, Zn, SO4, NH4, NO2, PO4
MT0_G03	NO3, TPest, ECond, Na, Cl, B, Pb, Cu, Zn, SO4, NH4, NO2, PO4
MT0_G04	NO3, TPest, ECond, Na, Cl, B, Pb, Cu, Zn, As, F, SO4, NH4, NO2, PO4
MT0_G05	NO3, TPest, ECond, Pb, Cu, Zn, As, F, SO4, NH4, NO2, PO4
MT0_G06	NO3, TPest, ECond, Pb, Cu, Zn, As, F, SO4, NH4, NO2, PO4
MT0_G07	NO3, TPest, ECond, Na, Cl, B, Pb, Cu, Zn, As, F, SO4, NH4, NO2, PO4

Table 5.68: Operational Monitoring – Selected Monitoring Determinands
(in addition to phisico-chemical parameters such as pH, DO and Temperature which are monitored at each station)

The set-up of the Operational Monitoring Programme will moreover be flexible enough to adopt any other parameters whereby any new risks are identified from the specific investigative studies which are planned to be carried out during the 2nd planning cycle.

5.5.4 Groundwater Threshold Values

A review of the Groundwater Threshold Values established for the purpose of the 1st WCMP was also undertaken as part of the formulation of the 2nd WCMP. The Groundwater Directive under Annex II requires Member States to establish threshold values for all "*pollutants and indicators of pollution which, pursuant to the characterisation performed in accordance with Article 5 of Directive 2000/60/EC, characterise bodies or groups of bodies of groundwater as being at risk of failing to achieve good groundwater chemical status.*" Part B to the same Annex outlines a minimum list of pollutants for which Member States are required to consider establishing threshold values.

As part of the implementation of the 1st Water Catchment Management Plan:

(i) Threshold Values were set for Chloride, Sulphate, Ammonium, Lead, Arsenic and Conductivity, since these parameters have been detected in groundwater.

(ii) Threshold values were also established for the following parameters, which are not included in the minimum list of the Groundwater Directive:
  - Copper and Zinc, due to the presence of these metals in the overlying soils;
  - Boron, due to the effects of sea-water intrusion; and
  - Fluoride, which is naturally present in the sea-level aquifer systems.

(iii) No threshold values were established for Cadmium, Mercury, Trichloroethylene and Tetrachlorethylene since these have never been detected in groundwater in Malta. This would be revised in subsequent Water Catchment Plans should there be a positive detection of a particular parameter in the periodic surveillance monitoring exercise. In such case, it is being proposed that the Threshold Value be set at 50% of the standard for Drinking Water.

The procedure and issues considered in the development of the Threshold Values are presented below.

Sea-water intrusion related compounds

The procedure for setting up Threshold Values for sea-water intrusion related compounds takes into consideration the different levels of contact with sea-water experienced by the three main groundwater body typologies in the Maltese islands.

i. Sea-level groundwater bodies

Background levels for the sea-level groundwater bodies need to take into consideration the fact that monitoring stations in these groundwater bodies are not limited to the central regions of the island but cover the whole extent of the water body, even those coastal areas which will be expected to be significantly affected by natural processes such as diffusion and hydrodynamic dispersion of salinity across the freshwater-saltwater interface. In as much, it is being proposed that the background levels for these water bodies be set on the basis of the quality results on the Comino Groundwater Body, which being a small relatively unexploited groundwater body is an ideal natural model of the impact of natural intrusion in the immediate near coastal zone.

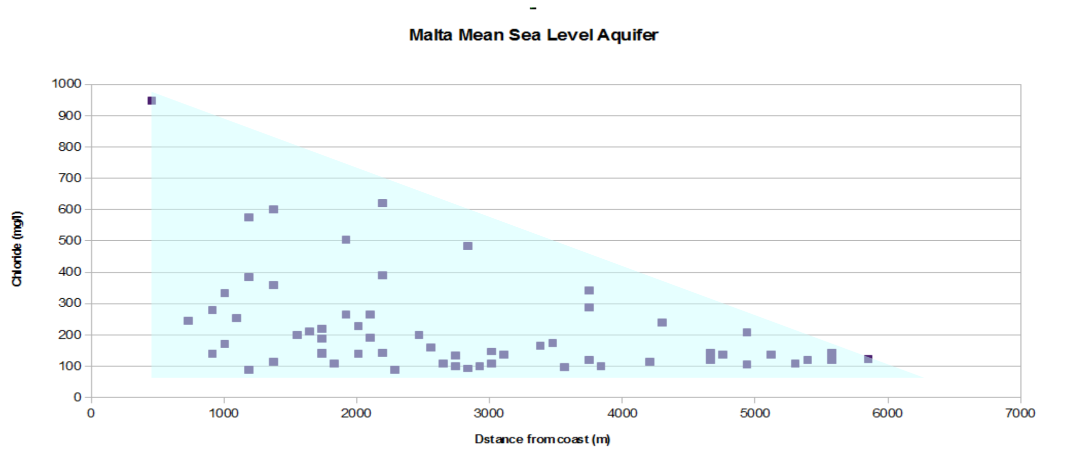


Figure 5.20: Increased variability in the salinity content of groundwater in proximity to the coast.
Salinity Content sourced from 1944 monitoring data when the sea-level aquifer system was practically still unexploited

This situation is further corroborated by an analysis of the initial salinity content in groundwater abstraction stations from the 1940's, at a time when the Malta mean-sea level aquifer systems was still relatively unexploited. The analysis shows that variability in the natural background content of salinity in groundwater increases towards the coastal zone.

The background levels for chloride and sodium content are higher than the established criteria values – which for this aquifer system are defined by the limit values of the Drinking Water Directive; and therefore the background levels will be adopted as the Threshold Values for these parameters. TV = BL.

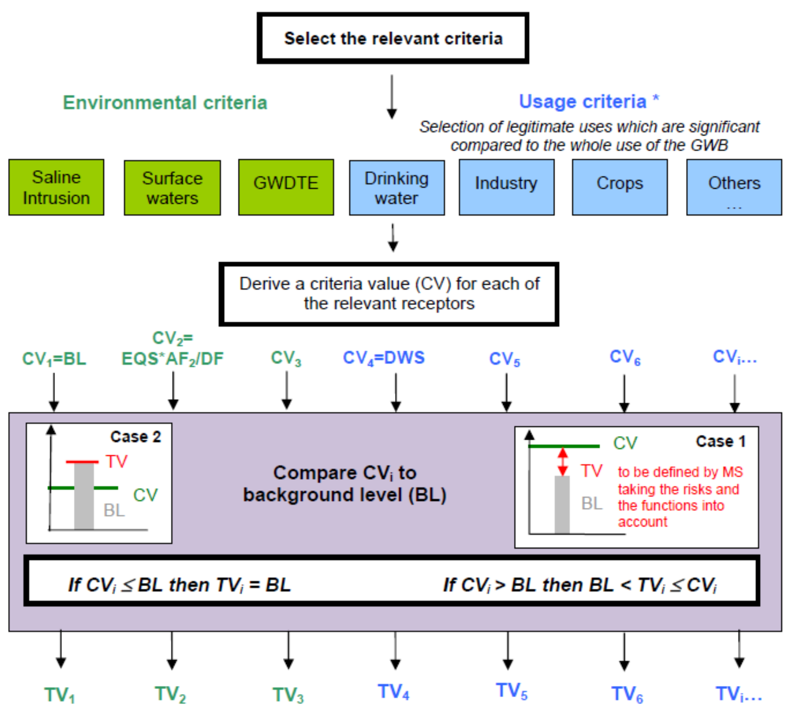


Figure 5.21: Methodology for the establishment of Groundwater Threshold Values based on Environmental and Usage Criteria as outlined under CIS Guidance Document 18 – Guidance on Groundwater Status and Trend Assessment

On the other hand, background levels for sulphate, boron and conductivity are lower than the Criteria Values. In the case of these parameters, the Threshold Values were fixed at 50% and 75% of the difference between the background value and the criteria value for chemical and indicator parameters respectively. It was taken into consideration the higher risk to human health of the chemical parameters of the Drinking Water Directive.

ii. Perched groundwater bodies

Background levels for the perched groundwater bodies were obtained from a monitoring station located in a relatively pristine region of these aquifer systems. Since the background levels for the parameters under consideration were significantly lower that the Drinking Water Criteria Value, Threshold Values were fixed at 50% and 75% of the difference between the background level and the criteria value for chemical and indicator parameters respectively.

iii. Coastal groundwater bodies

The small coastal groundwater bodies have historically been utilised exclusively for irrigation. The threshold values were therefore set at the mid-point of the criteria value range for irrigation water, which criteria value were adopted from FAO[210] figures.

The Threshold Values established under the procedures described above are presented in Table 5.68 below.

Groundwater Body	Threshold Values
Sea-Level Groundwater Bodies	
MT001 Malta Mean Sea Level MT006 Mizieb Mean Sea Level MT012 Kemmuna Mean Sea Level MT013 Gozo Mean Sea Level	Chloride: 1000mg/l Sodium: 450mg/l Boron: 0.6mg/l Sulphate: 475mg/l Conductivity: 4500µS/cm
Perched Groundwater Bodies	
MT002 Rabat Dingli Perched MT003 Mgarr-Wardia Perched MT008 Mellieha Perched MT014 Ghajnsielem Perched MT015 Nadur Perched MT016 Xaghra Perched MT017 Zebbug Perched MT018 Victoria-Kercem Perched	Chloride: 210mg/l Sodium: 160mg/l Boron: 0.5mg/l Sulphate: 190mg/l Conductivity: 2000µS/cm
Coastal Groundwater Bodies	
MT005 Pwales Coastal MT009 Mellieha Coastal MT010 Marfa Coastal	Chloride: 500mg/l Sodium: 450mg/l Boron: 1mg/l Sulphate: 475mg/l Conductivity: 3000µS/cm

Table 5.69: Established threshold values for each groundwater body

Heavy Metals

The State of the Environment Report for Malta[211] (2005) notes that "*The presence of heavy metals such as lead, copper and zinc in soil is an indicator of soil contamination. ...... In 25% of Maltese soils, the concentration of Lead exceeds the limit (100mg/kg) for the application of sewage sludge. 7% of soils exceed the 200mg/kg limit established for Zinc and in 3% of the soils the100mg/kg limit for Copper is exceeded*".

Since soils are present in the recharge areas of all groundwater bodies, there is the distinct possibility that leaching of heavy metals by recharging water may occur. Background levels for these compounds in

[210] FAO - Ayers and Westcott
[211] MEPA State of the Environment Report

groundwater are extremely low, and therefore threshold values are based exclusively on drinking water quality standards, and set at 50% of this criteria value. In the specific case of Zinc, since this metal is still present in abstraction pipe work, it is being proposed to set the threshold value at the level of the WHO quality standard. This Threshold Value will be revised in subsequent water catchment management plan's and lowered to 50% of the quality standard once and if abstraction pipe work is replaced.

Groundwater Body	Threshold Values
All groundwater bodies in the Maltese River Basin District.	Lead: 10μg/l Copper: 2mg/l Zinc: 3mg/l

Table 5.70: Threshold values for heavy metals in the Maltese Water Catchment District

Parameters of geogenic origin

Fluoride content in the Malta Mean Sea Level groundwater body is attributed to the presence of the 'phosphorite conglomerate' beds within the Globigerina Limestone formation. In effect, higher levels of fluoride are encountered in those regions of the mean sea level groundwater bodies where these beds are most developed. It is being proposed that Threshold values for Fluoride be established only for the sea-level groundwater bodies and set at the highest value encountered in each groundwater body.

Background levels for Arsenic content are generally lower than the Drinking Water Criteria Value for both main sea-level groundwater bodies although maxima of 7μg/l are encountered in the sea-level groundwater body of Gozo. It has thus been proposed that Threshold Values be established only for the sea level groundwater bodies in Malta and Gozo, and set at 50% and 75% of the Drinking Water quality standard respectively, the latter limit being higher to reflect the higher values encountered in the island of Gozo.

Groundwater Body	Threshold Values
MT001 Malta Mean Sea Level	Fluoride: 1.5mg/l Arsenic: 5μg/l
MT013 Gozo Mean Sea Level	Fluoride: 2.75mg/l Arsenic: 7.5μg/l

Table 5.71: Threshold values for Fluoride and Arsenic in the Mean sea level aquifers

Other Parameters

Ammonium and Nitrite are generally considered as an indicator of direct pollution by sewage. Given the relatively long infiltration and residence times of groundwater in Malta, both parameters are not generally encountered in results of groundwater monitoring exercises.

Given the low incidence of ammonium and nitrite pollution in groundwater, and the importance of these parameters as an indicator of sewage contamination it is suggested that the Threshold Value for Ammonium and Nitrite be set at 50% of the Drinking Water Quality Standards.

In the case of Phosphate, the importance of this parameter with regards to its potential to cause eutrophication in surface water bodies is considered as the most vulnerable criteria value for this parameter; when compared to drinking water where the maximum allowable concentration for phosphate established by the WHO stands at 5mg/l. EPA (US) standards for the protection from eutrophication are thus being adopted as the threshold value for this parameter in groundwater.

Groundwater Body	Threshold Values
All groundwater bodies in the Maltese Water Catchment District	Ammonium: 0.25mg/l Nitrite: 0.25mg/l Phosphate: 0.03mg/l

Table 5.72: Threshold value for Ammonium, Phosphate and Nitrite in the Maltese Water Catchment District

5.5.5 Protected Area Monitoring

Monitoring in Drinking Water Protected areas will continue to adopt the monitoring activities undertaken by the Water Services Corporation on all boreholes and pumping stations being utilised for the abstraction of groundwater intended for human consumption. These stations are currently monitored on a monthly basis for the parameters listed in table 5.72 below.

Abstraction Station Typology	Monitored Parameters
Borehole	Electrical Conductivity, Chloride and Nitrate
Pumping Station	Turbidity, Electrical Conductivity, pH, Ammonia, Nitrite, Phosphate, Chloride, Coliforms, EColi, Enterococci, TBC37 and TBC20

Table 5.73: Protected Area Monitoring – Monitoring Determinands

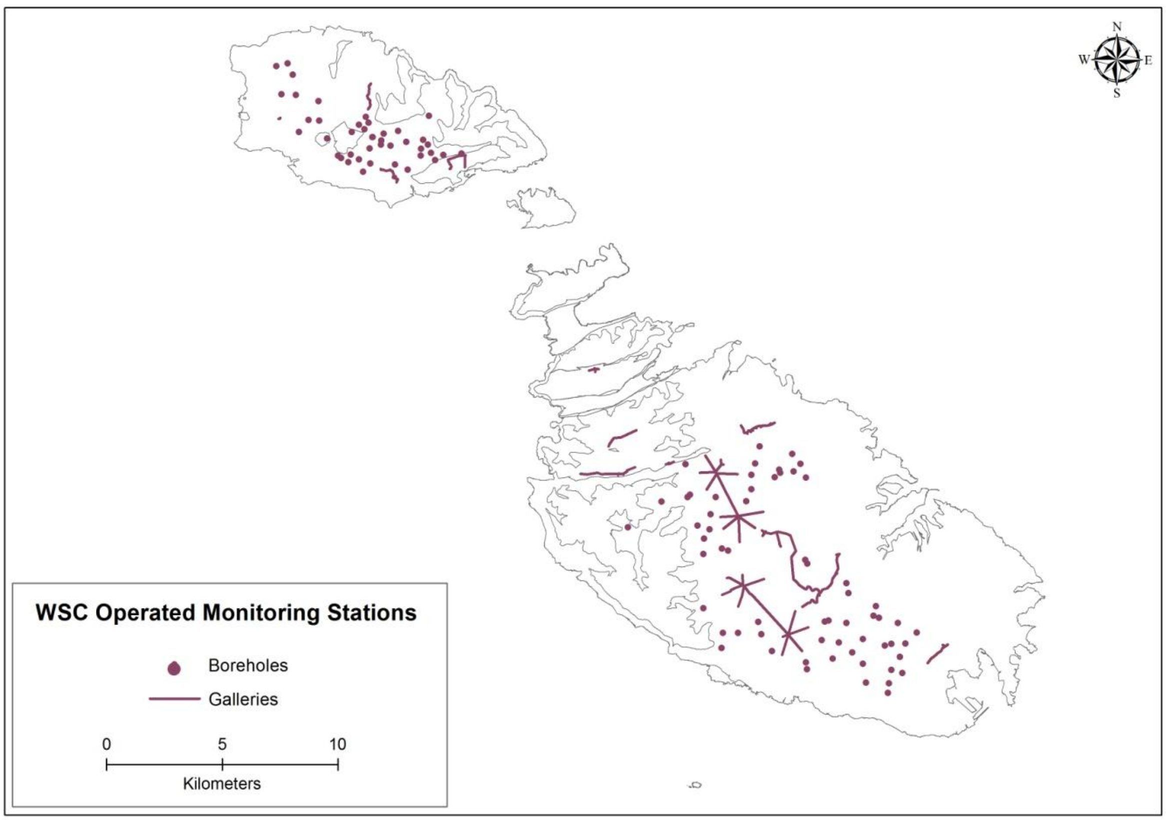


Figure 5.22: Drinking Water (protected area) monitoring stations

5.5.6 Hydrological Monitoring

The review of the 1st Water Catchment Management Plan and in particular the status assessment leading to the 2nd Water Catchment Management Plan has identified the need for the establishment of complimentary monitoring networks to support the quantitative status assessments for bodies of groundwater. These complimentary monitoring networks will enable the re-evaluation of the hydrological characteristics of the Malta Water Catchment District, and permit the reduction of uncertainties in the water balance calculations undertaken for these water bodies.

During the course of the 2nd WCMP, a number of representative water catchments will be selected and hydrological monitoring equipment will be installed in representative sites within these catchments. The establishment of these monitoring frameworks will enable both the direct measurement of hydrological parameters such as runoff and recharge rates, and their correlation with the annual rainfall and its distribution. The identified monitoring equipment and the determinands to be measures through the hydrological monitoring networks are outlined in table 5.74 below.

Monitoring Equipment	**Measured Determinands**
Raingauge	Rainfall Depth
Open Pan Evaporimeter	Annual Evaporation
Runoff Recorded	Runoff characteristics of the catchment
Lysimeter	Annual Recharge to Groundwater

Table 5.74: Catchment Hydrological Monitoring – Monitoring Determinands

This initiative will form part of a more comprehensive project focussing on the optimisation of the national hydrological monitoring capability which will be proposed for financing under Priority Axis 10 of the Cohesion Funds for Malta 2014-2020. It is planned thus planned that this project will be implemented during the course of the 2nd WCMP in order to be able to inform the development of the 3rd WCMP.

6 Assessment of Water Status

6.1 Assessment of Good Surface Water Status

To determine **ecological status** biological parameters or 'quality elements' (such as seagrass meadows (*Posidonia oceanica*); algae, benthic invertebrates, and the abundance of phytoplankton, etc.) have to be monitored together with the suite of physico-chemicals and hydromorphological elements.

For a water body to achieve good ecological status, the biological quality elements must show only slight signs of disturbance caused by human activity. Among other things, this requires the general chemical, physicochemical and hydromorphological quality of the water body to achieve the standards and conditions necessary to support the biological quality elements at good status. Figure 6.1 indicates how ecological status is assessed per surface water body under the Water Framework Directive.

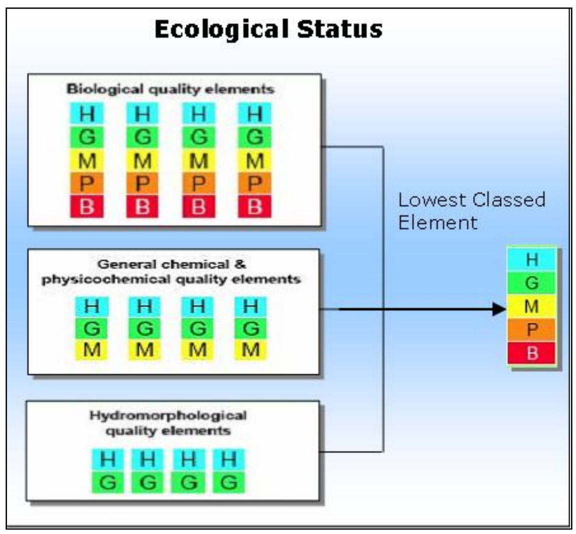


Figure 6.1: The determination of Ecological Status according to the Water Framework Directive 2000/60/EC

In the case of **chemical status** Malta has to be in compliance with all the quality standards established for chemical substances at European level. The Directive also provides a mechanism for renewing these standards and establishing new ones by means of a prioritisation mechanism for hazardous chemicals. This will ensure at least a minimum chemical quality, particularly in relation to very toxic substances, in the waters of the European Union. All the chemical substances required to be monitored in order to check chemical status of waters are listed in Annex X of the Water Framework Directive. Good Chemical Status can be said to be met when all chemical substances in a water body complies with the Environmental Quality Standards for all the priority substances and other pollutants listed in Annex I of the Environmental Quality Standards Directive (2008/105/EC amended by 2013/39/EU).

6.2 Determining the Conservation status and water related requirements of inland surface and transitional waters

The inland surface and transitional waters of the Maltese Islands are all protected areas of ecological significance and therefore the WFD requires that any water-related requirements of the legislation under which they are designated are met. This requires that the status of the water dependent habitats and species found in protected inland surface waters is defined. Table 6.1 below lists the water dependent habitats and protected species found within these areas and provides their current overall status as has been defined in their respective Natura 2000 management plans.

Protected Area	Water dependent habitats and protected species	Habitat/ species Code (where applicable)	Current Overall Status* *Current status includes the current condition of the area, structure and function of the habitat*	Future prospects
Wied il-Luq	***Salix alba* and *Populus alba* galleries**	92A0	**Unfavourable – Bad** The habitat is rare and very vulnerable. Its existence depends on the supply of a permanent spring of water. The main threats are agricultural practices, such as water extraction and the planting of Eucalyptus trees by farmers. The habitat also has to compete with *Arundo donax* (Giant reed) along the valley bed.	The targeted condition is to improve this habitat by means of implementation of the Natura 2000 management plan over the next few years. Reversal of the bad and deteriorating trend calls for the conservation of the existing habitat, restoration efforts to establish this habitat along the valley bed, and long term control on water extraction. There is also the need to control nutrient loading in sensitive sites.
	Breeding and Wintering Passerines		Unfavourable – **Inadequate** The extensive undergrowth at Buskett provides feeding sites for wintering passerines as well as many trans-Saharan autumn migrants. All birds also have a platitude of open heterogeneous plots at this site, including orchards, annual cultivations, fruit bearing scrubs and even **freshwater** for the summer months.	Improved management at the site and improvement of the habitats are likely to ensure that the future prospects for breeding and wintering passerines at this SAC are favourable. Once the Management Plan is in place measures implemented shall ensure the long term maintenance of the range, population and habitat of breeding.
	Discoglossus pictus pictus		**Common (as per Standard Data Form).** *Discoglossus pictus pictus* is considered to be of vulnerable status with a restricted distribution in the Mediterranean region and the Maltese Islands. *D. pictus pictus* is the only naturally occuring amphibian in the Maltese Islands. The water course at Wied il-Luq is important for this species. Its main threats are habitat destructon, pollution and direct targetting of the species. Article 17 reports that freshwater habitats and resources are overall rare in the Maltese Islands, and subject to considerable exploitation for various resources. This factor, coupled with an increased drought period in the dry season has led to a further reduction of freshwater in local ecosystems; this has affected most	The targeted condition is to maintain healthy populations of this Red Data Book listed species present in the site. In this regard an Action Plan needs to be elaborated and actions therein implemented as set in the Management Plan for the Buskett and Girgenti SAC.

Protected Area	Water dependent habitats and protected species	Habitat/ species Code (where applicable)	Current Overall Status* *Current status includes the current condition of the area, structure and function of the habitat*	Future prospects
			of the species depending on freshwater supply.	
Wied tal-Baħrija	*Salix alba* and *Populus alba* galleries	92A0	**Unfavourable – Bad** The habitat is rare and very vulnerable. Its existence depends on the supply of a permanent spring of water. The main threats are agricultural practices, such as water extraction and the planting of eucalyptus trees by farmers. The habitat also has to compete with *Arundo donax* (Giant reed) along the valley bed.	The targeted condition is to improve this habitat by means of implementation of the Natura 2000 management plan over the next few years. Reversal of the deteriorating trend calls for the conservation of the existing habitat, restoration efforts to establish this habitat along the valley bed, and long term control on water extraction. There is also the need to control nutrient loading in sensitive sites.
Wied Tal-Lunzjata	Waders and Aquatic birds (annex I and non Annex I birds)	A229 A022 A023 A123	**Unfavourable – Bad** The water course at Wied il-Lunzjata provides potential favourable staging habitat for many of these species. However, the N2K management plan indicates that the main threat is the overgrowth of *Arundo donax.* This invasive reed needs to be managed in order to maintain areas with open bodies of water. In addition the N2K plan highlights the following issues: *Human induced changes in hydrologic conditions:* The freshwater course of Wied ix-Xlendi is threatened by a number of human related activities mostly associated with agriculture. One threat is the alteration of the hydrodynamic functions of the watercourse due to irrigation and the direct pumping of freshwater from the stream (resulting in a general reduction in water flow throughout the valley system). In addition to this, extraction of water from springs from areas in the vicinity (resulting in an overall reduced volume of water supplied by the tributary system of Wied ix-Xlendi) is also practiced. In addition modification of structures of inland water courses, eutrophication and removal of sediments is also of importance.	Future prospects of this condition are still unfavourable unless action is taken to manage the giant reed overgrowth. The extent and significance of human induced pressures as highlighted by the N2K plans, however is unknown. Therefore there is a need to establish the significance first by means of further studies and monitoring (refer to Chapter 9).

Protected Area	Water dependent habitats and protected species	Habitat/ species Code (where applicable)	Current Overall Status* *Current status includes the current condition of the area, structure and function of the habitat*	Future prospects
Il-Qattara	Hard oligo-mesotrophic waters with benthic vegetation of Chara spp.	3140	Unfavourable – **Inadequate** Despite the fact that the area of the habitat is favourable, the introduction of alien species to the Qattara pool has been identified to be a main threat. The impacts of these alien species on the ecosystems present have not yet been studied but it is expected that they would contribute to an unstable habitat.	Introduction of alien species has brought instability to the ecosystems present. This therefore provides inadequate future prospects for the habitat. However once the Natura 2000 management plans are in place, measures to remove alien species are expected to improve the status considerably.
	Southern riparian galleries and thickets (Nerio-Tamaricetea and Securinegion tinctoriae)	92DO	Unfavourable – **Inadequate** The Habitat is unfavourable but stable. This is mainly due to the fact that the area is restricted to small detached pockets in the Qawra area.	Future prospects for this habitat are favourable since the targeted condition is to improve this habitat by means of implementation of the Natura 2000 management plan over the next few years. The management plan identifies the need to extend the habitat along the valley bed to unite populations located below Wied Għorof with those of Qattara.
Is-Salini	*Coastal lagoons	1150	**Unfavourable – Inadequate** The salt pans are considered to be the coastal lagoons on this area. In the past two years (2013-2014) the salt pans have been extensively modified and will be managed after years of abandonment. The NW extent of the site supports an important reed bed habitat to support the breeding of the *Acrocephalous scirpaceus.*	The prospects for this particular habitat seem good since efforts to manage the site are underway and favour the provision of optimal habitats for migratory birds and biodiversity to flourish.
	Salicornia and other annuals colonising mud and sand	1310	**Indeterminate** Recent field surveys carried out for purposes of the Natura 2000 Management plans indicate that this habitat is most likely occurring as a mosaic with habitat remnant remains of Mediterranean salt meadows and Mediterranean and thermo Atlantic halophilous scrubs. The wide anthropogenic access to the sites indicates that the canal is disturbed.	Future prospects for this habitat are slight in view of the poor structure and function of the habitat and the presence of ruderals which indicate high levels of disturbance. The Natura 2000 Management plan aims to improve the habitat by reducing the extent of disturbance.
	Mediterranean salt meadows	1410	**Unfavourable – Bad** This habitat is currently in a transitional phase due to ongoing salt pan restoration works. The	Continued disturbance at the site result in deterioration of the habitat. The Natura 2000 Management plan aims to

Protected Area	Water dependent habitats and protected species	Habitat/ species Code (where applicable)	Current Overall Status* *Current status includes the current condition of the area, structure and function of the habitat*	Future prospects
			area is limited and ruderal species have taken over the banks of the canal.	improve the habitat by reducing the extent of disturbance and restoring it.
	Mediterranean and thermo-Atlantic halophilous scrubs	1420	**Unfavourable – Bad** The habitat has been limited due to ruderal species that now dominate the banks of the canal. Opportunistic species have been observed also to intersperse with this habitat type.	Long term sustainability of this habitat also calls for habitat restoration and the minimising of disturbances.
	Southern riparian galleries and thickets	92D0	**Unfavourable – Bad** Invasive and competing Acacia trees have taken over this habitat meaning that the *Tamarix africana* is not taking up its full potential. The *Vitex agnus castus* is completely absent from this site.	Invasive species need to be controlled and habitat restored.
	Aphanius fasciatus	1152	**Unfavourable – Bad** The canal in which this species can be found is highly subjected to anthropogenic impacts. There is an indication from literature that the population has dwindled in recent years. Recent WFD monitoring indicated that no species were caught in the sampling minnow traps, though some fish were sighted during field visits.	The habitat is presently very vulnerable to water pollution. The site's location is at the mouth of a large water catchment which hosts intensive agriculture practices. The site itself lies adjacent to a major road. The management plan intends to monitor the species and water quality as well as mitigate sources of pollution.
	Acrocephalus scirpaceus	A297	**Unfavourable – Bad** This species is dependent on waterside vegetation and favours reeds. The greatest threat to this bird is the decline in reed bed habitat present at Salini. The reed habitat is also subject to disturbance including trampling and fire.	The management plan intends to limit access to the reed bed area and regular surveillance. This should encourage the reed warbler to nest at Salini.
Il-Magħluq ta' Marsaskala	*Coastal lagoons	1150	**Unfavourable – Bad** Despite the fact that the size of the water body is considered to be sufficient to support a long-term population of the Killifish, the site is highly vulnerable to engineering works; lack of circulation; surface runoff characterised by fertiliser and pesticide input; dumping and litter often resulting in poor water quality. Water fowl also contaminate the area.	The Natura 2000 management plan aims to monitor the habitat, plan a project for the expansion of the habitat and manage the area by removing waterfowl and controlling the rat population, improve circulation by removing access silt circulation and mitigate agricultural sources of pollution. Regular clean ups, which already take place in the area, also feature in the plan.

Protected Area	Water dependent habitats and protected species	Habitat/ species Code (where applicable)	Current Overall Status* *Current status includes the current condition of the area, structure and function of the habitat*	Future prospects
	Mediterranean salt meadows	1410	**Unfavourable – Bad** This habitat is limited to the boundaries of the water body. Domesticated waterfowl is negatively affecting this habitat. Invasive species also compete for the same fringes occupied by this habitat.	Apart from the measures above the management plan identifies the need to remove alien species from the wetland.
	Aphanius fasciatus	1152	**Unfavourable – Bad** The killifish population at il-Magħluq is threatened by various anthropogenic pressures – the lack of circulation results in fluctuating dissolved oxygen levels, sometime exacerbated by poor nutrient quality. There is also the impact of domesticated waterfowl and introduced predators from the sea, the *Mugil cephalus* (Flathead grey mullet).	The control of the water fowl and Mullet, as well as improved water quality by means of the Natura 2000 Management plan, indicates that future prospects are favourable for this species.
Il-Ballut ta' Marsaxlokk	Salicornia and other annuals colonising mud and sand	1310	**Unfavourable – Bad** The habitat, characterised by the *Salicornia ramosissima*, is located within along the fringes of the lagoon. Space for this habitat is being competed for by other habitat types (such as by habitats 1410 and 1420).	The Natura 2000 Management plan identified that in order for there to be a long term sustainability of this habitat there is a need to extend the marshland into the neighbouring parcels of land.
	Mediterranean salt meadows	1410	**Unfavourable – Bad** This habitat, characterised by the *Juncus maritimus* and *carex extensa*, is limited to the banks of the lagoon. The habitat is highly vulnerable to climate change and sea level rise.	If the lagoon extent is increased this habitat will be improved.
	Mediterranean and thermo-Atlantic halophilous scrubs	1420	**Unfavourable – Bad** This habitat is the most dominant at the site and has been increasing in coverage over recent years at the expense of habitat 1310. It is the small size of the marshland that renders this habitat to be in an unfavourable status. Nevertheless the habitat is stable.	Similar to the above two habitats, the status of this habitat could become favourable if the extent of the lagoon is extended.
Is-Simar	*Coastal lagoons	1150	**Unfavourable – Inadequate but stable** This site has enjoyed years of	The limiting factor is the size of the lagoons. The Natura 2000 management plan recognises the need to extend the wetland, in

Protected Area	Water dependent habitats and protected species	Habitat/ species Code (where applicable)	Current Overall Status* *Current status includes the current condition of the area, structure and function of the habitat*	Future prospects
			protection by the NGO Birdlife. As a result the structure of the habitat is considered to be favourable. Habitat area however is small and restrictive, limiting the number of successful breeding pairs in the reserve. The function of the habitat can also be improved should the wetland be extended.	order to ensure better opportunity for breeding and more bird diversity. Water quality monitoring is expected to continue in this lagoon.
	Aphanius fasciatus	1152	**Favourable** The size of the lagoon is adequate to support a stable and viable population of the killifish. Recent studies carried out under the WFD (2012 baseline studies on inland surface and transitional waters) confirm the favourable numbers reported in previous population estimates, carried out by Zammit Mangion, 2009.	The lagoon will continue to be managed and protected. Future prospects for this species therefore are favourable.
	Ixobrychus minutus		**Unfavourable – Bad** The little bittern (*Ixobrychus minutus*) species feeds on the killifish and builds its nests in the reedbeds. However this species only reproduced twice at Simar and the reasons for this is unknown but expert judgement points to the possibility that the site is too small. The extent of the reeds as an ideal nesting habitat is also too small.	The Natura 2000 management plan of the area indicates that it is not considered likely that the breeding of this species will be re-established at the site in its present state.
	Breeding wetland species		**Unfavourable – Bad** Reedbed at is-SImar is important for *Acrocephalus scirpaceus*, *Gallinula chloropus*, and *Fulica atra*. Also *Himantopus himantopus* is a prospective breeder at the lagoon. The reedbed and tamarisk groves at Is-Simar provide ideal habitat for species such as *Tachybaptus ruficollis, Anas crecca, Aythya ferina, Gallinago gallinago Rallus aquaticus Jynx torquilla, Emberiza schoeniclus* and *Scolopax rusticola*.	These species are dependent on the reedbeds and lagoons. The small size of the reserve limits the number of birds that can be supported during the winter and these habitats are thus considered to be inadequate at Simar. The limiting factor is the size of the lagoons. The Natura 2000 management plan recognises the need to extend the wetland, in order to ensure better opportunity for breeding and more bird diversity.
	Migratory Waterfowl and waders including Annex I migratory herons		**Unfavourable – Bad** Waterfowl such as *Anas acuta, Anas clypeata, Anas crecca, Anas platyrhynchos, Anas querquedula* and *Aythya ferina, Fulica atra, Gallinula chloropus* and waders	Enforcement efforts shall be sustained to ensure that no hunting activities are carried out within the boundary of the bird sanctuary.

Protected Area	Water dependent habitats and protected species	Habitat/ species Code (where applicable)	Current Overall Status* *Current status includes the current condition of the area, structure and function of the habitat*	Future prospects
			such as *Charadrius dubius, Calidris alpina, Calidris minuta, Tringa totanus, Tringa nebularia, Tringa ochropus, Gallinago gallinago, Calidris temminckii, Lymnocryptes minimus* and *Actitis hypoleucos,* make use of the open water areas, the islets and embankments.	
	Migratory wetland passerines		**Unfavourable – Bad** The reed bed is a national important roosting site for *Riparia riparia, Hirundo rustica* and *Motacilla flava.* Other passerines, particularly associated with the reedbeds during migration include: *Acrocephalus scirpaceus, Acrocephalus arundinaceus, Acrocephalus schoenobaenus, Hippolais icterina* and *Locustella lusciniodes.* It is considered that the extent of the reed bed is relatively small in the context of the entire site.	Natura 2000 management plan recognises the need to extend the wetland, in order to ensure better opportunity for breeding and more bird diversity.
	Discogossus pictus pictus		**N/A** *Discoglossus pictus pictus* is noted to be common in the reserve. This is the only amphibian present in the Maltese Islands, associated with freshwater rockpools, ponds, valley watercourses, springs and reservoirs. Vulnerable, it has a restricted distribution in the Mediterranean region and the Maltese Islands, becoming more restricted due to habitat destruction, pollution and persecution. The population size is not known.	The Management Plan sets out the need to elaborate an Action Plan for the RDB listed species, specifically for *Discoglossus pictus pictus*.
L-Għadira	*Coastal lagoons	1150	**Unfavourable – Inadequate but stable** The lagoon is considered to be inadequate due to its size limitations, affecting attractiveness to wetland birds. The lagoon supports a thriving population of *Aphianus fasciatus* endemic species (Annex II). The lagoon provides food and shelter to a large number of Annex II bird species, some of which overwinter and even breed at the reserve.	The Management Plan shall assess the possibility of wetland enlargement and dune restoration at the coastal front. Moreover maintenance and monitoring of water quality parameters will be carried out.

Protected Area	Water dependent habitats and protected species	Habitat/ species Code (where applicable)	Current Overall Status* *Current status includes the current condition of the area, structure and function of the habitat*	Future prospects
	Salicornia and other annuals colonising mud and sand	1310	**Inadequate** This habitat is intermittently submerged by water. The Natura 2000 Management Plan notes that anecdotal evidence suggests that this habitat gradually matures into other habitats (1410 and 1420 described below). The area occupied by this habitat has in fact decreased and is limited to the artificial islands that are submerged during the rainy period.	The Natura 2000 management plans indicates that since the processes affecting this habitat are natural rather than anthropogenic, there is little intervention that can be carried out to protect this habitat from disappearing.
	Mediterranean salt meadows	1410	**Inadequate** This habitat, characterised by *Juncus acutus*, *Inula crithmoides* and *Juncus subulatus* is found restricted to the waterline around and within the coastal lagoon. The structure and function of this habitat is considered to be favourable indicated by the presence of a number of rare species.	In spite of the fact that the prospects for the structure and function of this habitat are favourable, the lack of available area to extend the distribution limits the future prospects of this habitat to inadequate but stable.
	Mediterranean and thermo-Atlantic halophilous scrubs	1420	**Inadequate** Similar to habitat 1410 above, this habitat also borders the waterline around and within the coastal lagoon and competes with habitat 1310, generally occupying areas previously occupied by such a habitat. The structure of the habitat however is described as inadequate due to the fact that non-related species (particularly trees) were planted during the establishment of the bird sanctuary.	The future prospects for this habitat remain inadequate but stable due to the fact that the presence of tree cover dominated by non related species cannot be removed in their entirety due to the fact that the benefits of such a restoration measure would be outweighed by the potential loss of fodder and cover that is favoured by some rare avian specie which visit the reserve.
	Aphanius fasciatus	1152	**Favourable** The species at Ghadira is known to be present in large numbers. The size of the lagoon is deemed to be of sufficient size to maintain a healthy population of this fish species. Despite the high mortality rate due to extreme edaphic conditions (especially large fluctuations in temperature and Dissolved Oxygen during the summer months), the species is known to have a high recruitment rate.	Future prospects are favourable since water quality monitoring will be maintained and the habitats supporting this habitat will be protected.

Protected Area	Water dependent habitats and protected species	Habitat/ species Code (where applicable)	Current Overall Status* *Current status includes the current condition of the area, structure and function of the habitat*	Future prospects
	Discoglossus pictus pictus		**N/A** The SDF indicates that the Painted Frog is common at Ghadira, The Management plan identifies that the Painted frog is known from Ghadira.	The Management Plan sets out the need to elaborate an Action Plan for the RDB listed species, specifically for *Discoglossus pictus pictus*.
	Himantopus himantopus		**Indeterminate** The Black-winged stilt makes use of the lagoon. Three breeding pairs have successfully bred at Ghadira on occasions. This species makes use of the lagoon, favouring open views. However the size of the lagoon is a concern and it is considered unlikely to be able to support more than the three breeding pairs, in view of strong territorial behavior and the need for wide open views to protect its nest.	The Natura 2000 management plans to assess and monitor the range and population size of this species through the implementation of monitoring plans. The Natura 2000 Management Plan shall also assess the possibility of wetland enlargement.
	Wintering wetland species		The reedbed and tamarisk groves provide ideal habitat for species such as, *Tachybaptus ruficollis Anas crecca, Aythya ferina, Gallinago gallinago, Rallus aquaticus, Jynx torquilla, Emberiza schoeniclus* and *Scolopax rusticola*. However, the small size limits the availability of suitable resources, thus limiting number of species that can winter at the wetland.	The Natura 2000 management plans to ensure that the range and population size of breeding, wintering wetland birds are increased. The Management Plan indicates that monitoring of the the range and population size of wintering wetland woodland birds will be carried out.

Table 6.1: Current overall status of water dependent habitats and protected species in inland surface and transitional waters

6.2.1 Determining the water quality status of inland surface and transitional waters based on ecological indicators as defined by the WFD

The WFD enables the utilisation of particular species (the biological quality elements as identified in the WFD) as indicators of the ecological status of the aquatic ecosystem[212]. During the years 2012-2013 three separate monitoring programmes were carried out in these waters to establish a baseline[213] for the various quality parameters stipulated by Annex V of the WFD. The studies undertaken during the years 2012 to 2013 provide a very short-term representation of the environmental condition of the ten waters

212 European Commission, FAQ –Links between the Water Framework Directive (2000/60/EC) and the Nature Directives (Birds Directive 2009/147/EC and Habitats Directive 92/43/EEC), December 2011 http://ec.europa.eu/environment/nature/natura2000/management/docs/FAQ-WFD%20final.pdf.

213 The word 'Baseline' here must be interpreted with caution since the monitoring programmes for most of the parameters only covered one year, and is therefore insufficient to provide a sufficient baseline with confidence.

and the need for further monitoring within all of the inland surface and transitional waters is clearly evident.

The information collated during the first baseline monitoring is considered to be insufficient to clearly make out the ecological status of these waters. This is because hydrological intermittency and complexity, a characteristic of Maltese waters, influences the structure and function of aquatic ecosystems, making the biological, hydromorphological and physico-chemical evaluations of ecological status extremely difficult. Without long-term data and knowledge of the interactions of these quality elements, Malta will not be able to determine the ecological status of these waters with certainty.

Difficulties in interpreting the results of this first baseline monitoring also pertain to the fact that very little is known about the diurnal, seasonal and annual variations in hydromorphological and physico-chemical properties and their effects on the aquatic assemblages present. Moreover natural events such as floods and droughts create disturbance events that influence aquatic assemblages and further complicate our understanding of these waters. With this in mind, a summary of our interpretation of the status of these waters based on the first monitoring results, together with the main issues are divulged below.

6.2.1.1 Transitional Waters

The attempt to understand indications of the potential ecological quality in this water category was based on one critical biological quality element (invertebrates) together with supporting physico-chemical and hydromorphological parameters. No classification methods were identified for the other relevant biological quality elements (i.e. macrophytes, phytobenthos, fish and phytoplankton). It was however acknowledged that future monitoring programmes should consider indices that have been developed by Mediterranean Member States for macrophytes so that the classification of ecological status in these waters is improved (refer to Chapter 5).

In the case of invertebrate status, the application of the Shannon-Weiner index resulted in the transitional waters being classified under a range of statuses. The range in status (good to bad) in the different water bodies was due to several reasons, pertaining to fluctuations in water availability, species abundance and species richness throughout the year. This very fact indicates that the use of the simple diversity index may not be adequate given that the complex natural regime of these transitional waters is not yet understood.

Table 6.2 below indicates that the Shannon-Weiner index gave different results depending on the time of year. Since the Shannon index increases as both the richness and the evenness of the community increase it may not be suitable for waters which are constantly changing. Our transitional waters undergo severe fluctuations in their physico-chemical and hydrological make-up, thus influencing the ecological communities that thrive under their continuously changing conditions. Table 6.2 reveals that in most cases, where the Shannon-Weiner index was used, 'good' status was attributed to the water bodies during the wet season, when water levels peaked, and became poorer as the summer season approached.

Water body	Method applied	Invertebrate ecological status classification (very low certainty)	Description of status	Main pressures effecting BQEs
Salini	Shannon-Weiner index	**Poor/Bad** throughout the year	• Compromised ecological status • Status ranged from altered to very altered regardless of sampling season/sampling point • Species present were of low ecological value (composed mainly of microaerophilic /anoxic tolerant groups) • Anoxic conditions brought about by natural decay of *Posidonia oceanica* foliage however presence of faecal coliforms indicates that contamination by sewage contributes to high organic loads found at bottom of water body.	• Sewage • Contaminated runoff
Maghluq ta' Marsascala	Shannon-Weiner index	*Inner basin* ranges from **Good** to **moderate** depending on season (good – winter and moderate summer) *Outer basin* – **Poor** throughout	• Status mainly influenced by fluctuation of physico-chemical parameters, principally salinity throughout the year. • Points to possibility that method applied is not adequate for transitional waters where salinity pays an important role • Anoxic conditions found to be present. • Lower species than expected for typical Mediterranean transitional water systems possibly due to artificial nature of basin's edges.	• Hydromorphological influence • Seasonal nutrient enrichment related to seasonal inflow of freshwater • litter
Ballut ta' Marsaxlokk	Shannon-Weiner index	**Good** / **Moderate** / **Bad** - Good status was reported during the wet season, whilst bad status was reported during the dry season.	• Complex ecological assemblage influenced by periodical evaporation of the water body and levels of salinity. • Recolonisation process of assemblages begins at the end of the dry season. The first assemblages as highly unbalanced towards opportunistic species whilst a more structured assemblage follow this initial period – leading to an improvement in status.	• No perceived link with anthropogenic pressures since fluctuations in assemblage fits with physico-chemical and hydromorphological parameters. • Coastal erosion of water body is affecting size of water body
Għadira*	Chandler biotic score was applied since these waters were originally designated as 'pools'	Class – **Moderate /Poor/Bad** Since method is not suited to brackish water environments this classification is deemed to be inappropriate and requires revision	• Relative stability in assemblages indicated by presence of crustaceans • Fluctuation in level of salinity accounts for the absence of strict freshwater arthropods – therefore method applied is not applicable.	• Seasonal Nutrient enrichment from late spring through summer
Simar*	Chandler biotic score since these waters were originally designated as 'pools'	Class – **Moderate - Poor** Since method is not suited to brackish water environments this classification is deemed to be inappropriate and requires revision	• Relative stability in assemblages indicated by presence of crustaceans • Fluctuation in level of salinity accounts for the absence of strict freshwater arthropods – therefore method applied is not applicable	Nutrient enrichment during the end of summer

Table 6.2: Summary of findings of transitional water body status based on one year invertebrate monitoring and supporting parameters classification

* The two water bodies of Għadira and is-Simar were confirmed to be transitional waters since their physico-chemical makeup is akin to that of the other transitional waters.

In the case of the Ghadira and Simar water bodies, which were originally classified under the 'standing water' category, the Chandler Biotic Score (developed by a British scientist Chandler in 1970) was applied. This biotic index determines the water quality by assessing the presence and absence of key groups of organisms in a sampled assemblage. The difficulty with this score was that the species used to determine the index value are also limited to freshwater bodies. Species that are more tolerant to salinity or to marine influence score much lower. Both Ghadira and Simar have salinity ranges that are more akin to that of transitional waters, due to their proximity to the sea. **Therefore the classification obtained cannot be considered for purposes of setting status class and an alternative method would need to be sought for these particular water bodies.**

6.2.1.1.1 Status assessment of other BQEs

A status assessment of the remaining BQEs was not carried out because no potential classification methods were identified due to the paucity of data and limited knowledge about these waters. During the execution of the monitoring and development of this Water Catchment Management Plan, new potential methods have been identified and shall be tested in the upcoming cycle (refer to Chapter 5 for more details concerning the approach to be adopted).

6.2.1.1.2 Status assessment of supporting elements

(a) Physico-Chemical quality elements

The one year monitoring results for general physico-chemical parameters and nutrients in transitional waters reveals that there are large fluctuations in the physico-chemical make-up. This is to be expected given that transitional waters are by nature constantly changing due to their position between marine and freshwater ecosystems (refer to Chapter 2 for physico-chemical results). At this stage Malta cannot determine the level of the individual standards of these quality elements required to support the biological quality elements given that this is Malta's first monitoring attempt and very little is known of these systems.

It is generally noted that transitional waters are naturally eutrophic since they are at the receiving end of nutrient loadings from large catchment areas as well as from internal cycling processes between their sediment and water column because of their shallowness (Lucena-Moya et al., 2012)[214].

Mediterranean literature indicates that nutrient concentrations do not necessarily increase with decreasing ecological status, as transitional waters with poor ecological status do not always have higher nutrient concentrations than those waters with better ecological status. In the case of Malta there is too little data to come up with a status assessment of the biological quality elements let alone assess these in relation to nutrient status. Additional monitoring is therefore a requirement.

(b) Hydromorphological quality elements

These waters are significantly modified and as a result there is very limited water circulation. Former freshwater springs that fed some of the waters, such as in the case of il-Ballut ta' Marsaxlokk, have since dried up and any connections with the sea have either been blocked or can't be kept open due to present day infrastructural interventions that lead to increased rates of siltation. These systems are all considered to be **heavily modified systems** as they have been continuously engineered throughout history as indicated in table 6.3 below.

[214] Lucena-Moya, P., Gomez-Rodriguez, C., and Pardo I. 2012. Spatio-temporal variability in water chemistry of Mediterranean Coastal Lagoons and its management implications, in Wetlands **32**:1033:1045, April 2012.

Transitional water	Historical modification (Ecoserv, 2008)[215]
Is-Salini	Is- Salini refers to a U shaped canal, also referred to as Is-Sokkorsu, which encircles salt pans and whose channels direct runoff into Salina Bay.
Il-Magħluq ta' Marsascala	Originally the site was a saline marshland that developed at the mouth of the Wied ta' Sant Antnin. It is possible that during the 17th Century the marsh was excavated to create fishponds so that fish could be stored by fishermen bringing in their catch
Il-Ballut ta' Marsaxlokk	Similar to il-Magħluq ta' Marsaxlokk this site was also a former salt marsh that was then developed into fish ponds. These ponds were disused in the late 19th Century and were dredged to make way for a quay.
Is-Simar	Was formerly a natural coastal wetland that formed at the mouth of il-Wied tal-Pwales. It was often dredged for agricultural use and was also used as a dump. In 1992 it was engineered into an artificial permanent lagoon with differing water depths and today is a bird reserve.
Għadira	In the mid-16th Century the salt marsh was used to manufacture salt. By the 19th Century it was declared a game reserve by the British Governor and up til the 1960s it was used for bird shooting. In 1978 the area was declared a Bird Sanctuary and the marsh was converted into an engineered bird reserve. Artificial islands were also constructed.

Table 6.3: List of historic uses that have rendered these waters heavily modified.

6.2.1.2 Water Courses

The watercourses at Wied il-Baħrija, Wied il-Lunzjata and Wied il-Luq depend on the presence and abundance of freshwater flow, which is highest during the wet season and lowest or absent in the dry season. Being small streams with complex dynamics, typical of ephemeral or temporary water regimes, Maltese watercourses show seasonal variations in their physico-chemical parameters, particularly temperature and nutrients, which are interlinked with the level of dissolved oxygen and water flow (refer to Chapter 2: Characterisation). Nitrate levels in all watercourses are extremely high and all 3 watercourses have a link to groundwater through springs that are diverted for irrigation.

As mentioned in Chapter 2 their hydrological intermittency strongly influences the structure and functioning of assemblages present. The macroinvertebrate community, in particular, are greatly influenced by hydromorphological parameters of flow stability and minimum flows. This has been confirmed by studies carried out in Spain.[216] Perennial stable streams are often characterised by flow sensitive lotic (flowing) taxa (*Ephemeroptera, Plecoptera, Tricoptera*) whilst intermittent streams are predominantly dominated by lentic taxa (*Odanata, Coleoptera, Heteroptera* and *Diptera*). This of course has a bearing on the suitability of the methods applied to assess ecological status during the Malta's first baseline.

An increase in lentic conditions over time may also be associated with a decrease in the quality metrics that are assessed. It is very important that this fact is taken into account when assessing the status of our watercourses because a 'natural' low value may be confused with anthropogenic disturbances and may result in underestimating the resultant ecological quality. Abundance metrics are may not always be applicable in the Mediterranean region given that the strong fluctuation of the hydrologic regimes in these watercourses may produce a high variability in taxa abundance' (Sanchez-Montoya *et al*., 2011).[217]

[215] Ecoserv, 2008. The applicability of the monitoring and management criteria of the Water Framework Directive (2000/60/EC) to the inland surface water bodies identified for Malta.
[216] Belmar. O. et al. 2013. The influence of natural flow regime on macroinvertebrate assemblages in a semiarid Mediterranean Basin; *in* Ecohydrology, **6**:3, pages 363–379, June 2013
[217] Sanchez-Montoya, M. et al. 2011, Ecological Assessment of Mediterranean streams and the special case of temporary streams, in : River Ecosystems : Dynamics, Management and Conservation , Eds: Hannah S. Elliot, and Lucas E. Martin, 2011 Nova Science Publishers, Inc.

The first Baseline monitoring of the three watercourses resulted in no EPT (Ephemeroptera, Plecoptera, Tricoptera) being recorded. The presence of the following assemblages was recorded in all three water courses when water was present/ flowing. Once there was a cessation of flow, the assemblages in disconnected pools were only assessed if a disconnected pool happened to form in the area that was a priori established to be monitored along the reach of the water course. Therefore information in this regard is incomplete and will be enhanced through the second monitoring attempt (see Chapter 5 on Monitoring Programmes).

- Crustacea – *Proasellus* sp.; *Echinogammarus* sp.
- Insecta – Octhebius sp.; Chironomidae sp.; Agabus Sp (consisting mainly of Coleoptera and Diptera orders)
- Gastropoda – Lymnaea
- Tricladida – Dugesia cf.gonocephala

The results of the application of the extended biotic score to invertebrates within watercourses are provided in Table 6.4 below, revealing very inconsistent results highly influenced by water availability and flow.

Water body	Method applied	ecological status classification based on one method	Description of status	Main pressures effecting BQEs
Baħrija	Extended Biotic Index	**Moderate /Poor/Bad** depending on the water reach and season.	• Appears to be in a good natural state in the Upper reaches. • Status ranged from moderate to bad and this was linked directly to water flow. • Fluctuation in water flow rates resulted in absence of species requiring high oxygen concentrations and fast-moving water – therefore status scored less using this method. • Community present described as resilient. • Presence of well-structured crustacean community. • Variation in flow regime and the organic load of the watercourse may contribute significantly to the observed assemblages.	• Eutrophication – **extremely high nitrates.** • Chemical contaminants. • Contaminated runoff. • Alterations in water flow rate due to the diversion, abstraction and use of water/ uptake of water by the Giant Reed.
Wied il-Luq	Extended Biotic Index	**Moderate /Poor/ Bad** not linked to season	• Results revealed an altered ecological situation, slightly less disturbed in the upper reaches and more impacted in the lower parts. • Species requiring high oxygen concentrations and fast-flowing water were not present. • As a consequence the assemblage is less structured than continental rivers and therefore scores lower values in biotic indices. • Degradation is not linked to a particular season, suggesting that the whole watercourse undergoes	• Hydromorphological alterations is evident especially in upper and middle reaches. • Very high nitrates. • Dense reed beds compete for water.

			temporary loss of its ecological function. • Alteration to the natural state of the watercourse, dense reed beds and human disturbance are related to the degradation apparent in the lower parts.	
Wied il-Lunzjata	Extended Biotic Index	Moderate / Poor throughout	• Moderately altered ecological status. • Retrieved assemblage conditioned by the fluctuation in the flow rate and by the presence of soft substrate; resulting in the absence of species requiring high oxygen concentration and fast flowing water. • Very diversified community however is present – comparable to that of continental environments. • Reedbeds that surround upper and middle reaches believed to offer a stable environmeny for habitat therefore balance between the water take-up and habitat stabilisation properties need to be investigated further. • Direct abstraction from stream has been observed.	• Extremely high nitrates. • Contaminated runoff. • Alterations in water flow rate due to the diversion, abstraction, and use of water and the uptake of water by the Giant Reed. • (?) direct abstraction of water from the surface water body – unknown whether this is significant.

Table 6.4: Summary of findings of water course status based on one year invertebrate monitoring and supporting parameters classification

6.2.1.2.1 Physico-chemical and hydromorphological observations

As seen in Chapter 2, Malta's inland surface water courses are intermittent, in some cases ephemeral, and the freshwater pools are very small (ranging from 0.0001 to 0.001 km^2) and highly dynamic. Therefore the physico-chemical processes within them are highly variable. Water content and thermal conditions are key factors that control ecosystem and biogeochemical processes in sediments in temporary streams. Alternating dry and humid conditions stimulate microbial activity and lead to nutrient pulses following precipitation – or rewetting (Ademollo *et al*., 2011).

Hence in the case of Malta, establishing physico-chemical standards, including that for nutrients is difficult because a considerable amount of monitoring data is required to firstly refine our knowledge about their natural variations according to differences in hydrological regimes and secondly to pressures. In Malta research and monitoring of these waters has been historically neglected and therefore Malta is only just embarking on understanding the complex dynamics of the physico-chemical parameters in these waters. Similarly at a Mediterranean level, research on these types of waters has only initiated in the last few years.

Fluctuating water levels and low flows create ever changing environmental conditions and biological processes that in turn affect the availability and spatial variability in solute concentrations. For instance organic matter decomposition, nitrification and denitrification are affected by changes in stream conditions. Both spatial and seasonal variability in solute concentrations is known to occur with differing hydrological regimes. Malta is therefore yet to understand the changes in nutrient concentrations brought about by these natural alterations in the highly dynamic hydrological regimes of its inland surface waters.

Moreover when looking at the flow and connectivity data collated over the course one year for all 3 water courses (refer to chapter 2), it is evident that the water regimes of all 3 watercourses underwent intense drought periods with the consequence that disconnected pools and individual pool habitats developed. Since the degree of connectivity between the pools influences assemblage richness and diversity, whereby low connectivity results in low richness due to a lack of exchange of matter and energy, as expected low taxa richness was reported in the drier months, in all 3 watercourses.

Since these waters are solely important for biodiversity, Malta needs to also establish the water related requirements of the protected habitats and species that rely on these waters. Such requirements are deemed to be of significance especially when determining future benchmark conditions for nutrients that should be reflected in the definition of good status of these waters.

6.2.1.3 Standing waters

The standing waters of the Maltese Islands can be considered to be temporary ponds due to their significant fluctuations in water levels from the wet to the dry season (see Chapter 2 on characterisation). In addition the physical and chemical characteristics fluctuate considerably, and this may lead to a temporary approach or exceedance of the biological limits that any aquatic organisms can tolerate. This naturally has a bearing on the aquatic communities that are found in these ponds.

The two standing waters of Għadira ta' Sarraflu and Qattara were characterised by an enclosed water body lacking any evident flowing water. Water depth varied throughout the year depending on rainfall and temperature.

The status of the invertebrate quality element was assessed using the Chandler Biotic score. This score was initially designed for rivers but was selected because it works well for slow moving rivers as well as for pools. What the score fails to take into account is natural stress factors which can affect the final score achieved. In addition the score gives the larger weighting to species that are more common in temperate, Northern European waters. One must also keep in mind that the Maltese Archipelago is naturally lacking in many of the key invertebrate groups. This is therefore considered to be a significant flaw in the status classification and the results therefore have to be interpreted with caution and cannot be used to ultimately classify status.

A summary of the findings of standing water body status based on one year invertebrate monitoring and supporting parameters classification is presented in table 6.5 below. The Good status ranking of Qattara was ascribed during the winter months when water levels were relatively stable and the faunal assemblage was well-balanced and diversified. Qattara in fact can be considered to be the closest the Maltese Islands have to a freshwater reference site. Nevertheless the monitoring results were based on a one year study and further surveys would be needed to reaffirm the composition and resilience of the invertebrate communities at Il-Qattara. In the case of the Għadira ta' Sarraflu, the results indicated a highly altered ecological condition with no structured assemblage of benthic invertebrates.

Natural stresses of these temporary ponds are not the only factors influencing the aquatic communities present. The presence of alien species was considered to be the major pressure in both temporary pools (see Chapter 3- Pressures and Impacts). Measures related to the control of alien species have been identified to be a priority in the upcoming cycle.

Water body	Method applied	Preliminary ecological status classification	Description of status	Main pressures effecting BQEs
Qattara	Chandler Biotic Score and the extended biotic index	Good/ Moderate (Moderate during summer when water levels decreased).	• Ecological situation reported to be close to the maximal ecological level achievable in a Maltese freshwater context. • Observed ecological values were assigned to a moderate class rather than to a good class due to the absence of highly sensitive species and to the average level of biodiversity. • Lack of high scoring invertebrate groups (generally present in similar continental environments) negatively affects the outcome of the index. • Lower results scored during the summer months is expected to be attributed to the significant fluctuation of the water level.	• Increased nitrate levels linked with winter rains (but low for the rest of the year). • Alien species.
Għadira ta' Sarraflu	Chandler Biotic Score and the extended biotic index	Bad throughout the year.	• Highly altered ecological condition due to significant human impacts and modifications. • No structured assemblage of benthic invertebrates. • Anoxic conditions of the lower water layer stable throughout the year.. • Vertical edges and depth of basin limit the number of available ecological niches to support a more diversified assemblage. • High presence of alien species predate on aquatic invertebrates. • Nitrate concentrations peak during winter months.	• Alien species.

Table 6.5: Summary of findings of standing water status based on one year invertebrate monitoring and supporting parameters classification

6.2.1.3.1 Physico-chemical observations

As stated previously, the physical and chemical characteristics fluctuate considerably in temporary waters (refer to Chapter 2). Establishing physico-chemical criteria in these waters is difficult because a considerable amount of monitoring data are required to refine indications about them and therefore, once again, the results have been interpreted in light of this premise.

6.2.2 Chemical Status of inland surface and transitional waters

Two monitoring exercises were carried out to assess the chemical status of all 10 inland surface waters. The first monitoring exercise was intended to establish the baseline surveys of a range of contaminants in the water column. This monitoring took place between December 2011 and February 2012. This study involved the monitoring of 47 contaminants and water quality parameters. The second monitoring survey was carried out on bottom sediments for one week (End May /start of June 2013). This study covered 72 parameters.

A summary of the resultant chemical status for each water body is provided in table 6.6 below. The analysis that was carried out related to the pressures and impacts and associated exceedances in particular contaminants is provided in Chapter 3.

Water category/name	Chemical quality of the Water matrix		Chemical quality of the Sediment matrix	
Transitional water				
Is-Salini	Good	High confidence All parameters were below their respective EQS **Lead** (3.367 µg/l) was relatively high.	Good	High confidence All parameters were at levels below the guideline values of ecotoxicological significance in surface waters
Il-Maghluq ta' Marsascala	Good	High confidence All parameters were below their respective EQS	Bad	High confidence **Fluoranthene, Benzo(a)pyrene, Benzo(b)fluoranthene, and Benzo(g,h,i)-perylene**, were at levels above or close to the guideline values of ecotoxicological significance
Il-Ballut ta' Marsaxlokk	Good	High confidence All parameters were below their respective EQS.	Bad	High confidence **Fluoranthene, Benzo(a)pyrene, Benzo(b)fluoranthene, Benzo(g,h,i)-perylene**, and **Nickel** were at levels above or close to the guideline values of ecotoxicological significance.
Is-Simar	Good	High confidence All parameters were well below their respective EQS.	Good	High confidence All parameters were at levels below the guideline values of ecotoxicological significance in surface waters.
L-Ghadira	Good	High confidence All parameters were well below their respective EQS	Good	High confidence All parameters were at levels below the guideline values of ecotoxicological significance in surface waters
Water courses				
Bahrija	Good	Medium Confidence All parameters were below their EQS.	Good	High confidence All parameters were at levels below the guideline values of ecotoxicological significance in surface waters.
Wied il-Luq	Good	High confidence All parameters were well below their respective EQS.	Good	High confidence All parameters were at levels below the guideline values of ecotoxicological significance in surface waters.
Wied tal-Lunzjata	Good	High confidence **Mercury** (0.071 µg/l) exceeded the EQS (0.07 µg/l) in one sample. Other samples were very low and below detection.	Bad	High confidence **Lead** and **dioxin like compounds** were found to be above or close to the guideline values of ecotoxicological significance.
Pools				
Il-Qattara	Good	High confidence All parameters were well below their respective EQS.	Bad	High confidence **Cadmium, Lead** and **Zinc** were found to be above or close to the guideline values of ecotoxicological significance.
L-Ghadira ta' Sarraflu	Good	High confidence All parameters were below their respective EQS.	Good	High confidence All parameters were at levels below the guideline values of ecotoxicological significance in surface waters.

Table 6.6: Chemical quality of inland surface waters based on monitoring in water and sediment

The contaminants in the water matrix that were found to be of most concern and ubiquitous were di(2-ethyhexyl)phthalate (DEHP), Nickel and Lead. DEHP was the most ubiquitous contaminant found in all waters. However DEHP only occurred at levels above detection limits in the sediments of Il-Qattara. Its levels in water were moderately correlated with degree of urbanization of the respective water catchment basin.

Nickel and its compounds was the second most ubiquitous contaminant in the water column. Although it was not found at levels above the established EQS, it was also found to occur at levels above detection in the sediments of all 10 waters. Its levels as reported in sediments were considered to be of **low ecotoxicological significance**.

Lead was the contaminant which was found to occur in sediments at levels of potential ecotoxicological significance. As indicated in Chapter 2 its occurrence was mostly correlated with urban sprawling indicating that its main local sources are urban rather than industrial in origin. The correlation analysis[218] showed that lead levels in water were more moderately correlated with the extent of natural vegetation, rather than with urban development or industry in the various sub-water catchments. This thus points to the probability of more than one type of source of releases for this contaminant, not excluding bird hunting activity (from lead cartridges).

6.3 Ecological Status of Coastal Waters

6.3.1 Reference sites and reference conditions for different Biological Quality elements in the Maltese Islands

In Malta's first Water Catchment Management Plan, reference sites for only one BQE, *Posidonia oceanica* were tentatively identified for the relevant coastal water types in areas considered to be relatively pristine and where the healthiest meadows could be found locally as supported by scientific data at that time. It was not possible to identify reference sites for the other biological quality elements due to the fact that monitoring data for the other BQEs was unavailable.

The 2012/2013 comprehensive monitoring programme enabled tentative reference sites for the other BQEs to be established. In 2014 the intercalibration process for the Biological Quality Elements enabled Malta to confirm the reference sites for 2 of the 4 BQEs (Posidonia and Macroalgae). Given that the intercalibration process for benthic invertebrates and phytoplankton could not be completed, only tentative sites haven been identified at this stage based on spatial information of pressures and confirmed by the monitoring data. Sites which are undisturbed or where very minor disturbance is present were therefore selected. Full details of the results of Malta's first phase intercalibration exercise can be accessed from the following link: http://www.mepa.org.mt/topics-water-home

6.3.1.1 National reference conditions and reference sites for *Posidonia oceanica*

The reference criteria used for the selection of reference sites for this particular BQE was based on a hypothetical site since there are no truly pristine reference sites in the Maltese islands. Therefore in order to identify reference conditions a composite 'optimal' site was constructed based on the metrics used to assess the status of Posidonia meadows as applied by the PREI method.[219] This means that the hypothetical site would have ecologically ideal conditions in relation to each of the metrics.

[218] ECOSERV and CADA MEPA T08/2011, 2012. Baseline surveys of inland surface and transitional waters: Priority substances and certain other pollutants

[219] PREI - *Posidonia oceanica* Rapid Easy Index

The Mediterranean Geographical Intercalibration Group (MEDGIG), (whose role is explained in Chapter 2) also defined an alternative benchmark in order to determine conditions of high status. Malta identified two such benchmark sites on the basis of them reflecting least disturbed conditions. These are:

1. Water body MTC 102; WFD Surveillance monitoring station CS 02 Ramla l-Ħamra, Gozo (36^{o}04.269'N; 14^{o}17.060'E)

2. Water body MTC 103; WFD Surveillance monitoring station CS 03 Comino Channel (36^{o}00.334'N; 14^{o}21.710'E)

6.3.1.2 National reference conditions and reference sites for Macroalgae

The method to derive reference conditions for the national assessment method used to qualify status of Macroalgae was based on monitoring data of macroalgae along 14km of coast. The reference criteria used for the selection of reference sites was based on undisturbed sites that cover a wide range of coastal geomorphology types. The reference zone (i.e. coastal stretch representing high status) was the Northern coastal stretch of Gozo. This coastal stretch show EQR values higher than the reference values proposed by Spain.

The reference sites selected for phytoplankton are being selected as tentative sites given that longer term data is required in order to understand the seasonal variations in phytoplankton and whether the sites are a true reflection of pristine or near-pristine conditions. It is expected that with further monitoring the current sites which have been selected would be confirmed. The table below (table 6.7) indicates all the sites selected as type-specific reference sites for each of the four coastal water biological quality elements. A map of their location is included below (refer to Figure 6.2).

	Biological Quality Element			
	Angiosperms (Posidonia oceanica)	Macroalgae	Benthic Invertebrates	Phytoplankton*
Selected Reference Sites based on spatial screening of pressures and/or the intercalibration process	Ref Stations : MTC 102 - CS 02 Ramla l-Ħamra, Gozo; MTC 103 – Station CS 03 Comino Channel	Ref Stations : Coastal Stretch MTC 101 – (Covering coastal stretch from Station CN 01-1 northwards)	Tentative Ref Stations : MTC 101 - CS 01, Northern tip off Gozo) MTC 108 - CS 08 (coastal stretch off Hal Far, Benghisa)	Tentative Ref Stations : MTC 101 - CS 01, Northern tip off Gozo) MTC 108 - CS 08 (coastal stretch off Hal Far, Benghisa)

Table 6.7: Reference sites for each BQE

* Reference sites for Phytoplankton and Benthic Invertebrates are tentative given that not enough data has been collated covering a sufficient time span to arrive at EQRs for each water body

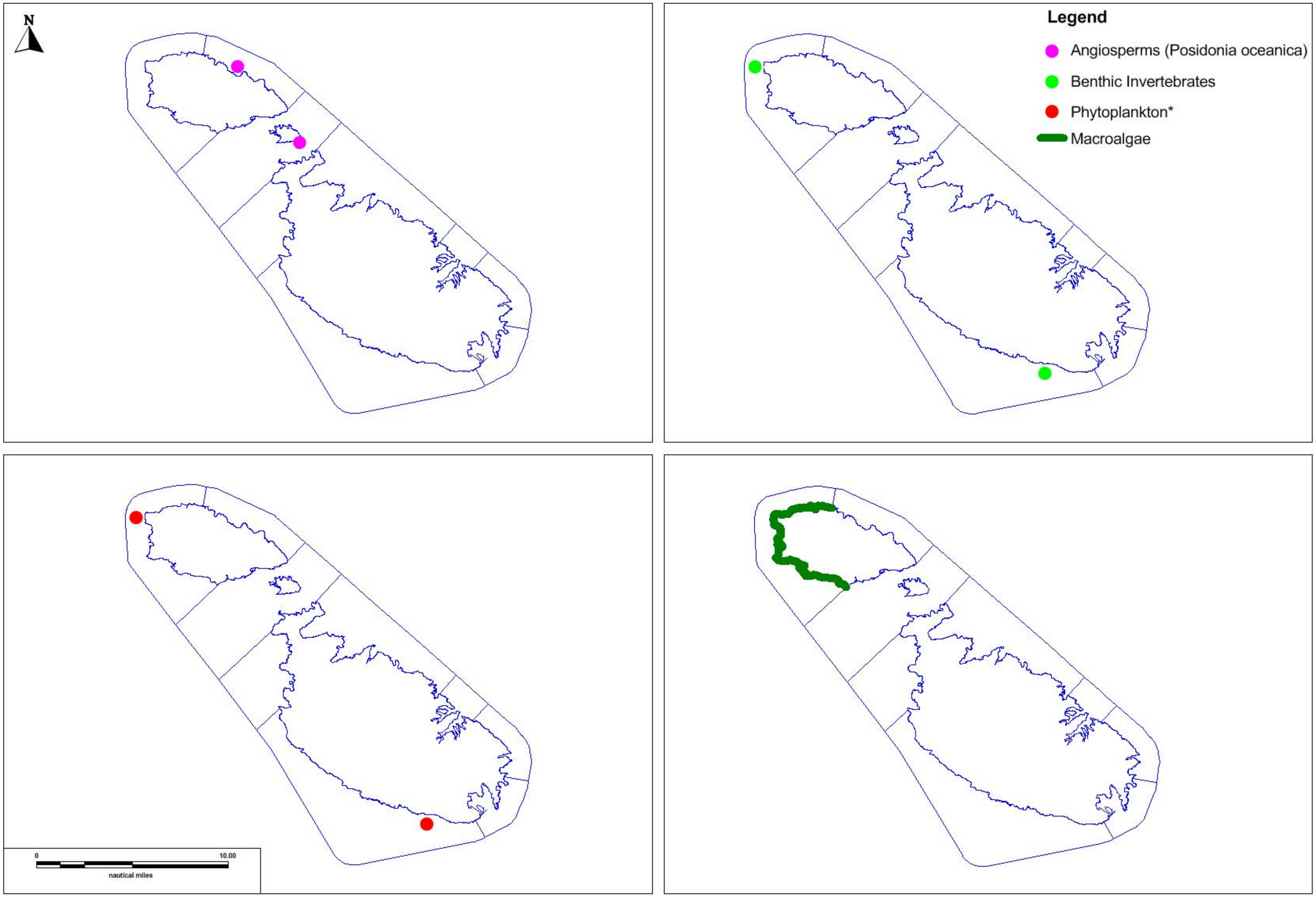


Figure 6.2: The reference sites established for the four Biological quality elements monitored to classify ecological status

6.3.2 Intercalibration

The coastal water monitoring results obtained during 2012-2013 were assessed against MED-GIG (Mediterranean Geographic Intercalibration Group) compliant methodologies, as follows:

- The PREI[220] index for angiosperms,
- The CARLIT[221] method for macroalgae,
- The AMBI[222] method for benthic invertebrates,
- The taxonomic composition, abundance, biomass and blooms for phytoplankton species.

Following this first attempt at using intercalibrated methods, further technical assistance was engaged in 2014 to undertake the necessary intercalibration work[223] for the harmonization of national reference conditions and to carry out the necessary class boundary adjustments on the data gathered during the first monitoring programme.

This intercalibration attempt resulted in it being possible for 2 of the 4 BQEs – *Posidonia oceanica* meadows and Macroalgae to be intercalibrated. The remaining 2 BQEs (benthic invertebrates and phytoplankton) could not be intercalibrated due to data and methodological problems encountered. Data gaps and future monitoring needs (refer to Chapter 5) required to ensure that future intercalibration work would be possible, were also identified.

6.3.2.1 Problematic BQEs that cannot be intercalibrated at this stage

Malta was unable to establish intercalibrated boundary classes for benthic invertebrates and phytoplankton under the first WCMP cycle. The technical reasons for the failure to complete the intercalibration process for these particular BQEs are provided in table 6.8 below.

Biological Quality Element	Reasons for failure	Monitoring requirement
Benthic invertebrates	The benthic samples were not collected at the monitoring stations used for other parameters, while the geographical coordinates of the actual sampling stations used were not available.	Malta needs to adopt the correct sampling procedure to study marine benthos in sublittoral waters. In the upcoming monitoring programme Malta has to collect most samples from the 8-12 m depth range. This requirement has been included in the revised MSFD-WFD monitoring programme. Malta is to follow the procedure that has been outlined by the consultants in the case that sandy sediment is not found within the stipulated depth range, agreed to at MEDGIG level.
	2012-2013 samples were collected from a water depth of 50m.	
	Essential data on sediment grain size is not available.	This requirement has been included in the coastal / marine monitoring programme (see Chapter 5).

[220] PREI - *Posidonia oceanica* Rapid Easy Index
[221] CARLIT - Cartography of littoral and upper-sublittoral rocky shore communities
[222] AMBI – Marine Biotic Index (Borja et al., 2000)
[223] Ecoserv Ltd. and UCV-IMEDMAR (Universidad Católica de Valencia) provided scientific expertise to render assistance in the intercalibration exercise of the four Biological Quality Elements (BQEs) for Maltese coastal waters.

Phytoplankton	Phytoplankton samples were collected at a water depth of 5m. Other Member States collected samples at several water depths, and also took more than one sample by sampling throughout the water column. Other Mediterranean Member States also included a surface water sample. Therefore it was not possible to use the dataset because it could not be demonstrated that the data collected at the 5m depth is representative of the whole water column. i.e. that there is a completely mixed water column with regards to light, temperature, water transparency etc.	During the first monitoring year Malta will be taking a transect approach in order to utilise the 2012-2013 data and shall start monitoring again at surface and sub-surface depth in the near shore zone.
	Not all of Malta's plankton sampling took place in the nearshore zone (i.e. 500m-1500m from the shore) as required for WFD monitoring. In order to make use of the 2012-2013 monitoring data Malta would need to establish a relationship between inshore/nearshore and offshore samples in order to estimate the nearshore equivalent of nearshore sites. However, transect data is not available for Malta and as a consequence this exercise could not be carried out.	Malta has taken this into consideration in the design of the coastal/marine monitoring programme (refer to Chapter 5). In addition to this Malta will need to collect Chlorophyll *a* data during winter since this was not carried out during the first baseline. Malta will be collecting monthly samples of Chlorophyll a during at least 1 year at a suitable number of stations.

Table 6.8: Problems encountered in Malta's attempt to intercalibrate benthic invertebrates and phytoplankton BQEs

6.3.2.2 Successful BQE intercalibration

Both the Angiosperm *Posidonia oceanica* and Macroalgae were successfully intercalibrated and Ecological Quality Ratios for the High-Good boundary and Good to Moderate boundary have been established accordingly. The intercalibration results are summarised in table 6.9 and resultant classification for the two BQEs are presented in table 6.10.

		Ecological Quality Ratios	
BQE	**National classification Method Applied**	**High /Good boundary**	**Good / Moderate boundary**
Posidonia oceanica	PREI	0.775	0.550
Macroalgae	CARLIT	0.75	0.60

Table 6.9: Intercalibration results for Posidonia oceanica and Macroalgae biological quality elements

	Biological Quality Elements	
WFD Water Body	**Macroalgae**	***Posidonia Oceanica***
MTC 101	High	High
MTC 102	High	High
MTC 103	High	High
MTC 104 (op 1)	High	Good
MTC 104 (op 2)	Good	High
MTC 105	Moderate	N.A.*
MTC 106 (op 1)	Good	Good
MTC 106 (op 2)	Good	Good
MTC 107	High	Good
MTC 108	High	N.A *
MTC 109	High	High

Table 6.10: Ecological Status results for the coastal waters based on Posidonia and Macroalgae intercalibration.

* *Posidonia oceanica is not found in Coastal Water Body MTC 105 whilst it was not monitored in Water Body MTC 108 but shall be monitored as part of the second WCMP monitoring programme.*

6.3.2.3 Future Requirements

Following this intercalibration exercise, Malta is midway in achieving full compliance with the WFD Annex V requirements related to coastal water assessment of status. Following the joint MSFD-WFD monitoring programmes that are to be implemented during the first year (2016), Malta will initiate a second intercalibration exercise covering the two remaining BQEs (Benthic invertebrates and Phytoplankton). The execution of the second IC stage required is expected to take place during 2017.

6.3.3 Establishing nutrient boundaries in coastal and marine waters

Currently available data on the status of marine biological elements and nutrient levels in coastal waters is not sufficient to enable analysis and definition of interrelationships across nutrient input in the marine environment, nutrient levels in coastal waters and related deviations from good status of coastal biological elements. Within this context, establishment of thresholds for nutrient levels in coastal waters is not possible at this stage and further long-term trend data is deemed necessary for the elaboration of sound thresholds.

In the interim, until the outcome of Malta's second intercalibration exercise related to phytoplankton and the collection of further monitoring data in the marine environment, Malta is adopting the Ecological Quality Ratios determined for High-Good and Good-Moderate ecological status in terms of Chlorophyll-a as a parameter indicative of phytoplankton biomass in Greece and Cyprus (as per Commission Decision 2013/480/EU) on the basis of the assumption that Maltese waters constitute Type IIIE coastal waters. Malta is thus applying the eutrophication scale provided in Simboura et al. (2005)[224]

[224] Simboura, N., Panayotidis, P.and Papathanassiuo, E. 2005. A Synthesis of the biological quality elements for the implementation of the European Water Framework Directive in the Mediterranean ecoregion: the case of Saronikos Gulf. *Ecological Indicators* **5**:253-266

(refer to table 6.11) for the purposes of determining ecological status in terms of chlorophyll-a concentrations on an interim basis. Parameter values are expressed in µg/l of Chlorophyll-a, for the 90th percentile calculated over the year in at least a five year period.

Eutrophication Scale	Chlorophyll-a (µg/l)	Ecological Quality Status
Oligotrophic	<0.1	High
Lower mesotrophic	0.1-0.4	Good
Lower mesotrophic	0.4-0.6	Moderate
Higher mesotrophic	0.6-2.21	Poor
Eutrophic	>2.21	Bad

Table 6.11: The Eutrophication scale as applied by Malta, after Simboura et al., 2005.

6.3.4 Current Status of the biological quality elements of the Natural Coastal Water bodies

In view of the above, the current status of the **natural** coastal water bodies is provided in table 6.12 and illustrated in Figure 6.3. These results are based on the intercalibration process and first comprehensive monitoring carried out during the first WCMP.

		Biological quality elements			
WFD Water Body	**Overall Status**	**Macroalgae**	***Posidonia Oceanica***	**Benthic invert.****	**Phytoplankton****
MTC 101	**High**	High	High	High	High
MTC 102	**High**	High	High	High	High
MTC 103	**High**	High	High	High	High
MTC 104 ^{Op1}	**Good**	High	Good	High	High
MTC 104 ^{Op2}	**Good**	Good	High	Good	Good
MTC 106 ^{Op1}	**Moderate**	Good	Good	High	Moderate
MTC 106 ^{Op2}	**Moderate**	Good	Good	High	
MTC 108	**Good**	High	N.A *	High	Good
MTC 109	**High**	High	High	High	High

Table 6.12: Status of the Biological quality elements natural coastal waters

* The relevant biological quality element was not found at the monitoring station and therefore was not used in the assessment of ecological status.

** The status assessment for benthic invertebrates and phytoplankton was based on monitoring results that have not been successfully intercalibrated, but have been used in the interim until further monitoring and the second intercalibration phase has been carried out.

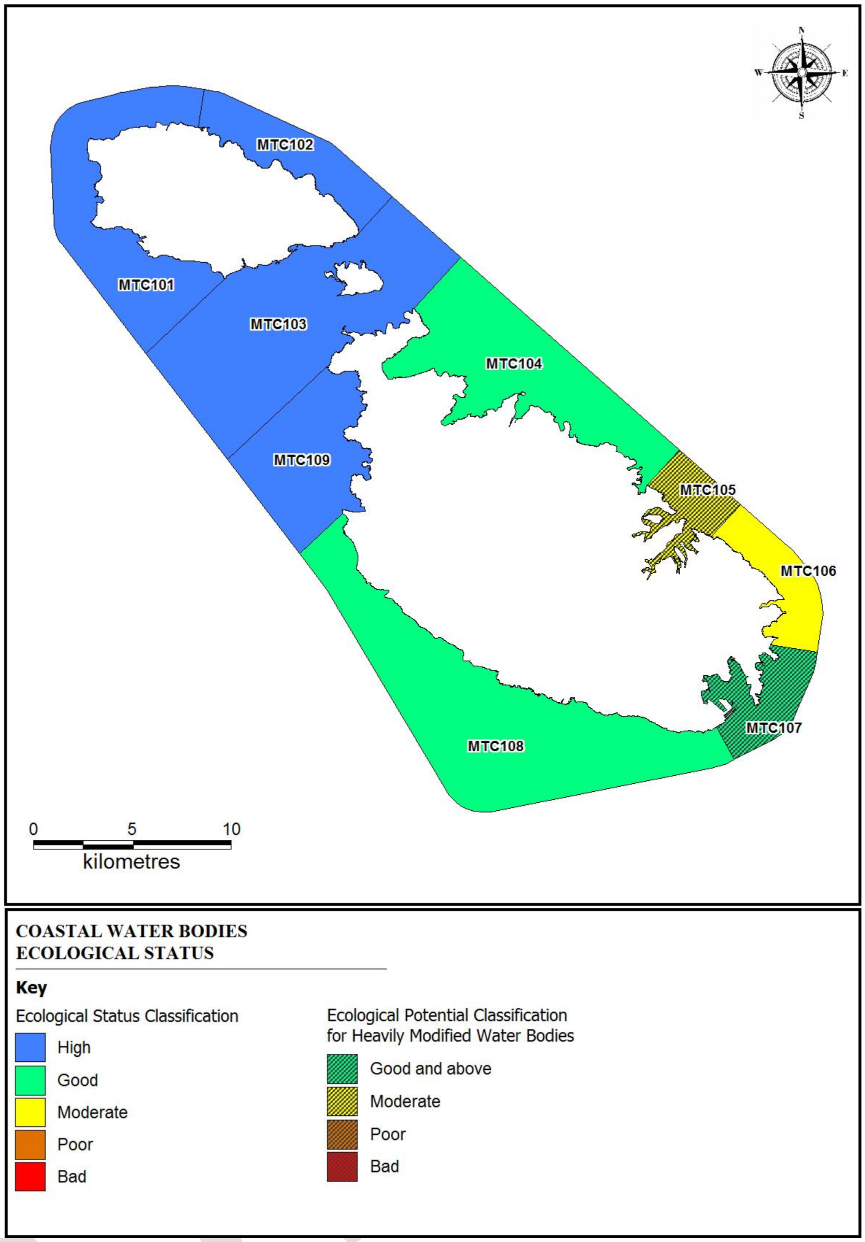


Figure 6.3: Status of the Biological quality elements in all coastal water bodies (natural and heavily modified) coastal waters.

6.3.5 Heavily Modified Water bodies and the definition of Good Ecological Potential

Hydromorphological alterations can lead to the designation of a water body as being heavily modified if substantial changes to the water body's character are extensive, and the modifications are neither temporary nor intermittent and in general alter both hydrological and morphological characteristics.[225] Therefore a heavily modified water body cannot meet 'good ecological status'. Any water body deemed to be heavily modified from anthropogenic hydromorphological modifications has to meet '**good ecological potential**' rather than good ecological status. The implications of any modification on the biota of the respective heavily modified water bodies need to be defined.

[225] WFD CIS Guidance Document no. 4 : Identification and designation of heavily modified and Artificial Water Bodies, Produced by Working Group 2.2 HMWB, Luxembourg: Office for Official Publications of the European Communities, 2003

6.3.5.1 Designation of heavily modified water bodies in the Maltese Islands

During the first WCMP, two coastal water bodies were designated as heavily modified. Such bodies comprise the harbour areas (Il-Port il-Kbir and Il-Port ta' Marsamxett; Il-Port ta' Marsaxlokk). The Grand Harbour and Marsamxett harbours (MTC 105) are subject to continuous morphological change and this has been the case since the 16th Century ever since the Knights of St. John used the harbour as the major point of defence. Dredging continuously takes place; land has been reclaimed for the building of weirs, platforms, quays and also for the carrying out of ship repairs. Today both historical and contemporary coastal reclamation in these two harbours is linked to industrial and tourism development. The transformation has inevitably led to a change in the hydrological dynamics of water and sediments and transformation of the biological communities.

The Port of Marsaxlokk (MTC 107) has also been subject to intensive physical alteration with the development of the Freeport and oil terminals. Changes to the coastline within established port areas are inherent for their continued commercial operation especially in order to retain competitiveness within the Mediterranean. The port is subject to large-scale marine constructions and land reclamation activities that are related to the construction and operation of Malta Freeport at the mouth of the harbour.

Periodic operational dredging activities are associated with Malta Freeport operations. Quay development is related to the development of the Delimara power station. Quay development within the inner-harbour area is related to fishing harbour activities. Beach reclamation has also taken place at Birzebbugia (Pretty Bay).

These water bodies were designated as such due to two main reasons:

1) Due to the fact that they are substantially changed from their original, natural hydromorphological condition and that such change is extensive and therefore permanent and irreversible. The list of criteria used to assess whether the water bodies are substantially changed in character are indicated in table 6.13.

   Furthermore it was believed that any changes to the hydromorphological characteristics of these water bodies necessary to achieve Good Ecological Status would result in significant adverse effects on the wider environment or on activities carried out within the port including port facilities, navigation and other reliant economic activities. The criteria used to judge significant adverse effects of potential measures to reverse the situation are described in table 6.13.

Impact related criteria	Pressure-related criteria	Use-related criteria related to the feasibility of implementing measures
- significant and irreversible morphological alteration - extent of area of modified bottoms, related to dredging activities - % of length of modified shore	- area covered by ports and navigation facilities - area of modified segments - frequency and extent of dredging activities	- The Grand Harbour and Marsamxett Harbour are both sites with patrimonial value and interest - The Grand Harbour, Marsamxett and Marsaxlokk harbours are characterised by port and quay facilities - The Grand Harbour and Marsamxett Harbour are of high tourist interest. - The extent of infrastructure development afforded protection by coast protection structures.

Table 6.13: Selected criteria to assess substantial changes in character of Coastal Water bodies MTC 105 and MTC 107

2) The objectives served by the modified characteristics of the water body cannot for reasons of technical feasibility and /or disproportionate costs be reasonably achieved by any other alternative means, which are significantly better environmental options.

   The alternative environmental options that were considered and confirmed to be infeasible include the replacement of the existing uses of the three port areas with better alternatives such as replacement of shipping with other environmentally friendly transport options; or the displacement of the existing use to another water body. The only feasible option for Malta would be to include measures in the WCMP with the aim of reducing the impact of these water uses on the quality of the marine environment.

Significant adverse effects of potential measures on the wider environment	- Endanger national heritage or historical/cultural monument should morphological alterations of the water body be changed. - Release of priority and/or priority hazardous substances due to reservoir of historic contaminated sediments in port areas - Significant job reduction
Significant adverse effects of potential measures on port facilities	- Significant reduction of shipping/transport (e.g. due to the reduction of depth/width of fairway should dredging be discontinued) - % loss of cargos or reduction in passenger traffic should quays/facilities be removed - Impossible to change the current hydromorphological condition: port facilities are completely consolidated in an urban area.

Table 6.14: Selected criteria to assess whether there are significant adverse effects should measures to be taken to reverse the hydromorphological quality of coastal Water bodies MTC 105 and MTC 107

6.3.5.2 Definition of Good Ecological Potential

A heavily modified water body needs to be assessed in terms of achieving Good Ecological Potential which is defined as slight changes in the relevant biological quality elements as compared to the values found at the Maximum ecological potential (MEP) that a heavily modified water body can achieve. The MEP in turn describes the best approximation to a natural water body that could be achieved given the hydromorphological characteristics present that cannot be changed with implicating adverse impacts on the wider use of the water body in question.

Malta has therefore adopted what is known as the Prague approach described in a CIS discussion paper [226] by which it can assess Good Ecological Potential. By means of this approach Malta first identified all potential mitigation measures that can be taken in coastal water bodies MTC 105 and MTC 107 that do not have a significant adverse effect on the wider use of either water body. It is our understanding that ecological potential can be achieved if all feasible and practical mitigation measures are taken to address hydromorphological impacts.

[226] Common Implementation Strategy Workshop Brussels, 12-13 March 2009 'Heavily Modified Water bodies: Information Exchange on Designation, Assessment of Ecological Potential, Objective setting and Measures' http://www.ecologic-events.de/hmwb/documents/Discussion_Paper_Updated.pdf, accessed on 5 March 2014.

Good ecological potential therefore refers to the values of the biological quality elements after all practical mitigation measures listed have been successfully implemented. This is better explained in Figure 6.4.

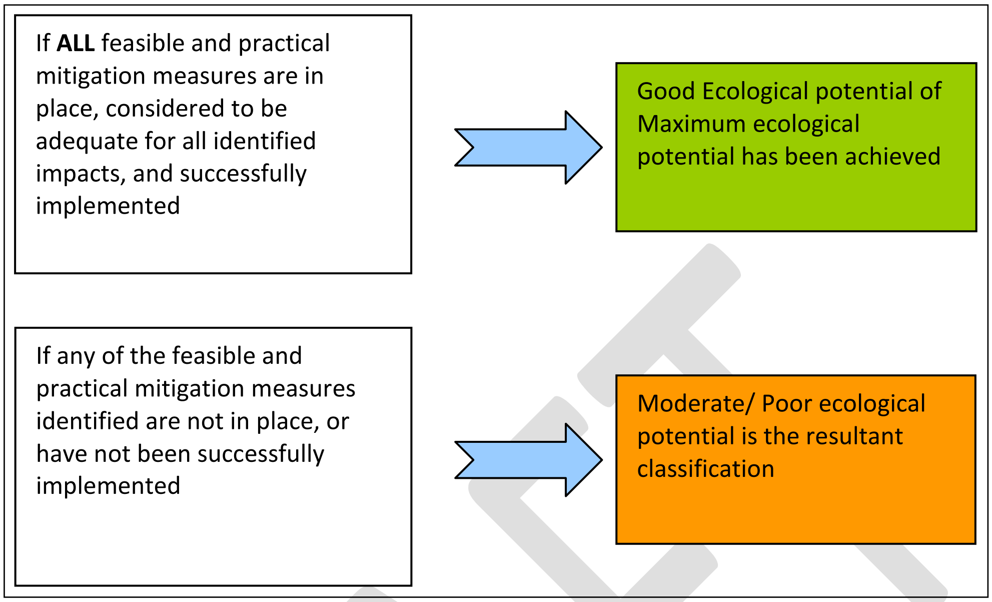


Figure 6.4: Approach adopted to define Good Ecological Potential in Il-Port il-Kbir, Il-Port ta' Marsamxett and il-Port ta' Marsaxlokk

The measures relevant to hydromorphological changes in these port areas that were identified under the first WCMP (2010-2015) as those that would not have an adverse effect on the wider use of the port were as follows:

1. Strengthen the existing environmental and planning regulatory processes to cater for the objectives of the WFD
2. The development and implementation of planning and environmental guidance on major coastal engineering works
3. Develop and implement a protocol for the disposal or reuse of dredged material from harbours

Coastal Water body	Impact	Relevant feasible mitigation measure	Status of implementation
MTC 105 MTC 107	Significant and irreversible morphological alteration	No feasible mitigation measures can be taken for historic /past modifications. New modifications are subject to Environmental impact assessment or general environmental assessment procedures	Implemented but there is scope to improve existing processes.
MTC 105 MTC 107	Extent of area of modified bottoms, related to dredging activities	Strengthen the existing environmental and planning regulatory processes to cater for the objectives of the WFD The development and implementation of planning and environmental guidance on major coastal engineering works Develop and implement a protocol for the disposal or reuse of dredged material from harbours	Implemented but there is scope to improve existing processes.
MTC 105	Length of modified	Strengthen the existing environmental and	Implemented but there is

MTC 107	shore	planning regulatory processes to cater for the objectives of the WFD The development and implementation of planning and environmental guidance on major coastal engineering works	scope to improve existing processes.
MTC 105 MTC 107	Alteration of key species and/or life stages composition and abundance of benthos.	Strengthen the existing environmental and planning regulatory processes to cater for the objectives of the WFD The development and implementation of planning and environmental guidance on major coastal engineering works	Implemented but there is scope to improve existing processes.

Table 6.15: Status of implementation of measures of heavily modified water bodies

6.3.5.3 Current status of Biological Quality elements in Heavily Modified Water Bodies

The assessment of ecological status for the biological quality elements present in the harbours using methods that are applied to natural waters and which have been intercalibrated at Mediterranean level resulted in a moderate – good status as follows:

HMWB	Overall BQE Status	Macroalgae	*Posidonia oceanica*	Benthic invert.**	Phytoplankton**
MTC 105	**Moderate**	Moderate	Not applicable	Good	Moderate
MTC 107	**Good**	High	Good	High	Good

The supporting physico-chemical parameters, more specifically those related to nutrients revealed that MTC 105 (il-Port il-Kbir and il-Port ta' Marsamxett) is particularly vulnerable to nutrient enrichment and therefore, whilst MTC 107 displayed lower nitrate concentrations throughout the year with occasional spikes during February to April, longer-term data would need to be collated in order to be in a better position to confirm status. Nevertheless with current data at hand and keeping in mind that the measures identified under the first plan are in place but are yet to be refined it can be said that the Ecological potential for MTC 105 is of **moderate potential** whilst that of MTC 107 is of **good potential.** Since good ecological potential has been achieved in MTC 107, there is a requirement to maintain such a status through the implementation of the measures that have been identified.

6.4 Chemical Status of coastal waters

6.4.1 Chemical status in the water column

The classification of the chemical status of Maltese coastal waters resulted to be good for nearly all parameters, apart from mercury. Lead and polyaromatic hydrocarbons (the latter in the case of sediments) are of additional concern in the sediment matrix. Mercury was the most common metal detected in the water column from all the sampling stations. All measured mercury concentrations were found to exceed the annual average EQS of 0.05μg/L. The encountered mercury concentrations in water do not necessarily represent a pollution problem, and long-term data is necessary for an adequate assessment of background concentrations and interpretation of the status of the water column in Maltese waters. Although mercury was the most ubiquitous element, other trace metals and organic pollutants were also found to be of potential concern in the water column, in individual water bodies. Each contaminant of concern detected at potential levels of concern within the water column (i.e. not necessarily impacting the status of each water body but require our attention) is individually discussed below.

6.4.1.1 Mercury

The mean mercury annual values for all monitoring stations were about 2-3 folds higher than the MAC-EQS (Maximum Allowable Concentration-Environmental Quality Standard) for surface waters as set by Directive 2008/105/EC. The main anthropogenic emissions of mercury occur during the fuel combustion of coal, waste or oil. Municipal sewage discharge can also potentially be an important source of mercury to the environment. The atmospheric deposition of mercury could also be a main contributor (Refer to Chapter 3 ‘Transboundary pollutants’).

The characteristics of the surrounding area to the sampling points were analysed in an attempt to understand the potential sources of mercury contamination. Monitoring stations CS03, CP04-1, CN05-1, CN03-2, CS09 and CP05 are receiving waters of predominant urban catchments. In the case of CP06-01a likely contributor is the Ta’ Barkat waste water treatment plant which discharges in close proximity, whist station CP07 is located within the port of Marsaxlokk, an important industrial area. These land uses point to potential sources from fuel combustion processes and sewerage discharges, but also to sea uses that contribute to ship waste or bilge waste.

A possible contribution of natural background mercury levels typical of the Mediterranean Sea as well as transboundary pollution via atmospheric deposition is to be further investigated in this second WFD cycle.

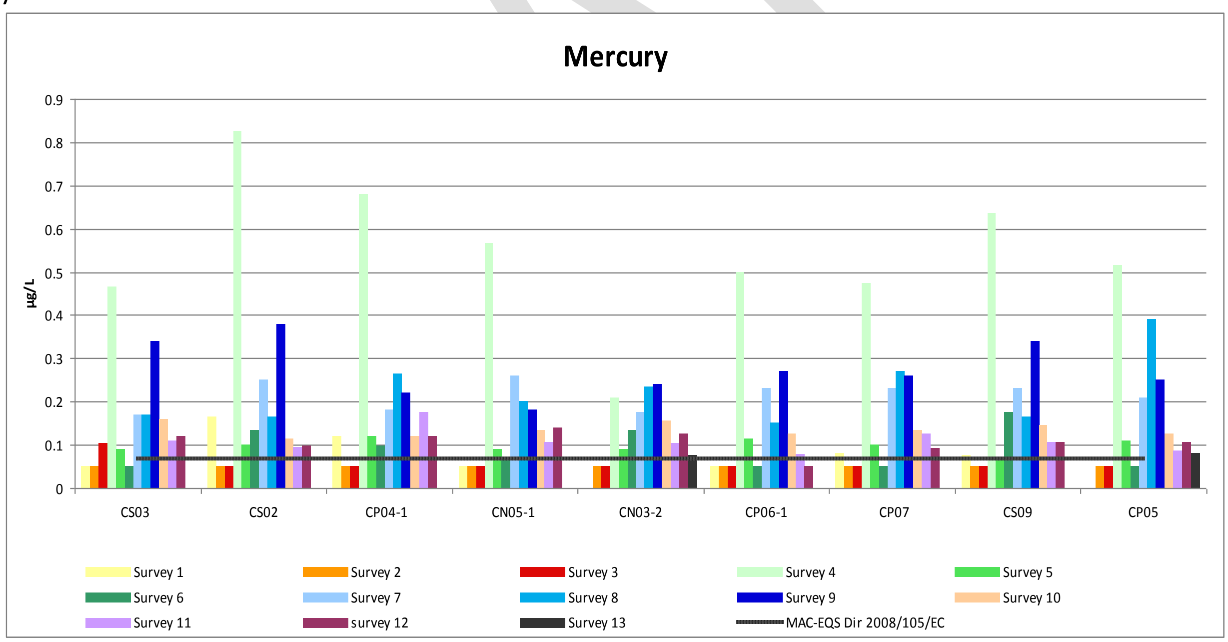


Figure 6.5: Mercury concentrations in water during the surveys and MAC-EQS value from Directive 2008/105/EC.

6.4.1.2 Lead

Three individual cases of lead exceedances were reported once at three stations (CS03, CS02 and CP06-1). The concentrations were higher than the annual average EQS of **7.2 µg L^{-1}** for surface waters. At each site, a wide temporal variation at a monthly scale was found; whilst insignificant differences were found among sites. As a consequence, the mean annual concentrations in the investigated sites ranged from 0.93 ± 0.98 µg L^{-1} to 1.98 ± 2.29 µg L^{-1}. The lower mean concentrations were found at the sites CP04-1, CP07 and CS09, whereas the highest mean concentration corresponded to the CP06-1 site. High lead concentrations in the surface waters could also originate from anthropogenic inputs via atmospheric deposition. Average lead concentrations in water are presented in Figure 6.6.

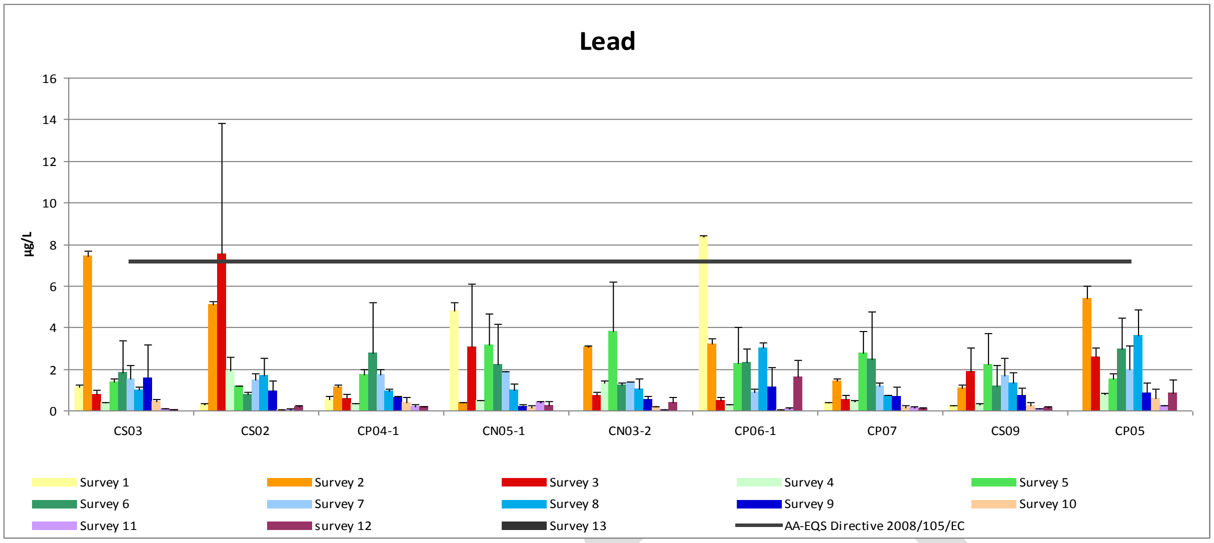


Figure 6.6: Lead concentrations in water during the surveys and AA-EQS value from Directive 2008/105.

6.4.1.3 Nickel

The average annual concentration for all the stations was quite similar with most below the annual average EQS of **20 µg L^{-1}** proposed for surface waters by the EQS Directive, with a few exceptions (mainly being CN03-2, CPO5, CN05-1, CP06-1, CS09). However, considering the values reported for the North Aegean surface waters (0-100 m) by Voutsinou-Taliadouri et al. (2000)[227] or for the Northern Adriatic by Tankere & Statham [228](1996), the concentrations found in the Maltese coastal waters are one order of a magnitude higher. Average nickel concentrations in the water column are provided in Figure 6.7.

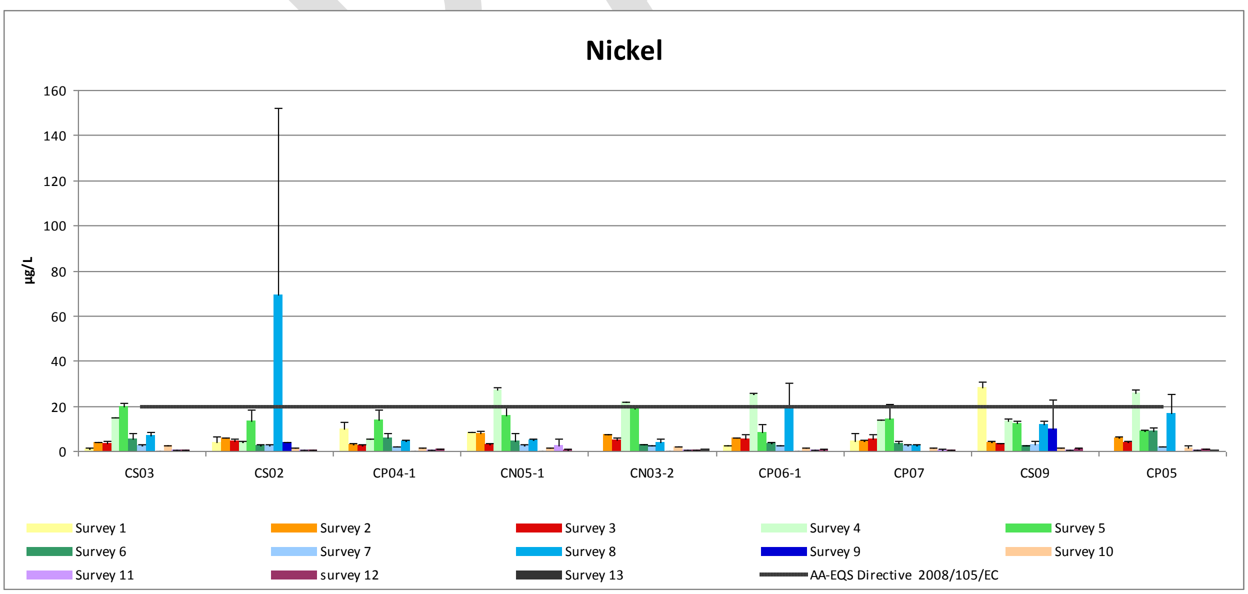


Figure 6.7: Nickel concentrations in water during the surveys and AA-EQS value from Directive 2008/105/EC

[227] Voutsinou-Taliadouri, F., Zeri, C., and Moriki, A. 2000. Distribution and transfer of trace metals in the Aegean Seawater (Eastern Mediterranean Basin), Mediterranean Marine Science, Vol 1/2 , 2000, 5-30.
[228] Tankere SPC, PJ Statham. 1996. Distribution of dissolved Cd,Cu, Ni and Zn in the Adriatic Sea. Mar. Pollut. Bull. 32:623-630

6.4.1.4 Organic pollutants

Of all the organic pollutants measured only polyaromatic hydrocarbons (PAHs) were detectable in the waters during a number of surveys (9-13) at various monitoring sites. For the group of priority substances of PAHs each individual EQS is applicable, i.e. the EQS for Benzo(a)pyrene, the EQS for the sum of Benzo(b)fluoranthene and Benzo(k)fluoranthene and the EQS for the sum of Benzo(g,h,i)perylene and Indeno(1,2,3-cd)pyrene must be met.

In the case of the Benzo(a)pyrene, the 2008 AA-EQS of 0,05 ug/l was not exceeded in any water body. The sum of Benzo(b)fluoranthene and Benzo(k)fluoranthene exceeded the established 2008 AA-EQS once in water bodies MTC 109 (monitoring station CS 09, during June) ; MTC 102 (monitoring station CS 02 during June, and MTC 105 (monitoring station CP 05, during July). These one off occurrences are considered to be anomalies and not of significance.

The sum of Benzo(g,h,i)perylene and Indeno(1,2,3-cd)pyrene also exceeded the 2008 established EQS on one occasion in water bodies MTC 102 (station CS 02) and MTC 105 (station CP 05). Two exceedances in the water column at monitoring station CN04-1 (coastal water body MTC 104) were recorded in April and July.

PAHs are not a failing parameter in the water column when considering 2008 EQS levels. Although the exceedances can be considered to be anomalies, the revised 2013 EQS may provide a potential future challenge. After analysing the specific characteristics of the areas surrounding the sampling points where anomalous results were recorded, there is an indication that these are located in waters which are in proximity to urban catchments, harbour activities and waste water treatment plants.

6.4.2 Chemical status in sediments

A number of priority substances established by Directive 2008/105/EC, and also substances of potential national concern to the water environment were monitored in superficial sediments collected from 17 selected sampling stations. Malta has not yet established Environmental Quality Standards (EQS) for sediments and thus, in order to carry out an indicative assessment, a comparison analysis was carried out between the measured values and the EQS's established in Italy (Decreto n.56/2009). The Italian quality standards were derived on the basis of field and laboratory ecotoxicology data.

It has to be noted that the EQS are expressed as annual averages, however the results from one field sampling as in this case can give a good indication of pollutant concentrations since one survey a year is usually considered sufficient to determine the environmental quality of the sediments. The results for metals show EQS exceedances for **mercury** and **lead** at three monitoring points (CP04-1, CP06-1 and CP06-2) (refer to Figure 6.8). Lead, in particular, presents very high concentrations (more than 6 times the EQS) in the sediment taken from CP06-1 and CP06-2 (Figure 6.9) whilst mercury is remarkably high (30 times the EQS) at the CP04-1 monitoring station. The concentrations of cadmium are below the EQS (0.3 mg/kg), although at monitoring points CP04-1, CP06-1 and CP06-2 they resulted very close to the EQS. In addition the concentrations of Copper, Zinc and Barium (not included in the list of parameters for which EQS' were established by Italian law) registered very high values compared to the other monitoring points.

Regarding the other compounds monitored in the baseline, very high values, significantly above the EQS, are found for the **PAH compounds** (aromatic oils) particularly in the Grand Harbour and Marsamxett harbour (monitoring points CN05-1, CN05-2 and CP05) (Figure 6.10). The monitoring points CN05-2 and CP05 measured the highest PAHs concentrations (in some cases even higher than 30 times the EQS).

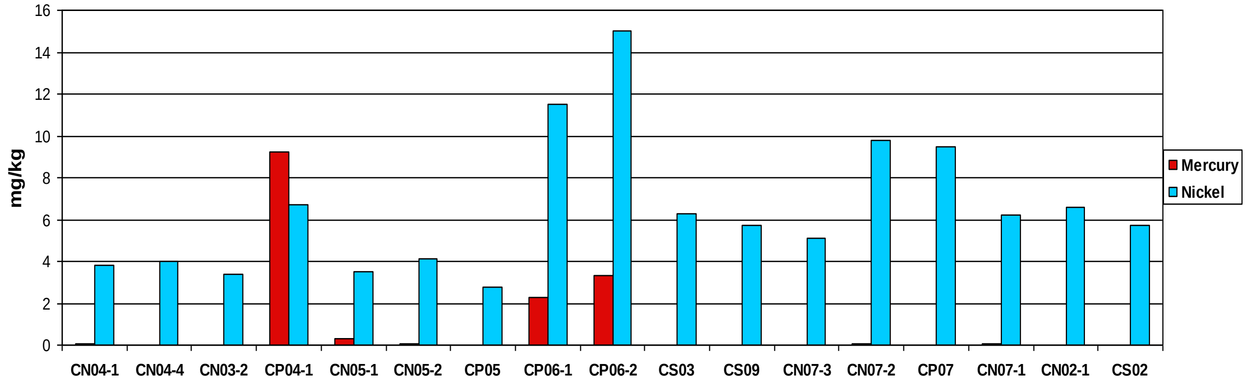


Figure 6.8: Mercury and Nickel concentrations (mg/kg dry weight) in sediments.

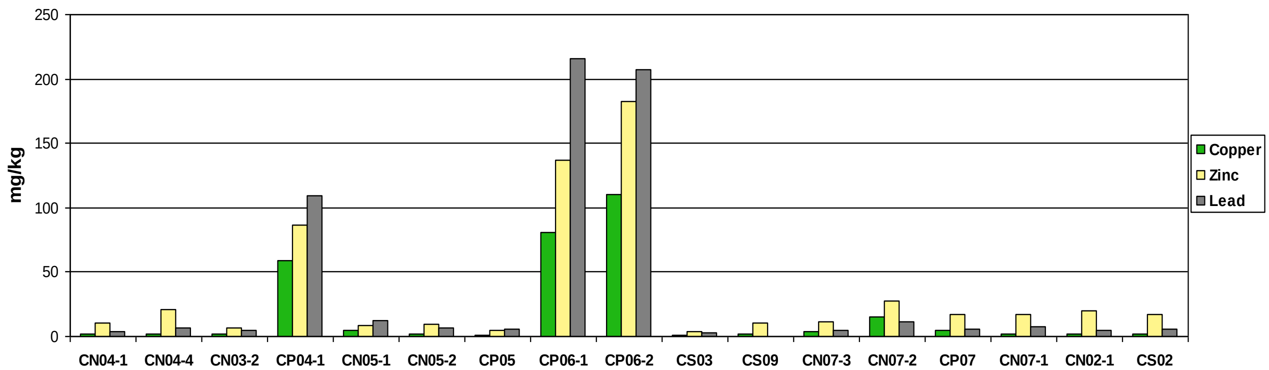


Figure 6.9: Copper, Zinc and Lead concentrations (mg/kg dry weight) in sediments.

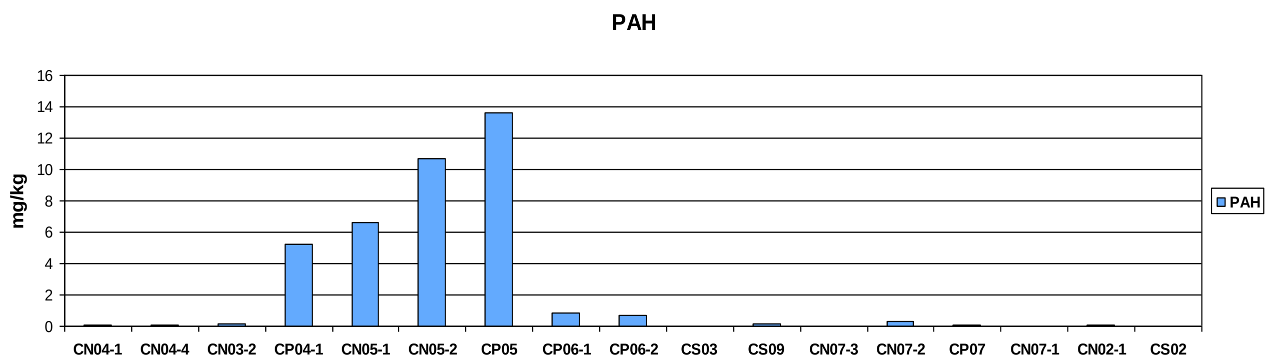


Figure 6.10: PAH concentrations (mg/kg dry weight) in sediments.

6.4.2.1 Comparison of trace metals in water and sediment

The re-suspension of sediments can be a process which remobilises trace metals present in the sediments to the water phase. The same metals monitored in the water phase (mercury, nickel and lead), as well as copper and zinc, are indicators of contamination by anthropogenic activities. The figure below shows that higher concentrations of the above metals are clustered at sites CP04-1, CP06-1 and CP06-2. At these sites nickel concentrations were also high, but this element was present in high concentrations also at CN07-2 and CP07.

Considering mercury, the contamination in the surface waters occurs not only where there is a high mercury contamination in sediments (sites CP04-1, CN05-1, CP06-1 and CP06-2) but also where the mercury concentrations in the sediments were low. After analysing the specific location of the points which show a high concentration of mercury, it could be seen that CP04-1 is close to an important urban area and that CP06-1 and CP06-2 are close to a waste water treatment plant; hence the high concentrations could be attributed to urban emissions from combustion activities in CP04-1 and discharge of domestic sewage in CP06-1 and CP06-2. However transboundary sources (such as atmospheric deposition and Mediterranean hydrographical transportation from Mediterranean states) could also have a part to play in contributing to the presence of mercury all around Maltese coastal waters. There is therefore a need to investigate potential mercury sources at a regional scale and look further into the potential contribution of transboundary sources. Any identified potential contributor would have to be attested by long-term monitoring data.

6.4.2.2 Comparison of organic pollutants in water and sediment

Unlike inland surface and transitional waters, DEHP was always below the limit of quantification limit in coastal waters. It has been occasionally detected in the sediment matrix of a number of coastal water body monitoring stations but the levels were low. Therefore DEHP is not considered to be contaminant of concern in the marine environment around the Maltese Islands. However its presence in sediments and not in the water could be explained on the basis of the physico-chemical properties of the molecule. DEHP's primary use is as one of several plasticisers in polyvinyl chloride resins used for fabricating flexible vinyl products. DEHP is insoluble in water and soluble in most organic solvents. With an octanol water coefficient (log K_{ow} of 7.5), DEHP is expected to be strongly adsorbed to organic matter and is therefore expected to be found in the solid organic phase in the environment. Due to its lipophilic nature and slow degradation under anaerobic conditions it is often found in high concentrations in sediment (European Union Risk Assessment Report, 2008)[229].

In sediments the PAHs were present at detectable concentrations at most sites. The higher values were found at sites CN05-1, CN05-2, CP05 and CP04-1 which only partially matched those contaminated by trace metals. Owing to the low aqueous solubility of PAHs and to their strong hydrophobic nature, these contaminants tend to associate with particulate material in the aquatic environment, with the underlying sediments as their ultimate sink.

6.4.3 Chemical status in biota

The WFD requires that hexachlorobenzene, hexachlorobutadiene and mercury are monitored in biota tissue by choosing the most appropriate indicator among fish, molluscs, crustaceans and other biota. The marine seagrass *Posidonia oceanica* was selected as a bio-indicator for the Maltese baseline, mainly for the natural features of the organism (benthic, long-living) and also due to its distribution (coastal areas, which are generally exposed to anthropogenic impacts) thus making the organism both prone to bioaccumulation and easy to collect, as required for the design of representative and cost effective biomonitoring programs.

Two surveys were carried out in spring and summer 2012. The results seem to indicate a substantial homogeneity among the different stations with respect to the organic xenobiotic compounds hexachlorobenzene (<0.0001mg/Kg) and hexachlorobutadiene (<0.01 mg/Kg), which are either absent or lower than the detection concentration.

[229] European Union Risk Assessment Report - BIS (2-Ethylhexyl)phthalate (DEHP), European Community 2008 Second Priority List Volume 80.
http://echa.europa.eu/documents/10162/e614617d-58e7-42d9-b7fb-d7bab8f26feb

The situation is different for mercury where the measured concentrations in biota have been compared to two different types of reference values, namely, mean values collected along Mediterranean coast from mild to high impacted areas, and measurements from marine zones that are generally considered to be relatively 'pristine' areas. The graph (Figure 6.11) allows the comparison among the measured concentrations from Malta and those from reference areas. This graph indicates that the Maltese data shown in blue are comparable with those from the reference site of Calvi and by far lower with respect to both mild and heavily impacted sites. The report states that it is generally acknowledged that the Western Mediterranean displays higher mercury concentration levels when compared to the Eastern part, mainly for natural reasons (e.g. because of the presence of natural deposits); however, this does not seem to be the case for the Maltese archipelago.

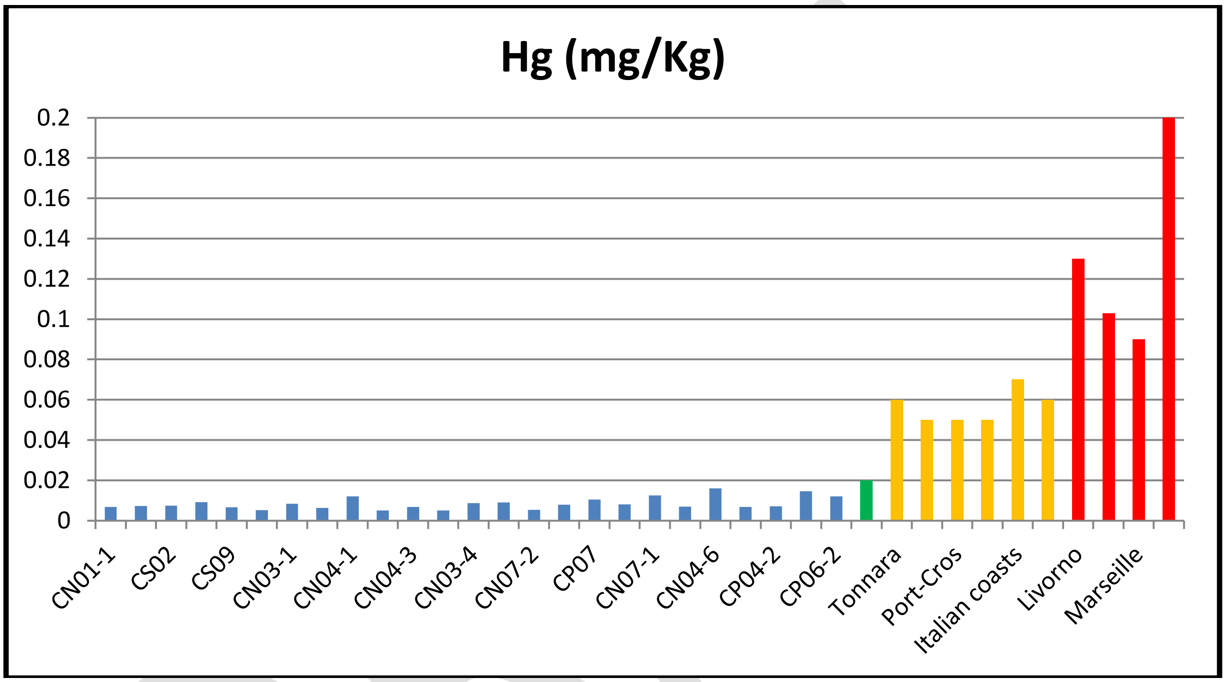


Figure 6.11: Comparison of Mercury concentrations in biota among Maltese coastal waters (marked in blue) and Mediterranean reference sites (green, yellow and red).

6.4.4 Change in status due to EQS Directive updates

In light of the reviewed EQS directive 2013/39/EU and results of the first monitoring cycle, certain amendments and additions to the Environmental Quality Standards Directive are forseen to affect the chemical status of certain water bodies. Malta is paying particular attention to the revised EQS' for the following parameters during the third WFD cycle:

(a) Lead - Based on the baseline studies, there were no particularly striking elevated levels of lead in both coastal as well as inland surface waters. However, the newly revised AA-EQS value of lead at 1.3 µg/L in transitional and coastal waters is particularly troublesome for Malta. Although Malta's surface waters are in line with 2008/105/EU it is highly unlikely that Malta will be able to achieve the seven-fold reduction in the concentration of lead by 2021. The number of exceedances for this revised EQS level per water body is summarised in Table 6.10.

(b) PAHs – In the case of PAHs, since the new metric to assess this parameter has been significantly altered Malta is yet to see whether the chemical status in water and biota will be at risk. For the 2008 Directive, (on which this chemical status assessment was based) the metric to assess the PAHs was based on having to meet each individual EQS that was set for Benzo(a)pyrene together with the sum of Benzo(b)fluoranthene and Benzo(k)fluor-anthene. The 2013 EQS Directive requires that Benzo(a)pyrene is used as a marker for the group. In addition to this, the new AA-EQS levels have decreased significantly by a factor of 295, since the monitoring strategy employed in 2012 / 2013 detection limits at 0.001µg/L.

In the case of benzo(g,h,i)perylene, the revised MAC-EQS is 0.00082µg/L. Since the limit tested was 0.001µg/L, it is still unknown whether this change will cause any significant concerns. With regards to the levels of benzo(b)fluoranthene as well as benzo(k) fluoranthene with the newly defined parametrics of 0.017 µg/L the change is not expected to be significant. Whether PAHs will be problematic remains to be seen.

(c) ***Nickel and Fluoranthene*** - With respect to nickel and fluoranthene the risk of failure in coastal water chemical status is unknown (refer to Tables 6.11 and 6.12). When comparing the achieved results with their respective revised EQS, some but not significant, exceedances in the EQS were recorded.

The revised decrease in the allowed nickel EQS by 25% in inland surface waters is likely to be problematic as the existing 2012/2013 monitoring values are very close, and in some cases also in breach of the 4 µg/L level.

Coastal water body & ***mon. station***		LEAD RESULTS IN COASTAL WATER MONITORING MAY 2012- JULY 2013												
Month of analysis		1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th	11th	12th	13th
MTC101														
MTC102	*CS02*		✓	✓	✓			✓	✓	✓				
MTC103	*CS03*		✓			✓	✓	✓		✓				
	CN03-1													
	CN03-2		✓		✓	✓	✓	✓	✓					
MTC104	*CP04-1*					✓	✓	✓						
MTC105	*CP05*		✓	✓			✓	✓	✓				✓	
	CN05-1	✓		✓		✓	✓	✓						
MTC106	*CP06-1*	✓	✓			✓	✓		✓	✓			✓	
MTC107	*CP07*		✓			✓	✓	✓						
MTC108														
MTC109	*CS09*			✓		✓	✓	✓	✓	✓				

	EXCEEDANCE IN THE 2013 EQS VALUE FOR LEAD IN INLAND SURFACE WATERS WATER MONITORING RESULTS DECEMBER 2011- FEBRUARY 2012									
Station number	Salini	Il-Maghluq ta' Marsacala Ma	Il-Ballut ta' Marsaxlokk	Baħrija Valley system	Wied il-Luq	Wied il-Lunzjata	Is-Simar	L-Għadira	IL-Qattara	L-Għadira ta' Sarraflu
December 2011	✓	✓	✓	✓				✓	✓	✓
January 2012										
February 2012			✓	✓		✓			✓	

Table 6.16: Showing the water bodies where the level of lead exceeded the revised EQS 2013 value of 1.3 μg/L, in at least one replicate of the analysis for any given sample taken at their respective monitoring sites.

Coastal water body & *mon. station*		NICKEL COASTAL WATER MONITORING RESULTS MAY 2012- JULY 2013												
Month of analysis		1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th	11th	12th	13th
MTC101														
MTC102	*CS02*													
MTC103	*CS03*				✓									
	CN03-1													
	CN03-2				✓									
MTC104	*CP04-1*	✓												
MTC105	*CP05*				✓	✓	✓		✓					
	CN05-1				✓									
MTC106	*CP06-1*				✓	✓			✓					
MTC107	*CP07*				✓	✓								
MTC108														
MTC109	*CS09*	✓			✓				✓					

	EXCEEDANCE IN THE 2013 EQS VALUE OF 4 µg/L FOR NICKEL IN INLAND SURFACE AND TRANSITIONAL WATER MONITORING RESULTS DECEMBER 2011-FEBRUARY 2012									
Station nnumber[230]	Salini	Il-Maghluq ta' Marsacala Ma	Il-Ballut ta' Marsaxlokk	Baħrija Valley system	Wied il-Luq	Wied il-Lunzjata	Is-Simar	L-Għadira	IL-Qattara	L-Għadira ta' Sarraflu
December 2011			✓						✓	
January 2012	✓	✓	✓						✓	
February 2012										

Table 6.17**:** Showing the water bodies where the level of Nickel exceeded the revised EQS 2013 value of 8.6 µg/L, in at least one replicate of the analysis for any given sample taken at their respective monitoring sites.

		FLUORANTHENE COASTAL WATER MONITORING RESULTS MAY 2012- JULY 2013												
Month of analysis		1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th	11th	12th	13th
MTC101														
MTC102	*CS02*										✓	✓	✓	
MTC103	*CS03*									✓	✓	✓		
	CN03-1													
	CN03-2											✓	✓	✓
MTC104	*CP04-1*										✓			
MTC105	*CP05*											✓	✓	✓
	CN05-1											✓		
MTC106	*CP06-1*									✓	✓	✓	✓	
MTC107	*CP07*											✓		
MTC108														
MTC109	*CS09*	✓									✓	✓		

Fluoranthene- did not exceed EQS 2008 values in any of the water bodies

Table 6.18: Showing the water bodies where the level of Fluoranthene exceeded the revised EQS 2013 value of 0.0063 µg/L, in at least one replicate of the analysis for any given sample, taken at their respective monitoring sites.

6.4.5 Overall Chemical Status of Coastal Water Bodies in the Maltese Water Catchment District

Table 6.13 provides the overall status classification of the coastal waters of the Maltese Islands. Where one contaminant was identified to be a failing parameter the coastal water body concerned was still given a 'good' quality status ranking. Where more than one substance was failing, the water body status was classified as 'bad'. Overall status classification of each coastal water body considering all other parameters is illustrated in Figure 6.12.

Mercury was the sole parameter that caused a failure in chemical status in all waters. It has therefore been singled out and represented in Figure 6.13.

Mon. station	Overall Status	Chemical quality of the Water matrix	Chemical quality of the sediment matrix	Chemical quality of the biota matrix *
CS 01	**Good**	Chemical monitoring was not carried out at Surveillance station during first cycle. The status classification provided in Figure 6.13 is based on expert judgement.		
CS 02	**Good**	■ Bad **mercury** exceeded 2008 EQS several times during the year	■ Good	■ Good
CS 03	**Good**	■ Bad **mercury** exceeded 2008 EQS several times during the year,	■ Good	■ Good
CP 04-1	**Bad**	■ Bad **Mercury** exceeded 2008 EQS several times during the year	■ Bad Mercury , PAHs	■ Good
CP 04-2				■ Good
CP 05	**Bad**	■ Bad **Mercury** exceeded 2008 EQS several times during the year	■ Bad PAHs	
CP 06-1	**Bad**	■ Bad **Mercury** exceeded 2008 EQS several times during the year,	■ Bad Lead, PAHs	
CP 06-2			■ Bad Lead	■ Good
CP 07	**Good**	■ Bad **Mercury** exceeded 2008 EQS several times during the year	■ Good	■ Good
CS 08	**Good**	Chemical monitoring was not carried out at Surveillance station during first cycle. The status classification provided in Figure 6.13 is based on expert judgement.		
CS 09	**Good**	■ Bad **Mercury** exceeded 2008 EQS several times during the year	■ Good	■ Good

Table 6.19: Overall classification of chemical status in the surveillance and operational monitoring stations in coastal waters
* Chemical status based on concentrations of mercury, hexachlorobenzene and hexachlorobutadiene in *Posidonia oceanica* rhizomes

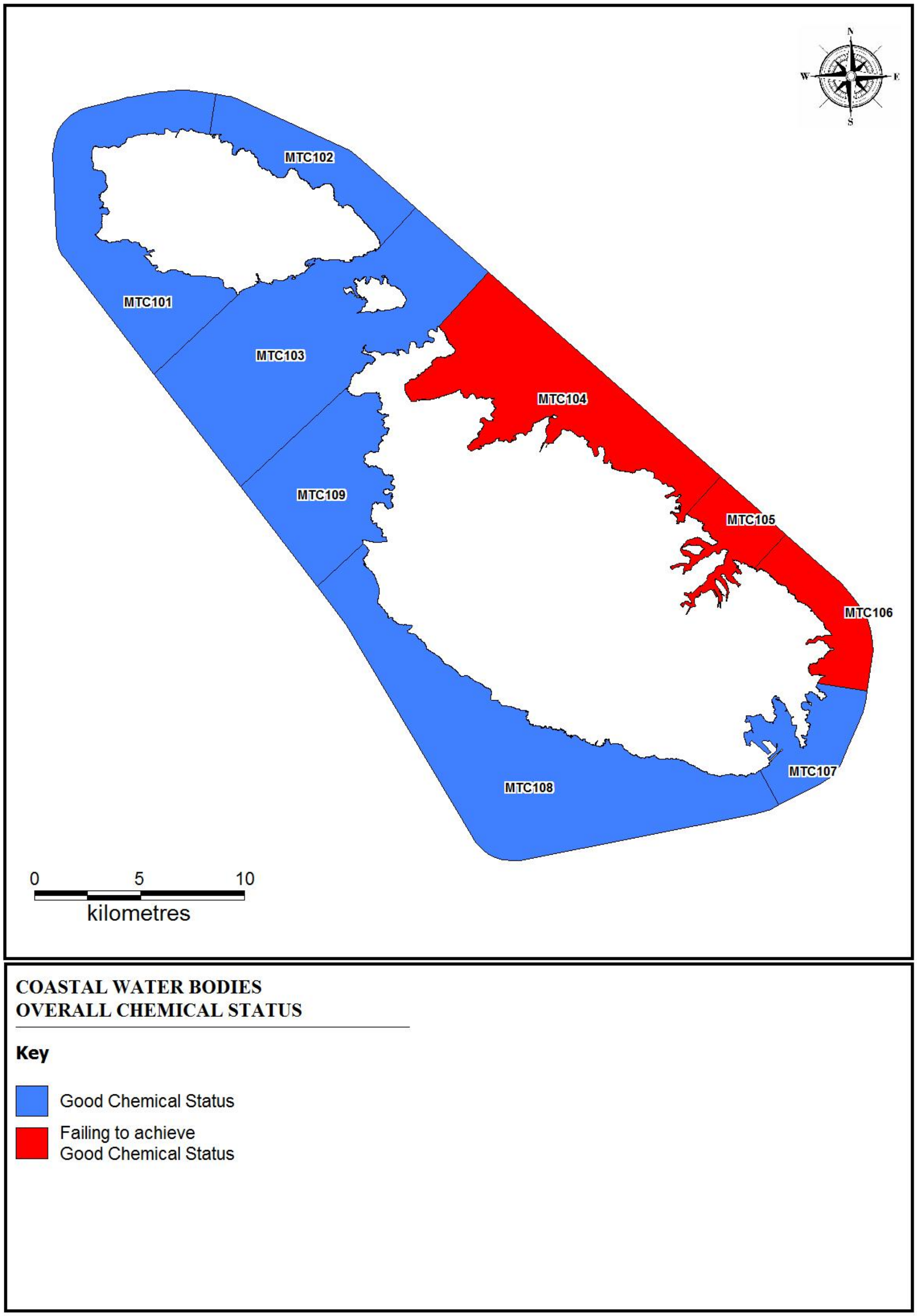


Figure 6.12: Overall chemical status in designated coastal water bodies

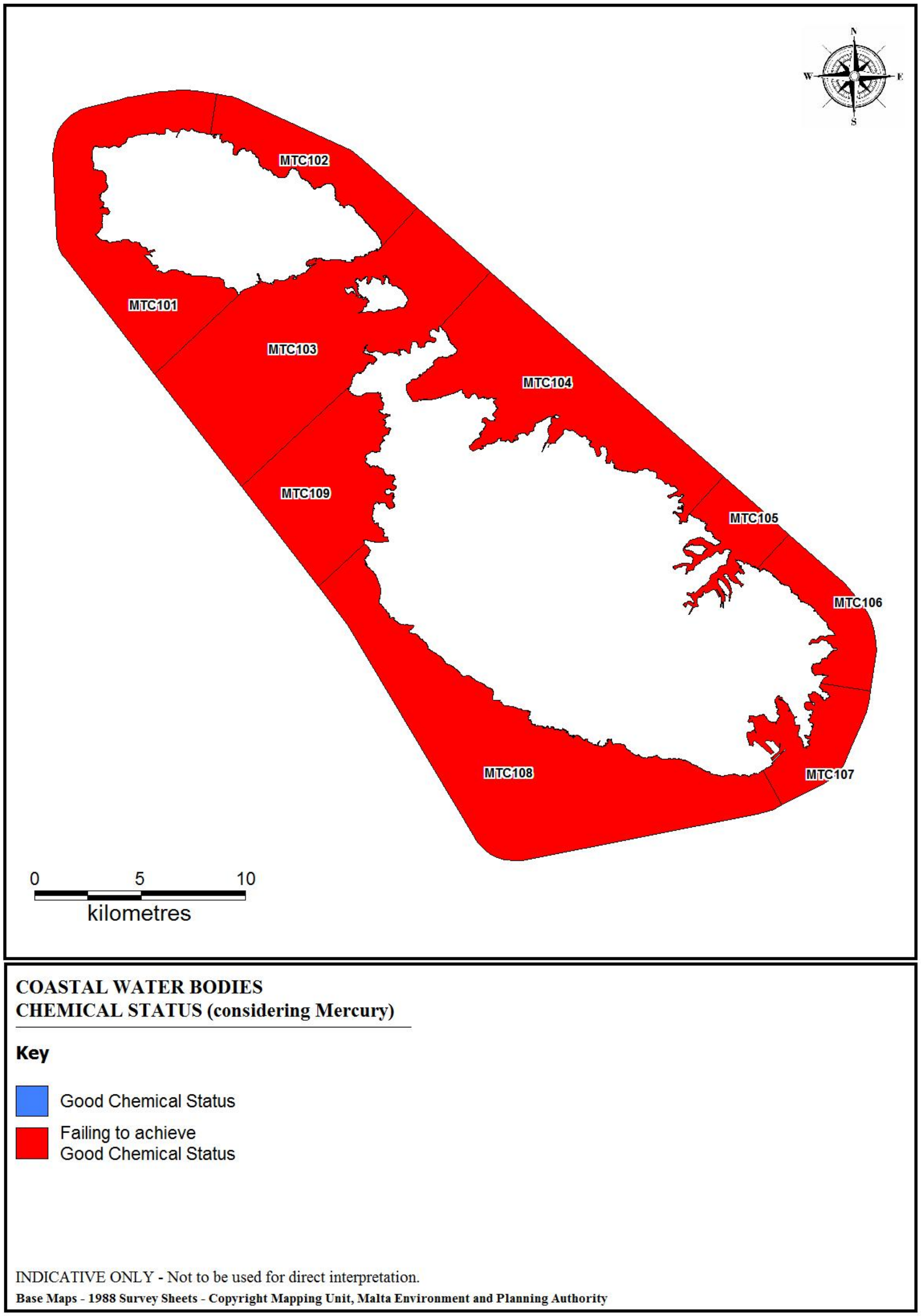


Figure 6.13: Chemical status in designated coastal water bodies considering the 2008 EQS established for mercury

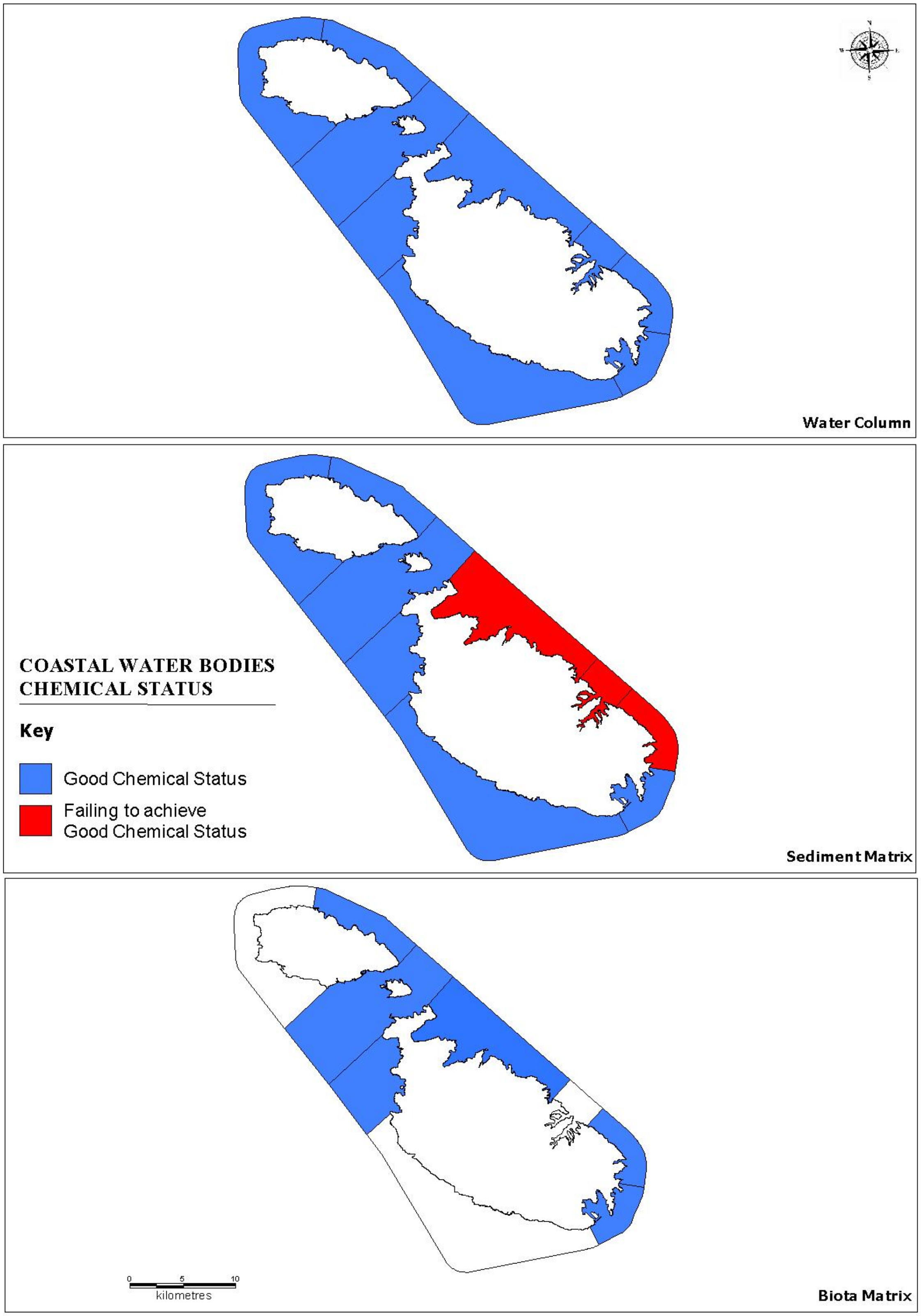
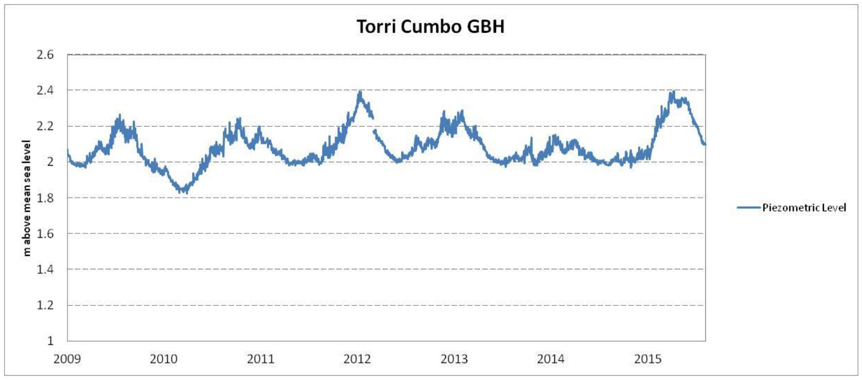


Figure 6.14: Chemical Status per matrix (without Mercury)

6.5.1 Assessment of Groundwater Quantitative Status

The monitoring data collected from the water level monitoring stations located in the Mean Sea Level Aquifer systems, shows a fairly stable piezometric (water table) environment during the period covered by the 1st Water Catchment Management Plan. These monitoring results are an indicator that the freshwater lens sustained in the sea-level aquifer systems are approaching a steady state, and thereby that long-term differences between abstraction and recharge are marginal.



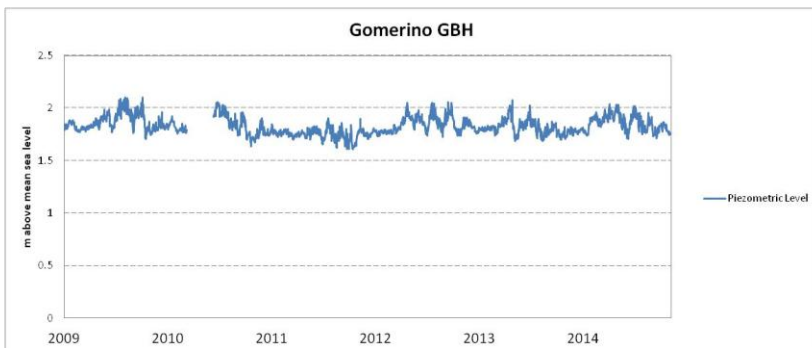


Figure 6.15 - Water Level readings from two gauging boreholes in the Malta mean sea-level aquifer system
Torri Cumbo GBH (Central Malta), Gomerino GBH (Western Malta)

Although, from the Water Framework Directive's point of view, achievement of a steady state is indicative of Good Groundwater Quantitative Status given that the attainment of these conditions requires abstraction (outflow) to be of the order of the mean annual recharge (inflow); from a national perspective efforts need to be undertaken to slowly induce the lens into a positive unsteady state leading to 'better' steady state conditions. In simple terms, this means that a net balance in recharge will be sought to induce the lens to higher piezometric levels.

Since, as indicated in the monitoring chapter, efforts to undertake water level measurements in the perched aquifer systems have failed, mainly due to the specific hydro-geological characteristics of these aquifer systems; quantitative assessments have been based on water balance models.

In as much a water balance tool has been developed for the purpose of the 2nd Water Catchment Management Plan, which assesses both the status of the respective aquifer typologies and that of the single groundwater bodies.

The water balance model is developed on the basic water balance equation, namely:

Input – Output = ΔStorage

In the case of the Mean Sea Level Aquifer Systems, the model can be represented by the following equation:

NR+LK+AR-WSC-AGRI-OTH-ND = ΔStorage

whilst in the case of the Perched Aquifer Systems, the equation needs to be slightly modified:

NR+AR-WSC-AGRI-OTH-LK = ΔStorage

where:
NR – Natural Recharge
LK – Leakage from Perched Aquifer
AR – Artificial Recharge
WSC – WSC Groundwater Abstraction
AGRI – Agricultural Groundwater Abstraction
OTH – Groundwater Abstraction by the other sectors
ND – Natural Groundwater Discharge

The water balance model for the mean sea-level aquifer systems is represented in the flow diagram below.

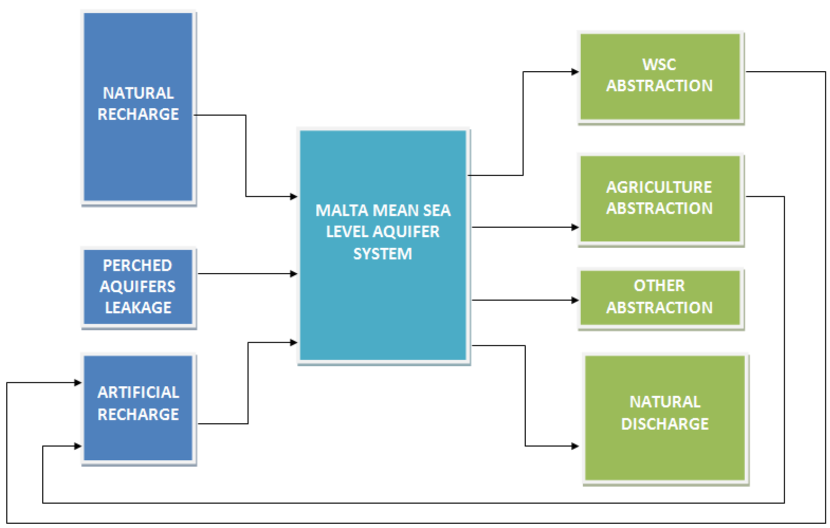


Figure 6.16 – Water balance scheme for Mean Sea Level Aquifer systems

The components making up the water balance scheme are described in the following section:

(i) Natural Recharge
The long-term natural recharge to the aquifer systems is a measure of the 'effective rainfall' – i.e. that part of precipitation which infiltrates to groundwater. In the case of the sea-level aquifer systems, this is assumed to account for 27% of the mean annual rainfall, where losses due to evapotranspiration and runoff are estimated to account for 63% and 10% respectively.

In the case of the Perched Aquifer systems, the effective rainfall component is increased to take into account the increased runoff retention capacity of the karstic (garigue) surface catchment areas of these aquifer systems. In this case, the effective rainfall is assumed to account for 35% of the mean annual rainfall, where losses due to evapotranspiration and runoff are estimated to account for 63% and 2% respectively.

Figure 6.17 – Characteristic Karstic (garigue) surface in the Upper Coralline Limestone.

These water balance coefficients are based on hydrodynamic modelling studies undertaken by BRGM (1991). The development of the new hydrodynamic models planned under the 2nd WCMP will support the progressive reduction of uncertainty in the determination of these coefficients.

(ii) Leakage from the Perched Aquifer Systems

The perched aquifer systems are estimated to contribute a depth of 63mm per annum to the underlying sea-level aquifer systems as infiltration through the Blue Clay formation. This leakage occurs mainly through inconsistencies in the Blue Clay formation arising from subterranean subsidence structures, patch-reef formations and other geo-structural inconsistencies.

In the water balance models of the perched aquifer systems, this component will be represented as a loss (output) from the aquifer system.

The estimated leakage depth through the Blue Clay formation is based on groundwater body models developed by BRGM (1991).

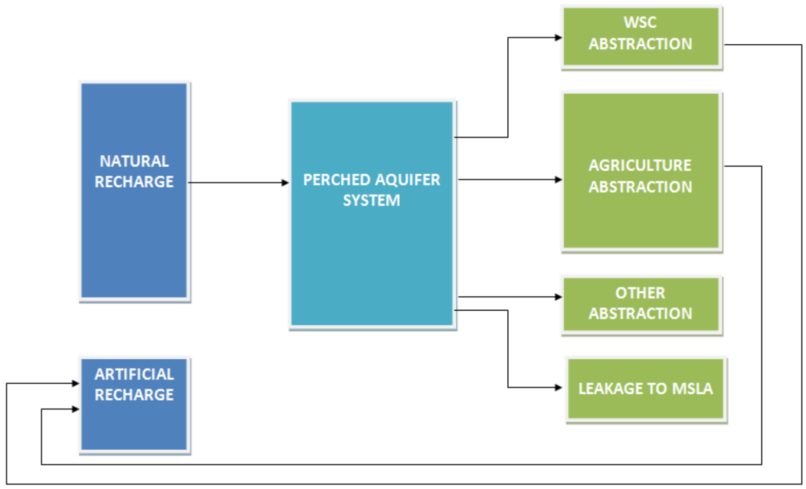


Figure 6.18 – Water balance scheme for Perched Aquifer Systems

(iii) Artificial Recharge

Artificial recharge to the aquifer systems in considered to be comprised of three components, namely

- return flow from irrigation, which is assumed at 20% of the net irrigation water applied over the surface catchment area of the aquifer system;
- leakages from the public distribution system, which takes into account leakages from both the municipal water distribution system and the sewer system; and
- enhanced recharge from Managed Aquifer Recharge schemes such as valley dams and roadside soakaways.

Return flow from irrigation is based on studies undertaken by the USGS in similar climatic conditions. *"In many irrigated areas, about 75-85 percent of the applied water is lost to evapotranspiration and retained in the crops (referred to as consumptive use). The remainder of the water either infiltrates through the soil zone to recharge groundwater or it returns to a local surface-water body through the sub-soil drainage systems (referred to as irrigation return flow). The quantity of irrigation water that recharges groundwater is usually significant relative to recharge from precipitation because large irrigation systems commonly are in regions of low precipitation and low natural recharge".* It is planned that the development of soil-water balance models will be attempted during the course of the 2nd WCMP to enable the detailed assessment of this water balance parameter under local conditions.

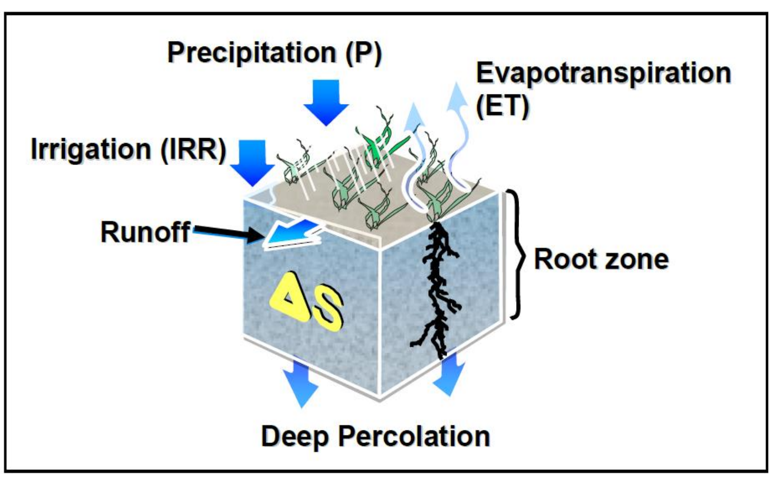


Figure 6.19 – Components of a soil-water balance model

Leakages from the municipal distribution system are assumed at 3.5 million m^3 per year, the current leakage levels reported by the Water Services Corporation. In the absence of direct measurement data on leakages from the sewer systems, these are being assumed at 4 million m^3 per year, based on a fixed percentage of water flow generated from use. This assumption therefore takes into consideration the water distributed by the Water Services Corporation and the flows treated at the islands' three wastewater treatment plants.

A component which takes into consideration the impact of MAR schemes is also introduced, and its contribution is assumed as the storage capacity of the existing MAR facilities, assuming a conservative 1.5 time use factor per year.

(iv) Abstraction by the Water Services Corporation

The abstraction of groundwater by the Water Services Corporation is metered, and thus real measured results are presented in the water balance model. Mean groundwater abstraction by the WSC in 2015 is indicated as 14 million m^3.

(v) Abstraction by the Agricultural Sector

The abstraction by the agricultural sector has been estimated on a triangulation of models and partitioned between the different aquifer systems on the basis of the proportion of agricultural land area present on the surface catchment area of the particular aquifer system.

The models used to assess the irrigation demand of the sector are:

(i) **Borehole Metering Model:** where readings from metered boreholes were extrapolated on a 55:45 ratio to take into account the abstraction of irrigation water from unmetered 'old' wells (spejjer). These 'old' wells have not been metered due to either their low flow (<1m^3/day) or the technical infeasibility of fixing flow meters to the source, either because the source is a spring (gravity flow of groundwater) or has no fixed pumping equipment. The extrapolation ratio is based on the relative proportion of irrigated land present on the surface catchment area of the mean sea level aquifer systems (where metered boreholes are primarily located) and the perched aquifer systems. This model is currently based on a sample of around 25% of all significant registered agricultural groundwater abstraction sources, for which there is a full one-year of collected metering data;

(ii) **Agricultural Land-use model:** an agricultural water demand model based on FAO's CROPWAT software package. CROPWAT is a computer program for the calculation of crop water requirements and irrigation requirements based on soil, climate and crop data. In addition, the program allows the development of irrigation schedules for different management conditions and the calculation of scheme water supply for varying crop patterns. CROPWAT can also be used to evaluate farmers' irrigation practices and to estimate crop performance under both rainfed and irrigated conditions. During this modelling exercise two scenarios were considered, namely the total irrigated land and the total irrigated land less lands classified by NSO as kitchen gardens; and

(iii) **Crop Production model:** an assessment of the water required for the cultivation of the crops sold through the organised farmers markets (pitkalija) which uses FAO coefficients specific for semi-arid climatic conditions for transforming crop tonnage into net irrigation water requirements. A 70% irrigation efficiency was assumed in this model.

The three models indicate a range in irrigation water demand between 10 and 18 million m^3, for 2013. For the purpose of the water balance calculation, the highest water demand estimate from these models has been used, that is 18 million m^3.

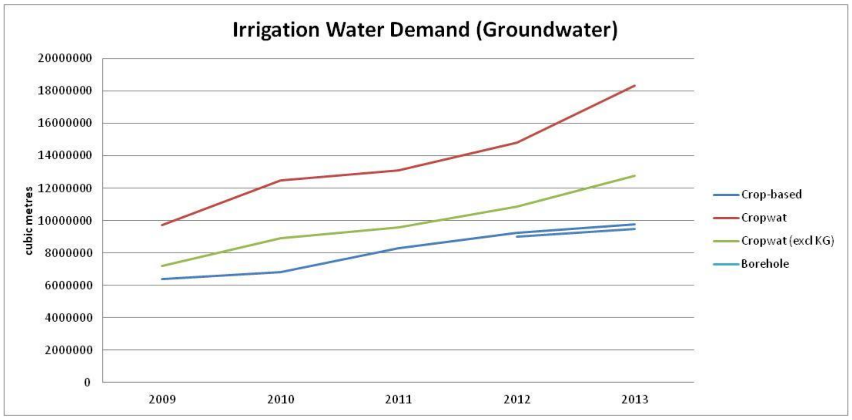


Figure 6.20: Irrigation water demand

The irrigation yield of each aquifer system typology was then partitioned on the ratio of the agricultural land area located on the surface catchment area of each respective aquifer typology. The ensuing partitioning ratios are:

Malta Mean Sea Level Aquifer system: 38%
Malta Perched Aquifer systems: 31%
Gozo Mean Sea Level Aquifer system: 18%
Gozo Perched Aquifer systems: 13%

Land-use data from NSO agricultural surveys has been utilised for these assessments.

Furthermore, Malta is currently participating in WODA, a collaborative project initiative coordinated by IMPEL (EU Network for the Implementation and Enforcement of Environmental Law), where the use of satellite data for the determination of crop-water demand is being tested. Malta is being used as one of the pilot sites in the project, where the methodologies developed under the project are being applied. The application of this demand modelling methodology during the course of the 2nd WCMP will provide an additional estimate of agricultural water demand which is not dependent of declarations by farmers, and therefore is expected to have a reduced bias.

(vi) Abstraction by other Sectors

This category accounts for the abstraction of the domestic, commercial and industrial sectors. Abstraction levels were calculated on a re-evaluation of the estimation methodology developed in support of the Malta Water Resources Review undertaken by the FAO in 2006. This re-evaluation led to an abstraction level of 5.25 million m^3 for 2015, which shows an increase of around 2 million m^3 on the FAO (2006) levels.

(vii) Natural Discharge to the coast

The natural discharge to the coast for the mean sea level aquifer systems is assumed at 50% of the mean annual recharge. This assumption is based on the numerical models for the aquifer systems developed by BRGM (1991). The development of new numerical models of the aquifer systems during the course of the 2nd WCMP will enable a re-assessment of this water loss factor.

It is noted that during the 2nd WCMP implementation period, efforts will be undertaken to reduce the uncertainty of these water balance calculations through measures seeking to:

- undertake a thorough assessment of the groundwater abstraction of the 'other' sectors, through the development of econometric models,
- develop a fourth model for the determination of agricultural water demand, based on methodology developed under the above mentioned WODA project, and
- developing a numerical model of the sea-level aquifer system which will enable an updated assessment of the natural coastal groundwater discharge.

The results of the water balance model for the four main aquifer typologies in the Maltese islands are presented hereunder:

Aquifer System	Natural Recharge Mm^3	Leakage from Perched Aquifers Mm^3	Artificial Recharge Mm^3	WSC Abstraction Mm^3	Agriculture Abstraction Mm^3	Other Sectors Abstraction Mm^3	Natural Discharge Mm^3	INFLOW Mm^3	OUTFLOW Mm^3	BALANCE Mm^3
Malta Mean Sea Level Aquifer System	28.8	1.4	6.25	(11.2)	(7.5)	(3)	(18)	36.25	(39.7)	**(3.45)**
Malta Perched Aquifer Systems	11	(1.4)	2.7	(0.8)	(5.6)	(1)	0	13.7	(8.8)	**4.9**
Gozo Mean Sea Level Aquifer System	9.75	0.75	2.35	(2)	(3.5)	(1)	(6.4)	12.85	(12.9)	**(0.05)**
Gozo Perched Aquifer System	2.2	(0.75)	0.9	0	(2)	(0.25)	0	3.3	(3.0)	**0.3**

Table 6.20: Water Balance Model for main aquifer typologies
Note: Numbers marked in ( ) indicate negative figures

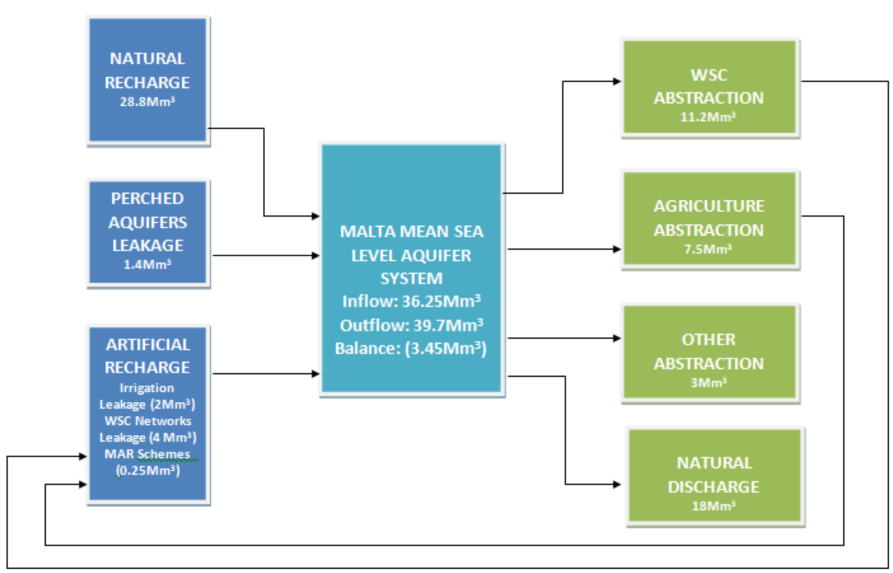


Figure 6.21: Water Balance Assessment for the Malta Mean Sea Level Aquifer System

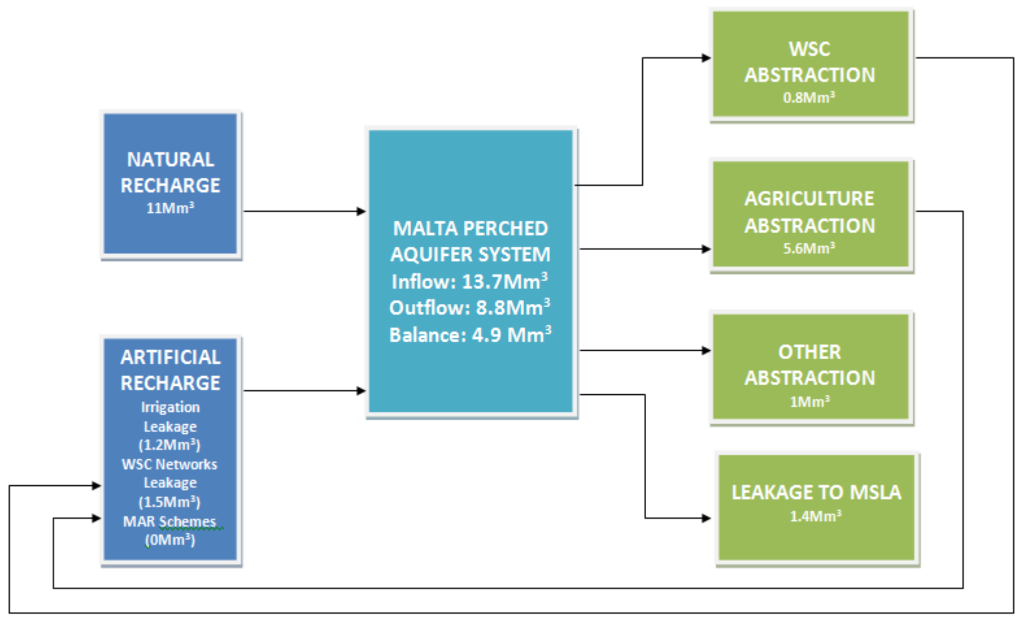


Figure 6.22: Water Balance Assessment for the Malta Perched Aquifer Systems

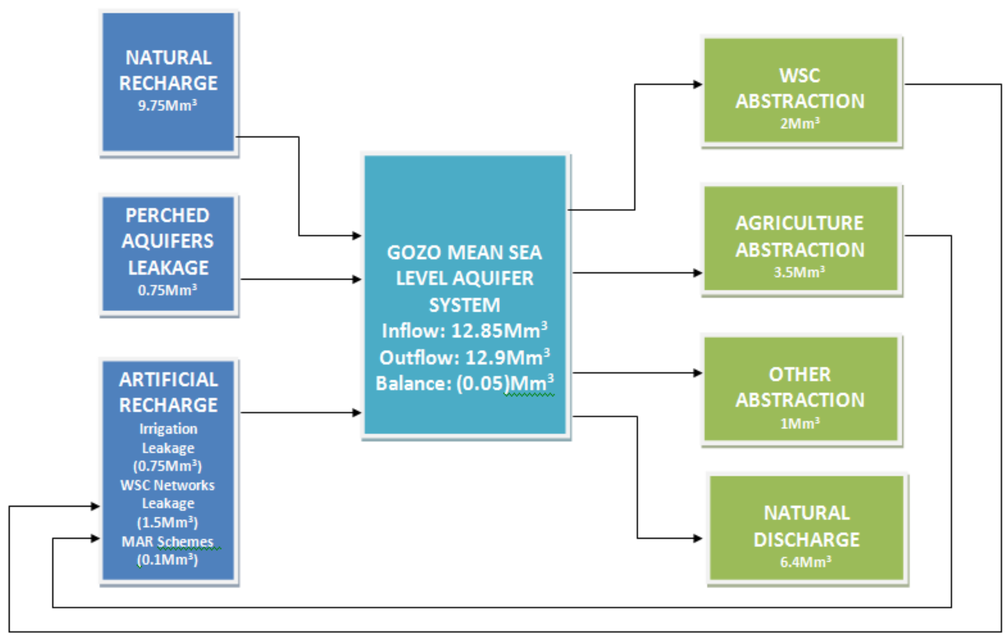


Figure 6.23: Water Balance Assessment for the Gozo Mean Sea Level Aquifer Systems

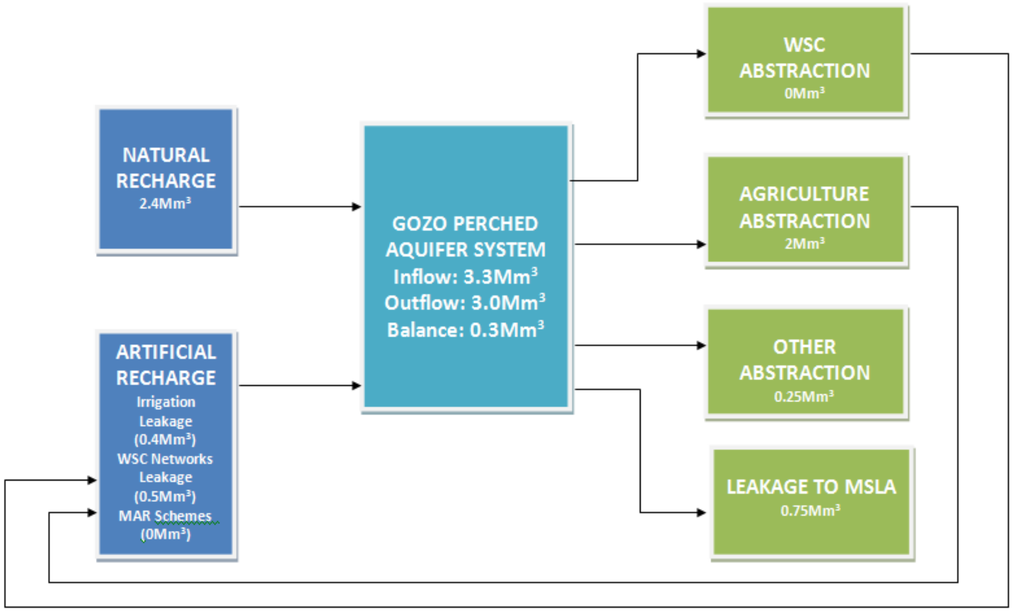


Figure 6.24: Water Balance Assessment for the Gozo Perched Aquifer Systems

The results of the water balance models were then extrapolated on a groundwater body basis and presented in table 6.15. The ensuing information was used to develop the 2015 groundwater quantitative status map for the Malta Water Catchment District which indicates that:
(i) the two main Lower Coralline Limestone (mean sea level) aquifer systems are in poor quantitative status,
(ii) the Upper Coralline Limestone aquifer systems (12 bodies of groundwater) are in good quantitative status,
(iii) the gap between recharge and abstraction has increased in the Malta mean sea-level aquifer system and decreased in the Gozo mean sea-level aquifer system.

Groundwater Body	**Size (km^2)**	**Inflow (Mm^3)**	**Outflow (Mm^3)**	**Balance (Mm^3)**	**Status**
Malta Mean Sea Level	216.6	36.25	39.7	-3.45	Poor Status
Rabat Dingli Perched	22.6	5.41	3.48	1.94	Good Status
Mgarr-Wardija Perched	13.7	3.28	2.11	1.17	Good Status
Pwales Coastal	2.8	0.16	0.16	0.0	Good Status
Mizieb Mean Sea Level	5.2	1.25	0.8	0.45	Good Status
Mellieha Perched	4.5	1.08	0.69	0.39	Good Status
Mellieha Coastal	2.9	0.69	0.45	0.25	Good Status
Marfa Coastal	5.5	1.32	0.85	0.47	Good Status
Comino Mean Sea Level	2.7	0.64	0.35	0.29	Good Status
Gozo Mean Sea Level	65.8	12.85	12.9	-0.05	Poor Status
Ghajnsielem Perched	2.7	0.71	0.64	0.06	Good Status
Nadur Perched	5.0	1.31	1.19	0.12	Good Status
Xaghra Perched	3.0	0.78	0.71	0.07	Good Status
Zebbug Perched	0.4	0.1	0.09	0.01	Good Status
Victoria-Kercem Perched	1.5	0.39	0.376	0.04	Good Status

Table 6.21: Application of the Water Balance Model at Groundwater Body level

From an ecosystems protection perspective, it is noted that the two bodies of groundwater supporting surface water bodies, namely the Rabat-Dingli and the Victoria-Kercem perched groundwater bodies are in good quantitative status. The outflow from the perched aquifer systems includes an allocation for outflowing groundwater from the natural springs which sustain these surface water bodies.

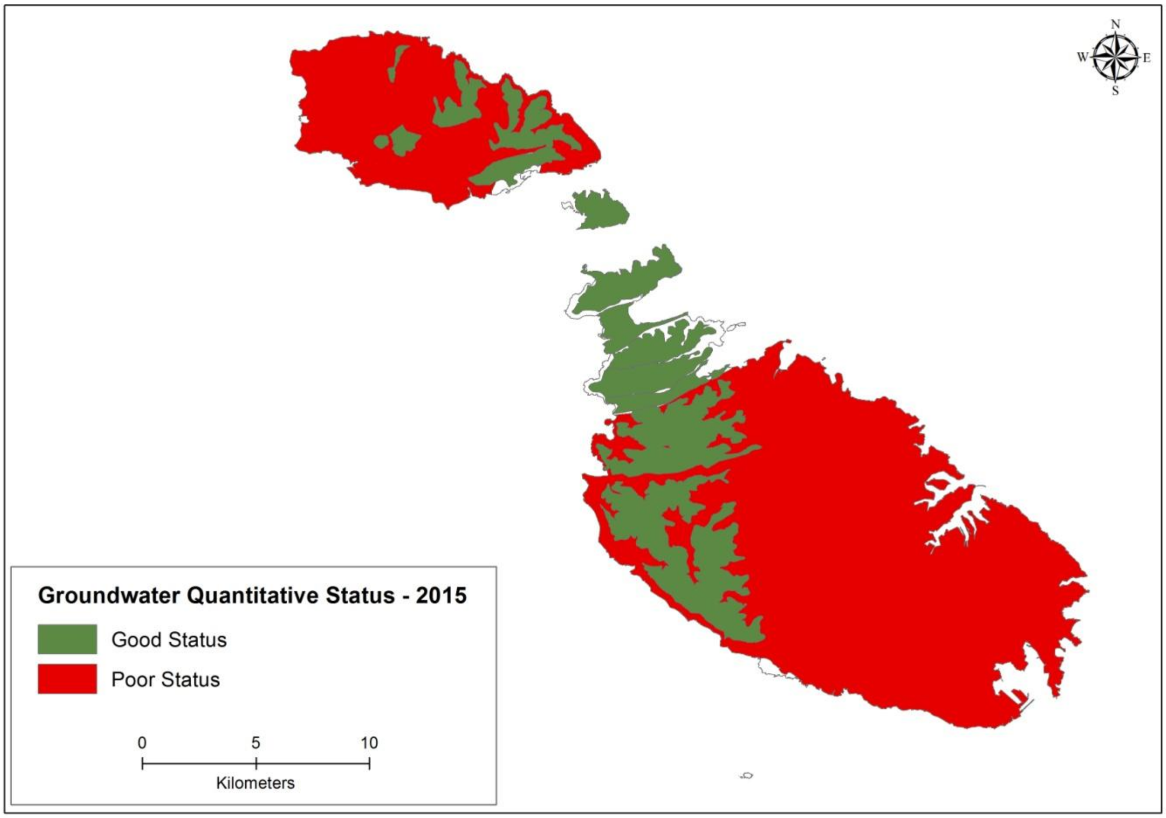


Figure 6.25: 2015 - Groundwater Body Quantitative Status Assessment

6.5.2 Assessment of Good Groundwater Qualitative Status

The qualitative status assessment of the groundwater bodies is based on the monitoring results on the WFD surveillance and operational groundwater quality monitoring networks.

The results from these monitoring stations indicate the following issues:

Nitrate Contamination

All groundwater bodies, with the exception of four: Mizieb Mean Sea Level, Qammiegh Coastal, Comino Mean Sea Level and the Gozo Mean Sea Level indicate levels of mean nitrate content in excess of the parametric value of 50mg/l.

The mean values for Nitrate content in each body of groundwater over the 1st Water Catchment Management cycle are present in table 6.16.

Groundwater Body	Mean Nitrate Content (2009-2014) mg/l
Malta Mean Sea Level	66.9
Rabat Dingli Perched	193.3
Mgarr-Wardija Perched	117.6
Pwales Coastal	407.6
Mizieb Mean Sea Level	43.3
Mellieha Perched	167.5
Mellieha Coastal	33.3
Marfa Coastal	217.4
Comino Mean Sea Level	15.8
Gozo Mean Sea Level	48.0
Ghajnsielem Perched	119.0
Nadur Perched	79.7
Xaghra Perched	237.5
Zebbug Perched	215.9
Victoria-Kercem Perched	226.7

Table 6.22: Mean Nitrate content in bodies of groundwater

Pesticides and Heavy Metals

Analysis for pesticides and heavy metals undertaken during the 1st Water Catchment Management Cycle did not record any occurrences of detection of pollution by pesticides and heavy metals in groundwater samples. With respect to pesticides, it is noted that analyses focused on particular active ingredients during the surveillance monitoring exercise and 'total pesticides' during the operational monitoring programme.

Sea-Water Intrusion Related Parameters

Sea-water intrusion was assessed on the basis of the mean Electrical Conductivity content in the groundwater bodies. Mean results for each body of groundwater over the period 2009-2104 were compared to the threshold values established in the 1st Water Catchment Management Plan for sea-water intrusion related parameters namely:

- Sea Level Aquifer Systems: Electrical Conductivity 4500uS/cm
- Perched Aquifer Systems: Electrical Conductivity 2000uS/cm
- Coastal Aquifer Systems: Electrical Conductivity 3000uS/cm.

Groundwater Body	Mean EConductivity Content (2009-2014) uS/cm
Malta Mean Sea Level	2900.04
Rabat Dingli Perched	1619.19
Mgarr-Wardija Perched	1302.98
Pwales Coastal	9206.72
Mizieb Mean Sea Level	2572.93
Mellieha Perched	2623.54
Mellieha Coastal	2139.44
Marfa Coastal	3720.27
Comino Mean Sea Level	2485.75
Gozo Mean Sea Level	2643.88
Ghajnsielem Perched	1822.0
Nadur Perched	992.2
Xaghra Perched	2293.53
Zebbug Perched	1780.62
Victoria-Kercem Perched	2307.08

Table 6.23: Mean EConductivity content in bodies of groundwater

Five groundwater bodies, namely Pwales Coastal, Mellieha Perched, Marfa Coastal, Xaghra Perched and Victoria-Kercem Perched exhibit electrical conductivity values exceeding the established threshold values. In the case of the perched aquifer systems, the high conductivity values indicate the possibility of the introduction of high salinity waters from other aquifer systems, through the use of these waters on their surface catchment area.

For the purpose of qualitative status assessment, groundwater bodies were also assessed for the following issues:
(i) Associated Surface Waters Test: the ability of the bodies of groundwater to sustain associated surface water systems, and
(ii) Drinking Water Tests: if the current status of the body of groundwater will require further treatment to that already in place for the production of drinking water.

A detailed assessment of the qualitative status of the groundwater bodies based on the assessment procedure developed under CIS Guidance Document No 18 was undertaken, the results of which are presented in table 6.18 below.

Groundwater Body	**General Qualitative Test**	**Saline Intrusion Test**	**Associated Surface Waters Test**	**Drinking Water Test**	**Status Assessment**
Malta Mean Sea Level	Fail	Pass	n/a	Pass	Fail
Rabat Dingli Perched	Fail	Pass	Pass	n/a	Fail
Mgarr-Wardija Perched	Fail	Pass	n/a	Pass	Fail
Pwales Coastal	Fail	Fail	n/a	n/a	Fail
Mizieb Mean Sea Level	Pass	Pass	n/a	Pass	Pass
Mellieha Perched	Fail	Fail	n/a	n/a	Fail
Mellieha Coastal	Pass	Pass	n/a	n/a	Pass
Marfa Coastal	Fail	Fail	n/a	n/a	Fail
Comino Mean Sea Level	Pass	Pass	n/a	n/a	Pass
Gozo Mean Sea Level	Fail	Pass	n/a	Pass	Fail
Ghajnsielem Perched	Fail	Pass	n/a	n/a	Fail
Nadur Perched	Fail	Pass	n/a	n/a	Fail
Xaghra Perched	Fail	Fail	n/a	n/a	Fail
Zebbug Perched	Fail	Pass	n/a	n/a	Fail
Victoria-Kercem Perched	Fail	Fail	Pass	n/a	Fail

Table 6.24: Results of the Qualitative Status Assessment Tests for Groundwater Bodies

The groundwater qualitative status (general status assessment test) is presented in figure 6.26 below, where four tests are considered based on the Nitrate, Pesticide, Sea Water Intrusion and other Chemicals (chloride, sodium, sulphate, boron and heavy metals) tests. The figure 6.27 also undertakes a comparative assessment on the respective status assessment between 2009 and 2015.

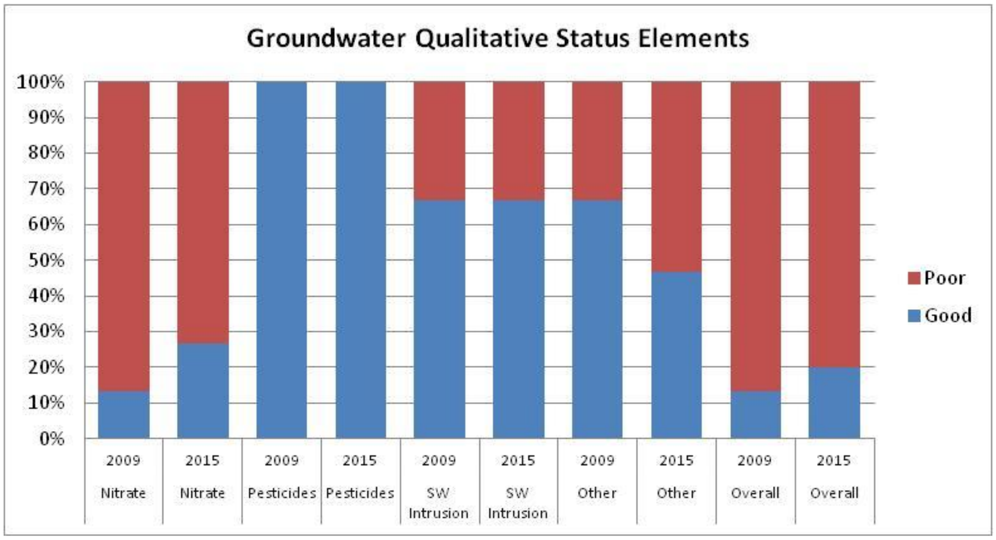


Figure 6.26: Groundwater Qualitative Status Elements

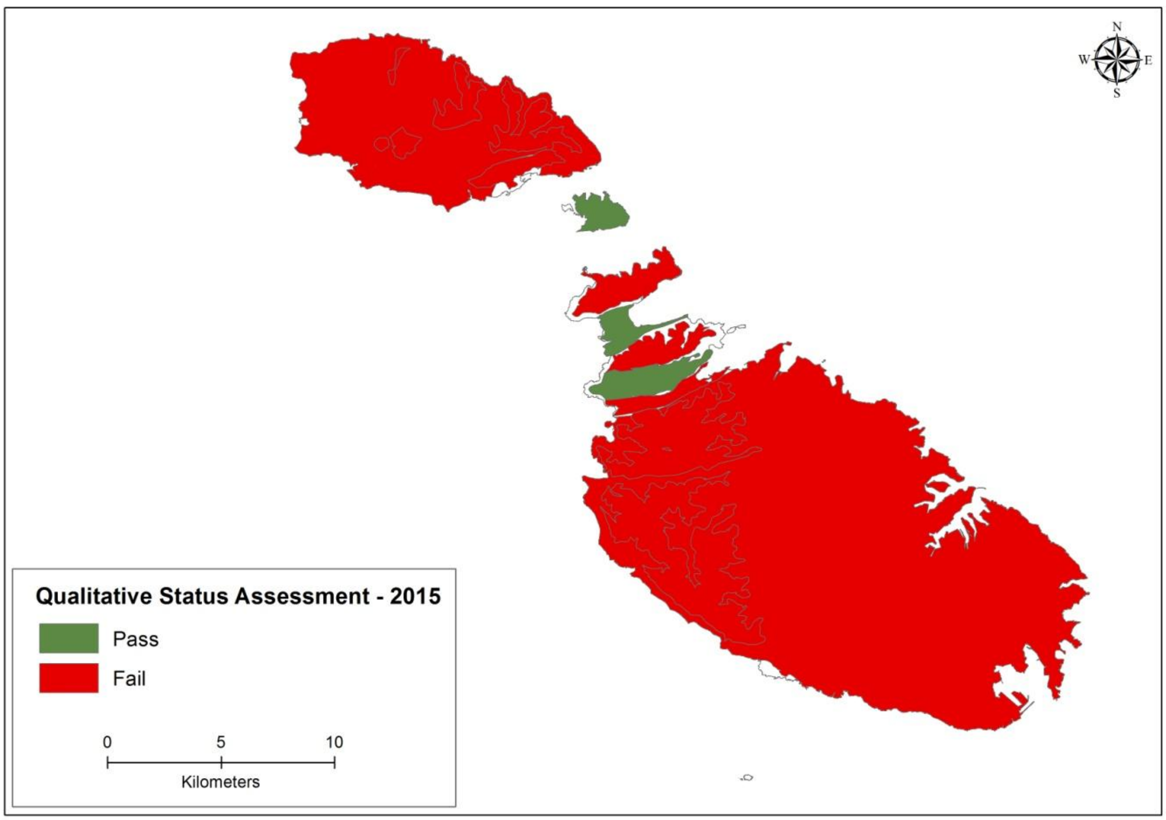


Figure 6.27: Groundwater Qualitative Status (2015)

6.5.3 Trend Assessment

The groundwater quality monitoring results from the surveillance and operational monitoring programmes were assessed for the occurrence of significant trends on a station level. In all, the monitoring programmes undertaken during the 1st water catchment management planning period provided 11 data points for each monitoring station.

Assessments for significant trends were undertaken using the Mann-Kendall assessment method at 95% confidence level for each monitoring station. It is noted that the analysis failed to identify a significant positive or negative trend in a high number of monitoring stations for the major parameters associated with poor status conditions for groundwater in the Malta water catchment district, namely chloride and nitrate. This fact could be indicative that the groundwater systems are reaching stable conditions, with respect to these parameters.

Groundwater Body	**Stations with a significant +ve trend**	**Stations with no significant trend**	**Stations with a significant –ve trend**
Malta Mean Sea Level	0	12	2
Rabat Dingli Perched	2	3	0
Mgarr-Wardija Perched	0	2	0
Pwales Coastal	0	1	0
Mizieb Mean Sea Level	0	1	0
Mellieha Perched	0	1	0
Mellieha Coastal	0	1	0
Marfa Coastal	0	1	0
Comino Mean Sea Level	0	0	1
Gozo Mean Sea Level	0	6	1
Ghajnsielem Perched	0	1	0
Nadur Perched	0	1	0
Xaghra Perched	1	0	0
Zebbug Perched	0	1	0
Victoria-Kercem Perched	0	0	1

Table 6.25: Trend Assessment at Monitoring Station Level – Nitrate Content

Groundwater Body	**Stations with a significant +ve trend**	**Stations with no significant trend**	**Stations with a significant –ve trend**
Malta Mean Sea Level	4	10	0
Rabat Dingli Perched	0	5	0
Mgarr-Wardija Perched	0	2	0
Pwales Coastal	0	1	0
Mizieb Mean Sea Level	1	0	0
Mellieha Perched	0	1	0
Mellieha Coastal	0	1	0
Marfa Coastal	0	1	0
Comino Mean Sea Level	0	1	0
Gozo Mean Sea Level	1	6	0
Ghajnsielem Perched	0	1	0
Nadur Perched	1	0	0
Xaghra Perched	0	1	0
Zebbug Perched	0	1	0
Victoria-Kercem Perched	0	2	0

Table 6.26: Trend Assessment at Monitoring Station Level – Electrical Conductivity Levels

Groundwater Body	Stations with a significant +ve trend	Stations with no significant trend	Stations with a significant –ve trend
Malta Mean Sea Level	6	7	1
Rabat Dingli Perched	1	4	0
Mgarr-Wardija Perched	0	2	0
Pwales Coastal	0	1	0
Mizieb Mean Sea Level	1	0	0
Mellieha Perched	1	0	0
Mellieha Coastal	0	1	0
Marfa Coastal	0	1	0
Comino Mean Sea Level	0	1	0
Gozo Mean Sea Level	2	5	0
Ghajnsielem Perched	0	1	0
Nadur Perched	1	0	0
Xaghra Perched	1	0	0
Zebbug Perched	0	1	0
Victoria-Kercem Perched	0	1	0

Table 6.27: Trend Assessment at Monitoring Station Level – Chloride Content

Trend assessments at monitoring station level were then considered collectively within the groundwater body in which the monitoring stations are located in order to enable the development of a significant trend assessment based on the groundwater body level. In cases where the groundwater body included monitoring stations exhibiting significant positive or negative trends, an assessment of the significance of the monitoring station at the groundwater body level based on the conceptual understanding of the respective groundwater body was undertaken in order to enable a comprehensive trend assessment at the groundwater body level. The results of this assessment are presented in Table 6.22 below.

Groundwater Body	Nitrate Content	Chloride Content	Electrical Conductivity Levels	Sodium Content	Sulphate Content
Malta Mean Sea Level	No	+ve	+ve	No	No
Rabat Dingli Perched	+ve	No	No	No	No
Mgarr-Wardija Perched	No	No	No	No	No
Pwales Coastal	No	No	No	-ve	No
Mizieb Mean Sea Level	No	+ve	+ve	No	+ve
Mellieha Perched	No	+ve	No	No	No
Mellieha Coastal	No	No	No	No	No
Marfa Coastal	No	No	No	No	No
Comino Mean Sea Level	-ve	No	No	No	No
Gozo Mean Sea Level	No	+ve	No	No	No
Ghajnsielem Perched	No	No	No	No	No
Nadur Perched	No	+ve	+ve	-ve	No
Xaghra Perched	+ve	+ve	No	No	No
Zebbug Perched	No	No	No	No	No
Victoria-Kercem Perched	No	No	No	No	No

Table 6.28: Trend Assessment at groundwater body level

Assessments for significant trends undertaken for other parameters included in the Operational Monitoring framework, namely Boron, Zinc, Lead, Copper, Fluoride and Arsenic did not reveal any significant trends.

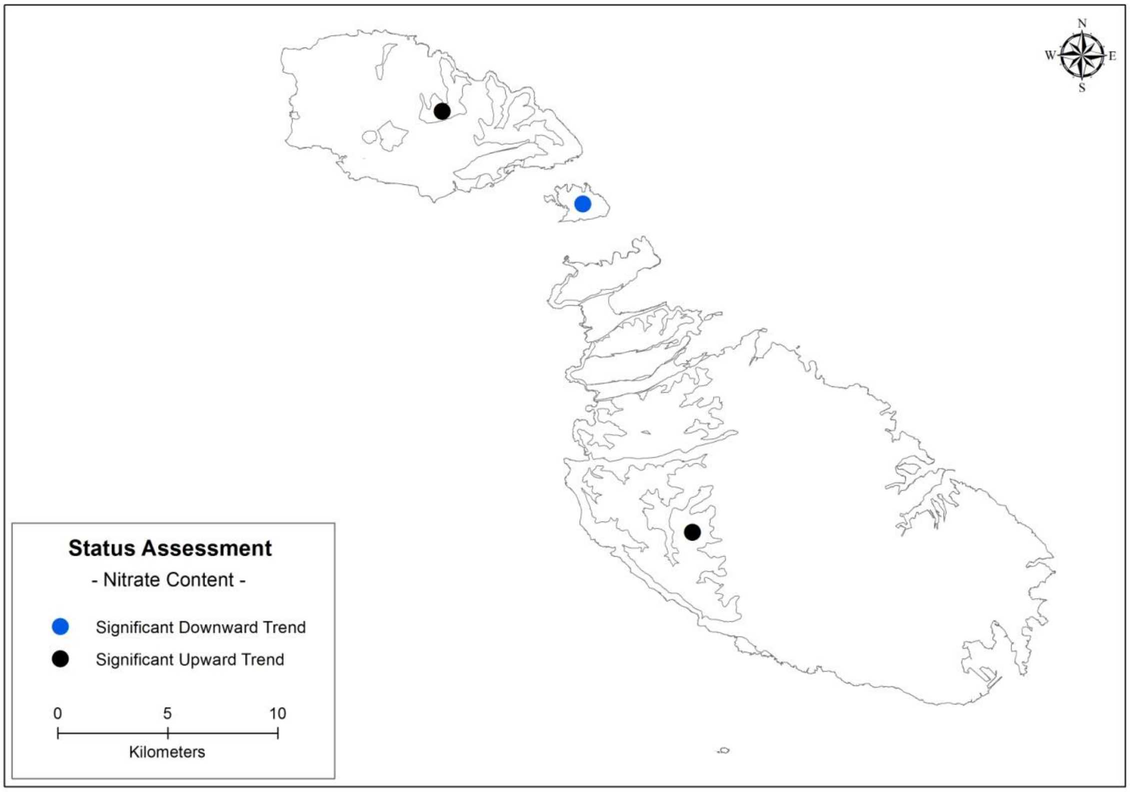


Figure 6.28: Groundwater Trend Assessment at Groundwater Body Level - Nitrate

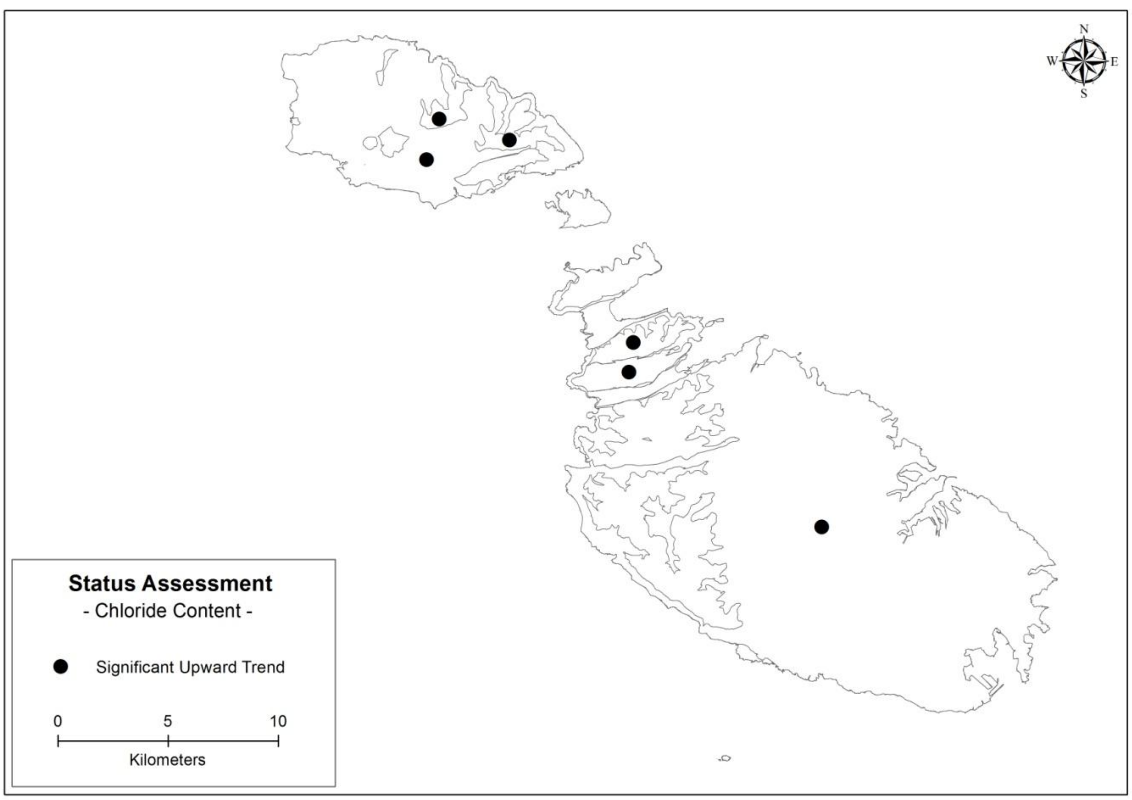


Figure 6.29: Groundwater Trend Assessment at Groundwater Body Level - Chloride

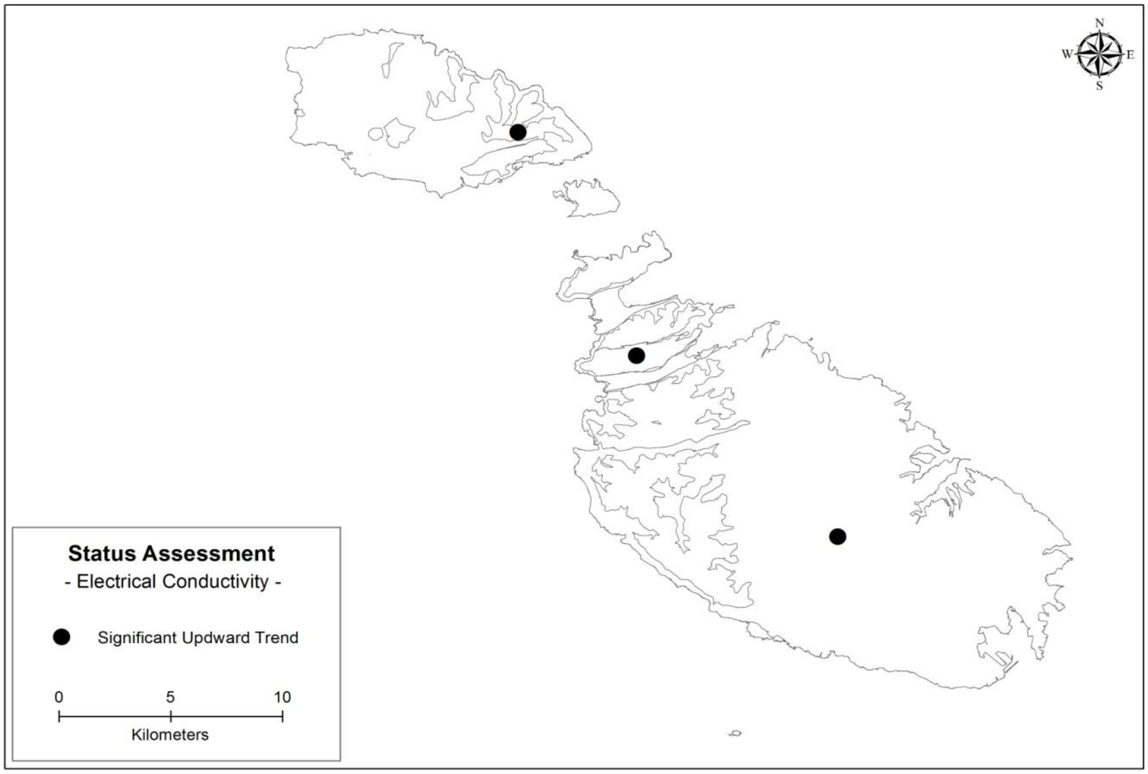


Figure 6.30: Groundwater Trend Assessment at Groundwater Body Level – Electrical Conductivity

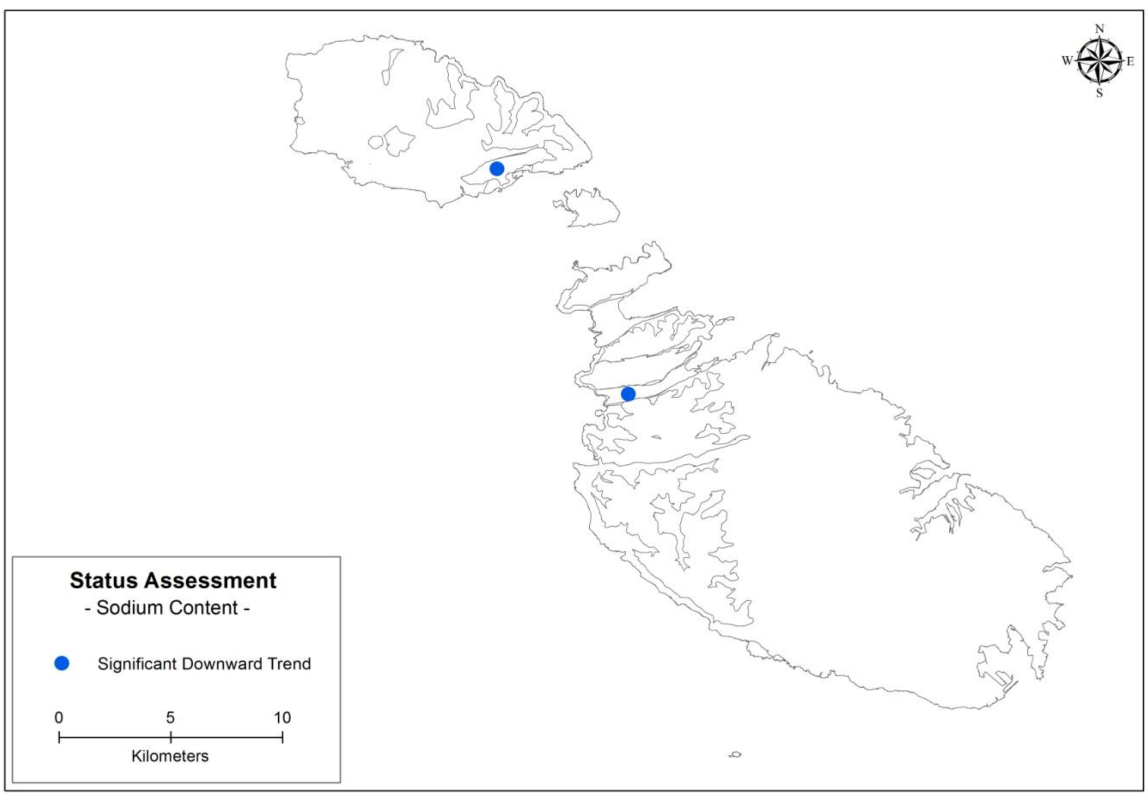


Figure 6.31: Groundwater Trend Assessment at Groundwater Body Level - Sodium

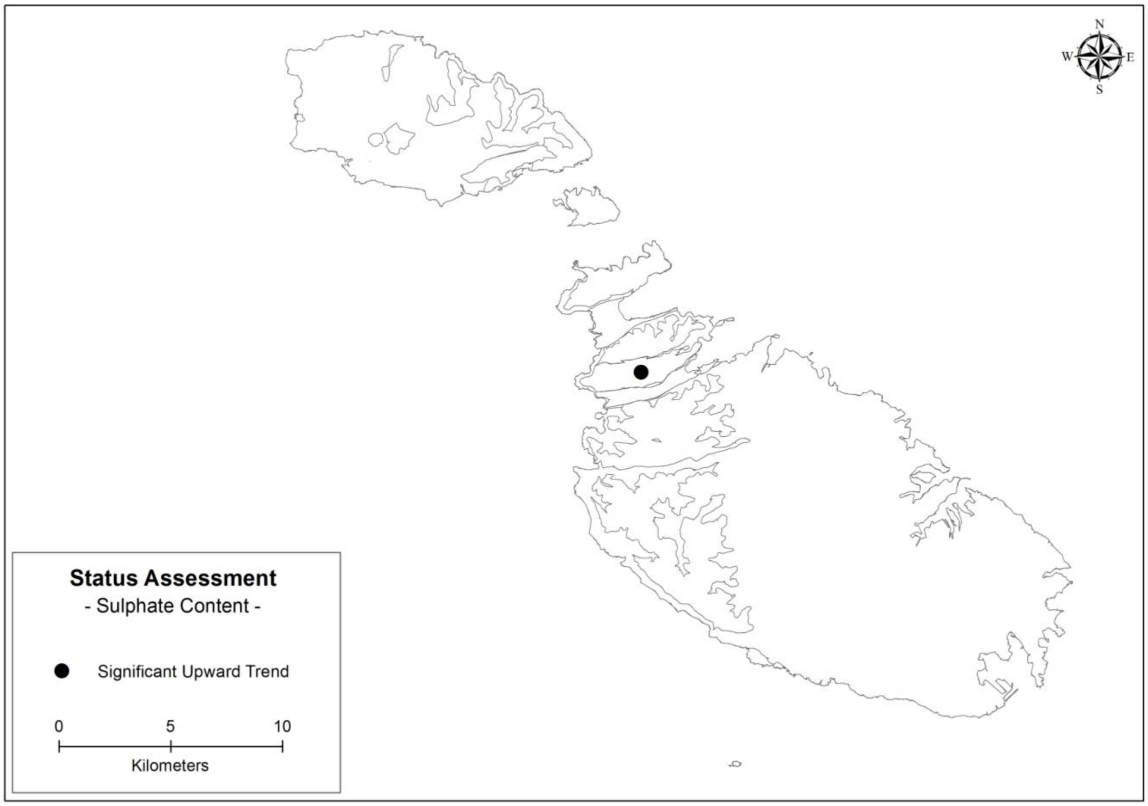


Figure 6.32: Groundwater Trend Assessment at Groundwater Body Level - Sulphate

7 Review of the Programme of Measures (2009-2015)

7.1 Assessment of the measures included in Malta's first Water Catchment management Plan

The objective of this chapter is to provide an account of the outcome of the first Programme of Measures that was included as part of Malta's first Water Catchment Management Plan, and how these outcomes have affected the planning for this second cycle. The chapter looks into the specific measures and details their status, their success and shortcomings, the obstacles encountered in implementation and the extent of the individual measures contribution to achieving the objectives of the WFD. Any financial instruments used and funding are also listed.

Some of the measures that were planned for 2009-2015 but which were not fully successful and have been reviewed and included in the 2015-2021 POM. The relevant justifications for the need to review or revisit the measure are included in this chapter.

7.1.1 Basic Measures emanating from other EU Directives

A number of basic measures identified in the first Water Catchment Management Plan emanate from action plans, programmes or strategies that have been derived as part of the implementation of other directives that are considered to support the objectives of the Water Framework Directive. Since the publication of the first WCMP Malta has made significant strides in the implementation of these measures. Monitoring results have indicated that the quality of our coastal waters is generally favourable but there are a number of pressures and impacts, which extent of damage on the marine environment has not been properly gauged yet. There are also large gaps of knowledge where the management of Malta's inland surface and transitional waters are concerned. Monitoring in these waters (Refer to Chapter 6, Status Assessment of Maltese Waters) indicates that there are a number of additional measures that need to be taken in order to reach good water status required to sustain ecologically important water dependent species and habitats.

(i) Implementing actions under the Nitrates Directive 91/676/EEC

During the first Water Catchment Management Plan (WCMP) a key milestone in the implementation of the Nitrates Directive was the development of the Nitrates Action Programme which was given legal effect by means of the Nitrates Action programme Regulations (S.L. 504.108). The aim of these regulations was to implement the Nitrates Action Programme so as to ensure compliance with the Nitrates Directive.

An Info Nitrates campaign funded by LIFE+ was also carried out during the first WCMP cycle. This campaign was designed to provide farmers and livestock breeders with information and training to act in accordance with the Nitrates Directive and the associated Action Plan. Throughout the campaign a total of 849 farmers and 1,739 part-time farmers holding more that 1.5 hectares of land received training. Farmers were provided with soil analysis kits and training sessions were also held with 925 livestock breeders.

Experience in the implementation of these regulations led to their further refinement and amended regulations were in fact published this year (LN 95 of 2015). During the upcoming WCMP cycle a number of additional studies will also be carried out. These are explained under Chapter 9 (Programme of Measures). All such changes are to be reflected in the revised Nitrates Action plan for Malta in 2015.

(ii) Implementation of the Bathing Water Directive 2006/7/EC

Under implementation of the Bathing Water Directive, 87 coastal bathing sites are monitored for microbiological contamination from the third week of May to the third week of October every year for the required minimum frequency as per Annex IV of the 2006/7/EC Bathing Water Directive (The EHD is monitoring all sites every week when the Directive requires a minimum frequency of once every 30 days). For bathing water reporting under the provision of Directive 2006/7/EC based on 4 years data last year i.e. 2014 all 87 sites have classified as excellent. The bathing water monitoring programme is carried out by the Health Inspectorate Services within the Environmental Health Directorate (EHD). Monitoring costs each year are estimated to be around € 102,000.

In accordance to the provisions of Article 6 of the Directive 2006/7/EC and to Regulation 11 Schedule III of the Regulations as transposed by Legal Notice 125 of 2008 and amended by Legal Notice 237 of 2011the EHD also developed 29 Bathing Water profiles. Each bathing water profile provides a general description of the bathing waters and surrounding areas, a location of the bathing area and the monitoring points; a land-use map and the water quality classification over 4 years (2009-2012). An update is also published for all 29 bathing water profiles following the publication of the Commission Bathing Water Report. Thus since the development of these bathing water profiles 2 up-dates have been published i.e. covering data for 2010-2013 and 2011-2014. Existing pressures for each site are also described and mitigation measures identified. Contact information in the case of a pollution incident within a bathing area is provided for each bathing profile. The overall estimate for the development of these beach profiles was € 20,300.

Apart from the establishment of the beach profiles, a Bathing Water Management Committee is set up every year to identify which sites are to be listed as official bathing sites and monitored accordingly. The Committee also establishes the official bathing season for that year and notifies the European Commission and the European Environmental Agency accordingly.

(iii) Implementation of the Urban Waste Water Directive 91/271/EEC

Since the publication of the First Water Catchment Management Plan, Malta has made significant progress in relation to the treatment of urban waste water. All agglomerations now meet the requirements stipulated for collection systems. These collection systems are subject to continuous improvements and extensions to replace or supplement old parts of the sewerage network to serve the ever growing urbanisation and development needs. The WSC have projected 4 million euro investment costs in this regard, in relation to the connection of the Baħrija, Bieb ir-Ruwa, Ghajn Qajjiet , Ghajn il-klieb and Tas-Salib hamlets to the sewer system.

Since publication of the plan, three treatment plants are now fully operational meaning that municipal waste water is no longer seen to be a major pressure along the Xghajra water body (MTC 106). Main sources of funding for these plants came from Cohesion Funds Priority Axis 5 (Protecting the environment). Nevertheless problems related to the discharge of animal waste into the sewerage network have created operational problems at the point of treatment. Consequently, an Inter-ministerial Committee was set up in order to discuss and provide solutions in this regard. Moreover, a study was commissioned to update as necessary the Agricultural Waste Management Plan in order to ensure compliance with the relevant EU environment directives.

(iv) Implementation of the Nature Directives

During 2012 and 2013, 30 Natura 2000 Management plans (of which 8 are Conservation Orders), for terrestrial sites have been drafted covering nine of the 10 protected inland surface water sites. The WFD objectives have been integrated in the draft Natura 2000 Management plans that have been developed over the past two years. Respective measures for each water body have been identified in each plan. Consultation on the plans was carried out extensively during the process of developing the respective plans during 2013/2014. The public had access to the issues under discussion by means of a web url where further information was made available on each of the respective sites. Any water related measures that have been included in these plans will be implemented over the next 6 years and are described in more detail in Chapter 9 of this WCMP.

With respect to Marine Protected Areas, 4 new sites were designated after the first WCMP was published and have thus been included in the new Protected Area Registry (refer to Chapter 4). For these new sites, Member States are required to establish measures within 6 years from the date that they are designated to form part of the Natura 2000 Network. The process of establishing conservation measures is therefore ongoing and will form part of the upcoming Marine Protected Area Management Plans.

Three projects with a focus on the marine environment are currently underway which have been launched by Birdlife Malta and MEPA. In 2011 Birdlife Malta launched the **LIFE Malta Seabirds project** with the aim of identifying and designating any areas important for certain bird species (http://maltaseabirdproject.wordpress.com/about/). In 2012 MEPA was also awarded EU Life funds to coordinate **the LIFE Migrate project** with the aim of identifying and designating any marine areas important for the loggerhead turtle, *Carretta caretta* and the bottlenose dolphin, *Tursiops truncatus* (http://lifeprojectmigrate.com/). MEPA has also embarked on the LIFE BaĦAR for Natura 2000 (LIFE12 NAT/MT/000845) which aims to extend existing marine Sites of Community Importance (SCIs) and identify new SCIs for inclusion within the Natura 2000 network, as deemed appropriate through the acquired data on sandbanks, reefs and sea caves. The project budget is of €2.6 million, 50% of which is co-financed by the EU LIFE funding programme. The project commenced on the 1st October 2013 and will run until June 2017.

(v) Implementing actions under the Sustainable Use of Pesticides Directive 2009/128/EC

Since publication of the first WCMP the Malta Competition and Community Affairs Authority (MCCAA) have issued Malta's National Action Plan for Sustainable Use of Pesticides (NAPSUP). This plan was issued following public consultation. A number of measures that have been included under the Action Plan are now being implemented. These can be categorized as follows:

1. Training of professional users and distributors of plant protection products have been carried out through courses.
2. Inspection services currently being carried out by the Paying Agency (on behalf of the MCCAA) as part of their cross-compliance obligations. The MCCAA have established MoUs with the Paying Agency in order for the inspections to be carried out. The correct disposal of pesticide packaging is also checked by means of these inspections.
3. Integrated Pest Management: The MCCAA have also issued a Guidance Document on Integrated Pest Management for the Maltese Islands. As indicated by the guidelines that have been developed, the MCCAA is promoting low pesticide-input pest management and prevention of use. The MCCAA have also liaised with MSDEC to include such measures in the draft Rural Development Programme. Examples of actions that are considered under integrated pesticide management include: the reduction in use of herbicides and the prohibition in vulnerable zones, the use of traps for monitoring purposes etc.
4. Policy measures related to the protection of waters from pesticides by means of distance rules of application of pesticides have also been included in the guidelines.

7.1.2 Basic Measures to protect the Coastal Water environment which stem from the WFD

A number of basic measures are derived from obligations that are stipulated in the Water Framework Directive as well. A lot of these measures were successfully completed during the First WCMP implementation cycle whilst others are ongoing or require continued effort so that they may be improved during the upcoming second implementation plan. Progress achieved to date with respect to these measures is described below.

REG 1-2 Adopt a regulatory framework for industrial operational practices

This measure deals with improving the current legislative base for environmental permitting to ensure that any diffuse and point sources of pollution from industrial installations of concern are adequately controlled. This measure is considered key as it supports a wide number of additional measures and contributes significantly to the protection of all water categories, groundwater and surface water.

Over the past years MEPA has built a regulatory system for the application and issuing of environmental operating permits. Today this system follows a risk-based approach with high-risk sites being permitted through a site specific environmental permit and lower risk sites being regulated by means of general binding rules.

A review was carried out by the European Union Network for Implementation and Enforcement of Environmental Law (IMPEL) of this regulatory framework in 2014. The report compiled states that:
"*MEPA have developed a rigorous regulatory strategy around the control of industry and waste that is appropriate to a very densely populated island. The strategy revolves around a high degree of control being maintained primarily through time limiting permits. MEPA have very good permitting systems and approaches that enable them to license in a risk based and effective manner. Highlights include a risk based hierarchy (Exemptions, GBRs, Permits), sectoral approaches, integrated permits and a central conditions bank.*"[231]

The IMPEL review identified areas where such a regulatory system could improve. In addition, experience implementing the regulatory controls over the past few years also exposed a number of areas where environmental permitting could be enhanced. Therefore this key measure will be taken forward to the next WCMP cycle by means of a new measure (Refer to Chapter 9 – KEY 1).

QUAL 3-6 Create a pollution abatement programme for priority hazardous substances, priority substances and other substances of concern

During implementation of the first WCMP, any WFD and related EQS Directive requirements were integrated within the Environmental Permitting Process in order to ensure that the emissions from various industrial operations were in line with obligations arising from these Directives. Today any pollution abatement programme for priority substances is integrated in the conditions of the environmental permit that is issued on an individual basis. Due to the regulatory set up under measure REG 1-2 above, the effectiveness of these conditions is assessed on a yearly basis since all operators are required to submit an Annual Environmental Report to MEPA detailing the full monitoring results and any exceedances in the standards set for priority substances and other substances of national concern.

In addition, MEPA has also drafted a guidance document that deals with discharge limits imposed on various discharges to the marine environment. This guidance document is considered to be a living document since it is updated to keep abreast with international standards.

COAST 9-1 Develop tools to link Environmental Quality Standards to emission limits for marine discharges.

To date Malta has developed very few emission limit values (ELVs) for marine discharges, mainly due to the fact that monitoring data for contaminants of concern has been limited and an understanding of the links between environmental quality standards and acceptable emission limits is still evolving. Therefore during the past few years' Malta has adopted a precautionary approach by setting the environmental

[231] IMPEL REVIEW INITIATIVE (IRI) 2014 "A voluntary scheme for reporting and offering advice to environmental authorities" - Report on the IRI that took place in Malta from 17 to 20 June 2014 at the Malta Environment & Planning Authority (MEPA).

quality standards as emission limits and these are generally provided to operators when an environmental permit is issued.

When a new industrial installation is being considered the existing ambient environmental conditions of the area to be impacted by the installation is considered. Best Available technique ELVs are applied when there is sufficient evidence that the Emission Limit Values stipulated by the Best Available technologies are not likely to cause pollution levels in excess of the Environmental Quality Standards as established by the EQS Directive.

This measure is considered to play a central part of the implementation of REG 1-2 described previously and therefore will continue to be implemented on a case by case basis throughout the second cycle as part of the environmental permitting regime.

KNO 3-2 Set up a database and inventory of industrial sites
Malta was obliged to establish an inventory of emissions, discharges and losses of all priority substances and contaminants listed in the Environmental Quality Standards Directive. Substances that are to be included are those that are relevant at the Water Catchment District (the inventory has to address all inputs of relevant substances into the environment irrespective of the compartment involved that are likely to reach surface waters).

The inventories are expected to give information on the relevance of the Priority Substances at the spatial scale and on the loads discharged to the aquatic environment. The CION uses these inventories for compliance checking with the environmental objectives of the WFD. The inventories are to provide not only yearly inputs but also include concentrations in sediment and biota (where appropriate). Where there is a link between groundwater and surface waters, those substances exceeding national groundwater thresholds should also be considered to be potentially of relevance. The inventory is also expected to shed light on to what extent monitored concentrations are caused by natural sources or processes or long-range transport processes.

During the 1st WCMP Malta assessed the relevance of the substances at RBD level using monitoring information and information on existing restrictions on production and marketing of substances. Substances were included if:

- a substance causes failure to achieve good chemical status,
- the level of the concentration is above ½ of the EQS in more than 1 water body;
- the PRTR (Pollutant release and transfer register) shows releases that may lead to concentrations matching previously mentioned criteria; and known sources and activities that may cause concentrations matching the above criteria).

More elaborate monitoring data has enabled a better understanding of the type of substances that needed to be included in the inventory and ultimately enabled Malta to use this as a tool to come up with a number of substance specific measures. Nevertheless a large number of gaps do still exist and Malta tackled these gaps by developing a number of supporting measures for the second management plan to assist in enhancing our knowledge related to specific potential sources of pollutants, which in turn would ultimately feed into the inventory (see Chapter 9 for full list of measures).

7.1.3 Supplementary Measures related to the Coastal Water Environment

COAST 1-1 To develop and implement MEPA guidance for the disposal or reuse of dredged material from harbours

National guidelines for the management and disposal of dredged material were drafted and used on a pilot basis during the first WCMP cycle. These guidelines set out clear regulatory policy guidelines when an application for dredging takes place within Maltese territorial waters. Operators are guided on how to characterise the material that they are to dredge; what the sampling and analytical requirements are and how to carry out a screening assessment in order to determine suitable disposal methods.

To date the guidelines are being used as part of the regulatory process when the Environment Directorate assesses the environmental implications of a number of development projects that involve capital dredging. They are used as a tool to integrate construction management conditions into the planning permit. The implementation of this measure has led to better management of dredged material, which following testing, results to be of poor quality.

COAST 1-2 and 1-3 Develop and implement harbour environmental management plans

Over the past years MEPA has undertaken a thorough review of activities located within and adjacent to the harbour area within the ports of Marsaxlokk, Marsamxett and the Grand Harbour. Particular attention was given to those activities that interface with the water body. The review identified associated potential pressures on the water bodies MTC 105 and MTC 107, as well as related issues, apparent regulatory overlaps and gaps. Communication with Transport Malta clarified that a number of perceived gaps identified by MEPA, and listed below, were being regulated by Transport Malta (TM) and therefore there was a need to revisit the scope of the measure as initially described in the first plan.

- The clean-up of minor oil-spills at sea are regulated by TM even where the responsible source is not identified.
- TM confirmed that adequate oil/chemical contingency resources of the various port installations are also in place.

The main gaps that are still present deal with the provision of adequate waste management facilities for vessels that are moored or berthed within public areas as well as the lack of upkeep of public areas. Litter was also identified to be a significant issue. A number of regulatory overlaps were also identified which often results in bureaucratic procedures. The scope therefore to streamline regulatory efforts that come from a number of entities remains. Intergovernmental discussions have led to the recognition that there may be more effective ways by which these gaps and overlaps can be resolved.

The nature of these gaps requires that alternative measures or existing measures be extended to provide more cost-effective solutions. Such revised alternatives include for instance:

1. Encourage ports to provide adequate waste management services by means of establishing agreements (consortium) between Local Councils, Port operators and the Cleansing Services Directorate (MTI)
2. The Development of Memorandum of Understanding between regulatory entities so that regulatory overlaps are clarified and regulatory control efforts is synergised at a national level rather than at entity level.
3. The enhancement of human resource capacity to ensure effective implementation of existing and upcoming regulatory tools for monitoring compliance with legislation or permit conditions.

These alternatives are discussed under appropriate measures envisaged for the second WCMP under Chapter 9.

COAST 3-1 Monitor dumping operations at the Spoil Ground

The monitoring of dumping operations at the Spoil Ground is necessary to ensure that the spoil ground is being operated in accordance with the regulations in place so that dumping activities at sea do not pose a significant threat to the marine environment.

Disposal at sea is regulated by MEPA through the Waste Consignment Note Procedure. MEPA checks that the quality of waste that is loaded on the barges is in accordance to the regulations. Data on the type and quality of waste is also maintained.

The actual monitoring of operations (i.e. the trip the barge carrying the waste takes to the spoil ground) is undertaken by Transport Malta. The movement of barges are effectively monitored by means of the Vessel Traffic Services and visible through the Automatic Identification Service. The movements of and communications with the vessel are logged. This measure is therefore considered to have been successfully completed.

COAST 4-1 and COAST 4-2 Define and implement operational guidance for aquaculture activities
Draft Operational guidance for aquaculture activities was drafted during implementation of the first WCMP, however its adoption was superseded due to the drafting of the aquaculture strategy and the resultant new policy direction developed for this particular sector. Following these developments it is thought more opportune if this measure is amended to bring aquaculture activities in line within the environment permitting regime. This is reflected in the new Programme of Measures (refer to Chapter 9).

COAST 5-3 Develop and Implement environmental regulations for recreational boating
The original measure described the need to regulate recreational boating in coastal waters through the development of regulations for individual boat owners and the management of swimming zones. In addition the measure identified the need to protect sensitive benthic ecosystems by setting up no anchoring zones and zones of ecological mooring.

During implementation of the first WCMP consultations with the Malta Tourism Authority, Ministry for Gozo, Fisheries Control Directorate, Transport Malta, and fishermen representatives have shown that regulations to set up no anchoring zones was too early at that point in time. This is mainly because such zoning impacts fishermen and tourism in different ways. Nevertheless, headway has been made with respect to the setting up of a no anchoring zone in Marine Protected Areas (within a radius of 1 nautical mile around the islet of Filfla). Implementation of this measure therefore requires synergy with the development of NATURA 2000 management plans for Marine Protected Sites. Such plans for MPAs have not been developed yet and will need to be compiled during this second WCMP implementation phase.

It must be noted, however, that in the interim until such management plans are developed, the monitoring programme that has been developed for MSFD and WFD requirements, makes reference to the need to collect data on the extent of anchoring occurring in Bunkering Area 1. This specific area is located within the North eastern Marine Protected Area. The *Posidonia* meadows in the area will also be monitored. Thus the monitoring programme may be able to shed some light on the interactions of anchoring with benthic habitats.

Apart from the establishment of non anchoring zones however, during the early stages of implementation of this measure, sewage discharge from recreational crafts was in part legally addressed through newly proposed amendments to the Recreational Craft Directive 94/25/EC amended by Directive 2003/44/EC as per COM (2011) 456 whereby the new requirement included the '*mandatory installation of holding tanks to watercraft fitted with toilets in order to contribute to marine environmental protection*.'

Consultation with TM and the Department for Environmental Health on this particular measure has resulted in the identification of alternative measures necessary to bring about further desired changes to how recreational boating activities are regulated. These include the need to carry out joint (TM and MEPA) inspections to ensure that marina operations abide to best environmental practice. This is considered to be a win-win measure and is further described under Chapter 9.

A need to link Bathing water areas designated by the Department for Environmental health under the Bathing Water Directive with the swimming zones that are designated and controlled by TM, was also identified. This is being suggested such that where swimming zones and bathing waters are in close proximity to each other, they are streamlined so as to offer maximum protection to swimmers (i.e. reduce risks not only caused by potential accidents at sea but also health risks that may be brought about by, for instance, irregular discharges of recreational boats in the vicinity of swimming zones and over-nighting of pleasure boats near swimming zones.).

COAST 6-2 Installation of a pipe diffuser for discharge of treated wastewater to the coastal environment

Implementation of the first WCMP saw the Installation of a 1km submarine pipeline to discharge treated effluent from the Wastewater Treatment plant constructed at Ta' Barkat limits of Xghajra. The outfall was one of the components of the CF116 project - Malta South Wastewater Treatment Infrastructure co-financed through the EU Cohesion Fund 2007-2013 programme. This measure has been successfully completed.

QUAL 4-1 Set up an environmental pollution emergency response team

Prior to the first WCMP, environmental accidents revealed that a national emergency response procedure is much needed particularly since some important stakeholders who may be responsible for assets that are placed at risk due to the accident, are not timely informed. Vague ad-hoc procedures cause inevitable delays in deploying the right response at the right time and as a consequence the degree of environmental risk and related costs increase considerably. The intention of the measure was to set up an environmental pollution emergency response team for accidents occurring on land; and enhancing Malta's already established marine contingency plan to cater for accidents taking place at sea.

In the case of terrestrial accidental response, as a result of the first WCMP a draft procedure had been put together by the Interministerial Committee for Water. The procedure was subject to cross ministerial discussions which exposed a number of requirements that were needed in order to make such an emergency response team functional.

In parallel a Malta Critical Infrastructure Protection Directorate (CIPD) was also set up under the Office of the Prime Minister. This Unit has a coordinating role of all critical infrastructure protection and emergency and disaster management issues on a national level. A fundamental role of the Malta CIPD is to coordinate and support general emergency preparedness plans capable of responding to national emergencies involving the emergency services.

It would therefore be necessary that the emergency response procedure for terrestrial accidents drawn up during the first WCMP be reviewed in light of national discussions taking place within the framework of the Malta CIP Unit.

With respect to the National Marine Pollution Contingency Plan that was adopted by the Maltese Cabinet in 2010, a National Audit exercise was carried out in 2014 whereby a number of deficiencies were highlighted. The NMPC will be updated in the coming months as part of TMs bid to improve oil and hazardous noxious substances spill response at a national scale.

In January 2014, a project was launched between the Norwegian Coastal Administration forces and Transport Malta in order to strengthen Malta's preparedness to pollution risks from shipping and maritime activities. The project is co-funded by EEA grants (Programme Area 7 – Adaptation to Climate Change). The aim of the project is to strengthen Malta's capacity to respond to maritime pollution incidents in an effective manner through the provision of training for Tier 2 and Tier 3 spills; the establishment of training programmes once training needs have been identified; the upgrading of training equipment and facilities; and to address pollution from offshore oil drilling operations within and outside of Malta's territorial waters. The total project amount is €614,000.

REG 4-3 Improve the regulatory system for industrial discharges into the public sewerage network

The objective of this measure was to control the impact of discharges to sewers, to urban waste water treatment plants, and ultimately to the coastal water environment, by improving the quality of the sewage discharge permits. Efforts by the Water Service Corporation (WSC) have been ongoing to streamline the operations of their Discharge Permitting Unit with MEPA's Environmental Permitting Regime. The WSC is also working towards accepting online submissions of the discharge permit applications. The IT system that is being developed by WSC in conjunction with MITA (Malta Information technology Agency) is envisaged to be up and running by mid 2016. The system will have a dual functionality. It will serve as both a front office for entities/individuals wishing to apply for a permit and also as a back office for the Discharge Permitting Unit to be able to perform its administrative duties efficiently and more effectively especially through its GIS integration. The applicant will have the facility to fill in the application online, make payments through the portal and also submit any documentation through the same system.

The use of online data inputting and sharing has once again been identified to be a key measure and is considered to be central to the streamlining of the sewage discharge permits with environmental permits issued by MEPA.

The efforts that go into compliance checking when spot checks are carried out by the WSC are significant. The WSC laboratory has recently undergone a substantial investment programme in order to expand and renovate its operations to be better equipped to meet the requirements of WSC and its monitoring obligations.

REG 1-3 and COAST 2-1 Strengthen the existing environmental and planning regulatory processes to cater for the objectives of the WFD and Develop and implement planning and environmental guidance on major coastal engineering works

The first WCMP resulted in a need to clearly indicate to land use planners, environmental officers, applicants and the general public, how measures to protect water resources during the planning, construction and operational stages of a development are streamlined into the development planning process. For this reason a guidance document describing the existing mechanisms for WFD integration into strategic land-use planning and the development planning process was developed.

The guidance document also presents planning and environmental guidance for coastal engineering works by indicating what the general permit conditions are in order to mitigate coastal engineering impacts. The guidance document also illustrates what the monitoring programmes required for coastal engineering works should include.

The guidance needs to be updated to provide more guidance on actual expected impacts and the mitigation required for particular engineering projects. Given that the Marine Strategy Framework Directive has introduced new descriptors for the marine environment, this guidance document should explore the impacts on all marine elements and give an indication of the potential mitigation measures available. This document will therefore be updated during the second WCMP cycle with the aim of providing guidance on how development can effectively mitigate acute and chronic hydromorphological, physico-chemical, chemical and ecological alterations to any surface water environment during its construction and operation. This overriding objective can be achieved by means of the following targets:

- To ensure impacts arising from any development are adequately addressed and mitigated by means of best available techniques, and on the basis of the current level of knowledge Malta has on the potential impacts various pressures may have on the coastal and inland surface water environment.
- appropriate baseline monitoring data is collated prior to the actual construction of a development (polluter-pays)
- To ensure local-scale monitoring programmes are in place to keep track of potential impacts during operation (polluter-pays)

This measure has therefore been taken up during the second WCMP cycle and is clearly described in Chapter 9 (see SWM 1).

KNO 2-2 Study the impact of the National spoil grounds off Xghajra

This measure is considered to complement measure COAST 3-1 *Monitor dumping operations at the Spoil Ground*, described previously. Whilst measure COAST 3-1 dealt with monitoring and controls of the actual dumping operations, the aim of this measure was to increase our knowledge on the state of physical and chemical impact of the only marine spoil ground in Malta on the marine environment. This is required so that future policy related to dumping waste at sea is carried out on the basis of scientific knowledge. This measure was not implemented during the first cycle due to a lack of funds and due to a loss of human resources to oversee the implementation of the study. This measure will therefore have to be taken up during the second cycle (Chapter 9 measure KNO 1).

It has been ensured that the joint MSFD and WFD monitoring programme also makes reference to the need to re-assess seabed topography and bathymetry within the spoil ground area in the longer-term (refer to Chapter 5 and corresponding Monitoring fact sheet on hydrographical changes).

KNO 2-3 Study the need for ballast water management and control

The management of ships ballast water to minimise chemical and biological pollution in the marine environment is required. During the first WCMP, the need to study the extent of the problem of ballast waters in Malta was identified due to the fact that very little is known about whether ballast water practices are creating problems in Maltese territorial waters. The need for the study was however superseded by IMO Ballast Water Management (BMW) Convention which is expected to come into force in the very near future.

In anticipation of the entry into force of the BWM Convention, the Mediterranean Coastal States, including Malta, have adopted interim arrangements to address the risk of invasion by alien species via ships' ballast water and sediment within their areas. The "*Harmonized voluntary arrangements for ballast water management in the Mediterranean region*" (IMO BWM.2/Circ 35) require ships sailing in the Mediterranean to exchange their ballast water in accordance with the requirements set out in the D-1 Standard of the BWM Convention. These arrangements are of a voluntary and interim nature and were implemented on 1 January 2012. The arrangements will be in force until the date the BWM Convention enters into force.

KNO 3-1 Complete the farm holding database

The aim of this measure was to have a complete farmer registry, incorporating livestock farms and land parcel holdings in order to obtain a clearer picture on environmental practices and waste management on a whole farm level. Legal Notice 321 of 2011 specifically sub regulation 18, lays down provisions for the Agriculture Directorate to draw up and maintain a National Nitrates Database containing the following information:

(a) registered farmers making use of fertilisers;
(b) information concerning the holdings pertaining to the farmers;
(c) information concerning livestock buildings and storage facilities on a holding, including a link with the National Livestock Database;
(d) information concerning land management practices;
(e) information concerning the landscape including the presence of any karstic features and natural topography, soil types, water sources and water courses;
(f) information concerning the sale and movement of livestock manure;
(g) data concerning the sales and purchases of inorganic fertilisers;
(h) information on checks conducted by other authorities;
(i) findings of monitoring and controls;
(j) list of advisors and technical experts;
(k) list of manure transporters.

This data has been compiled and maintained since 2011 yet in 2014 and 2015 the process to populate the Farmer Registry of the Agriculture Directorate as (also known as the Nitrates Registry) was initiated, with farmers going to the Front Office to register their relative parcels which is to also serve as a basis for the compilation of a crop plan and fertiliser plan through approved technical services providers.

Even though there is a legal obligation for farmers to register all utilisable area in the Nitrates Registry, there are cases were the land's right of use is contested or else the land user is unknown. In these occurrences there will be difficulty to recognize the right-full land user and most importantly were infringements are identified there again will be an issue to trace the appropriate user.

A separate mapping exercise was also carried out in line with the Commission's request during the Pilot. Livestock farms, namely bovine and swine farms, but also rabbit, poultry caprine and ovine farms were digitised on a GIS layer, allowing the authorities to establish a spatial database in which farm clusters, and proximity to water sources and courses may be identified.

The proposal to incorporate the mapping exercise into the Nitrates registry has been discussed and costs are being quantified for the materialisation of this proposal.

Findings pertinent to the controls made by the Agriculture Directorate are also expected to be incorporated within the Nitrates Registry- Control system, enabling the authorities to have a complete database not only identifying characteristics and operations of farms but also allows for better monitoring of such holdings on breaches that may have been identified.

AWA 1-4 Develop a National Water Information System

During 2011-2013 MEPA developed a Shared Environmental Information System Geoportal (www.seismalta.org.mt/) that comprised of a set of web and desktop tools for:

(i) Monitoring, reporting and disseminating environmental data, and
(ii) Supporting the development of environmental policy according to the requirements of the European Union and the Government of Malta.

The SEIS-Malta makes use of ESRI/GIS and Geoportal Technologies combined with custom developed web services with the aim of providing the public and MEPA with user-friendly interfaces. Currently this geoportal provides the public access to soil, water, air, and noise and radiation data. Water data has to be inputted manually and therefore the system is rather time-consuming to maintain.
There is a need to review the system due to problems arising from the software used and also because of limitations concerning the range of data that can be displayed. There is scope to extend the data platform to cover important data streams coming from other entities as well as include marine data, that shall be generated when the MSFD, WFD and Regional Conventions Monitoring Programme is fully operational. Therefore under the second cycle an open platform for data management will be developed with the aim of doing away with current constraints (see measure KEY 3, Chapter 9).

7.1.4 Supplementary Measures directly related to the inland surface water environment
Under the first Water Catchment Management Plan Malta had included two measures related to inland surface waters that were considered key to the management of protected areas.

ECO 1-1 Establish ecological flows within sub-catchments of ecological importance (Natura 2000 sites).
During the first WCMP, Malta embarked on its first step towards establishing the baseline of the flow regime in three water courses by monitoring surface water flow. 'Baseline' here is being interpreted as the present flow regime within these three sub-catchments. However years of frequently gathered data is required to understand the contribution of natural flows to the water-dependent habitats and species. In addition further work would be required to understand the habitat requirements and the selection of indicator species. The process of establishing ecological flows will therefore naturally extend into subsequent WFD cycles. The monitoring programme described in Chapter 5 aims at contributing to the achievement of this target. In addition the Natura 2000 management Plans that were designed during 2012 – 2014 are also expected to contribute to the process of understanding water related requirements and hence shall in turn inform the process of developing ecological flows. Reference to individual measures dealing with studying the flow regime in water courses is made in Chapter 9 of this plan.

ECO 2-1 and ECO 2-2 A pilot project to illustrate and implement integrated valley management
Integrated valley management is an overriding measure that looks at all aspects of land use and environment management at a sub-catchment scale. The aim of the measure was to select a pilot study area of a valley system at sub-catchment scale, to define the management needs of the particular valley system, and to come up with measures that catered for those needs in an integrated manner.

The Buskett woodland was selected as to illustrate how principles of integrated valley management could be applied in practice. A Master Plan for the management of the Buskett woodland was drawn up. Part of the Master Plan is being implemented by means of a LIFE+ Project entitled 'Soil stabilisation measures to protect Annex I habitats in Buskett-Girgenti Natura 2000 site'. In short it is known as the Life Saving Buskett Project. The project budget is €2.7 million, 50% of which is co-financed by the EU LIFE Funding Programme under the Nature and Biodiversity priority area. The project commenced in July 2013 and is expected to be completed by May 2018. (http://lifesavingbuskett.org.mt/).

The aim of the project is to protect the habitats of EU importance composed of mature trees at Buskett along the watercourse and the banks of Wied il-Luq. The objectives of the project are the following:

1. To protect the watercourse and its banks supporting the Annex I priority habitat **Arborescent matorral* with *Laurus nobilis* and Annex I *Salix Alba* and *Populus alba* galleries, and other trees characteristic of riparian woodland, such as *Fraxinus angustifolia* and *Ulmus sp*, through (i) the repair/restoration/rebuilding of the retaining walls that define the watercourse; and (ii) the reduction of soil and debris that make their way down to the watercourse from the valley sides causing sedimentation in, and occlusion of, the watercourse.

2. To protect the stability of the substratum on the valley sides supporting the following Annex I habitats: **Arborescent matorral* with *Laurus nobilis*, Mediterranean pine forests with endemic Mesogean pines, *Olea* and *Ceratonia* forests, and *Quercus ilex* and *Quercus rotundifolia* forests.
3. To remove alien invasive species that compete with targeted habitats and plant new trees characteristic of the targeted habitats.

Identified mitigation measures include:

- The repairing, rebuilding and restoration of retaining walls and arched buttresses along the watercourse. Such soil stabilisation measure, apart from consolidating the definition of the watercourse itself will reduce the deposition and sedimentation of soil and debris on the watercourse coming down from the valley sides. Signs to guide visitors in proximity to the watercourse will be put in place.
- The introduction of additional soil stabilisation measures which include the placing of geo-textile material, mulches over exposed areas, and dead wood to serve as obstruction structures will also be put in place. The action at the upper sides of the valley will complement the interventions along the watercourse since the down slope movement of soil and debris will be checked at various levels on the sides of the valley. Signs to guide visitors along the targeted areas will be put in place.
- Selective removal of silt and boulders from parts of the watercourse that are negatively affecting the targeted habitats.
- Removal of alien species that are competing with native species.
- Planting of new trees characteristic of the targeted habitats.
- Restoration of footpaths to reduce damage from random trampling by visitors

New project ideas for the restoration of the natural hydrodynamics of Wied il-Luq are also being explored (such as the restoration of old water galleries; changing of impermeable asphalted roads with ecological, permeable paving material; the better management of groundwater abstraction for irrigation of landscaped areas; the repair of reservoirs; and the restriction of vehicular access by third parties in the watercourse).

Apart from the pilot project itself the process of developing integrated valley management has evolved to take into account current practices regarding valley management. This included the revision of current procedures adopted by MEPA for the cleaning, maintenance and reconstruction of dams and retaining walls within valley catchments.

7.1.5 Financing of coastal water and inland surface water measures under the first WCMP

Implementation of the majority of measures falling under the responsibility of different entities entirely depends on internal sources of funding for implementation. This is the case for most of the basic measures except for the Nitrates Info Campaign that was funded by LIFE+ funds and the construction of the Urban Waste Water treatment plants, funded through Cohesion Policy.

The majority of supplementary measures are also financed by national funds. In some cases, however various EU funds have been secured, in particular for measures dealing with awareness raising and research initiatives. EU funds secured during the first WCMP implementation cycle range from Rural Development, Cohesion, Structural and Life + funding sources. Other sources of funding (namely EEA and Norwegian funds) were secured to enhance capacity building related to marine contingency response.

7.2 Review of Measures addressing the optimisation of the management of Water Resources

7.2.1 Basic Measures

- Measures to promote efficient and sustainable water use

The 1st Water Catchment Management Plan saw the undertaking of a number of initiatives focused on the efficient and sustainable use of water resources. These included:

(i) the introduction of smart metering technology on the potable water distribution network, which provides a new tool for better assessing water use at a household level. The use of this technology has permitted the utility to advice customers with high consumption rates on water misuse in their homes;

(ii) the metering of groundwater abstraction sources operated by the agricultural and commercial sectors was undertaken during the 1st planning period. This process also included the development of a data analysis tool which will permit the identification of high water abstractors to direct the focus of agri-advisory services.

(iii) A pilot project in the island of Gozo was undertaken in which water saving kits were distributed to all households on the island, to help optimise the conservation of water by these households. This initiative will be extended to the island of Malta during the 2nd catchment management cycle.

- Measures for the protection of water abstracted for drinking water

Groundwater safeguard zones were revised during the 1st catchment management cycle and planning controls established for these zones by the planning regulatory authority. A four tiered safeguard zone was established based on the 100m, 200m, 300m and merged radii of influence around groundwater abstraction sources intended for human consumption. Planning controls prohibiting particular potentially polluting developments and requiring the adoption of increased pollution prevention measures were established for these zones by the Planning Regulator through planning policy and planning guidance documents.

- Controls over the abstraction of groundwater

The 1st Water Catchment Management Cycle saw the enactment of an optimised regulatory framework to better control abstraction of groundwater. This regulatory framework is based on the following legislation:

Legal Notice 254 of 2008, entitled Borehole Drilling and Excavation Works within the Saturated Zone Regulations; which established a regulatory framework for borehole drilling and excavation works carried out partly or totally within the saturated zone.

Legal Notice 255 of 2008, entitled Notification of Groundwater Sources Regulations; which established a time-limited period wherein existing groundwater abstraction sources were to be notified to the regulator; following which all un-notified abstraction sources would be considered as illegal.

Legal Notice 241 of 2010, entitled Groundwater Abstraction (Metering) Regulations; which established a requirement for the metering of all significant groundwater abstraction sources.

Legal Notice 395 of 2010, entitled Groundwater Sources (Application) Regulations; which allows the notification of historical and low yield (<1m^3/day) groundwater abstraction sources.

- Controls, including a requirement for prior authorisation of artificial recharge or augmentation of groundwater bodies

A pilot project on Managed Aquifer Recharge (MAR) was initiated during the 1st Catchment Management Cycle with the aim of developing a regulatory framework for the assessment of MAR schemes. In particular, this regulatory framework will take full consideration of the requirements of the Water Framework, Groundwater and Environmental Impact Directives on the authorisation of MAR schemes. This pilot project is being undertaken under the EU financed MARSOL Project (Framework Programme 7), and is envisaged to be concluded by December 2016.

- Prohibition of direct discharge of pollutants to groundwater
The direct discharge of pollutants to groundwater in the Maltese islands is prohibited in terms of Legal Notice 108 of 2009 entitled Protection of Groundwater Against Pollution and Deterioration Regulations.

7.2.2 Supplementary Measures

REG5.1 - Setting up an Inter-Ministerial Water Committee to oversee the implementation of the Plan
This measure envisaged the establishment of an administrative framework to ensure the effective and timely implementation of the WCMP. The Committee was required to monitor and follow-up each measure together with the leading authority and the responsible entities during the lifetime of this plan.

The committee was set up in 2011 with the participation of authorities and agencies involved in the management of water resources and/or the provision of water services. The lead agency up to 2013 was the Malta Resources Authority, when competency was handed over to the Sustainable Energy and Water Conservation Unit. The following agencies are represented on the committee:
- Malta Environment and Planning Authority,
- Ministry for Resources and Rural Affairs (up to 2013),
- Ministry for Sustainable Development, Environment and Climate Change (from 2013),
- Department for Rural Affairs,
- Malta Resources Authority,
- Water Services Corporation,
- Transport Malta,
- Ministry for Gozo, and
- Ministry for Finance

Throughout the implementation period of the 1st WCMP meetings of the Committee were held on a six-monthly basis, wherein discussions focused on the implementation of the measures outlined in the Programme of Measures, with the scope of identifying shortfalls requiring immediate attention on the ground.

AWA1.1 – Develop a nation-wide awareness campaign on water management issues
This measure recognizes that the successful implementation of the Water Catchment Management Plan depends significantly on the readiness of the community to adopt and implement the measures outlined under the Plan's Programme of Measures.

The implementation process of the measure therefore sought to raise national awareness on general water issues including water demand, water conservation, health related aspects of water use, water pollution mitigation etc. This was undertaken through maintaining a regular presence with stakeholders with stakeholders throughout the implementation period of the 2nd WCMP through the organisation of information meetings, specific events on World Water Day and presence in national activities. The information and consultation concept was further developed and the commissioning of a National Water Conservation Awareness Centre and the undertaking of a National Water Conservation Campaign are envisaged during the 2nd Water Catchment Management Period.

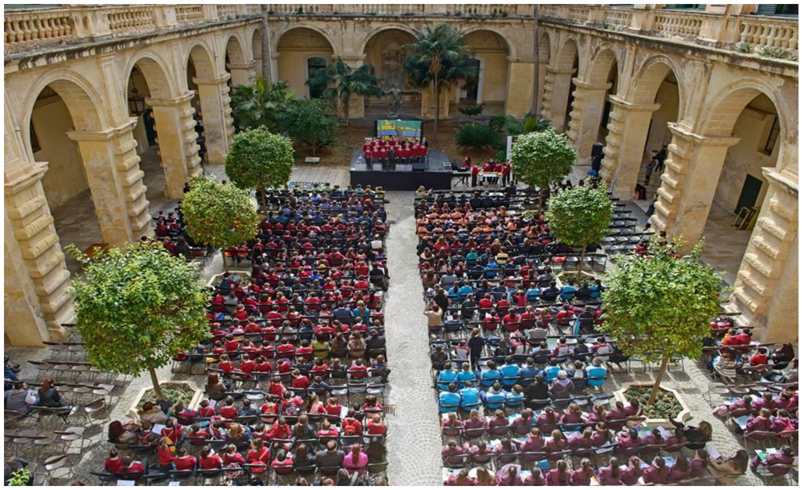


Figure 7.1: Public Awareness Activities – activities for school children under the Catch the Drop Project

Furthermore, during the implementation of the 1st Water Catchment Management Plan various coordinated initiatives were launched to encourage public participation and empower stakeholders towards their direct involvement on water issues. These initiatives were conducted with the support of the Eco-Gozo regional initiative, Nature Trust (Malta) through the Eco-skola initiative, a local bank and Global Water Partnership Mediterranean (GWP-Med) and were focused at different sections of society. During the second RBMP these initiatives will be further developed by way of:

AWA 1.3 - Development of awareness campaigns for individual water user groups targeted by measures under the WCMP

The scope of this measure is aimed at developing awareness in different sectors to explain the scope of each measure under the WCMP and the envisaged benefits (environmental, social and economical) arising from its implementation.

Figure 7.2: Awareness Campaign on Efficient Water Use in the Domestic Sector developed under the SWMED Project

The implementation of this measure focused on the organisation of focused workshops on specific topics in line with the implementation process of specific measures under the WCMP. The issues addressed included water re-use, grey-water recycling, water efficiency, managed aquifer recharge and the optimisation of water use by the commercial and agricultural sector.

GW 1.1 - Regulation of Water Supply Operators

The implementation of this measure has seen the bringing into force of Section 3 of the Water Supply and Sewerage Services Regulations (Legal Notice 525 of 2004) requiring the registration and licensing of private water operators in the water sector, thus effectively requiring that all private operators operate under a licence issued by the Regulator for Electricity and Water Services (REWS).

During the first planning cycle, operational licenses were issued to all private operators. These licenses require amongst others the complete monitoring and reporting of their operations, thus setting the base on which further regulatory provisions for the sector can eventually be based.

Figure 7.3: Flow meter being fitted to an agricultural groundwater abstraction source

GW1.2 - Metering of private groundwater abstraction sources.

Legislation enacted in 2007 required the notification of all private groundwater abstraction sources. Through the enactment of Legal Notice 241 in 2010, the metering of all significant groundwater abstraction sources was required. The implementation of this measure saw the metering of all private (commercial and agricultural) groundwater abstraction sources. This will ensure the availability of data both to the user and the authorities on which measures incentivising a more efficient use of the abstracted water can be based during the 2nd catchment management cycle.

GW1.3 - Reduction of losses in the municipal distribution system

The implementation of a leakage management and control programme by the Water Services Corporation (the public water utility in the Maltese islands) in the municipal distribution network, has since 1997 contributed to a significant reduction in the municipal water demand. The implementation of this programme was actively continued during the first planning cycle.

In this respect it is noted that leakages have been reduced from approximately 10.3 million m^3 in 2002 to only 3.5 million m^3 in 2014; that represents a 66% reduction of the volumes lost each year trough leakages since 2002. Moreover, studies undertaken during the 1st implementation cycle place the economically optimum levels of network leakages at 3.2 million m^3 (considering the costs of water produced offset by the additional resources required to drive the leakage further than current levels). That being the case, current leakage levels would be nearly at optimal levels. This efforts have particularly, allowed for sustaining an increased public water demand (approximately by 1.3% per year since 2005) while at the same time decreasing production (an average 0.2% per year since 2005). Up to 2014, this reduction in the system demand has brought down the abstraction of groundwater by approximately 7 million m^3 since 1995, or a decrease of 34.5%.

GW1.4 - Increase the capacity of rainwater run-off storage facilities

Rainwater Runoff is considered as an important resource of water in the Maltese islands. During the first water catchment management cycle, the following actions were undertaken to optimise the management of this alternative resource:

- financial incentive schemes were launched under the Rural Development Programme (2007-2013) for the construction of rainwater runoff storage facilities (reservoirs) by the agricultural sector;
- maintenance works on water catchment dams along the island's main valleys were continued by the Ministry for Transport and Infrastructure (MTI) and the Ministry for Gozo (MGoz); and
- the publication in 2013 of Technical Guidance F (Conservation of Fuel, Energy and Natural Resources under Legal Notice 238 of 2006) enables/facilitates the increased coordination in the implementation of existing legislative instruments requiring the construction of water reservoirs with new urban developments.

GW1.5 - Pilot projects on water demand management and supply augmentation measures.
During the first management cycle, investigations on a pilot scale on the potential of various water demand management and supply augmentation measures were undertaken. It is noted that the data and experience gathered through these pilot projects helped guide the development of direct measures on a national scale in the Programme of Measures being planning cycles.

Three pilot projects were implemented through EU-funded research programmes and the involvement of the main national stakeholders in the implementation process was actively sought. These pilot projects focused on the following issues:
- Optimising the efficiency of water use in the domestic sector
Water saving kits was distributed in to domestic households in the island of Gozo, and changes in the domestic water demand at a local level monitored. This pilot project was undertaken under the SWMED Project, co funded by the ENPI-Med Programme.
- Managed aquifer recharge through the use of highly polished treated effluents
The response of the sea-level aquifer system to a Managed Aquifer Recharge event was analysed in a pilot site operated under the MEDIWAT Project, co-funded under the INTERREG MED Programme. The quality of the recharge effluent and the response of the aquifer system to the MAR event was extensively monitored during the pilot project, effectively demonstrating a time-lag between quantitative and qualitative impacts, which provide added safety in the implementation of such measures.
- the use of highly polished treated sewage effluent as a source of crop-irrigation water.
A pilot treated wastewater polishing plant was developed under the MORISO Project, co-funded under the INTERREG Italia-Malta Programme. This polishing plant permitted the production of highly polished treated effluent and its testing on a pilot irrigation agriculture site.

GW1.6 – Modelling of the Mean Sea Level Aquifer Systems
One of the main components of the water balance for a coastal aquifer system is natural discharge to the sea. Since it cannot be directly measured, this discharge has to be estimated. During the first water catchment planning cycle, the conceptual model of the sea level aquifer systems in the Maltese islands was reviewed. A pilot initiative was undertaken through the EU-funded MORISO project for the development of a 3D Numerical Model for the small island of Comino.

A cooperation agreement was also signed with the Italian National Research Centre (CNR-IRPI) which initiated the process for the development of a full numerical model for the Malta mean sea-level aquifer system. The development of this modelling framework will ensure the compilation of more reliable estimates on natural water losses and thus better define the sustainable mean annual yield of these systems.

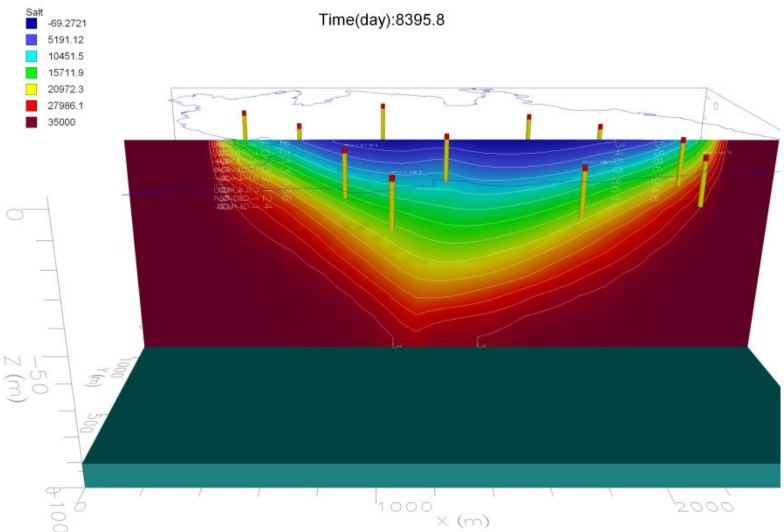


Figure 7.4: Numerical Groundwater Model for the Sea Level Aquifer System in the island of Comino

8 Establishment of the Environmental Objectives

8.1 The Environmental objectives of the WFD and exemptions to achieving those objectives

The first Chapter of this plan lists the environmental objectives expected to be achieved for surface waters, groundwaters and protected areas. These environmental objectives had to be achieved in a given water body or protected area by 2015 unless Malta applied exemptions under the first WCMP for particular water bodies where the water bodies were deemed to be at risk of failing to achieve these objectives, and where the conditions and the process for application of exemptions as outlined by the WFD, were fully adhered to.

There are four different types of exemptions that can be applied, subject to strict conditions:

- the extension of the deadline, in other words, good status must be achieved by 2021 or 2027 at the latest or as soon as natural conditions permit after 2027 (Article 4.4);
- the achievement of less stringent objectives under certain conditions (Article 4.5);
- the temporary deterioration of the status in case of natural causes of force majeure (Article 4.6);
- New modifications to the physical characteristics of a surface water body or alterations to the level of bodies of groundwater, or failure to prevent status deterioration of a body of surface water (including from high to good status) as a result of new sustainable human development activities. (Article 4.7).

When exemptions are applied in one body Malta must ensure that these exemptions do not permanently exclude or compromise the achievement of the environmental objectives in other water bodies. When applying exemptions Malta must also ensure that the same level of protection must be achieved as provided for by other existing legislation, for instance the Nature Directives, Bathing Water Quality Directive or the Marine Strategy Framework Directive.

This Chapter assesses the achievement of the environmental objectives in each water category and establishes whether the exemptions applied for under the first WCMP still apply; whether they can be removed on the basis of improved information; or whether there is a need for the introduction of new exemptions.

8.2 Assessment of the achievement of the environmental objectives for inland surface, transitional water bodies

During the first WCMP, no water related environmental objectives were set for inland surface and transitional waters due to the fact that no assessment had been carried out on the water related requirements of these Natura 2000 areas. The water quality baseline monitoring carried out in 2012 and 2013 allowed for this first assessment to be executed using WFD quality elements. As detailed in chapter 5 a number of difficulties encountered meant that good status, as defined by WFD normative definitions and Annex V requirements, could not be defined. Nevertheless the Natura 2000 management plans for each of the sites and the water quality monitoring carried out under the first WCMP has enabled a qualitative assessment of some of the water related requirements of the various water dependent habitats and species. Further future monitoring is expected to shed more light on the water quality and quantity of these environments.

8.3 Assessment of the need for exemptions and alternative objectives for inland surface and transitional waters

The Favourable Conservation Status (FCS) as defined by the Nature Directives of all water dependent species and habitats is described in detail in Chapter 4. The FCS together with the first water quality monitoring allowed the identification of environmental objectives and targets related to the water environment.

In some cases, even where monitoring of the various water quality elements indicated good water quality, size restrictions of the actual habitat meant that the status of the water dependent habitats from a habitats perspective is inadequate. Size restrictions mean that the habitats are limited but with the proper management measures in place they are considered to be stable and therefore the environmental target in this case is to maintain good water quality and a stable habitat and species status. In these cases no exemptions were applied.

In other cases, the water quality, habitat and species status of particular sites was indicated to be poor or unfavourable due to significant pressures that are yet to be addressed by means of basic measures that were identified in the Natura 2000 management plans, and additional measures that were identified as part of the implementation of the first Water Catchment Management Plan. These measures are described in detail in Chapter 9. Several of the measures recognize the considerable gaps in knowledge on the water related requirements of the particular habitats and species; the need for restoration of particular habitats; as well as the need for greater controls on land activities taking place within the respective catchments of these waters.

In the case of such waters the FCS of these water dependent habitats and species was identified to be unfavourable and of poor water quality status. Therefore the environmental objectives set had to take into consideration the lengthy timescales required to restore the habitats to suitable conditions which favour species growth. Currently little is known about the rate of natural recovery of these disturbed habitats. It could be longer than expert judgement forecasts. Nevertheless there are indices that can be used in the interim that should show signs of habitat regeneration which are to be monitored frequently during the water monitoring programme. These should be used as indicative milestones of progression.

Due to the fact that a need for an exemption was identified, the flow chart illustrated below (figure 8.1) was used to derive the exemptions needed for each inland surface and transitional water. In such cases **exemption type 4.4** of the WFD has been applied.

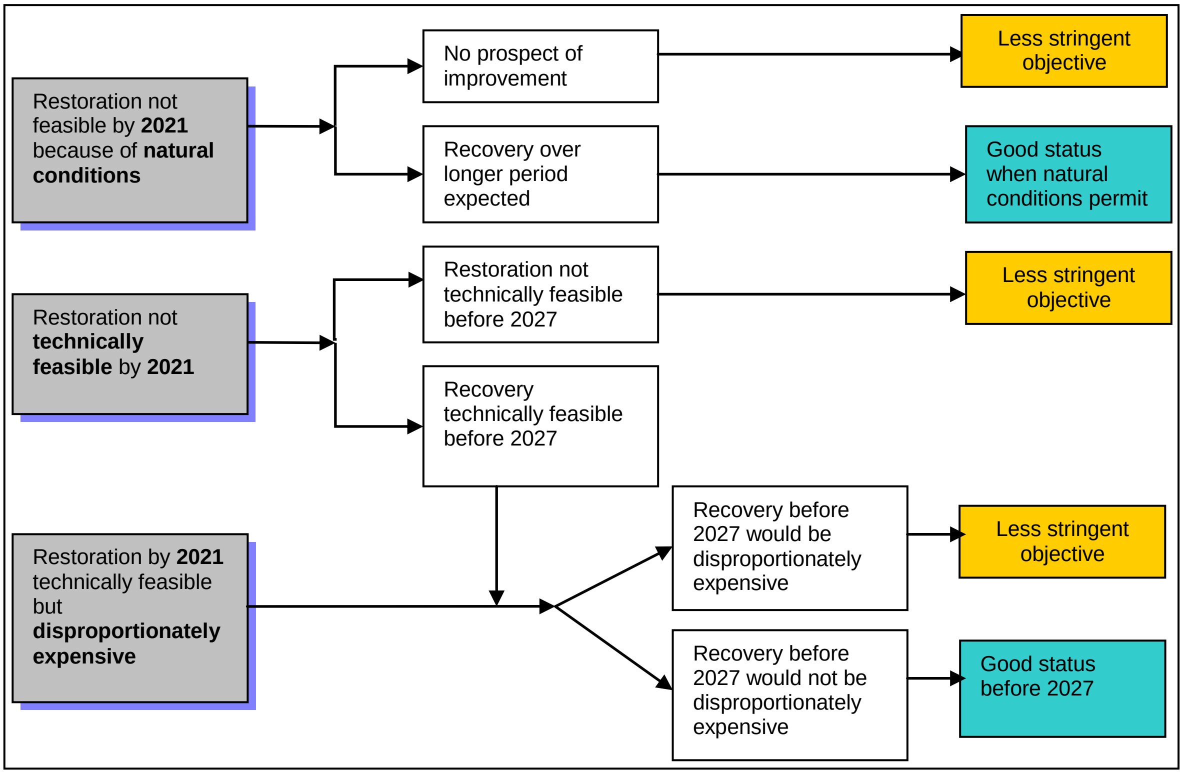


Figure 8.1: Decision diagram used to determine types of exemptions that are to be applied to inland surface waters

Exemption type 4.4 states that the deadlines established under the WFD may be extended for the **purposes of phased achievement** of the objectives for bodies of water. This is permitted provided that no further deterioration occurs in the status of the affected water body when Malta determines that all necessary improvements in the status of the respective water bodies cannot reasonably be achieved within the timescales set out for when natural conditions do not allow timely improvement in the status of the body of water. Any extensions are limited to a maximum of 2 further updates of the Water Catchment Management Plan (i.e. up till 2027) except in cases where the natural conditions dictate that the objectives of the WFD cannot be achieved within this period.

The assessment of the applicability of exemptions per water dependent habitat and species found at each protected water body is divulged in table 8.1 below.

Protected Area and related water dependent habitats and protected species	Current Overall Status as defined by the Habitats Directive*	Assessment of applicability of exemption if water related requirements cannot be seen to be met by 2021 (based on expert judgement)	
		Explanation	**Type of exemption**
Wied il-Luq			
Salix alba and *Populus alba* galleries	**Unfavourable – Bad**	Reversal of the bad and deteriorating trends calls for the: • the long term control on water extraction and reestablishment of an adequate flow regime • control of nutrient loading in sensitive sites • establishment of lateral and longitudinal connectivity of the riparian habitat along the watercourse and reintroduction of native riparian species • control of Invasive Alien species • Access control to reduce trampling impacts • Discussions with local stakeholders including land owners and land users to successfully implement the above.	Recovery over longer period expected for *Populus alba* habitats as well as related water quality. The *Salix alba* will be reintroduced as well as required water quality. **Exemption type 4.4: Good status when natural conditions permit**
Breeding and Wintering Passerines	Unfavourable – Inadequate	Improved management at the site and improvement of the habitats are likely to ensure that the future prospects for breeding and wintering passerines at this SAC are favourable. This includes Improvement of the riparian structure including fruit bearing undergrowth, and the availability of water during the summer months. Once the Management Plan is in place measures implemented shall ensure the long term maintenance of the range, population and habitat of breeding.	Recovery over longer period expected for *Populus alba* habitats as well as related water quality. The *Salix alba* will have to be reintroduced. **Exemption type 4.4: Good status when natural conditions permit**
Discoglossus pictus pictus	**Common as per Standard Data form** .	The targeted condition is to maintain healthy populations of this Red Data Book listed species present in the site. In this regard an Action Plan needs to be elaborated and actions therein implemented as set in the Management Plan for the Buskett and Girgenti SAC	No exemption necessary
Wied tal-Baħrija			
Salix alba and *Populus alba* galleries	**Unfavourable – Bad**	The targeted condition is to improve this habitat by means of implementation of the Natura 2000 management plan over the next few years. Reversal of the bad and deteriorating trends calls for the: • the long term control on water extraction and reestablishment of an adequate flow regime • control of nutrient loading in sensitive sites • establishment of lateral and longitudinal connectivity of the riparian habitat along the watercourse and reintroduction of native riparian species • control of Invasive Alien species • Access control to reduce trampling impacts	Recovery over longer period expected for this riparian habitat **Exemption type 4.4: Good status when natural conditions permit**

		Discussions with local stakeholders including land owners and land users to successfully implement the above.	
Wied tal-Lunzjata			
No Annex I and Annex II species under the Habitats Directive however other important water dependent species thrive here such as the fresh water crab (*Potamon fluviatile lanfrancoi)*, frog (*Discoglossus pictus pictus)* *And* the following RDB invertebrate species which are dependent of freshwater *Haemopis sanguisuga*; *Planorbis moquini*; *Physa acuta*; *Pseudamnicola melitensis*; *Mercuria* cf. *Similis*; *Pisidium casertanum* Annex I birds and non annex I waders and aquatic birds thrive here	**Unfavourable watercourse habitat though size and range of populations of the waders and aquatic birds is favourable**	Future prospects of this condition are still unfavourable unless action is taken to manage the giant reed overgrowth. In addition the N2K plan highlights the following issues: Human induced changes in hydrologic conditions: The freshwater course of Wied Xlendi is threatened by a number of human related activities, mostly associated with agriculture. One of the most important threats is alteration of the hydrodynamic functions of the watercourse such as irrigation and the direct pumping of freshwater (resulting in a general reduction in water levels and water flow throughout the valley system). In addition to this, extraction of water from the aquifer from areas in the vicinity (resulting in an overall reduced volume of water supplied by the tributary system of Wied ix-Xlendi) is a practice as well. In addition modification of structures of inland water courses, eutrophication and removal of sediments (mud) has been reported to be of importance. Action Plans are to be prepared for Invertebrate species.	Recovery is not expected to be achieved by 2021. **Exemption type 4.4: Good status when natural conditions permit**
Il-Qattara			
Hard oligo-mesotrophic waters with benthic vegetation of Chara spp.	**Unfavourable** – **Inadequate**	Introduction of alien species has brought instability to the ecosystems present. This therefore provides inadequate future prospects for the habitat. However once the Natura 2000 management plans are in place, measures to remove alien species are expected to improve the status considerably.	Although the waters are of unfavourable conservation status, the preliminary indication of ecological water status is considered to be good. Significant pressures will be dealt with within the timeframes required by the WFD. **(i.e. 'Good status' is achievable by 2021)**
Southern riparian galleries and thickets (*Nerio-Tamaricetea* and *Securinegion tinctoriae*)	**Unfavourable** – **Inadequate**	Future prospects for this habitat are favourable since the targeted condition is to improve this habitat by means of implementation of the Natura 2000 management plan over the next few years. The management plan identifies the need to extend the habitat along the valley bed to unite populations located below Wied Għorof with those of Qattara.	
L-Ghadira ta' Sarraflu			
No Annex I and Annex II species however other important water dependent species thrive here		The main threat which is the introduction of alien species into the water environment would try to be addressed. It is noted however that *Rana bedriagae* is known to be difficult to eradicate subsequent to its establishment, while consideration to the short maturation period of *Gambusia affinis* would require intensive removal action to exhaust the population. Currently it is difficult to indicate whether the removal of alien	No exemption is being requested

		species can be achieved by 2021, especially if the population dynamics of both species and their resilience to removal actions are unknown. The actual status would have to be reassessed in 2021	
Is-Salini			
*Coastal lagoons *(*denotes priority habitat)*	**Unfavourable – Inadequate**	The prospects for this particular habitat seem good since efforts to manage the site are underway and favour the provision of optimal habitats for migratory birds and biodiversity to flourish.	Recovery over a longer period is expected for this water body when all measures being proposed are in place. **Exemption type 4.4: Good status when natural conditions permit**
Salicornia and other annuals colonising mud and sand	**Indeterminate**	Future prospects for this habitat are slight in view of the poor structure and function of the habitat and the presence of ruderals which indicate high levels of disturbance. The Natura 2000 Management plan aims to improve the habitat by reducing the extent of disturbance.	
Mediterranean salt meadows	**Unfavourable – Bad**	Continued disturbance at the site result in deterioration of the habitat. The Natura 2000 Management plan aims to improve the habitat by reducing the extent of disturbance and restoring it.	
Mediterranean and thermo-Atlantic halophilous scrubs	**Unfavourable – Bad**	Long term sustainability of this habitat also calls for habitat restoration and the minimising of disturbances.	
Southern riparian galleries and thickets	**Unfavourable – Bad**	Invasive species need to be controlled and habitat restored.	
Aphanius fasciatus	**Unfavourable – Bad**	The habitat is presently very vulnerable to water pollution. The site's location is at the mouth of a large water catchment which hosts intensive agriculture practices. The site itself lies adjacent to a major road. The management plan intends to monitor the species and water quality as well as mitigate sources of pollution.	
Acrocephalus scirpaceus	**Unfavourable – Bad**	The management plan intends to limit access to the reed bed area and regular surveillance. This should encourage the reed warbler to nest at Salini.	
Il-Maghluq ta' Marsaskala			
Coastal lagoons	**Unfavourable – Bad**	The Natura 2000 management plan aims to monitor the habitat, plan a project for the expansion of the habitat and manage the area by removing water fowl, improve circulation by removing access silt circulation and mitigate agricultural sources of pollution. Regular clean ups in the area also feature in the plan.	Recovery over a longer period is expected for this water body when all measures being proposed are in place. **Exemption type 4.4: Good status when natural conditions permit**
Mediterranean salt meadows	**Unfavourable – Bad**	Apart from the measures above the management plan identifies the need to remove alien species from the wetland.	

Aphanius fasciatus	**Unfavourable – Bad**	The control of the waterfowl and Mullet, as well as improved water quality by means of the Natura 2000 Management plan, indicates that future prospects are favourable for this species.	
Il-Ballut ta' Marsaxlokk			
Salicornia and other annuals colonising mud and sand	**Unfavourable – Bad**	The Natura 2000 Management plan identified that in order for there to be a long term sustainability of this habitat there is a need to extend the marshland into the neighbouring parcels of land.	No exemption required since size restrictions of the actual habitat means that the status of the water dependent habitats from a habitats perspective is inadequate.
Mediterranean salt meadows	**Unfavourable – Bad**	If the lagoon extent is increased this habitat will be improved.	
Mediterranean and thermo-Atlantic halophilous scrubs	**Unfavourable – Bad**	Similar to the above two habitats, the status of this habitat could become favourable if the extent of the lagoon is extended.	
Is-Simar			
Coastal lagoons	**Unfavourable – Inadequate but stable**	The limiting factor is the size of the lagoons. The Natura 2000 management plan recognises the need to extend the wetland, in order to ensure better opportunity for breeding and more bird diversity. Water quality monitoring is expected to continue in this lagoon.	No exemption is required since water environment is stable and size is the limiting factor. In case of *Aphanius fasciatus* and *Discoglossus pictus pictus* no exemption is required in view that status is considered to be favourable.
Aphanius fasciatus	**Favourable**	The lagoon will continue to be managed and protected. Future prospects for this species therefore are favourable.	
Ixobrychus minutus	**Unfavourable – Bad**	The Natura 2000 management plan of the area indicates that it is not considered likely that the breeding of this species will be re-established at the site in its present state.	
Breeding wetland species	**Unfavourable – Bad**	The small size of the reserve limits the number of birds that can be supported during the winter and these habitats are thus considered to be inadequate at Simar. The limiting factor is the size of the lagoons.	
Migratory Waterfowl and waders including Annex I migratory herons	**Unfavourable – Bad**	Threatened by illegal hunting and size restrictions rather than water quality. Natura 2000 management plan recognises the need to extend the wetland, in order to ensure better opportunity for breeding and more bird diversity.	
Migratory wetland passerines	**Unfavourable – Bad**	Natura 2000 management plan recognises the need to extend the wetland, in order to ensure better opportunity for breeding and more bird diversity. Therefore size rather than water quality is the limiting factor	
Discogossus pictus pictus	**Common** as per draft Management Plan	*Discoglossus pictus pictus* is noted to be common in the reserve. This is the only native amphibian present in the Maltese Islands, associated with freshwater rock pools, ponds, valley watercourses, springs and reservoirs.	

		Vulnerable, it has a restricted distribution in the Mediterranean region and the Maltese Islands, becoming more restricted due to habitat destruction, pollution and persecution. The population size is not known.	
L-Għadira			
Coastal lagoons	**Unfavourable – Inadequate but stable**	The increase in the extent of the habitat would improve the future prospects for this particular coastal lagoon, as in the case of other coastal lagoons.	No exemption is required for the water dependent species and habitats since size restrictions of the actual habitat means that the status of the water dependent habitats and protected species from a habitats perspective is inadequate. The water quality required is considered to be appropriate to support the species and habitats.
Salicornia and other annuals colonising mud and sand	**Inadequate**	The Natura 2000 management plans indicates that since the processes affecting this habitat are natural rather than anthropogenic, there is little intervention that can be carried out to protect this habitat from disappearing.	
Mediterranean salt meadows	**Inadequate**	In spite of the fact that the prospects for the structure and function of this habitat are favourable, the lack of available area to extend the distribution limits the future prospects of this habitat to inadequate but stable.	
Mediterranean and thermo-Atlantic halophilous scrubs	**Inadequate**	The future prospects for this habitat remain inadequate but stable due to the fact that the presence of tree cover dominated by non related species cannot be removed in their entirety due to the fact that the benefits of such a restoration measure would be outweighed by the potential loss of fodder and cover that is favoured by some rare avian specie which visit the reserve.	
Aphanius fasciatus	**Favourable**	Future prospects are favourable since Water quality monitoring will be maintained and the habitats supporting this habitat will be protected.	
Discoglossus pictus pictus	**N/A**	The Species data fact sheet indicates that the Painted frog is common at Ghadira, The Management plan identifies that the Painted frog is known from Ghadira.	No exemption considered necessary
Himantopus himantopus	**Indeterminate**	The size of the lagoon is a concern and is consdered unlikely to be able to support more than the three breeding pairs, in view of strong territorial behavior and the need for wide open views to protect its nest.	
Wintering wetland species	**Unfavourable – Inadequate**	Once again, the small size limits the availability of suitable resources, thus limiting number of species that can winter at the wetland.	

Table 8.1: Breakdown of exemption application per inland surface and transitional protected water

8.4 Assessment of the need for exemptions and alternative objectives for groundwater dependent water courses

8.4.1 Ecological status and Potential

Chapter 6 indicated that the ecological water quality status of the inland surface water and transitional waters varies according to water category. Although specific methods to determine the status of biological quality elements is yet to be determined, there is a clear indication that watercourses fail to achieve good ecological status due to very high nutrient levels. Two of the three watercourses, Wied Lunzjata and Wied tal-Baħrija can be considered to be groundwater dependent systems and therefore any exemptions requested to achieve acceptable levels of nitrates in these valley systems is linked to the groundwater objectives and exemptions to achieve good qualitative status by 2021 or beyond as soon as natural conditions permit after 2021.

For Wied il-Luq, given that the water body has been heavily modified and water flow from spring galleries have been diverted since the time of the Knights of St. John, Malta is yet to determine the maximum ecological potential of this particular valley system. The paucity of historic data makes the reconstruction of the ecological maximum potential very difficult and requires that the water availability and balance in the valley system be adequately studied. Malta has therefore developed measures that aim to improve current knowledge about this system. Therefore any exemptions being requested for this system deal with the water related habitats and species that are indicators of a better water environment.

In the case of the other water categories, i.e. the ponds and the transitional waters, the ecological status could not be determined with much certainty since the methods pertaining to the biological quality parameters were inadequate and new methods have yet to be tested during this second cycle (see Chapter 5). In addition, unlike watercourses, none of the supporting physico-chemical parameters in the transitional and standing water categories clearly pointed towards a failure in good ecological class achievement. Although it must be highlighted that the transitional waters have all been heavily modified and therefore the determination of ecological class in these cases will have to take this into account.

8.4.2 Chemical Status

In terms of chemical quality, the one time monitoring indicated that all inland surface and transitional waters had good water quality but the sediment matrix of il-Magħluq ta’ Marsakala, il-Ballut ta’ Marsaxlokk, Wied Lunzjata and il-Qattara exceeded guideline ecotoxicological values that were used from literature for a number of chemical substances (refer to Chapter 6). Monitoring however was carried out once and therefore Malta will be repeating the monitoring for these contaminants in the sediment matrix. No exemption is being applied for these waters given that sediment monitoring was limited to a one month reading.

8.5 Assessment of the progress made towards the achievement of the environmental objectives for coastal water bodies

During the first WCMP Malta applied 6 exemptions in 3 water bodies. These exemptions pertained to the two heavily modified water bodies (MTC 105 and MTC 107) and to the coastal waters of Xghajra where Malta had been discharging the majority of its untreated waste water into the sea for several decades. The exemptions applied were of article 4.4 (a) and (c) of the WFD and were based on expert judgement.

With monitoring data now in hand, Malta has had to revisit the exemptions applied for, since the status assessment carried out (see Chapter 6) resulted in particular water bodies being of better water quality (in terms of ecological status) than originally thought. The exemptions applied in 2011 are being presented in table 8.2 below.

Water Body Code	Water Body Name	Environmental Objective (including exemption)	Reason for exemption
MTC 106	Ix-Xgħajra	Good ecological and Good Chemical Status (2021)	Article 4 4(a)(iii) – natural conditions do not allow for timely improvement in the status of the body of water
MTC 105	Il-Port il-Kbir – Il-Port ta' Marsamxett	Good Ecological Potential and Good Chemical Status (2021)	Article 4 4(a)(i) - the scale of improvements required can only be achieved in phases exceeding the timescale, for reasons of technical feasibility. Article 4 4(a)(iii) – natural conditions do not allow for timely improvement in the status of the body of water.
MTC 107	Il-Port ta' Marsaxlokk	Good Ecological Potential and Good Chemical Status (2021)	Article 4 4(a)(i) - the scale of improvements required can only be achieved in phases exceeding the timescale, for reasons of technical feasibility. Article 4 4(a)(iii) – natural conditions do not allow for timely improvement in the status of the body of water

Table 8.2: Exemptions applied to the three coastal water bodies under the first WCMP (2011)

8.5.1 Coastal water body MTC 106 (Ix-Xgħajra)

The single most significant pressure leading to the request for an exemption for this water body during the first cycle was the disposal of untreated sewage prior to 2010. The basic measure to construct and operate a waste water treatment plant in this area (Ta' Barkat) was successfully completed. An additional supplementary measure related to the use of a pipe diffuser for discharge of treated waste water into this coastal stretch was also successfully completed during the first WCMP (refer to Chapter 7 on progress related to implementation of first WCMP measures).

Although no trend data is available to indicate recovery in MTC 106, ever since Malta's largest waste water treatment plant was made operational in 2010, the monitoring of the biological quality elements together with the supporting physico-chemical and hydromorphological elements have indicated that the water body is of moderate status rather than bad status, with phytoplankton being singled out as being of 'moderate' status (refer to Chapter 6). Given that macroalgae gives a clear indication of nutrient status, and this BQE resulted to be of good status, it is likely that the coastal environment is recovering. Therefore the environmental target related to the achievement of good ecological status by 2021 is being maintained.

The chemical status in this particular water body, on the other hand, indicates that there are problems with 3 main substances / groups of substances of concern. Monitoring has revealed that mercury is already problematic in the area. Lead and poly aromatic hydrocarbons could also be potentially problematic in the future (Chapter 6). The question that would guide Malta's application of exemption where chemical quality of MTC 106 is concerned, is whether with the current level of knowledge on the contaminants of concern mentioned above, would allow Malta to identify the necessary action required to address the sources of these contaminants in time for good chemical status to be achieved by 2021.

8.5.2 Heavily modified Water Body MTC 105 Il-Port il-Kbir and Il-Port ta' Marsamxett and MTC 107 Il-Port ta' Marsaxlokk.

The water bodies MTC 105 and MTC 107 are the two heavily modified water bodies characterised by significant historically induced hydromorphological change brought about by large scale coastal engineering works. The exemptions requested for these two water bodies pertained to the fact that the scale of improvements to achieve good ecological potential and good chemical status could only be achieved over a longer timeframe since both water bodies have been subjected to historic contamination and therefore require considerable investment to alleviate the impacts. Moreover, the permitting system in place to regulate all harbour activities requires time to give positive and quantifiable results.

The monitoring data of the first cycle revealed the ecological status of both these water bodies to be moderate in the case of MTC 105 and good in the case of MTC 107. These results mean that the exemption on achieving good ecological potential for MTC 107 applied on the basis of expert knowledge at that time is no longer considered necessary because the objective of good ecological potential has already been met. On the other hand the status of MTC 105 indicates that although the status is better than what was assumed under the first WCMP, there is some time yet before good ecological potential can be said to have been achieved.

In fact, measures included under the first cycle related to these water bodies included the setting up of a regulatory framework for industrial operational practices. The Environment Authority is currently implementing such a regulatory system for the application and issuing of environmental operating permits for industrial activities of environmental significance. Environmental permits also incorporate pollution abatement action programmes for substances that are of concern and control discharges to sea.

A guidance document related to obligations governing the regulation of discharges to the water environment was also drafted to inform industrial operators, environmental consultants and the general public of environmental operational aspects and best practices for the regulation of discharges to the water environment.

Another measure directly targeting harbours is the development and implementation of harbour management plans, the aim of which is to set the necessary framework for good practices for all operations and activities within and adjacent to the harbour area to improve the overall water quality of the harbour.

MEPA has also drafted guidance for the disposal and reuse of dredged material which provides clear standards and criteria for the assessment of dredged material and appropriate disposal methods. This guidance is already being implemented on a pilot basis through the environmental and development planning framework.

The above mentioned measures for these HMWBs are considered to be prerequisite measures since they set a sound regulatory base for improving water quality in these water bodies. It is expected that they will continue to be implemented in the second WFD cycle (refer to Chapter 9). Keeping in mind that the measures identified under the first plan are in place but are yet to be refined Malta is yet to establish whether the current status of MTC 105 is the **maximum ecological potential** that can be achieved.

8.5.3 New water bodies which have not achieved good chemical status

An additional water body that fails to achieve the WFD's chemical status objectives is MTC 104. This water body stretches from the Northern tip of Mellieha to Sliema and hosts a multitude of economic sector activities due to the fact that this stretch of the coastline is physically the most accessible and therefore the most developed.

Chapter 6 indicated that this water body fails to achieve good chemical status due to mercury and PAH contaminants found at levels that exceed the Environmental Quality Standards on more than one occasion during the monitoring year 2012-2013. Once again the level of knowledge concerning the potential sources and the extent of contribution of those sources to both mercury and PAH contamination is low and therefore any measures that have been developed as part of this plan may not be sufficient to guarantee that good chemical status will be achieved in MTC 104 by 2021.

8.6 Assessment of the need for exemptions for coastal waters

Given the above discussions, Malta has had to revisit the application of exemptions for coastal waters. The revised exemptions are provided in Table 8.3 below:

Water Body Code	Water Body Name	Revised Environmental Objective (including exemption)	Reason for exemption
MTC 101,102,103, 104, 105, 106, 107, 108, 109		Less stringent objective is applied for Mercury	Article 4 4(a)(i) - The necessary improvements in the chemical status of the water body cannot be reasonably achieved by 2021 due to the fact that these water bodies are failing to achieve the relevant EQS level established for mercury concentrations in the water column. It is not yet known whether mercury is problematic due to transboundary issues. Malta needs to investigate this further. Given that this is a significant gap that requires additional monitoring and investigation the scale of improvements required can only be achieved in phases exceeding the timescale, for reasons of technical feasibility.
MTC 104	Il-Mellieha – tas-Sliema	Good Chemical Status (2027)	In addition to mercury in water, mercury and PAHs were problematic in sediments based on the Italian EQS limit that was used in this water body. Additional monitoring and investigations into the possible sources for such contamination is required. Therefore Article 4 4(a)(i) is also being applied for PAHs - The necessary improvements in the chemical status of the water body cannot be reasonably achieved by 2021 due to the fact that the scale of improvements required can only be achieved in phases exceeding the timescale, for reasons of technical feasibility.
MTC 105	Il-Port il-Kbir – Il-Port ta' Marsamxett	Good Ecological Potential (2021)	Article 4.5 – Less stringent environmental objectives are required due to the fact that this Water body is so affected by human activity, that the achievement of the WFD objectives would be infeasible and disproportionately expensive.
		Good Chemical Status (2027)	In addition to mercury in water, PAHs were problematic in sediments based on the Italian EQS limit that was applied to this water body. Additional monitoring and investigations into the possible sources for such contamination is required.

			Article 4 4(a)(i) - The necessary improvements in the chemical status of the water body cannot be reasonably achieved by 2021 due to the fact that the scale of improvements required can only be achieved in phases exceeding the timescale, for reasons of technical feasibility.
MTC 106	Ix-Xgħajra	Good ecological status will be achieved by 2021	No additional exemption (i.e. in addition to the exemption that Malta applied in 2011) is required.
		Good chemical status to be achieved by 2027	In addition to mercury in water, lead was problematic in sediments based on the Italian EQS limit that was applied to this water body. Additional monitoring and investigations into the possible sources for such contamination is required. Article 4 4(a)(i) - The necessary improvements in the chemical status of the water body cannot be reasonably achieved by 2021 due to the fact that the scale of improvements required can only be achieved in phases exceeding the timescale, for reasons of technical feasibility. Or due to transboundary contaminants
MTC 107	Il-Port ta' Marsaxlokk	Good Ecological Potential has been achieved	No exemption is required.

Table 8.3: List of exemptions for ecological and chemical status in coastal waters.

8.6.1 Reasons for applying exemption 4.4 in the case of mercury in all coastal water bodies

Mercury levels in Maltese coastal waters unexpectedly failed the 2008 established water-EQS in all coastal water bodies, including those waters considered to be less vulnerable to land-based sources of pollution. Substantial scientific literature indicates that the Mediterranean region is already very rich in natural background mercury levels due to the presence of geologic cinnabar deposits and active volcanic activity[232]. In addition there may also be contributions from atmospheric mercury cycles and associated atmospheric deposition[233]. The biogeochemical cycles of mercury in the Mediterranean and Maltese waters therefore need to be looked into. Other more localised activities contributing to mercury are yet to be found since no significant pressure sources on land or within Maltese territorial waters have been identified as yet; although there are assumptions that particular activities, such as landfills and bunkering could be potential contributors.

Due to the fact that there is very little knowledge on potential pressures, Malta needs to investigate the matter rigorously and scientifically, using whatever research has already been carried out at a regional scale. Keeping in mind that it is not yet known whether Malta's issue is mainly attributed to transboundary sources, Malta will have to apply for a less stringent objective in the interim until more

[232] Rajar, R., Četina, M., Horvat, M.,and Žagar, D. 2007. Mass balance of mercury in the Mediterranean Sea, *Marine Chemistry,* 107:1 (2007) 89-102.

[233] Pirrone, N., Ferrara, R.,, Hedgecock, I.M., Kallos, G., Mamane, Y., Muthe, J., Pacyna, J.M., Pytharoulis, I., Sprovieri, F., Voudouri, A., Wangberg, I. 2003. Dynamic processes of mercury over the Mediterranean region: results from the Mediterranean Atmospheric Mercury Cycle System (MAMCS) project, *Atmospheric Environment*, Pergamon 37 Supplement No. 1 (2003) S21-S39.

light is shed on the problem and a roadmap for further action is outlined. Such action has been identified to be a necessary measure in Chapter 9.

8.6.2 Reasons for applying exemption 4.5 'Less stringent objective' in the case of ecological potential for Heavily Modified Water Body MTC 105

8.6.2.1 Cultural heritage

The Grand Harbour is a natural port and has a very rich history. It has been described as the "historical, symbolical and political heart of the island"[234]. The Port lies in between the Three Cities of Senglea, Vittoriosa and Cospicua and Malta's capital city Valletta which itself is a UNESCO World Heritage Site. Upon entering the Grand Harbour from the sea one cannot miss the massive fortifications, palaces and marinas on which the Knights of St John erected large imposing buildings manifesting their artistry and aesthetics.

Fort St. Angelo, lying in the centre of the Grand Harbour is a historic fortification which is believed to have existed since the 13th century. It was rebuilt by the Order of St John in the 16th century and was used by the British as a stone frigate. Another historical site standing at the edge of the Valletta peninsula that separates Marsamxett Harbour from the Grand Harbour is Fort St. Elmo, mostly known for its role in the victory over the Turks in the Great Siege of Malta of 1565. While the aforementioned forts enjoy most prominence, there are other forts in the Grand Harbour that possess historical value, including Fort Ricasoli situated in Kalkara.

Malta's economy was historically oriented around maritime traditions, including ship building, repair and the servicing industry. The shipyards date back to the 1500s. These services are still in operation such as the Malta shipyard located in the French Creek above of which, one can find St. Paul's Bastion which forms part of the Cottonera lines.

Other historical sites in the Grand Harbour include the Bighi Hospital, built around 180 years ago, which served as a naval hospital in the 19th and 20th centuries and the Floriana bastions found next to the Valletta Waterfront. The latter also has heritage value as the baroque wharf was originally used as stores and warehouses.

Marsamxett also has a cultural and heritage value as this port played an important role in the establishment of the City of Valletta. The Marsamxett area is full of Baroque architecture highlighting the unique aesthetics and craftsmanship of earlier periods. One thing which makes Marsamxett area stand out from contemporary European cities is the survival of many of its monuments and buildings from several military attacks throughout the times. A prominent fort in the Marsamxett Harbour is Fort Manoel, built by the Order of St. John and which was completed in 1755 after 32 years of construction. It served as an active military establishment until 1906, when the British decommissioned it's guns. Recently, in 2009, it reopened to the public after having undergone restoration works. Fort Tigne, situated in Sliema is another fort with a long history. It was constructed around 220 years ago by the Knights of Saint John to protect the harbour. Another historical site within Marsamxett port is Lazaretto – a quarantine hospital used to control the periodic influx of plagues and diseases on board visiting ships. It was built by Grandmaster Lascaris in 1643 and enlarged by Sir Henry Bouverie between 1837 and 1838.

8.6.2.2 Recent developments

After the turn of the millennium, the Maltese government has gained particular interest in the rehabilitation of the Grand Harbour area. The main mission was to transform the living environment in the Maltese Islands through economically, socially, and environmentally sustainable urban development whilst also creating an excellent physical and living environment for sustainable land transport networks and systems.

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[234] http://marenostrumproject.eu/news-events/blog/rising-land-use-pressures-in-malta-grand-harbour

In recent years, the government has outlined a series of regeneration projects within the Grand Harbour area to regenerate the cities, conserve the existing urban heritage and prevent further deterioration, restore economic activity and revive community development by attracting new residents to the area. In addition, these activities also aim to promote the Harbour area as a thriving community attracting once again, discerning residents; economic activity; artisan and specialist trades, social regeneration and tourism activity. Some of the projects include:

1. **Valletta Cruise Liner Terminal**: A total project area of 30,000m^2 including reclamation and quay extensions. This investment amounted to around €22 – €32 million. This project was also instrumental in establishing Malta as a cruise home port. Additionally, the rehabilitation project of the Pinto Wharfs resulted in the opening of the Valletta Waterfront catering and retail facilities which complimented the Cruise Liner Terminal product. This project was officially inaugurated in 2006.

2. **Cottonera Waterfront Redevelopment**: This project was completed in 2007 and cost around €60 million. This was brought about by the restoration of historic buildings, most of which were to the industrial heritage of the Maltese Islands. Moreover, the project introduced new activities in the Cottonera and sought new investments based on public-private partnerships to regenerate the area leading to a better socio-economic environment. In addition it also introduced the creation of high quality accommodation through the creation of St. Angelo Mansions; and the building of a yacht marina, attracting a number of super yachts.

3. **Dock 1 Project**: This project was completed and was officially inaugurated in August 2014. Central to the project was the transformation of the run-down dockyard area into a promenade between Senglea, Cospicua and Vittoriosa, including a pedestrian bridge across Dockyard Creek at the mouth of the dock. The project cost € 11 million and was partly funded by the EU.

The Grand Harbour region has significantly benefited from the aforementioned renovations. The Valletta Cruise terminal is not only limited to port operations. The area covers nearly five hectares filled with 17th century warehouses that are being renovated and developed. To date, some €40 million has been invested in restoration and maintenance. The result is what is known as the Valletta Waterfront, an urban development site that has won various international awards.

Following the projects to revamp the Grand Harbour, the government proposed similar developments in the Marsamxett area in 2007 with the aim of reinvigorating it. Such projects included the construction of two cruise liner quays and a cruise liner terminal, replacing Evans building with a 5-star hotel and building a promenade at Tigne Point. Another project proposed to increase activity in Marsamxett Port is the development of a Yacht Marina at Sa Maison. The Environmental Impact Assessment related to such project revealed the possibility of installing a breakwater at the mouth of the harbour which would make it an all-year commercial port.

8.6.2.3 Economic activities

Apart from giving fresh impetus to Malta's port development, these investments also have significant economic impact. The number of cruise tourists more than tripled in a decade and in turn these tourists spend money in Maltese restaurants, museums and take other various excursions. In 2013, it was also estimated that cruise tourism generated €81 million in Malta. Tourist activity has also led to the creation of 2,250 direct jobs, primarily in the capital[235].

[235] CLIA Europe (2014), The Cruise Industry: Contribution of Cruise Tourism to the Economies of Europe 2014 Edition

These various rehabilitation initiatives within the Grand Harbour area have resulted in a number of activities. Today the economic activity within the harbour is once again considered to be an important contributor to the Maltese economy.

The cruise liner industry has experienced continuous expansions in recent years. Investment in the Valletta cruise terminal, coupled with a strategic location at the centre of the Mediterranean proved instrumental in generating the volume increases to make Valletta one of Europe's top cruise harbours.
Cruise passengers for 2014 stood at 471,554, a rise of 9.3% over 2013. There were 303 cruise liner calls in 2014, with an average 1,556 passengers per vessel, compared to 286 calls and an average of 1,508 passengers per vessel in 2013. The economic impact of visitors to the islands through cruise liner activity is also important for the sector. Research by the Malta Cruise Network and the National Statistics Office shows that cruise passengers spent an average of €29.70 each whilst ashore, excluding the costs of pre-booked excursions. If multiplied by the number of passengers ashore during the same period, cruise passengers left an estimated average of €14 million for the year ended 2014.

Malta has become the largest ship register in Europe and the seventh largest in the world. This is particularly thanks to its strategic location between the cross roads of Europe and Africa and Malta's strong maritime history and infrastructures. According to NSO's transport statistics [5], during 2013 Malta registered nearly 700 new vessels tallying the number of vessels registered as at the end of 2013 to 6,248. These include 2,930 yachts, 770 fishing vessels. 1,399 dry cargo vessels and 616 liquid bulk vessels.

Yachting activities have grown substantially over the past years and hold a promise for further future expansion. The former Planning Authority and former Malta Maritime Authority published a Yachting Subject Study in 1997, which looked into the demands of the industry and investigated the yachting development potential of the Islands. The study shows that Malta is in a strategic location to reap the benefits from the stop over traffic cruising the Mediterranean. Language, the social environment and the availability of good quality chandlery and yard services in Malta are perceived as advantageous qualities to promote Malta on the international yachting scene.

According to recent NSO statistics [236], Malta has 1,883 berths; 1,815 permanent marinas and 68 seasonal marinas. The Grand Harbour Marina alone has 250 berths and the Kalkara Yacht Marina has 110 berths. As at 2013, Malta had some 300 people working within the super yacht industry, while other 200 jobs were indirectly dependent on this business. A study commissioned by Transport Malta in 2010, estimated that the total annual economic output of this industry at around €31 million.

The Grand Harbour also offers ferry services between Malta and Sicily. The operation of high speed ferries between Malta and Sicily started in 1988 and is still a thriving activity used by both for leisure and commercial activity. The main boat used has a capacity of 600 passengers; 65 cars/ trucks/ caravans/ coaches/ trailers, makes over 500 round trips every year between Valletta and Pozzallo (90 minute) and Catania (3 hours) effectively making Malta part of mainland Europe. In addition, Malta through this link, serves as the main market for tourism to Sicily through this ferry boat since tour operator companies sell Sicily through Malta as a day excursion or as a part of two-island holiday.

The revival of the waterfront project in Valletta and the Yacht Marinas have led to increased economic activity in the area; retail activity has increased and more leisure and ancillary activities has been generated as a result of the rehabilitation of the waterfronts. The cultural activity in the area of the Grand Harbour,

[236] Grant Thornton, 2015. Cost-effectiveness Analysis Report for the Management of Malta's water bodies, including analysis of cost disproportionality, August 2015

through invented food and historical festivals and pageantry, art exhibitions, concerts and new cultural attractions have led to more and more people visiting these areas for entertainment purposes.

8.6.2.4 Economic justification for cost disproportionality

From the salient points mentioned above it is clear that reversing the hydromorphological alterations of the Grand Harbour would have significant adverse effects on the wider environment. This could lead to:

- Endangering the national heritage and the area's rich culture
- Reduce the economic activities around the area such as; cruise tourism, ferries to Sicily, waterfronts' retail activity and other indirect economic activities generated through tourism
- Material loss in employment which are directly and indirectly related to the economic activity of the Grand Harbour area.

8.6.3 Reasons for applying exemption 4.4 'extension of the deadline' to achieve chemical status in water bodies MTC 104, MTC 105, and MTC 106

Three main contaminants of concern emerged from the chemical quality monitoring of all coastal water bodies in 2012 and 2013. These were mercury in the water matrix, and mercury, Lead and PAHs in the sediment matrix. To date the measures that have been developed to mitigate land based sources of pollution are in place and therefore, although there is room to improve the implementation of the measures themselves, there is the need for other potential hydrographic and atmospheric pathways for such contaminants to be investigated thoroughly.

In order to carry out the necessary investigations and identify suitable measures, the timescales to achieve good chemical status as provided by the WFD would be insufficient. Measures to plug these knowledge gaps have been introduced in this second WCMP (refer to Chapter 9) however the outcome of these studies is largely unknown and the measures required to tackle any of the sources identified are expected to initiate towards the middle or end of the second cycle. This gives little time for Malta to achieve the required objectives by 2021. Furthermore there is considerable uncertainty related to potential transboundary impacts which need to be investigated further.

8.7 Establishing Environmental Objectives for bodies of groundwater

The Water Framework Directive requires that due consideration is given to both quantitative and qualitative aspects in the achievement of overall good status in each body of groundwater. Following the implementation of the measures envisaged in the 1st Water Catchment Management Plan a status review was undertaken, as described in Chapter 6 of this document. Furthermore, an assessment of the impact of the programme of measures developed under this 2nd Catchment Planning document has been undertaken in order to enable a projection on the expected quantitative and qualitative status of groundwater bodies in 2021.

8.7.1 Quantitative Status

The implementation of the 1st Water Catchment Management Plan has led to the achievement of good quantitative status in all 12 Upper Coralline Limestone aquifer systems in the Maltese Water Catchment District. Only two bodies of groundwater, namely the Malta Mean Sea Level and the Gozo Mean Sea Level groundwater bodies remained in poor quantitative status in 2015.

The measured developed under the Programme of Measures in the 2nd Water Catchment Management Plan therefore included an increased focus on these two bodies of groundwater to progressively support the achievement of good quantitative status conditions, namely that the annual abstraction from the groundwater body is less than the mean annual recharge, in these two bodies of groundwater.

The measures developed thus target an increased efficiency in water use in those sectors dependent on groundwater abstracted from these bodies of groundwater, as well as the development of alternative water resources which can be utilised by these sectors in substitution of groundwater. Furthermore, the restoration of good status will be further supported through the development of Managed Aquifer Recharge schemes aimed at increasing the mean annual recharge to the groundwater body.

The projected impact of these water management measures accounts to:
- increased efficiency in the municipal and agricultural sector: projected reduction in national water demand of the order of 2 million m^3/year;
- development of alternative water resources to be used in substitution of groundwater: increase in the national water resource base of 9 million m^3/year;
- rehabilitation of existing and development of new Managed Aquifer Recharge schemes: increase in the mean annual recharge of 2 million m^3/year, with the recharge source water being primarily derived from alternative water resources.

The cumulative impact of the 2nd Water Catchment Management Plan's measures is projected to be of the order of 13 million m^3 per year.

The quantitative impact of the measures envisaged to be implemented during the 2nd Water Catchment Management Cycle is therefore considered sufficient to ensure the achievement of good quantitative status in all the groundwater bodies within the Malta Water Catchment District by the end of the 2nd Catchment Management Period, that is by 2021.

The water balance model developed for the purpose of status assessment, has been applied for the four main groundwater body typologies in the Maltese islands taking into consideration the water demand and supply projections for 2021. These water balance models indicate that good quantitative status conditions will be achieved with sufficient confidence in all bodies of groundwater by the end of the 2nd Water Catchment Management planning period. Water balance models for the groundwater body typologies are presented in figures 8.2 to 8.5 below.

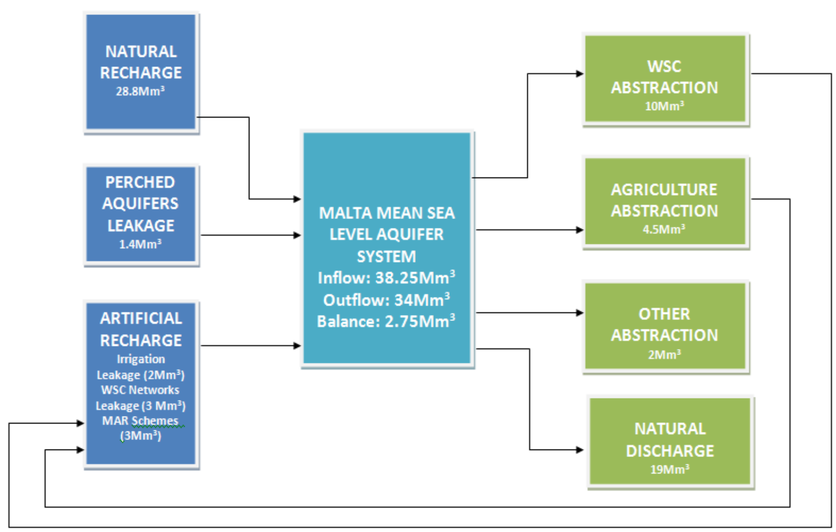

Figure 8.2: Malta Mean Sea Level Aquifer system – Quantitative Status Assessment 2021

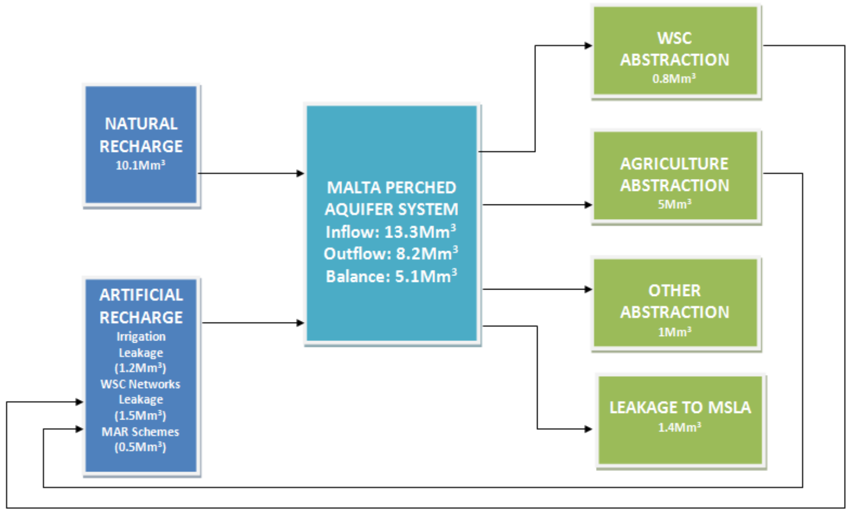

Figure 8.3: Malta Perched Aquifer system – Quantitative Status Assessment 2021

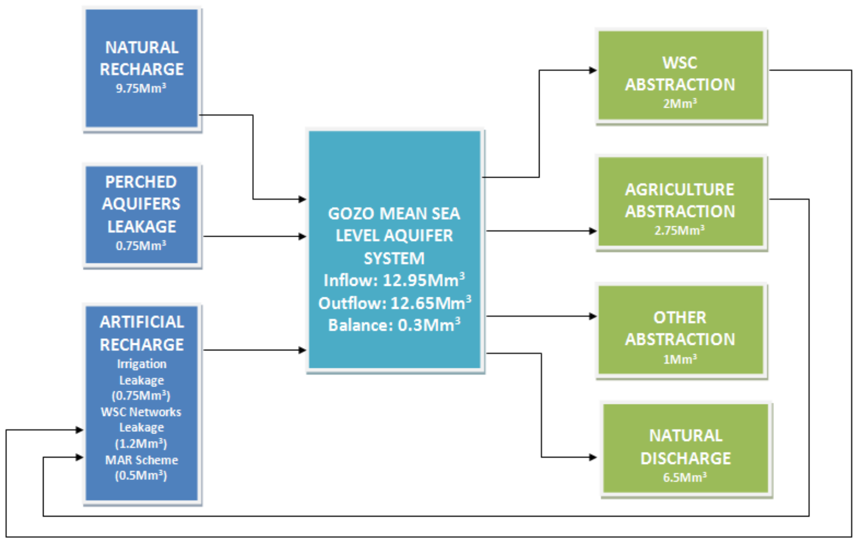

Figure 8.4: Gozo Mean Sea Level Aquifer system – Quantitative Status Assessment 2021

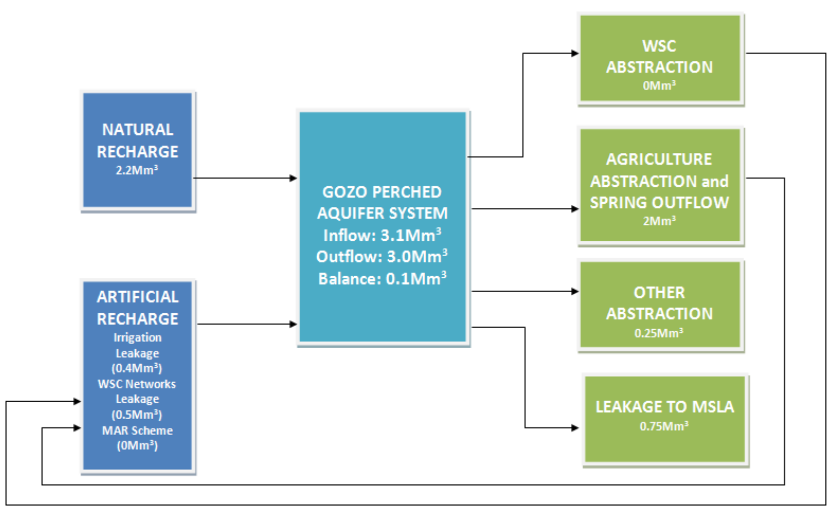

Figure 8.5: Gozo Perched Aquifer system – Quantitative Status Assessment 2021

In this respect, it is further noted that the Programme of Measures needs to address a quantitative gap over the whole Water Catchment District, which in 2015 has been estimated to account for around 4 million m^3/year. The implementation of the proposed Programme of Measures, with an envisaged positive volumetric impact of 13 million m^3/year thus gives sufficient confidence that good quantitative status objectives will be achieved in all groundwater bodies in the Malta Water Catchment District by 2021.

Furthermore, the implementation of the Programme of Measures outlined under the 2nd WCMP is expected to sufficiently shift the water supply base towards the use of alternative water resources such as harvested rainwater runoff and New Water resources, to reduce the dependency on groundwater resources from the current 61% to an estimated 47%, thereby further contributing to the protection of this resource.

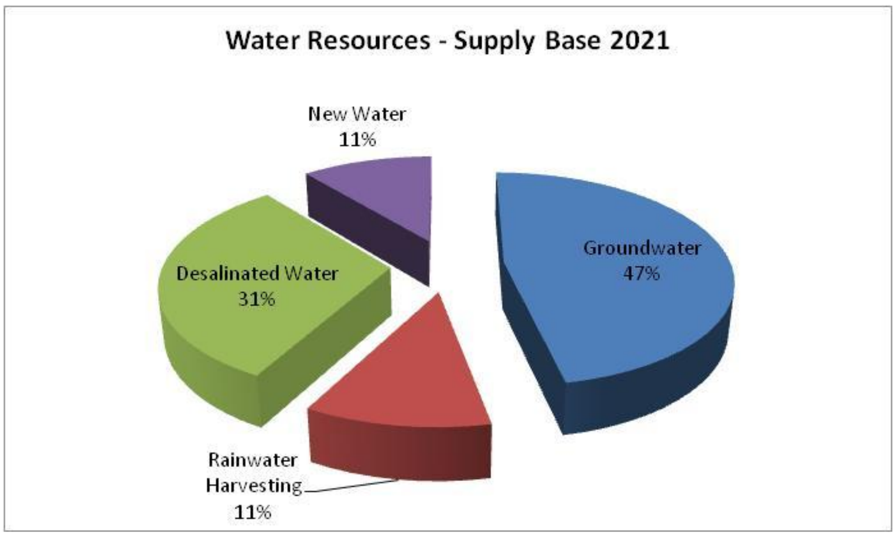

Figure 8.5: Envisaged water resources supply base for 2021

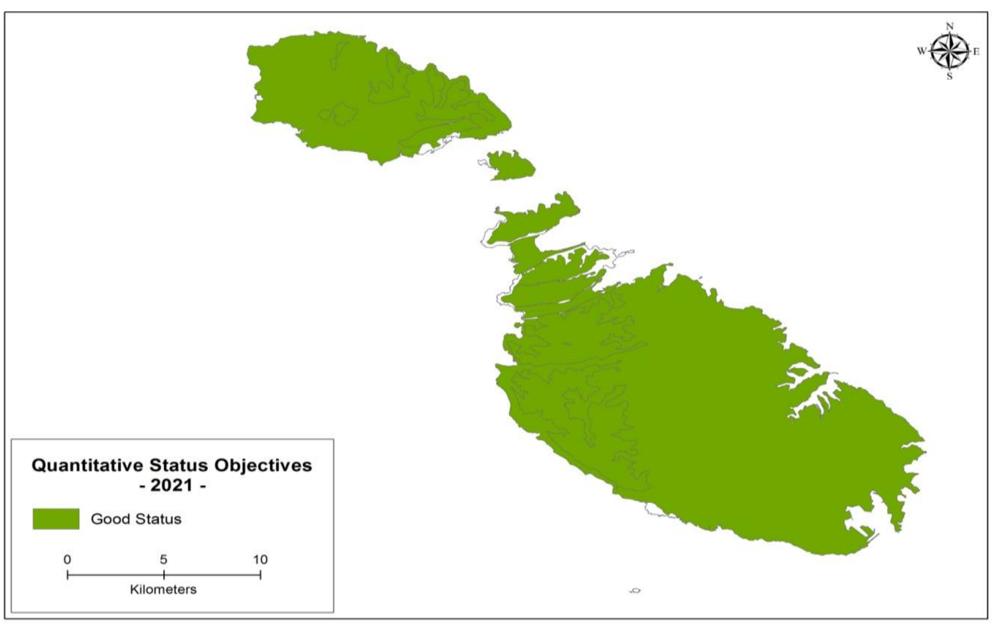

Figure 8.6: Good Quantitative Status objectives for 2021

8.7.2 Qualitative Status

The Qualitative Status assessment presented under Chapter 6 of this Water Catchment Management Plan indicates that the main concerns pertaining to the achievement of good qualitative status in the bodies of groundwater within the Malta Water Catchment District are due to:
- sea-water intrusion related parameters, and
- contamination by nitrates.

Sea-water intrusion related parameters are primarily a direct consequence of the current poor quantitative status of the sea-level aquifer systems. Issues related to the presence of these parameters in groundwater, are expected to be addressed through measures ensuring the progressive achievement of good quantitative status by 2021.

The implementation of the measures envisaged under the Nitrates Action Programme (as part of the implementation of the Nitrates Directive) are expected to progressively reduce the leaching of nitrate to groundwater and thus contribute to the achievement of good status in all bodies of groundwater. The response of the aquifer system to these measures however depends on a number of factors, most important of which are:
- the travel time of percolating groundwater in the unsaturated zone, and
- the retention time of groundwater within the saturated zone.

Conceptual models of the hydrogeological system in the Maltese islands supported by groundwater age assessments through the use of hydrogen (tritium) isotopes and other anthropogenic indicators such as CFCs and SF_6 indicate that slow flow through the aquifer matrix is the major groundwater recharge and flow component for both the aquifer systems. In fact unsaturated zone travel times are considered to be of the order of tens of years due to the low estimated flow rates based on the transmissivity values of the rock formations in the respective unsaturated zones, and saturated zone residence times ranging between 15 and 60 years have been estimated through these modelling techniques for the mean sea level aquifer systems in the Malta Water Catchment District. Flow are and residence time values for the four main aquifer typologies are presented in table 8.4 below.

Aquifer Typology	Unsaturated zone flow rate (based on transmissivity values of the overlying formations)	Residence time in the saturated zone (estimated through CFC modelling)
Malta Mean Sea Level	0.5 – 2.8 m/year	15-40 years
Malta Perched	0.2-0.5 m/year	Low
Gozo Mean Sea Level	0.5 – 2.8 m/year	30-60 years
Gozo Perched	0.2-0.5 m/year	Low

Table 8.4: Saturated and Unsaturated Zone travel times

The slow percolation time in the unsaturated zone and relatively high groundwater retention periods in these aquifer systems entails that the impact of Nitrate management measures undertaken in the catchment district will be felt with a delay period in the saturated zone. This delay period is directly dependent on both the magnitude of both factors.

Furthermore, the initial high levels of nitrate contamination in aquifer systems with a high groundwater storage potential will also entail a relatively long mixing period in which recharging water will mix and progressively dilute the resident (storage) groundwater. This factor is particularly important in perched aquifer systems with a basin-like storage structure such as the Mgarr and Ghajnsielem perched aquifer systems, and the two sea-level aquifer systems where the floating lens structure entails a high storage capacity (estimated of the order of 2 billion m^3 through groundwater numerical modelling) compared to the mean annual recharge (estimated of the order of 50 million m^3).

Given the above mentioned characteristics of the identified groundwater body typologies, the following environmental objectives are being established (and/or confirmed) for the groundwater bodies. These deadline extensions are required due to the natural conditions of the groundwater bodies which entail a slow response/reaction to pollution management measures undertaken at the groundwater body's surface catchment area due to the slow percolation times in the unsaturated zone and the long residence times in the saturated zone.

Achievement of **good qualitative status by 2021** and/or when natural conditions (due to the long groundwater residence time in the aquifer systems) permit:
- Gozo Mean Sea Level groundwater body
- Rabat Dingli Perched groundwater body
- Mellieha Perched groundwater body
- Nadur Perched groundwater body
- Xghara Perched groundwater body
- Victoria-Kercem groundwater body

Achievement of **good qualitative status by 2027** and/or when natural conditions (due to the long groundwater residence time in the aquifer systems) permit
- Malta Mean Sea Level groundwater body
- Mgarr Perched groundwater body
- Ghajnsielem Perched groundwater body

Furthermore, **Less Stringent Objectives** are being confirmed for the minor groundwater bodies which are considered to be significantly affected by human activities in a way as to preclude the possibility of the achievement of good status conditions. Moreover, due to their small size, their high exploitation levels and their direct contact with the bounding saline waters, these aquifer systems are also influenced by the natural intrusion (diffusion) of saline waters. It should also be noted that cumulatively these three bodies of groundwater represent less than 3% of the total potential groundwater resources of the islands.

Less stringent objectives are thus being proposed for the following groundwater bodies:
- Pwales Coastal groundwater body
- Marfa Coastal groundwater body
- Zebbug Perched groundwater body

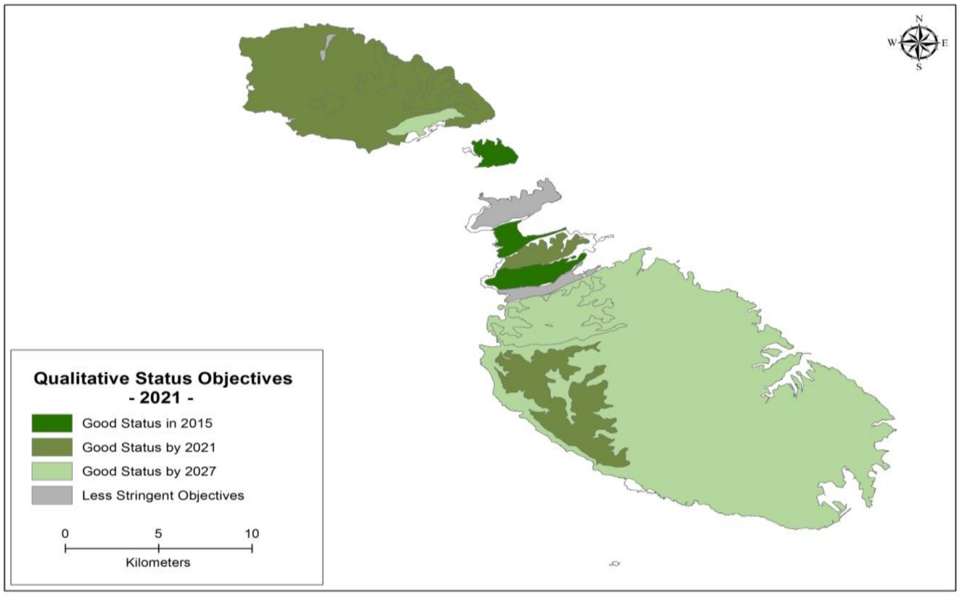

Figure 8.7: Qualitative Status objectives for 2021

The status of these water bodies will be reviewed in each planning cycle and presented in each successive Water Catchment Management Plan.

8.7.3 Overall status

Water balance models indicate that good quantitative status objectives are projected to be achieved in all bodies of groundwater by the end of the 2nd Water Catchment Management Cycle (2021). The achievement of overall status is therefore dependent on the achievement of good qualitative status, for which a phased achievement during successive water catchment management cycles are envisaged, due to the characteristic long groundwater residence time of these groundwater bodies.

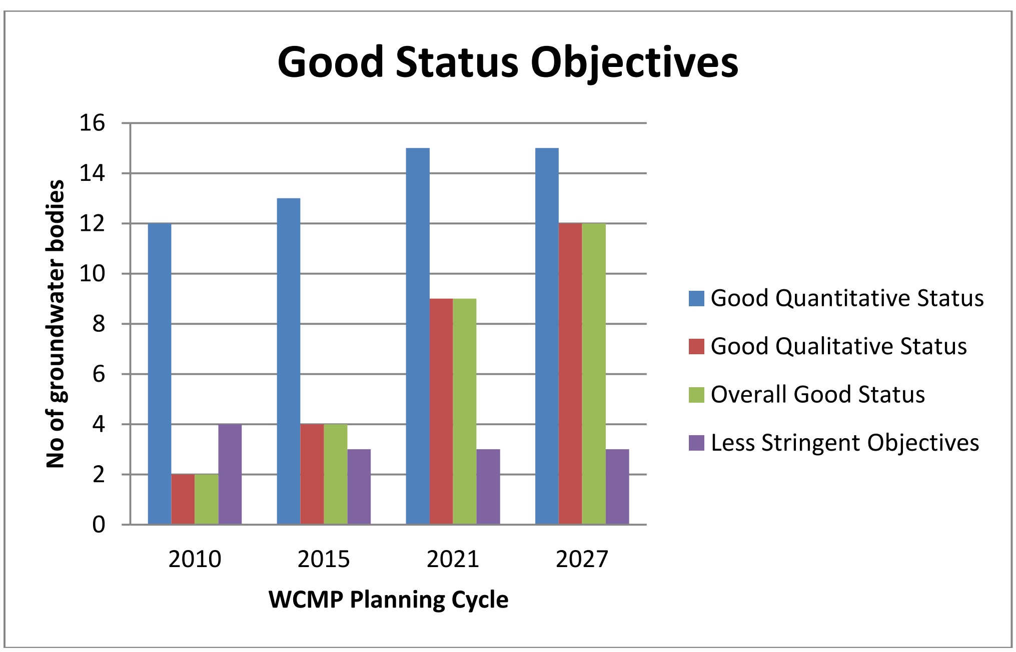

Figure 8.8: Good Status Objectives during successive Catchment Management Cycles

Table 8.5 below outlines the current status, the environmental objective, the envisaged date for its achievement and the exemption required for each body of groundwater. The exemptions take into consideration the analysis of good qualitative status objectives, given that the 2nd Water Catchment Management Plan envisaged the achievement of good quantitative status in all bodies of groundwater by 2021.

Groundwater Body Name	Code	Status (2015)	Environmental Objective	Date	Exemption
Malta Mean Sea Level	MT001	Poor	Good	2027 or as soon as natural conditions permit after 2027	Extension of Deadline due to Natural Conditions
Rabat-Dingli Perched	MT002	Poor	Good	2021 or as soon as natural conditions permit after 2021	Extension of Deadline due to Natural Conditions
Mgarr-Wardija Perched	MT003	Poor	Good	2027 or as soon as natural conditions permit after 2027	Extension of Deadline due to Natural Conditions
Pwales Coastal	MT005	Poor	Less Stringent Objective	Less Stringent Objectives	High impact of local anthropogenic activities
Mizieb Mean Sea Level	MT006	Good	Good	2015	No exemption required
Mellieha Perched	MT008	Poor	Good	2021 or as soon as natural conditions permit after 2021	Extension of Deadline due to Natural Conditions
Mellieha Coastal	MT009	Good	Good	2015	No exemption required
Marfa Coastal	MT010	Poor	Less Stringent Objective	Less Stringent Objectives	High impact of local anthropogenic activities
Kemmuna Mean Sea Level	MT012	Good	Good	2015	No exemption required
Gozo Mean Sea Level	MT013	Poor	Good	2021 or as soon as natural conditions permit after 2021	Extension of Deadline due to Natural Conditions
Ghajnsielem Perched	MT014	Poor	Good	2027 or as soon as natural conditions permit after 2027	Extension of Deadline due to Natural Conditions
Nadur Perched	MT015	Poor	Good	2021 or as soon as natural conditions permit after 2021	Extension of Deadline due to Natural Conditions
Xaghra Perched	MT016	Poor	Good	2021 or as soon as natural conditions permit after 2021	Extension of Deadline due to Natural Conditions
Zebbug Perched	MT017	Poor	Less Stringent Objective	Less Stringent Objectives	High impact of local anthropogenic activities
Victoria-Kercem Perched	MT018	Poor	Good	2021 or as soon as natural conditions permit after 2021	Extension of Deadline due to Natural Conditions

Table 8.6: Status Objectives and Exemptions for groundwater bodies

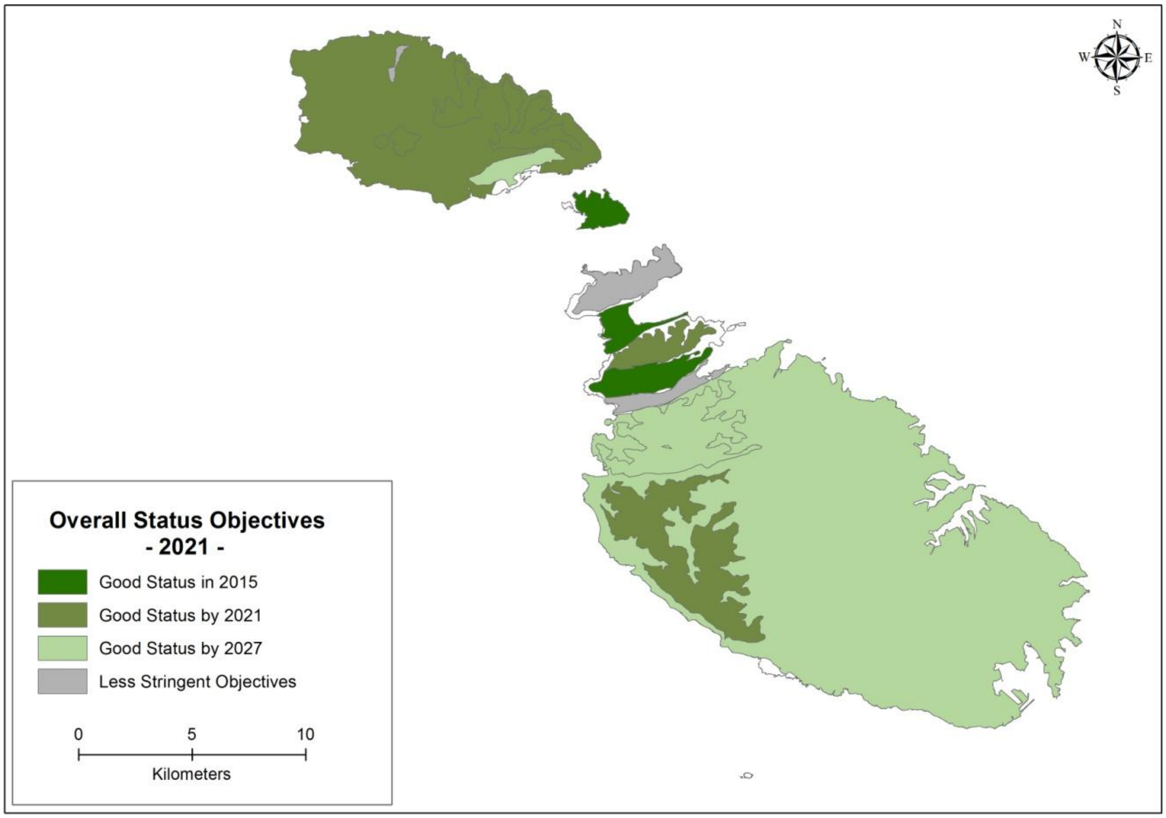

Figure 8.9: Overall Status objectives for 2021

9. Measures required to improve and protect our waters

9.1 Identifying which measures are required for surface waters

Several ongoing processes throughout the years of implementing Malta's first Water Catchment Management Plan have enabled the identification of measures related to coastal and inland surface waters to be included in this second plan. These were:

1. Learning experiences related to implementation of the first programme of measures under the first WFD cycle;
2. Implementation of monitoring programmes as part of implementation of the first WCMP which allowed for a better status assessment of our waters and therefore a better identification of which additional measures would be required;
3. The carrying out of the Initial Assessment under the Marine Strategy Framework Directive which also complimented the gap analysis towards achieving good status in coastal waters and highlighted areas where action was further needed to close such gaps;
4. The compiling of Natura 2000 Management Plans for most of Malta's protected inland surface and transitional waters after thorough consultation with the public, local councils, government entities and non-governmental organisations.

The above processes led to the identification of the most pressing management issues that require a nation-wide concerted effort in order to ensure that 'good quality status' is maintained or achieved in coastal and protected inland and transitional surface waters by 2021; or in certain cases, when good status can be realistically achieved.

Some of the issues identified in the previous preparation phase (i.e. 2009) of the first Water Catchment Management Plan are still present day realities and are therefore reiterated in this plan (refer to Chapter 7 for details about what was implemented under the first cycle). In addition, however, comprehensive monitoring of our coastal waters in 2012-13 has brought to the fore additional issues of concern. Additional measures have therefore been identified to deal with these management issues. Such measures would be required in order to ensure that good status is maintained in waters where this has already been achieved; and good status is met in those waters where this is yet to be accomplished.

A cost-effectiveness analysis of the Programme of Measures was also carried out with the aim of selecting the most cost-effective package of measures. The outcome of this study is included under **Chapter 11** o f this plan, **Cost of Programme of measures (2015 – 2021).**

9.1.1 Coastal water significant management Issues

Issue 1: Poor chemical quality of our coastal waters

In 2012-2013 MEPA carried out a comprehensive monitoring programme to assess the quality of our coastal waters. Various ecological and chemical aspects were monitored at around 30 monitoring sites around the Maltese Islands. The quality of the ecology of Maltese coastal waters resulted to be of very good status. Efforts to maintain this good ecological quality will be ensured through the regulation of activities that could be of constant threat.

Chemical quality, on the other hand resulted to be of poor or moderate status in most water bodies due to very few parameters (refer to Chapter 6 for Status Assessment). The following contaminants resulted to be of concern:

1. Nutrient contamination is restricted to some enclosed bays and harbours around the Maltese Islands.
2. Occasional contamination by Polycyclic Aromatic Hydrocarbons (PAHs) was observed in water and sediment along the north western coastal stretches of Malta, off the northern tip of Mellieha, between Malta and Comino and within the harbours of Marsamxett and the Grand Harbour.
3. High concentrations[237] of some trace metals were found in the coastal stretch off Pembroke; in the water body of Xgħajra and in the harbour area of Marsaxlokk. These consisted of mercury, lead and occasionally nickel.
4. The most ubiquitous chemical of concern is mercury.

Additional gaps in knowledge related to the potential sources of contaminants are linked to hydrological processes at sub-catchment scale; more specifically the role sub-catchments and dry valley systems play in transporting contaminants to the coastal water environment.

In light of the above, the following actions were initially proposed to keep most of these contaminants at bay and to also address the knowledge gap pertaining to the role of hydrological catchments as a pathway and contributor to contaminants, including nutrients in the coastal water environment:

- Continue current efforts to regularize industrial discharges;
- Continue efforts to improve agricultural practices and waste management at farm and national level;
- Clamp down on unauthorized discharges to sea;
- Target public awareness campaigns on the appropriate disposal of chemicals and chemical containers; and
- Qualify the role of sub-catchments as major pathways of contaminant transportation to the immediate coastal environment.

Issue 2: The need to enhance our knowledge on the sources of certain contaminants of concern and the hydrographic characteristics of the marine environment beyond our shores

The sources of some of the contaminants monitored in coastal waters are not always easy to identify and therefore there would be a need to investigate the possible sources of these contaminants further. The extent of transboundary pollution and how it impacts our waters is also a phenomenon of which little information is known. There is a need to take a closer look at the fate of pollutants originating from neighbouring Mediterranean shores.

This need is closely linked with the requirement to enhance current knowledge on hydrographical conditions in the Mediterranean, particularly information related to sea currents and mixing which could influence the fate of contaminants in the coastal environment.

Emerging contaminants could become of concern. These are contaminants that might not necessarily have been monitored to date in our waters but may emerge to be problematic in the future. Due to the

[237] High concentrations means that quantities of these trace metals exceeded their Environmental Quality Standard (EQS) in water as stipulated by the Environmental Quality Standard Directive (2013/39/EU); and some exceeded their EQS in sediments as established in Italy (Decret n.56/2009).
Environmental quality standard (EQS) means the concentration of a particular pollutant or group of pollutants in water, sediment (*any material transported by water and settled to the bottom*) or biota (*all living organisms of an area*) which should not be exceeded in order to protect human health and the environment.

hazardous nature of certain emerging pollutants, a precautionary approach would need to be undertaken meaning that proactive measures to identify and if need be, control, these contaminants are identified.

Proposed efforts to increase our knowledge were as follows:
- Launch an investigative monitoring programme for certain contaminants of concern, such as mercury;
- Investigate sources of contaminants in the Mediterranean by looking at case studies and by participating in the regional cooperation process of the Marine Strategy Framework Directive;
- Set up a watch list mechanism to monitor certain emerging substances identified at EU level that could potentially be of concern.

Issue 3: The need to control and investigate cumulative impacts in particular stretches of coastal water bodies
Stretches of coast subject to a multitude of activities that are of a small scale, such as unauthorized discharges and brine discharges, to sea can cumulatively be of significant impact and need to be curtailed or regulated.

Potential actins identified to control and investigate cumulative impacts include:
- Carry out a survey of all discharges to sea and identify their source, with the objective of setting out a plan to curtail or regulate such discharges.

9.1.2 Inland surface and transitional waters of ecological significance – significant water management issues

Issue 1: Poor chemical quality of inland surface and transitional waters
Water quality monitoring in protected watercourses, standing waters and transitional waters was carried out in 2011 and 2012. The results of chemical quality monitoring highlight potentially significant pressures and gaps in knowledge related to what could be contributing to deterioration in the chemical status of these waters. Ultimately poor chemical quality will impact the habitats and species dependent on water resources.

The main issues highlighted can be summarized as follows:
- Exceedingly high nitrate quantities in our watercourses
- Particular ubiquitous chemicals, Di(2-ethylhexyl)phthalate and nickel were found in most inland surface waters. Although these chemicals did not reach levels of concern, their ubiquitous nature requires that their sources are investigated and controlled.
- The need to further investigate the concentrations of perchlorate, dichloromethane and trichloromethane, and fluoranthene in water. Perchlorate was identified to be of potential concern in air[238].
- Lead was the contaminant which was found to occur in sediments at levels of the highest ecotoxicological significance.

Proposed actions required to improve the chemical quality of our waters are:
- The stepping up of efforts to improve agricultural practices and waste management at farm and national level;

[238] Vella, A.J., Aquilina, B., Delicata, F., and Farrugia, A. 2012. Perchlorates in Dust Fall: evidence of environmental contamination by fireworks in Malta, 13th international Symposium on fireworks, Valletta, Malta

- Target public awareness campaigns on the appropriate disposal of chemicals and/or chemical containers such as pesticide and fertilizer packaging;
- Ensure that inland surface waters are kept litter free through appropriate management regimes
- Continue to monitor these inland surface and transitional waters as they are important ecological niches, and also reflect the quality of the terrestrial environment in the Maltese Islands.

Issue 2: Ensuring the protection of important water dependent habitats and species
Protected habitats and species dependent on the already limited freshwater resources are being threatened by additional pressures in the catchment area. There is a lack of knowledge on the extent of groundwater and surface water abstraction, both of which have been identified as potential pressures that may be leading to a reduction in water flow. Additional pressures competing for water are invasive alien species competing with other water dependent species and altering habitats within water course environments. Increased alterations in the hydromorphological conditions of inland surface and transitional waters also create additional problems.

Identified actions to mitigate these pressures include:
- Quantify the degree of water use from water courses which feed important freshwater habitats, with the aim of understanding how the needs of water dependent ecosystems and other users could in practice be achieved;
- Eradicate and/or control invasive or alien species within particular watercourses and pools;
- Rigorously monitor dumping and excavation works in the vicinity of inland surface and transitional waters.

9.2 Basic Measures

9.2.1 Basic measures emanating from other Directives
As Chapter 7 of this plan has indicated, there are a number of basic measures that stem from other European Union directive obligations that contribute significantly to the achievement of the WFD's objectives. The implementation of these Directives calls on a wide range of entities and is by nature cross-sectoral. Therefore the task of overseeing the implementation of these Directives and ensuring synergies is carried out at Interministerial level by means of a number of Committees.

(i) Implementing actions under the Nitrates Directive 91/676/EEC
Under implementation of the Nitrates Directive during the coming years it is expected that the continuous controls, enforcement and evaluation procedures related to the overseeing of implementation of the Nitrates Action Programme Regulations, estimated to cost € 140,000 per annum will be maintained.

In addition a number of additional measures shall be carried out to improve the knowledge base and availability of data to assist in the regulatory controls brought about by Malta's Nitrates Action Programme. These include:

- A crop yield study and the undertaking of studies related to manure quality and soil nitrogen content estimated as well as the building and management of a soil monitoring surveillance network estimated at € 70,000; and
- The maintenance of a database for monitoring changes in agricultural practices in terms of farm holdings, manure application and soil and manure analysis estimated at € 88,000

(ii) Implementation of the Bathing Water Directive 2006/7/EC

The Environmental Health Directorate shall continue to monitor all protected bathing areas over the 23 week monitoring period. In addition the 29 bathing water profiles[239] that have also been developed by the Environmental Health Directorate (as provided under Chapter 4 of this plan) during the first WCMP will be updated continuously following the publication of the Commission Bathing Water Report. The bathing water profiles indicate any pressures with a potential of impacting the quality of these waters. Each bathing water profile provides a general description of the bathing waters and surrounding areas, a location of the bathing area and the monitoring points; a land-use map and the water quality classification over 4 years (2009-2012). Apart from identifying pressures, a series of mitigation measures are also identified. Contact information in the case of a pollution incident within a bathing area is provided for each bathing profile.

(iii) Implementation of the Urban Waste Water Directive 91/271/EEC

The Water Services Corporation is working on the following measure that directly relates to Article 3 – Collection Systems of the Urban Waste Water Treatment Directive, by connecting the remote hamlet of Bahrija directly to the main sewerage network. This hamlet is currently served with a communal cesspit and bowser emptying, an arrangement that has inadequate capacity to cope with the future projections of the catchment it currently serves. Project is worth Euro 5 million and scheduled for completion by the 1st quarter 2016.

(iv) Implementation of the Nature Directives

(a) Terrestrial Natura 2000 Management Plans

As indicated under Chapter 7, a number of water related measures targeting 9 of the ten inland surface and transitional waters were included as part of the Natura 2000 Management plans that were developed for all terrestrial Natura 2000 areas in the Maltese Islands. These measures are summarised in table 9.1 and 9.2 below, together with their priority level. Further details on the plans and implementation of the measures are accessible from the following web page: http://www.natura2000malta.com.mt/

Water-related measures that were identified in each of the relevant plans can be grouped as follows:

- Measures related to Species Protection
- Measures dealing with the eradication of alien species
- Measures related to water quality / Water regime monitoring
- Measures dealing with the enlargement of the water habitat and restoration of the habitats
- Measures dealing with Agricultural practices to limit nutrient and pesticide inputs
- Measures dealing with the overall management of the site.

Each Management Plan that has been drawn up has a timeframe of 5 years. During implementation, progress must be reported back to the Environment and Resources Authority on an annual basis. In the Management Plans a priority rating was set for each operational objective that was identified. The priority ratings as indicated for each operational objective, provided in tables 9.1 and 9.2 was defined in the Natura 2000 Management Plans, as follows:

[239] https://ehealth.gov.mt/healthportal/public_health/environmental-health/health_inspectorate/env._hlt._risk_management/bathing_water_profiles_report.aspx

- Critical: The fulfilment of this objective is a prerequisite for the implementation of the Management Plan as a whole. It must be dealt with within the first two years of the implementation period.
- High: The objective is of main importance and its fulfilment is a prerequisite for the implementation of a major part of the Management Plan. To be accomplished within the first three years of the implementation period.
- Medium: The objective is of main importance but it either follows the accomplishment of another objective or it can be accomplished at any time within the five year period of the implementation period.
- Low: The objective is of complementary importance. To be accomplished within the last two years of the Management Plan, it may also be transferred to the next management period.

Natura 2000 management plans are additional tools that are being used for the implementation of the Birds Directive. The Birds Directive will continue to be implemented through Subsidiuary Legislation 504.71, taking into account the overriding need to maintain bird populations at a satisfactory level.

(b) Marine Protected areas
Currently there are five Marine Protected Areas (MPAs). A management plan which will set conservation objectives is being compiled for the MPA between Rdum Majjiesa and Ras ir-Raħeb. It is envisgaed that the conservation objectives will seek to maintain or restore to a favourable conservation status those features, mainly comprising of protected habitats, for which such areas were designated.

Another aspect related to the implemention of the Habitats and Birds Directives, respectively, is the identification and designation of more areas as marine protected areas. In fact three studies are underway to identify such areas. These studies are being carried out through the Life Malta Seabirds Project, Life Migrate, and the Life BaHAR for Natura 2000 projects. For the Life BaHAR for Natura 2000, conservation objectives will be identified for those sites which will be designated for hosting sandbanks, sea caves and reefs.

Measure	Simar	Ghadira	Salini	il-Ballut ta'Marsaxlokk	il-Maghluq ta' Marsascala
Measures related to water dependent species protection					
Water dependent fish species: **Annual monitoring of the range and population size of *Aphanius fasciatus* in the lagoon**	**Code: OO41.1 To establish and implement a programme for the annual monitor of the range and population size of *Aphanius fasciatus* in the lagoon (P1 and P4)** *Priority rating:* Implementation will follow the delivery of the relevant monitoring plans, thus it may start from the second year of the management plan implementation period.	**OO13.1. To conserve, maintain and improve current population of Annex II listed *Aphianus fasciatus*** Priority Rating: High	**Code: OO9.1.To undertake seasonal inspections to monitor the range, assess and monitor the population size of *Aphanius fasciatus* within the site (P1 and P4)** *Priority Rating:* Medium		**Code: OO6.2. To monitor the range and population size of *Aphanius fasciatus.*** *Priority Rating:* High
Water dependent avifauna: **Monitoring the range, population size and habitat suitability of prospective breeders**	**OO23.1. To monitor the range, population size and habitat suitability of prospected breeders *Ixobrychus minutus* and *Himantopus himantopus*, breeding and wintering wetland species (P1 and P4)** *Priority rating:* Implementation will follow the delivery of the relevant monitoring plans, therefore it may start from the second year of the MP implementation period. In any case it cannot exceed a 5 years period from the previous first assessment, i.e. the 2013 year assessment undertaken in the context of the MP preparation.	**OO18.1. / OO19.1. / OO20.1. To monitor the range and population size of *Himantopus himantopus*, and *Calandrella brachydactyla* and of the breeding, wintering and staging wetland birds (P1 and P4), and** **P.13 provision of ideal Breeding grounds for *Charadrius dubius*** *Priority Rating:* Implementation will follow the delivery of the relevant monitoring plans; therefore it may start from the second year of the MP implementation period. In any case it cannot exceed a 5 years period from the previous first assessment, i.e. the 2013 year assessment	**OO10.1. To maintain the function of the marshland as an Important Bird Area and to improve the status of the bird species using the site (possibly encouraging further nesting and breeding in the area) (P8)** *Priority Rating:* Medium		

		undertaken in the context of the MP preparation.			
Measure	**Simar**	**Ghadira**	**Salini**	**il-Ballut ta'Marsaxlokk**	**il-Maghluq ta' Marsascala**
Other Water Dependent Species that are not listed in Annex II of the Habitats Directive: Red Data Book (RDB) species	**OO24.1 To elaborate Action Plans for Red data Book Species (*Discoglussus pictus pictus*) and apply actions prescribed (P2 and P5)** *Priority rating:* Medium – Action plans are to be delivered with the first 3 years from the start of the Implementation of the Management Plan	**OO21.1 To elaborate Action Plans for Red data Book Species and apply actions prescribed** *(Discoglossus pictus pictus)* **(P2 and P5)** *Priority rating:* Medium – Action plans are to be delivered with the first 3 years from the start of the Implementation of the Management Plan	**OO11.1 To protect and maintain the habitat of existing RDB species** (referring to invertebrate species and the *Discoglossus pictus pictus)* **(P2 and P5)** *Priority rating:* Medium – Action plans are to be delivered with the first 3 years from the start of the Implementation of the Management Plan	**OO4.1 To elaborate Action Plans for Red data Book Species and apply actions prescribed** *Priority rating:* Medium – Action plans are to be delivered with the first 3 years from the start of the Implementation of the Management Plan	
Measures related to maintaining or improving the Water quality /water regime monitoring					
Measure	**Simar**	**Ghadira**	**Salini**	**il-Ballut ta'Marsaxlokk**	**il-Maghluq ta' Marsascala**
Undertaking regular water quality monitoring of the waters in the lagoon/water body	**OO14.2 To undertake regular water quality monitoring of waters in the lagoon (P3)** *Priority rating:* High – to start during the first year of the management plan implementation period.	**OO1.2 To maintain and monitor water quality parameters (D2, P10, P11)** *Priority rating:* High – to start during the first year of the management plan implementation period. **P10: Building and maintaining database with water quality baseline data for management of the reserve** *Priority rating:* High – to start during the first year of the management plan implementation period.	**OO3.1 To monitor the quality of water reaching habitat 1150 (from land and sea) to ensure maintenance of favourable conditions and compliance with the WFD (P6 and M2)** *Priority rating:* High.	Although the Natura 2000 management plan for this site did not identify water quality monitoring to be a main measure, Chapter 5 indicates that water quality monitoring will be carried out as per WFD requirements	Although the Natura 2000 management plan for this site did not identify water quality monitoring to be a main measure, Chapter 5 indicates that water quality monitoring will be carried out as per WFD requirements
Elaboration of a study for the re-establishment of the hydrological regime				**OO7.1 To elaborate an assessment study of the status of the hydrological regime within the marsh land**	**OO2.1. To ensure proper maintenance and, if possible, improve the lagoon-sea interface connection (D2)**

				and examine trends and alternative solutions *Priority rating:* Critical/High	**OO2.2. To ensure the prevention of excess silt accumulation at the sea interface and inside the lagoon** *Priority Rating:* High
Measures dealing with hydromorphological alterations - enlargement of the water habitat and restoration of habitat					
Measure	**Simar**	**Ghadira**	**Salini**	**il-Ballut ta'Marsaxlokk**	**il-Maghluq ta' Marsascala**
Planning, implementing and monitor a plan for the enlargement of the lagoon/ water habitat	**OO1.1 / OO2.1 To plan, implement and monitor a plan for the enlargement of the Simar lagoon habitat (P6) and to establish a monitoring programme for the first 5 years following creation of the new lagoon.** *Priority rating:* High – to start during the first year of the management plan implementation period.	**OO1.1 To assess the possibility of wetland enlargement and dune restoration (P3)** *Priority rating:* Medium.	**OO4.2 To achieve an extension in the area covered by the saline marshland through a scientific habitat restoration / engineering intervention (P7)** *Priority rating:* Medium.	**OO5.1 To investigate possibilities of utilising land adjacent to wetland (P5)** *Priority rating:* Critical/ High. **OO5.2 To elaborate a restoration study, implement any required technical works and monitor the new habitat trends** *Priority Rating:* High	**OO1.1 To plan and implement a project for the expansion of habitat 1150* in conjunction with future national flood relief proposals (P2)** **OO1.2 To monitor the success of the lagoon expansion project in the first 5 years following its implementation** *Priority rating:* Medium.
Undertaking an annual /seasonal inspections to monitor the size, structure and function of habitats ; or enhancing the habitat	**OO25.1 To maintain and enhance the saline marshland and associated wetland habitats** *Priority rating:* Medium	**OO2.1/3.1/4.1 To maintain islands and salt marsh vegetation (P12, P13 and P14 including habitat and flora mapping of artificial islands, maintenance of breeding conditions for *Charadius dubius* and creation of artificial islands made up of felled and dead dried trees)** *Priority rating:* High	**OO3.2, OO4.1, OO5.1, OO6.1, OO8.1 to undertake annual inspections to monitor the size, structure and function of habitats 1150, 1310, 1410, 1420 and 92D0** *Priority rating:* Medium	**OO1.1./OO2.1/OO3.1. To undertake annual inspections to monitor the size, structure and function of habitats 1310, 1410, 1420** *Priority rating:* Low	**OO3.1 / OO4.1 To undertake seasonal inspections to monitor the size, structure and function of habitats 1150* and 1410; to monitor the range and population (P1 and P3)** *Priority rating:* High
Hydromorphological Engineering		**OO2.1, OO3.1, OO4.1 - P14: Creation of artificial islands made up of felled and dead dried trees to create an ideal habitat for waterfowl and herons**		**OO8.1 To study coastal erosion, identify interventions and implement recommendations of the study (P6, P7 and**	

		Priority rating: High – to start during the first year of the management plan implementation period.		**P8)** *Priority rating:* Critical/High P6, elaboration of a study for the reestablishment of the natural hydrological regime within the marshland, the restoration of the acquired land and eradication of alien plant species. P7 elaboration of a technical study and specifications for coastal erosion control P8 implementation of the technical works specified by the studies on coastal erosion control on the reestablishment of the natural hydrological regime and on the restoration of the wetland	
Measures dealing with Agricultural practices					
Measure	**Simar**	**Ghadira**	**Salini**	**il-Ballut ta'Marsaxlokk**	**il-Maghluq ta' Marsascala**
Achieving compliance with the Code of Good Agricultural Practice and NAP	**OO28.1 To achieve compliance of cultivation over a 5 year period (M2)** *Priority rating:* High	**P11. Creation of a plan together with farmers for the reduction of use of pesticides/fertilisers in the fields around the reserve** *Priority rating:* High **OO25.1 To achieve compliance of cultivation over a 5 year period (M1)**			**OO7.1 To achieve compliance of cultivation over a 5 year period (M1)** *Priority rating:* High

To engage local farmers on nature conservation management	**OO28.2 To engage local farmers on nature conservation management (P9)** *Priority rating:* High				**OO7.2 To engage local farmers on nature conservation management (D5)** *Priority rating:* Medium
Measures dealing with managing use of the site					
Measure	**Simar**	**Ghadira**	**Salini**	**il-Ballut ta'Marsaxlokk**	**il-Maghluq ta' Marsascala**
To lobby with users of the site for better protection of the site / issuing of guidelines for better use of the site	**OO29.2 lobby with the users of the site for the better protection of site (P9)** *Priority rating:* High		**OO2.1 To incorporate ecological principles into salina management techniques (M1)** M1 : Incorporation of guidelines for the ecological operation of salt harvesting in order for salina to also act as a priority lagoon saltmarsh habitat for migratory/wintering and breeding habitat for avifauna		**OO9.1. To continue to undertake regular clean-ups of the area.** Clean-ups of the site already take place. The site is regularly cleaned by MTI-CSD. *Priority Rating:* High **OO9.3. To hold an annual environmental education and public awareness activity related to the site to engage with the local population. (D6)** *This action should help so that the public would not introduce any waterfowl into the lagoon.* *Priority Rating:* High
To patrol / warden the site according to an established roster throughout the year with increases frequency during the hunting season, during weekends, public holidays and during planned activities	**OO29.1 To patrol/warden the site according to an established roster throughout the year with increased frequency during the hunting season, during weekends, public holidays and during planned activities. (D1)** *Priority rating:* High – to be delivered during first year of implementation of the Management Plan	**OO27.1 To patrol/warden the site** P 9 Prescription of a patrolling schedule D 1 Implementation of the patrolling schedule *Priority rating:* High – to be delivered during first year of implementation of the Management Plan	**OO12.1 To patrol/warden the site** Prescription of a patrolling schedule Implementation of the patrolling schedule *Priority rating:* High – to be delivered during first year of implementation of the Management Plan	**OO12.2 To patrol/warden the site (P13 and D1)** Prescription of a patrolling schedule Implementation of the patrolling schedule *Priority rating:* High – to be delivered during first year of implementation of the Management Plan	**OO8.1. To patrol/warden the site according to an established roster throughout the year, with increased frequency during weekends (P6 and D1)** *Priority Rating:* High

Measures dealing with eradication of alien species					
Measure	**Simar**	**Ghadira**	**Salini**	**il-Ballut ta'Marsaxlokk**	**il-Maghluq ta' Marsascala**
To plan, implement and monitor an alien plant / fauna eradication programme				**OO6.1 To plan, implement and monitor an alien plant eradication programme** *Priority rating:* Critical/ High *Relevant Performance indicator:* Timely delivery of the eradication programme	
Pest eradication that are a threat to water dependent species		**P.19 Control impact of rat populations on the Reserve's fauna** *Priority rating:* High – to be delivered during first year of implementation of the Management Plan			**OO2.3. To remove the domestic waterfowl population and ensure that no more domestic fowl are introduced (D3)** *Action:* Removal of the domestic waterfowl population from the Marsaskala wetland *Priority Rating:* High

Table 9.1: Basic measures for protected transitional waters as identified in the respective Natura 2000 Management Plans

	Water courses			Pools
Measure	**Wied il-Luq**	**Wied tal-Bahrija**	**Wied Lunzjata**	**Qattara**
Measures related to species protection				
Water dependent avifauna: Monitoring the range, population size and habitat suitability of prospective breeders			**OO31.1. To maintain the habitat for waders and aquatic birds within the SAC (P19)** *Priority Rating:* Medium **OO30.1. To collect annual data on migratory waders and aquatic birds and their use of the site (P3 and P4)** *Priority Rating:* High	**OO40.1. To maintain the current habitats for waders and aquatic birds (P21)** *Priority Rating:* Medium **OO26.1/OO28.1./OO30.1./OO32.1./OO34.1/OO36.1 To monitor the range and population size of *Calandrella brachydactyla, Monticola solitarius, Cisticola juncidis, Sylvia conspicillata, Sylvia melanocephala, Miliaria calandra* at the site; and** **OO39.1/OO42.1./OO46.1. To collect annual data on migratory aquatic birds, migratory birds of prey and migratory passerines and their use of the site. (P1 and P2)** *Priority Rating:* High
Other Water Dependent Species that are not listed in Annex II of the Habitats Directive: Red Data Book (RDB) species	**OO23.1. To elaborate Action Plans for RDB species and apply the actions and the recommendations prescribed (P2 and P5)** *Priority Rating:* High	**OO38.1. To elaborate Action Plans for RDB species and apply the actions and the recommendations prescribed** **(P2 and P5)** *Priority Rating:* Medium	**OO35.1. To elaborate Action Plans for RDB species and apply the actions and the recommendations prescribed (P5 and P6)** *Priority Rating:* Medium	**OO47.1 To elaborate Action Plans for RDB species and apply the actions and the recommendations prescribed (P3 and P4)** *Priority Rating:* Medium
To plant saplings of the typical and characteristic tree species	**OO5.1. To plant saplings of the typical and characteristic tree species of habitat 92A0.** *Priority Rating:* High			
Water quality /water regime monitoring measures				

Measure	Wied il-Luq	Wied tal-Bahrija	Wied Lunzjata	Qattara
To undertake regular water quality monitoring of the waters in the lagoon/water body	**OO4.4. To monitor the quantity and quality of water in habitat 92A0 on a seasonal basis (P6)** *Priority Rating:* High	**See measure further down Code OO10.2**	**OO36.1 To establish and implement a surveillance programme to collect data on the amount, permanence, and quality of the water in the water courses and other natural surface water bodies (P20)** *Priority Rating:* High	
Elaboration of a study for the re-establishment of the hydrological regime	**OO27.1. To elaborate a baseline hydrological study of the Buskett Girgenti catchment area (P3)** *Priority Rating:* Medium		**OO36.2 To establish opportunities for water quality assessment and monitoring of the aquifers in conjunction with the SEWCU (P21)** *Priority Rating:* Medium	
To monitor water extraction in the SAC areas containing water dependent habitats		**OO10.2/ OO10.3 To monitor water extraction in the SAC areas containing habitat 92AO and to monitor the quality of water sources feeding habitat 92A0 (P3)** *Priority Rating:* High		
Measures dealing with enlargement of the water habitat and restoration of habitat				
Measure	**Wied il-Luq**	**Wied tal-Bahrija**	**Wied Lunzjata**	**Qattara**
To undertake annual /seasonal inspections to monitor the size, structure and function of habitats	**OO5.1 and OO4.1 To undertake seasonal inspections to monitor the size, structure and function of habitats 5230, and 92A0 and establish the favourable conservation status of habitats 5230 within the site (P1 and P4)** *Priority Rating:* High	**OO10.3 To monitor the quality of water sources feeding habitat 92AO** *Priority Rating:* **OO10.4. To undertake annual inspections to monitor the size, structure and function of Annex I habitat 92A0** **(P1 and P4)** *Priority Rating:* High		**OO5.2 To undertake annual inspections to monitor the size, structure and function of habitats 3140** *Priority Rating:* High

To restore the watercourse and its banks	**OO4.1. To restore the watercourse and its banks supporting habitat 92A0.** **Codes C1, C2 and C3 -** Repair/restoration/rebuilding of retaining walls, arched buttresses and stone slabs along watercourse supporting Annex I habitats; and soil stabilization - Rubble wall/ Retaining walls. Actions also involve the introduction of Geo-textile, mulch and deadwood to reduce the rate of erosion; the restoration of footpaths to reduce trampling and encourage the vegetation regeneration; And the selective removal of boulders and silt from the water course to improve the hydrodynamics, natural vegetation and water quality. *Priority Rating:* High		**OO36.4. To identify locations where watercourse banks require restoration or siltation is occurring and devise a project for the rehabilitation of such areas (P22 and P23)** *Priority Rating:* High *Relevant performance Indicator:* List of locations and restored areas	
	OO5.1 To plant saplings of the typical and characteristic tree species of habitat 92AO (C5) *Priority:* High			
Measures dealing with Agricultural practices				
Measure	**Wied il-Luq**	**Wied tal-Bahrija**	**Wied Lunzjata**	**Qattara**
To achieve compliance with the Code of Good Agricultural Practice and the Nitrates Action Programme (NAP)	**OO26.1. To achieve compliance of cultivations over a 5 year period (M1)** *Priority Rating:* High	**OO39.1 To achieve a compliance of cultivations over a 5 year period (M2)** *Priority Rating:* High	**OO37.1 To achieve a compliance of cultivations over a 5 year period. (M1)** *Priority Rating:* High	**OO50.6 To achieve a compliance of cultivations over a 5 year period.** *Priority Rating:* High

To engage local farmers on nature conservation management		**OO39.2 To engage local farmers on nature conservation management (P 14)** *Priority Rating:* High	**OO36.3 To organise outreach activities among farmers with land in the SAC and shepherds to provide information on the impacts of agriculture on the aquifers and water run-off in the valleys (P24)** **OO37.2. To engage local farmers on nature conservation management and rubble wall maintenance to avoid soil erosion and valley siltation (P25)** *Priority Rating:* Critical	
Measures dealing with managing use of the site				
Measure	**Wied il-Luq**	**Wied tal-Bahrija**	**Wied Lunzjata**	**Qattara**
Ensuring carrying capacities are respected **To lobby with users of the site for better protection of the site**	**OO2.2. / OO4.3. To control access to habitats 5230 and 92A0 to reduce trampling effects / over-use.** *Priority Rating:* High			

To patrol / warden the site according to an established roster throughout the year with increases frequency during the hunting season, during weekends, public holidays and during planned activities	**OO31.1 / OO31.3/ OO24/OO31.2 To establish and maintain a green warden system within the site; To patrol/warden the site according to an established roster throughout the year, with increased frequency during the hunting season, during weekends and public holidays; To establish and enforce site regulations (P14 and D1)** *Priority Rating:* High	**OO34.5. / OO35.4./OO41.1. To patrol/warden the site according to an established roster throughout the year, with increased frequency during the hunting season, the seabird nesting and fledging season and during weekends and public holidays. (P17 and D1)** *Priority Rating:* High	**OO23.6/ OO24.5/ OO40.1/OO27.1/OO32.1 To patrol habitat, to prevent illegal hunting activities** *Priority Rating:* High	**OO50.1. To patrol/warden the site according to an established roster throughout the year, with increased frequency during the hunting season, during summer (inland sea), during weekends and public holidays and special events, to ensure that no illegal activities take place within the site and to monitor the impacts of allowable activities for any future controls that may be required (D1)** *Priority Rating:* Critical
Measures dealing with eradication of alien species				
Measure	**Wied il-Luq**	**Wied tal-Bahrija**	**Wied Lunzjata**	**Qattara**
To plan, implement and monitor an alien plant / fauna eradication programme	**OO5.2. To remove invasive alien species from habitat 92A0. (C4)** *Priority Rating:* High Monitoring for this action include noticeable reduction of invasive species during site patrol. Carrying of annual mapping to identify extent of removal and any trends.	**OO10.1. To eradicate/control alien and invasive species from habitat 92A0 (P6)** *Priority Rating:* Medium		**OO4.1/OO51 To ensure the conservation of the Qattara pool by removing the alien fish species from the habitat. (P10)** *Priority Rating:* High

Table 9.2: Basic Measures for Protected Inland surface Waters

(v) Implementing actions under the Sustainable Use of Pesticides Directive 2009/128/EC

Directive 2009/128/EC establishes a framework to achieve a sustainable use of pesticides by reducing the risks and impacts of pesticide use on human health and the environment and promoting the use of integrated pest management and of alternative approaches or techniques such as non-chemical alternatives to pesticides. A National Action Plan for the Sustainable Use of Pesticides for Malta 2013-2018 has been developed as a strategy to minimize human and environmental health impacts resulting from the use of pesticides and as a requisite of the Directive. The actions include:

- Information and Awareness Raising
- Pesticide application equipment certification
- Specific practices and uses – aerial spraying
- Specific measures to protect the aquatic environment and drinking water
- Reduction of pesticide use or risks in specific areas
- Handling and storage of pesticides and treatment of their packaging and remnants
- Integrated Pest Management
- Promotion of Organic Farming
- Farm Advisory Services
- Risk Indicators: Coastal and Inland Surface Waters, Ground water , Drinking water, Biodiversity Index, Soil, Development of risk indicators for human health
- Poison Centre
- Development of Guidelines

9.2.2 Basic measures to protect the Surface Water environment which stem from the WFD

The following section provides details on the basic measures that emerge directly from the WFD. The costs of these measures are included under Chapter 11. The basic measures have been divided into the following types:

KEY measures (Green): Measures that are considered to be prerequisite measures that are required to support the implementation of other measures, without which additional measures would be difficult to implement

General Surface water Measures (Blue): Measures that aim to tackle the most significant point and diffuse sources identified as an outcome of the monitoring programmes carried out under the first WCMP.

KEY 1: Continue to refine the regulatory framework for industrial operational practices

(a) Why is it important?

This measure is deemed to be a key measure due to its pivotal function in ensuring appropriate operational practices, mitigating pollution and ensuring environmental protection and water management across the catchment district and across the various economic sectors (industrial, tourism, agriculture and fisheries, aquaculture). The success of several complimentary measures, included in this programme of measures, also rely on this key process.

Industrial operational practices vary in nature and magnitude and can have a range of impacts on the water environment if not appropriately managed. During the first WCMP cycle, the MEPA[240] had defined a system of environmental permitting to improve the regulatory framework applicable to industrial activities of environmental significance (See Chapter 7). The intention was to create a regulatory system that would not only improve the protection of the environment but simultaneously offer several advantages to industry, such as legal certainty, a clearer definition of environmental liability and the opportunity to identify priority environmental issues so as to enable appropriate risk management.

The current system follows a risk-based approach with high-risk sites being permitted through a site specific environmental permit and lower risk –sites being regulated by means of general binding rules. There is however a need to enhance the legislative backing of such a system to enable better regulation in terms of performance, monitoring and compliance checking.

(b) What does the Measure entail?

A number of high-risk industries are already obliged to obtain an environmental permit. These include waste management facilities, quarries, petrol stations, VOC solvent activities and any activity that entails a discharge to sea. Other high-risk industries however may not be covered by existing legal obligations to be in possession of such a permit. These include SEVESO establishments, oil/fuel terminals, marine container terminals, Shipyards, Batching and asphalt plants; as well as medium risk plants such as manufacturing plants of considerable size, pharmaceutical plants, marinas, hospitals and fish farms or industrial operations that are considered to be of lower risk – such as wood, paper, rubber, food and beverage manufacturing, sea ports and hotels.

With improvement in the legislative base, the operator would have to submit an application form with any relevant supporting documentation depending on the applicable level of environmental permitting required. Usually higher risk industries which fall below the IPPC thresholds require an Environmental Permit (EP) and lower risk industries require a registration form to comply with General Binding Rules (GBR). These are then reviewed by the Environmental Resources Authority and the EP or GBR is issued containing a number of environmental conditions that relate to air, noise, water and waste management as well as emergency response.

The submission of reports by low risk sites would be limited. However in the case of larger/higher risk sites, the operator would be obliged to meet any operational monitoring requirements that would be requested through the issuing of an EP. The operator would need report these by means of the Annual Environment Report that is submitted to the Environment and Resources Authority annually. The ERA would then follow-up on required action and carry out spot-checks according to the performance of the individual installation.

Any information / data pertaining to water and waste water that is submitted by the operator will be digested by the experts engaged by the authority to work on water quality (See related measures SWM 2 and Key 2) and the data will be fed automatically into the database system that is to be developed by means of a separate measure (refer to measure Key 3).

(c) What is the geographical scope?

The measure applies to the entire Water Catchment District

240 At the time of publication of this plan, The Malta Environment and Planning Authority is being spilt into two separate authorities: The Malta Development and Planning Authority (MDPA) and The Environment and Resources Authority (ERA). Reference shall therefore be made to the MEPA when indicating past activities linked with implementation of the first Water Catchment management Plan. Reference to the two separate entities is included for the identification of future entities that shall be responsible for implementing particular measures detailed in this plan.

(d) What is the expected timeline for implementation?
The measure is considered to be an ongoing measure. The refinement of the regulatory framework started during the 1st WCMP phase and is a continuous process.

(e) Who is responsible for implementing this measure and which stakeholders need to be involved?
Lead: The Environmental Permitting Unit within the Environment and Resources Authority
The following stakeholders would need to be engaged in the process:
- The Water Services Corporation
- Transport Malta
- The Veterinary Affairs Division
- The Civil Protection Department
- The Regulator for Energy and Water Services

✧

SWM 1: Continue to strengthen the relationship between environmental and planning regulatory processes (including Marine Strategy Framework Directive concerns).
(a) Why is it important?
The measure aims at effectively mitigating acute and chronic hydromorphological, physico-chemical, chemical and ecological alterations to any surface water and marine environment during construction and operation of any facility through the provision of adequate guidance to architects, applicants, development planners and environmental monitors. This measure is thus important in streamlining both the Water Framework Directive and Marine Strategy Framework Directive (MSFD) requirements throughout development permitting mechanisms and related assessments with a view to ensure that existing mechanisms work towards the achievement of the goals of both Directives.
The aim of the guidance will be to ensure that adequate and sufficient information is provided to applicants, architects and the Competent Authorities on relevant WFD and MSFD issues and related requirements that need to be taken into consideration during the preparation, design, reviewing/assessment and approval of plans and development projects which are likely to affect the surface water environment. In doing this the following objectives will be reached:
- To ensure appropriate baseline monitoring data is collated prior to the initiation of development works;
- To ensure that adequate assessment procedures that conform to both the WFD and MSFD principles are carried out by environmental consultant when evaluating the environmental acceptability of the development.
- To ensure that the most sensitive construction techniques are employed during construction;
- To ensure local-scale monitoring programmes are in place to keep track of potential impacts during operation;
- To propose potential mitigation measures that may be required depending on the site location and context of the proposed development and also depending on the type of engineering intervention proposed.
- To ensure that ERA compliance officers are provided with the tools necessary to formalise and standardise how development applications are assessed in relation to their impacts on the surface water environment; and the knowledge to deal with such applications is easily transferable to new team members; and
- To ensure that the relevant entities have sufficient capacity to draft detailed permit conditions for developments and that these are tested for effectiveness (refer to Measure Key 2).

(b) What does the Measure entail?

Update the existing guidance document, as developed under the first WCMP, so as to provide guidance to officers working in the planning and environmental fields, as well as architects and potential applicants requiring development permission regarding:

- Requirements related to the assessment of potential impacts any engineering works, and waste management works may have on both inland waters, transitional waters and coastal / marine waters, including offshore waters. Engineering works can include construction of quays, jetties, slipways, pontoons, dams, reservoirs and coastal roads, beach replenishment, land reclamation, dredging, dumping etc. Waste Management works can include: infilling of landfills, waste reception facilities, waste management at farm level, waste water treatment, collective waste management facilities;
- Requirements related to the identification of mitigation measures and any related conditions that are stipulated by the Environment and Resources Authority;
- Requirements related to monitoring of the impacts vis-à-vis water quality monitoring that is to be carried out by the applicant before and after the development is constructed and fully operational.

By standardising the approach to be taken the Environment and Resources Authority will be able to:

a) Ensure minimum requirements are always met;
b) Facilitate the transfer of knowledge gained in dealing with such applications;
c) Provide transparency to potential developers on the suitability of project designs and likely permitting costs.

(c) What is the geographical scope?

The entire Water Catchment District[241] and marine waters falling under Malta's jurisdiction.

(d) What is the expected timeline for implementation?

The measure will initiate in 2016 as soon as the new Environment and Resources Authority is established. It is expected that 6 months are required for the development of more comprehensive guidelines.

(e) Who is responsible for implementing this measure and which stakeholders need to be involved?

Lead: The Environment and Resources Authority

The following stakeholders would need to be engaged in the process:

- The Malta Development and Planning Authority
- The Continental Shelf Department
- Transport Malta - Ports and Yachting Directorate
- The Fish and Farm Regulation and Control Department

✧

SWM 2: Continue to control priority hazardous substances, priority substances and other substances of concern via the environmental permitting process.

(a) Why is it important?

To ensure the maintenance or achievement of good chemical quality in coastal/ marine and transitional, inland surface waters in the Maltese Islands with the following targets in mind:

241 The entire **water catchment district** includes coastal waters up to 12 nautical miles

- To control the discharge; emissions and losses of priority substances and specific pollutants of concern from industrial installations via the Industrial environmental permitting process;
- To phase out the use of any priority hazardous substances from industrial operations by means of the environmental permitting process.

(b) What does the Measure entail?

The effective control and phasing out of use of chemicals that are considered to be of concern can only be achieved through the environmental permitting system. The success of this measure hinges on two main prerequisites:

1. A robust Environmental Permitting system with effective mechanisms in place to ensure that monitoring data related to water quality and discharges to sea and the sewer is adequately collated by all responsible entities and the data is adequately managed by the Environment and Resources Authority.
2. An inventory of discharges, emissions and losses (refer to basic measure SWM 3 below) clearly indicates which of the substances (and their by-products) used in industry are priority /priority hazardous substances, together with their amounts and discharge quantities.

Key changes to the current situation include:

- MEPA will gain access to improved interactions with other stakeholders by means of improved reporting streams. In this respect kindly refer to KEY3.
- Based upon this, the Environment and Resources Authority will be able to issue more specific risk based permit compliance and monitoring requirements on a case by case basis.
- The Environment and Resources Authority will also be fed with chemical results of various sewage discharges by applicants (as part of the environmental permitting process via SWM 1 and Key 2). This will allow the new Environment and Resources Authority to extract the required information to address any data gaps and adopt a more sophisticated risk based approach towards compliance monitoring.

(c) What is the geographical scope?

All installations requiring an environmental permit on the landward side of the Water Catchment District Including installations having a discharge point to surface waters along the coast.

(d) What is the expected timeline for implementation?

The measure is considered to be an ongoing measure. Controlling the discharge of priority substances, priority hazardous substances and substances of concern started during the 1st WCMP phase and is a continuous process via the environmental permitting regulatory system.

(e) Who is responsible for implementing this measure and which stakeholders need to be involved?

Lead: The Environment and Resources Authority

The following stakeholders would need to be engaged in the process:

The Water Services Corporation

The Malta Competition and Consumer Affairs Authority

SWM 3 – Update inventory of discharges (EQS Directive)

(a) Why is it important?

As indicated in Chapter 7 (measure KNO 3-2) MS are obliged to establish an inventory of emissions, discharges and losses of all priority substances and contaminants listed in the Directive. The inventories are expected to give information on the relevance of the Priority substances at the spatial scale and on the loads discharged to the aquatic environment. The inventory is also expected to shed light on the extent any of the monitored concentrations are caused by natural sources or processes or long-range transport processes.

(b) What does the Measure entail?

For the first cycle Malta had to assess the current relevance of the substances at Water Catchment District level using monitoring data and any other information that was obtainable from existing restrictions on production and marketing of substances.

As a second step Malta would need to adopt a more detailed analysis. This measure will lead to enhanced knowledge by constantly revising and refining the Inventory of discharges, losses and emissions as stipulated by the EQS Directive. The effectiveness of this measure is reliant on various other measures and regulatory control processes including the setting up of a coherent open platform of data sharing between the necessary entities (refer to measure KEY 3) environmental permitting, as well as additional supplementary measures that have been included under the Section '*Supplementary measures'* below, measures SWM 10, KNO 3, KNO 4 and KNO 5 in particular.

(c) What is the geographical scope?

The entire Water Catchment District (including coastal waters) including the consideration of data sources from other environmental media monitoring (i.e. such as soil and air). Any research initiatives required to support this inventory would go beyond the Water Catchment District to consider potential transboundary pathways where air deposition and hydrographic pathways are concerned (refer to supporting supplementary measures SWM 10, KNO 4, and KNO5).

(d) What is the expected timeline for implementation?

The measure is considered to be an ongoing measure. Data collated through ongoing monitoring will feed into the inventory and this would be assessed on an annual basis.

(e) Who is responsible for implementing this measure and which stakeholders need to be involved?

Lead: The Environment and Resources Authority

The following stakeholders would need to be engaged in the process:

The Ministry for Energy and Health – Sustainable Energy and Water Conservation Unit

The Malta Competition and Consumer Affairs Authority

The Agriculture Directorate (due to provision of data generated by means of their Integrated Agricultural Control System and Land Parcel Information System).

The Water Services Corporation

9.2.3 Supplementary Measures related to Surface Waters

After evaluating the likely impact of the basic measures, in terms of their ability to help achieve the goals set out in the WFD, and after taking into consideration the current water and chemical status of all water bodies, a number of additional supplementary measures were established to assist in the maintenance or achievement of the WFD objectives.

Similar to Basic measures, Supplementary measures have been categorised into the 5 following types:

1) KEY measures (Green): Measures that are considered to be prerequisite measures that are required to support the implementation of other measures, without which additional measures would be difficult to implement.
2) General Surface water Measures (Blue): Measures that aim to tackle the most significant point and diffuse sources identified as an outcome of the monitoring programmes carried out under the first WCMP.

3) Knowledge-based measures (Orange): Measures required to fill the most pertinent gaps in knowledge; gaps that are considered to limit Malta's ability to deal with pressures in an effective manner.
4) Emergency related measures (Red): Measures that have been devised to improve upon Malta's existing efforts to deal with emergency response on land and at sea.
5) Awareness Raising Measures (Purple): Measures that stimulate discussion across sectors and raise public awareness on certain significant water management issues.

These measures are then re-organised in the following groups:
1 Measures to refine existing regulatory controls within the Environment and Resources Authority
2 Data management measures
3 Measures dealing with enhancing the knowledge base
4 Measures related to improving marine and terrestrial emergency contingency response
5 Communication and awareness raising

9.2.3.1 Measures to refine existing regulatory controls within the Environment and Resources Authority

Key 2: Create an effective feedback mechanism within the Environment and Resources Authority to ensure compliance and risk mitigation

(a) Why is it important?

There is a need to ensure a feedback mechanism is in place within the Environment and Resources Authority to guarantee that the monitoring data collected at pre-development and post-development stage; as well as emergency response data, are brought together in a meaningful manner. It is also necessary that this data feeds into the open platform database (Refer to Measure KEY 3) so that such data can be used by multi-disciplinary environmental officers for purposes of different types of environmental assessments that are required to be undertaken as basic functions of the Environment and Resources Authority. This measure further stresses the importance of having a centralised, fully-functional database system in place

(b) What does the Measure entail?

The measure requires that any information that is made available post development construction or during operation (via the environmental permitting process) is inputted directly through online sources within the open database system that shall be developed as per Measure Key 3 (below). Once the data is inputted in the system, compliance officers and technical officers would be notified so that the information or data could be checked; and potential risks are highlighted. This is required to ensure that any appropriate follow-up action could be planned accordingly and environmental risks are handled in an efficient manner.

Such a system would facilitate the Environment and Resources Authorities' role to carry out risk based compliance checks; the carrying out of enforcement responsibilities; the ability to direct monitoring efforts where these are most required; and also carry out effective follow-up accidental response.

(c) What is the geographical scope?

The entire Water Catchment District and marine waters.

(d) What is the expected timeline for implementation?

Since this measure requires the MEPA split process to take place and a coherent database system to be in place, it is expected that this measure will start at the beginning of 2017.

(e) Who is responsible for implementing this measure and which stakeholders need to be involved?
Lead: The Environment and Resources Authority
The following stakeholders would need to be engaged in the process depending on which data is being assessed or the type of environmental risks that may emerge from the analysis of the data:
The Sustainable Energy and Water Conservation Unit, Ministry for Energy and Health
The Water Services Corporation,
Transport Malta, Ministry for Transport and Infrastructure,
The Environmental Health Directorate
The Malta Tourism Authority
The Storm Water and Valley Management Unit,
The Cleansing Department, Ministry for Transport and Infrastructure

✧

SWM 5 – Publish guidelines for the disposal of dredged material
(a) Why is it important?
If not properly managed, dredging activities can have a significant environmental impact. Dredging brings about the removal or disturbance of benthic habitats, an increase in turbidity, changes in water currents, and the release of contaminants within sediments; all of which can negatively affect water quality and marine ecosystems.

One of the major environmental risks relates to historical contamination in sediments, which is an issue of particular significance within harbours and ports such as the Grand Harbour. Marine sediment acts as a sink for coastal water contaminants, including particulate matter and a variety of chemicals arising from port activities as well as from industrial installations located within port areas.

Marine sediments can act as a source of contamination which can be transported through the water column as a result of activities such as dredging. Sediment disturbance and prevailing hydrodynamic conditions can also result in plume formation, which is dependent on the sediment's physical characteristics. Contaminants mobilised through such actions can result in water quality impairment and can be toxic to aquatic receptors, including fish. Sediment data held by the Environment and Resources Authority on dredged material shows high levels of certain contaminants in certain sediments, which raises concerns regarding the proper management and disposal of such material.
While recognising the need for dredging activities for the proper operation of local ports and harbours, there is an equally important need to ensure that activities arising from related actions are sustainable and not detrimental to the environment. Dredging and dredge material treatment/disposal thus requires adequate planning, design and management to avoid the negative impacts which may arise through inadequate handling of contaminated dredged material.

The measure is therefore required to maintain and improve good water quality at the spoil ground by means of policy development related to the disposal of dredged material at sea.

(b) What does the Measure entail?
As indicated in Chapter 7 COAST 1-1, a draft has already been produced and was used on a pilot basis during the first WCMP. This measure will publish the guidelines following a scoping exercise for integration of additional requirements that emanate from the Marine Strategy Framework Directive as well. These guidelines would be made accessible to industrial operators. The guidelines provide clear and consistent standards and criteria for the assessment of dredged material in order to facilitate and improve decision making, particularly in terms of managing contaminated sediments. The guidelines also address the appropriate disposal of contaminated sediments.

(c) What is the geographical scope?
The entire Water Catchment District (including coastal waters).

(d) What is the expected timeline for implementation?
To make these guidelines fully operational by end 2016. The Environment Authority envisages a revision of this document in 3 to 4 years time, as further scientific information becomes available.

(e) Who is responsible for implementing this measure and which stakeholders need to be involved?
Lead: The Environment and Resources Authority
Stakeholders that would need to be engaged in the process: The Malta Development and Planning Authority

SWM 6: Carry out joint inspections with Transport Malta, the Civil Protection Directorate, the Occupational Health and Safety Authority and the Water Services Corporation to ensure that industrial operations abide to best environmental practice
(a) Why is it important?
Currently the regulation of a number of industrial and sea-related leisure activities is catered for by two or more separate regulatory processes. For example there exists the environmental permitting procedure which is carried out by MEPA and the submission of waste management plans and emergency contingency plans that may be required by separate entities such as Transport Malta (TM), and the Civil Protection Directorate.

This creates additional administrative burden for the operators, who are required to submit two plans rather than merging requirements into one document. Furthermore, both regulators each undertake separate inspections. Such practices increase the private entities' costs in relation to dealing with inspections; and also result in higher public sector costs as certain regulatory aspects overlap and are duplicated.

MEPA is already successfully conducting joint inspections with the Civil Protection Directorate and the Occupational Health and Safety Authority in the case of COMAH (Control of Major Accident Hazards) establishments. There is scope to extend this further to other entities and to better achieve compliance with water related legislation.

(b) What does the Measure entail?
This measure aims to streamline inspectorate regulatory procedures that exist within the Environment and Resources Authority with those of other entities that have to deal with regulating activities that may impact the water and marine environment. This is necessary so as to reduce regulatory overlaps; improve on transparency of inspections as well as encourage self-regulation through a reduction in bureaucracy; improve collaboration between the various entities regulating activities and pressures that may impact the water environment and improve governance. Any enforcement or compliance follow-up would also be expected to take place in a joint manner. Such a measure would increase the collaboration between the various entities and the Environment and Resources Authority.

(c) What is the geographical scope?
The entire water catchment district

(d) What is the expected timeline for implementation?
Measure is expected to be operational by the start of 2017.

(e) Who is responsible for implementing this measure and which stakeholders need to be involved?

Lead: Environment and Resources Authority

The following stakeholders may have to be engaged in the process, as relevant:

- Transport Malta
- The Civil Protection Department
- The Environmental Health Directorate (Bathing Water)
- The Occupational Health and Safety Authority
- The Water Services Corporation
- Local Councils
- Cleansing Services Directorate

✧

SWM 7: Develop a system to encourage adequate litter management and control in coastal areas

(a) Why is it important?

During the process of implementation of the measure related to the development of Harbour Environmental Management Plans during the first WCMP, there was considerable discussion regarding how best to deal with waste issues that arise outside the confines of terminals and industrial installations in public spaces within port and coastal areas. Although some waste facilities are provided by Local Councils these are considered to be insufficient due to the fact that problems with litter still arise.

During stormy weather substantial marine litter is washed inshore and collects in sheltered inlets and bays. Heavy rains may also contribute to marine litter when land-based litter ends up in the marine environment. Marine litter is difficult to control and requires immediate action to ensure collection. The impacts of marine litter on marine life and on the chemical quality of the water environment are undesirable, apart from being aesthetically degrading. Therefore effort to minimise the undesirable impacts of marine litter is necessary.

(b) What does the Measure entail?

This measure encourages the pooling of resources in order to reduce marine litter by coming up with possible actions and coordinating clean ups and / or cleansing in common areas which fall outside the competency of major regulatory entities. The Cleansing Services Directorate (CSD) have already initiated an extensive marine litter collection system around the Maltese coastline. The CSD have invested in a dinghy to collect floating marine litter when the need arises. There is a need to support this initiative by:

- establishing a national clean-up strategy that can contribute to the cleansing that is already followed by the Cleansing Services Directorate to maintain the public shoreline in a clean state;
- providing the necessary financial support to encourage frequent cleaning of coastal waters and
- providing adequate training to personnel entrusted with the task of collecting floating shore based and marine based litter;

(c) What is the geographical scope?

Coastal water stretches in all coastal water bodies

(d) What is the expected timeline for implementation?

To start drawing up the strategy in 2016 and implementation to partially continue through the current efforts of the Cleansing Services Directorate.

(e) Who is responsible for implementing this measure and which stakeholders need to be involved?

Lead: The Cleansing Services Directorate

The Environment and Resources Authority

The following stakeholders may have to be engaged in the process:
Malta Tourism Authority
Any relevant Local Councils
The Storm Water, Marine and Valley management Unit

SWM 8: Improve operational standards for the aquaculture sector via the environmental permitting process

(a) Why is it important?

The new Aquaculture Strategy for the Maltese Islands highlights the need to regulate the management of all aquaculture zones. Policy also calls for a review of the licensing procedure for aquaculture development with a view to introduce a periodic operational permitting procedure for improved environmental performance. This measure therefore intends to achieve optimal practice through the established environmental permitting procedure of the Environment and Resources Authority, and in so doing clarify the responsibilities of the various stakeholders involved.

(b) What does the Measure entail?

In order to improve aquaculture practice through the environmental permitting regime, a series of stakeholder meetings are needed to establish clear guidelines with respect to Environmental Permitting requirements. Agreements would need to be reached between the Fish and Farm Regulation and Control Department and the Environment and Resources Authority on regulatory requirements related to waste management, pollution response and periodic water quality, sediment quality and benthic habitat quality of the marine environment immediately underneath the cages and in the area of influence of each aquaculture site.

These requirements would then be translated into permit conditions required to control the appropriate management of the various waste streams generated by the aquaculture industry; the use of petroleum products and medicines, as well as the creation of standardised terms of reference clearly outlining the monitoring parameters and programmes required to ensure adequate monitoring of the marine environment.

(c) What is the geographical scope?

Coastal water bodies MTC 103, MTC 104, MTC 105, MTC 106 and MTC 107

(d) What is the expected timeline for implementation?

Effort to improve aquaculture practice through the environmental permitting regime is expected to start 2016. The measure itself is considered to be continuous due to the fact that any requirements would be streamlined through the environmental permitting process.

(e) Who is responsible for implementing this measure and which stakeholders need to be involved?

Lead: The Environment and Resources Authority
Fish and Farm Regulation and Control Department

The following stakeholders may have to be engaged in the process:
Transport Malta

SWM 9: Creation and Implementation of the Agriculture Waste Management Plan

(a) Why is it important?

Animal waste disposal in the public sewer creates technical problems at waste water treatment plants and water quality issues at point of discharge into the coastal water bodies. This issue has been impinging on WFD and UWWTD compliance for several years. In fact, the Government is committed towards a management plan to better tackle the agricultural waste. This has already been proposed with some measures to ensure compliance with the relevant EU and national legislation. Such a plan will outline a comprehensive governance structure which will be responsible for co-ordinating centrally the management of all farm waste. The waste will be monitored from its generation to its final disposal. Further steps in line with the Agricultural Waste Management Plan will lead to improvements in the urban waste treatment plants.

(b) What does the Measure entail?

The first step established in the above-mentioned management plan is the establishment of a governance structure to analyse all available options. This will ensure a centralised management system to ensure the optimal use and treatment of manure in compliance with the obligations emerging from several directives. It is intended that the system would cater for:

- The registration and acceptance of the waste produced;
- The oversight of application of manure to fields consistent with regulatory arrangements and the implementation or oversight of the required treatment approaches adopted;
- The disposal of residual waste after treatment;
- Overseeing the exportation of untreated pig waste to other Member States as and when required.

(c) What is the geographical scope?

The entire Malta Water Catchment District including the Nitrate Vulnerable Zone.

(d) What is the expected timeline for implementation?

The timelines for implementation are defined within the Agricultural Waste Management Plan

(e) Who is responsible for implementing this measure and which stakeholders need to be involved?

Lead: the governance structure within the Ministry for Sustainable Development, the Environment and Climate Change (MSDEC)

Stakeholders:

- Sustainable Energy and Water Conservation Unit
- Malta Environment & Planning Authority
- Department for the Environment and Climate change (MSDEC-DECC)
- Agriculture Directorate, Rural Development Department
- Water Services Cooperation
- WasteServ Malta

SWM 10: Establish a Mercury Management Plan to enable the investigation of potential sources of mercury and potential mitigation measures.

(a) Why is it important?

Monitoring results for the first WCMP cycle revealed Mercury to be a major contaminant of concern in coastal waters not only due to its exceedances (of the established EQS) but also due to its ubiquitous nature, even in water bodies that are considered to be relatively 'pristine'. We do not know enough about the potential sources of mercury in our waters and there is a high probability, based on literature findings that multiple sources, including transboundary issues, are contributing to our mercury problem. Due to its unique physico-chemical properties mercury has, for a long time, been employed in a wide variety of industrial applications. Apart from anthropogenic sources of mercury, volcanic activity and geologic cinnabar deposits are also known to contribute to mercury levels in the environment. Malta is yet to understand what can be considered to be the natural occurring background level of mercury in the Mediterranean and what could be contributing to increments in mercury found in our waters. There is thus a need to investigate what these potential sources could be and the extent of their contribution to mercury contamination.

(b) What does the Measure entail?

The first step of the measure would be to carry out a thorough investigation of all potential sources of mercury pollution including potential land-based sources, sea-based sources and potential atmospheric sources to the coastal and marine environment. An understanding of the fate of these inputs in relation to existing physico-chemical, atmospheric and hydrographical processes in the Mediterranean would also be required.

- Possible land based sources of contaminants would need to be investigated as part of the assessment that would be carried out to enhance Malta's Inventory of emissions, discharges and losses (refer to measure SMW 3).
- The investigation of both sea-based sources and air based sources would require that literature of the Mediterranean region together with data that is available from regional monitoring networks are thoroughly investigated with the objective of assessing risks to Maltese coastal and marine waters.

The expected deliverable of the first phase of the measure would be a report detailing the levels of risk posed by potential contributors to mercury inputs in Maltese coastal and marine waters.
The second stage would be to identify potential measures to mitigate Mercury contamination coming from sources that can be controlled from land. The costs regarding the implementation of this activity are unknown and will be updated in the second implementation phase of Malta's water catchment plan.

(c) What is the geographical scope?

The Maltese Water Catchment District and the Mediterranean Basin

(d) What is the expected timeline for implementation?

The first phase is expected to take 1 year. The second phase would depend on the outcome of the first phase.

(e) Who is responsible for implementing this measure and which stakeholders need to be involved?

Lead: The Environment and Resources Authority
Involved stakeholders: Waste management sector, Mediterranean regional partners, Research entities such as the University of Malta.

SWM 11: Streamline designated Bathing waters as defined by the Environmental Health Directorate with designated Swimming Zones as regulated by Transport Malta where these two areas overlap or are in close proximity to each other

(a) Why is it important?

There are currently two types of designated swimming areas in the Maltese Islands. The **Bathing Areas** are designated in accordance with the Bathing Water Directive and are frequently monitored for microbiological contamination. The **Swimming zones**, on the other hand, are established by Transport

Malta, and are intended to ensure the safety of swimmers. Since the regulation of recreational boating activities by Transport Malta has an important function in maintaining good quality bathing water, whilst simultaneously ensuring safety at sea; there is a need for the two independently designated areas to be streamlined in areas where bathing is acceptable from an environmental health point of view.

(b) What does the Measure entail?

The measure requires that by means of the Bathing Water Committee agreements are reached between Transport Malta and the Department for Environment Health to ensure that, where suitable, bathing waters and swimming zones are streamlined. Areas located in harbours cannot be considered for purposes of this streamlining activity due to the fact that bathing in harbour areas would not be acceptable from a health perspective. Furthermore, additional measures may be identified by the Bathing Water Committee as deemed appropriate, to regulate recreational boating in priority areas, whereby such activity is known to cause problems. These additional measures may include site-specific measures that establish buffers and control over-nighting of vessels particularly in popular bathing areas.

There is also the need to increase public awareness on the difference between the two designations so that bathers can make an informed choice of their bathing area based on both health and safety criteria.

(c) What is the geographical scope?

Bathing areas and Swimming zones which are located in close proximity around the coastal stretch of the Maltese Islands.

(d) What is the expected timeline for implementation?

Relevant discussions at Bathing Water Quality Management Committee (as established by LN 125 of 2008, as amended) are expected to start 2016.

(e) Who is responsible for implementing this measure and which stakeholders need to be involved?

Lead: The Bathing Water Quality Management Committee (which is composed of representatives from the Environmental Health Directorate and Transport Malta, amongst others).
Involved stakeholders: The Environmental Health Directorate, Superintendent of Public Health
Transport Malta and the Environment and Resources Authority; The Malta Tourism Authority

SWM 12: Extend the basic measure related to the removal of alien species from the Qattara habitat, as identified in the Natura 2000 Management Plan, to the Għadira ta' Sarraflu

(a) Why is it important?

Baseline water quality monitoring has indicated that alien species are a significant threat to the ecological well-being of this particular pool. The Levant water frog (*Pelophylax bedriagae*), an alien amphibian, was deliberately released in the late 1990s in l-Għadira ta' Sarraflu, where it has established a population. This alien can out-compete the Siculo-Maltese endemic (i.e. found only in Malta and Sicily) painted frog (*Discoglossus pictus pictus*).[242] A population of ducks and geese as well as other aquatic alien species such as the *Carassius auratus* (Gold fish), the *Gambusia affinis* (Mosquito fish) and the

242 Schembri, P.J. 2010. *A tale of two frogs,* in The Gozo Observer no..22, June 2010

Occurrence of the alien Bedriaga's frog (Rana bedriagae) Camerano, 1882 in the Maltese Islands, and implications for conservation, Sciberras & Schembri (2006)

Trachemys scripta (Painted terrapin) were also observed in the pool during the monitoring. Due to their potential to alter the water habitat, species have to be controlled.

(b) What does the Measure entail?

It is expected that frequent monitoring of the pool would enable any new alien species to be detected and dealt with immediately. However for those alien species that have been established in the pool for several years, and are deemed to be of significant threat to other important species, it is necessary that these are removed.

Prior to determining the methodology required for the removal of the alien species, consideration will be given to the resistance (the ease or difficulty of eradication) and the resilience (the ability to absorb disturbance and return to its original state of stability) of the established alien species concerned. The eradication and/or control of the species is to be carried out in a manner which prevents the further spread of the species.

When carrying out the removal of alien species, the monitoring of both the effectiveness of the measures as well as the impacts these may have on non-target species and the habitat is required. Where necessary, follow up actions and/or revision of the methodology are to be carried out to ensure the effective removal of the alien species or to mitigate the impacts on non-target species and the habitat.

Removing the species alone would be futile unless awareness raising on the problems associated with the introduction of such species would be introduced. Therefore the measure also proposes that the efforts to increase public awareness are given greater impetus especially when dealing with such unique water environments and their ecological importance at a national level. Efforts at raising public awareness should also target the pet industry as this is one of the main sources of such aliens. Pet-shop owners are to be included in such efforts and encouraged to advise the public against releasing non-native species into the habitat. Additional measures which can be considered include the installation of signage on site; the encouragement of frequent visitors to the area to take ownership of the habitat and report anything of concern; as well as patrolling.

Where appropriate, measures removing the alien species will be accompanied by actions aimed at increasing the resilience of the ecosystem to future invasions, as well as the restoration of the damaged ecosystem.

(c) What is the geographical scope?

Protected pool Għadira ta’ Sarraflu

(d) What is the expected timeline for implementation?

To be implemented in 2018.

(e) Who is responsible for implementing this measure and which stakeholders need to be involved?

The Environment and Resource Authority

SWM 14: Develop a strategic policy framework to encourage integrated valley management

(a) Why is it important?

The demonstration of ‘integrated valley management’ was called for in Malta’s first Water Catchment Management Plan as an overriding measure that considers land use and environmental management at the sub catchment scale. In order to practically demonstrate this integrated concept it was decided that a study area be selected as a showcase of best practice for applying 'integrated management' principles to valley catchments.

During the course of implementation of the first WCMP measure, a consensus was reached between involved entities that in addition to a pilot project, in order to facilitate the achievement of integrated valley management, the procedures in place for regulating valley maintenance and cleaning had to be revised to ensure that a more holistic and efficient assessment was carried out. If need be a fast track system could be adopted to assist in cases where maintenance or clean up initiatives in valley catchments were of a recurrent nature. It was also agreed that valleys should be considered on their own individual merit due to their different functions (ecological, hydrological and cultural importance) such that the acceptability of any proposed actions deemed necessary to be undertaken in valley environments could be assessed against such functions.

(b) What does the Measure entail?

In addition to the standard procedure and guidance for general clean-up and maintenance of valleys that has been developed by MEPA over the years; management plans or 'plan of actions' are required to be drawn up on an individual level to take into account the unique function of each valley environment. This requires that valleys are first categorized into classes, with each class indicating the function and related importance of each respective valley catchment. Management measures would then be assessed on the basis of the classification of each respective valley catchment or valley segment.

The combination of these two mechanisms (i.e. standard guidelines and complementary management plans) would allow for the regular maintenance of each valley to be based on agreed-to norms and practices in a structured framework, rather than be subjected to ad hoc cleaning and maintenance works.

The measure therefore requires that concerned Ministries and Departments collaborate on a strategic policy framework for the valleys of the Maltese Islands to achieve the following tasks:

1. Categorisation of valley systems according to agreed-to sensitivity criteria;
2. Development of management plans for valley catchments in consultation with relevant Local Councils, land users and interested NGOs

(c) What is the geographical scope?

The valley catchments of the Maltese Islands

(d) What is the expected timeline for implementation?

The process is to start in 2016 and run up to 2021.

(e) Who is responsible for implementing this measure and which stakeholders need to be involved?

Lead: The Environment and Resource Authority

Involved stakeholders:

The Marine, Storm Water and Valley management Unit, MTI
The Sustainable Energy and Water Conservation Unit, MEH
The Ministry for Gozo

The following stakeholders may have to be engaged in the process:

Local Council Association, relevant local councils, Environmental NGOs

9.2.3.2 Data Management Measures

Key 3: Enhance water and marine data using an open platform

(a) Why is it important?

The Malta Environment and Planning Authority's efforts to improve data flows between the various environmental units and between other regulatory entities and stakeholders improved substantially during the first WCMP cycle. However as explained in Chapter 7 there is a need to consolidate these efforts and improve the means of sharing information. The current systems lacks the flexibility needed to allow the sharing of new data sources and presents numerous other limitations.

The new Environment and Resources Authority aims at integrating environmental data into an open GIS platform, whereby all environmental data, even that generated by other entities, would have a spatial reference and could be easily inputted within the database structure developed. Such a system would allow existing, envisaged, and future data requirements to be integrated easily. Viewers or data analysts would be in a better position to access various data sources and to view different data sources simultaneously through the use of data layers.

(b) What does the Measure entail?

Apart from the necessary investment in a robust database structure and GIS Open platform, a number of agreements between various entities would be required so that any environmental data foreseen to be of significance to the water and marine environment could feed into the system. This would require discussions between the MSDEC, the ERA, MITA and the various entities on a one-to-one level whereby the following would have to be agreed to:

- The type of data that can be shared;
- How the system would work from the stage of delivery and uploading of the data to the display of the specific data;
- How the quality assurance and quality control procedure of the data is to be carried out;
- The sensitivity of the data concerned and related access rights;
- The frequency of providing the relevant datasets;
- Agreed-to formats including projections and related coordinate systems;
- Any conversion requirements of the data that can be provided by the separate entities;
- The INSPIRE compliance requirement of the data and the ensuring of the necessary links with Malta's INSPIRE geoportal.

Draft Policy Guidelines have been drawn up by the Malta Information Technology Agency (MITA) concerning the facilitation of Data and Service Sharing between entities and are at time of publication of this plan, pending approval. These draft guidelines are accessible from site https://msdi.data.gov.mt/. Any data sharing agreements between entities will consider these guidelines.

(c) What is the geographical scope?

The Maltese Water Catchment District and marine waters

(d) What is the expected timeline for implementation?

The setting up of the database structure and GIS open platform would require at least a year. is the process of setting up the structure is expected to start as soon as the new Environment and Resources Authority is set up in 2016 and therefore the system is expected to be in place towards the end of 2016. Agreements with the various entities would start in parallel. Given the vast range of environmental data that would need to be centralised the process of developing agreements and inputting data would be an ongoing process.

(e) Who is responsible for implementing this measure and which stakeholders need to be involved?

Lead: The Environment and Resources Authority
The Ministry for Sustainable Development and Climate Change

Involved stakeholders:
Under the Ministry for Sustainable Development, the Environment and Climate Change:

- National Parks, Afforestation and the Countryside,
- Managing Authority - Rural Development,
- The Agriculture Department,
- Fish and Farm Regulation and Control,
- Veterinary services division

Under the Office of the Prime Minister

- The Malta Development and Planning Authority

Under the Ministry for Energy and Health: The Environmental Health Directorate:

- The Sustainable Energy and Water Conservation Unit;
- The Water Services Corporation,
- The Regulator for Energy and Water Services

Under the Ministry for Transport and Infrastructure:

- Transport Malta;
- Cleansing Department;
- Stormwater and Valley management Unit,
- Continental Shelf Department

Ministry for Gozo

Ministry for Tourism:

- The Malta Tourism Authority

Ministry for Finance:

- National Statistics Office

Ministry for the Economy, Investment and Small Businesses:

- Malta Enterprise,
- Maritime Policy and Promotion

Ministry for Social Dialogue, Consumer Affairs and Civil Liberties:

- Environmental Non Governmental Organisations
- Malta Competition and Consumer Affairs Authority
- Malta Medicines Authority

Ministry for Education and Employment:

- University of Malta (Various faculties)
- Malta Council for Science and Technology
- Malta College for Arts, Science and Technology

9.2.3.3 Measures dealing with enhancing the knowledge base

KNO 1: Study the impacts of the national spoil ground off Xghajra
(a) Why is it important?

Currently, there is a lack of knowledge on the state of impact of the only marine spoil ground in Malta. The official national marine spoil ground, designated by Legal Notice 128 of 1997, as amended, is located some 4km off the Grand Harbour and consists of a circular area with a radius of around 350m, centred on the following coordinates: N35o 55.1'/E14o 34.0'. The spoil ground is used for the dumping of inert material which includes rocks, stones, rubble and other material that originates from excavation and demolition works in connection with construction activities on land. A previous study that was commissioned by the Malta Environment and Planning Authority (MEPA) in 2008 has indicated the presence of spoil extending beyond the perimeter of the official designated area.

Consequently a study to raise awareness is needed so that future policy related to dumping waste at sea is carried out on the basis of scientific knowledge. More specifically, the study is needed to enhance knowledge on the extent of marine chemical quality impacts of the spoil ground and to improve knowledge on the dispersive characteristics of the spoil ground so as to inform the methods and locations required to dump inert waste.

(b) What does the Measure entail?
The measure involves a study which will enhance knowledge on the state of impact of the national spoil ground off Xghajra. The study would be on the physical and chemical sediment attributes and marine benthic diversity at the National Designated Marine Spoil Ground and its Environs as compared to control sites.
The specific objectives of the study would be

- To collect sediment samples from the seabed at the national designated marine spoil ground and from the seabed at sites close to where dumping of spoil has been carried out, extending beyond the perimeter of the official designated area (Sampling points have to be identified, in specific areas not covered with spoil waste);
- To collect sediment samples from control monitoring stations at distant sites from the spoil ground, which however also display similar natural environmental characteristics to those at the spoil ground;
- To assess sediment quality, including granulometric analysis and chemical analysis of the sediment samples collected;
- To study sediment benthic diversity of the sediment samples collected.
- To interpret the results obtained from the granulometric analysis, the chemical analysis and the sediment benthic diversity study through the use of statistical tools.

The results of the study will be made available to research entities and the public.

(c) What is the geographical scope?
MTC 106 together with the extent of the spoil ground and surrounding environs.

(d) What is the expected timeline for implementation?
Study to start in 2018

(e) Who is responsible for implementing this measure and which stakeholders need to be involved?
Lead: The Environment and Resources Authority

KNO 2: Carry out a technical feasibility assessment regarding the management of ballast waters
(a) Why is it important?
The uncontrolled discharge of ballast waters may bring about the unwanted introduction of invasive alien species into the Mediterranean, which depending on the climatic conditions, may thrive and displace other

important species within the marine environment, with the potential of causing widespread ecosystem dysfunction. This in turn may impact the fishery sector and even water treatment infrastructure.

(b) What does the Measure entail?

The International Convention for the Control and Management of Ship's Ballast Water and Sediments highlights the responsibility of Member Parties and ships to adopt measures in order to prevent, minimize and ultimately eliminate the risks of introduction of Harmful Aquatic Organisms and Pathogens through ships entering in ports.

Malta has initiated the process to ratify such a convention. Malta acknowledges that in order to ensure effective implementation of the Convention, it requires to carry out a study to establish the best manner in how implementation in Malta should take place.

In accordance with the Convention, Member Parties need to implement strategies for the reception and treatment facilities available to ensure environmentally safe disposal of ballast tanks sediments. Port States should provide information to ships on details of their requirements concerning the ballast water management; location and terms of use of alternative exchange zones; other port contingency arrangements; any other information on the availability, the location and capacities to reception facilities provided. Each ship shall have on board a detailed Ballast Water Management Plan.

Considering that the Ballast Water Management for Ships is different according to date of ship's construction and Ballast Water Capacity (outlined in Regulation B-3 of the Convention), a Ballast Water Exchange conducted by ships shall take place at least 200 nautical miles from the nearest land and in water at least 200 metres in depth (Regulation B-4), or where not applicable, as far from the nearest land and in all cases at least 50 nautical miles from the nearest land and in water at least 200 metres in depth.

Moreover, Malta should establish designated areas for exchange of ballast waters and ensure that such areas are not:

- areas known to contain outbreaks, infestations, or populations of Harmful Aquatic Organisms and Pathogens (e.g., toxic algal blooms) which are likely to be of relevance to Ballast Water uptake or discharge;
- areas near sewage outfalls; or
- areas where tidal flushing is poor or times during which a tidal stream is known to be more turbid.

(c) What is the geographical scope?

The study will need to look at Malta's national capacity requirements and it is therefore relevant to the entire water catchment district.

(d) What is the expected timeline for implementation?

Terms of reference for the study will be developed and awarded by second quarter 2016

(e) Who is responsible for implementing this measure and which stakeholders need to be involved?

Lead: Joint leaders MSDEC and MTI

Stakeholders: Transport Malta
Malta Environment and Planning Authority

KNO 3: Characterise and quantify hydrological input of land based contaminants (including litter) to coastal waters from major sub catchments.

(a) Why is it important?

Monitoring results detailed in Chapters 3 and 6 of this plan have indicated that the current state of knowledge in the Maltese Islands on diffuse sources of land based contaminants is very limited. This is considered to be a significant water management issue since it inhibits the proper identification of the necessary policy measures to deal with diffuse pollution at a national water catchment scale. The inventory on discharges, losses and emissions also highlighted this significant gap.

Improved knowledge of the quality of stormwater runoff and rates of runoff from various principal sub-catchments of the Maltese Islands would greatly enhance our understanding and inform future policy and measures.

(b) What does the Measure entail?

This project involves the characterisation of stormwater quality from major catchment nodes to the bays located to the north eastern to south eastern coastal stretch of Malta and the north eastern and southern stretch of Gozo. To obtain useful results, the project will need to be carried out over 3 years. Its purpose is to characterise flow and to characterise quality of stormwater from major catchments and draw comparisons with land-use characteristics.

The main actions to be carried out are as follows:

- Characterising flow / loads: In order to characterise quantity of flow in terms of loads, where possible, flow meters will be deployed, however in most cases manual gauging during storms will be required;
- Use GIS modelling to refine understanding of sub-catchments and corresponding land-use patterns;
- Characterise quality of stormwater by collecting samples after key storm water events (including flash flood events). In particular, there will be monitoring for nutrients, PAHs and heavy metals.

(c) What is the geographical scope?

Selected sub-catchments in Malta and Gozo

(d) What is the expected timeline for implementation?

The project is expected to be carried out over three years to collect as much data as possible. It is expected to start in 2017.

(e) Who is responsible for implementing this measure and which stakeholders need to be involved?

Lead: The Environment and Resources Authority

Involved stakeholders: The Marine, Storm water and Valley Management Unit, MTI
The University of Malta

KNO 4: Investigate the role transboundary contaminants through hydrographic pathways and the extent of its contribution to marine contamination

(a) Why is it important?

Similar to measure KNO 3 related to the importance of gauging the extent of contribution of stormwater runoff to contaminants at sea, there is also the need to understand the role of the sea as a mechanism of transporting contaminants in the Mediterranean. It is recognised that a number of pollutants that end up in our marine waters, may not necessarily originate from activities that take place on land or within Maltese jurisdictional waters. Some substances that end up in the immediate coastal environment in the northern or southern Mediterranean may end up in Maltese waters due to transportation mechanisms brought about by sea currents, winds and waves. The understanding of these mechanisms is once again essential to inform future policy. Any measures that may have to be dealt with regionally rather than nationally can as a consequence of such a study also be identified.

(b) What does the Measure entail?

This measure involves an investigation of the sources of contaminants in the Mediterranean by building up a network with other Mediterranean States and by participating in the regional cooperation process of the Marine Strategy Framework Directive. Ideally this investigation should be in the form of a project that would have to be implemented in stages:

Stage 1: Establish a network of Mediterranean partners whose role would be to identify key data requirements to enable regional modelling of hydrographic characteristics. Essential data parameters and monitoring requirements as well as the geographical extent will be established by all partners.

Stage 2: National Scale: Consolidate existing national efforts that are already in place to collate hydrographical data around the Maltese Islands. Based on the requirements identified under Stage 1, there would be a need to identify what national data gaps exist and define what further investment would be needed to fill such gaps.

Stage 3: Together with other Mediterranean partners Malta would construct numerical models to simulate current circulation and contaminants transport (not limited to oils but also including other contaminants of concern such as heavy metals and litter).

The first model would be required to simulate current circulation considering the bathymetry, wind data, friction coefficients and boundary conditions (etc).

The second model would be needed to simulate the migration and dissipation of selected contaminants using the outcome of the first model (velocity) whilst considering a given concentration of the contaminant, decay rate, dispersion coefficient etc.

(c) What is the geographical scope?

Regional – Mediterranean Sea: The precise geographical scope would be defined by the partners once the project starts.

(d) What is the expected timeline for implementation?

It is expected that the study will start in 2017. Given the extent of the study and the amount of data that would be required it is expected to run for 4 - 5 years.

(e) Who is responsible for implementing this measure and which stakeholders need to be involved?

Lead: The Environment and Resources Authority

Involved stakeholders: The University of Malta
The Physical Oceanography Unit

KNO 5: Carry out investigations to gauge potential contribution of contaminants to our coastal waters by atmospheric deposition.

(a) Why is it important?

A major data gap was identified during the execution of the WFD monitoring programme related to atmospheric deposition budgets. Literature has revealed that atmospheric deposition in the Mediterranean can be a significant contributor to contaminants found in our coastal waters however very little is known on whether it is in fact significant or what the sources could be. Monitoring results during the first WCMP resulted in there being cases where broad-scale water or sediment contamination with some pollutants was detected but no hot spots or known discharges related to those contaminants could be identified. This calls for the need to further investigate the contribution of atmospheric deposition to our waters. This measure is similar to measure KNO 4 above but instead, in this case, Malta will be attempting to understand how air deposition contributes to contaminant dispersant in the Mediterranean Sea.

(b) What does the Measure entail?

A step-wise assessment strategy to investigate the contribution of atmospheric deposition of contaminants to Malta is needed. Consequently, it is required to:

1. Establish whether air deposition is a significant issue by carrying out a literature review and collation of relevant data from ambient air data and emission inventories, taking into consideration the Mediterranean context. The literature review is needed to determine estimated, measured, or modelled deposition rates in the Mediterranean region.
2. Carry out a rough calculation to estimate the potential load from atmospheric deposition.
3. If air deposition is deemed significant, an air advisory group would be engaged to design an air deposition assessment strategy to be implemented in third WFD cycle.

(c) What is the geographical scope?

The entire Water Catchment District;

(d) What is the expected timeline for implementation?

The first phase of the project will be initiated in 2016. At this stage the duration of the project is unknown. It depends on the outcome of the first part of the project. Should air deposition be determined as a main source, the project would take a minimum of 3 years.

(e) Who is responsible for implementing this measure and which stakeholders need to be involved?

Lead: The Environment and Resources Authority

Involved stakeholders: The University of Malta - the Department of Physics, the Department of Chemistry

KNO 6: Carry out a survey of all direct discharges to sea and identify their source with the objective of setting up a plan to curtail / regulate such discharges.

(a) Why is it important?

The cumulative impact of several minor discharges to sea may be significant. Currently there are no studies to gauge the extent of this potential pressure and this warrants further investigation particularly along the northern and south eastern coastline of Malta.

(b) What does the Measure entail?

A survey is required to be carried out spanning the entire shoreline of the Maltese Islands. This survey should consider that the Bathing Water profiles as created by the Environmental Health Directorate has already established what discharge points are present in the bathing water bodies of the Maltese Islands. There is a need to extend this survey to the entire coastline. It is expected that this survey would cover two aspects:

- The mapping of the location and the potential source of all discharge points (surface waters and sub-surface discharges).
- An assessment of the coastal stretches considered to be hotspots of point source discharges
- The carrying out of hydrodynamic studies of water residence times in areas of main discharges

(c) What is the geographical scope?
The entire coastline of the Maltese Water Catchment District

(d) What is the expected timeline for implementation?
The surveys are expected to start mid-2016 and extend to mid-2018.

(e) Who is responsible for implementing this measure and which stakeholders need to be involved?
Lead: The Environment and Resources Authority
Involved stakeholders: Environmental Health Directorate

KNO 7: Carry out seasonal surveys of mooring or anchorage areas
(a) Why is it important?
Very little information is available on the extent of damage that mooring of vessels is causing to the benthic environment. Moreover potential conflicts may arise due to the fact that the mooring of vessels also occurs in the vicinity of bathing areas. Thus, there is a need to gauge the extent of mooring activities in order to better allocate mooring areas around the Maltese coastline whilst avoiding the more environmentally sensitive and bathing water sensitive sites.

(b) What does the Measure entail?
Monitoring and mapping of the mooring/anchorage areas is done through seasonal surveys (Winter and Summer). This would then be used to inform policy action when Marine Protected area management and other management actions are being devised under other relevant legislation. This measure is also considered to be complimentary to SWM 11 described previously.

(c) What is the geographical scope?
The entire coastline of the Maltese Water Catchment District

(d) What is the expected timeline for implementation?
The surveys are expected to start during 2017.

(e) Who is responsible for implementing this measure and which stakeholders need to be involved?
Lead: The Environment and Resources Authority
Involved stakeholders: Transport Malta
The Bathing Water Quality Management Committee
The Malta Tourism Authority

9.2.3.4 Measures related to improving Marine and Terrestrial contingency response

EMER 1: Creation of a working group tasked with the updating of sensitivity maps to enable better marine emergency response
(a) Why is it important?
Various environmental receptors, as well as important national infrastructural assets; and their dependent economic sectors are placed at risk when major pollution incidents occur. There is a need therefore, to clearly map out these important environmental and infrastructural assets so that any spill response strategy deployed during the aftermath of the incident is fully informed of the assets at stake and any clean-up strategy is devised accordingly.

(a) *What does the Measure entail?*

Various stakeholders would need to coordinate the updating of a series of sensitivity maps that can be used for effective emergency response on the day of the incident. The stakeholders identified below are those who hold information data related to the various assets that need to be protected and therefore their participation would be essential. In order to encourage effective participation a working group composed of key representatives from the lead entities listed below would be set up. All representatives would meet frequently so that all sensitive assets are mapped out. The working group will have to ensure that:

- The maps created are in formats that are easily retrievable on the day of the incident.
- The maps are openly shared between key players of marine and terrestrial contingency response.
- The maps are user-friendly so that all necessary information can be quickly retrieved from the information displayed on the map.
- The mapped data is INSPIRE compliant.

(c) What is the geographical scope?

The entire Maltese Water Catchment District and marine waters

(d) What is the expected timeline for implementation?

The Working Group is to be set up during 2017.

(e) Who is responsible for implementing this measure and which stakeholders need to be involved?

Lead: The Critical Infrastructure Protection Directorate (OPM)

Working Group Reps:

- The Civil Protection Department (MHAS)
- The Malta Development and Planning Authority (OPM)
- The Environment and Resources Authority (MSDEC)
- Fish and Farm Regulation and Control (MSDEC)
- The Sustainable Energy and Water Conservation Unit (MEH)
- The Water Services Corporation (MEH)
- The Regulator for Energy and Water Services (MEH)
- The Environmental Health Directorate(MEH)
- Transport Malta (Merchant Shipping Directorate and Ports and Yachting Directorate), (MTI)
- Stormwater and Valley management Unit (MTI)
- Continental Shelf Department (MTI)
- *Ministry for Gozo*
- The Malta Tourism Authority (MOT)

EMER 2: Create an ERA pollution response log for environmental incidents occurring at land and at sea

(a) Why is it important?

The keeping of a log of all pollution events, not just major events, is required to be maintained by the Environment and Resources Authority. Knowing the extent and nature of oil and chemical spills in the environment is necessary to design site specific measures and policies as well as to inform monitoring programmes. The pollution response log is also required as a means to inform when investigative monitoring as defined by the Water Framework Directive should be triggered.

(b) What does the Measure entail?

A standard operation procedure and a database to log information related to any spill (whatever the scale) are to be developed by the Environment and Resources Authority. The standard operation procedure would need to set out:

- The main contact point at the Authority to receive any relevant information from the enforcement section and other entities, most likely to be informed of the spill.
- The designated person/s responsible for maintaining the database
- The type of information that needs to be inputted within the system (This information can include: the location of the spill and the extent of the spill by the time clean-up response was successfully deployed; the time and date; the chemical/s or substance/s involved; the approximate amount spilled; any relevant MSDS (Material Safety Data Sheet) or PSDS (Product Safety Data Sheet) submitted; an outline of what clean-up action was taken; details on the monitoring of the environmental media (water, soil, sediment) carried out during and after the spill took place; appropriate links to the monitoring results).

In order to make this pollution response log fully functional, agreements would be required for the sharing on information between the current holders of such information and the new Environment and Resources Authority. This requirement has already been identified in the joint MSFD-WFD monitoring programmes in the case of marine pollution. Any information or data sharing agreements required would be tackled under supplementary measure KEY 3.

(c) What is the geographical scope?

The entire Maltese Water Catchment District

(d) What is the expected timeline for implementation?

Discussions with relevant entities holding this information (the Malta Development and Planning Authority – Enforcement section for terrestrial emergency events, and Transport Malta for marine pollution events) to start at the beginning of 2016, the creation of the log is expected to start 2017 after infrastructure related to KEY 3 is in place.

(e) Who is responsible for implementing this measure and which stakeholders need to be involved?

Lead: The Environment and Resources Authority

Involved stakeholders: Transport Malta
The Malta Development and Planning Authority

EMER 3: Put into place the terrestrial emergency response strategy

(a) Why is it important?

Environmental accidents on land have shown that a national emergency response procedure is much needed. Vague ad-hoc procedures cause inevitable delays in deploying the right response at the right time and as a consequence the degree of environmental risk and related costs increase considerably.

A draft terrestrial emergency response procedure was developed during the first WCMP which outlined the resource and structural requirements in order for such a response system to work effectively. There is a need to now adopt a strategy so that this procedure can be fully implemented.

(b) What does the Measure entail?

A procedure that has been discussed across Ministries identified action to be taken at the different stages of the accident response, including:

1. How to report an incident;
2. How and which entity is responsible for carrying out a preliminary investigation;
3. How to deploy clean-up and who should be involved;
4. What monitoring programme should be carried out; which entity should draw up the terms of reference for monitoring, and what further follow up action is required depending on the outcome of the monitoring exercises;
5. Who should forfeit the costs of the clean-up and environmental damage.

Key roles and responsibilities are however yet to be defined. In addition decisions need to be taken regarding some of the key processes that would be triggered in order to make this response strategy fully operational such as the on-call structure; the preliminary investigation procedure; response to be deployed (including clean-up resources) and monitoring. There is a need to engage resources to oversee the implementation of such a procedure; to refine it to reflect present day administrative structures; and to ensure that the necessary funds are secured to ensure that relevant ongoing training is carried out as required.

(c) What is the geographical scope?
The entire Maltese Water Catchment District

(d) What is the expected timeline for implementation?
Due to the fact that there are a number of stakeholders involved any resources required to enable the implementation of the draft strategy need to be made available during 2016 with the aim to start implementation by 2017.

(e) Who is responsible for implementing this measure and which stakeholders need to be involved?
Due to the wide range of potential environmental receptors that could be at risk in the event of an environmental accident, various National Authorities and Corporations have to be employed or consulted in the execution of the proposed procedure.

A list of Authorities and Agencies that should be involved in the procedure is:

- Civil Protection Department (MHSA)
- The Environment and Resources Authority (MSDEC)
- Malta Development and Planning Authority (OPM)
- The Environmental Health Directorate (MTI)
- The Water Services Corporation (WSC)
- The Sustainable Energy and Water Conservation Unit (MEH)
- Occupational Health and Safety Authority (MEH)
- Ministry for Gozo (MGOZ)

9.2.3.5 Communication and Awareness raising

AWA 1: Targeted awareness campaign on impacts of marine litter
(a) Why is it important?
The fate and impacts of litter (land-based and marine based) is not widely acknowledged by the general public. Apart from the aesthetic degradation to the surrounding environment the dumping of litter may bring about additional risks to human and ecological health.

Even if biodegradable plastics have become more commonly used, these types of plastics may not necessarily be degradable without being subjected to industrial degradation processes. Litter that ends up in the marine environment could potentially be ingested by marine mammals. Litter may also act as a transportation medium for contaminants in the marine environment either due to the additives that are sometimes added to plastics during their production, or as chemical compounds which attach to plastics once these are out in the environment.

Land based litter is easily controllable however once it finds itself in the sea, the transport and deterioration process of that litter is very difficult to influence or control. Controlling litter at source is therefore a necessity and hence awareness raising should be a primary objective in the attempt to control the generation of litter.

(b) What does the Measure entail?

This measure is aimed at addressing the lack of public awareness on the impacts of litter in the marine environment including the possible fate of litter disposed of on land, litter washed ashore, litter in the water column, litter deposited on the sea-floor and litter ingested by marine mammals.

A nation-wide attempt to raise public awareness targeting different age groups and involving both private and public entities is required. Environmental NGOs should also be supported to assist in awareness raising activities. A public awareness strategy would therefore need to be developed with the aim of:

- Identifying appropriate awareness raising initiatives according to target age groups,
- Identifying key stakeholders (Government entities and Local Councils, Environmental NGOs, Research Institutions, and Private bodies) willing to take forward the various awareness raising initiatives,
- Identifying funds necessary to support the strategy,
- Developing a clear timeline for the execution of the strategy with targets,
- Developing a feedback mechanism to monitor the success of the overall awareness campaign

(c) What is the geographical scope?

The entire Maltese Water Catchment District and marine waters

(d) What is the expected timeline for implementation?

The strategy is to be developed during 2017 and applied during 2018.

(e) Who is responsible for implementing this measure and which stakeholders need to be involved?

Coordinating role: The Environment and Resources Authority

Key players who have a role in raising awareness either due to their regulatory functions or due to the role they have in society pertaining to the raising of awareness on environmental Issues:

General cleansing:

- Local Councils
- The Local Council Association
- The Cleansing Services Directorate (MTI)
- Waste Serv

Public awareness targeting the following sectors:

- Tourism Sector: Malta Tourism Authority
- Fisheries and aquaculture sector: The Fish and Farm Regulation and Control Department
- Shipping Sector: Transport Malta

- The construction industry: The Malta Development and Planning Authority, The Developers Association

Young children, teenagers and adults:

- The Malta National Aquarium
- Environmental NGOs (Nature Trust – EKO Skola, Lets do it, Friends of the Earth and Flimkien għal-Ambjent Aħjar)
- The University of Malta
- Malta College for Art, Science and Technology

AWA 2: Targeted awareness campaign and training of relevant professionals on the appropriate disposal of chemicals and/or chemical containers, including medicines, pesticides, and fertilisers and related packaging.

(a) Why is it important?

Despite the availability of adequate waste reception facilities around the Maltese Islands, a recent survey carried out by Waste Serv, the Company responsible for the management and operation of integrated waste systems in Malta indicated that there is a lack of public awareness on where used / unwanted chemicals and their containers (including medicines, pesticides, and fertilisers) can be disposed of. According to the Medicines Authority most medicines are actually disposed of incorrectly as patients would have to go to a specialized bring in site to dispose of medicines.

In addition there is limited appreciation that the inappropriate disposal of chemicals, some of which may be potentially hazardous and toxic, may cause severe damage to the environment and to human health.

(b) What does the Measure entail?

An awareness raising campaign linked to the management of domestic, agricultural and industrial chemical waste and waste packaging is to be carried out targeting different consumers. Similar to Measure AWA 1 described above a strategy would first need to be developed focusing on consumers and pharmacies with the following objectives in mind:

- Identifying appropriate awareness raising avenues,
- Identifying key stakeholders (Government entities and Local Councils, Environmental NGOs, Research Institutions, and Private bodies, and pharmacies) willing to take forward the various awareness raising initiatives
- Identifying funds necessary to support the strategy,
- Training pharmacists as part of the strategy and awareness raising initiative
- Developing a clear timeline for the execution of the strategy with targets
- Developing a feedback mechanism to monitor the success of the overall awareness campaign

(c) What is the geographical scope?

The entire Maltese Water Catchment District

(d) What is the expected timeline for implementation?

The strategy is to be developed during 2017 and implemented during 2018.

(e) Who is responsible for implementing this measure and which stakeholders need to be involved?

Coordinating role: Waste Serv

Key players who have a role in raising awareness either due to their regulatory functions or due to the role they have in society pertaining to the raising of awareness on environmental Issues:

General cleansing:

- Local Councils
- The Local Council Association
- The Cleansing Department (MTI)
- Waste Serv

Public awareness targeting the following sectors:

- Fisheries and aquaculture sector: The Fish and Farm Regulation and Control Department
- Agriculture Sector: The Agriculture Directorate (MSDEC)
- Plant Protection Products: the Malta Competition and Consumer Affairs Authority
- Medicines: The Medicines Authority

9.2.4 Summary of basic and supplementary surface water measures (except those that were identified in the Natura 2000 Management Plans whose timeframe for implementation has been identified in table 9.1. and 9.2) implementation timelines

Code	Title of measure	Implementation date
BASIC measures emanating from the WFD 2000/60/EC		
KEY 1	Continue to refine the regulatory framework for industrial operational practices	Continuous- 2016
SWM 1	Continue to strengthen the relationship between environmental and planning regulatory processes (including Marine Strategy Framework Directive concerns).	Continuous- 2016
SWM 2	Continue to control priority hazardous substances, priority substances and other substances of concern via the environmental permitting process.	Continuous- 2016
SWM 3	Update inventory of discharges (EQS Directive)	Continuous- 2016
Supplementary Measures		
KEY 2	Create an effective feedback mechanism within the Environment and Resources Authority to ensure compliance and risk mitigation	2017
SWM 5	Develop guidelines for the Disposal of dredged material	Continuous - 2016
SWM 6	Carry out joint inspections with Transport Malta, the Civil Protection Directorate, the Occupational Health and Safety Authority and the Water Services Corporation to ensure that industrial operations abide to best environmental practice	2016
SWM 7	Develop a system to encourage adequate litter management and control in coastal areas	2016
SWM 8	Improve operational standards for the aquaculture sector via the environmental permitting process	Continuous - 2016
SWM 9	Creation and Implementation of the Agriculture Waste Management Plan	Already started (2015)
SWM 10	Establish a Mercury Management Plan to enable the investigation of potential sources of mercury and potential mitigation measures	Second half 2016
SWM 11	Streamline designated Bathing waters as defined by the Environmental Health Directorate with designated Swimming Zones as regulated by Transport Malta, where these overlap or in close proximity to each other.	2016
SWM 12	Extend the basic measure related to the removal of alien species from the Qattara habitat, as identified in the Natura 2000 Management Plan, to Ghadira ta' Sarraflu	2017
SWM 13	Set up a watch list mechanism to monitor certain emerging substances identified at EU level that could potentially be of concern (refer to Chapter 5).	2016
SWM 14	Develop a strategic policy framework to encourage integrated valley management	2016
KEY 3	Enhance water and marine data using an open platform	2016
KNO 1	Study the impacts of the national spoil ground off Xghajra	2018
KNO 2	Carry out a technical feasibility assessment regarding the management of ballast waters	2016
KNO 3	Characterise and quantify hydrological input of land based contaminants	2017

	(including litter) to coastal waters from major sub catchments	
KNO 4	Investigate the role transboundary contaminants through hydrographic pathways and the extent of its contribution to marine contamination.	2017
KNO 5	Carry out investigations to gauge potential contribution of contaminants to our coastal waters by atmospheric disposition	2016
KNO 6	Carry out a survey of all direct discharges to sea and identify their source with the objective of setting up a plan to curtail/regulate such discharges	2016 –2018
KNO 7	Carry out seasonal surveys of mooring or anchorage areas	2017
EMER 1	Creation of a working group tasked with the updating of sensitivity maps to enable better marine emergency response	2017
EMER 2	Create an ERA pollution response log for environmental incidents occurring at land and at sea	2017
EMER 3	Put into place the terrestrial emergency response strategy	2017
AWA 1	Targeted awareness campaign on impacts of marine litter	2018
AWA 2	Targeted awareness campaign on the appropriate disposal of chemicals and/or chemical containers, including medicines, pesticides, fertilisers and related packaging	2018

9.3: Identifying which measures are required to address the efficient use of water resources in the Malta Water Catchment District and thus contribute to the achievement of the WFD's good status objectives for natural inland water resources.

9.3.1 Introduction

The process leading to the formulation of the 2nd Water Catchment Management Plan identified ten priority issues and developed measures to address each priority issue. The identified issues are:

Priority 1 – Governance and Capacity Building

Sustainable management of water resources draws on clear administrative measures supported by a robust legal framework. Effective governance necessitates a clear definition of roles and responsibilities/functions both of regulatory agencies and service providers, to ensure the optimal use of resources in an equitable manner which takes into account all the interests of stakeholders. Existing regulations governing the regulation and service provision of water and wastewater are today spread over several government agencies, occasionally overlapping or even leading to conflicting roles. The WCMP will address these anomalies.

Priority 2 – Water Demand Management

Water demand management is a primary tool for the sustainability of water resources and aims to maximise the benefits of water use by various sectors. It comprises a wide set of measures which generally seek to reduce pressure on resources whilst inducing a conservation attitude amongst stakeholders. The European Commission assigns demand management on top of the priority list of measures which Member States should seriously implement before considering supply augmentation to meet sectorial demand.

Water use by different stakeholders varies in time and space and unless the factors leading to these variations are clearly understood it will be difficult to plan a strategic approach towards sustainable use. The Water Catchment Management Plan thus foresees a preliminary assessment of the current usage as well as the efficiency levels registered by different stakeholders. Special focus will be given to the integrity of the infrastructural network and to the setting of efficiency standards to be achieved by users and service providers. Also hi-tech systems will be identified and applied to improve network performance and promote the use of water-saving devices by the domestic and industrial sectors.

The domestic sector consumes around 40% of the national demand and thus it is a sector which merits specific attention in a water conservation strategy. As such measures will include educational programmes targeted towards attitude change and increase of awareness by domestic consumers who will be educated on new technology to save water, safe methods for recycling of greywaters in households and the use of harvested rainwater for secondary purposes.

The water demand of the agricultural sector is almost completely dependent on groundwater abstraction. Reducing the dependency of the sector on groundwater therefore leads to a direct environmental benefit particularly where the aquifers have been historically overdrawn. The application of 'smart' irrigation techniques carries uncontested advantages both in relation to water saving and crop efficiency.

Priority 3 – Water Supply Augmentation

In a scenario where water resources are scarce the conjunctive use of groundwater with other non-conventional sources is key to the scope of augmentation of water supply whilst respecting sustainability. The alternative sources which will be focused upon are rainwater run-off, New Water and desalinated water.

One of the most pressing needs of the water sector in the Maltese Water Catchment District is the rehabilitation of the two major 'mean sea-level aquifer systems' which have been historically over-drawn for various reasons. Observing a sustainable yield is therefore the first measure to be followed to restore the sensitive hydrostatic balance of the aquifers – a legislative measure also required by the Water Framework Directive. Groundwater management needs to be based on sound hydro-geological information any will ultimately lead to a careful recharge programme to enable the recovery of the piezometric head and simultaneously the retreat of the sea-water interface. Abstraction will then be optimised under this recovery regime.

The harvesting of rainwater offers a renewable alternative to other more costly sources of supply. Historically all buildings were statutorily required (Code of Police Laws) to have a storage facility for rain-water harvesting. With time, this requirement was weakly enforced and the current situation is far from that desired to deliver the expected benefits on a national scale. Data in this respect is severely lacking and measures will address its timely collection. Measures to repair and maintain existing storage facilities as well as for the commissioning of new storage both at domestic and local scale will be strongly supported in order to increase the national rainwater harvesting capacity.

Desalinated water has been increasingly used in Malta and Gozo to ensure the delivery of a safe water supply for potable purposes. Nationally, it is accepted to make cautious use of desalination on economic and environmental ground. This in order to amongst others manage the carbon foot-print for water production. The existing three reverse-osmosis facilities have been continuously subject of improvement and upgrading, and were key to the achievement of high quality standards of tap water in both Malta and Gozo.

New Water production facilities are currently being developed in three distinct locations in Malta and Gozo. There is therefore a high potential for the use of these New Water resources particularly by the agricultural and industrial sectors, subject to the attainment of the right qualitative standards and the eventual acceptance of this new resource by consumers. More investment will be targeted to polish the New Water to higher standards thus widening the spectrum of its use, even to specific high quality demanding applications. Furthermore, an educational campaign will be initiated to educate users and remove unfounded apprehensions.

Why is supply augmentation important?

Supply augmentation is required to provide an alternative source of water supply suitable for uses other than domestic consumption. In this context, the imminent availability of New Water, will provide a potential alternative to meet non-potable needs.

Priority 4 – Stakeholder Engagement
The Water Catchment Management Plan needs to be 'owned' by stakeholders. This requires a long-term educational campaign to educate users and to instil awareness on the value of water conservation in a water-scarce region like the Malta Water Catchment District. The lack of water shortages following the commissioning of desalination plants in the last thirty years, generated the wrong impression amongst consumers that our municipal supply can never fail. More education is therefore needed to change public perceptions and to teach the younger generations the importance of water conservation as one of the key elements of sustainable development.

Priority 5 – Monitoring and Data Management
The management of groundwater resources draws heavily on accurate monitoring and data collection, both hydrological and climatological. Currently, a network of monitoring points exists but this falls short of providing the necessary cover to all the hydrological and climatological data required to achieve high confidence in the status assessment of groundwater bodies. New extensions of the network are therefore envisaged to provide more data on the dynamic behaviour of all aquifers. This data will assist the decision maker in assessing qualitative and quantitative trends of groundwater, update mathematical models and furthermore adopt management strategies that ensure sustainability.

Priority 6 – Research and Development
The water sector is continuously evolving and innovating. Scientific research is the key element which generated new concepts and engineering improvements that are useful to improve operational efficiency and water availability especially in scarce areas. The MCAST, UOM and the IWT will be drawn in to contribute in research programmes most of which will be funded through EU funds.

Priority 7 – Qualitative Aspects
Malta has to observe stringent regulatory obligations regarding water quality, both at source and at consumer end. The major issues concerning groundwater quality originate from nitrate pollution and over abstraction, whilst land-use can also generate trace pollutants dangerous to human health. There will be more thrust to build the necessary capacity that will enable the identification of pollutants and the protection of recharge areas. New investment will be planned to improve the national infrastructure for wastewater collection to better protect the resource value of wastewater.

Priority 8 – Flood Management
The Floods Directive requires all Member States to identify all flood-prone areas and for each the associated risks and hazards to the community. Malta has already satisfied its reporting obligations required by the Directive, nonetheless more research is called for to identify hot-spots and devise measures which can mitigate the effects of flooding whilst improving storage of run-off as a non-conventional resource.

Priority 9 – Water-Energy Nexus
The provision of water and energy supplies have to be considered in a holistic and economic manner if sustainability is to be achieved. Water production, desalination in particular, and water distribution in Malta is heavily dependent on electrical energy. Desalination facilities are subject to continuous renovation to improve performance and efficiency for the purpose of reducing operational costs and

delivering tap-water at the lowest cost possible. Transfer of water between production facilities and storage reservoirs merits further assessment to identify energy consumption requirements and possibly propose more cost-effective alternatives.

Priority 10 – Economic Aspects
The economic aspects of water resources embrace various stages of the whole cycle, from source to discharge point. An economic assessment will therefore aim to identify and evaluate the hidden costs and benefits associated with the management of the water resource, taking full consideration of the environmental, social and resource aspects. It will also seek to set targets for operational efficiency and the cost-effectiveness of measures to achieve those targets. These studies will inform cost reviews to ensure an equitable charging for the costs of water services.

The Programme of Measures within the 2nd Water Catchment Management Plan presents 45 measures aimed at directly and indirectly addressing these 10 identified significant issues. The table below classifies the identified measures according to the significant issue which is being directly addressed by each respective measure.

Significant Water Management Issue	Measures
Governance and Capacity Building	GVN1, GVN3, GVN4, GVN5, GVN7
Water Demand Management	PUB1, PUB2, PUB3, PUB4, PUB5, PUB6, DOM1, AGR1, AGR3
Water Supply Augmentation	GWM1, GWM2, GWM4, RWH1, RWH2, RWH4, RWH6, DES2, NEW1, NEW2, NEW3, NEW4, ALT1, ALT2
Stakeholder Engagement	STE1, STE2, STE3
Monitoring and Data Management	MDM1, MDM7
Environmental Aspects	QLT2, (SMW4), (SMW9)
Flood Management	FLD1, FLD2, FLD3, FLD5
Water-Energy Nexus	ENE1, ENE2, ENE3
Economic Aspects	ECO1, ECO2, ECO3

Table 9.3: Allocation of measures according to the significant water management issue addressed

The 2nd Water Catchment Management Plan was developed in parallel with the National Water Management Plan which develops a ten-year framework addressing the significant issues facing the Malta Water Catchment District. The Programme of Measures presented under the 2nd Water Catchment Management Plan is thus part of a wider set of measures developed to ensure the achievement of good status in the inland natural water systems of the Maltese islands.

In as much, the National Water Management Plan is intended to bridge over to the 3nd Catchment Management Cycle and thus ensure continuity between the 2nd and 3rd Water Catchment Management Plans.

9.3.2 Programme of Measures
The Programme of Measures identified under the 2nd Water Catchment Management Plan for the purpose of optimising the management and use of water resources in the Malta Water Catchment District presents a set of 45 supplementary measures, addressing the following issues:
- development of administrative instruments,
- development of codes of good practice,
- demand management measures,
- efficiency and reuse measures,
- desalination plants,
- artificial recharge of aquifers,
- educational projects,

- research, development and demonstration projects, and
- other relevant measures.

The identified measures are described in the following sections.

9.3.2.1 Administrative instruments

GVN1 – Determination of the roles and responsibilities of all public sector agencies involved in the wider management of water resources.

(a) Why is it important?

Good governance supports the effective implementation of policy measures conducive towards sustainability. It requires that regulatory responsibilities, currently spread between different institutions, become streamlined by defining clear functions and competencies on water and by enacting specific regulatory remits supported by a strong legal framework. This measure will create the administrative capacity necessary to improve the decision-making process. It will also enable a fair and equitable allocation of resources and access to services for different stakeholders. The definition of administrative roles is also essential to ensure transparency with stakeholders and obtain high levels of administrative efficiency.

(b) What does the measure entail?

The measure entails a study into the current roles and responsibilities of all Government departments and public sector agencies involved in the development, regulation and implementation of water management measures will be undertaken in order to assess regulatory overlaps and gaps in the current public administrative framework. The resulting assessment will propose to Government a regulatory scheme identifying clear roles and responsibilities to ensure the establishment of the administrative capacity necessary for the full implementation of the 2nd Water Catchment Management Plan.

(c) What is the geographical scope?

The measure applies to the entire Water Catchment District.

(d) What is the expected timeline for implementation?

The implementation of this measure is envisaged to start in 2016 during the first year of implementation of the 2nd WCMP. Its implementation period is expected to be concluded by 2017.

(e) Who is responsible for implementing this measure and which stakeholders need to be involved?

Lead: Sustainable Energy and Water Conservation Unit

The following stakeholders would need to be engaged in the process:

- The Sustainable Development, Environment and Climate Change Directorate General (SDECCDG) of the Ministry for Sustainable Development and Climate Change (MSDEC)
- The Rural Development Directorate General (RDDG) of the Ministry for Sustainable Development and Climate Change (MSDEC)
- The Policy Development Directorate (PDD-MTI) within the Ministry for Transport and Infrastructure (MTI)
- The Eco-Gozo Regional Development Directorate within the Ministry for Gozo (MGoz)
- The Superintendent of Public Health (SPH)
- The Regulator for Energy and Water Services (REWS)
- The Environment and Resources Authority (ERA)
- The Environmental Health Department (EHD)

- The Planning Authority (PA)
- The Water Services Corporation (WSC)
- The Marine, Storm Water and Valley Management Unit (MSWVMU) within the Ministry for Transport and Infrastructure (MTI)
- The Buildings Regulations Office (BRO)
- Transport Malta (TM)

RWH2 – Development of the administrative capacity required to ensure the effective implementation of current legislative requirements in relation to the development of rainwater harvesting facilities and associated secondary water conveyance systems.

(a) Why is it important?

Responsibilities for the implementation of rainwater capture, at urban level are today spread between several agencies. The urban sector offers potential for the use of alternative sources, in particular rainwater run-off, to broaden the sector's resource base and reduce its dependence on the municipal supply - groundwater and desalinated water. Effective implementation of the regulatory requirements outlined under Technical Guidance Document F for the Conservation of Fuel, Energy and Natural Resources is thereby required to ensure the development of a national capacity for alternative water resources and also ensure their effective use.

(b) What does the measure entail?

This measure will seek the development of the administrative capacity required to ensure the effective enforcement of legislative requirements related to the development of rainwater harvesting facilities and associated secondary water conveyance systems with all new developments.

Furthermore, in collaboration with the Planning Authority, a technical review of existing legislation will be undertaken to optimise the storage requirements for rainwater harvesting cisterns in view of existing constant-use scenarios as opposed to the needs for a carrying over capacity from the wet to dry season. It is envisaged that this review could result in lower storage requirements, and thus lower the economic impact to users related to the development of these facilities.

(c) What is the geographical scope?

The measure applies to the entire Water Catchment District.

(d) What is the expected timeline for implementation?

The implementation of this measure is envisaged to start in 2017, and expected to be concluded by 2018.

(e) Who is responsible for implementing this measure and which stakeholders need to be involved?

Lead: Sustainable Energy and Water Conservation Unit (SEWCU)
The following stakeholders would need to be engaged in the process:
- The Superintendent of Public Health (SPH)
- The Environmental Health Department (EHD)
- The Planning Authority (PA)
- The Buildings Regulations Office (BRO)

9.3.2.2 Codes of good practice

GVN3 – Development of guidance documents to assist operators in achieving best practice in water management practices

(a) Why is it important?

Water is today being utilised by a wide spectrum of operators in several sectors, where awareness on water efficiency and water conservation is often lacking. Wasteful practices resulting from lack of knowledge and experience lead to excessive usage and add pressures to the limited resources available. In some instances misuse of water can unknowingly create health hazards on the ground.

Health and safety issues will attain a higher level of importance with the coming on-stream of treated wastewater. The guidance documents will aim to develop a knowledgeable operation supported by proper documentation (manuals) to enable proper use and avert wastage.

(b) What does the measure entail?

Technical guidance documents aimed at assisting operators in the water management sector to achieve best technical operational practice will start to be developed and published by the Sustainable Energy and Water Conservation Unit. These guidance documents will provide the necessary information required by these operators to ensure that operations in the water sector are undertaken in a safe and environmentally sustainable manner. The documents will tackle issues such as:

- the correct management of groundwater abstraction sources,
- the adoption of water efficient practices,
- the re-use of grey waters,
- the safe use of New Water resources, and
- the use of harvested rainwater.

(c) What is the geographical scope?

The measure applies to the entire Water Catchment District.

(d) What is the expected timeline for implementation?

The implementation of this measure is envisaged to start in 2017, and its implementation will continue during the 2nd catchment planning period.

(e) Who is responsible for implementing this measure and which stakeholders need to be involved?

Lead: Sustainable Energy and Water Conservation Unit

The following stakeholders would need to be engaged in the process:

- The Sustainable Development, Environment and Climate Change Directorate General (SDECCDG) of the Ministry for Sustainable Development and Climate Change (MSDEC)
- The Rural Development Directorate General (RDDG) of the Ministry for Sustainable Development and Climate Change (MSDEC)
- The Policy Development Directorate (PDD-MTI) within the Ministry for Transport and Infrastructure (MTI)
- The Eco-Gozo Regional Development Directorate within the Ministry for Gozo (MGoz)
- The Superintendent of Public Health (SPH)
- The Regulator for Energy and Water Services (REWS)
- The Environment and Resources Authority (ERA)
- The Environmental Health Department (EHD)
- The Planning Authority (PA)
- The Water Services Corporation (WSC)

- The Marine, Storm Water and Valley Management Unit (MSWVMU) within the Ministry for Transport and Infrastructure (MTI)
- The Buildings Regulations Office (BRO)
- Transport Malta (TM)
- The University of Malta (UoM)
- The Malta College for Arts, Science and Technology (MCAST)

PUB6 – Establishment of water-use standards and guidelines for water use in public landscaping initiatives.

(a) Why is it important?
Landscaping contributes to an improved quality of life but is heavily on irrigation water. The use of alternative resources can reduce the impact of landscaping on natural water resources. With the commissioning of the three new polishing plants an alternative source of water will be available, which can potentially be used for landscaping activities.
Ensuring that 'green principles' with respect to water use are adopted and adhered to in the development and running of landscaping schemes will ensure that the water footprint of such activities is optimised.

(b) What does the measure entail?
This measure will establish water-use standards for public landscaping initiatives undertaken by both central government and local councils. These standards will require such initiatives to increasingly acquire their irrigation water from alternative resources such as harvested rainwater runoff and New Water, and thus reduce the impact of these initiatives on groundwater resources.

(c) What is the geographical scope?
The measure applies to the entire Water Catchment District.

(d) What is the expected timeline for implementation?
The implementation of this measure is envisaged to start in 2018, and expected to be concluded by 2019.

(e) Who is responsible for implementing this measure and which stakeholders need to be involved?
Lead: Sustainable Energy and Water Conservation Unit
The following stakeholders would need to be engaged in the process:
- The Sustainable Development, Environment and Climate Change Directorate General (SDECCDG) of the Ministry for Sustainable Development and Climate Change (MSDEC)
- The Rural Development Directorate General (RDDG) of the Ministry for Sustainable Development and Climate Change (MSDEC)
- The Policy Development Directorate (PDD-MTI) within the Ministry for Transport and Infrastructure (MTI)
- The Eco-Gozo Regional Development Directorate within the Ministry for Gozo (MGoz)
- The Superintendent of Public Health (SPH)
- The Environment and Resources Authority (ERA)
- The Environmental Health Department (EHD)
- The Water Services Corporation (WSC)
- Transport Malta (TM)
- Local Councils

9.3.2.3 Demand management measures

PUB1 – Development of a Water Demand Map representing the spatial variation of water demand in terms of quality and quantity, and establishment of benchmarks for efficient water use.

(a) Why is it important?
Understanding what water is needed where is the first step to set the process of identifying the most appropriate sources to meet the specific demand efficiently. The study of the spatial variation of demand is therefore deemed to be the initial step towards more rational use of water resources where quantitative demand is matched with quality parameters of a given source of supply. The study will guide future initiatives and investments in the water sector, and will provide a useful reference document for service providers.

(b) What does the measure entail?
A study will be undertaken to develop a Water Demand Map of the Maltese islands. The results of this study will spatially map the water demand requirements (both in quantitative and qualitative terms) of the different water using sectors. This map will thus provide the information necessary to guide the future integrated, sustainable and economic use of the natural and alternative water resources of the islands.

(c) What is the geographical scope?
The measure applies to the entire Water Catchment District.

(d) What is the expected timeline for implementation?
The implementation of this measure is envisaged to start in 2016, and expected to be concluded by 2018.

(e) Who is responsible for implementing this measure and which stakeholders need to be involved?
Lead: Sustainable Energy and Water Conservation Unit
The following stakeholders would need to be engaged in the process:
- The Sustainable Development, Environment and Climate Change Directorate General (SDECCDG) of the Ministry for Sustainable Development and Climate Change (MSDEC)
- The Rural Development Directorate General (RDDG) of the Ministry for Sustainable Development and Climate Change (MSDEC)
- The Policy Development Directorate (PDD-MTI) within the Ministry for Transport and Infrastructure (MTI)
- The Eco-Gozo Regional Development Directorate within the Ministry for Gozo (MGoz)
- The Superintendent of Public Health (SPH)
- The Regulator for Energy and Water Services (REWS)
- The Environment and Resources Authority (ERA)
- The Environmental Health Department (EHD)
- The Planning Authority (PA)
- The Water Services Corporation (WSC)
- The Marine, Storm Water and Valley Management Unit (MSWVMU) within the Ministry for Transport and Infrastructure (MTI)
- The Buildings Regulations Office (BRO)
- Transport Malta (TM)
- Local Councils

DOM1 – Support mechanisms for water consumption audits in households

(a) Why is it important?

Household consumption forms a substantial portion of the municipal supply. Water-use efficiency in households, although already low compared to the situation in other Member States, still offers a potential for use optimisation to reach higher conservation levels. Losses from faulty appliances and plumbing installations are often the cause of high water bills. Water audits on households can therefore inform consumers on measures to take to reduce their personal consumption and identify losses within private residences.

(b) What does the measure entail?

Through the implementation of this measure, Government will seek to establish the necessary capacity for providing water consumption audits to interested households. Through these water audits households can be advised on the actions which need to be undertaken to optimise their water consumption. This measure is doubly beneficial in as much as it aims to reduce the water demand of the domestic sector and will result in lower water bills for households. The measure will also seek to establish synergies with similar measures in the energy sector due to the strong nexus between water and energy consumption in households.

This measure will subsequently be also extended to commercial enterprises.

(c) What is the geographical scope?

The measure applies to the entire Water Catchment District.

(d) What is the expected timeline for implementation?

The implementation of this measure is envisaged to start in 2017, and its implementation will be continued throughout the 2nd catchment planning period.

(e) Who is responsible for implementing this measure and which stakeholders need to be involved?

Lead: Sustainable Energy and Water Conservation Unit

The following stakeholders would need to be engaged in the process:

- The Superintendent of Public Health (SPH)
- The Regulator for Energy and Water Services (REWS)
- The Environmental Health Department (EHD)
- The Water Services Corporation (WSC)
- The Buildings Regulations Office (BRO)
- Local Councils

AGR1 – Support schemes for the uptake of efficient irrigation technology by the arable agricultural sector.

(a) Why is it important?

The agricultural sector is one of the main water consuming sectors in the Maltese islands, and therefore should be assisted to further optimise water use efficiency levels in line with the 'more crop per drop' concept. Though efficient irrigation techniques such as drip- and sprinkler- irrigation are widely applied by farmers today, options for further optimising the water-use of the sector should be actively considered. Increased efficiency, will enable the agricultural sector to reduce its dependency on natural water resources and thus contribute to the protection of its resource base.

(b) What does the measure entail?

Financial schemes to support the uptake of efficient irrigation technology by the arable agricultural sector will be included under Malta's Rural Development Programme. Financed measures will need to have a potential water saving impact of 5% of the current water usage by the respective operator. This in line with the statutory water efficiency requirements outlined under Article 36 of Regulation (EU) No 1305/2013. Furthermore, only interventions on irrigation schemes operating from a legal source of natural water will be supported.

(c) What is the geographical scope?

The measure applies to the entire Water Catchment District.

(d) What is the expected timeline for implementation?

The implementation of this measure is envisaged to start in 2016, and its implementation will be continued throughout the 2nd catchment planning period.

(e) Who is responsible for implementing this measure and which stakeholders need to be involved?

Lead: Managing Authority, Funds and Programmes Division (FPD – MEAIM)

The following stakeholders would need to be engaged in the process:

- Sustainable Energy and Water Conservation Unit (SEWCU)
- The Sustainable Development, Environment and Climate Change Directorate General (SDECCDG) of the Ministry for Sustainable Development and Climate Change (MSDEC)
- The Rural Development Directorate General (RDDG) of the Ministry for Sustainable Development and Climate Change (MSDEC)

AGR 2 – Support schemes for the uptake of efficient water technology by the animal husbandry sector.

(a) Why is it important?

The animal husbandry sector is a consumer of municipal water. Maintenance of good veterinary standards warrant continuous availability of a wholesome supply of good quality freshwater on the holding to maintain hygiene standards and prevent propagation of disease. Farmers should be encouraged to utilise potable water exclusively for drinking water requirements whilst other non-conventional sources like harvested rainwater should be utilised for non consumptive needs. Financial schemes under the Rural Development Programme can support such initiatives. Increased water use efficiency will reduce pressure on the municipal supply, and thus costs to the operator; whilst also reducing the impact of the sector on natural water resources.

(b) What does the measure entail?

Financial schemes to support the uptake of efficient water-use technology by the animal husbandry sector will be included under Malta's Rural Development Programme. Financed measures will need to have a potential water saving impact of 5% of the current water usage by the respective operator. This in line with the statutory water efficiency requirements outlined under Article 36 of Regulation (EU) No 1305/2013. Furthermore, only interventions on schemes operating from a legal source of water will be supported.

(c) What is the geographical scope?

The measure applies to the entire Water Catchment District.

(d) What is the expected timeline for implementation?

The implementation of this measure is envisaged to start in 2016, and its implementation will be continued throughout the 2nd catchment planning period.

(e) Who is responsible for implementing this measure and which stakeholders need to be involved?
Lead: Managing Authority, Funds and Programmes Division (FPD – MEAIM)
The following stakeholders would need to be engaged in the process:
- Sustainable Energy and Water Conservation Unit (SEWCU)
- The Sustainable Development, Environment and Climate Change Directorate General (SDECCDG) of the Ministry for Sustainable Development and Climate Change (MSDEC)
- The Rural Development Directorate General (RDDG) of the Ministry for Sustainable Development and Climate Change (MSDEC)

RWH4 – Support schemes for the development of rainwater runoff harvesting facilities in the agricultural and commercial sectors

(a) Why is it important?
The agricultural sector is highly dependent on groundwater which is the main source for irrigation water, followed by harvested rainwater and treated sewage effluent. Promoting alternative sources for irrigation water is key to reducing groundwater abstractions for irrigation, whilst maintaining the operational capacity of the sector. There still is good potential for rain-water harvesting especially from rural roads and tracks to provide an irrigation alternative to groundwater.

(b) What does the measure entail?
This measure will seek the establishment of financial incentive schemes to support the development of rainwater runoff facilities in the agricultural and commercial sectors.

In the case of the agricultural sector, these schemes will be integrated in the Rural Development Programme under the EAFRD. Financed measures will need to have a potential water saving impact of 5% of the current water usage by the respective operator. This in line with the statutory water efficiency requirements outlined under Article 36 of Regulation (EU) No 1305/2013.

(c) What is the geographical scope?
The measure applies to the entire Water Catchment District.

(d) What is the expected timeline for implementation?
The implementation of this measure is envisaged to start in 2016, and its implementation will be continued throughout the 2nd catchment planning period.

(e) Who is responsible for implementing this measure and which stakeholders need to be involved?
Lead: Sustainable Energy and Water Conservation Unit (SEWCU), Managing Authority, Funds and Programmes Division (FPD – MEAIM), Malta Enterprise (ME)
The following stakeholders would need to be engaged in the process:
- The Rural Development Directorate General (RDDG) of the Ministry for Sustainable Development and Climate Change (MSDEC)
- The Policy Development Directorate (PDD-MTI) within the Ministry for Transport and Infrastructure (MTI)
- The Eco-Gozo Regional Development Directorate within the Ministry for Gozo (MGoz)
- The Superintendent of Public Health (SPH)
- The Environmental Health Department (EHD)
- The Planning Authority (PA)
- The Buildings Regulations Office (BRO)

9.3.2.4 Efficiency and reuse measures

PUB2 – Establishment of minimum technical and economic levels of leakage in the municipal distribution network, and achievement of these thresholds through the ongoing leakage management and control programme operated by the public utility.

(a) Why is it important?

Demand management is needed to remove wasteful practices and instill good water behaviour. Besides being an important tool to support sustainability by reducing the pressures of water services, it reduces wastage, while doing away with unnecessary investment for supply augmentation – an approach strongly advocated by the European Commission. Malta has a strong and successful history with demand management when municipal system demand was reduced following the modernisation of the infrastructural network, the implementation of a leakage detection programme and a meter replacement campaign. Maintaining and improving these high levels of operational standards is important to ensure the achievement of high cost-recovery levels in the operations of the public utility.

(b) What does the measure entail?

The minimum technical and economic levels of leakage achievable under the water distribution conditions prevailing in the Maltese islands will be established. The network leakage management programme undertaken by the Water Services Corporation will target the achievement of these minimum leakage objectives. This measure therefore aims at lowering the system demand of the Water Services Corporation, resulting in reducing the need for source water from the desalination plant and the groundwater abstraction network.

(c) What is the geographical scope?

The measure applies to the entire Water Catchment District.

(d) What is the expected timeline for implementation?

This measure should be considered as an ongoing measure, and its implementation will continue throughout the 2nd catchment management cycle.

(e) Who is responsible for implementing this measure and which stakeholders need to be involved?

Lead: Water Services Corporation (WSC)

The following stakeholders would need to be engaged in the process:

- The Sustainable Energy and Water Conservation Unit (SEWCU)
- The Regulator for Energy and Water Services (REWS)

9.3.2.5 Desalination Plants

DES2: Comprehensive assessment of the uptake capacity of the tourism and commercial sectors of membrane based water treatment technology, and development of support schemes to attain this capacity.

(a) Why is it important?

The LIFE+ Investing in Water Project has identified a significant potential for improving and diversifying water use by the tourism and commercial sector. There are still numerous possibilities where desalination and in-house recycling can improve water-efficiency and reduce reliance of the sector on communal sources of supply.

(b) What does the measure entail?

A survey of the current level of adoption of in-house membrane based water treatment technology by tourism and commercial entities will be undertaken. This survey will seek to identify those operators who have not installed in-house water treatment technology, including:
- sea-water desalination units, in the case of tourism and commercial entities located in the coastal areas; and
- grey-water treatment units.
These operators will be consulted in order to identify the barriers leading them not to utilise this technology. Support schemes will then be developed to address identified barriers and assist these operators to shift their water demand to alternative water resources. Through this measure, these operators will be supported to shift to a lower cost source of water increasing their competitiveness, whilst indirectly shifting their demand from groundwater resources.

(c) What is the geographical scope?
The measure applies to the entire Water Catchment District.

(d) What is the expected timeline for implementation?
The implementation of this measure is envisaged to start in 2018, and its implementation will be continued throughout the 2^{nd} catchment planning period.

(e) Who is responsible for implementing this measure and which stakeholders need to be involved?
Lead: Sustainable Energy and Water Conservation Unit (SEWCU)
The following stakeholders would need to be engaged in the process:
- The Eco-Gozo Regional Development Directorate within the Ministry for Gozo (MGoz)
- The Superintendent of Public Health (SPH)
- The Environment and Resources Authority (ERA)
- The Planning Authority (PA)
- The Water Services Corporation (WSC)
- Malta Enterprise (ME)

ENE1: Establishment of specific power benchmarks for WSC Desalination Plants and continued upgrading programmes for the phased achievement of these benchmarks.

(a) Why is it important?
Specific power consumption of RO facilities is a measure of operational efficiency and a major component of the cost of desalinated water. It also reflects the carbon footprint of desalinated water and as such it bears on the quantity of emissions of greenhouse gases. This measure draws on the Water Services Corporation's efforts to keep abreast with the most innovative technology in membrane efficiency and energy recovery applications.

(b) What does the measure entail?
The Water Services Corporation will continue the upgrading programme of its sea-water desalination plants and provide added focus to the reduction of the specific power (the energy required for the production of one cubic metre of freshwater from sea-water) of these plants. The Corporation will establish specific power benchmarks based on current 'best available technology' and develop the action plants necessary for their phased achievement.

(c) What is the geographical scope?
The measure applies to the entire Water Catchment District

(d) What is the expected timeline for implementation?

This measure should be considered as an ongoing measure, and its implementation will be continued during the 2nd catchment management cycle.

(e) Who is responsible for implementing this measure and which stakeholders need to be involved?

Lead: Water Services Corporation (WSC)

The following stakeholders would need to be engaged in the process:

- The Sustainable Energy and Water Conservation Unit (SEWCU)
- The Regulator for Energy and Water Services (REWS)

9.3.2.6 Artificial recharge of aquifers

GWM4: Development of Managed Aquifer Recharge schemes for aquifer management purposes

(a) Why is it important?

In recent years, managed aquifer recharge has become increasingly important to hasten the natural processes of infiltration leading to recovery of depleted aquifers. With the availability highly polished treated sewage effluent, it is possible to explore the application of this non-conventional source of water for artificial recharge purpose of the Mean Sea Level Aquifer (MSLA) in Malta and Gozo. Artificial recharge will contribute to raising the potentiometric head of groundwater bodies, and simultaneously push deeper the fresh/saltwater interface.

(b) What does the measure entail?

The application of Managed Aquifer Recharge schemes to increase inflow (recharge) to the aquifer systems will be assessed under this measure. The first Managed Aquifer Recharge scheme will be developed in the area known as Ta' Barkat (l/o Xghajra, Zabbar – Malta) where the application of New Water to create a freshwater barrier to limit sea-water intrusion will be assessed. Based on the results of this first scheme, further Managed Aquifer Recharge sites will be developed using different types of source (recharge) water. The development of these MAR sites will be undertaken through EU research project initiatives.

(c) What is the geographical scope?

The measure applies to the entire Water Catchment District.

(d) What is the expected timeline for implementation?

The implementation of this measure is envisaged to start in 2018, and its implementation will be continued throughout the 2nd catchment planning period.

(e) Who is responsible for implementing this measure and which stakeholders need to be involved?

Lead: Sustainable Energy and Water Conservation Unit (SEWCU)

The following stakeholders would need to be engaged in the process:

- The Sustainable Development, Environment and Climate Change Directorate General (SDECCDG) of the Ministry for Sustainable Development and Climate Change (MSDEC)
- The Policy Development Directorate (PDD-MTI) within the Ministry for Transport and Infrastructure (MTI)
- The Superintendent of Public Health (SPH)
- The Regulator for Energy and Water Services (REWS)
- The Environment and Resources Authority (ERA)
- The Environmental Health Department (EHD)
- The Planning Authority (PA)

- The Water Services Corporation (WSC)
- The Marine, Storm Water and Valley Management Unit (MSWVMU) within the Ministry for Transport and Infrastructure (MTI)
- Transport Malta (TM)
- Local Councils

9.3.2.7 Educational projects

STE1: Development of a long term National Water Conservation Campaign

(a) Why is it important?
Heightening public response towards the importance of a water-conservation philosophy fosters water-saving diligence nation-wide and encourages consumers to do more with less. The national Water Conservation Campaign will be launched with this objective. It will lead towards a net reduction in water demand and lower pressures on natural resources, groundwater in particular. Consequently, aquifers will restore faster and the environmental objectives of the Water Framework Directive will be achieved quicker. Accepting a more diligent water behaviour, nation-wide, is key to successful achievement of good resource standards, both qualitative and quantitative.

(b) What does the measure entail?
Government will seek the development of a long-term National Water Conservation Campaign to increase awareness in the public in general on water management issues. This campaign will be developed in parallel with the implementation process of the National Water Management Plan and will thus provide specific support to the implementation of the specific water management measures envisaged under the National Water Management Plan and the 2nd Water Catchment Management Plan. The National Water Conservation Campaign will include several stakeholder engagement initiatives and adopt a variety of tools to address the specific characteristics of different stakeholder groups. The campaign will serve as a focal point for all national water management and information initiatives and therefore ensure the development of a single national coordinated approach.

(c) What is the geographical scope?
The measure applies to the entire Water Catchment District.

(d) What is the expected timeline for implementation?
This measure should be considered as an ongoing measure, and its implementation will be continued throughout the 2nd catchment management cycle.

(e) Who is responsible for implementing this measure and which stakeholders need to be involved?
Lead: Sustainable Energy and Water Conservation Unit (SEWCU)
The following stakeholders would need to be engaged in the process:
- The Sustainable Development, Environment and Climate Change Directorate General (SDECCDG) of the Ministry for Sustainable Development and Climate Change (MSDEC)
- The Rural Development Directorate General (RDDG) of the Ministry for Sustainable Development and Climate Change (MSDEC)
- The Policy Development Directorate (PDD-MTI) within the Ministry for Transport and Infrastructure (MTI)
- The Eco-Gozo Regional Development Directorate within the Ministry for Gozo (MGoz)
- The Superintendent of Public Health (SPH)
- The Regulator for Energy and Water Services (REWS)
- The Environment and Resources Authority (ERA)

- The Environmental Health Department (EHD)
- The Planning Authority (PA)
- The Water Services Corporation (WSC)
- The Marine, Storm Water and Valley Management Unit (MSWVMU) within the Ministry for Transport and Infrastructure (MTI)
- The Buildings Regulations Office (BRO)
- Transport Malta (TM)
- Malta Enterprise (ME)
- The University of Malta (UoM)
- The Malta College for Arts, Science and Technology (MCAST)
- Local Councils

STE2: Specific campaign to focus on educational activities on water management in schools

(a) Why is it important?
The acceptance of a more diligent water behaviour by the community is key to the successful achievement of good resource standards, both qualitative and quantitative. Educational campaigns targeted at different age-groups can deliver quantifiable results. Special focus will be dedicated to school children as it is believed that they can synergise and influence a positive attitude towards water conservation. Furthermore by improving water management practices in schools a substantial reduction of water consumption can be achieved, whilst offering a practical experience to students on the application of water demand management measures.

(b) What does the measure entail?
A specific campaign addressing education on water management on water management issues in schools will be developed in parallel with the National Water Conservation Campaign. This educational campaign will continue to build on the work currently being undertaken as part of the Eco-Skola initiative, and seek to provide the technical support, funds and resources necessary to widen the scope of the current activities undertaken by Eko-Skola. The campaign will also seek to fund the undertaking of water demand management initiatives in schools to enable the direct and practical involvement of students in the development and management of water management projects.

(c) What is the geographical scope?
The measure applies to the entire Water Catchment District.

(d) What is the expected timeline for implementation?
This measure should be considered as an ongoing measure, and its implementation will be continued throughout the 2nd catchment management cycle.

(e) Who is responsible for implementing this measure and which stakeholders need to be involved?
Lead: Sustainable Energy and Water Conservation Unit (SEWCU)
The following stakeholders would need to be engaged in the process:
- The Ministry for Education (MEDE)
- The Eco-Gozo Regional Development Directorate within the Ministry for Gozo.
- The Environment and Resources Authority (ERA)
- The Water Services Corporation (WSC)
- Nature Trust Malta (NTM)
- The University of Malta (UoM)
- The Malta College for Arts, Science and Technology (MCAST)
- Local Councils

9.3.2.8 Research, development and demonstration projects

NEW3: Development of Demonstration sites for the application of New Water Resources.

(a) Why is it important?

The acceptance of New Water by users is a long process which necessitates a strong dialogue between authorities and stakeholders in order to convince the latter to switch to this alternative supply. Demonstration projects will therefore produce visibility of results and will allow stakeholders to evaluate the outcome, freely and independently. These projects will be supported by professional analytical services with the aim of transparently providing the necessary information on the safe use of this new water resource.

(b) What does the measure entail?

The Water Services Corporation will coordinate the development of pilot sites where the application of New Water Resources will be undertaken, in order to effectively demonstrate the safe application of these resources for irrigation to potential users. The development of these pilot sites will be undertaken with the engagement of MCAST and farmers, and will be ideally located within agricultural areas.

(c) What is the geographical scope?

The measure applies to the entire Water Catchment District.

(d) What is the expected timeline for implementation?

The implementation of this measure is envisaged to start in 2016, and its implementation will be continued throughout the 2nd catchment planning period.

(e) Who is responsible for implementing this measure and which stakeholders need to be involved?

Lead: Water Services Corporation (WSC)

The following stakeholders would need to be engaged in the process:

- The Sustainable Energy and Water Conservation Unit (SEWCU)
- The Rural Development Directorate General (RDDG) of the Ministry for Sustainable Development and Climate Change (MSDEC)
- The Eco-Gozo Regional Development Directorate within the Ministry for Gozo (MGoz)
- The Superintendent of Public Health (SPH)
- The Regulator for Energy and Water Services (REWS)
- The Environment and Resources Authority (ERA)
- The Environmental Health Department (EHD)
- Malta Enterprise (ME)
- The Malta College of Arts, Science and Technology (MCAST)

ALT1: Comprehensive assessment of the exploitation potential of natural coastal and submarine groundwater discharge.

(a) Why is it important?

The mean sea-level aquifers in Malta and Gozo consist of a fresh-water lens floating on seawater which develops as a result of density contrast between fresh and saltwater. The structure of the aquifers entails an outflow gradient towards the sea, physically reflected in a significant loss of freshwater reserves. Under natural conditions therefore, these lenses lose a substantial portion of the freshwater content derived through natural recharge, by way of scattered diffusion through submarine springs. The potential exploitation of these coastal discharges provides a challenging possibility for supply augmentation.

(b) What does the measure entail?
The natural subsurface discharge of groundwater along the coastal zone is estimated to account for around 50% of the mean annual recharge to the groundwater environment. The studies proposed under this measure will investigate the groundwater discharge mechanisms prevailing in the Maltese islands and attempt the characterisation of any identified significant discharge points. Furthermore, the studies will also focus on the near coastal environment in order to assess the presence and/or potential contribution of any submerged karst features to this natural discharge. The results of these studies will be utilised for the development of a comprehensive assessment of the exploitation potential of this natural discharge and its re-integration in the national water cycle.

(c) What is the geographical scope?
The measure applies to the entire Water Catchment District.

(d) What is the expected timeline for implementation?
The implementation of this measure is envisaged to start in 2017, and its implementation will be continued throughout the 2nd catchment planning period.

(e) Who is responsible for implementing this measure and which stakeholders need to be involved?
Lead: Sustainable Energy and Water Conservation Unit (SEWCU)
The following stakeholders would need to be engaged in the process:
- The Regulator for Energy and Water Services (REWS)
- The Environment and Resources Authority (ERA)
- The Water Services Corporation (WSC)

ALT2: Comprehensive assessment of the exploitation potential of the saline aquifer system underlying the mean sea level aquifer systems.

(a) Why is it important?
The use of desalination technology is currently constrained to coastal areas. Localised high demands for high quality water can be effectively met through inland desalination plants. Therefore a study will be made on the potential of drawing saline water and discharging brine below the freshwater lens subject to properly engineered infrastructure which respects the necessary protection measures against seawater intrusion.

(b) What does the measure entail?
The exploitation potential of the deep sea saline aquifer systems underlying the mean sea-level fresh aquifer systems will be investigated through the utilisation of EU research funding opportunities. The potential utilisation of these aquifer systems will open up opportunities for the development of inland desalination facilities servicing high-volume and/or high-quality consumers, thereby reducing their dependency on freshwater groundwater resources. The envisaged studies will undertake assessments on the environmental impact of deep saline water abstraction and discharge on the freshwater lens of the sea-level aquifer system; and develop implementation guidelines for any such initiatives to effectively remove any potential adverse impact of such projects on the fresh-groundwater environment.

(c) What is the geographical scope?
The measure applies to the entire Water Catchment District.

(d) What is the expected timeline for implementation?
The implementation of this measure is envisaged to start in 2018, and its implementation will be continued throughout the 2nd catchment planning period.

(e) Who is responsible for implementing this measure and which stakeholders need to be involved?
Lead: Sustainable Energy and Water Conservation Unit (SEWCU)
The following stakeholders would need to be engaged in the process:
- The Regulator for Energy and Water Services (REWS)
- The Environment and Resources Authority (ERA)
- The Water Services Corporation (WSC)
- Malta Enterprise (ME)

STE3: Development of demonstration projects to showcase the application of innovative technology in the local water sector.

(a) Why is it important?
Research is one of the necessary tools to drive innovation. The themes of key interest include, membrane technology, re-use applications, energy efficiency, network efficiency and modelling, remotely operated control, groundwater management, and smart irrigation. Demo-projects will be developed in collaboration with the University and the MCAST and these will provide opportunity for students to further their studies and improve chances of career progression

(b) What does the measure entail?
Government will seek the development of demonstration and pilot projects to showcase the application of innovative technology in the local water sector. These demonstration actions will support the implementation of the measures envisaged under the 2nd Water Catchment Management Plan and focus on priority issues such as:
- the use of New Water resources,
- Managed Aquifer Recharge,
- Innovative Desalination Technology,
- Efficient Irrigation Technology, and
- Grey water recycling.

These pilot actions will be funded through European Research Programmes in order to ensure the direct involvement of established expertise from European research institutions. As far as possible Government will seek the involvement of higher educational institutions in the development and management of these demonstration projects in order to provide an added educational dimension to these initiatives.

(c) What is the geographical scope?
The measure applies to the entire Water Catchment District.

(d) What is the expected timeline for implementation?
This measure should be considered as an ongoing measure, and its implementation will be continued throughout the 2nd Catchment Management cycle.

(e) Who is responsible for implementing this measure and which stakeholders need to be involved?
Lead: Sustainable Energy and Water Conservation Unit (SEWCU)
The following stakeholders would need to be engaged in the process:

- The Sustainable Development, Environment and Climate Change Directorate General (SDECCDG) of the Ministry for Sustainable Development and Climate Change (MSDEC)
- The Rural Development Directorate General (RDDG) of the Ministry for Sustainable Development and Climate Change (MSDEC)
- The Policy Development Directorate (PDD-MTI) within the Ministry for Transport and Infrastructure (MTI)
- The Eco-Gozo Regional Development Directorate within the Ministry for Gozo (MGoz)
- The Superintendent of Public Health (SPH)
- The Regulator for Energy and Water Services (REWS)
- The Environment and Resources Authority (ERA)
- The Environmental Health Department (EHD)
- The Planning Authority (PA)
- The Water Services Corporation (WSC)
- The Marine, Storm Water and Valley Management Unit (MSWVMU) within the Ministry for Transport and Infrastructure (MTI)
- The Buildings Regulations Office (BRO)
- Transport Malta (TM)
- Malta Enterprise (ME)
- The Malta College for Arts, Science and Technology (MCAST),
- The University of Malta (UOM),
- Local Councils

9.3.2.9 Other Supplementary Measures related to water resources management

GVN4: Establish the training needs for public organisations involved in the water management sector.

(a) Why is it important?
Training and continuous professional development is a capital investment and constitutes an essential process in the course of a proper capacity building exercise. Specialised water expertise in the public sector is limited. Public officers will be encouraged to follow in-house training programmes in water related disciplines, including, operations management, desalination technology, water conservation, environment and hydrology. The Institute of Water Technology lends itself as the ideal institution to develop training programmes in the water sector.

(b) What does the measure entail?
An assessment of the training needs of professional staff currently employed with public agencies involved in the water management sector will be undertaken. The results of this study will guide the development of specialised training programmes which will ensure that these public agencies are best equipped to develop and implement the measures being proposed under the 2nd Water Catchment Management Plan.

(c) What is the geographical scope?
The measure applies to the entire Water Catchment District.

(d) What is the expected timeline for implementation?
The implementation of this measure is envisaged to start in 2016, and its implementation will be continued throughout the 2nd catchment planning period.

(e) Who is responsible for implementing this measure and which stakeholders need to be involved?
Lead: Sustainable Energy and Water Conservation Unit (SEWCU)

The following stakeholders would need to be engaged in the process:
- The Ministry for Education (MEDE)
- The Sustainable Development, Environment and Climate Change Directorate General (SDECCDG) of the Ministry for Sustainable Development and Climate Change (MSDEC)
- The Rural Development Directorate General (RDDG) of the Ministry for Sustainable Development and Climate Change (MSDEC)
- The Policy Development Directorate (PDD-MTI) within the Ministry for Transport and Infrastructure (MTI)
- The Eco-Gozo Regional Development Directorate within the Ministry for Gozo (MGoz)
- The Superintendent of Public Health (SPH)
- The Regulator for Energy and Water Services (REWS)
- The Environment and Resources Authority (ERA)
- The Environmental Health Department (EHD)
- The Planning Authority (PA)
- The Water Services Corporation (WSC)
- The Marine, Storm Water and Valley Management Unit (MSWVMU) within the Ministry for Transport and Infrastructure (MTI)
- The Buildings Regulations Office (BRO)
- Transport Malta (TM)
- Malta Enterprise (ME)
- The Malta College for Arts, Science and Technology (MCAST)
- The University of Malta (UOM)
- Local Councils

GVN5: Provision of specialised training opportunities for public officers in the water management field.

(a) Why is it important?

The competent authorities responsible for water resources management require highly trained officials in a wide range of disciplines. Water management is a specialised field which is often not included on the curricula of degree courses. Specialised training in specific fields related to water is essential to develop a high professional capacity in the public and private sectors. On-the job training programmes will be therefore useful to employees in the public water sector. This measure will ensure a future know-how on water management and water conservation.

(b) What does the measure entail?

This measure will seek to re-establish the Institute of Water Technology at the Water Services Corporation as a national training centre serving public agencies involved in the water management sector. Specialised training opportunities will be developed at the Institute of Water Technology to address the training needs identified in the assessment undertaken under measure GVN4. The technical support of international training institutions will be sourced through the participation of the Institute for Water Technology in EU co-financed initiatives funded under programmes such as the European Social Fund and the Erasmus+ Programme.

(c) What is the geographical scope?

The measure applies to the entire Water Catchment District.

(d) What is the expected timeline for implementation?

The implementation of this measure is envisaged to start in 2017, and its implementation will be continued throughout the 2nd catchment planning period.

(e) Who is responsible for implementing this measure and which stakeholders need to be involved?
Lead: Sustainable Energy and Water Conservation Unit (SEWCU)
The following stakeholders would need to be engaged in the process:
- The Ministry for Education (MEDE)
- The Sustainable Development, Environment and Climate Change Directorate General (SDECCDG) of the Ministry for Sustainable Development and Climate Change (MSDEC)
- The Rural Development Directorate General (RDDG) of the Ministry for Sustainable Development and Climate Change (MSDEC)
- The Policy Development Directorate (PDD-MTI) within the Ministry for Transport and Infrastructure (MTI)
- The Eco-Gozo Regional Development Directorate within the Ministry for Gozo (MGoz)
- The Superintendent of Public Health (SPH)
- The Regulator for Energy and Water Services (REWS)
- The Environment and Resources Authority (ERA)
- The Environmental Health Department (EHD)
- The Planning Authority (PA)
- The Water Services Corporation (WSC)
- The Marine, Storm Water and Valley Management Unit (MSWVMU) within the Ministry for Transport and Infrastructure (MTI)
- The Buildings Regulations Office (BRO)
- Transport Malta (TM)
- Malta Enterprise (ME)
- The Malta College for Arts, Science and Technology (MCAST)
- The University of Malta (UOM)
- Local Councils

GVN7: Facilitate the public's access to information and their understanding of the decision making process to increase confidence in the institutions and policy formulation.

(a) Why is it important?
Access to information is a means of encouraging partnership between the public and the institutions and a means of promoting acceptance of policy measures. More accessibility will be allowed to water quality information including that on New Water. This information will be explained in simple terms to enable stakeholders evaluate the wholesomeness of this new resource and thereafter decide freely on its application to their requirements.

(b) What does the measure entail?
All public organisations involved in the water management sector will be required to provide stakeholders with sufficient information and incentives so that they can have an active participation in the development of sectoral policies. A centralised water-information portal will be developed by the Sustainable Energy and Water Conservation Unit, with the aim of providing a central reference point for all water related information on the implementation of water management policies in the Maltese islands.

(c) What is the geographical scope?
The measure applies to the entire Water Catchment District.

(d) What is the expected timeline for implementation?

The implementation of this measure is envisaged to start in 2016, and its implementation will be continued throughout the 2nd catchment planning period.

(e) Who is responsible for implementing this measure and which stakeholders need to be involved?

Lead: Sustainable Energy and Water Conservation Unit (SEWCU)

The following stakeholders would need to be engaged in the process:

- The Ministry for Education (MEDE)
- The Sustainable Development, Environment and Climate Change Directorate General (SDECCDG) of the Ministry for Sustainable Development and Climate Change (MSDEC)
- The Rural Development Directorate General (RDDG) of the Ministry for Sustainable Development and Climate Change (MSDEC)
- The Policy Development Directorate (PDD-MTI) within the Ministry for Transport and Infrastructure (MTI)
- The Eco-Gozo Regional Development Directorate within the Ministry for Gozo (MGoz)
- The Superintendent of Public Health (SPH)
- The Regulator for Energy and Water Services (REWS)
- The Environment and Resources Authority (ERA)
- The Environmental Health Department (EHD)
- The Planning Authority (PA)
- The Water Services Corporation (WSC)
- The Marine, Storm Water and Valley Management Unit (MSWVMU) within the Ministry for Transport and Infrastructure (MTI)
- The Buildings Regulations Office (BRO)
- Transport Malta (TM)
- Malta Enterprise (ME)
- Local Councils

PUB3: Establishment of a voluntary Eco-Labelling scheme for water-use fixtures and appliances.

(a) Why is it important?

This is an important tool for water conservation. It seeks to induce a market shift from conventional water use-fixtures to those which are economical and can actually procure water saving. The scheme will give the necessary information to consumers enabling them to make correct decisions with respect to high levels of water use efficiency.

(b) What does the measure entail?

Government will seek the establishment of a national eco-labelling scheme to clearly identify efficient water-use fixtures and appliances, on the lines of existing eco-schemes for vehicle emissions and energy consumption. The development and management of this scheme will be undertaken in full consultation with representatives of importers and retailers, to ensure its acceptability by the sector. The eco-labels, once adopted, will support consumers in making an informed choice on the water consumption characteristics of any new fixtures and appliances which they intend to acquire. The scheme will provide the necessary information structure on which future fiscal incentive schemes to support the acquisition of water efficient devices can be based.

(c) What is the geographical scope?

The measure applies to the entire Water Catchment District.

(d) What is the expected timeline for implementation?
The implementation of this measure is envisaged to start in 2018, and its implementation will be continued throughout the 2nd catchment planning period.

(e) Who is responsible for implementing this measure and which stakeholders need to be involved?
Lead: Sustainable Energy and Water Conservation Unit (SEWCU)
The following stakeholders would need to be engaged in the process:
- The Superintendent of Public Health (SPH)
- The Water Services Corporation (WSC)
- The Buildings Regulations Office (BRO)
- The General Retailers and Traders Union (GRTU)

PUB4: Upgrading of the water use efficiency of public buildings and structures.

(a) Why is it important?
Public buildings, particularly the ones located in Valletta were built with a far-reaching vision for water conservation with large underground cisterns designed to capture roof run-off.
This storage was utilised in the past for several purposes unlike present day when several of these structures have fallen in disuse. The restoration of these structures coupled with an education campaign can improve the efficiency of water use in public buildings.

Water efficiency in office buildings also needs to be addressed comprehensively by adopting a wide range of measures. In particular the installation of water-efficient fixtures, such as spring taps, flow reducers and dual flush toilets is lacking in many instances. Upgrades of office buildings with this equipment will improve efficiency and reduce consumption of these establishments.

(b) What does the measure entail?
Good practice water use thresholds will be established and introduced for all public buildings and structures. The implementation of these thresholds will be supported as part of the National Water Conservation Campaign, where the reduction in water consumption achieved in public buildings will then be used to help guide the adoption of similar measures in the private commercial sector.

(c) What is the geographical scope?
The measure applies to the entire Water Catchment District.

(d) What is the expected timeline for implementation?
The implementation of this measure is envisaged to start in 2019, and its implementation will be continued throughout the 2nd catchment planning period.

(e) Who is responsible for implementing this measure and which stakeholders need to be involved?
Lead: Sustainable Energy and Water Conservation Unit (SEWCU)
The following stakeholders would need to be engaged in the process:
- The Planning Authority (PA)
- The Water Services Corporation (WSC)
- The Buildings Regulations Office (BRO)
- The Eco-Gozo Regional Development Directorate within the Ministry for Gozo (MGoz)

PUB5: Support mechanisms for research initiatives on grey-water recycling systems for the domestic and commercial sectors.

(a) Why is it important?

Greywaters constitute a reliable source of secondary waters, for household and commercial establishments, which effectively increase their water-use efficiency. As yet very little use is made of this resource possibly due to a lack of commercial interest to apply treatment technological on a small scale. Research initiatives directed towards the development of modular facilities on a small scale will be supported and encouraged during the period under consideration.

(b) What does the measure entail?

The in-house recycling of grey-water for secondary uses has the potential of reducing direct water use by between 20 and 30%. Unfortunately, locally adapted recycling systems which can be easily acquired by consumers do not exist. This measure will seek to incentivise the local industrial sector to initiate research activities aimed at developing local solutions for low-cost, easily installable and safe grey-water recycling solutions, by making available research grants which can support operators to undertake such initiatives.

(c) What is the geographical scope?

The measure applies to the entire Water Catchment District.

(d) What is the expected timeline for implementation?

The implementation of this measure is envisaged to start in 2018, and its implementation will be continued throughout the 2nd catchment planning period.

(e) Who is responsible for implementing this measure and which stakeholders need to be involved?

Lead: Sustainable Energy and Water Conservation Unit (SEWCU)

The following stakeholders would need to be engaged in the process:

- The Superintendent of Public Health (SPH)
- The Regulator for Energy and Water Services (REWS)
- The Environmental Health Department (EHD)
- The Planning Authority (PA)
- The Water Services Corporation (WSC)
- The Buildings Regulations Office (BRO)
- The Malta Council for Science and Technology (MCST)
- The Malta College for Arts, Science and Technology (MCAST)
- The University of Malta (UoM)

AGR3: Advisory services to support farmers interpret groundwater metering data to better streamline their operations and achieve higher levels of water use efficiency.

(a) Why is it important?

The use of water at field level can vary widely. The assessment of water consumption, at field level by a professional advisory service will support efforts to improve water efficiency and reduce operating costs. Information on individual water use will enable the identification of heavy consumers followed by an outreach programme where advice will be given to these users to optimise their water use and thus reduce consumption.

(b) What does the measure entail?
This measure will seek the development of advisory services to support farmers to interpret the groundwater abstraction metering data and correlate it with their cropping plans. These services will assist operators to identify high water uses and develop the corrective measures to ensure a more efficient use of water resources.

(c) What is the geographical scope?
The measure applies to the entire Water Catchment District.

(d) What is the expected timeline for implementation?
The implementation of this measure is envisaged to start in 2017, and its implementation will be continued throughout the 2nd catchment planning period.

(e) Who is responsible for implementing this measure and which stakeholders need to be involved?
Lead: Sustainable Energy and Water Conservation Unit (SEWCU)
The following stakeholders would need to be engaged in the process:
- The Rural Development Directorate General (RDDG) of the Ministry for Sustainable Development and Climate Change (MSDEC)
- The Eco-Gozo Regional Development Directorate within the Ministry for Gozo (MGoz)
- The Environment and Resources Authority (ERA)
- The Water Services Corporation (WSC)
- Farmers Organisations

GWM1: Review of existing groundwater resource models and development of a new numerical model to assess sustainable groundwater yield.

(a) Why is it important?
During the last five years the improved monitoring programmes has generated valuable data on groundwater behaviour. Moreover new modelling packages were developed to simulate the behaviour of groundwater systems under different conditions of stress. Aquifer models are important management tools for groundwater predictions and resource assessment purposes.

(b) What does the measure entail?
The Sustainable Energy and Water Conservation Unit will seek the development of a reliable numerical model of the mean sea level aquifer systems in Malta and Gozo in order to better determine the sustainable yield of these aquifer systems. The model development process will be undertaken in partnership with established international institutions, who will provide the expertise necessary to increase the confidence in the results of the model. Furthermore, the model will be utilised to assess the response of the aquifer systems under future scenarios including those potentially arising due to climate change.

(c) What is the geographical scope?
The measure applies to the entire Water Catchment District.

(d) What is the expected timeline for implementation?
The implementation of this measure is envisaged to start in 2016, and its implementation is expected to be concluded by 2019.

(e) Who is responsible for implementing this measure and which stakeholders need to be involved?
Lead: Sustainable Energy and Water Conservation Unit (SEWCU)

The following stakeholders would need to be engaged in the process:
- The Environment and Resources Authority (ERA)
- The Water Services Corporation (WSC)

GWM2: Optimisation of the public groundwater abstraction network infrastructure to limit localized sea-water intrusion and protect the yield of public groundwater abstraction stations.

(a) Why is it important?
There exists a direct relationship between salinity and abstraction from sea-level coastal aquifers. Real-time monitoring can be fed in a mathematical model and processed to predict flow behaviour following which abstraction is optimised minimise intrusion through upconing. This exercise will provide added protection to the fragile sea-level aquifers.

(b) What does the measure entail?
This measure will seek the development of predictive groundwater abstraction technology which will enable groundwater abstraction rates to be varied according to the temporal response function of the particular groundwater abstraction station. The adoption of this technology will enable the Water Services Corporation to optimise the quality of the groundwater supply blend thus providing better quality water to consumers. Furthermore, by limiting saline upconing beneath groundwater abstraction stations, this measure will also seek to better protect the sea-level aquifer systems from saline intrusion.

(c) What is the geographical scope?
The measure applies to the entire Water Catchment District.

(d) What is the expected timeline for implementation?
The implementation of this measure is envisaged to start in 2018, and its implementation will be continued throughout the 2nd catchment planning period.

(e) Who is responsible for implementing this measure and which stakeholders need to be involved?
Lead: Water Services Corporation (WSC)
The following stakeholders would need to be engaged in the process:
- The Sustainable Energy and Water Conservation Unit (SEWCU)
- The Regulator for Energy and Water Services (REWS)
- The Environment and Resources Authority (ERA)

RWH1: Survey on the status of existing rainwater harvesting infrastructure, identification of potential users of rainwater harvested in these infrastructures, undertaking of rehabilitation works and development of a management framework to ensure the effective use of harvested rainwater.

(a) Why is it important?
Several rainwater harvesting initiatives were undertaken in the past – a direct reflection of the importance given to this resource. Most of the stream channels in the major catchments were barred by shallow dams whilst open reservoir schemes were constructed to capture storm water. Underground reservoirs and cisterns, dating back to British and Knights period can be found in towns and villages where good use can be made with the harvested rainwater for landscaping and other secondary purposes. The optimum use of these facilities provides an important potential for bettering the management of rainwater runoff.

(b) What does the measure entail?

This measure will address the state of existing public rainwater harvesting infrastructure and aim to undertake a comprehensive restoration of these public assets to ensure their effective use in the management of rainwater runoff. The implementation of the measure will be undertaken in four parallel phases, namely:

a) identification of the location of existing infrastructure through assessment of existing documentation and a public engagement campaign;

b) survey of the status of these infrastructures and assessment of the rehabilitation works required;

c) identification of potential users for harvested rainwater, and development of management agreements with such users; and

d) undertaking of rehabilitation works to restore the rainwater harvesting infrastructures.

(c) What is the geographical scope?

The measure applies to the entire Water Catchment District.

(d) What is the expected timeline for implementation?

The implementation of this measure is envisaged to start in 2017, and its implementation will be continued throughout the 2nd catchment planning period.

(e) Who is responsible for implementing this measure and which stakeholders need to be involved?

Lead: Sustainable Energy and Water Conservation Unit (SEWCU)

The following stakeholders would need to be engaged in the process:

- The Policy Development Directorate (PDD-MTI) within the Ministry for Transport and Infrastructure (MTI)
- The Eco-Gozo Regional Development Directorate within the Ministry for Gozo (MGoz)
- The Superintendent of Public Health (SPH)
- The Environment and Resources Authority (ERA)
- The Environmental Health Department (EHD)
- The Planning Authority (PA)
- The Marine, Storm Water and Valley Management Unit (MSWVMU) within the Ministry for Transport and Infrastructure (MTI)
- Local Councils

RWH6: Rehabilitation of existing rainwater harvesting dam structures in valleys.

(a) Why is it important?

The importance of valley protection is undiscounted, not only for resource purposes but also for the conservation and protection of ecosystems which thrive in these areas. Valleys provide the lowest terrain of a water catchment and as such are very important for natural recharge. The restoration of dams is therefore conducive towards this aim as it will augment infiltration of harvested rainwater.

(b) What does the measure entail?

This measure will seek the development of a valley management master plan which will regulate the long-term rehabilitation of rainwater runoff storage areas behind valley dam structures whilst ensuring the necessary level of protection to the valley ecosystem. The master plan will seek to identify opportunities for the development of these valley systems into sustainable recreational areas which provide educational information about the important ecosystems sustained in the valley systems.

(c) What is the geographical scope?

The measure applies to the entire Water Catchment District.

(d) What is the expected timeline for implementation?

The implementation of this measure is envisaged to start in 2017, and its implementation will be continued throughout the 2nd catchment planning period.

(e) Who is responsible for implementing this measure and which stakeholders need to be involved?

Lead: Sustainable Energy and Water Conservation Unit (SEWCU)

The following stakeholders would need to be engaged in the process:

- The Sustainable Development, Environment and Climate Change Directorate General (SDECCDG) of the Ministry for Sustainable Development and Climate Change (MSDEC)
- The Rural Development Directorate General (RDDG) of the Ministry for Sustainable Development and Climate Change (MSDEC)
- The Policy Development Directorate (PDD-MTI) within the Ministry for Transport and Infrastructure (MTI)
- The Eco-Gozo Regional Development Directorate within the Ministry for Gozo (MGoz)
- The Environment and Resources Authority (ERA)
- The Planning Authority (PA)
- The Marine, Storm Water and Valley Management Unit (MSWVMU) within the Ministry for Transport and Infrastructure (MTI)
- Local Councils

NEW1: Commissioning of three polishing plants with a production capacity of 7 million m3/year

(a) Why is it important?

Treated wastewater in Malta has quality characteristics which constrain its utilisation by agriculture and industry. To overcome this limitation, three new polishing plants will polish secondary treated effluent by ultra-filtration and membrane processes. The resulting product will achieve high quality specifications, making its application possible for irrigation of, for industrial applications, landscaping and for artificial recharge schemes.

(b) What does the measure entail?

The Water Services Corporation will finalise the works for the development of three polishing plants, two in Malta and one in Gozo, with an annual production capacity of 7 million cubic meters of New Water Resources.

(c) What is the geographical scope?

The measure applies to the entire Water Catchment District.

(d) What is the expected timeline for implementation?

The implementation of this measure is envisaged to be concluded in 2016.

(e) Who is responsible for implementing this measure and which stakeholders need to be involved?

Lead: Water Services Corporation (WSC)

The following stakeholders would need to be engaged in the process:

- Sustainable Energy and Water Conservation Unit (SEWCU)
- The Rural Development Directorate General (RDDG) of the Ministry for Sustainable Development and Climate Change (MSDEC)
- The Superintendent of Public Health (SPH)
- The Regulator for Energy and Water Services (REWS)
- The Environment and Resources Authority (ERA)

- The Environmental Health Department (EHD)

NEW2: Development and implementation of a branding campaign for New Water Resources

(a) Why is it important?
Branding will seek to promote New Water as a reliable alternative to more costly sources of supply. It will develop an image for New Water projecting this resource as a safe alternative to groundwater particularly for irrigation and commercial purposes.

(b) What does the measure entail?
A branding framework to support the introduction of New Water Resources will be developed by MCAST's Institute of Arts and Design. This framework will then be utilised for the development of a long-term branding campaign aimed at presenting these New Water resources as a safe and strategic resource to ensure the continued sustainable use of water resources in the Maltese islands.

(c) What is the geographical scope?
The measure applies to the entire Water Catchment District.

(d) What is the expected timeline for implementation?
The implementation of this measure is envisaged to start in 2016, and its implementation will be continued throughout the 2^{nd} catchment planning period.

(e) Who is responsible for implementing this measure and which stakeholders need to be involved?
Lead: Water Services Corporation (WSC)
The following stakeholders would need to be engaged in the process:
- Sustainable Energy and Water Conservation Unit (SEWCU)
- The Regulator for Energy and Water Services (REWS)

NEW4: Development of dedicated distribution facilities for New Water to enable its availability at the point of use.

(a) Why is it important?
New Water treatment works will be developed at existing sites located along the shoreline. These locations are rather distant from the points of use thus necessitating the development of a proper distribution network. Distribution networks will ensure availability of New Water at the point of use and facilitate uptake.

(b) What does the measure entail?
Through this measure, the Water Services Corporation will develop short and long term strategies aimed at guiding the development of dedicated distribution networks to deliver the New Water resources to agricultural and industrial users. The implementation of the measure will start with a feasibility assessment based on the results of the Water Demand Map envisaged under Measure PUB1, on which the spread of the distribution facilities will be initially assessed. Furthermore, the assessment will investigate the potential need for further localized polishing facilities to widen the consumer base for the New Water resources.

(c) What is the geographical scope?
The measure applies to the entire Water Catchment District.

(d) What is the expected timeline for implementation?

The implementation of this measure is envisaged to start in 2017, and its implementation will be continued throughout the 2^{nd} catchment planning period.

(e) Who is responsible for implementing this measure and which stakeholders need to be involved?

Lead: Water Services Corporation (WSC)

The following stakeholders would need to be engaged in the process:

- Sustainable Energy and Water Conservation Unit (SEWCU)
- The Rural Development Directorate General (RDDG) of the Ministry for Sustainable Development and Climate Change (MSDEC)
- The Eco-Gozo Regional Development Directorate within the Ministry for Gozo (MGoz)
- The Regulator for Energy and Water Services (REWS)

MDM1: Comprehensive upgrading of the hydrological cycle monitoring capacity

(a) Why is it important?

The accuracy of a Water Resource Assessment depends on data availability, its accuracy and representativity. The existing real-time monitoring network requires upgrading to improve data resolution and ascertain a high quality collection. With this data a more accurate resource assessment would be possible once the governing parameters are revised and possibly recalculated.

b) What does the measure entail?

A review of the current hydrological monitoring framework will be undertaken in order to identify representative catchments in which to install climatological, rainwater runoff and infiltration monitoring station. New hydrological data management and modelling frameworks will also be acquired/developed to ensure the optimised use of the collected data. This measure thus seeks to upgrade the current hydrological cycle monitoring capacity to increase the reliability of water resource (availability) assessments.

(c) What is the geographical scope?

The measure applies to the entire Water Catchment District.

(d) What is the expected timeline for implementation?

The implementation of this measure is envisaged to start in 2017, and its implementation will be continued throughout the 2^{nd} catchment planning period.

(e) Who is responsible for implementing this measure and which stakeholders need to be involved?

Lead: Sustainable Energy and Water Conservation Unit (SEWCU)

The following stakeholders would need to be engaged in the process:

- The Environment and Resources Authority (ERA)
- The Water Services Corporation (WSC)
- The Marine, Storm Water and Valley Management Unit (MSWVMU) within the Ministry for Transport and Infrastructure (MTI)
- The Eco-Gozo Regional Development Directorate within the Ministry for Gozo (MGoz)
- The Malta College for Arts, Science and Technology (MCAST)

MDM7: Development of a water scarcity and drought monitoring and assessment platform.

(a) Why is it important?
Water scarcity and drought indices support decision makers in planning resource availability and allocation to different sectors. The development of Malta-specific indicators which take into account semi-arid conditions can lead to better understanding of the hydrological cycle at local level and possibly improve predictions on water availability

(b) What does the measure entail?
This measure will seek the development of a water scarcity and drought monitoring platform through the adoption of a suite of water stress indicators. The information generated by this platform will be publicly available and will be utilised to generate increased awareness on the significant challenges facing the Maltese water sector. Furthermore, the results of the platform will be used to effectively demonstrate the relative importance of the natural drought conditions prevailing in the Maltese islands as compared to the baseline conditions in other European Member States.

(c) What is the geographical scope?
The measure applies to the entire Water Catchment District.

(d) What is the expected timeline for implementation?
The implementation of this measure is envisaged to start in 2018, and its implementation will be continued throughout the 2nd catchment planning period.

(e) Who is responsible for implementing this measure and which stakeholders need to be involved?
Lead: Sustainable Energy and Water Conservation Unit (SEWCU)
The following stakeholders would need to be engaged in the process:
- The Sustainable Development, Environment and Climate Change Directorate General (SDECCDG) of the Ministry for Sustainable Development and Climate Change (MSDEC)
- The Rural Development Directorate General (RDDG) of the Ministry for Sustainable Development and Climate Change (MSDEC)
- The Eco-Gozo Regional Development Directorate within the Ministry for Gozo (MGoz)
- The Environment and Resources Authority (ERA)
- The Water Services Corporation (WSC)
- The Malta Meteorological Office

QLT2: Upgrading of the public sewerage system to reduce both leakages from sewers as well as the infiltration of sea-water into sewers.

(a) Why is it important
Sewer pipes in coastal urban areas are the most vulnerable to seawater infiltration and a source of concern for network operations. These areas will be given priority during the network upgrading programme. On completion a quality improvement of the treated effluent is anticipated thus requiring less polishing and reducing overall cost. It will also enable increased production of New Water from existing treatment plants, whilst optimising the possibilities of increasing nutrient levels in irrigation water.

(b) What does the measure entail?
The Water Services Corporation will continue its upgrading programme of the public sewerage system in order to both reduce leakages from the sewer network and also reduce the infiltration of sea-water into

the sewers where these are located below sea-level. These actions are necessary in order to reduce the risk of contamination of Malta's groundwater resources; and also to protect the resource value of wastewater for the development of New Water resources.

(c) What is the geographical scope?
The measure applies to the entire Water Catchment District.

(d) What is the expected timeline for implementation?
This measure should be considered as an ongoing measure, and its implementation will be continued throughout the 2nd catchment management cycle.

(e) Who is responsible for implementing this measure and which stakeholders need to be involved?
Lead: Water Services Corporation (WSC)
The following stakeholders would need to be engaged in the process:
- Sustainable Energy and Water Conservation Unit (SEWCU)
- The Regulator for Energy and Water Services (REWS)

FLD1: Modelling the impact of the National Flood Relief Project on flood hazard and risk in identified catchments.

(a) Why is it important?
The National Flood Relief Project has introduced a network of underground tunnels and other conduits which transfers the conveyance of rainwater runoff underground. This process modifies the hydrodynamic characteristics of the catchment and hence it is important to examine the impact of this change on interested urban areas.

(b) What does the measure entail?
A flood hazard and risk assessment will be undertaken to assess the actual mitigation impact of the works undertaken under the National Flood Relief Project, and indentify and residual flood risk impact in the catchments in question. The results of this assessment will be utilized to update the flood hazard and risk classification of these catchments.

(c) What is the geographical scope?
The measure applies to the entire Water Catchment District.

(d) What is the expected timeline for implementation?
The implementation of this measure is envisaged to start in 2017, and its implementation is expected to be concluded by 2019.

(e) Who is responsible for implementing this measure and which stakeholders need to be involved?
Lead: Sustainable Energy and Water Conservation Unit (SEWCU)
The following stakeholders would need to be engaged in the process:
- The Policy Development Directorate (PDD-MTI) within the Ministry for Transport and Infrastructure (MTI)
- The Environment and Resources Authority (ERA)
- The Eco-Gozo Regional Development Directorate within the Ministry for Gozo (MGoz)
- The Planning Authority (PA)
- The Marine, Storm Water and Valley Management Unit (MSWVMU) within the Ministry for Transport and Infrastructure (MTI)
- Transport Malta (TM)

- The Civil Protection Department (CPD)
- Local Councils

FLD2: Flood Hazard and Risk Assessment in catchments not included in the National Flood Relief Project.

(a) Why is it important?

It is important to extend the Flood hazard assessment to those catchments which were not assessed during the initial studies undertaken under the National Flood Relief Project. The results of the study will identify any flood hazards in these areas and will propose measures to mitigate such risks. It will also enable the development of catchment-wide measures to optimise rainwater management.

(b) What does the measure entail?

A modelling exercise will be undertaken to assess the flood hazard and risk levels in the water catchments not covered under the National Flood Relief Project. This exercise will continue to build on the work undertaken in the Storm Water Master Plan for the Maltese islands. Three model scenarios representing low, medium and high flood return periods will be considered in this study. The results of this assessment will help guide the development of future upstream and downstream flood risk mitigation projects in these catchments.

(c) What is the geographical scope?

The measure applies to the entire Water Catchment District.

(d) What is the expected timeline for implementation?

The implementation of this measure is envisaged to start in 2018, and its implementation will be continued throughout the 2nd catchment planning period.

(e) Who is responsible for implementing this measure and which stakeholders need to be involved?

Lead: Sustainable Energy and Water Conservation Unit (SEWCU)
The following stakeholders would need to be engaged in the process:
- The Policy Development Directorate (PDD-MTI) within the Ministry for Transport and Infrastructure (MTI)
- The Environment and Resources Authority (ERA)
- The Planning Authority (PA)
- The Eco-Gozo Regional Development Directorate within the Ministry for Gozo (MGoz)
- The Marine, Storm Water and Valley Management Unit (MSWVMU) within the Ministry for Transport and Infrastructure (MTI)
- Transport Malta (TM)
- The Civil Protection Department (CPD)
- Local Councils

FLD3: Comprehensive assessment for the inclusion of Sustainable Urban Drainage Systems and Natural Water Retention Measures to mitigate flood hazard and risk

(a) Why is it important?

Diversifying the tools available to manage rainwater runoff is an important aspect of any integrated flood management strategy. Sustainable Urban Drainage Systems and Natural Water Retention Systems offer a high potential for the development of 'green' tools to optimise the upstream management of rainwater and reduce the generation of rainwater runoff in the downstream reaches of the catchments.

(b) What does the measure entail?

This measure will seek the development of a master plan identifying the potential inclusion of Sustainable Urban Drainage Systems and National Water Retention Measures in the urban and rural framework of the Maltese islands as environmentally friendly flood mitigation measures. The master plan will identify key measures and projects where the introduction of such measures can be undertaken on a national level. Furthermore, in collaboration with the Planning Authority, the development of a planning guidance document to better guide the adoption of these measures will be developed.

(c) What is the geographical scope?

The measure applies to the entire Water Catchment District.

(d) What is the expected timeline for implementation?

The implementation of this measure is envisaged to start in 2019, and its implementation will be continued throughout the 2nd catchment planning period.

(e) Who is responsible for implementing this measure and which stakeholders need to be involved?

Lead: Sustainable Energy and Water Conservation Unit (SEWCU)

The following stakeholders would need to be engaged in the process:

- The Policy Development Directorate (PDD-MTI) within the Ministry for Transport and Infrastructure (MTI)
- The Environment and Resources Authority (ERA)
- The Planning Authority (PA)
- The Eco-Gozo Regional Development Directorate within the Ministry for Gozo (MGoz)
- The Marine, Storm Water and Valley Management Unit (MSWVMU) within the Ministry for Transport and Infrastructure (MTI)
- Transport Malta (TM)
- The Buildings Regulations Office (BRO)
- Local Councils

FLD5: Implementation of Sustainable Urban Drainage Systems and Natural Water Retention Measures as identified under measure FLD3.

(a) Why is it important?

The implementation of the plans developed under measure FLD3 is important to ensure that the full potential of these alternative rainwater runoff management systems is harnessed.

(b) What does the measure entail?

This measure will support the implementation of Sustainable Urban Drainage Systems and Natural Water Retention Measures projects identified under measure FLD3. The implementation of this measure will be coordinated with Local Councils in order to increase the appreciation of these sustainable water management systems in the local context. Project implementation will be prioritised according to the project mitigation potential, both from a quantitative perspective (reduction in rainwater runoff generation) and the impact on the population and economic activities in the catchment.

(c) What is the geographical scope?

The measure applies to the entire Water Catchment District.

(d) What is the expected timeline for implementation?

The implementation of this measure is envisaged to start in 2020, and its implementation will be continued throughout the 2nd catchment planning period.

(e) Who is responsible for implementing this measure and which stakeholders need to be involved?

Lead: Sustainable Energy and Water Conservation Unit (SEWCU)

The following stakeholders would need to be engaged in the process:

- The Policy Development Directorate (PDD-MTI) within the Ministry for Transport and Infrastructure (MTI)
- The Environment and Resources Authority (ERA)
- The Planning Authority (PA)
- The Eco-Gozo Regional Development Directorate within the Ministry for Gozo (MGoz)
- The Marine, Storm Water and Valley Management Unit (MSWVMU) within the Ministry for Transport and Infrastructure (MTI)
- Transport Malta (TM)
- The Buildings Regulations Office (BRO)
- Local Councils

ENE2: Optimisation programmes to reduce energy requirements for the conveyance and distribution of municipal water supply.

(a) Why is it important?

Distribution of municipal water accounts for an additional operating costs to the utility. An optimisation exercise will seek to reduce energy consumption for RO product transfer from plant to distribution reservoirs and also reduce energy costs for water distribution at municipal level.

(b) What does the measure entail?

The Water Services Corporation will continue the upgrading programme of the primary municipal water distribution network in order to reduce energy losses during water distribution and therefore reduce the energy footprint of water distribution. The Corporation will establish best practice benchmarks based on current ‘best available technology’ and develop the action plans necessary for their phased achievements.

(c) What is the geographical scope?

The measure applies to the entire Water Catchment District.

(d) What is the expected timeline for implementation?

This measure should be considered as an ongoing measure, and its implementation will be continued throughout the 2nd catchment management cycle.

(e) Who is responsible for implementing this measure and which stakeholders need to be involved?

Lead: Water Services Corporation (WSC)

The following stakeholders would need to be engaged in the process:

- Sustainable Energy and Water Conservation Unit (SEWCU)
- The Regulator for Energy and Water Services (REWS)

ENE3: Comprehensive assessment of the potential utilisation of fresh- and saline- saturated zones for heating and cooling purposes.

(a) Why is it important?
This assessment is needed to study the impact of using the subsurface for heat dissipation and to ensure protection of the groundwater bodies from such practices.

(b) What does the measure entail?
Studies will be undertaken to assess the environmental impact on Malta's groundwater resources related to the use of the fresh- and saline- saturated zones for heating and cooling purposes. These studies will be proposed as part of EU funded research and development programmes, which will enable the experience of similar situations in other EU Member States to be fully considered. Regulatory instruments guiding the development of such practices will then be established on the basis of the scientific results of these studies.

(c) What is the geographical scope?
The measure applies to the entire Water Catchment District.

(d) What is the expected timeline for implementation?
The implementation of this measure is envisaged to start in 2019, and its implementation will be continued throughout the 2nd catchment planning period.

(e) Who is responsible for implementing this measure and which stakeholders need to be involved?
Lead: Sustainable Energy and Water Conservation Unit (SEWCU)
The following stakeholders would need to be engaged in the process:
- The Environment and Resources Authority (ERA)
- The Eco-Gozo Regional Development Directorate within the Ministry for Gozo (MGoz)

ECO1: Establish targets for the reduction of apparent losses in the municipal water distribution network and development of action programmes for the achievement of these targets.

(a) Why is it important?
Apparent losses induce a loss of revenue to the service provider. Their reduction is key to the cost-effective running of the Water Services Corporation and will ultimately improve operational efficiency.

(b) What does the measure entail?
The minimum technical and economic levels of apparent losses in the municipal water distribution system will be established by the Water Services Corporation. The Corporation will present an action programme outlining the timeframes in which these optimum operational levels will be achieved.

(c) What is the geographical scope?
The measure applies to the entire Water Catchment District.

(d) What is the expected timeline for implementation?
This measure should be considered as an ongoing measure, and its implementation will be continued throughout the 2nd catchment management cycle.

(e) Who is responsible for implementing this measure and which stakeholders need to be involved?
Lead: Water Services Corporation (WSC)
The following stakeholders would need to be engaged in the process:

- Sustainable Energy and Water Conservation Unit (SEWCU)
- The Regulator for Energy and Water Services (REWS)

ECO2: Increase awareness on the actual operational and maintenance costs related to groundwater abstraction and their impact on respective activities.

(a) Why is it important?

Few operators are aware of the effective operational costs of groundwater sources, boreholes in particular. These costs do not only include expenditure to cover energy and meter tariffs, but also capital cost for drilling and installation of pumping equipment. Groundwater abstraction is not free. Once these costs are made known, an increased appreciation of the value of groundwater abstraction will lead to more efficient practices in water use

(b) What does the measure entail?

An information campaign on the actual operational and maintenance costs incurred by operators of groundwater abstraction stations in the agricultural and commercial sectors will be undertaken with the aim of making these operators increasingly aware of the hidden costs of groundwater abstraction. A high level of awareness on these costs will induce operators to take increasing care in groundwater use.

(c) What is the geographical scope?

The measure applies to the entire Water Catchment District.

(d) What is the expected timeline for implementation?

The implementation of this measure is envisaged to start in 2017, and its implementation will be continued throughout the 2^{nd} catchment planning period.

(e) Who is responsible for implementing this measure and which stakeholders need to be involved?

Lead: Sustainable Energy and Water Conservation Unit (SEWCU)

The following stakeholders would need to be engaged in the process:

- The Rural Development Directorate General (RDDG) of the Ministry for Sustainable Development and Climate Change (MSDEC)
- The Eco-Gozo Regional Development Directorate within the Ministry for Gozo (MGoz)
- The Regulator for Energy and Water Services (REWS)
- The Environment and Resources Authority (ERA)
- The Water Services Corporation (WSC)

ECO3: Identification and quantification of non-monetized costs and benefits related to the wider use of water resources.

(a) Why is it important?

This is an economic study key to the development of the 2^{nd} RBMP and based on principles of IWRM. It is important to develop a wide economic study which takes into account resource and environmental costs and benefits, to enable a comprehensive assessment of economic water use

(b) What does the measure entail?

A study to quantify the non-monetized costs and benefits related to the use of water resources by the municipal, agricultural and commercial sectors will be undertaken. This study will attempt to quantify the benefits and costs to the country arising from the sue of water resources by these sectors.

(c) What is the geographical scope?
The measure applies to the entire Water Catchment District.

(d) What is the expected timeline for implementation?
The implementation of this measure is envisaged to start in 2018, and its implementation will be continued throughout the 2nd catchment planning period.

(e) Who is responsible for implementing this measure and which stakeholders need to be involved?
Lead: Water Services Corporation (WSC)
The following stakeholders would need to be engaged in the process:
- Sustainable Energy and Water Conservation Unit (SEWCU)
- The Regulator for Energy and Water Services (REWS)

9.3.3 Summary Table

The 2nd Water Catchment Management Plan identifies 45 measures intended to improve the water use characteristics within the Malta Water Catchment District, and therefore contribute to the achievement of the Water Framework Directive's good status objectives for inland natural water resources. These 45 measures are listed in the below table, which also highlights the envisaged implementation (start) date for each measure.

Code	Title of Measure	Implementation (Start) Date
Administrative Measures		
GVN1	Determination of the roles and responsibilities of all public sector agencies involved in the wider management of water resources	2016
RWH2	Development of the administrative capacity required to ensure the effective implementation of current legislative requirements in relation to the development of rainwater harvesting facilities and associated secondary water conveyance systems	2017
Codes of Good Practice		
GVN3	Development of guidance documents to assist operators in achieving best practice in water management practices	2017
PUB6	Establishment of water-use standards and guidelines for water use in public landscaping initiatives	2018
Demand Management Measures		
PUB1	Development of a Water Demand Map representing the spatial variation of water demand in terms of both quantity and quality, and establishing benchmarks for efficient water use.	2016
DOM1	Support mechanisms for water consumption audits in households.	2017
AGR1	Support schemes for the uptake of efficient irrigation technology by the arable agricultural sector	2016
AGR2	Support schemes for the uptake of efficient water	2016

	technology by the animal husbandry sector	
RWH4	Support schemes for the development of rainwater runoff harvesting facilities in the agricultural and commercial sectors	2016
Efficiency and Reuse Measures		
PUB2	Establishment of minimum technical and economic levels of leakage in the municipal distribution network, and achievement of these thresholds through the ongoing leakage management and control programme operated by the public utility	Ongoing / 2016
Desalination Plants		
DES2	Comprehensive assessment of the uptake of the tourism and commercial sectors of membrane based water treatment technology, and development of support schemes to attain this capacity	2018
ENE1	Establishment of specific power benchmarks for WSC Desalination Plants and continued upgrading programmes for the phased achievements of these benchmarks	Ongoing / 2016
Artificial Recharge of aquifers		
GWM4	Development of Managed Aquifer Recharge schemes for aquifer management purposes	2018
Educational Projects		
STE1	Development of a long-term National Water Conservation Campaign	Ongoing / 2016
STE2	Specific campaign to focus on educational activities on water management in schools	Ongoing / 2016
Research, development and demonstration projects		
NEW3	Development of Demonstration Sites for the application of New Water Resources	2016
ALT1	Comprehensive assessment of the exploitation natural coastal and submarine groundwater discharge	2017
ALT2	Comprehensive assessment of the exploitation potential of the saline aquifer system underlying the mean sea level aquifer system	2018
STE3	Development of demonstration projects to showcase the application of innovative technology in the local water sector	Ongoing / 2016
Other Supplementary Measures		
GVN4	Establish the training needs for public organisations involved in the water management sector.	2016
GVN5	Provision of specialised training opportunities for public officers in the water management field	2017
GVN7	Facilitate the public's access to information and their understanding of the decision making process to increase confidence in the institutions and policy formulation.	2016

PUB3	Establishment of a voluntary Eco-Labelling scheme for water-use fixtures and appliances.	2018
PUB4	Upgrading of the water use efficiency of public buildings and structures.	2019
PUB5	Support mechanisms for research initiatives on grey-water recycling systems for the domestic and commercial sectors	2018
AGR3	Advisory services to support farmers interpret groundwater metering data to better streamline their operations and achieve high levels of water use efficiency.	2017
GWM1	Review of existing groundwater resource models and development of a new numerical model to assess sustainable groundwater yield.	2016
GWM2	Optimisation of the public groundwater network infrastructure to limit localised sea-water intrusion and protect the yield of public groundwater abstraction stations.	2018
RWH1	Survey of the status of existing rainwater harvesting infrastructure, identification of potential users of rainwater harvested in these infrastructures, undertaking of rehabilitation works and development of a management framework to ensure the effective use of harvested rainwater.	2017
RWH6	Rehabilitation of existing rainwater harvesting dam structures in valleys.	2017
NEW1	Commissioning of three polishing plants with a production capacity of 7 million m3/year	2016
NEW2	Development and implementation of a branding campaign for New Water Resources	2016
NEW4	Development of dedicated distribution facilities for New Water to enable its availability at the point of use.	2017
MDM1	Comprehensive upgrading of the hydrological cycle monitoring capacity.	2017
MDM7	Development of a water scarcity and drought monitoring and assessment platform.	2018
QLT2	Upgrading of the public sewerage system to reduce both leakages from sewers as well as the infiltration of sea-water into sewers.	Ongoing / 2016
FLD1	Modelling the impact of the National Flood Relief Project on flood hazard and risk in identified catchments.	2017
FLD2	Flood Hazard and Risk Assessment in catchments not included in the National Flood Relief Project.	2018
FLD3	Comprehensive assessment for the inclusion of Sustainable Urban Drainage Systems and Natural Water Retention Measures to mitigate flood hazard and risk.	2019

FLD5	Implementation of Sustainable Urban Drainage Systems and Natural Water Retention Measures as identified under measure FLD3	2020
ENE2	Optimisation programmes to reduce energy requirements for the conveyance and distribution of municipal water supply.	Ongoing / 2016
ENE3	Comprehensive assessment of the potential utilisation of fresh- and saline- saturated zones for heating and cooling purposes.	2018
ECO1	Establish targets for the reduction of apparent losses in the municipal water distribution network and development of action programmes for the achievement of these targets.	Ongoing / 2016
ECO2	Increase awareness on the actual operational and maintenance cost related to groundwater abstraction and their impact on respective activities.	2017
ECO3	Identification and quantification of non-monetized costs and benefits related to the wider use of water resources.	2018

10. Economic Analysis of Water Use

10.1 The dependency of market and non market activities on the coastal and marine environment

This section of the economic analysis concerns coastal waters and is based on the findings of the Economic and Social Analysis carried out as part of Malta's implementation of the Marine Strategy Framework Directive Initial Assessment[243]. The full report is accessible from the following webpage and should be consulted for more detailed information: http://www.mepa.org.mt/water-msfd-initial_assessment. For purposes of this Chapter activities carried out in coastal waters as well as land based and offshore activities which have potential effects on the quality of coastal waters were included in the assessment.

The Marine Waters Accounts Approach was applied to assess the direct and indirect use made of the marine environment with respect to two broad types of activities:

- Economic Sectors – marketed activities;
- Recreational and others – non-marketed activities[244].

The indicators that could be used to estimate the use of coastal waters by economic sector are the following:

- Production value,
- Use of intermediary products (at purchase prices),
- Gross value added,
- Employer's wages,
- Labour force.

Potential indicators of importance for assessing use values not reflected in market values are:

- Expression of economic and social preferences, via public consultation, newspapers, etc.;
- Market prices for complementary products (e.g. fishing licenses, scuba equipment);
- Recreation values;
- Different survey results (e.g. opinion polls, willingness-to-pay studies).

The **Marine Waters Accounts Approach** firstly involves the identification of those economic sectors using coastal and marine waters, including direct and indirect-use economic sectors and activities as well as non-use values (refer to Box 1). Economic benefits derived from the economic sector's use of coastal waters are then quantified in terms of production value, intermediate consumption, value added, and number of employees and compensation of employees. Finally impacts generated by these sectors on the marine environment are quantified.

10.1.1 Marketed Activities: Economic Sector dependency on coastal waters

When considering the activities engaged by economic sectors, it is estimated that approximately 15.4% of Malta's economy is dependent on the marine environment [245] for one of the following reasons:

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[243] AAE Consortium, 2013. Result 3B: A report on the economic and social analysis of the use of marine waters and of the costs of degradation of the marine environment as defined by the MSFD, stating assumptions and sensitivity of analysis and integration of this report in the MSFD Initial Assessment.

[244] Non-marketed activities also include activities that are marketed but the price charged for their consumption is not a true reflection of their worth to the economy. Potable water (in the form of desalinated sea water) is an example of this.

[245] This reflects the average marine dependence over the period 2006-2012 as calculated in the AAE Consortium 2013 report

- Marine waters **provide resources** that are required directly or as an intermediate consumption by these sectors; e.g. Economic sectors 'fishing and aquaculture' and 'water collection, treatment and supply' directly extract the sea's resources. Other sectors including 'crop and animal production' or manufacturing of food products' make use in part of desalinated sea water as an intermediate product in the manufacture of their goods.
- the marine environment is used as a **direct/indirect input into the product or service provision** of certain economic sectors. Examples of such economic activity include the manufacturing of marine transport equipment; water transport; recreation and tourism activities; telecommunications/cables etc.
- the marine environment acts as **a sink for waste and/or by-products** produced by some sectoral activities such as urban waste water discharges, desalinated water brine discharge, crop and animal production waste by-products; and construction waste disposed of at sea.

The value of 15.4% compares to approximately 3-5% of Europe's GDP[246] that is generated from sea-related industries and services. The greater dependence of Malta on the marine environment is expected due to the fact that Malta is an island, and therefore it relies to a greater extent to marine-related activities both for recreational and marketed activities. In addition, the fact that Malta is a small island state implies that (i) the proportion of coastal area to total land area is proportionately large; and (ii) the possibility for diversification into a variety of activities is more restrictive, implying that Malta's dependence on the marine environment would naturally be greater (AAE, 2013).

		Use of the coastal environment				
Economic Activity	**Description of activity**	**Provision of resources**		**Input into product or service provision**		**Absorbing waste or by-products**
		Directly	**Inter-mediate consumption**	**Directly**	**Indirectly**	
Aquaculture and mariculture fisheries	Crop and Animal Production	✓				
Shipping construction and transport	Manufacture of transport equipment			✓		
	Repair and installation of machinery equipment			✓		
Defence - Military	Public administration and defence; social security			✓		
Tourism	Retail trade, except of motor vehicles and motorcycles				✓	
	Accommodation,			✓		
	Food and beverage service activities				✓	
	Real Estate				✓	
	Travel Agency, tour operator and other reservation services and related activities			✓		
Mining (gravel, sand and shell extraction)	Other mining and quarrying	(✓)				
	Mining support service					

[246] This is estimated for 2004

	activities					
Oil and Gas	Electricity, gas, steam and air conditioning supply					
Cables (e.g. Power transmission, Telecommunications, Pipelines – interconnectors)	Land transport and transport via pipelines Telecoms Gaming				(✓) ✓ ✓	
Water abstraction	Water collection, treatment and supply	✓	✓			✓
The use of the marine water for waste and wastewater disposal (agriculture, industry, households etc.)	Sewerage Remediation activities and other waste management services					✓ ✓
Water Transport	Water transport Warehousing and support activities for transportation			✓ ✓		(✓)
Supporting infrastructure (e.g. ports, marinas, navigation, aids)	Civil engineering Specialised construction activity			✓ ✓		
Others	Crop and animal production Manufacture of food products Manufacture of beverages Insurance, reinsurance Legal and accounting Architectural and engineering Scientific research and development Veterinary activities Creative arts and entertainment Library, museum, Culture Sports activities and amusement and recreation activities Activities of membership organisations		✓ ✓ ✓	✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓	✓	✓

Table 10.1: Economic sector dependency on coastal and marine waters

The use of the marine environment per sector was analysed in the AAE report (AAE, 2013) and then aggregated in order to obtain a global value for each of the variables assessed. A summary of the outcome of the analysis per sector is presented in the table below.

NACE Code	Economic sector (based on NACE codes)	Description of the use of coastal and marine resources	Estimated % dependency of economic sector on coastal water[247]
1	**Crop and Animal Production**	Use of desalinated water as an input into product provision.	9.5%
		Sink function for waste and other by-products (runoff off from fertilised land contributes to nutrient enrichment of coastal waters).	
3	**Fishing and aquaculture**	Fishing results in direct extraction of resources from the sea.	100%
8, 9	**Mining and mining support activities**	Sporadic oil exploration activity is undertaken in Malta. To date no oil has been extracted in commercial quantities however part of this activity takes place at sea.	5%
10, 11	**Manufacturing of food products and beverages**	Desalinated sea water is partly used as an input in the manufacturing of food products. Approximately 39.9% of all water consumed by this sector is desalinated sea water.	39.9%
		Desalinated sea water is also used as an intermediate consumption in the production of beverages in Malta.	49.5%
30, 33	**Manufacture of transport equipment and repair and installation of machinery equipment**	Since shipping is an important sector to the national economy, the sea is directly used as an input for the provision of this service. 56% of activities related to the manufacturing of transport equipment and repair was attributed to shipping.	56%
35	**Electricity, gas, steam and air conditioning supply; Water Collection, treatment and Supply; Sewerage and other waste management services**	Electricity production requires water as an intermediate consumption for cooling purposes. In addition the importation of oil and gas is a sea-based activity.	90%
36		The direct extraction of sea water is used for consumption as well as intermediate consumption for some sectors.	
37,39		Treated sewerage is disposed of at sea and is therefore used as a sink.	
42	**Civil Engineering and specialised construction activity**	Marine related construction is significant in Malta and therefore the sea is directly used as an input in the provision of marine infrastructure.	8.6%
43		Some construction waste is also disposed of at sea.	
47	**Retail trade**	Malta, as a sun and sea destination indirectly adds the amount of retail sales via tourism activity.	6.6%
50	**Water Transport**	Water transport necessarily implies that this sector requires the sea in order to provide its service	100%
52	**Warehousing and support activities for transportation**	Warehousing includes the activities of the Malta Freeport Corporation which makes direct use of the sea in its operations. This NACE category also includes the activities of ship chandlers among others that make direct use of the sea in order to service ships/cruise liners.	90%
55	**Accommodation**	A 2012 Malta Tourism Authority (MTA) survey was used to estimate the percentage of tourists that make use of the sea. Activities such as swimming, diving, water sports, make up a substantial percentage of the activities by tourists	62.3%

[247] Based on findings of AAE Consortium 2013 report

56	**Food and beverage service activities**	Dining at restaurants with a sea view is generally more attractive. As a result this sector makes indirect use of the sea in the provision of its service. There is a significant incidence of coastal restaurants in the Maltese Islands.	75%
61	**Telecoms**	A substantial part of the telecoms sector's activity makes direct use of the sea due to its dependence on cables between Malta and Sicily for its service provision.	35%
65	**Insurance and reinsurance**	A small amount of insurance activity in Malta is carried out on maritime vessels and on goods transported by sea.	4%
71 and 72	**Architectural and engineering Scientific research and development**	To some extent architectural and engineering activities together with Research and Development are assumed to pertain to marine-related activities such as marine infrastructural projects and marine research.	5%
79	**Travel agency, tour operators and other reservation service**	Similar to the accommodation sector, a number of tourists come to Malta to engage in sea related activities. A number of tourists also visit Malta on cruise liners.	62.3%
84	**Public administration and defence; social security**	A part of the activities of the public sector relate to the marine environment. Particular reference here is made to the activities of the marine squad of the Armed Forces of Malta (AFM) as well as the customs department. The customs department is estimated to employ approx. 3.7% of total employees in public administration. In addition approx. 1.3% of government expenditure is estimated to be spent on irregular migration.	4.9%
90	**Creative arts and entertainment**	The film industry in Malta makes use of the marine environment and this economic sector continuously growing.	15%
92	**Gaming**	As in the Telecoms sector this sector is heavily dependent on underwater cables for its operation.	35%
93	**Sports activities and recreation**	Some sports activities/ events and recreational activities directly use the marine environments as an input into its service provision.	10%

Table 10.2: Estimated dependency of the economic sector on coastal waters (%)[248]

Through the assessment made it emerged that it is important to assess the marine-dependent element of marine sectors within the total economy. Therefore, in order to gauge how relevant the marine environment is to Malta's economy and how important it is to safeguard, the same exercise is undertaken with respect to all economic sectors in Malta.

Table 10.3 illustrates Malta's dependence on the marine environment for 2006-2012. For 2012, the following rates apply:

- 14% in terms of FTE employment;
- 22% in terms of Output;
- 27% in terms of Intermediate consumption;
- 14% in terms of Gross Value Added;
- 17% in terms of Gross Operating Surplus;
- 13% in terms of Compensation to Employees

[248] This is based on the average GPD of 2006-2012 period

	Total Economy marine-related sectors							
	2006	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**Average Growth**
FTE employment*	83,876	85,656	86,474	86,666	87,579	89,543	90,899	1.3%
Output	5,093,138	5,739,337	6,552,902	6,452,288	6,951,706	7,282,125	7,755,512	7.3%
Intermediate Consumption	2,893,935	3,321,105	3,828,030	3,783,814	4,161,306	4,424,311	4,820,266	8.9%
Gross Value Added	2,199,204	2,418,233	2,724,872	2,668,473	2,790,400	2,857,815	2,935,245	4.9%
Gross Operating Surplus	1,220,027	1,367,355	1,574,217	1,578,219	1,637,440	1,904,175	1,688,158	5.6%
Compensation to Employees	1,012,713	1,079,227	1,166,987	1,167,002	1,171,016	967,312	1,257,895	3.7%

	Proportions of Economy Depending on Marine Environment to Total Economy							
	2006	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**Average Growth**
FTE employment*	15%	15%	16%	14%	14%	14%	14%	-0.2%
Output	19%	20%	22%	21%	21%	21%	22%	0.5%
Intermediate Consumption	22%	23%	26%	24%	24%	25%	27%	0.8%
Gross Value Added	15%	15%	17%	16%	15%	15%	14%	-0.1%
Gross Operating Surplus	17%	18%	18%	19%	18%	18%	17%	0.0%
Compensation to Employees	14%	14%	16%	14%	13%	13%	13%	-0.3%

Table 10.3: Total dependence of marine-related sectors on the marine environment

*****_FTE employment is measured in number of persons. Other variables are in €000s_

The national economy's dependence on the marine environment, with respect to employment and GVA as shown in Table 10.3, has experienced a decline over the period 2006-2012. The annual decline in marine-dependent employment averaged 0.2% since 2006 (also reflected in a reduction in compensation to employees) whereas marine-dependent GVA contracted by 0.1% p.a.

Though a decline in Malta's dependence on the marine environment has been registered over the six years (2006-2012) when the economic study was carried out, the GVA of the marine-dependent portions of the sectors of economic activity under review actually grew by an average of 4.2% p.a. However, since total economic activity increased by 4.7% p.a. over the same period, the dependence on the marine environment is seen to have declined. This is illustrated in table 10.4 below.

This assessment is made in Table 10.4. The table also shows that the growth in employment of marine-dependent sectors (in proportion to their dependence on the marine environment) grew by 0.5% p.a. compared to 1.3% p.a. of total employment. This also reflects the drop in dependence on the marine environment (with respect to GVA and employment) in 2012 from 14% compared to the average for the period 2006-2012 which amounted to approximately 15%. This could be due to a shift to services that make use of the marine environment to a lesser extent than primary and secondary sectoral activities[249]. This trend could in future be reversed as a result of specific economic growth strategies which focus more directly on the use of the marine environment including transport, land reclamation and energy investments as well as potential research and development based and knowledge creation activities.

[249] A notable exception to this has been the shift in recent years towards gaming whose activity is partly dependent on the marine environment as a result of its extensive use of underwater cables.

Sectors	NACE Codes	Marine Dependent GVA/ TOTAL ECONOMY GVA	Marine Dependent Employment/ Total Economy Employment	Growth in Marine Dependent GVA	Growth in Marine dependent employment
Aquaculture, mariculture & fisheries	3	0.4%	0.5%	-8.5%	1.6%
Shipping construction and transport	30, 33	0.6%	0.7%	2.0%	-26.7%
Defence - Military	84	0.3%	0.4%	1.4%	-2.4%
Tourism	47,55,56,68,79	4.4%	6.6%	4.6%	2.2%
Mining (gravel, sand and shell extraction)	8, 9	0.0%	0.0%	-9.0%	-7.6%
Oil, Gas, Water Abstraction, Waste and Wastewater	35,36,37,39	1.2%	1.4%	-	-3.4%
Cables (e.g. power transmission, telecommunications, Pipelines – interconnectors)	49, 61, 92	3.4%	1.2%	14.4%	12.4%
Water transport	50, 52	3.8%	2.1%	6.1%	2.1%
Supporting infrastructure (e.g. ports, marinas, navigation aids)	42, 43	0.2%	0.3%	6.9%	5.1%
Agriculture	1	0.1%	0.3%	-0.1%	0.6%
Food and Beverage Manufacturing	10, 11	0.8%	0.8%	2.6%	-0.8%
Others	65, 69, 71, 72, 75, 90, 91, 93, 94	0.2%	0.3%	10.2%	8.3%
Total		**15.4%**	**14.7%**	**4.2%**	**0.5%**

Table 10.4: Average use and growth of the marine-dependent sectors (2006-2012[250])

When assessing the average dependence on the marine-environment by sector over the period 2006-2012 the tourism sector is considered to be that with the highest dependence (based on GVA and FTE employment), and to a lesser extent, followed by water transport and cables/telecoms[251]. This, however, also reflects the size of these sectors in the local economy and not strictly their dependence. The aquaculture/fisheries sector is considered to be the seventh most marine-dependent sector in the Maltese economy notwithstanding its 100% dependence on the marine environment as opposed to the third ranked cables/telecoms sectors that are assumed to use the marine environment for 35% of their total economic activity.

10.1.2 Non- Market Activities: Other dependencies on the coastal and marine environment

Other non-marketed activities were also assessed by means of the economic assessment carried out in 2012. These were:

(i) Non Market recreational activities

(ii) The production of potable water which depends on direct abstraction from the sea

(iii) The total value of the benefits from implementing the EU environmental acquis (with particular reference to the EU's water directives)

[250] The term "oil and gas" does not include the exploitation of hydrocarbons (corresponds with NACE 8&9).

[251] The % of FTE employees in the marine-dependent activities of the Oil, Gas, Water abstraction, Waste and Wastewater exceed those in the Cables sectors though the latter is larger in terms of GVA.

(i) *An evaluation of the contribution of the marine environment to non-market recreational activities in Malta – the willingness to pay for making use of beaches and similar amenities.*
Two dissertations carried out at a post graduate level at the University of Malta attempted to value the beaches at Pretty Bay in Birzebbuga and Ramla Bay in Gozo, in part by means of survey exercises aimed at deriving the willingness of respondents to pay for the use of the beaches. These studies, which are based on a sample of 100 visitors to each beach during the peak summer period, found that respondents were on average willing to pay €1.40 (at 2004 valuations/prices) per visit to Pretty Bay and €1.60 (at 2005 valuations/prices) per visit to Ramla Bay. The same studies report the number of annual visits to Pretty Bay and Ramla Bay at around 285,000 and 265,000 respectively. Adjusted for the effects of inflation since the reference periods of these studies to report values at 2012 prices, these results entail that the annual value created out of the willingness to pay to visit Pretty Bay and Ramla Bay during the summer period only amounts to around €475,000 and €490,000 respectively per annum. Considering the shore length of each of these two beaches in relation to the total shore length used for bathing in Malta and the assumptions made within this study, the willingness to pay to visit bathing areas in the country would be estimated at around €7 million[252] per annum.

This estimate is subject to the assumption that valuations for Pretty Bay and Ramla Baycan be extended to other bathing sites in Malta, and is also subject to the same limitations arising from the potentially high sampling errors in estimating the values of Pretty Bay and Ramla Bay. Furthermore, Ramla Bay and Pretty Bay are in different geographical areas and are both sandy beaches and may therefore not be representatives of other sandy beaches or indeed rocky sites.

(ii) The contribution of the marine environment to the production of potable water in Malta
This was assessed on the basis of the JASPERS (2008) report. An estimate of the direct use contribution of the marine environment to the production of potable water in Malta is made by considering the cost of replacing water production techniques, based on the desalination of sea water, with storm-water harvesting6. - The incremental cost of rainwater harvesting infrastructure is estimated to equal €9.1 per m^3. Extending this cost to the 18.7 million m3 of water per annum produced through desalination would yield an estimate of the avoided cost of almost €170 million per year. This can be considered as an estimate, however partial, of the value which the marine resource provides to the production of water in Malta. The bulk of this cost emanates from the need for storage and associated distribution facilities. Assuming that the costs of storage are around 75% of the total, a more prudent estimate of the contribution of the marine resource to water production in Malta is derived on the basis of 75% of the result which would imply a contribution of €127.4 million per annum.

(iii) Benefits emerging from implementation of water related EU Acquis
Protection of the coastal and marine environment as an important resource is important in ensuring that goods and services can continue to be provided and benefits to health are guaranteed. Therefore the environmental, economic and social benefits that is likely to arise from successful implementation of EU environmental legislation needs to be taken into account too.

The AAE report (2013) make reference to the ECOTEC et al (2001)[253] study which estimated the environmental, economic and social benefits that are likely to arise from the full implementation of the

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252 This estimate reflects the fact that the shorelines of Ramla Bay and Pretty Bay constitute 14% of the total shoreline length of bathing areas in Malta. This estimate is subject to the assumption that valuations for Pretty Bay and Ramla Bay can be extended to other bathing sites in Malta, and is also subject to the same limitations arising from the potentially high sampling errors in estimating the values of Pretty Bay and Ramla Bay. In addition Ramla Bay and Pretty Bay are in different geographical areas and are both sandy beaches and may therefore not be representatives of other sandy beaches or indeed rocky sites.
253 ECOTEC et al., 2001, "The benefits of compliance with the environmental acquis for the candidate countries", DG Environment, European Commission, Brussels.

EU environmental legislation in the countries that were candidate states at that time[254]. It assesses the hidden costs to the economy caused by lower environmental standards through a loss of output and inefficient production. This assessment, therefore, does not estimate the costs of implementing the EU environmental legislation but quantifies the benefits of doing so.

This study explored what type of benefits arise from implementing the acquis, the extent of these benefits and the economic value of the avoided costs once the EU environmental acquis is fully implemented. It must be kept in mind that studies like these do not gauge the impacts of the EU Directives with precision.

The value of benefits reaped represent the level of income people would be willing to give up for a specific benefit, for instance clean drinking water or health, and the value to society as a whole of avoiding a number of cases of premature death. They are not a measure of increased wealth or GDP. Nevertheless, assessing what the benefits are worth is a useful tool for understanding the implications of implementing EU directives or of delaying their implementation.

The total value of the benefits Malta was to derive from full compliance with the EU's water related directives (by 2010) according to the ECOTEC report was estimated to lie in the range of €13 and €47 million. The ECOTEC (2001) was updated in 2011 by the EC to assess the costs, to the 27 EU member states, of not implementing the EU environmental acquis. The directives that aim to improve the quality of water were analysed in this report with the estimated total cost accruing to the EU-27 member states estimated to range between €5 and 20 billion per annum.

10.2 Assessing the costs of impacts on coastal and marine waters cause by economic and non-market activities

The economic analysis carried out in 2012 also assessed how economic and non-marketed activity is causing undue pressure on the marine environment and the ensuing impacts generated. Most of this assessment was carried out qualitatively, although a quantitative assessment is provided when assessing the costs of CO2 emissions resulting from these marine-dependent sectors using shadow pricing.

10.2.1 Method

The report shows how, in 2011, the sectors that are most dependent on the marine environment were also those most emitting CO2 emissions. These sectors were estimated to contribute approximately 63% of total emissions, valued at a shadow cost of some €47 million, or approximately 8% of Malta's GVA in 2011. The linkages between the environmental impacts and the marine dependent sectors are then used to estimate the costs of degradation of the marine environment using the Ecosystem approach. Two approaches are adopted, namely:

(i) *From environmental impacts to the marine-dependent economic sectors:* This assessment aims to answer the question "if the marine environment (or its use) were to be degraded, which economic activities would be affected?" Therefore the report assesses how the degradation of the marine environment (magnitudes of environmental impacts) would affect the marine dependent economy and, as a result, the economy in its entirety;

(ii) *From the marine-dependent economic sectors to the environmental impacts*: This assessment aims to answer the question "in order to preserve the marine environment (and move towards achieving good ecological and good chemical status under the WFD and Good environmental status under the MSFD), which economic activities must be focussed upon in a

[254] These include: Bulgaria, Cyprus, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Malta, Poland, Romania, Slovakia, Slovenia and Turkey.

priority manner for technological and environmental management improvements with respect to their impact on the marine environment and the associated level of costs which would be justifiable?" This will, therefore, assess how certain economic activity is causing degradation of the marine environment and, therefore, the justifiable costs (in terms of additional investment) that the country would be willing to entail in order to ensure technological and environmental management improvements that would limit damage so as to preserve the marine environment and possibly reach both WFD and MSFD objectives.

A number of scenarios were considered under each approach, each with varying degrees of impacts on the marine environment.

For (i) i.e. From environmental impacts to the marine-dependent economic sectors:

- **Scenario 1:** The Business as Usual (BAU) scenario portrays a situation where the degradation of the marine environment will follow current trends (assuming a level deterioration in each of the impact indicators of 5%)[255].
- **Scenario 2:** The scenario analysis assesses the effects on sectoral and total economy's GVA of a 10% level deterioration of just one of the environmental impact indicators at a time.

For (ii) i.e. From the marine-dependent economic sectors to the environmental impacts:

- **Scenario 1:** The Business as Usual (BAU) scenario shows the impact on environmental degradation of the share of the marine dependent economy (average 2006-2012).
- **Scenario 2** assesses the additional investment required to ensure technological and environmental management improvements that would achieve a 10% level reduction in environmental degradation:
    - 1. The assessment will first consider the investment required in those sectors that cause most environmental degradation in total, namely (a) water transport, (b) oil, gas , water abstraction, waste and wastewater, and (c) tourism;
    - 2. The required investment expenditure in those sectors that are less environmentally-harmful is then also considered.
- **Scenario 3** estimates the improvement in environmental degradation as a result of a 10% reduction in the responsiveness of environmental impact indicators with respect to the economic activity of those sectors that currently cause most harm to the marine environment (for instance due to technological improvement).

10.2.2 Results

10.2.2.1 From environmental impacts to the marine-dependent economic sectors: Scenario 1

In the absence of better information, expert opinion assumed that the degradation of the marine environment, as reflected by the worsening of 8 impact indicators under review, would deteriorate as follows:

i) Physical loss – 5%;
ii) Physical damage – 5%;
iii) Other physical disturbance – 5%;
iv) Interference with hydrological processes – 5%;

[255] This report identifies levels of degradation without assigning a time dimension to it due to the lack of data. As more information becomes available, the analysis and results can be adapted for this purpose. The 5% loss was arbitrarily chosen for illustrative purposes.

v) Contamination by hazardous substances – 5%;
vi) Systematic and/or intentional release of substances – 5%;
vii) Nutrient and organic enrichment – 5%;
viii) Biological disturbance – 5%.

After multiplying each of these with the corresponding elasticity and summing these up for each sector, one can determine the effect of environmental degradation on sectoral value added. A summary of the broad effects of this is provided in Table 10.5.

Economic Sector	NACE CODE	Elasticity	Rank
Aquaculture, mariculture & fisheries	3	1.63	1
Shipping construction and transport	30, 33	0.06	10
Defence - Military	84	0.00	12
Tourism	47,55,56,68,79	0.94	2
Mining (gravel, sand and shell extraction)	8, 9	0.13	8
Oil, Gas, Water Abstraction, Waste and Wastewater	35,36,37,39	0.81	3
Cables (e.g. power transmission, telecommunications, Pipelines – interconnectors)	49, 61, 92	0.13	8
Water transport	50, 52	0.06	10
Supporting infrastructure (e.g. ports, marinas, navigation aids)	42, 43	0.50	5
Agriculture	1	0.50	5
Food and Beverage Manufacturing	10, 11	0.59	4
Others	65, 69, 71, 72, 75, 90, 91, 93, 94	0.49	7

Table 10.5: Baseline Scenario results when assessing if the marine environment (or its use) were to be degraded, which economic activities would be affected

Given the relationships assessed, environmental degradation is seen to be most harmful to the fishing and aquaculture sector and to a lesser degree tourism and the group that aggregates oil, gas[256], water abstraction, waste and wastewater activities. The impact of environmental degradation on the total economy is estimated to amount to 0.4%[257] in terms of lost economic value added.

10.2.2.2 From environmental impacts to the marine-dependent economic sectors: Scenario 2

Through this scenario analysis, it was assumed that one of the impact indicators worsens by 10% whilst keeping all others constant. The main resultant impacted on the GVA was from an increased contamination of marine waters by hazardous substances followed by other physical disturbance (including noise pollution and marine litter), and the systematic and intentional release of substances.

[256] The term "oil and gas" corresponds with the Electricity, Gas, Steam and Air-conditioning supply as defined by NACE 35 of Eurostat. It does not include the exploitation of hydrocarbons (which would correspond with NACE 8&9).

[257] The loss in GVA is considered to be a level loss. This implies that the loss of 0.4% occurs once and not on an annual basis. It is, however, considered to be a permanent loss.

10% deterioration in impact indicator:	Loss in GVA	Rank
Physical loss	0.07%	6
Physical damage	0.11%	4
Other Physical Disturbance	0.14%	2
Interference with Hydrological Processes	0.07%	7
Contamination by hazardous substances	0.15%	1
Systematic and/or intentional release of substances	0.12%	3
Nutrient and organic matter enrichment	0.06%	8
Biological disturbance	0.07%	5

Table 10.6: Loss in GVA due to a 10% deterioration in one of the Impact Indicators

The sectors contributing most to the loss in GVA, both due to the impact suffered as well as their size in proportion to the rest of the Maltese economy relate in the most part to tourism, while oil, gas, water abstraction, waste and wastewater as well as the food and beverage industry are also affected mainly when contamination of water is concerned. The fishing and aquaculture sector, despite its small size, emerged also as a main cause for the decline in economy GVA where environmental degradation is caused by the physical loss, nutrient and organic enrichment as well as biological disturbance impact indicators.

10.2.2.3 From the marine-dependent economic sectors to the environmental impacts – Scenario 1

When considering the effects that economic activity has on the marine environment, it is estimated that the activities of 15.4% of the economy (i.e. the marine-dependent economy) cause approximately 11.7% level deterioration in the marine environment. The sectors that are considered to be causing most harm (also due to their size) are (i) Water transport, (ii) Tourism, and (iii) Oil, Gas, Water Abstraction, Waste and Wastewater. If one were not to consider the size of the sector, other activities such as the shipping construction and transport sectors, supporting infrastructures and fishing and aquaculture sectors also lead to substantial degradation of the marine environment. Table 10.7 summarizes and ranks the impact on environmental degradation by unit of activity.

Economic Sector	NACE CODE	Ranking- Overall average impact on environmental degradation	Ranking- Average impact on environmental degradation by unit of activity
Aquaculture, mariculture & fisheries	3	6	5
Shipping construction and transport	30, 33	5	3
Defence - Military	84	7	8
Tourism	47,55,56,68,79	2	10
Mining (gravel, sand and shell extraction)	8, 9	12	7
Oil, Gas, Water Abstraction, Waste and Wastewater	35,36,37,39	3	1
Cables (e.g. power transmission, telecommunications, Pipelines – interconnectors)	49, 61, 92	4	11
Water transport	50, 52	1	1
Supporting infrastructure (e.g. ports, marinas, navigation aids)	42, 43	10	3
Agriculture	1	11	6
Food and Beverage Manufacturing	10, 11	8	11
Others	65, 69, 71, 72, 75, 90, 91, 93, 94	9	9

Table 10.7: Average impact on environmental degradation by economic sector

Total environmental degradation, amounting to 11.7%, reflects the effects that marine-dependent economic activity has on the individual impact indicators. The environmental impacts that are being most affected by this economic activity in Malta are (i) physical damage, (ii) other physical disturbance, and (iii) contamination by hazardous substances as indicated by table 10.8.

10% deterioration in impact indicator:	Effect on indicator	Rank
Physical loss	10.1%	4
Physical damage	19.6%	1
Other Physical Disturbance	15.8%	2
Interference with Hydrological Processes	7.1%	7
Contamination by hazardous substances	15.3%	3
Systematic and/or intentional release of substances	9.2%	6
Nutrient and organic matter enrichment	6.8%	8
Biological disturbance	10%	5

Table 10.8: Ranking of impact indicators most harmed by economic activity

Physical damage is mostly caused by the extensive occurrence of boating in Malta as well as dredge spoil occasionally disposed of at sea. Other physical disturbance mainly reflects noise pollution (caused by boating as well as other activities including oil exploration) and marine litter. Lastly a number of activities are seen to pollute by way of hazardous substances including, among others, water transport, waste as well as agriculture. A more detailed description of the sectors affecting each impact indicator is provided in the report itself which is accessible from: http://www.mepa.org.mt/water-msfd-initial_assessment.

10.2.2.4 From the marine-dependent economic sectors to the environmental impacts – Scenario 2

In the case of Scenario 2 the estimation of the required investment that Malta would be willing to entail in order to ensure technological and environmental management improvements that would result in a 10% level reduction in environmental degradation was assessed. Two options were taken:

(i) investment in those sectors that cause most environmental degradation;

(ii) investment in all other sectors.

In the case of (i) The sectors that are considered to cause most damage to the marine environment include: (a) Water transport, (b) Oil, gas, water abstraction, waste and wastewater, and (c) Tourism. If just these sectors were targeted in order to achieve a reduction in environmental degradation of 10%, then the required investment expenditure would amount to 12.9% of the sectors' value added. This is equivalent to 1.2 percentage points of the total marine-dependent GVA.

With respect to (ii) the required investment expenditure in those sectors causing less harm would amount to 43.1% of their value added – equivalent to 4.1 percentage points of total marine-dependent GVA. The willingness to pay for investment, in terms of annualised capital outlay values, in improvement in technology and management with respect to the impact of sectors on the marine environment can be established at the level of the foregone value added which would have to take place to achieve equivalent environmental results should this investment not materialise.

With present patterns of degradation, the output foregone in the more damaging sectors (1.2 percentage points) would be lower than that in the less intensive sectors (4.1 percentage points) such that an investment of 12.9% is estimated to be equivalent to 43.1% in the less intensive sectors. Therefore, in order to achieve an improvement in the quality of the marine environment, it would be more effective to target those sectors that are causing greatest impact on coastal and marine waters.

10.2.2.5 From the marine-dependent economic sectors to the environmental impacts – Scenario 3

The last scenario considers the introduction of policy and/or cleaner technology, for instance, in order to reduce the responsiveness of the environmental impact indicators to economic activity by 10%. The sectors considered for this scenario are those found to cause most harm to the marine environment, namely water transport, oil, gas, water abstraction, waste and wastewater, and tourism.

This would imply that the 15.4% marine-dependent economic activity would cause a 10.8% level deterioration of the marine environment (compared to the original 11.7%). Therefore, the impact indicators would show an improvement of 8% over the business as usual scenario. The results from this approach, particularly with respect to the interlinkages between marine-dependent economic sectors and environmental impacts can assist in the development of indicators used to measure Good Environmental Status in terms of the Marine Strategy Framework Directive, which can also be used for the WFD.

The costs of degradation of the marine environment were also estimated through the Cost Based approach. Two aspects were considered in this regard, namely:

(i) The WFD Programme of Measures implementation (2011) report provides an indication of the costs of implementing the actions that were introduced as part of the 1st WCMP required by the Water Framework Directive (WFD) by 2015 as well as other EU directives including the Nitrates Directive, and the Urban Waste Water Treatment, the Bathing Water Directive, and the Drinking Water Directive, among others.

    The total costs incurred by MEPA in implementing basic and supplementary measures under the first WCMP amounted to €90.9 million in investment costs[258] and €132,000 in annual operational costs.

(ii) MEPA estimates of the costs involved in coastal management, including monitoring the cleanliness of the marine environment, are also assessed. Approximately €4 million is expected to be spent over 3 years on coastal and marine monitoring including monitoring related to the Nitrates Directive (NiD), the Water Framework Directive (WFD), the Marine Strategy Framework Directive and the Barcelona Convention, amongst others.

10.3 Economic Characterisation of Groundwater Use

This chapter examines the economic characteristics of groundwater resources in Malta as required by Article 5 of the WFD 2000/60/EC and as transposed by Legal Notice 194/2004 on the Water Policy Framework Regulations. The main economic elements in the WFD are:

- Article 4 which specifies the environmental objectives and indicates that the selection of measures for achieving good ecological status should be based on economic analyses such as cost-effectiveness and/or disproportionate cost assessments, especially where measures would be attaining objectives that are less stringent than those set out in the Article;

[258] These costs relate to all water category measures (including groundwater)

- Article 5 & Annex III which require that an economic analysis of water uses is to be conducted by the Member State.
- Article 9 which require the Member State to consider the principle of recovery of the costs of water services, including environmental and resource costs and to ensure that different users are adequately contributing to the recovery of the costs of water services.

The main objectives of carrying out an economic characterisation of groundwater uses is to assess the importance of this resource to the development of the various economic sectors operating within the river basin district and to determine the disproportionate costs (if any) of the significant water uses to attain the objectives of good status by 2021. Within the framework of the WFD, an economic characterisation has a number of functions:

- to identify the water uses in each RBD;
- to assess trends in water supply, water demand and investments;
- to assess the current levels of cost-recovery of water services;
- to support the selection of a PoM for each RBD on the basis of cost effectiveness criteria;
- to assess the potential role of incentive pricing in the PoM;
- to assess the need for a potential derogation from the Directive's environmental objectives based on the PoM's costs and benefits and on the cost of alternatives for providing the same objective.

This chapter builds upon the analysis carried out in the economic analysis that was carried out as part of the 1st Water Catchment Management Plan. In particular, it takes note of the data constraints identified in that report and has taken advantage of efforts to close, as far as possible, the highlighted data gaps. As part of the development process of this chapter, the methodological approach that was adopted by its predecessor was reviewed and efforts have been made to provide greater detail on the cost recovery levels of water services and the contribution of the PoM towards groundwater sustainability. .

The methodological approach adopted in this economic analysis, particularly to define the cost recovery levels, is based on the WATECO and ECO2 guidance documents and on the discussions held during Commission workshops on the implementation of the relevant articles of the WFD.

10.3.1: Water Services, Prices and Cost Recovery Levels

The provision of a product or service, its price and the level of cost recovery are interrelated aspects that need to be analysed holistically, for example; an underpriced product will normally result in its overconsumption and in an adverse impact on the cost recovery level for its provision. Historically, the production, distribution and sale of potable water in Malta has been subsidized in order to maintain a fixed (and affordable) price given the vital importance of water in sustaining an adequate standard of living and an acceptable rate of productive activity. Similarly, the collection and disposal of wastewater was deemed to be a public service that had to be carried out irrespective of whether the entity that provided these services was fully recovering its costs. Failure to do so would create a public health hazard and endanger people's lives. Over the past years, developments in affordability together with pricing efficiency considerations have led to a substantial increase in the rate of financial cost recovery of water services out of water tariffs.

Water Services

Article 2 of the WFD, defines a 'water service' as; *"all services which provide, for households, public institutions or any economic activity:*

(1) Abstraction, impoundment, storage, treatment and distribution of surface water or groundwater; and

(2) *Wastewater collection and treatment facilities which subsequently discharge into surface water"*.

This definition ties with Article 9 of the WFD, which states that; *"all Member States need to consider the principle of recovery of the costs of water services, including environmental and resource costs, according to the polluter pays principle".*

More specifically, the WFD requires that the Member State shall ensure that:

(1) Water pricing policies provide adequate incentives for users to use water resource efficiently, and thereby contribute to the environmental objectives of the WFD;
(2) An adequate contribution of the different water users, disaggregated into at least industry, households and agriculture, to the recovery of the costs of water services;
(3) To account for social, environmental and economic effects in defining the pricing policy.

For the purpose of the analysis conducted under this chapter, a water service is defined as per Article 57 TFEU, which requires a bilateral relationship between the supplier and the final user, such as that found in the provision of water supply activities and wastewater treatment. Water users are therefore excluded from this definition, as clarified by the European Court of Justice in European Commission vs. the Federal Republic of Germany (C-525/12 of 11 September 2014).

Therefore, the sole entity that falls under the definition of water services supplier is the Water Services Corporation (WSC) which is the public utility responsible for the water production, storage, distribution and sale, as well as, the collection, treatment and disposal of treated wastewater. Thus the WSC is wholly responsible for the complete urban water cycle from production to its safe disposal.

The operational setup of the WSC for water production, storage, distribution and sale involves the operation of an extensive groundwater abstraction network and three Reverse Osmosis plants, namely the Pembroke, Lapsi and Cirkewwa plants, the maintenance and control of 24 reservoirs with a total capacity of 400,000m^3 and a distribution network of over 2,136 km of pipes, pumps, reservoirs, automated and manual valves and other components. The WSC has approximately 142,000 water service connections and services all households and industries in Malta. The WSC in its potable water production process uses groundwater sources to blend with desalinated water and hence all related abstraction costs are included within the cost structure of the Corporation.

The wastewater collection, treatment and disposal services provided by the WSC require the operation and maintenance of a large network of gravity and pressure sewage mains and the cleaning and maintenance of about 400km of sewers each year using jetting/suction bowsers. Additionally, about 822 cesspits which are not connected to the public sewer system are emptied by the WSC. The treatment of raw sewage thus collected is carried out in three WWTP, namely the Ta' Barkat, Ic-Cumnija and Ras il-Hobz plants. All wastewater generated on the Island is treated prior to disposal at sea, making Malta the first country in the Mediterranean and the seventh in Europe to treat all its wastewater prior to its disposal.

Furthermore, the WSC is moving towards the inclusion of re-use in its water cycle within the timeframes of the 2nd RBMP, through the development of polishing plants and dedicated distribution networks for this new water resource. This approach will change the baseline scenario considerably since the WSC will start moving (and eventually achieve) a net-zero impact on the natural water cycle, whereby the volumes of water that are being abstracted for the purposes of water production will be returned, directly or indirectly, through the implementation of a number of measures, including the production of new water, the use of MAR Schemes, upgrades in the sewer-line network and a number of measures to promote water efficiency and conservation by end-users. This 'net-zero impact' approach is expected to generate substantial environmental and resource benefits without disproportionately impinging on water users.

Groundwater is also directly abstracted by a number of economic operators. This privately abstracted groundwater may be used for one's own consumption or production purposes or may be sold to other end-users and transported using the services of water tankers (bowsers). These activities fall outside the responsibility of the WSC and are regulated by the MRA in-line with Government policy direction in this area. Issues related to water quality are regulated by the Environmental Health Division.

Water Prices

When viewed within the ambit of the WFD, water pricing policies should provide an incentive toward the efficient use of water resources that contribute towards attaining (or maintaining) good status of the water body whilst ensuring that the costs incurred to provide the water service are being adequately recovered. The Member State should also consider the Polluter Pays Principle (PPP) when drafting price structures while taking into account the socio-economic implications of the price levels charged for the provision of water services.

There are a number of ways that a price can be charged for the provision of water services, and in fact, water pricing itself can be defined differently, for example the European Environment Agency (EEA) defines it as; *"applying a monetary rate or value at which water can be bought or sold"* whilst Arcadis et al. apply a broader definition of water pricing as; *"monetizing the abstraction, use, or pollution of water"*. In the context of this chapter, the second definition was deemed to be more appropriate given its wider scope and hence is applied in the local context as detailed in the following Sections.

Water Pricing in the European Union

A comparative exercise was carried out to provide an overview of the water pricing structures applied in a number of EU Member States for which sufficient information was available. This analysis relies heavily on a report published by the EEA.

Across EU countries, the type of tariff charged, as well as the rate, would mainly depend upon the service provided, the type of consumer and the volume being consumed (or generated in the case of wastewater). Thus, for example; the average rate that is charged for private groundwater abstraction for irrigation purpose would differ from the average rate that is charged for municipal potable water sold to residential households.

A fixed charge or a volumetric tariff or a mix of both instruments may be used on the sale of water and/or on the collection and treatment of wastewater by different countries. In many cases, the tariff for these two services is combined into a single pricing structure, as is the case locally. A comprehensive list of tariff structures and respective rates in a selected number of EU Member States is found in Annex III to the WCMP and as provided by the EEA.

Notwithstanding, a direct comparison of tariff rates between Member States is not very useful given the fixed/volumetric components in the rates. A more useful benchmarking metric would be the annual average water bill paid by a representative household in a given year, as shown in Figure 10.1 below.

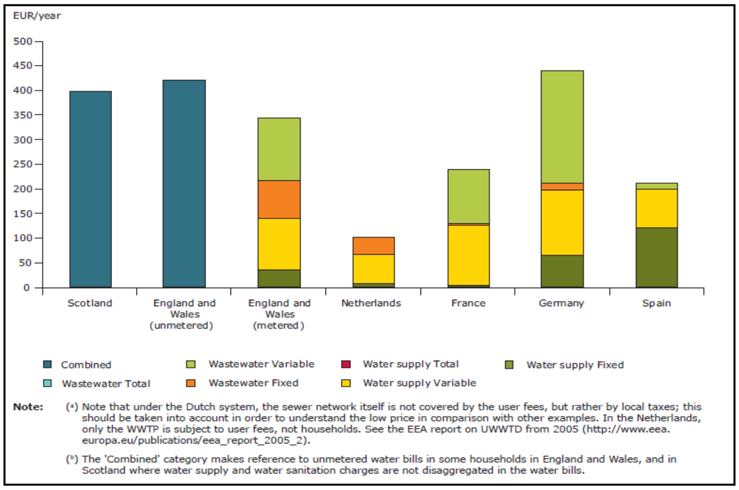


Figure 10.1: Annual Average Water Tariff per Household in the Surveyed EU Member States. Source: EEA, 2013

The annual average ‘bill’ for the public supply of water services (hence including wastewater collection and treatment) inclusive of the service charge is estimated at €197 per residential account in Malta as compared to a low of €100 per residential account in the Netherlands and a high of €450 per residential account in Germany.

Price Structure of Public Water Services

The WSC recoups the costs incurred for the provision of water production, distribution and sale and from wastewater collection, treatment and disposal services through a rising block tariff system for both the residential and non-residential consumers. An exception is made to non-residential consumers with an annual consumption greater than 40,000 m^3 per year. Table 10.9 below lists the tariffs charged by WSC and as applicable from 31st March 2014.

Residential Tariffs		
Consumption Band	**Consumption Band (m^3)**	**Tariff Rate (€/m^3)**
1st Tier	<=33 per person	1.396
2nd Tier	>33 per person	5.139
Domestic Tariffs		
Consumption Band	**Consumption Band (m^3)**	**Tariff Rate (€/m^3)**
1st Tier	<=33 per person	2.185
2nd Tier	>33 per person	5.139
Non-Residential Tariffs		
Consumption Band	**Consumption Band (m^3)**	**Tariff Rate (€/m^3)**
1st Tier	<=168	1.995
2nd Tier	>169 & <=40,000	2.375
3rd Tier	>40,000	1.662

Table 10.9: Tariffs for Public Water Services Source: MRA, 2010

Additional to this volumetric tariff structure from the sale of water, the WSC also charges a 'stand alone' service charge of €59 per year for residential households and €130 for non-residential consumers. The non-residential sector accounts for around 30% of revenue generated through pricing of water services.

It is important to note at this stage that revenues from water pricing in Malta covers the entirety of the costs of production of potable water by WSC and one half of the costs of waste water treatment. The other half is covered by a Government contribution to the system on account of the environmental benefit being produced by this activity, which is in line with the 'beneficiary pays' principle. These environmental benefits include a cleaner marine environment and enhanced protection of the environmental conditions in the immediate shoreline, including beaches that are an important for tourism and recreation activities, and improved health conditions for marine flora and fauna.

10.3.2: Cost Recovery Levels for Water Services

EU guidelines aimed at establishing best practices on how the Member State may calculate the level of cost recovery in the provision of water services distinguish between financial, resource and environmental costs. The principle of cost recovery in the pure financial sense refers to the amount of money that needs to be paid by the users to recover the cost incurred in the provision of water services. This concept may be extended to non-financial costs such as those associated with forgone opportunities of alternative water uses and those having negative environmental impacts. The pricing instruments used to recover these costs from the various consumers will vary between Member States, and indeed, between the water utilities themselves.

The WFD also requires the Member State to consider the polluter pays principle when assessing the pricing mechanisms that are in place. The PPP identifies the extent to which groups of users of water services should contribute towards the total cost in accordance with their role in generating these costs. Hence, the group of users who are generating the highest proportion of the total costs should likewise pay a commensurate proportion for the recovery of these costs. To align consumers' behavior with the polluter pays principle, the WFD urges the Member State to use incentive pricing to design the pricing structure accordingly. This way, the choice of pricing instrument would be taking into consideration how users are paying for the water services that they use and that the price being charged is sending the right signal to the right users.

Financial Costs

Financial costs are defined as; *"those costs that are incurred from the provision and administration of water services including wastewater treatment"*. These costs include all operational and maintenance costs, capital costs (principal and interest payment) and return on equity (where appropriate). The [financial] cost recovery level needs to be identified for both the public and private abstractors of groundwater, disaggregated by, at least, industry, households and agriculture.

The Financial Statements of the Public Utility

The Water Services Corporation Act (1991), and subsequent amendments, oblige the public utility to present its audited accounts to the Cabinet by the end of each reporting period. These financial statements are to provide a true and fair view of the Utility's state of affairs and of the profit or loss for this period.

Presently, these financial statements are unbundled between the direct costs incurred for the provision of the two main services, namely production, distribution and sale of water and treatment, collection and disposal of wastewater and indirect costs such as administrative expenses, pension payable and net finance cost. Figure 10.2 below illustrates the trend in the costs incurred by the WSC over the past two decades.

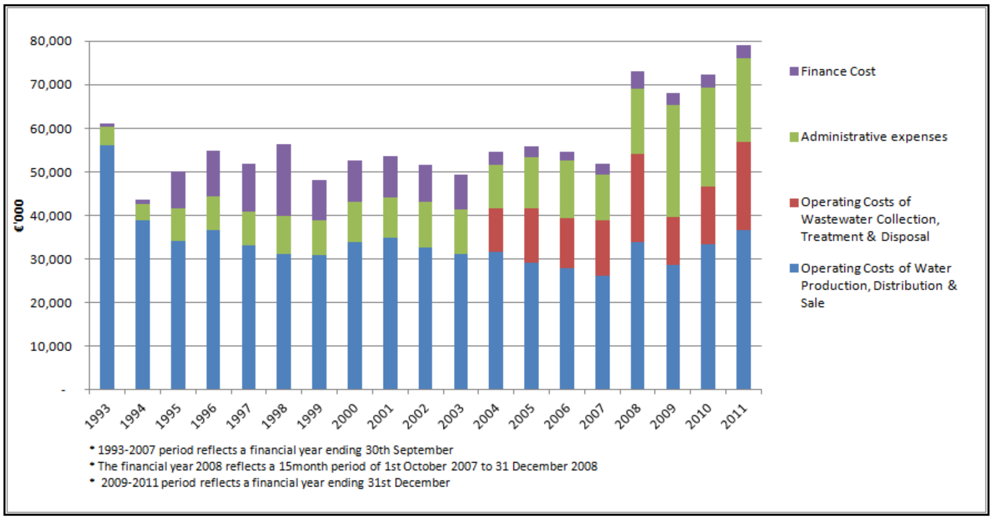


Figure 10.2: WSC Cost Components Source: WSC, Annual Reports 1993-2011

Further disaggregation of these costs, as at the year ending December 2011, is provided in Figure 10.3 below. It indicates that the bulk of the expenses pertain to wages & salaries (30%) followed by depreciation and electricity charges (25% respectively) with the other cost items cumulatively accounting for the remaining expense (20%).

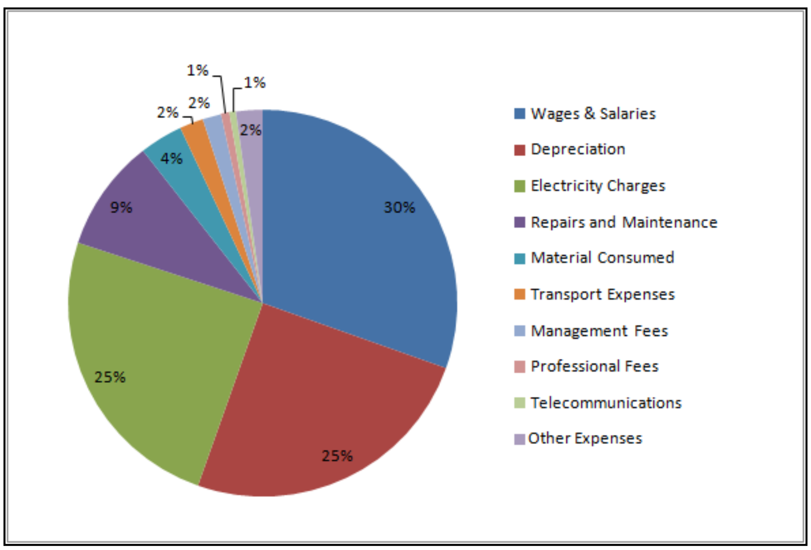


Figure 10.3: WSC Cost Breakdown Source: WSC, Annual Report 2011.

As stated in its annual reports, the WSC is constantly seeking ways to reduce these costs, and the focus is on reducing the specific energy consumption of the desalination and wastewater treatment plants, which has, in fact, improved over the past 5 years.

Accounting for Real and Apparent Losses

Implicit in the above costs are real and apparent losses. Real losses are of a technical nature (such as leakages from the distribution network) whilst apparent losses generally refer to water which is consumed but not billed.

The WSC has shown significant improvements during the past decade in the control of real losses. Leakages have been reduced from approximately 10.3 million m^3 in 2002 to 3.5 million m^3 in 2014; which represents a 66% reduction of the volumes lost each year. A recent study undertaken by the WSC places the economically optimum levels of network leakages at 3.2 million m^3. Therefore, the current leakage levels would be nearly at optimal levels. These loss reduction efforts have supported WSC to meet an increased water demand (approximately by 1.3% per year since 2005) while at the same time decreasing production (an average 0.2% per year since 2005). Up to 2012, these developments allowed for a reduction in the abstraction of groundwater by WSC by approximately 7 million m^3 since 1995, or a decrease of 34.5%.

Figure 10.4 below illustrates the extent of these two types of losses incurred with respect to the billed units. As can be seen, real and apparent losses constitute almost half the produced units (as at 2013), whilst the greatest share of losses is due to **apparent** losses. Over-and-above the ongoing efforts by the WSC to reduce real water losses, additional measures have been identified and are expected to be implemented during the present RBMP cycle, that are specifically aimed at further reducing apparent water losses during the consumption stage of the water cycle, such as continued meter replacement and smart metering.

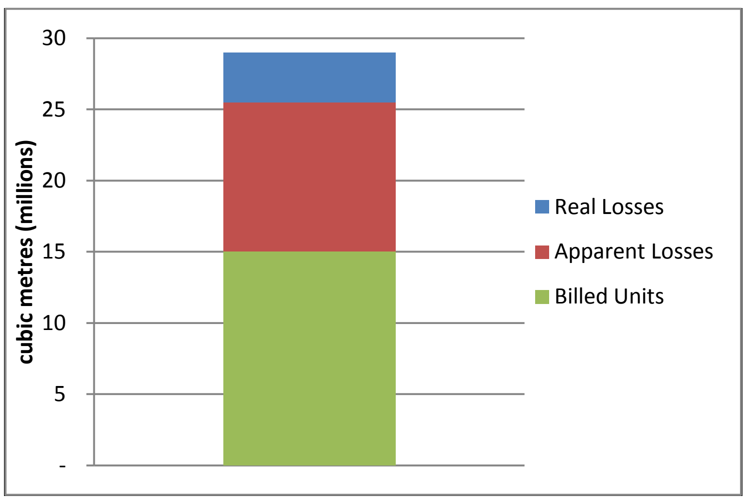


Figure 10.4: WSC Billed Units and Losses

Cost Recovery Methodology for Water Services

The regulatory authority is in the process of implementing a proposal which would entail a full cost recovery of the cost of water services in Malta, through the combination of pricing from consumers, reflecting the 'user pays 'principle, and a contribution from public resources to reflect environmental benefits of groundwater conservation arising from specific activities undertaken by WSC, reflecting the 'beneficiary pays' principle. Moreover, the system will entail strong elements of financial incentives to reduce losses and enhancing the recycling of water resources, in line with the principles of 'resource cost' and 'polluter pays'.

Within the context of operations and activities leading to good water status, WSC will therefore be generating a very high level of cost recovery, practically covering financial elements in their entirety, based on consumer charges and public contributions. At present (2014), consumer charges are already recovering around 88% of the total costs (excluding Government Subvention) of water services in Malta.

10.3.3: Financial Cost Recovery of Private Groundwater Abstraction

Apart from the WSC, the abstraction, sale and end-use of groundwater is also carried out by a number of private individuals and economic operators. Self-abstraction is not considered to be a 'water service' as implied in Article 5 of the WFD and further clarified by the European Court of Justice in European Commission vs. the Federal Republic of Germany (C-525/12 of 11 September 2014. Notwithstanding, the MRA carried out an exercise to determine the financial cost recovery of these users according to the volumes being abstracted.

In the case of private abstraction of groundwater, the financial cost of water abstraction is dependent on three main factors, namely, the volume of the water abstracted, the depth of the borehole and the power rating of the pumping equipment[259]. Hence, the cost incurred would vary in between abstractors according to these criteria.

In the absence of data that provides the necessary information on these 3 factors for each abstractor, a benchmark scenario was constructed, which assumes an average depth of 100 metres that is required to access the MSL aquifer and a pumping equipment having an electricity requirement of 0.0072kwh/m^3/metre. Other cost assumptions include the amortized cost of the pumping equipment over 10 years and the cost of drilling the borehole itself amortized over 30 years. Figure 10.x below illustrates the abstraction cost curve derived from this model. This curve is compared with the price of the non-residential tariff charged for municipal water.

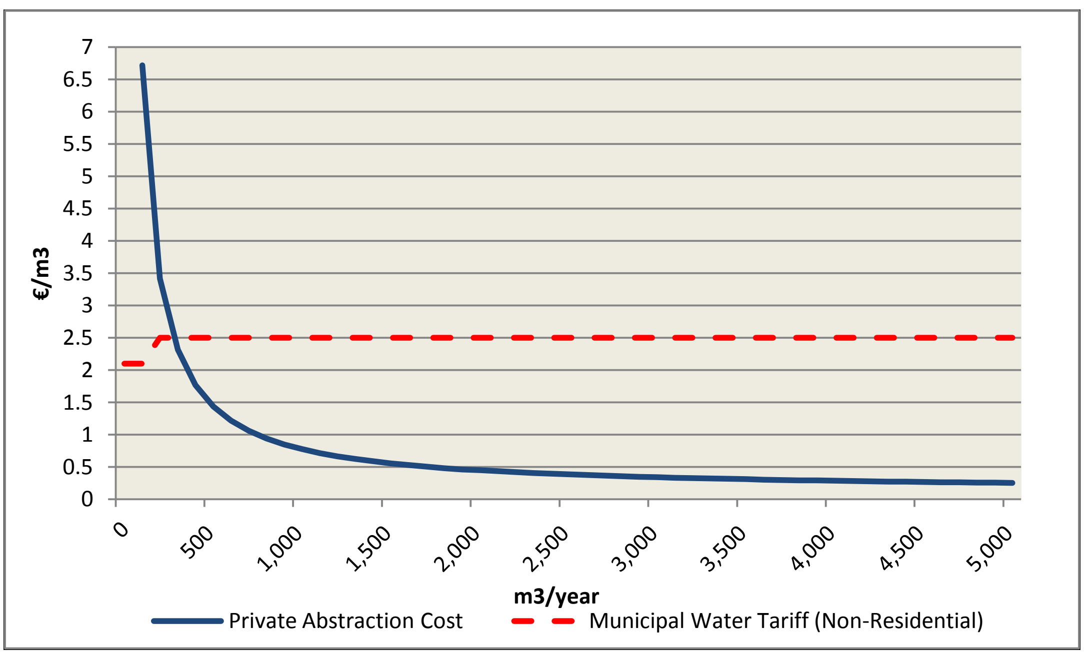


Figure 10.5: Private Groundwater Abstraction Cost Curve

It is clear that there is a non-linear inverse relationship between the quantity of water abstracted and the cost of abstracting an additional cubic metre of groundwater, keeping all other factors constant. At low rates of abstraction, the marginal cost of abstracting groundwater would be higher than the cost of purchasing water from the water utility. More specifically, the benchmark scenario indicates that at

[259] Other factors would impact, to a lesser degree, the abstraction cost including the age and condition of the pumping equipment, friction on piping equipment, maintenance costs etc.

abstraction rates lower than 300m^3 per year, the abstraction cost would be higher than municipal water (at the non-residential tariff rates).
This implies that in the case of small farm holdings that abstract relatively low quantities of groundwater, it would be cheaper to switch to other alternative sources of water supply. The case to switch towards alternative water sources would be stronger even at higher abstraction volumes in the case of 'new water', were it is expected that this source will be made available at a lower price than municipal water.

Following the installation of borehole metering equipment, an analysis of metering data for a full year for a sample of 800 boreholes in the agricultural sector, indicated a mean abstracted volume of groundwater per borehole of 1,500m^3. This suggests that in the case of these private operators, it would financially benefit by switching to alternative water sources since it is expected that these water sources will be made available to end users at a competitive cost in order to incentivise its use and to form a secure source of water to gradually substitute groundwater. Moreover, the cost of alternative water sources will be covered by the 'user pays' and 'beneficiary pays' charges and contributions.

Irrespective of the abstraction rate, the financial cost of abstracting groundwater, including the construction of the borehole itself and its housing, the purchase of the pumping equipment and the fuel or electricity costs required to operate this equipment is being wholly borne by the private abstractor and thus the level of financial cost recovery of groundwater abstraction is of 100 percent[260].

Environmental and Resource Costs in the Context of a Zero-Net Impact Approach on the Water Cycle

Article 9 of the WFD requires that Member States be cognizant of the resource and environmental costs when viewed from the polluter pays principle. A resource cost is defined as; *"the cost of foregone opportunities which other users suffer due to the depletion of the resource beyond its natural rate of recharge or recovery"*. 'Other users' encompass both the present, and future, groundwater users. Hence, it is *ex ante* being assumed that the water resource is [becoming] scarce and that users are obliged to switch to alternative water supplies or to reduce their consumption and production activities (assuming that all productive efficiency gains have been wholly availed of). In the absence of clear market signals, the resource cost of groundwater may be proxied by its opportunity cost in a scenario where this resource is already scarce, for example in the case of a severe drought. The opportunity cost of groundwater is largely a factor of the quality requirements for its use. Production activities that require low water quality would normally have wider substitution possibilities, such as rainwater and TSE, and these would have a lower price tag than municipal water. However, these alternative water supplies would generally also be more expensive than the cost of groundwater abstraction.

An environmental cost is defined as; *"the costs of damage that water uses impose on the environment and ecosystems and those who use the environment"*, for example, environmental damages due to (over)abstraction, storage and impoundment. Hence, environmental costs can be seen as negative benefits and avoided costs. In the case of groundwater overabstraction, the impact on the natural environment includes the intrusion of saltwater from the sea in the case of the MSL aquifers. Overabstraction of the perched aquifers could lead to its drying up with a concomitant detrimental effect on the flora and fauna that subsist directly on this resource. These freshwater ecosystems have their own existential value and therefore, the degradation of groundwater would have wider negative implications over-and-above the direct financial costs. Degradation in groundwater quality may also be

[260] It is being assumed that no subsidies were given to operator on the purchase of the pumping equipment and related infrastructural work. If this were to be the case, then the amortized value of the subsidy that was given to the operator has to be deducted from the cost incurred.

due to pollution, either from point and/or diffuse sources, such as nitrate contamination from fertilizers used in the agricultural sector or stormwater runoff from urbanized areas.

As stated above, the WSC is moving towards a net-zero impact on the natural water cycle in its operational activities when providing water services whereby the water that is abstracted from the groundwater bodies is eventually returned back, thus maintaining a balance between the two activities and ensuring the sustainable use of groundwater. This approach is conceptually illustrated in the Figure below.

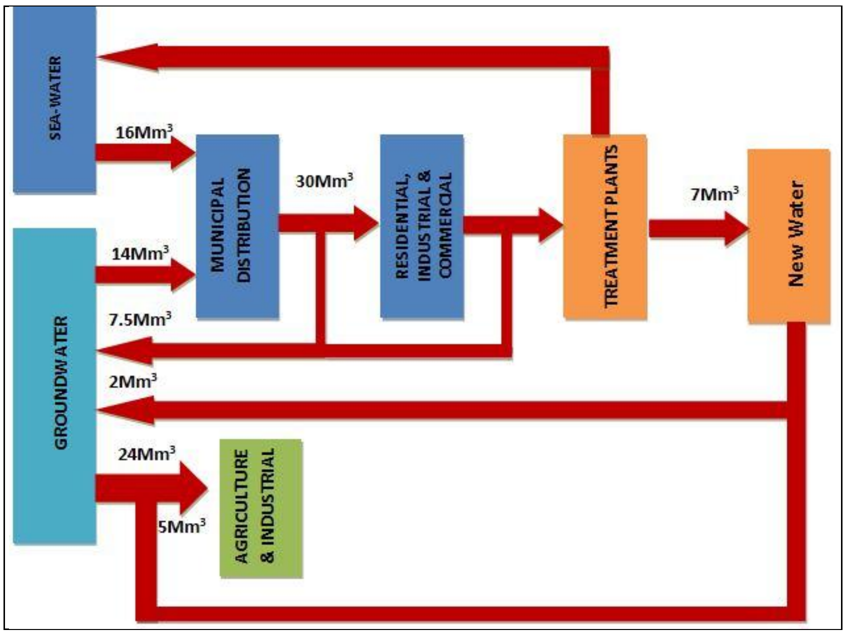


Figure 10.6: Net-zero impact approach of water services

It is to be highlighted that an approach that is solely based on incentive pricing is considered to be of a partial equilibrium nature, which is aimed at deriving costs from relatively narrow set of economic and environmental considerations of the water resource. It is however essential to consider the final cost from a general equilibrium perspective, that is, taking into account the effects of the complete water cycle on the groundwater resource. The analysis presented in Chapter 11 shows that the water services activities in Malta, within the context of ongoing and planned interventions, are expected to lead to a status of good water balance defined as achieving equilibrium between groundwater abstraction and recharge. From this perspective, it is considered that the use of pricing as an economic instrument to protect the sustainability of groundwater resources is not required.

Notwithstanding, price instruments can still have a role in determining the aggregates of abstractions and recharges and the relative distribution of water resources across different sectors of the economy. In the design and implementation of measures which are likely to increase pricing efficiency in this regard, it is very likely that disproportionate costs would be imposed on relatively vulnerable yet strategic sectors, chiefly agriculture. It is thus considered that alterations to pricing mechanisms should not follow solely pricing efficiency considerations but also wider economic and social implications, especially within the context that such alterations are not needed to achieve a measure of good water status.

10.3.4: The Economic Impact of Groundwater

Groundwater is an essential input in the production of many goods and services and may be used directly in the production process or as an intermediary input in the production of final goods. Groundwater therefore is an economic good that has an economic value because its use generates value added to the economy.

Importance of Groundwater at the Intra-Sectoral Level

The transformation of groundwater into value added is dependent on a number of factors. At the intra-sectoral level, it would mainly depend on the efficiency of the production process of operators producing a similar good. Hence, an efficient operator would need less groundwater to produce the same quantity of goods relative to a less efficient operator and thus the quantity of groundwater used by the former operator would be reflected into a higher value added, keeping all other factors constant.

To estimate the contribution of groundwater to value added would require, *a priori*, data on the quantity and cost of groundwater used by each producer. It is therefore essential to obtain readings from the water meters installed with the registered boreholes of the economic operators covering at least a 12 month period. A detailed study is being carried out in conjunction with the WSC to obtain the meter readings from all metered private boreholes operated by economic operators over, at least, a 12 month period. This information would allow for a benchmarking exercise of groundwater use between producers and as a consequence, to identify the most inefficient water users. This, in turn, greatly augment the implementation of water saving and conservation measures particularly in those sectors where water is a direct production input.

Importance of groundwater at the Inter-Sectoral Level

At the inter-sectoral level, the correlation between groundwater use and the value added being generated would depend on the type and value of the final good produced and whether groundwater is a direct or an indirect input in the production process. Normally, in those production processes where groundwater is a direct input and the final good has a low value, the corresponding contribution to value added would be relatively lower than in those processes where groundwater constitutes an indirect input to produce a high value end-product.

The current available data only allows for an estimation of an aggregated average consumption in the agricultural and non-agricultural sectors. Similarly, lack of data restricts the estimation of the cost of groundwater abstraction incurred by the economic operator and a more general cost figure based on the abstraction cost model developed as part of this economic analysis need to be taken.

Using the available data, and taking the aforementioned cost and consumption figures, a comparative analysis of groundwater abstraction relative to gross domestic product, output, income and employment of the agricultural and non-agricultural sectors was carried out. The results are presented in Table 10.11 below.

Sector	NACE Classification	Groundwater Consumption	GDP	Output	Income	Employment
		%	%	%	%	%
Agricultural Sector	A	77.06	1.36	1.58	0.97	2.05
Non-Agricultural Sectors	B to S	22.94	98.64	98.42	99.03	97.95

Table 10.10: Importance of Groundwater to GDP, Output, Income and Employment
Note: Groundwater abstraction excludes the residential sector

Table 10.10 indicates that by far the largest user of groundwater is the agricultural sector which accounts for approximately 77% of groundwater abstracted for the production of goods and services by the economic operators in 2011. On the other hand, this particular sector contributes very little, in percentage terms, to gross domestic product (GDP) and to output and income levels. The contribution to employment is also relatively low, at just 2% of the total equivalent full-time employees[261].

To further compare the input-output correlation, the groundwater required to produce €1000 worth of goods was estimated for each sector, in both volumetric and monetary terms. The results are shown in Table 10.12 below.

Sector	NACE Section	Output		Income	
		m^3/€'000	€ (gw)/€'000 (output)	m^3/€'000	€ (gw)/€'000 (income)
Agricultural Sector	A	223.39	58.08	704.23	183.10
Non-Agricultural Sectors	B-S	14.12	3.67	62.83	16.33

Table 10.11: Input-Output Correlation
Note: Groundwater abstraction excludes the residential sector

The above table indicates that the agricultural sector requires the highest quantity of groundwater, and incurs a correspondingly high financial cost, to produce the same value in output, and to generate the same income levels, relative to other economic activities. Thus to produce €1000 worth of agricultural produce, this sector requires circa 223m^3 of groundwater at an input cost of €58 per €1000 units of output. Similarly, to generate €1000 in income, this sector would require 704m^3 and €183 worth of groundwater. Moreover, the marginal cost of groundwater per unit of output or income would increase at lower abstraction and/or lower production rates.

These results indicate that groundwater constitutes a far more important input to the agricultural sector relative to other economic activities that make use of this resource. The implication is that any measure that:
(1) restricts the supply of groundwater to this sector; or
(2) imposes a price for the use of this resource; or
(3) imposes mandatory substitution obligation towards more expensive supply sources,
would carry a relatively much higher cost to the operators within this sector relative to other sectors.

Notwithstanding, any such measure would lead to a loss in economic value, output, income and employment that is comparatively smaller relative to the loss that would be incurred by other economic sectors.

Following the installation of borehole metering equipment, analysis of metering data for a full year for a sample of 800 boreholes in the agricultural sector indicated a mean abstracted volume of groundwater per borehole of 1,500m^3. According to the groundwater abstraction cost curve (figure 10.5 above), the abstraction cost at this volume amounts to Eur0.56/m^3. Applying this cost to the estimated 18,000,000m^3 of groundwater abstracted annually by the agricultural sector, would lead to an **indicative** net abstraction cost for the sector of Eur9.2 million. This is equivalent to 14% of the net factor income of the agricultural sector, which stood at Eur73.3 million in 2013. Further increases in the cost of private abstraction would continue to further erode the incomes and profit margins of economic operators in this sector.

[261] Assuming that part-time employees work 20hrs per week

The Importance of the Agricultural Sector to Societal Welfare

Unlike most other economic activities, the agricultural sector contributes towards other aspects of society that have an important non-monetary value such as national food security and those related to the environmental, amenity and heritage values of agricultural land and on the cultural importance of the local artisan food and beverage 'cottage' industries. These non-monetary values are difficult to estimate and rely on stated preference techniques to valuate in monetary terms. An attempt was made to gauge the impact of the agricultural sector on food security given that a worsening in this factor would have a fairly wide adverse implication on societal welfare.

In 2011, the agricultural sector produced around 92.5 thousand tons of fruit and vegetables, 12.5 thousand tons of meat and 45.3 thousand tons of poultry and dairy products or approximately 73% of total agricultural food consumed in the Country. This figure is exclusive of 'manufactured' food and beverages such as bread, pastries and confectionery and mineral water, soft drinks, wine and beer. Table 10.13 below compares the local agricultural produce with food imports in terms of both the gross weight and in monetary value for the 4 year period 2008-2011.

	Local Agricultural Food Production		**Imported Food Products**		**Local Production as a percentage of Imported Food Products**	
	tons	€'000	tons	€'000	% (by weight)	% (by value)
2008	152,851	68,539	55,883	87,836	73	44
2009	138,990	67,393	58,474	86,867	70	44
2010	147,998	67,505	56,823	89,797	72	43
2011	150,433	68,562	52,080	93,318	74	42

Table 10.12: Comparison of Local and Imported Food Products Source: NSO, 2013

Table 10.12 indicates that the production of local food is approximately 3 times higher than imported food by weight. This implies that food consumption (and hence food security) is heavily reliant on the production of local agricultural produce. Conversely, when comparing the local and imported food in monetary terms, the local agricultural produce has a much lower value relative to the imported food. This indicates that locally produced agricultural products are cheaper, on average, than imported food and thus any shift towards greater reliance on imported agricultural produce would result in higher prices for consumers and to a concomitant adverse impact on food affordability and food security.

Therefore, an increase in the cost of abstracting groundwater, would be reflected either in an immediate increase in the price of local food products with an equivalently adverse impact on consumers, or consumers would shift their demand (or part thereof) in favour of imported food products, with adverse implications on food security. A third possible impact of a higher groundwater abstraction cost is an overall reduction in the local agricultural output. Apart from the loss of employment and income to operators active in this sector, such a reduction in output would also translate into an increase in food prices arising directly from a lower supply of local produce. Any one of these three scenarios would have an adverse impact on affordability and food security.

Hence, any measure that is implemented with the aim of safeguarding groundwater resources will need to take into account its impact on other economic sectors and the wider ripple effects that these sectors have on the economy and on societal welfare. In the case of the agricultural sector, these ripple effects are expected to be reflected in higher food prices to a concomitant deterioration in food affordability and security.

11. Cost of the Programme of Measures

11.1 The cost of protecting and improving our surface water status

The objective of this section is to:

- Provide a cost estimate of the *basic* and *supplementary* measures that shall be implemented. Basic measures have been listed and defined in Chapter 9 of this plan, and include:
  - (a) Measures which emanate from other European Community legislation which would contribute to the protection of water
  - (b) Measures which stem directly from Article 11 of the Water Framework Directive
- Assess the cost effectiveness of all *supplementary* surface water Programme of measures. All surface water supplementary measures have also been listed in Chapter 9.
- Identify instances where costs for fully meeting the WFD obligations may be deemed as being disproportionate to the expected benefits.

During the preparation phase of this WCMP the Malta Environment and Planning Authority commissioned a Cost-effectiveness analysis[262] to be carried out on the draft list of measures MEPA had at that time. Due to the fact that the measures were still undergoing consultation several measures were altered as the costs were being estimated.

The scope of the cost-effectiveness analysis can be said to be limited due to the fact that:

- The study focused on incremental measures only. That is, costs and measures that have already been incurred are ignored since they have already been sustained.
- Basic measures do not require a cost effectiveness analysis. The costs relating to basic measures were included only for information purposes but the evaluation of their respective effectiveness rests outside the scope of the study.
- Due to data limitations, it was not possible to quantify the exact costs and effects of every measure. Various cost estimation methods were used to fill such gaps. However it is important to specify that, though such estimates represent the best available information at the time the cost-effectiveness analysis was being carried out, they are by nature imprecise.

The effectiveness of the programme of measures was evaluated through the use of multi-criteria analysis. This was performed through a series of discussions between the economic consultants engaged to carry out the study, a technical expert selected by the economic consultants to assist in their evaluation, and MEPA representatives.

The costs in this chapter are presented in real terms. In addition all costs are measured assuming no other substantial changes occur. This is important to keep in mind when evaluating measures that impose a large cost to the private sector. Such costs may distort the competitiveness of the industry and result in a reduction in the quantity of goods supplied. Such impacts are not calculated when examining the costs of the measures. They are instead discussed when evaluating the measures' effectiveness through the use of multi-criteria analysis.

[262] Grant Thornton, 2015. Cost Effectiveness Analysis report for the Management of Malta's water bodies, including analysis of cost disproportionality, August 2015

11.1.1 Costs for Basic Measures stemming from other Directives

Table 11.1 indicates the costs incurred for implementing other directives which have a significant bearing on water management. The responsible entities are indicated in green.

Relevant EU Directive	Description of measure to be carried out	Expected / estimated cost
The Nitrates Directive Responsible entity: The Agriculture Directorate	A crop yields study and undertaking of studies related to manure quality and soil nitrogen content and the building of a soil monitoring surveillance network (to support implementation of the Nitrates Directive)	€ 70,000
	Maintenance of a database for monitoring changes in agricultural practices in terms of farm holdings, manure application and manure analysis	€ 88,000
	Controls, enforcement and compliance procedures related to overseeing implementation of the Nitrates Action Programme Regulations (LN 321 of 2011 as amended).	€ 140,000
The Bathing Water Quality Responsible entity: Environmental Health Directorate	Monitoring costs related to Bathing Water Quality status at 87 coastal bathing sites	€ 150,000
	Updating of beach profiles	To be determined
The Urban Waste Water Directive Responsible entity: Water Services Corporation	Improving existing collection systems and extensions to replace or supplement old parts of the sewerage network to serve growing needs	€ 4,000,000
The Nature Directives Habitats and Birds Responsible entity: The Environment and Resources Authority, The Wild Birds Regulation Unit	Implementation of the Terrestrial Natura 2000 Management Plans – measures related to water dependent habitats and species and the respective waters as described in this plan	
	Development of Marine Protection Area Management Plans	Yet to be determined
Sustainable Pesticides Directive Responsible entity: The Malta Competition and Consumer Affairs Authority	Implementation of the Sustainable Pesticide National Action Plan	Yet to be determined

Table 11.1: Costs of basic measures emanating from other water related directives.

11.1. 2 Costs for Basic measures stemming from the Water Framework Directive

Measure Code	Title of Measure	Description of costs	Cost estimate
SWM 13	**Set up a watch list mechanism to monitor certain emerging substances identified at EU level that could potentially be of concern**	The list of candidate substances selected for the watch list (refer to Chapter 5 of this plan) comprises of substances identified during the last review of the priority substances list, and substances directly proposed by Member States and other stakeholders (Carvalho et al., 2015). Malta shall undertake monitoring related to this watch list as from this year 2015.	It is estimated that this monitoring will cost approximately € 20,000 for the first year.
Key 1	**Continue to refine the regulatory framework for industrial operational practices (beyond IED requirements)**	Any information and/or data pertaining to water that is submitted by operators via the environmental permitting process will be digested by the experts engaged by ERA to work on water quality (See related measures SWM 2 and Key 2) and the data will be fed automatically into the database system that is to be developed by means of a separate measure (Key 3). This measure will have a large impact to the work load flowing to ERA's Monitoring and Compliance Unit. Furthermore it will require that the ERA gains substantial new competencies. The recruitment process will however be staggered over a number of years in order to give the organisation time to train.	It is estimated that in total, 13 new recruits would be required at an annual cost of circa € 450,000 Total - € 2.7 million (450,000 x 6 years)
SWM 1	**Continue to strengthen the relationship between environmental and planning regulatory processes (including Marine Strategy Framework Directive concerns).**	The costs to implement this project are: (i) the human resources required to complete the drafting of the guideline document, and; (ii) Additional compliance costs resulting from greater enforcement, borne by the private sector, and relating mainly to costs for undertaking post project completion surveys. (1) It is estimated that the finalisation of the draft document would require two persons working for 4 months. (2) The average cost of post completion monitoring to be borne by the operator was calculated by applying an estimate of typical underwater surveying costs per square metre to an average area that would be required to be surveyed. The latter figure was guess-estimated through an analysis of past development applications, whilst the typical monitoring cost per square meter was estimated by using costs that exist from the commissioning of similar monitoring activities. The resulting estimate for the cost per monitoring instance was multiplied by the average	**Cost component 1: Finalisation of Guidance document** The opportunity cost for utilising resources in this manner equates to €23,360. **Cost Component 2: Monitoring costs by private sector upon project completion** A. Estimated average cost per project € 3,750 B. Estimated average project closing per annum: € 378 C. Total annual cost: € 1,417,500 D. Total annual cost for non-compliant entities : € 354,375

Measure Code	Title of Measure	Description of costs	Cost estimate
		number of new applications received annually over the last three years. The implicit assumption is that, on average, the total number of projects closing in any one year will approximate the number of new projects being commissioned per annum. This figure was subsequently multiplied by a factor of 25%, representing a guess estimate as to the current non-compliance rate (which will be addressed through the measure).	
SWM 2	**Continue to control priority hazardous substances, priority substances and other substances of concern via the environmental permitting process.**	Two key costs are envisaged in relation to this measure: (i) **Public sector compliance monitoring cost**: One new compliance officer holding a relevant qualification in chemistry is envisaged. (ii) **Increased private sector compliance costs:** The private sector will likely need to introduce new measures to mitigate or abate the costs involved in using substances of concern, or to shift onto the use of less harmful substances. The UK government commissioned and published an impact assessment in relation to the implementation of the same directive which is driving this measure[263]. The report estimated a transition cost of 1% of revenue generated by impacted companies. It is assumed that half of this adjustment of the transition cost is already absorbed and that additional enforcements detailed in this measure will bring about the remaining transition process. This estimate was applied on an industry by industry basis, after obtaining MEPA input as to which industries are more likely to be impacted. Furthermore, MEPA's best estimate of the current non-compliance rate amounts to 25% of total premises impacted by the regulation.	**Public sector compliance monitoring cost:** One new recruit is envisaged at an annual cost of €35,040 per person. Total: € 210,240 **Increased private sector compliance costs:** The analysis resulted in an estimated cost of € 2,611,013 per annum
SWM 3	**Update inventory of discharges (EQS Directive)**	The cost of this measure depends on the cost estimates for a number of additional supplementary measures that have been included to support the update of the inventory (particularly Key 3, KNO 3, KNO 4, KNO 5 and KNO 6). The costs related to the actual maintenance of the Inventory is equivalent to one new recruit focusing on the continuous updating of this inventory	One new recruit is envisaged at an annual cost of €35,040 per person – these costs however have already been included under costings for measure KEY 2.

[263] http://www.legislation.gov.uk/uksi/2012/3032/pdfs/uksifia_20123032_en.pdf

11.1.3 Costs of implementing supplementary measures

Measure Code	Title of Measure	Description of cost assumptions	Cost estimate
Key 2	**Create an effective feedback mechanism within the Environment and Resources Authority to ensure compliance and risk mitigation**	2 officers with a chemistry degree (in addition to those required for SWM 2 and SWM 3) to keep track of data that is inputted in database (KEY 3) and following up with the Environmental Permitting Unit; Monitoring and Compliance Unit ; and the Biodiversity and Quality Units with regards to conducting risk based compliance checks.	***Monitoring and compliance checks*** Based on the current remuneration packages offered to similarly qualified persons, the annual cost for each officer is estimated at €35,040 (thereby resulting in a total cost of €70,080 per annum). Total cost: (70,080*5) = € 350,400
SWM 5	**Develop guidelines for the disposal of dredged material**	***Costs related to the development of the guidelines*** have already been incurred and an advanced draft is already available. ***Cost of surveying sediment prior to disposal choice***: Since the method of sediment treatment and disposal is based upon the level of contamination of the sediment material, the new guidelines requires that potential developers undertake extensive surveying of the sediment in question. To quantify the private sector cost for complying with this new requirement, past applications which required dredging in the past were analysed in order to establish: • The average number of development applications requiring dredging. • The average length of dredging works per development application. • An estimate of the average cost of surveying sediment per square meter. Through an analysis of the location of past development applications it is estimated that 90% of all applications occur in harbour areas and therefore the sediment is likely to be contaminated. A typical project involves dredging approximately 370,000 m3. On average only 2 such projects are undertaken per year. ***Cost of dealing with sediments:*** Two sediment scenarios, each associated with different regulatory compliance costs apply; (1) Contaminated sediment requiring exporting for intensive treatment prior to disposal abroad,	***Costs related to the development of the guidelines*** - nil ***Cost of surveying sediment prior to disposal choice*** – This depends on the extent of the area to be dredged. Given past applications it has been estimated that costs can range between €10,000 – €15,000 per year ***Cost of dealing with sediments:*** The incremental sediment disposal costs per cubic meter of dredging were estimated at €228/m^3 for contaminated sediment if export and treatment is required. Costs related to the containment of slightly contaminated sediment, based on the Amsterdam study amounted to €7.89/m^3. This equates to an annual cost of €1,179,278 p.a.

Measure Code	Title of Measure	Description of cost assumptions	Cost estimate
		(2) or lightly contaminated sediment requiring treatment prior to local disposal. **Dredging contaminated sediment** will now require that sediment is exported for extensive treatment and specialist disposal or containment. As such the draft guidance does not instruct exporting. However the volume of dredging currently occurring in Malta is significantly smaller than required to render such specialist treatment options financially feasible. It is therefore assumed that such dredged material will require exportation. Shipment and gate fee costs were estimated by making reference to costs currently incurred by WasteServ Malta Limited in the exportation of similar waste streams. Alternatively slightly contaminated material may be subject to other containment techniques such as including containment in building material. The cost of this was estimated through reference to an Amsterdam based case study264. The costs were adjusted to take into account of inflation and purchasing power differences. **Dredging non-contaminated sediment** will not require treatment prior to disposal.	
SWM 6	**Carry out joint inspections with Transport Malta, the Civil Protection Directorate, the Occupational Health and Safety Authority and the Water Services Corporation to ensure that industrial operations abide to best environmental practice**	Costs in relation to the measure are limited to the time that needs to be invested by relevant officials to merge procedures and negotiate the logistics involved in coordinating joint inspections. Such costs are however considered to be easily accommodated within the schedules of existing personnel. Furthermore, the measure will generate some cost savings, in terms of efficiency gains in undertaking inspections, as well as administrative cost savings for the private sector. These are assumed to offset the implementation costs resulting in a cost neutral measure.	No additional costs expected.
SWM 7	**Develop a system to encourage adequate litter management and control in coastal areas**	The costs envisaged are: • Tender drafting, publication and adjudication costs; • Investment costs in relation to undertaking to required work; training the required personnel and purchasing the	***Tender drafting, publication and adjudication cost*** were estimated at € 25,000 ***Investment costs:*** Varies depending on equipment bought and training needs identified.

[264] Hakstege, P. Handling of dredged material in the Netherlands.

Measure Code	Title of Measure	Description of cost assumptions	Cost estimate
		required equipment to collect marine litter. An analysis of available literature indicated an average common area maintenance cost for the cleaning ports of €0.785 per square meter (excluding extraordinary maintenance).	€ 200,000 should be budgeted for this.
SWM 8	**Improve operational standards for the aquaculture sector via the environmental permitting process**	It is anticipated that the measure entails utilising the equivalent of approximately 160 hours of an existing compliance officer's time in order to draft the new guidelines. The cost of this measure is already accounted for in Key 1.	Cost already accounted for under separate measure KEY 1
SWM 9	**Creation and Implementation of the Agriculture Waste Management Plan**	Cost for creation for the Agriculture waste management plan is (€27,490). The implementation costs of the said plan are not yet known since the measures identified in the plan are still to be further developed. However, such costs will be included in the second implementation phase, in 2018 when the measures proposed have been fully developed	Costs to be considered during the second implementation phase of this plan.
SWM 10	**Establish a Mercury Management Plan to enable the investigation of potential sources of mercury and potential mitigation measures.**	The estimated costs to carry out the investigation which will involve inspection of all potential sources of mercury pollution (land-based, air based and transboundary sources) add up to €50,000. The second stage would be to identify potential measures to mitigate Mercury contamination coming from sources that can be controlled from land. The costs regarding the implementation of this activity are unknown and will be updated in the second implementation phase of Malta's WCMP.	Costs of first phase of study estimated at €50,000. Costs of the second phase will be considered during the second implementation phase of this plan.
SWM 11	**Streamline designated bathing waters as defined by the Environmental Health Directorate with designated swimming zones as regulated by Transport Malta**	The costs of this measure are expected to be subsumed by existing processes. The Bathing Water Management Committee meet regularly and both TM and the EHD would be able to streamline designation via this working Committee.	No additional costs envisaged.
SWM 12	**Extend the basic measure related to the removal of alien species from the Qattara habitat, as identified in the Natura 2000 Management Plan, to Ghadira ta' Sarraflu**	The cost of this measure is divided into 2: - Costs related to the actual removal of the species - Costs related to targeted awareness raising in the area	- Costs related to targeted awareness raising in the area – estimated at approx. € 2,500
SWM 14	**Create a strategic policy framework for Integrated Valley Management**	Costs related to assessing and categorizing the valley systems Costs related to compilation of management plans together with stakeholders, including interested public and NGOs	€ 1 million

Measure Code	Title of Measure	Description of cost assumptions	Cost estimate
Key 3	**Enhance water and marine data using an open platform**	The current system implementation and running costs were estimated as follows: ***Implementation costs:*** An information resources officer will be engaged to oversee the implementation of the system – it can be assumed that a staff complement of 4 new officers would be required to assist the process. This cost will be incurred for three consecutive years with the project being expected to kick-off early 2016. ***Running costs*** envisaged relate to licence fees	The ***implementation cost*** is estimated to amount to € 180.000. ***Running costs:*** € 220.000 during the first year and € 40.000 each year thereafter Total - € 600,000
KNO 1	**Study the impacts of the national spoil ground off Xgħajra**	The action to be taken in this respect involves a study which will enhance knowledge on the state of impact of the national spoil ground off Xghajra. The costs involved relate to the outsourcing of the study.	The cost to complete the study is estimated at around €60,000. No recurrent costs are expected.
KNO 2	**Carry out a technical feasibility assessment regarding the management of ballast waters**	The technical feasibility assessment would need to look into what capacity of facilities would be required and which type of service providers would be needed to carry out the tasks of waste management from the stage of removal of the waste (water and/or sediment) from the ship, on to the stages of storage, treatment and final disposal. Therefore research based upon the opening schedules for similar feasibility studies was carried out and an average cost of the bids for each tender was taken as the best estimate for this measure. This amounted to approximately to €57,000.	Average estimate of study amounted to €57,000
KNO 3	**Characterise and quantify hydrological input of land based contaminants (including litter) to coastal waters from major sub catchments.**	***GIS Modelling:*** Costs involve the recruitment of one person, on a contract basis, to undertake the modelling exercises. ***Collecting water quality and manual flow gauge testing:*** It is being assumed that five major sub-catchment areas in the Maltese Islands will require further study. The Cost estimation is based upon the assumption that a days worth of an expert's time, per site, will be required to conduct flow gauging and to collect water samples. This equates to five days' worth of a relevant expert's time spread across a year. The monitoring would be expected to take place across a three year period, resulting in a 15 working day requirement. The cost of this was estimated using a charge-out rate of €100 per hour,	***GIS Modelling:*** at an estimated cost of €35,000. ***Collecting water quality and manual flow gauge testing:*** €50,000 ***Laboratory Analysis costs:*** *For testing of nutrients, heavy metals and PAHs in storm water at 3 nodes per sub-catchment:* €200,000

Measure Code	Title of Measure	Description of cost assumptions	Cost estimate
		resulting in a total cost of €12,000 excluding VAT, spread evenly across three years. It is assumed that the work will be contracted out to a consultant and the assumed charge-out rate is intended to cover all costs, including the use of the consultant's equipment. ***Laboratory Analysis costs:*** It is estimated that 3 samples will be taken from different parts of each catchment area, each year. This results in €45 samples that require sample testing. Through previous experience, the costs of undertaking such tests (related to heavy metals, nutrients and Polyaromatic hydrocarbons) would amount to approximately €2,500 per test. This results in a total bill for laboratory tests amounting to €112,500 spread evenly across three years.	
KNO 4	**10.1 Investigate the role transboundary contaminants through hydrographic pathways and the extent of its contribution to marine contamination.**	***Consultancy services in relation to Funding application:*** It is estimated that internal and outsourced costs will be required to draw up the application for a funding programme (e.g. Horizon 2020). This includes costs in relation to finding a suitable partner from another Member State. ***Tender drafting, publication and adjudication costs:*** Given the size and complexity of the tender internal and outsourced costs would also need to be considered in relation to the drafting, publication and evaluation of the tender document. ***Actual study:*** Estimating the cost involved in a regional study of this nature is difficult, particularly before establishing more details with regards what technical requirements would be entailed. This estimate is based upon reviewing tender values for large and related tenders published on the Tenders Electronic Daily website (ted.europa.eu). The average value across all applicable tenders amounts to €527k. The studies found were however not very similar to the work envisaged. To try and account for this, each study was assessed on four criteria that determine the respective study's similarity weight; (1) whether the studies are of a transboundary nature; (2) whether the studies are of a technical or scientific nature; (3) whether the studies require the collection of primary data/feedback, and; (4) whether the studies relate to an environmental theme.	***Consultancy services in relation to Funding application:*** Approximate internal and outsourced costs amount to €15,000 ***Tender drafting, publication and adjudication costs:*** internal and outsourced costs would amount to €10,000 ***Actual study:*** The weighted average cost based on the criteria explained amounted to €450,000. This was used as an estimate for the value of this research opportunity and it was further assumed that the cost of the study would be spread across one year.

Measure Code	Title of Measure	Description of cost assumptions	Cost estimate
KNO 5	**Carry out investigations to gauge potential contribution of contaminants to our coastal waters by atmospheric disposition.**	As a first step (as explained in Chapter 9) a literature review is needed to gauge estimated, measured, or modelled deposition rates in the Mediterranean region. If the study results in air deposition being significant, an air advisory group would need to be engaged to design an air deposition assessment strategy which would then need to be implemented in third WFD cycle. The implementation costs of the study will be incurred in the second implementation phase and cannot be estimated as yet.	It is estimated that the costs related to the first study is around €30,000. The implementation costs of second part cannot be estimated until the first part has been concluded – costs of second part will be known in the second implementation phase.
KNO 6	10.2 **Carry out a survey of all direct discharges to sea and identify their source with the objective of setting up a plan to curtail/regulate such discharges.**	It is expected that this survey would cover two aspects: • The mapping of the location of the discharge points. • Hydrodynamic studies of water residence times in areas of main discharges.	The mapping of the location of the discharge points is estimated at €35,000. The hydrodynamic studies are estimated at €100,000.
KNO 7	10.3 **Carry out seasonal surveys of mooring or anchorage areas**	The costs are related to the outsourcing of this study and are similar to the costs required to map the discharge points (see KNO 6 above). However, it will occur over 2 seasons meaning that costs incurred are doubled.	€40,000.
EMER 1	10.4 **Creation of a working group tasked with the updating of sensitivity maps to enable better marine emergency response**	Given that the task of the working group is to coordinate the updating of sensitivity maps in relation to emergency response, the costs involved can be subsumed by internal day-to day working efforts.	No additional costs envisaged.
EMER 2	10.5 **Create an ERA pollution response log for environmental incidents occurring at land and at sea**	Since a standard operation procedure and database to log information is required, the costs are expected to be internal and shall be absorbed by the normal day-to-day operations.	No additional costs envisaged.

Measure Code	Title of Measure	Description of cost assumptions	Cost estimate
EMER 3	**10.6 Put into place the terrestrial emergency response strategy**	The main costs involved relate to: - the assigning of existing personnel to an on-call register so that sufficient resources are available to respond effectively to spills in a terrestrial setting - Training requirements to ensure that on-call personnel are fully equipped and able to deal with the range of terrestrial emergencies that can take place. Costs related to training were estimated on the basis of similar costs that have been incurred by training related to marine spill contingency.	The assigning of existing personnel to an on-call register is expected to cost approximately €13,600 for the ERA The training of on-call personnel - €600,000
AWA 1	**10.7 Targeted awareness campaign on impacts of marine litter**	The cost of the campaign is estimated by taking an average of the bids submitted for tenders of a similar nature.	Based on large campaigns, the expected cost is approximately €280,000
AWA 2	**10.8 Targeted awareness campaign on the appropriate disposal of chemicals and/or chemical containers, including medicines, pesticides, fertilisers and related packaging.**	The cost of the campaign is estimated by taking an average of the bids submitted for tenders of a similar nature.	Based on large campaigns, the expected cost is approximately €280,000

Table 11.2: Costs of Basic measures stemming from the Water Framework Directive

11.1.4 Summary of total costs

The table below (Table 11.2) gives a summary of the total costs to be incurred by the private and public sector over the period 2015-2021. It is to be noted that some of the measures involve the change of a process or policy which do not require dedicated resources but instead will be performed by existing, non-incremental resources. Such costs have not been quantified.

Cost type	Public/ Private Sector	Recurrent Capital	2015	2016	2017	2018	2019	2020	2021	Total	NPV* at 5%
SWM 13 Monitoring costs	Public	Capital	20	unknown	unknown	unknown	-	-	-	20	16
KEY 1											
HR costs	Public	Recurrent	-	175	245	456	456	456	456	2,243	
Training costs	Public	Capital	-	15	15	15	15	15	15	90	
			-	190	260	471	471	471	471	2,333	1,931
SWM 1 Finalisation of guidance document	Public	Capital	-	23	-	-	-	-	-	-	
Ex-post surveying costs	Private	Recurrent	-	354	354	354	354	354	354	2,126	
			-	377	354	354	354	354	354	2,126	1,799
SMW 2 Compliance cost	Public	Recurrent	-	35	35	35	35	35	35	210	
Abatement cost	Private	Recurrent	-	2,611	2,611	2,611	2,611	2,611	2,611	15,666	
			-	2,646	2,646	2,646	2,646	2,646	2,646	15,876	13,431
KEY 2 Monitoring costs	Public	Recurrent	-	-	70	70	70	70	70	350	289
SWM 3	No inc. costs		-	-	-	-	-	-	-	-	
SWM 5											
Surveying costs			-	-	-	-	-	-	-	-	
Costs of dealing with sediments	Private	Recurrent	-	1,179	1,179	1,179	1,179	1,179	1,179	7,076	5,986
SWM 6	No inc. costs		-	-	-	-	-	-	-	-	
SWM 7 Training and purchasing of equipment	Public	Capital	-	25	200	-	-	-	-	225	190
SWM 8	No inc. costs		-	-	-	-	-	-	-	-	
SWM 9											

Plan development costs	Public	Capital	27	-	-	-	-	-	-	27	27
	Public	Recurrent				Not yet determined				-	
SWM 10											
Consultancy services	Public	Capital	-	50	-	-	-	-	-	50	48
KEY 3											
Implementation	Public	Capital		30	30	30	30	30	30	180	
IT system set up costs	Public	Recurrent	-	220	40	40	40	40	40	600	
			-	250	70	70	70	70	70	780	659
KNO 1											
Consultancy services	Public	Capital	-	-	-	60	-	-	-	60	51
KNO 2											
Consultancy services	Public	Capital	-	60	-	-	-	-	-	60	51
KNO 3											
GIS modelling costs	Public	Capital	-	-	35	-	-	-	-	35	
Gauge measuring and water sampling	Public	Recurrent	-	-	-	16	16	16	-	48	
Laboratory costs	Public	Recurrent	-	-	-	66	66	66	-	200	
			-	-	35	82	82	82	-	283	239
KNO 4											
Consultancy services	Public	Capital	-	-	450	-	-	-	-	450	
Administrative costs	Public	Capital	-	-	15	-	-	-	-	15	
Tender drafting, publication and adjudication costs	Public	Capital	-	-	10	-	-	-	-	10	
			-	-	475	-	-	-	-	475	431
KNO 5											
Consultancy services (part 1)	Public	Capital	-	30	-	-	-	-	-	30	29
KNO 6											
Consultancy services (Mapping study)	Public	Capital	-	35	-	-	-	-	-	35	
Consultancy services (Hydrodynamic study)	Public	Capital	-	100	-	-	-	-	-	100	
			-	135	-	-	-	-	-	135	114

KNO 7 Consultancy services	Public	Capital	-	20	20	-	-	-	-	40	37
EMER 1	No inc. costs		-	-	-	-	-	-	-	-	
EMER 2	No inc. costs		-	-	-	-	-	-	-	-	
EMER 3 Resource costs	Public	Recurrent	-	-	14	14	14	14	14	68	56
AWA 1 Outsourced Campaign costs	Public	Capital	-	-	-	277	-	-	-	277	239
AWA 2 Outsourced Campaign costs	Public	Capital	-	-	-	277	-	-	-	277	239
Total			**47**	**4,962**	**5,323**	**5,500**	**4,886**	**4,886**	**4,804**	**30,553**	**19,876**
	Public	Capital	47	388	775	659	45	45	45	2,004	725
	Public	Recurrent	-	430	404	697	697	697	615	3,540	
	Private	Capital	-	-	-	-	-	-	-	-	-
	Private	Recurrent	-	4,144	4,144	4,144	4,144	4,144	4,144	24,864	-

* NPV – Net Present Value

Table 11.3: A summary of the cost estimates for incremental measures (€ ‘000).

11.1 Cost-effectiveness assessment of surface water measures

The costs of the measures presented in Section 11.1 takes into account the monetary expenses that shall be incurred by both the private and public sector. It does not account for any of the benefits that are anticipated from the measures. Therefore there is a need to evaluate the impacts of these measures in terms of their benefits by using a multi-criteria analysis technique.

11.2.1 Method

The criteria used to assess the measures using the multi-criteria analysis are grouped into 3 perspectives:

- Social
- Economic
- Environmental

A systematic evaluation was then carried out based on these perspectives. For each perspective the evaluation considers the effectiveness of the measure’s design to address key issues falling within the respective perspective, whilst also evaluating whether the measure utilised the tools offered under each perspective. In addition for each perspective the evaluation also considers whether the measure might have created costs or drawbacks which were not quantified.

Each perspective has equal weighting and is evaluated on a score range between 0 and 10. A measure that has no particular issue with any of one of the three perspectives would be assigned a score of 5. If the measure however can bring about potential drawbacks, then the score would be lowered and vice-versa in cases where the measure addresses issues.

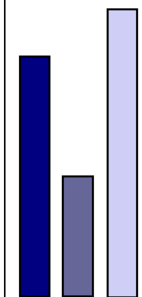
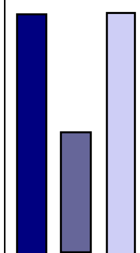
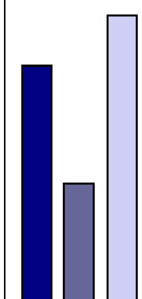
For example – Measure KNO 7 dealing with the surveying of anchorage and mooring areas of recreational boats around the Maltese Islands may have social implications. Should the measure lead to the posing of a limit on recreational craft in ecologically sensitive areas, such a measure may be resisted due to the potential to strain a highly popular leisure activity. It would also be difficult to enforce without ensuring that an enforcement team is in place. Therefore the measure loses points if the measure is not linked to improved enforcement functions. Similarly, unless the measure finds a way to mitigate resistance to change, the measure would lose effectiveness points from a social perspective. Table 11.3 provides the considerations for each perspective.

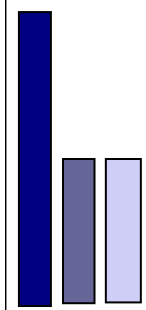
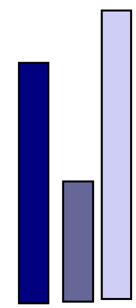
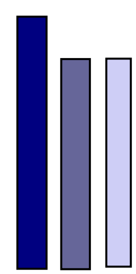
Perspective	Effectiveness Concerns	Drawback Concerns
Social Perspective	▪ will society easily find ways of avoiding measure? ▪ will society resist change, and have elements to mitigate resistance to change been considered for inclusion?	▪ are costs and rewards of measure equitably distributed? ▪ will measure lead to a disproportionate burden on particular elements of society? ▪ does the measure impinge on the enjoyment or value of cultural or historic assets?
Economic Perspective	▪ has the measure considered the potential of economic incentives as a tool to improve effectiveness? ▪ has the measure considered the use of behaviour economics techniques to improve effectiveness, and does the measure embrace the polluter pays principal?	▪ does the measure lead to unintended economic incentives that can distort the distribution of resources? ▪ does the measure have a notable and uncompetitive impact on productivity that has not been quantified? ▪ does the measure lead to information asymmetry problems or uncertainty?
Environmental Perspective	▪ is the measure likely to have a material impact in attaining WFD targets? ▪ is the measure anticipated to be implemented in a timely manner? ▪ is the measure focused on key sources of pollution? ▪ is the design of the measure based upon sufficient environmental data? ▪ does the measure sufficiently address wider environmental issues?	▪ does the measure lead to other environmental impacts not measured as part of WFD targets? ▪ does the measure negatively impact the value of environmental assets?

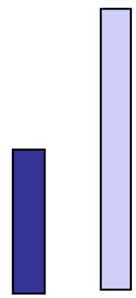
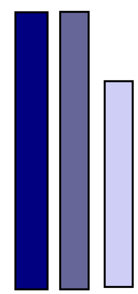
Table 11.4: Criteria used to assess the cost-effectiveness of surface water measures for each evaluation perspective

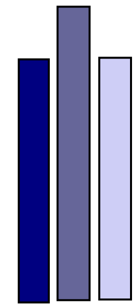
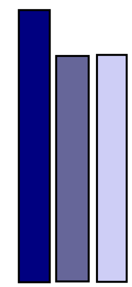
Table 11.5 summarises the evaluation of the measures which is a result of discussions with economic and technical experts.

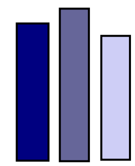
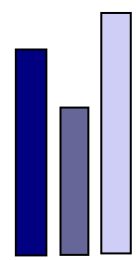
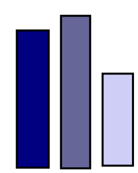
Analysis of measure cost effectiveness

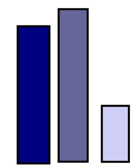
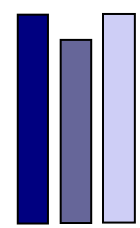
Measure	Social Perspective		Economic Perspective		Environmental Perspective		Score balance	Overall score
Key 1: Continue to refine the regulatory framework for industrial operational practices	8	**+** Greatly improves widespread enforcement **-** Awareness raising initiative concerning the change could heighten behavioural shift induced through measures. The measure could be more effective if accompanied by such a campaign	3	**+** no major productivity issues or unintended incentives **-** lack of polluter pays principal (fines for non compliance could be increased to cover cost	10	**+** widespread improvement to compliance for WFD related regulations impacts many water bodies simultaneously		21
SWM 13: Set up a watch list mechanism to monitor certain emerging substances identified at EU level that could potentially be of concern	8	+ increases social awareness on emerging pollutants that could potentially be of concern to human health	3	- costs for monitoring and analysis could be high given that substances are emerging and Malta is not equipped with laboratories or research institutions to carry out the necessary research	8	+ Improved knowledge on the potential threats to ecosystems and human health		19
SWM 1: Continue to strengthen the relationship between environmental and planning regulatory processes	8	+ improves widespread compliance and enforcement + awareness raising concerning the change could heighten behavioural shift induced through measure - The measure could be more effective if accompanied by a campaign	3	**+** no major productivity issues or unintended incentives **-** lack of polluter pays principal (fines for non compliance could be increased to cover cost	10	**+** widespread improvement impacting many water bodies simultaneously - the significance of impacts of industrial discharges to the marine environment are not fully understood at present		21

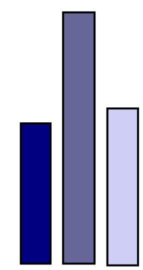
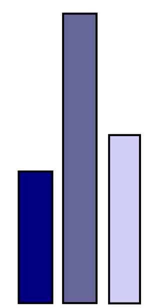
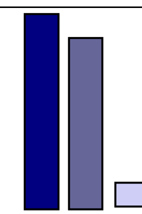
Measure	Social Perspective		Economic Perspective		Environmental Perspective		Score balance	Overall score
SWM 2: Continue to control priority hazardous substances, priority substances and other substances of concern	10	+ significant enhancement in enforceability + synergies with AWA 2 which will also raise awareness + improved health benefits due to cleaner environment	5	+ results in higher production costs for controlled substances, thereby creating an economic incentive to switch to alternatives	5	+ widespread improvement in the quality of surface water bodies - the significance of impacts of industrial discharges to the marine environment are not fully understood at present		20
Key 2: Create an effective feedback mechanism within ERA to ensure compliance and risk mitigation	8	+ greatly improved widespread enforcement + awareness raising concerning the change could heighten behavioural shift induced through measure - The measure, however, could be more effective if accompanied by a campaign	3	+ no major productivity issues or unintended incentives - lack of polluter pays principal (fines for non compliance could be increased to cover cost	10	+ widespread improvement in the quality of surface water bodies		21
SWM 3: Update the inventory of discharges (EQS Directive)	10	+ improves public awareness of potential sources of pollution and environmental risks + leads to behavioural changes across sectors on management of chemicals that are of concern	8	+ Used as a tool to enable better decision making when designing measures so that specific sectors are targeted where attention is most needed	8	+ better management measures designed to target environmental issues of most concern		26

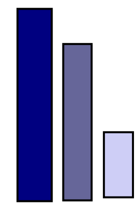
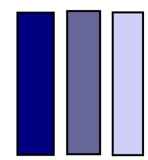
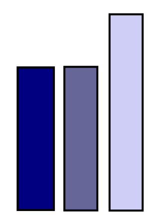
Measure	Social Perspective		Economic Perspective		Environmental Perspective		Score balance	Overall score
SWM 5 - Develop and implement guidelines for the disposal of dredged material	5	+ toxic, bioaccumulative and persistent contaminants from sediment are controlled in the marine environment such that these contaminants are not readily absorbed by fish which is later consumed. -measure exacerbates cost of maintenance dredging in contaminated sediment areas. These costs are concentrated on a few existing operators and no transitionary or compensatory mechanisms are currently envisaged. - these organisations often render services (such as grain importation or passenger ferrying). Cost increases may have a social impact by elevating prices of such goods.	-	- Due to the lack of local treatment plants, the cost of dealing with contaminated sediment is higher in Malta than elsewhere. The added cost is quantified in the cost side of this analysis, but the lost competitiveness is not. No compensatory measures are currently envisaged to offset this. - The measure considerably increases the cost of dredging in contaminated areas. However the cost is excessive considering the need to export waste and may exceed the value of the externality that it is correcting. This may result in an inefficient allocation of resources away from port infrastructure.	10	+ the release of contaminants from sediment damaging to the environment in which it is deposited.		15
SWM 6 - Carry out joint inspections with entities to ensure that industrial operations abide to best environmental practice	10	+ Reviewing a holistic plan covering both sets of regulation allows for more simple and effective enforcement. + Results in private sector savings, thereby facilitating compliance.	10	+ results in improved resource use across the public sector + streamlining regulations into one plan request facilitates the ease of doing business by rendering administrative requirements more transparent and easier to find.	7	+ improved efficiency of operation is likely to result in compliance officers able to focus more energy on value adding areas rather than more bureaucratic processes		27

Measure	Social Perspective		Economic Perspective		Environmental Perspective		Score balance	Overall score
SMW 7: Develop a system to encourage adequate litter management and control in coastal areas	7	+ measure provides wider social benefits beyond improvements to quality of water bodies	10	+ Action addresses public spaces which are difficult and impractical to restrict access. Such areas are by nature public goods and thus would be better maintained with such planned public sector interventions. +investing in cleaner coastal waters enhances Malta as a better tourist destination	7	+ the measure does cater for a major source of water pollution and is likely to have a material impact on related water bodies.		24
SMW 8: Improve operational standards for the aquaculture sector via the environmental permitting process	10	+ Pollution from aquaculture impacts the enjoyment of popular beaches. This a social issue that has raised complaints in the past + better operational guidance leads to better quality produce which can be enjoyed	7	+ improving the environmental efficiency of the aquaculture sector assists the sustainability of other economic sectors (tourism).	7	+ efficiency leads to better water quality in most water bodies where aquaculture activity is present		24
SMW 9: Creation and Implementation of the Agriculture Waste Management Plan	n/a	Insufficient information to evaluate measure	n/a	Insufficient information to evaluate measure	n/a	Insufficient information to evaluate measure	n/a	

Measure	Social Perspective		Economic Perspective		Environmental Perspective		Score balance	Overall score
SMW 10: Establish a Mercury Management Plan to enable the investigation of potential sources of mercury and potential mitigation measures.	5	Although positive effects are expected once the measure has been fully implemented, no observations from a social perspective at this stage the measure essentially recognises the problem, and budgets for additional study. Future measures stemming from such studies would require further evaluation in the second implementation stage.	6	+ it should be noted that professional services are often associated with few economic leakages. In economic terms (*from a keynesian multiplier perspective*), money spent on such items in fact costs less than its pure financial value as the spend is quickly converted to direct and indirect GVA. No further observations were possible due to a lack of information on other measures stemming from the future plan.	4	+ mercury was identified as an issue in various water bodies and the problem clearly needs to be addressed. - The measure makes no tangible improvement in WFD targets at this stage.		15
KEY 3: Enhance water and marine data using an open platform for data management	8	+ greatly improves widespread knowledge, compliance and enforcement - awareness raising concerning the change could heighten behavioural shift induced through measure	5	+ no major productivity issues or unintended incentives	10	+ widespread improvement to compliance for WFD related regulations impacts many water bodies simultaneously		23
KNO 1 - Study the impacts of the national spoil ground off Xghajra	5	No observations from social perspective at this stage the measure essentially recognises a potential problem, and budgets for additional study. Future measures stemming from such studies would require further evaluation in the third WFD cycle.	6	+ it should be noted that professional services are often associated with few economic leakages. In economic terms (*from a keynesian multiplier perspective*), money spent on such items in fact costs less than its pure financial	3	+ The chemical status of sediment at Xghajra (MTC106) is problematic. This measure begins to tackle a likely source. - The measure makes no tangible improvement WFD targets at this stage.		14

Measure	Social Perspective		Economic Perspective		Environmental Perspective		Score balance	Overall score
				value as the spend is quickly converted to direct and indirect GVA. No further observations were possible due to uncertainty on other measures stemming from any future action that may be required to be taken.				
KNO 2 - Carry out a feasibility assessment related to the capacity required to manage ballast waters	5	No observations from a social perspective	6	+ it should be noted that professional services are often associated with few economic leakages. + address an area of vital economic importance (shipping). Ensuring efficient and correct decisions is essential, thereby increasing the benefit from further study.	2	+ Maltese marine waters host considerable international traffic. Pollution from dumping of ballast waters could be significant. - Measures makes no tangible improvement WFD targets at this stage.		
KNO 3: Characterise and quantify hydrological input of land based contaminants (including litter) to coastal waters from major sub catchments.	8	+ targeted action as outcome of study will in the longer run result in cleaner coastal waters and a better tourism product.	7	+ it should be noted that professional services are often associated with few economic leakages. + Understanding the quality of stormwater may result in improved reuse applications of stormwater in various economic sectors resulting in increased water savings	8	Due to the urbanisation of valley systems, storm water run-offs are likely to contribute to nutrient enrichment, mercury and lead pollution in a variety of water bodies. + Investing in knowledge is likely to render any future actions more effective and result in cleaner bathing waters/ coastal waters. + The characterisation of storm water run-off may increase our understanding of the potential		23

Measure	Social Perspective		Economic Perspective		Environmental Perspective		Score balance	Overall score
						for the collection and treatment of such water.		
KNO 4: Investigate the role transboundary contaminants through hydrographic pathways and the extent of its contribution to marine contamination.	5	No observations from a social perspective	10	+ it should be noted that professional services are often associated with few economic leakages. + the potential for obtaining external financing for the transboundary project could lower the cost for the Maltese economy	6	+ Some contaminants are expected to be the result of transboundary contamination and this was identified as a potential issue in a number of water bodies and the problem needs to be addressed. - Measure makes no tangible improvement in WFD targets at this stage.		21
KNO 5: Carry out investigations to gauge potential contribution of contaminants to our coastal waters by atmospheric disposition	5	No observations from social perspective	10	+ it should be noted that professional services are often associated with few economic leakages. + the potential for obtaining external financing for the transboundary project could lower the cost for the Maltese economy	6	+ Some contaminants are expected to be the result of transboundary contamination and this was identified as an issue in a number of water bodies and the problem clearly needs to be addressed. - The measure makes no tangible improvement in WFD targets at this stage.		21
KNO 6: Carry out a survey of all direct discharges to sea and identify their source with the objective of setting up a plan to	7	+ Such a survey would require contact with a variety of operators thereby raising awareness about upcoming actions.	6	+ it should be noted that professional services are often associated with few economic leakages.	1	- Measure makes no tangible improvement WFD targets at this stage.		14

Measure	Social Perspective		Economic Perspective		Environmental Perspective		Score balance	Overall score
curtail/regulate such discharges.								
KNO 7: Carry out seasonal surveys of mooring or anchorage areas	6	+ yachting and boating is a major recreational hobby in Malta. A detailed study which includes a consultation exercise is likely to more easily strike a balance between environmental and social issues whilst also facilitating the change process.	5	+ it should be noted that professional services are often associated with few economic leakages. - Even though the measure deals with a study, the implications of the survey may in the future translate into restricted areas for yachting which may result in financial implications on the yachting and tourist industry. This consideration will have to be taken into account following use of the survey results.	3	+ will improve our understanding of *posidonia* meadows, which will also facilitate the vetting of development applications. - Measure makes no tangible improvement in WFD targets at this stage.		15
EMER 1: Creation of a working group tasked with the updating of sensitivity maps to enable better marine emergency response	5	+sensitivity maps would aid in effective emergency response, and assist in the protection of crucial infrastructural assets which the general public rely on such as water and energy supplies	5	+ critical infrastructural assets could be safeguarded as a result of immediate emergency response informed by sensitive maps	5	+ Ecologically sensitive areas would be safeguarded and relevant clean-up strategies deployed would ensure that the needs for the sensitive sites are catered for in case of an emergency response.		15
EMER 2: Create an ERA pollution response log for environmental incidents occurring at land and at sea.	5	No observations from social perspective	5	No observations from economic perspective.	8	+ critical tool required to instigate investigative monitoring in coastal water stretches where pollution incidents may leave undesirable impacts on the environment and ecosystems present		18

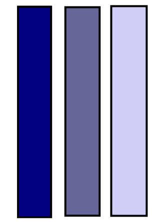
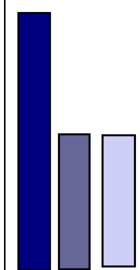
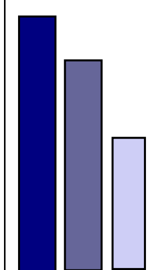
Measure	Social Perspective		Economic Perspective		Environmental Perspective		Score balance	Overall score
EMER 3: Put into place the terrestrial emergency response strategy.	8	+ the protection of crucial infrastructural assets which the general public rely on such as water and energy supplies	8	+ critical infrastructural assets could be safeguarded as a result of immediate emergency response	8	+ ecologically sensitive areas would be safeguarded and relevant clean-up strategies deployed in an effective manner thereby limiting the extent of damage.		24
AWA 1: Targeted awareness campaign on impacts of marine litter	10	+ directly engaging the public and raising awareness is an effective means of raising long-term compliance.	5	+ it should be noted that professional services are often associated with few economic leakages. - measure could be reinforced by increased use of fines and greater enforcement of marine areas.	5	+ widespread improvement impacting many water bodies simultaneously - marine litter is not considered a major source of pollution in Malta at present		20
AWA 2: Targeted awareness campaign on the appropriate disposal of chemicals and/or chemical containers, including medicines, pesticides, fertilisers and related packaging.	10	+ Directly engaging the public and raising awareness is an effective means of raising long-term compliance.	8	+ it should be noted that professional services are often associated with few economic leakages. + Measure is coupled with increased enforcement of sewage discharges and compliance with priority substance control.	3	+ widespread improvement impacting many water bodies simultaneously - The significance of impacts of industrial discharges to the marine environment are not fully understood at present		23

Table 11.5: Analysis of measure cost effectiveness

Based on the analysis described in Table 11.4 a prioritisation of measures by the cost per score of effectiveness was possible. It must be kept in mind that the method used is not sufficiently scientifically robust enough to create a strict quantification of benefits to costs. However it achieves the purpose of informing this plan by identifying key issues.

It should also be kept in mind that the cost-effectiveness analysis carried out clearly pointed to the fact that assessing the value of measures that are different in nature is difficult. More specifically the methodology used does not sufficiently distinguish between tangible measures and studies. It is obvious that tangible measures would cost more whilst at the same time, the study of a study alone is useless unless it is followed by action. Thus, whilst studies are vital in order to inform future measures the costs included in this analysis do not include the cost of measures needed to make use of the study.

The methodology therefore provides a huge cost per benefit point advantage to studies. This does not diminish the value of the evaluation; however it must be kept in mind when evaluating the results of this analysis. Keeping this in mind, Table 11.5 presents the final assessment of cost per benefit point.

Code	Total cost	Total score	Cost per score	Comment	Ranking: tangible only	Overall Ranking
Key 1	2,700,000	21	128,571		8	15
Key 2	350,400	21	16,686		5	13
Key 3	780,000	23	33,913	The cost covers the implementation costs of the IT system for the first three years only. This could be considered at "stage 1" of the project, and omits full implementation costs.	6	12
SWM 1	2,126,250	21	101,250		7	14
SWM 2	15,876,315	19	835,596		10	17
SWM 5	7,075,667	15	471,711		9	16
SWM 6	-	27	-	There are no incremental cost in this measure since it will be carried out with the existing operation	n/a	n/a
SWM 7	225,000	23	9,782	Incomplete information. So the resulted score may be overstated or understated.	2	8
SWM 8	-	21	-	The cost of this measure is already included in Key 1	n/a	n/a
SWM 9	27,490	n/a	-	Insufficient information to evaluate this measure.	n/a	n/a
SWM 10	50,000	15	3,333	Insufficient information because it is not taking into account future implementation of the future mercury implementation plan (essentially study type measure at this stage).	n/a	4
KNO 1	60,000	14	4,285	Study	n/a	6
KNO 2	60,000	13	4,285	Study	n/a	5
KNO 3	300,000	23	13,043	Study	n/a	9
KNO 4	475,000	21	22,619	Study	n/a	11
KNO 5	30,000	21	1,429	Study. Cost is made up of consultancy service for part 1 only. Much larger cost anticipated for other stages.	n/a	1
KNO 6	135,000	14	9,642	Study	n/a	7
KNO 7	40,000	15	2,667	Study	n/a	2
EMER 1	-	15	-	Insufficient information and no incremental cost involved	n/a	n/a
EMER 2	-	18	-	Insufficient information and no incremental cost involved	n/a	n/a
EMER 3	68,000	24	2,833		1	3
AWA 1	276,920	20	13,846		4	10
AWA 2	276,920	23	12,040		3	9

Table 11.6: Costs per score

11.2.2 Conclusion of cost effectiveness

SWM 5 and SWM 2 have notably higher a cost per benefit score than all other measures. In the case of SWM 2, the costs are high, but so are the benefits. Furthermore, the costs are highly subjective as they involve an assessment of private sector economic transition costs. It is probable that such costs would only be felt in the short term, and the economy would be able to shift resource allocations to minimise the impact of higher substance controls in the long-term. It was therefore concluded that SWM 2 is not to be evaluated as ineffective and adjustments were not recommended.

On the other hand, SWM 5 appeared to be problematic because the measure fails to take into account potential economic costs that are likely to be incurred upon implementation. The key concerns raised by means of the economic cost-effectiveness analysis are:

- Malta lacks sufficient scale to render a local sediment treatment facility feasible. Thus contaminated sediment is anticipated to require exportation. After undertaking research on the matter, very high costs for exporting such waste resulted. As a result dredging in Malta would be expected to be much higher than in other countries. Bearing in mind that quays require regular maintenance dredging, the fact that sediment treatment costs would be expected to be higher in Malta than in key competing European destinations is likely to render commercial port operations uncompetitive in the medium term. This is particularly relevant for the container transhipment, ship yard services, as well as for internationally oriented Grain and Oil terminals.
- In the long-term, the measure may result in a reduction in resources being allocated to port development. It is possible that this reduction would result in a cost to society that is higher than the benefits derived from the proper treatment of contaminated sediment. This is due to the high costs of exporting sediment.

Even though the total impact to the Maltese economy as a whole is not material, the impact to individual international oriented businesses, such as the Freeport, are notable and this deserves further study. It may be possible that such studies conclude that public sector involvement in the market, either by subsidising commercial outfits or through the direct provision of sediment exportation services would be beneficial. This would avoid export oriented business from losing competitiveness in comparison to other European players.

The cost-effectiveness analysis of the programme of measures concluded that the designed programme of measures adequately takes into account the current status of water bodies; and that the programme provides a reasonable series of measures aimed at meeting the objectives of the Water Framework Directive. Costs required to meet the good ecological potential objectives of the WFD for heavily modified water body MTC 105 (Port il-Kbir and Port ta' Marsamxett) are deemed to be disproportionate and therefore, as indicated in Chapter 8, Malta is applying for less stringent environmental objectives.

11.3 The Cost of Optimising Water Use in order to Protect Groundwater Resources

The Programme of Measures (PoM) under the 2nd Water Catchment Management Plan presents a suite of 45 measures aimed at directly or indirectly optimising water use and water production in the Maltese Islands. The main drive of these measures is to enable the protection of Malta's groundwater resources and the achievement of the WFD good status objectives.

The development of these measures took into consideration the particular characteristics of the Maltese Islands, and hence the need to develop water supply augmentation and water demand management in parallel, supported by strong awareness-raising and knowledge acquisition measures. Moreover, the 2nd Programme of Measures was developed in full synergy with Malta's

National Water Management Plan (NWMP), which addresses water sustainability in the Maltese Islands on a longer timeframe.

The total cost of the PoM is estimated to be €156 million[265] and it is expected to generate an annual net volumetric impact of around 13 million cubic meters. The funding for the measures will make use of a number of instruments including:

- National Funds (public and private) (NAT)
- Cohesion Funds (CF)
- European Regional Development Fund (ERDF)
- European Agricultural Fund for Rural Development (EAFRD)
- European Social Fund (ESF)
- LIFE Integrated Project (LIFE)
- Horizon 2020 Programme (H2020)
- Inter-regional Funds (INTERREG)
- ERASMUS +.

The PoM presents four main typologies of measures, namely;

- **Supply Augmentation Measures** – which focus on widening the national resource base, mainly through the development of alternative water resources such as New Water and increasing the rainwater harvesting capacity;
- **Supply Substitution Measures** – which are aimed at accelerating the substitution of groundwater by alternative water resources;
- **Water Demand Measures** – which incentivise the reduction of water demand through the adoption of efficiency and conservation measures; *and*
- **Enabling (or supporting) measures** – which have no specific direct volumetric impact on groundwater abstraction but are essential to support the implementation of the aforementioned measure typologies.

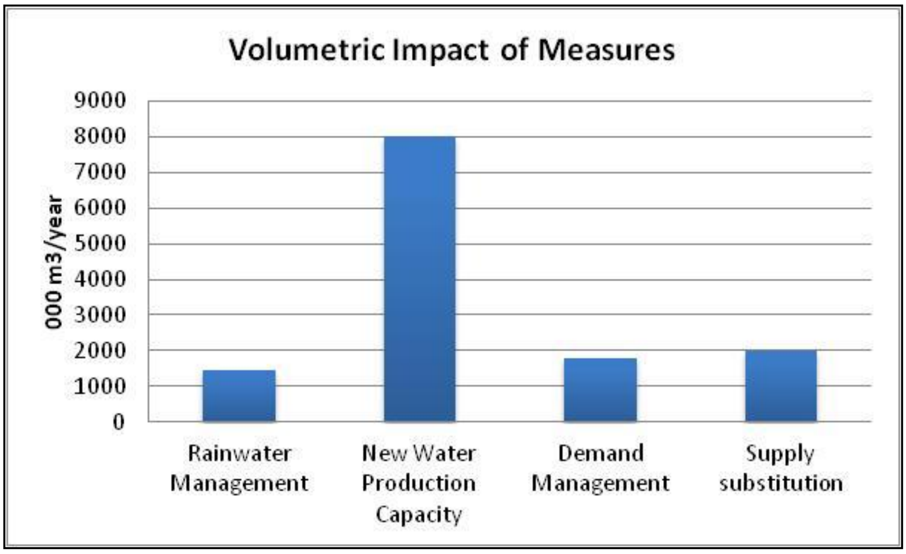


Figure11.1: Volumetric impact of measure typologies

Table 11.6 below lists the planned measures, the funding instruments which are expected to be utilised for their implementation and their mean annual volumetric impact.

[265] This cost pertains to financial costs only and is undiscounted. It also excludes the reinvestment cost for some measures. The discounted financial cost inclusive of reinvestments amounts to €186 million.

Code	Title of Measure	Implementation (Start) Date	Funding Instrument	Impact	Mean volumetric impact per year (m3)
	Administrative Measures				
GVN1	Determination of the roles and responsibilities of all public sector agencies involved in the wider management of water resources	2016	NAT	Supporting	n/a
RWH2	Development of the administrative capacity required to ensure the effective implementation of current legislative requirements in relation to the development of rainwater harvesting facilities and associated secondary water conveyance systems	2017	NAT	Increase in harvested rainwater	10,000
	Codes of Good Practice				
GVN3	Development of guidance documents to assist operators in achieving best practice in water management practices	2017	NAT	Supporting	n/a
PUB6	Establishment of water-use standards and guidelines for water use in public landscaping initiatives	2018	NAT, LIFE	Substitution of supply	10,000
	Demand Management Measures				
PUB1	Development of a Water Demand Map representing the spatial variation of water demand in terms of both quantity and quality, and establishing benchmarks for efficient water use.	2016	NAT, LIFE	Supporting	n/a
DOM1	Support mechanisms for water consumption audits in households.	2017	NAT, LIFE	Reduction of 1% of municipal demand	200,000
AGR1	Support schemes for the uptake of efficient irrigation technology by the arable agricultural sector	2016	EAFRD	Reduction in water demand	10,000
AGR2	Support schemes for the uptake of efficient water technology by the animal husbandry sector	2016	EAFRD	Reduction in water demand	10,000

RWH4	Support schemes for the development of rainwater runoff harvesting facilities in the agricultural and commercial sectors	2016	NAT, EAFRD	Increase in harvested rainwater	25,000
Efficiency and Reuse Measures					
PUB2	Establishment of minimum technical and economic levels of leakage in the municipal distribution network, and achievement of these thresholds through the ongoing leakage management and control programme operated by the public utility	Ongoing / 2016	NAT	Reduction in water demand	100,000
Desalination Plants					
DES2	Comprehensive assessment of the uptake of the tourism and commercial sectors of membrane based water treatment technology, and development of support schemes to attain this capacity	2018	NAT, LIFE	Supporting	n/a
ENE1	Establishment of specific power benchmarks for WSC Desalination Plants and continued upgrading programmes for the phased achievements of these benchmarks	Ongoing / 2016	NAT, CF, ERDF	Supporting	n/a
Artificial Recharge of aquifers					
GWM4	Development of Managed Aquifer Recharge schemes for aquifer management purposes	2018	NAT, LIFE, CF, H2020	Increase in mean annual recharge	2,000,000
Educational Projects					
STE1	Development of a long-term National Water Conservation Campaign	Ongoing / 2016	NAT, LIFE, CF	Reduction of 5% of municipal demand	1,000,000
STE2	Specific campaign to focus on educational activities on water management in schools	Ongoing / 2016	NAT, LIFE	Supporting	n/a
Research, development and demonstration projects					

NEW3	Development of Demonstration Sites for the application of New Water Resources	2016	NAT, LIFE, INTERREG	Supporting	n/a
ALT1	Comprehensive assessment of the exploitation natural coastal and submarine groundwater discharge	2017	CF, INTERREG, H2020	Supporting	n/a
ALT2	Comprehensive assessment of the exploitation potential of the saline aquifer system underlying the mean sea level aquifer system	2018	CF, INTERREG, H2020	Supporting	n/a
STE3	Development of demonstration projects to showcase the application of innovative technology in the local water sector	Ongoing / 2016	NAT, CF, INTERREG, H2020	Supporting	n/a
Other Supplementary Measures					
GVN4	Establish the training needs for public organisations involved in the water management sector.	2016	NAT	Supporting	n/a
GVN5	Provision of specialised training opportunities for public officers in the water management field	2017	ESF, ERASMUS+	Supporting	n/a
GVN7	Facilitate the public's access to information and their understanding of the decision making process to increase confidence in the institutions and policy formulation.	2016	NAT, LIFE	Supporting	n/a
PUB3	Establishment of a voluntary Eco-Labelling scheme for water-use fixtures and appliances.	2018	LIFE	Reduction of 1% of municipal demand	200,000
PUB4	Upgrading of the water use efficiency of public buildings and structures.	2019	NAT, CF	Reduction of 10% of government demand	100,000
PUB5	Support mechanisms for research initiatives on grey-water recycling systems for the domestic and commercial sectors	2018	NAT, CF	Supporting	n/a

AGR3	Advisory services to support farmers interpret groundwater metering data to better streamline their operations and achieve high levels of water use efficiency.	2017	NAT	Reduction of 1% of agricultural demand	180,000
GWM1	Review of existing groundwater resource models and development of a new numerical model to assess sustainable groundwater yield.	2016	NAT	Supporting	n/a
GWM2	Optimisation of the public groundwater network infrastructure to limit localised sea-water intrusion and protect the yield of public groundwater abstraction stations.	2018	CF	Supporting	n/a
RWH1	Survey of the status of existing rainwater harvesting infrastructure, identification of potential users of rainwater harvested in these infrastructures, undertaking of rehabilitation works and development of a management framework to ensure the effective use of harvested rainwater.	2017	CF	Increase in harvested rainwater	1,000,000
RWH6	Rehabilitation of existing rainwater harvesting dam structures in valleys.	2017	CF, ERDF	Increase in harvested rainwater	300,000
NEW1	Commissioning of three polishing plants with a production capacity of 7 million m3/year	2016	ERDF	Increase in New Water Production Capacity	7,000,000
NEW2	Development and implementation of a branding campaign for New Water Resources	2016	NAT	Supporting measure NEW1	n/a
NEW4	Development of dedicated distribution facilities for New Water to enable its availability at the point of use.	2017	CF, EAFRD	Supporting measure NEW1	n/a
MDM1	Comprehensive upgrading of the hydrological cycle monitoring capacity.	2017	CF	Supporting	n/a

MDM7	Development of a water scarcity and drought monitoring and assessment platform.	2018	NAT, LIFE	Supporting	n/a
QLT2	Upgrading of the public sewerage system to reduce both leakages from sewers as well as the infiltration of sea-water into sewers.	Ongoing / 2016	NAT, CF	Increase in New Water Production Capacity	1,000,000
FLD1	Modelling the impact of the National Flood Relief Project on flood hazard and risk in identified catchments.	2017	NAT	Supporting	n/a
FLD2	Flood Hazard and Risk Assessment in catchments not included in the National Flood Relief Project.	2018	NAT, LIFE	Supporting	n/a
FLD3	Comprehensive assessment for the inclusion of Sustainable Urban Drainage Systems and Natural Water Retention Measures to mitigate flood hazard and risk.	2019	NAT, LIFE, INTERREG	Supporting	n/a
FLD5	Implementation of Sustainable Urban Drainage Systems and Natural Water Retention Measures as identified under measure FLD3	2020	CF	Increase in groundwater recharge	100,000
ENE2	Optimisation programmes to reduce energy requirements for the conveyance and distribution of municipal water supply.	Ongoing / 2016	NAT, CF, ERDF	Supporting	n/a
ENE3	Comprehensive assessment of the potential utilisation of fresh- and saline- saturated zones for heating and cooling purposes.	2018	LIFE, INTERREG, H2020	Supporting	n/a
ECO1	Establish targets for the reduction of apparent losses in the municipal water distribution network and development of action programmes for the achievement of these targets.	Ongoing / 2016	NAT, CF	Supporting	n/a
ECO2	Increase awareness on the actual operational and maintenance cost related to groundwater abstraction and their impact on respective activities.	2017	NAT, CF, LIFE, EAFRD	Supporting	n/a
ECO3	Identification and quantification of non-monetized costs and benefits related to the wider use of water resources.	2018	NAT	Supporting	n/a

Table 11.7: Indicative mean annual volumetric impact of each measure within the Programme of Measures.

11.4 Cost-Effectiveness Analysis of the Water-Use Optimisation Measures

A cost effectiveness analysis (CEA) of the PoM was carried out in order to garner a better picture of the volumetric impact of the measures (individually and cumulatively) with respect to their financial costs and economic benefits. This analysis subsequently allowed for the ranking of the measures at their margin when compared to the 'social cost of inaction'[266].

A priori, this exercise required a series of cost benefit analyses, albeit non-exhaustive, of each measure in order to obtain two key variables, namely the economic net present value (ENPV) and the volumetric impact of the measures on groundwater abstraction.

It was recognised from the outset that the impact of any single measure on groundwater abstraction was not going to be a straightforward exercise due to the inter-dependency and circular nature of the water cycle especially in a scenario where the use of New Water and rainwater harvesting are widespread. Therefore, to improve the certainty in the estimation of the volumetric impact of the PoM, a 'Water Flow Model' was developed that simulates the various aspects of the water cycle. The aim of this model is to represent the various water flows and their interlinkages - from supply, storage, production, use and re-use – of water resources.

This model also allows for the identification of the volumetric impact of single measures (or typologies of measures) on the 'baseline' water cycle whilst concurrently estimates a number of financial and economic metrics. Hence it allows for an analysis of several scenarios under the PoM.

This model is based on a graphical user interface and allows for a large degree of flexibility when modelling a large number of measures that impact the water cycle in different ways over a period of 25 years. The underlying specifications of the model, including the exogenous and endogenous variables feeding into it, and the simultaneous equations that make up its framework, are found in Annex II to the 2nd WCMP.

This modelling approach was adopted for all measures listed in the PoM and their cumulative impact on the groundwater bodies, as well as on the demand for municipal water, was identified for the 25 year period, as shown in the figures below:

[266] The cost of inaction represents the cost of having to switch to alternative water sources in a scenario where the groundwater bodies have been degraded from pollution or depleted due to over-abstraction, beyond use. This cost is proxied by the water tariff of €2.18/m^3 applicable to residential consumers for municipal water.

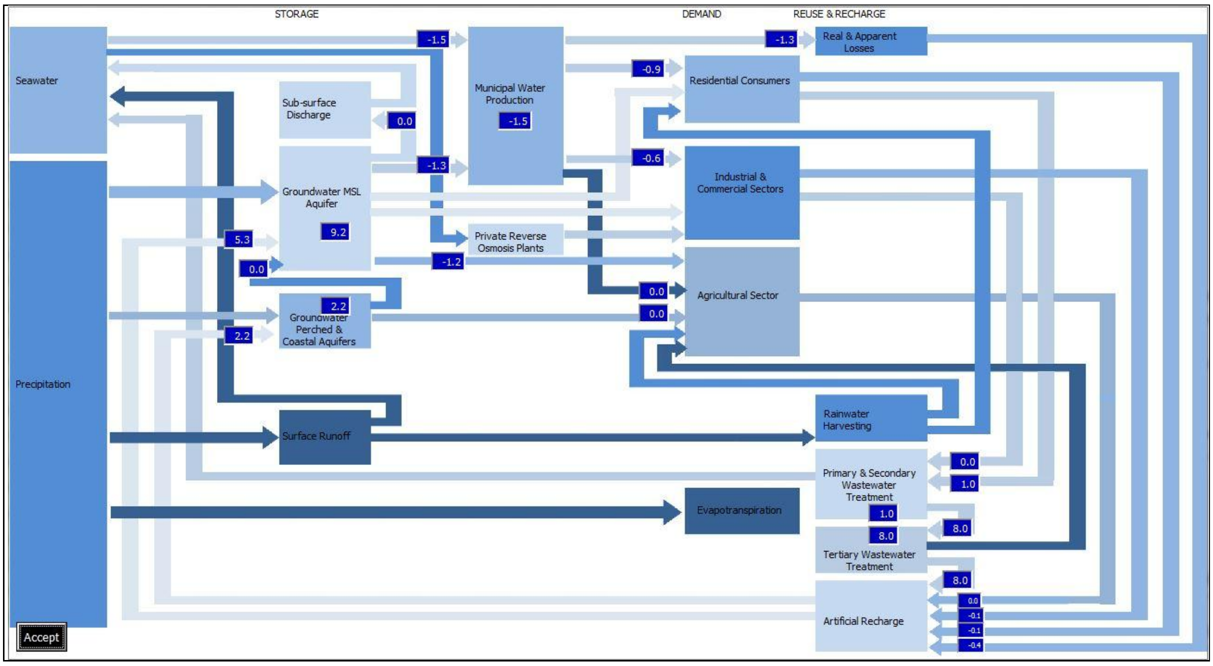


Figure 11.2: Volumetric Impact on the Water Cycle of the Programme of Measures as at 2021

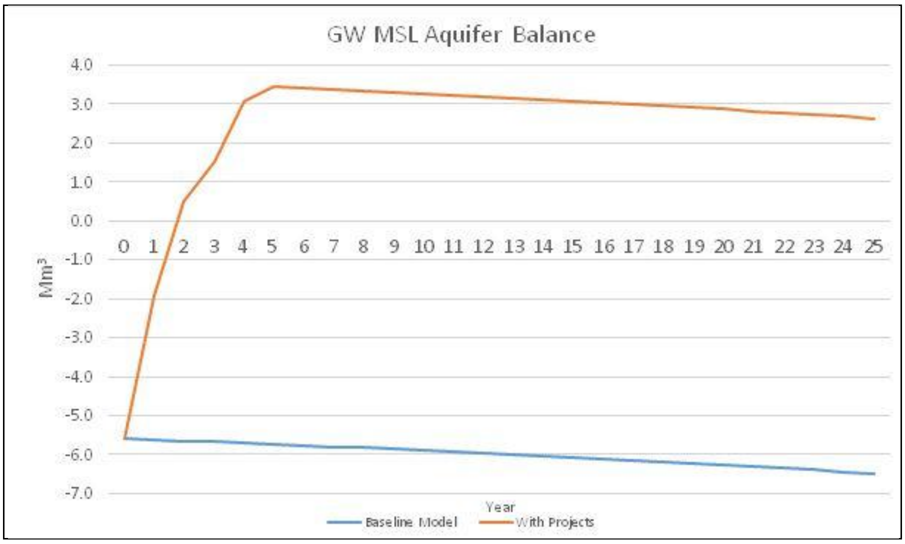


Figure 11.3: Volumetric Impact on the Mean Sea Level Aquifer Balance of the Programme of Measures over the Projected Period

To obtain the financial cost of the PoM and its economic costs and benefits, a CBA modelling tool was developed and integrated with the Water Flow Model described above. Through this tool, the economic value of groundwater in terms of its benefits to the environment, and as an essential resource for present and future generations, as well as to account for the time value of money, was estimated.

The information on the investment and annual cost of the measure, its implementation year and expected lifetime are presented in Table 11.6. The measures whose effective lifetime could be gauged were assumed to require a reinvestment cost every 6 years whilst those measures whose lifetime could not be determined, were assumed to remain effective for 25 years. The main results extracted from the model concerning the financial and economic aspects of the PoM are provided in Table 11.7 below:

FNPV[267]	(€185.8 million)
ENPV	€5.3 million
ERR[268]	7.3%
B-C Ratio[269]	1.03

Table 11.8: Financial & Economic Indicators of the Programme of Measures

The above indicate that the [discounted] economic net present value of the PoM is approximately €5.4 million and has an economic rate of return of 7.3%. As at December 2015, the risk-free rate of return quoted by the 25 year yield-to-maturity for Government securities was of 2.5% while the average gross dividend yield of the major private companies listed in the Malta Stock Exchange index was 5%.

Hence, the implementation of the PoM would reap positive economic benefits over its effective lifetime. This claim is supported by a benefit-cost ratio of 1.03, meaning that for every €1 spent to implement the measures, a return of €1.03 would be obtained, largely from the [monetized] resource and environmental benefits of having a sustainable groundwater resource.

It is pertinent to note that these figures took into consideration the economic benefits to the groundwater resources **only.** However, some of the measures, particularly those related to flood relief and rainwater harvesting, would have other social and economic benefits, such as reducing the damage from stormwater runoff and the prevention of loss of lives from flood events. If these external benefits were to be monetized and included in this analysis, the above metrics would be even more favourable.

A Cost Effectiveness Analysis of the PoM was carried out in order to rank the different measures and to thus single out the one that are most cost effective in terms of economic cost and volumetric impact. The marginal cost of the measures were ranked in ascending order from the least expensive to the most expensive in terms of reductions in groundwater abstraction. Plotting the resultant rankings would illustrate a marginal cost curve; with the 'low hanging fruit' being represented by those measures on the left hand side and below the horizontal axis. These are measures that are both financially worthwhile[270] and reduce groundwater abstraction. Moving to the right of the horizontal axis would represent more costly measures.

[267] The net present value of a project is the sum of the discounted net flows of a project. It represents the present amount of the net benefits (i.e. benefits less costs) flow generated by the investment expressed in one single value with the same unit of measurement used in the accounting tables. The difference between a financial NPV and economic NPV is that in the latter indicator, the [monetized] economic costs and benefits are also included. Source: *'Guide to Cost-Benefit Analysis of Investment Projects, Economic Appraisal Tool for Cohesion Policy 2014-2020'*, DG Regio, December 2014.

[268] The internal rate of return (IRR) is defined as the discount rate that zeroes out the net present value of flows of costs and benefits of an investment. The IRR is an indicator of the relative efficiency of an investment. A positive economic return shows the society is better off with the project, i.e. the expected benefits on society justify the opportunity cost of the investment. Source: *'Guide to Cost-Benefit Analysis of Investment Projects, Economic Appraisal Tool for Cohesion Policy 2014-2020'*, DG Regio, December 2014.

[269] The benefit-cost ratio is the present value of project benefits divided by the present value of project costs. If B/C >1, the project is suitable because the benefits, measured by the present value of the total inflows, are greater than the costs, measured by the present value of the total outflows. Source: *'Guide to Cost-Benefit Analysis of Investment Projects, Economic Appraisal Tool for Cohesion Policy 2014-2020'*, DG Regio, December 2014.

[270] As denoted by a positive ENPV

Those measures that are situated above the horizontal axis could still be worthwhile to implement if their marginal cost does not exceed the social cost of inaction. As stated above, this latter cost was proxied by a water tariff of €2.18/m^3 applicable to residential consumers for municipal water. The marginal cost rankings of the mitigating measures listed in the PoM are illustrated in the figure below.

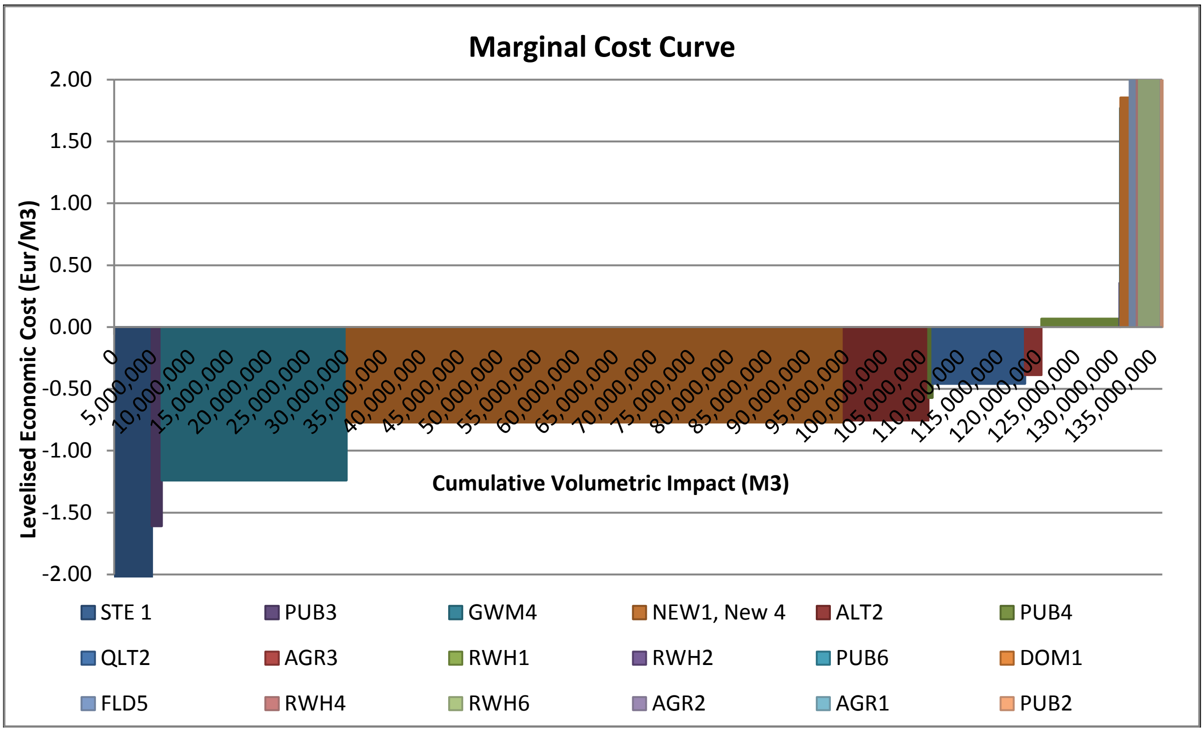


Figure 11.4: Marginal Cost Curve of the Programme of Measures

Using this approach, it would be economically worthwhile to implement all the proposed measures because their marginal cost is below the social cost of inaction. Furthermore, those measures that are above the horizontal line mostly pertain to measures addressed towards incentivising rainwater harvesting and flood relief. As stated above, these measures have other social and economic benefits that **have not** been included in this analysis, such as reducing the damage from stormwater runoff and the prevention of loss of lives from flood events, and hence, their full economic benefit is under-estimated in this analysis.

12. Climate Checking our Plan

12.1 Background

Water resources are highly vulnerable to changing climatic conditions. For the Mediterranean region, climate change is expected to negatively affect water resources and the socio-economic activity that depends on them. The fact that water resources are already under stress from human activities, renders such resources even more susceptible to climate change impacts. Hence, adaptation of the water sector to climate change impacts is of primary importance.

Climate change may significantly hinder attempts to restore water bodies to good ecological, chemical and quantitative status. Climate change can affect the conditions and pressures that the WFD is seeking to manage and will affect and interact with WFD implementation activities at different stages (Dworak & Leipprand, 2007[271]). Warranting achievement of WFD objectives within a changing climate requires a good understanding of how climate change may affect WFD processes throughout its implementation.

There is thus a strong link between WFD implementation and adaptation to climate change impacts since, firstly the WFD provides an opportunity for managing long-term impacts of climate change on the water environment; hence providing an opportunity for implementing adaptation action within the water sector. Secondly, adaptation needs to be considered in the WFD implementation to ensure resilience of WFD measures or actions (Chapter 9) to climate change impacts and thus to ensure that WFD objectives will also be met in a changing climate.

Consideration of climate change in the WFD process can also create synergies between WFD measures and national mitigation and adaptation efforts, including adaptation efforts in other sectors.

The main objective of the climate check therefore, is to address climate change impacts on the performance of WFD measures, thus enhancing the potential for achieving WFD objectives within a changing climate. Effects of WFD measures on the environment have not been considered through this climate check. This is the role of a separate environmental assessment which evaluates the effects of the measures on other environmental sectors including biodiversity, waste, landscape and climatic factors.

12.2 Climate Change Impacts in the Maltese Islands

The limited availability of local data and information on climate change impacts represents one of the major hurdles to the climate check, which can be partly overcome through consideration of global/regional climate projections and impact scenarios. While these data models[272] may not be necessarily applicable to the Maltese Islands in view of their low resolution, they are considered an important source of information providing an indication of the climate change impacts to which Malta may be exposed to.

Temperature & Precipitation: Drought

Locally generated scenarios are quite robust with respect to temperature predictions but much less robust for precipitation. Projected temperature and precipitation changes at the European level, indicate an increase in mean annual temperature of +3.5 to +5 and a change in the annual

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271 Dworak, T (Ecologic Vienna) & Leipprand, A. (Ecologic Berlin) (2007) Climate Change and the EU Water Policy – Including climate change in River Basin planning

272 Intergovernmental Panel on Climate Change, 2007. Climate Change 2007 – *Impacts, Adaptation and Vulnerability*; Contribution of Working Group II to the Fourth Assessment Report of the IPCC; ISBN 92-9169-121-6

precipitation ranging from -10% to -40% for the Southern European region. As a result of higher temperatures, decreased precipitation and longer, more frequent dry spells, Southern European regions will be subject to an increase in the frequency and intensity of droughts. The Mediterranean basin will suffer from a decrease in water resources; hence climate change will result in reduced water availability within a region that already suffers from water stress.

Trends in local observational data corroborate with the projected increase in temperature, which is also in line with regional predictions. An increase in atmospheric temperature by the end of the century is thus almost certain for the Maltese Islands.

With regards to precipitation, the scenarios project a decrease of about 2% by 2100 and a shift of precipitation events to shorter time windows. These scenarios are associated with significant uncertainties and should be interpreted with caution. Local observational data may be interpreted as a decrease in the total amount of precipitation but an increasing trend for convective type rainfall or heavy rainfall. While uncertainties prevail, the trends identified from data observations are in line with regional scenarios with regards to both decrease in precipitation and an increase in extreme weather events, which for Malta would mainly translate into heavy rainfall events.

Overall, the Maltese Islands are almost likely to be subject to an increase in temperature coupled to an overall decrease in precipitation; hence the possibility of drought periods. **Given that trends in temperature and precipitation are already evident from observational data, such changes in climate are expected to take place in the short/medium term.**

Sea Level Rise

Global mean sea level has been rising, with a global increase of 17cm recorded during the twentieth century (IPCC, 2007; European Commission, 2007). From 1961 to 2003, the average rate of sea level rise was 1.8 ± 0.5 mm yr–1. Climate contributions, thermal expansion and loss of mass from glaciers, ice caps and the Greenland and Antarctic Ice Sheets constitute the main factors in sea level rise.

Data within the Mediterranean region however shows both decelerations in sea level rise for the 20th century and decreases in sea level in the latter part of the century (IPCC Third Assessment Report 2001). It is suggested that this deceleration may be caused by the increase in density of the Mediterranean Deep Water and air pressure changes linked to the North Atlantic Oscillation. Whichever the cause, long-time series data and site specific studies are necessary in order to verify the occurrence of sea level rise in a specific location.

While the development of regional scenarios for sea level change in the Maltese Islands was not possible, local observations from June 1992 to December 2006 indicate a fall in sea level at an average rate of 0.50 $\pm$ 0.15 cm/yr. The time-period of such observational data is too short to allow appropriate identification of trends in the mean sea level in the Maltese Islands and interpretation of such data should be done with caution.

While there are many uncertainties associated with Sea Level Rise, a precautionary approach is being applied in this case and **an increase in mean sea level around the Maltese Islands is being assumed in the long-term, based on global scenarios.**

Storm surges

A study on the Mediterranean region projected a reduction in both the number and frequency of storm surge events during the 21st century[273]. The study however also reports that there is

273 (European Environment Agency. (2013). *What is the trend in storm surges and extreme sea levels across European seas?.* Available: http://www.eea.europa.eu/data-and-maps/indicators/storms-and-storm-surges-in-europe-1/assessment-1. Last accessed 20 Nov 2015).

considerable variation in storm events but there is no long term trend in storminess in Europe. Despite this variation in storminess, water levels along the most vulnerable coastlines of the Mediterranean Sea have shown no signs of significant storm-related variation. Therefore the assumption that the Maltese Islands will be subject to more frequent storm surges in the coming 6 years was no longer considered under this climate check review.

12.3 Climate Change impacts of relevance to surface

The potential effects of climate change impacts as predicted for the Maltese Islands on surface waters were identified. While there are a lot of uncertainties associated with climate change impacts, the majority of the effects are potentially negative in nature. Climate change is thus expected to exacerbate pressures on water resources and this highlights the need to ensure that WFD measures address such increase in pressures.

Possible climate change impacts on surface waters were identified as follows:

Temperature

- An increase in atmospheric temperature would potentially lead to a general increase in water demand due to increased evapotranspiration rates caused by higher temperatures, leading to perturbations in the soil water balance. Increase in water demand would introduce further pressures on water abstraction where this takes place in surface water environments and will thus further impact on the limited water resources.

- Higher water temperatures particularly in standing waters and low-flow situations can bring about changes in the physico-chemical conditions of water bodies with potential effects on biological elements depending on such water bodies.

- In the marine environment increase in atmospheric temperature may result in increased sea surface temperature, which can:
  - lead to shifts in species composition and changes in species' life cycle;
  - promote growth of algae and microbes;
  - result in changes in water stratification[274];
  - result in changes in dissolved oxygen mainly due to changes in water stratification and/or water circulation.

- Higher temperatures, coupled to increased heavy rainfall spells and longer periods of low flows exacerbate many forms of water pollution including enhanced load of nutrients in surface water. However higher temperatures can also increase the degradation rate of some pesticides and organic pollutants, which may reduce their concentrations in water bodies. Hence the effect of high water temperatures on pollutant behaviour is uncertain at this stage.

- An increase in water temperature would facilitate the establishment of thermophilic species in Maltese coastal waters, introduced through shipping activities, or through the natural spread of such species.

Precipitation the increase in the frequency of heavy rainfall spells would

274 It should be noted that according to EEA-JRC-WHO (2008), the combination of increase in temperature and decrease in run-off is not expected to change stratification conditions greatly because of the compensating effects of increasing temperature and increasing salinity on the density of water.

(i) significantly increase the discharge of pollutants from both point and diffuse sources (albeit at a lower discharge concentration) within coastal inlets and bays and water catchments and
(ii) lead to increased demand for construction of infrastructure for the control of floods thus resulting in geomorphological changes and water flow modification particularly in valley systems in protected areas;
(iii) Increased erosion, hence changes to hydromorphology of natural habitats
(iv) Temporary increase in turbidity in coastal waters due to increased run-off during heavy rainfall events

Decreased rainfall would :
(v) Reduced water availability possibly resulting in changes in physico-chemical characteristics of inland surface waters
(vi) Reduction in water flow and/or changes in water regime potentially impacting on ecosystems dependent on the presence of freshwater

Drought Freshwater resources in Malta are already limited and an increase in the frequency of drought periods will exacerbate the situation and result in further deterioration of the quantitative and qualitative status of inland surface and ground waters.

Sea-Level rise Potential climate change impacts in this regard include the following:
(i) inundation of coastal areas thus impacting on coastal ecosystems
(ii) Saline intrusion leading to salinisation of coastal wetlands
(iii) Coastal erosion leading to loss of coastal wetlands

12.4 Climate Change impacts of relevance to the management of water resources

12.4.1 Background

The potential impacts of the above described climate change impacts on the management of water resources within the Malta Water Catchment District are presented in the table below:

Temperature (short/medium term)	An increase in atmospheric temperature would bring about: - an increase n water demand for human activities and agricultural purposes; - resulting increases in evapo-transpiration rates may lead to perturbations in the soil water balance; - higher temperatures, coupled to increased heavy rainfall spells and longer periods of low flows may exacerbate many forms of water pollution including enhanced load of nutrients in infiltrating water to groundwater. However higher temperatures can also increase the degradation rate of some pesticides and organic pollutants, which may reduce their concentrations.

Precipitation (short/medium term)	A decrease in precipitation will impact on the availability of water resources in the Maltese islands. An increase in heavy rainfall events will lead to flooding. Floods would result in sudden increase in superficial water flows thus tending to increase run-off which can have various effects such as decreased groundwater recharge and increased loading of nutrients in recharge waters.
Drought (short/medium term)	An increase in the frequency of extreme drought periods will impact on the quality and quantity of water.
Sea-level rise (long term)	Marginal impacts on groundwater resources

Table 12.1: Potential climate change impacts on the management of water resources

12.4.2 Climate Change effects on water resource management pressures

The main objective of the analysis of the effects of climate change on anthropogenic pressures is to identify the risks of not attaining WFD objectives due to climate change-induced changes in these pressures. Knowledge of such risks posed by potential changes in pressures would ensure that the WCMP measures target both current and future pressures on water resources.

The pressures determined through the characterisation process with respect to water resources management pressures include water demand and groundwater abstraction, point sources and diffused sources of pollution.

The potential effects of climate change impacts as predicted for the Maltese Islands/Mediterranean region, on each pressure were identified. The risks for such effects to hinder achievement of WFD objectives were also identified and classified as ‘High’, ‘Medium’ or ‘Low’ risks. Climate change impacts that were taken into consideration include:

- increase in atmospheric temperature;
- changes in precipitation:
  - decrease in precipitation
  - increase in frequency of heavy rainfall events

12.4.3 Analysis of climate change effects on pressures

There are a lot of uncertainties associated with climate change impacts, hence with the identified effects of climate change on pressures. The majority of the effects are potentially negative in nature. Climate change is thus expected to exacerbate pressures on water resources and it therefore had to be ensured that such increase in pressures is addressed by the measures identified.

Major risks for not attaining WFD objectives due to climate change were identified as follows:

- an increase in the frequency of heavy rainfall spells would (i) significantly increase the discharge of pollutants from both point and diffused sources (albeit at a lower discharge concentration) and (ii) result in the construction of infrastructure for the control of floods thus leading to geomorphological changes and water flow modification particularly in valley systems;
- the increase in atmospheric temperature coupled to the decrease in precipitation would result in higher water demand leading to (i) increased groundwater abstraction and (ii) construction of further infrastructure for water storage resulting in geomorphological changes in both valley systems and along the coast and water flow modification within valley systems.

These risks are mainly related to the predicted increase in temperature and changes in precipitation patterns, which with respect to temperature are already discernible from observational data of climatic parameters. Risk with respect to groundwater resources management are thus expected in the medium to long term, and should continued to be addressed within the 2nd Water Catchment Management Cycle. The climate check should therefore ensure that climate change induced increases or changes in pressures are addressed by the measures or actions presented in the WCMP so as to reduce the risk of not achieving WFD objectives.

12.5 Climate Checking the Measures

The second part of the climate check focussed on climate checking the measures identified in the Programme of Measures. For this purpose a methodology was developed (see box 12.1). As an outcome a number of recommendations were put forward to ensure that the WFD measures take into consideration climate change effects on pressures and will perform under a changing climate (i.e. measures are climate resilient), or to render the measure amenable to adaptation.

BOX 12.1: Methodology to climate check the Programme of Measures

First a screening of the Programme of Measures was guided by the following principles:

1. Measures should be resilient to a wide range of future predicted climate scenarios
2. The outcome of measures should be beneficial regardless of the eventual nature of climate variability and change to avoid irreversible decisions and investments that may not be cost effective under changing climatic conditions

Each measure was then assessed against a set of criteria:

1. Is the measure addressing climate change impacts?
2. Does the measure address the predicted changes in pressures due to climate change?
3. Is the measure likely to cope with a range of future conditions including changes in temperature, precipitation, sea level rise and storm surges
4. Is the measure flexible in a way that it can be changed in the future?

For each criterion the potential outcomes (positive, negative neutral and uncertain) were assessed. This made possible the overall classification of each measure as either being **win-win, low regret, flexible or**

The classification of measures as **Win-Win** are those measures or actions which in addition to addressing the changes in WFD pressures to climate change impacts, (if and to performing within a range of changing climatic conditions, are also deemed amenable to adaptation to climate change impacts and are of socio-economic or environmental benefit. A total of 15 measures were identified as Win-Win. With the eventual taking up of the recommendations presented in the climate check several other measures may still have the potential of being reclassified as win-win.

The majority of the POM measures have been classified as **low-regret** options. These measures would be beneficial regardless of the eventual nature of climate variability and change. Measures classified as such were those dealing with the definition of good practices that are not relevant to adaptation to climate change impacts; development of regulatory processes and the enforcement of existing regulations; the setting up of advisory services; the carrying out of studies and improvement of knowledge. In these cases most of the measures could be easily modified to cater for climate change impacts. A number of recommendations in this regard were provided, the majority of which were taken up.

Flexible options are measures which as currently designed may not perform effectively within a changing climate, either because they are not addressing the predicted climate induced changes in pressures or they are not likely to cope with a range of future climatic conditions. Such measures, however, can be modified to deal with climatic impacts.

Regret measures are those measures which may not perform within a changing climate and that once implemented cannot be modified at a later stage. No measures were identified to belong to this category.

Measures seeking the development and provision of technical training could not be classified since these are mainly administrative measures that would support the implementation of the PoMs and is not influenced by any climate change impacts.

Win-Win ☺	Measures or actions which in addition to addressing the changes in WFD pressures to climate change impacts, are also deemed amenable to adaptation to climate change impacts and are of socio-economic or environmental benefit.
Low Regret 😐	Measures which would be beneficial regardless of the eventual nature of climate variability and change
Flexible ~	Measures which as currently designed may not perform effectively within a changing climate, either because they are not addressing the predicted climate induced changes in pressures orthey are not likely to cope with a range of future climatic conditions. Such measures, however, can be modified to deal with climatic impacts,
Regret ☹	Measures which may not perform within a changing climate and once implemented cannot be modified at a later stage.
Unclassified **NC**	Measures which are not influenced by any climate change impact.

Table 12.2: Climate Check classification

The table below (table 12.3 A and 12.3 B) gives an outline of the results of the climate check classification as explained above. The climate check classification is given through the corresponding symbols placed along each measure.

Code	**Title of measure**	**Climate Change Classification**
BASIC measures emanating from the WFD 2000/60/EC		
KEY 1	Continue to refine the regulatory framework for industrial operational practices	😐
SWM 1	Continue to strengthen the relationship between environmental and planning regulatory processes (including Marine Strategy Framework Directive concerns).	~
SWM 2	Continue to control priority hazardous substances, priority substances and other substances of concern via the environmental permitting process.	😐
SWM 3	Update inventory of discharges (EQS Directive)	😐

Key 2	Create an effective feedback mechanism within the Environment and Resources Authority to ensure compliance and risk mitigation	~
SMW 5	Develop guidelines for the Disposal of dredged material	😐
SMW 6	Carry out joint inspections with Transport Malta, the Civil Protection Directorate, the Occupational Health and Safety Authority and the Water Services Corporation to ensure that industrial operations abide to best environmental practice	😐
SMW 7	Develop a system to encourage adequate litter management and control in coastal areas	☺
SMW 8	Improve operational standards for the aquaculture sector via the environmental permitting process	😐
SMW 9	Creation and Implementation of the Agriculture Waste Management Plan	😐
SMW 10	Establish a Mercury Management Plan to enable the investigation of potential sources of mercury and potential mitigation measures	😐
SMW 11	Streamline designated Bathing waters as defined by the Environmental Health Directorate with designated Swimming Zones as regulated by Transport Malta, where these overlap or in close proximity to each other.	😐
SWM 12	Extend the basic measure related to the removal of alien species from the Qattara habitat, as identified in the Natura 2000 Management Plan, to Ghadira ta' Sarraflu	😐
SWM 13	Set up a watch list mechanism to monitor certain emerging substances identified at EU level that could potentially be of concern (refer to Chapter 5).	😐
SWM 14	Develop a strategic policy framework to encourage integrated valley management	☺
Key 3	Enhance water and marine data using an open platform	~
KNO 1	Study the impacts of the national spoil ground off Xghajra	😐
KNO 2	Carry out a technical feasibility assessment regarding the management of ballast waters	😐
KNO 3	Characterise and quantify hydrological input of land based contaminants (including litter) to coastal waters from major sub catchments	😐
KNO 4	Investigate the role transboundary contaminants through hydrographic pathways and the extent of its contribution to marine contamination.	~
KNO 5	Carry out investigations to gauge potential contribution of contaminants to our coastal waters by atmospheric deposition	~
KNO 6	Carry out a survey of all direct discharges to sea and identify their source with the objective of setting up a plan to curtail/regulate such discharges	😐
KNO 7	Carry out seasonal surveys of mooring or anchorage areas	😐
EMER 1	Creation of a working group tasked with the updating of sensitivity maps to enable better marine emergency response	😐

EMER 2	Create an ERA pollution response log for environmental incidents occurring at land and at sea	😐
EMER 3	Put into place the terrestrial emergency response strategy	😐
AWA 1	Targeted awareness campaign on impacts of marine litter	☺
AWA 2	Targeted awareness campaign on the appropriate disposal of chemicals and/or chemical containers, including medicines, pesticides, fertilisers and related packaging	😐

Code	**Title of Measure**	**Climate Change Classification**
Administrative Measures		
GVN1	Determination of the roles and responsibilities of all public sector agencies involved in the wider management of water resources	😐
RWH2	Development of the administrative capacity required to ensure the effective implementation of current legislative requirements in relation to the development of rainwater harvesting facilities and associated secondary water conveyance systems	☺
Codes of Good Practice		
GVN3	Development of guidance documents to assist operators in achieving best practice in water management practices	😐
PUB6	Establishment of water-use standards and guidelines for water use in public landscaping initiatives	☺
Demand Management Measures		
PUB1	Development of a Water Demand Map representing the spatial variation of water demand in terms of both quantity and quality, and establishing benchmarks for efficient water use.	😐
DOM1	Support mechanisms for water consumption audits in households.	☺
AGR1	Support schemes for the uptake of efficient irrigation technology by the arable agricultural sector	☺
AGR2	Support schemes for the uptake of efficient water technology by the animal husbandry sector	☺
RWH4	Support schemes for the development of rainwater runoff harvesting facilities in the agricultural and commercial sectors	☺
Efficiency and Reuse Measures		
PUB2	Establishment of minimum technical and economic levels of leakage in the municipal distribution network, and achievement of these thresholds through the ongoing leakage management and control programme operated by the public utility	☺

DES2	Comprehensive assessment of the uptake of the tourism and commercial sectors of membrane based water treatment technology, and development of support schemes to attain this capacity	~
ENE1	Establishment of specific power benchmarks for WSC Desalination Plants and continued upgrading programmes for the phased achievements of these benchmarks	😐
Artificial Recharge of aquifers		
GWM4	Development of Managed Aquifer Recharge schemes for aquifer management purposes	☺
Educational Projects		
STE1	Development of a long-term National Water Conservation Campaign	😐
STE2	Specific campaign to focus on educational activities on water management in schools	😐
Research, development and demonstration projects		
NEW3	Development of Demonstration Sites for the application of New Water Resources	😐
ALT1	Comprehensive assessment of the exploitation natural coastal and submarine groundwater discharge	😐
ALT2	Comprehensive assessment of the exploitation potential of the saline aquifer system underlying the mean sea level aquifer system	😐
STE3	Development of demonstration projects to showcase the application of innovative technology in the local water sector	😐
GVN4	Establish the training needs for public organisations involved in the water management sector.	NC
GVN5	Provision of specialised training opportunities for public officers in the water management field	NC
GVN7	Facilitate the public's access to information and their understanding of the decision making process to increase confidence in the institutions and policy formulation.	😐
PUB3	Establishment of a voluntary Eco-Labelling scheme for water-use fixtures and appliances.	😐
PUB4	Upgrading of the water use efficiency of public buildings and structures.	☺
PUB5	Support mechanisms for research initiatives on grey-water recycling systems for the domestic and commercial sectors	😐

AGR3	Advisory services to support farmers interpret groundwater metering data to better streamline their operations and achieve high levels of water use efficiency.	☺
GWM1	Review of existing groundwater resource models and development of a new numerical model to assess sustainable groundwater yield.	😐
GWM2	Optimisation of the public groundwater network infrastructure to limit localised sea-water intrusion and protect the yield of public groundwater abstraction stations.	😐
RWH1	Survey of the status of existing rainwater harvesting infrastructure, identification of potential users of rainwater harvested in these infrastructures, undertaking of rehabilitation works and development of a management framework to ensure the effective use of harvested rainwater.	☺
RWH6	Rehabilitation of existing rainwater harvesting dam structures in valleys.	😐
NEW1	Commissioning of three polishing plants with a production capacity of 7 million m3/year	😐
NEW2	Development and implementation of a branding campaign for New Water Resources	😐
NEW4	Development of dedicated distribution facilities for New Water to enable its availability at the point of use.	😐
MDM1	Comprehensive upgrading of the hydrological cycle monitoring capacity.	😐
MDM7	Development of a water scarcity and drought monitoring and assessment platform.	☺
QLT2	Upgrading of the public sewerage system to reduce both leakages from sewers as well as the infiltration of sea-water into sewers.	😐
FLD1	Modelling the impact of the National Flood Relief Project on flood hazard and risk in identified catchments.	😐
FLD2	Flood Hazard and Risk Assessment in catchments not included in the National Flood Relief Project.	😐
FLD3	Comprehensive assessment for the inclusion of Sustainable Urban Drainage Systems and Natural Water Retention Measures to mitigate flood hazard and risk.	😐
FLD5	Implementation of Sustainable Urban Drainage Systems and Natural Water Retention Measures as identified under measure FLD3	☺
ENE2	Optimisation programmes to reduce energy requirements for the conveyance and distribution of municipal water supply.	☺

ENE3	Comprehensive assessment of the potential utilisation of fresh- and saline- saturated zones for heating and cooling purposes.	☺
ECO1	Establish targets for the reduction of apparent losses in the municipal water distribution network and development of action programmes for the achievement of these targets.	😐
ECO2	Increase awareness on the actual operational and maintenance cost related to groundwater abstraction and their impact on respective activities.	😐
ECO3	Identification and quantification of non-monetized costs and benefits related to the wider use of water resources.	😐

Table 12.3A and 12.3B: Climate Check Classification of Measures for Surface and Groundwaters

The table below presents and outcome of the classification of measures following the undertaking of the climate check. By far, most of the water management measures (94%) were classified under the win-win and low-regret categories.

Classification Options	**Distribution**	
	Number	**Percentage**
win-win	18	25%
low-regret	47	64%
flexible	6	8%
regret	0	0%
unclassifiable	2	3%

Table 12.4: Classification of Measures

13. PUBLIC CONSULTATION PROCESS

13.1 Consultation process in relation to surface waters management issues

The Malta Environment and Planning Authority streamlined consultation on management issues related to surface waters with other consultation processes of related environmental acquis, mainly being that of the Marine Strategy Framework Directive and Habitats Directive; that were being carried out in parallel. In addition interministerial committees related to the implementation of the Nitrates Action Programme and Farm waste management also were used to sound water management concerns.

13.1.1 Consultation on characterisation of waters and economic importance

Consultation related to the characterisation process of coastal waters in the WFD was very much related to the MSFD consultation process since such a process explored the pressures and impacts extensively by means of the 11 descriptors of the marine environment identified by the MSFD. The WFD monitoring data was being made available at such a time when it could directly feed into the MSFD initial assessment report, which offered a good opportunity to present the preliminary results of the WFD coastal water monitoring to stakeholders. Consultation on the MSFD processes were continued following the submission of the MSFD Initial Assessment, with a view to involve relevant sectors of the public in the required revision processes, particularly in relation to the definitions of 'Good Environmental Status' and environmental targets. One consultation session held in June 2014 at the Malta EU Steering Action Committee (MEUSAC) provided the opportunity to present the whole set of results of the WFD coastal water monitoring to relevant sectors.

Figure 13.1: Consultation session on the MSFD – Malta links the implementation of the WFD and MSFD through joint consultation events on the marine environment, June 2014.

In addition the initial assessment documentation together with the socio-economic analysis was made available for public viewing on the following webpage: http://www.mepa.org.mt/water-msfd-initial_assessment

(ii) Information session and consultation on monitoring requirements and coastal and marine monitoring programmes

During March 2015, a MEUSAC information Session was held in order to introduce the new monitoring requirements related to the Environmental Quality Standards Directive and the definition of chemical status. The Watch List mechanism was also explained. New standards related to the monitoring of Biological Quality elements were introduced to the public.

Figure 13.2: MEUSAC Session on Chemical status and priority substances linked to the new Environmental Quality Standards Directive, 11 March 2015.

Another MEUSAC consultation session related to the joint MSFD and WFD process was held in May 2015 in order to present the proposed coastal and marine monitoring programmes to the public. Attendees represented various entities namely, MEIB (Ministry for the Economy, Investment and Small Businesses), the Water Services Corporation, Transport Malta, the Malta Competition and Consumer Affairs Authority, MEIAM (Ministry for European Affairs and Implementation of the Electoral Manifesto); NGO Birdlife Malta and Integrated Resource Management Co. Ltd.

(iii) Consultation on the Programme of Measures

(a) Bilateral meetings and meetings with key players on specific water management issues

Malta initiated bilateral consultation on the preliminary list of measures as from October 2014. These extended to October 2015. A number of bilateral meetings have been held with the Environmental regulators (the environmental arm of the Malta Environment and Planning Authority, Transport Malta (MTI), the Water Services Corporation, the Managing Authority for Rural Development Funding, the Agriculture Department where nitrate related measures are concerned and the regulators for pesticides and authorization of substances (the MCCAA – Malta Competition and Consumer Affairs Authority within the Minister for Social Dialogue, Consumer Affairs and Civil Liberties), the Cleansing Services Directorate (MTI) and the Storm Water, marine and valley management Unit (MTI). A meeting on the importation of chemical substances and record keeping was also held with the MCCAA, the Customs Department and the National Statistics Office.

In order to approach this consultation phase holistically, these consultation meetings were also being held in conjunction with officers working on the Marine Strategy Framework Directive implementation programme. In this way any issues related to both the WFD and MSFD could be tackled in synergy.

(b) Interministerial meetings
A few Interministerial meetings were held with the above mentioned entities and a number of additional government authorities, such as the Continental Shelf Department, the Fish Farm Regulation and Control Department, and the Malta Tourism Authority. These Interministerial sessions were lead by the Ministry for Sustainable Development, the Environment, and Climate Change (MSDEC) as they were held in conjunction with the MSFD to discuss issues common to multiple stakeholders in relation to coastal and marine water management. The issues discussed consisted of marine litter management, data management and data sharing across different entities and establishing common data sharing platforms; and waste management.

(c) Consultation on the draft chapters of the plan
Additional stakeholders were included as the measures were developed and the draft chapters were circulated. These included the Malta Information Technology Agency (MITA); Medicines Authority; the National Parks, Afforestation and countryside, the Critical Infrastructure and Protection Directorate; the University of Malta and the Ministry for Gozo. The draft chapters of the plan were also uploaded on the MEPA website for public view: http://www.mepa.org.mt/topic-wcmp

13.1.2 Consultation on Inland surface waters and transitional waters

Since all of Malta's inland surface waters and transitional waters are protected sites of ecological importance related WFD objectives refer to the safeguarding of the water related requirements required for water-dependent habitats and species. For this reason the WFD objectives have been integrated in the draft Natura 2000 Management plans that have been developed over the past two years. Respective measures for each water body have been identified in each plan. Consultation on the plans themselves has already been carried out during the process of developing the respective plans during 2013 and 2014. The public was engaged by means of meetings held within their respective local council premises in Malta and Gozo. During 2013 and 2014 the public had access to the issues under discussion by means of a web url where further information was available on each of the respective sites.

Figure 13.3: Website that was launched for consultation on the N2K plans and respective measures (2013/2014) (ADI-Associates.com)

The Natura 2000 management plans were once again launched for a final public consultation phase at the end of July 2015. The management plans are available for public download from the following website: http://www.natura2000malta.org.mt/index.php/management-plans/

13.2 Consultation process in relation to groundwater management issues

A critical review of the public consultation process leading to the development of the 1st Water Catchment Management Plan was undertaken at the start of the planning process of the 2nd WCMP formulation process. This critical review outlined the lack of direct specific meetings with water-user categories as the main weak point of the 1st WCMP public consultation process, and thus a strategic decision was taken to base the new public consultation process on more direct contacts with the main water use categories in the Maltese Water Catchment District.

A categorization of water users was thus undertaken, and specific tools developed to ensure the direct involvement of each user category. The result of this categorisation is presented below:

User Category	Consultation Tools
General Public	Generic and issue specific public consultation meetings
Agricultural Sector	Informal meetings with farmers in small groups
Public Sector	Technical Workshops
Commercial Sector	Informal meetings with operators in small group
Public Utility	Technical Workshops

Table 13.1: Identified Consultation Tools

A series of stakeholder consultation activities, using all the consultation tools identified in the above table, were held in the process which led to the formulation of the measures included under the draft 'Programme of Measures'. These consultation meetings discussed the issues being faced by the respective sectors, and stakeholders were involved in the development of specific measures. Following the drafting of the 'Programme of Measures', further consultation meetings were undertaken to discuss the identified measures with stakeholders, with particular reference to the practical issues related to the implementation process of these measures.

The consultation process leading to the development of the 2nd Water Catchment Management Plan was initiated in March 2014 with a National Conference, which discussed the main challenges facing the water sector (significant water management issues) in the Maltese islands. This national conference was open to the general public and was extensively advertised in the local press.

This national conference presented best practice examples from the implementation of measures in the 1st Water Catchment Management Plan period involving issues such as educational initiatives, sustainable urban drainage systems, water efficiency measures, unconventional water resources and managed aquifer recharge. This with the aim of providing practical examples to stakeholders of water management measures which have been successfully implemented, and therefore present the message that the Water Catchment Management Plan will present doable actions which can have real tangible results which can leave a positive effect on the water management framework in the Maltese islands. Furthermore, the conference presented the proposed approach in the 2nd Water Catchment Management Plan to tackle prevailing issues such as water resources management, water demand management, water quality, water sector management, eco-systems and extreme events (floods and drought management). These issues were discussed in break-out sessions in which stakeholders could discuss and present potential measures in small groups. The conference was concluded with a plenary discussion which discussed the conclusions of the topic-specific working groups.

Figure 13.4: National Conference - National Water Management Plan

Following this national conference a series of subject specific consultation national workshops were held between March and October 2014 dealing with specific water management issues, such as:

(i) Significant Water Management Issues in the Maltese WCD
(ii) Efficient Use of Water Resources
(iii) Water use by the Industrial and Commercial Sectors
(iv) Optimising Groundwater Management
(v) Energy-Water Nexus
(vi) Development of a Water Management Plan (Programme of Measures)

These national workshops were open to participation from the general public.

Figure 13.5: National Workshop on the Efficient use of Water Resources

It is also noted that these consultation workshops were complemented by further information activities held under the frame of the World Water Day 2014 activities. These events included three public information meetings dealing with Significant Water Management Issues, the Energy-Water Nexus and the development of the Water Management Plan for the Maltese islands, which essentially is the Programme of Measures for the Maltese Water Catchment District.

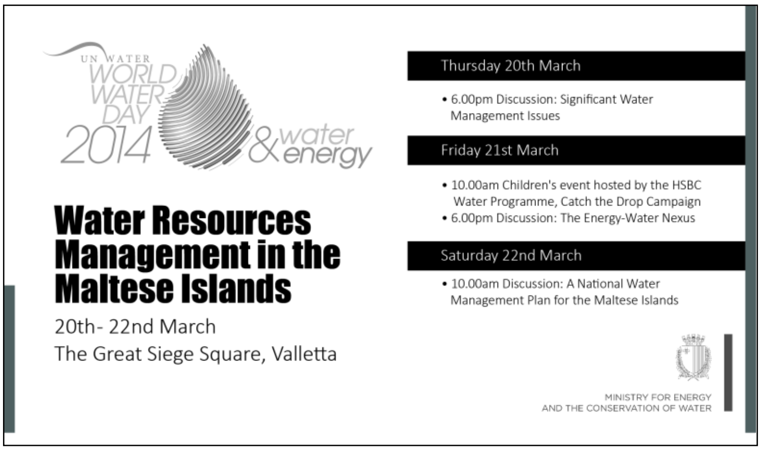

Figure 13.6: Activities marking World Water Day 2014

These public consultation workshops were followed by a second phase of the consultation process which focused on informal meetings with representatives of the main water use categories in the Maltese islands. These informal meetings were open only by invitation and participation was limited to a small number of participants, not exceeding 20 persons for each meeting in order to stimulate a healthy and open discussion with the stakeholders.

During this second consultation phase, twelve consultation meetings were held with representatives of the agricultural sector (including a meeting in Gozo) during the period November to March 2015. The total attendance to these meetings reached around 300 full time farmers, around 25% of the total full time farming population in the Maltese islands. These consultation meetings were organised in cooperation with the Assocjazzjoni tal-Bdiewa (Farmers' Association).

Figure 13.7: Consultation Meeting with the agricultural sector

These meetings discussed the 2nd Water Catchment Management Plan measures dealing with the use of water by the agricultural sector namely:

- the introduction of water efficient technologies,
- the development of rainwater harvesting facilities, and
- the introduction of New Water resources (highly polished treated effluents)

These meetings discussed the practical implementation aspects related to the implementation of these measures, the users' perceptions and expectations as well as their suggestions for improving the implimetability of the measures from a practical point of view.

Figure 13.8: Consultation Meeting with the agricultural sector

A further consultation meeting on the same subject was organised at the Institute of Agro-Business at the Malta College of Arts, Science and Technology (MCAST), which is the main technical institute serving the agricultural sector. This meeting was held on the 6th January 2015.


Figure 13.9: Consultation meeting held at the MCAST Agro-Business Institute

These consultation meetings were further complemented by a series of 'expert water tables' which discussed the more technical aspects of the envisaged water management measures with technical experts from public and private organisations.

These ‘expert water tables’ were undertaken with technical experts both the main public stakeholders such as:
- the Ministry for Transport and Infrastructure
- the Malta Resources Authority
- the Ministry for Gozo (Eco-Gozo Directorate)
and technical officials from the Water Services Corporation, the public utility.

Discussions focused on the development and implementation of specific topics such as rainwater runoff management, water demand management and municipal water supply production and supply optimisation.

Figure 13.10: Expert Water Table on Municipal Water Management

Figure 13.11: Expert Water Table on Water Demand Management

Following the compilation of the draft Programme of Measures, a third consultation cycle to discuss the draft measures making part of the 2nd Programme of Measures with stakeholders was initiated in March 2015, as part of the activities marking World Water Day 2015. The consultation meetings held between March and September 2015 included:

20th March 2015 – a consultation workshop was held at the Palace in Valletta where measures in the draft Programme of Measures related to the development of further polishing facilities to enable the re-use of treated sewage effluent were presented and discussed. The workshop considered both the policy and technological aspects of these measures through presentations delivered by experts from the Sustainable Energy and Water Conservation Unit (SEWCU) and the WSC.

Figure 13.12: Consultation workshop held at the Palace in Valletta on 20th March 2015

25th March 2015 – SEWCU participated in the Malta Water Week, where measures in the draft Programme of Measures supporting innovation in the local water sector were presented and discussed.

Figure 13.13: Malta Water Week held on 25th March 2015

26th March 2015 – a consultation and information meeting was held at the Institute of Applied Science within the Malta College for Arts, Science and Technology (MCAST) on measures for supporting the introduction of grey-water recycling in Malta. In the meeting, the experience of the application of this technology in Cyprus was presented by an invited speaker. The meeting was supported by Global Water Partnership (Mediterranean).

Figure 13.14: Consultation meeting held at the MCAST on 26th March 2015

April 2015 – Measures to address the sustainability of the perched aquifer systems were presented in a public information meeting held to mark the 400th anniversary of the Wignacourt Aqueduct. Springs from the perched aquifer systems were the main sources of water feeding into this aqueduct and which, up to the early 20th century, used to deliver potable water to the main urban areas in the Maltese islands.

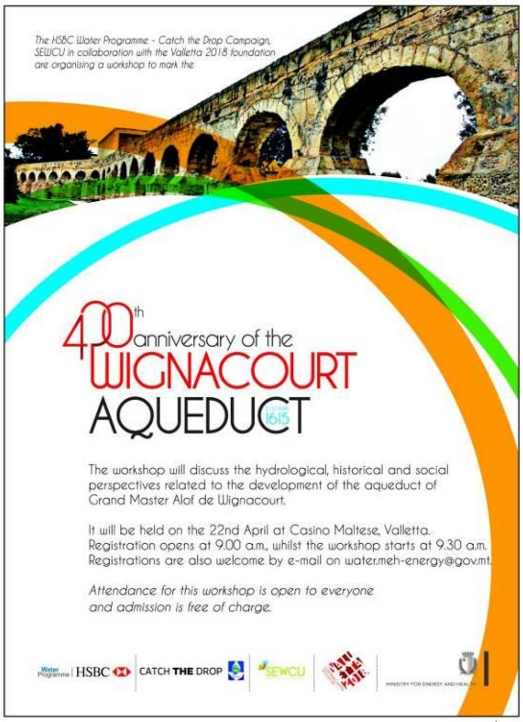

Figure 13.15: Public information meeting to be held on 22nd April 2015

April 2015 – Consultation workshops with operators in the Tourism and Commercial Sectors to discuss the implementation of the measures in the WFD Programme of Measures addressing these sectors. These workshops were organised with the support of the Malta Business Bureau (MBB).

Figure 13.16: Consultation meeting with operators in the tourism sector held on 29th April 2015

April/May 2015 – A series of on-site information meetings for farmers on the use of highly polished treated effluent for irrigation were held during April, May 2015 at a pilot crop-irrigation site which is being managed with the collaboration of the Agribusiness Institute of the Malta College for Arts, Science and Technology. These information meetings serve to present to the farmers the direct results of crop irrigation with highly polished treated effluent, and discuss their perceptions related to the introduction of this new water resource during the 2nd water catchment management cycle.

Figure 13.17: Information meeting on the use of highly polished treated effluent for farmers

September 2015 – A technical meeting for invited experts was held dealing with measures on Managed Aquifer Recharge. This technical meeting was organized with the support of the EU MARSOL Project, and provided the opportunity for the discussion between Maltese and Mediterranean experts on the best development and implementation of MAR measures.

13.3 Conclusion of the Consultation Process

The consultation process on the 2nd Water Catchment Management Plan was concluded on the 25th September 2015 with the organization of a National Stakeholder Consultation Workshop, which was jointly organised by the two WFD competent authorities. This workshop presented the updated draft RBMP to stakeholders, through a series of presentation by experts from the two WFD competent authorities, SEWCU and MEPA. It also presented an opportunity for a final discussion on the 2nd WCMP, prior to its finalisation.

The issues discussed during this national workshop included:
- Characterisation of Water Bodies
- Monitoring and Status Determination
- Environmental Objectives and Exemptions
- Programme of Measures
- Economic Characterisation
- Implementation of the WCMP (Administrative set-up)

The presentations of this workshop can be downloaded from the following web-link:
http://sewcu.gov.mt/en/Documents/RBMP%20Workshop%202592015.pdf

Figure 13.18: National Consultation Conference on the 2nd Water Catchment Management Plan

14. IMPLEMENTATION OF THE 2nd WCMP

14.1 Inter-Ministerial Committee on Water

The successful implementation of the actions or programme of measures identified in this 2nd Water Catchment Management Plan relies on the commitment of several actors coming from a wide spectrum of backgrounds to work together. The 1st Water Catchment Management Plan saw the establishment of an Inter-Ministerial Committee on Water, which oversaw the effective and timely implementation of this first plan.

The main responsibilities of this Inter-Ministerial committee on water are:
- to oversee the implementation of the water related directives and ensure the integration of the measures into each entity's business plan (including time frames for implementation);
- advise on the integration of WFD principles and objectives in sectoral policies, plans and programs and to recommend mechanisms that enable implementation of measures for adoption;
- monitor the progress of implementation and report to the competent authorities and ministries;
- with the help of assisting sub-committees, identify constraints that hinder implementation and recommend alternative measures by reviewing subcommittees reporting and recommendations on implementation of respective measures; and
- inform the Water Catchment Management Plan implementation process of other issues that are likely to affect implementation.

The majority of the measures set out in this 2nd catchment management plan involve once more a wide spectrum of players and will be undertaken by a large number of public bodies. It is expected that these implementing agencies would record their progress and communicate these to the inter-ministerial committee. To facilitate this process there is a need to set up ad-hoc sub-committees that would assist and inform the inter-ministerial committee. The sub-committees would work with other local entities and stakeholders to help integrate the measures of this plan into local plans and strategies.

It is important that the sub-committees welcome the input of local players and stakeholders to drive action at the local level. The linking of the water catchment management plan with other plans and programmes thus should also be encouraged. This would guarantee maximum input and involvement from other parties. For this reason the sub-committees would encourage stakeholders to include this plan's considerations into their respective plans, policies and strategies.

The public entities which will be represented on the Inter-Ministerial Water Committee are:
Chair: Sustainable Energy and Water Conservation Unit (SEWCU)
Co-Chair: Malta Environment and Planning Authority (MEPA)
Ministry for Energy and Health (MEH)
Ministry for Sustainable Development, the Environment and Climate Change (MSDEC)
Ministry for Transport and Infrastructure (MTI)
Ministry for Gozo (MGoz)
Rural Development Directorate (MSDEC)
Transport Malta (TM)
Malta Resources Authority (MRA)
Regulator for Energy and Water Services (REWS)
Water Services Corporation (WSC)
Environmental Health Directorate (EHD)

The Inter-Ministerial Committee will also seek to ensure that the 2nd Water Catchment Management Plan supported the implementation of other national plans and programmes, in order to contribute

to the development of an active Integrated Water Resources Management platform. These plans include:
- National Water Management Plan
- Operational Programme I (2014-2020)
- The Strategic Plan for Environment and Development, July 2015
- National water management plan
- Operational Programme I (2014-2020)
- Operational Programme II (2014-2020)
- White paper – Improving Business Inspections
- National Tourism Policy (2015-2020)
- National Climate Change Adaptation Strategy (2012)
- National Environment Policy (2012)
- National Biodiversity Strategy and Action Plan 2012-2020 (2012)
- Nitrates Action Plan (2011)
- Rural Development Programme 2014 - 2020
- National Aquaculture Strategy (2014)
- National Environment and Health Action Plan 2013-2017
- Development of Yachting Facilities in Malta: Identification of Potential Sites for All-Weather Marinas and Temporary Marinas (2009)

14.2 Stakeholder Water Tables

The implementation of the 2nd WCMP will also be supported by the establishment of a Stakeholder Water Table where the active input of interested stakeholders in support of the implementation of the WCMP will be sought. These water tables will be established during 2016 following the publication of an expression of interest by the WFD Competent Authorities.

It is planned that this Water Table will meet on a bi-annual basis and will discuss and analyse the implementation process of the 2nd Water Catchment Management Plan with the scope of identifying any corrective actions which would be required to ensure that the WCMP meets its objectives.

ANNEX I
MANAGEMENT PLANS FOR EXTEME EVENTS

1 Introduction

The 2nd Water Catchment Management Plan aims to develop an integrated water management framework for the Malta Water Catchment District which takes full consideration of challenges emerging from extreme water management events such as 'water scarcity and droughts' and 'flood events'. The sections under this Annex present an outlook of how the 2nd WCMP addresses these issues, with particular reference to the implementation of the challenges outlined under the following documents:

(i) Communication from the Commission to the European Parliament and the Council addressing the challenge of water scarcity and droughts in the European Union, and

(ii) Directive 2007/60/EC of the European Parliament and of the Council of 23 October 2007 on the Assessment and Management of Flood Risks.

2 Water Scarcity and Droughts

In 2007, the EU put forward a Communication addressing the challenge of water scarcity and droughts. Under this document, EU policy related to water scarcity and droughts is based on the principle of a 'water heirarchy' – namely that additional water supply infrastructures should be considered only when demand-side measures have been implemented.

The process leading to the development of the 2nd WCMP, considered the impact of Water Scarcity and Droughts in the context of the Malta Water Catchment District. For the purpose of this analysis the following definitions were adopted:

WATER SCARCITY – *a situation where insufficient water resources are available to satisfy long-term average requirements. It refers to long-term water imbalances, where the availability is low compared to the demand for water, and means that water demand exceeds the water resources exploitable under sustainable conditions.*

DROUGHT – *represents relevant temporary decrease of the average water availability – important deviations from the average levels of natural water availability and is considered as a natural phenomenon.*

An important consideration was made to the relativity of droughts, in particular given the Mediterranean climatic conditions prevailing in the Maltese islands. In this context, the impact of a drought in Malta is expected to be more severe than that experienced in most of the other EU Member States, given the starting benchmark of low natural water availability. It might well be that drought conditions in other Member States would, from a rainfall depth point of view, represent water availability levels well exceeding those occurring in extremely wet years in the Maltese islands. In as much, it was felt necessary to introduce in the analysis the concept of Aridity, and the following definition was adopted:

ARIDITY – *a natural permanent imbalance in the water availability consisting in low average annual precipitation, with high spatial and temporal variability resulting in overall low moisture and low carrying capacity of the ecosystem.*

In this context the following analytical framework was developed:

WATER SCARCITY = *f(Water Availability, Water Demand)*

Where:

WATER AVAILABILITY = *f(Climatic and Hydro-geological characteristics)*

WATER DEMAND = *f(Demographic and Social conditions)*

The naturally low availability of water in the Maltese islands, has always required that due consideration be given to water demand management measures. This has led to the development of an underlying 'water saving culture' which results in the Maltese islands having one of the lowest per capita water consumption rates in the European Union.

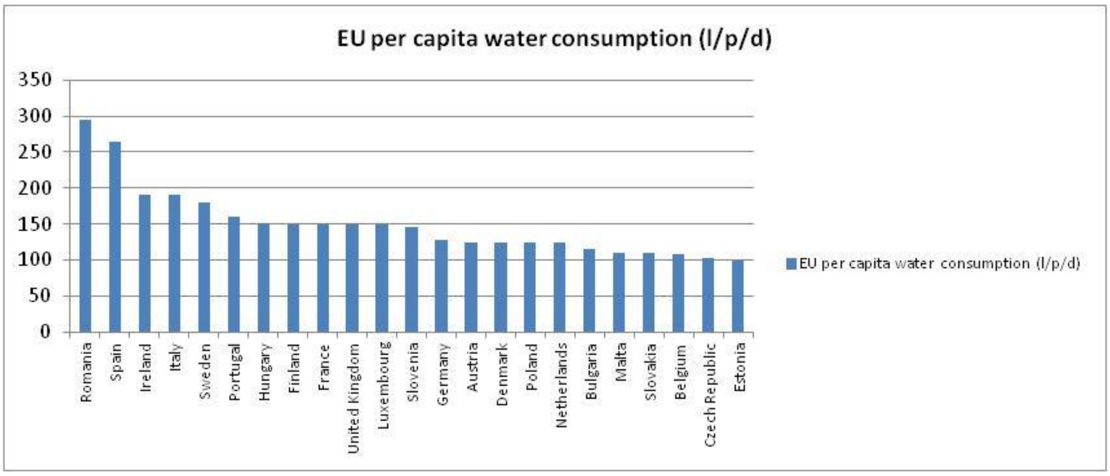

Figure 1: Water Consumption per Capita in EU Member States – Source: Waterwise

Furthermore, efficiency measures across all water using sectors, as well as the undertaking of water demand management measures on a national scale, leaves Malta with the lowest freshwater abstraction rates (per inhabitant) compared to all EU Member States. Even should, the production of water by desalination be taken into consideration, the water production rate per inhabitant would still stand on the lower end, compared to other EU Member States.

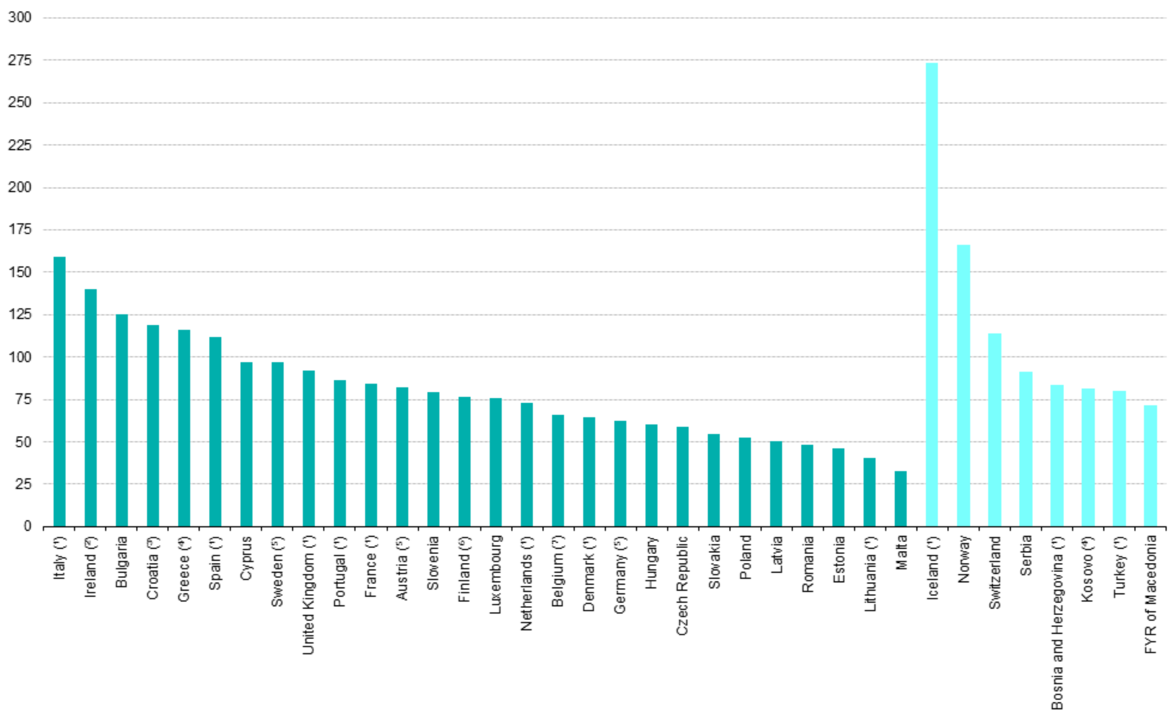

Figure 15.2: Total freshwater abstraction by public water supply, 2013 (m3 per inhabitant) – Source: EEA

This has been possible through the undertaking along the years of important water demand management measures, such as the National Water Leakage Management Programme. Significant efforts have been made by the Water Services Corporation to reduce real losses: leakages have been reduced from approximately 10.3 million m^3 in 2002 to only 3.5 million m^3 in 2014; that represents a 66% reduction of the volumes lost each year through leakages since 2002. Moreover, a recent study places the economically optimum levels of network leakages at 3.2 million m^3 per hour (considering the costs of water produced offset by the additional resources required to drive the leakage further than current levels). **That being the case, current leakage levels would be nearly at optimal levels.** These efforts have particularly, allowed for sustaining an increased public water demand (approximately by 1.3% per year since 2005) while at the same time decreasing production (an average 0.2% per year since 2005). Up to 2012, this reduction in the system demand has brought down the abstraction of groundwater by approximately 7 million m^3 since 1995, or a decrease of 34.5%.

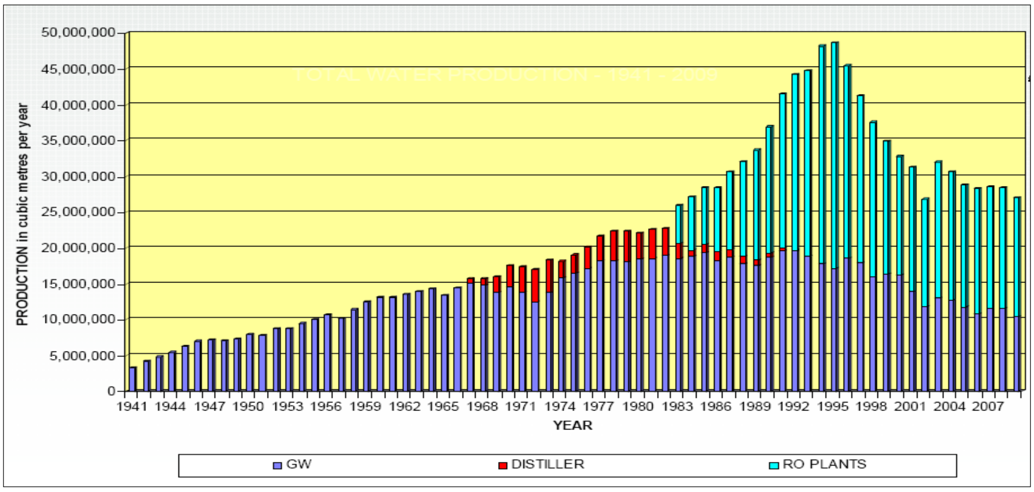

Figure 15.3: Reduction in the Municipal Water Demand, achieved by
Water Demand Management Measures undertaken by the Water Services Corporation

Similarly, the low availability of natural water resources, has guided the development of the arable agricultural sector, where the irrigation efficiency of agriculture in the Maltese islands is already high (78%, Plan Bleu 2008). Therefore achieving further '*efficiency gains*' presents an increased challenge. This high efficiency rate in irrigation water use is reflected in the wide use of water saving irrigation devices in almost all irrigated areas in the Maltese islands (100%, Plan Bleu 2013).

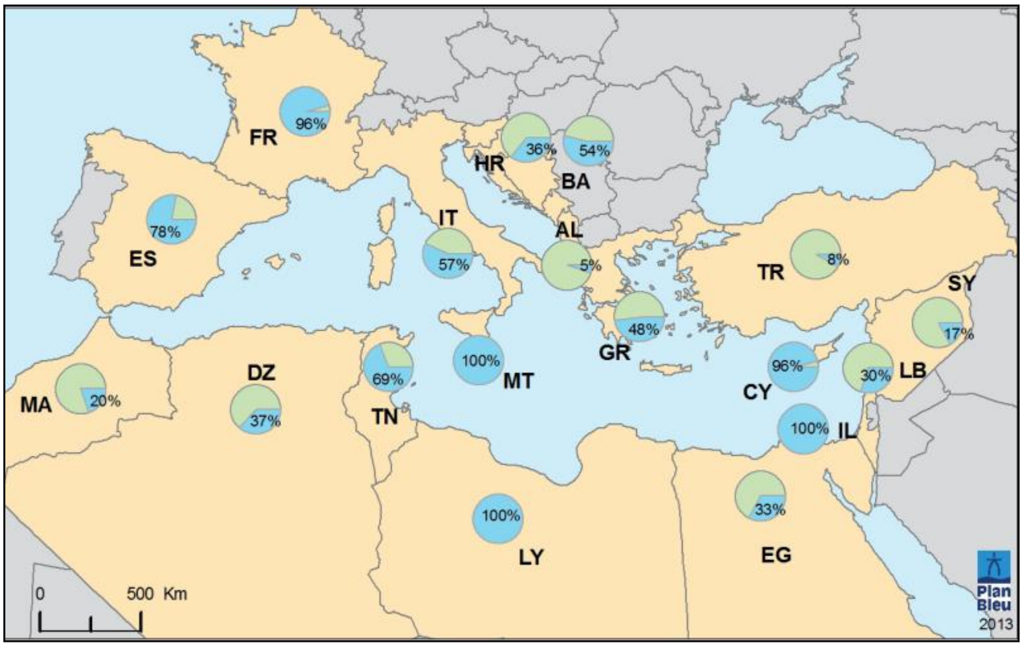

Figure 15.4: Proportion of irrigated surface areas fitted with water saving devices (Plan Bleu – 2013)

The 2nd WCMP takes note of the above baseline scenario, and has therefore identified a suite of measures to continue to optimise water management in the Maltese islands in view of the specific challenges due to Water Scarcity and Droughts. This process has taken full consideration of the existing high efficiency benchmarks present in the Water Catchment District and therefore seeks the continued optimisation of water-use in the Maltese islands.

The Water Scarcity and Droughts Management framework within the 2nd WCMP thus seeks to increase the resilience of the water management framework in the Maltese islands by focusing on the optimisation of the efficiency in the use of water resources through a number of focused water demand management measures and the efficiency in the production of water resources through a number of measures focused on the recycling/re-use of water resources and the harvesting of rainwater runoff. In as much, through this two pronged approach, the measures under the 2nd WCMP will seek to reduce the pressure on Malta's naturally renewable groundwater resources, support their quantitative and qualitative re-enstatement in order to increase their resilience to support the national water supply base in periods of extended drought conditions.

The actions within the Programme of Measures addressing the achievement of the objectives of the Water Scarcity and Drought management framework are:

Integrated Analytical Framework
MDM7 - Development of a Water Scarcity and Drought monitoring and assessment platform

Water Demand Management Measures
STE1 – Development of a long-term National Water Conservation Campaign
DOM1 – Support mechanisms for water consumption audits in households
AGR1 – Support schemes for the uptake of efficient irrigation technology by the arable agricultural sector
AGR2 – Support schemes for the update of efficient water technology by the animal husbandry sector
PUB2 – Establishment of minimum technical and economic levels of leakage in the municipal distribution network, and achievement of these thresholds through the ongoing leakage management and control programme operated by the public utility

PUB3 – Establishment of a voluntary Eco-Labelling scheme for water use fixtures and appliances

Optimisation of Rainwater Runoff Harvesting Capacity

RWH1 – Survey of the status of existing rainwater harvesting infrastructure, identification of potential users of rainwater harvested in these infrastructures, undertaking of rehabilitation works and development of a management framework to ensure the effective use of harvested rainwater

RWH2 – Development of the administrative capacity necessary to ensure the effective implementation of current legislative requirements in relation to the development of rainwater harvesting facilities and associated secondary water conveyance systems

RWH4 – Support schemes for the development of rainwater runoff facilities in the agricultural and commercial sectors

RWH6 – Rehabilitation of existing rainwater harvesting dam structures in valleys

Development of New Water Resources

NEW 1 – Commissioning of three polishing plants with a production capacity of 7 million m^3/year.

NEW2 – Development and implementation of a branding campaign for New Water Resources.

NEW3 – Development of demonstration sites for the application of New Water Resources.

NEW4 – Development of dedicated distribution facilities for New Water to enable its availability at the point of use.

Introduction of Innovative Water Management Technology

STE3 – Development of demonstration projects to showcase the application of innovative technology in the local water sector

PUB5 – Support mechanisms for research initiatives on grey-water recycling systems for the domestic and commercial sectors

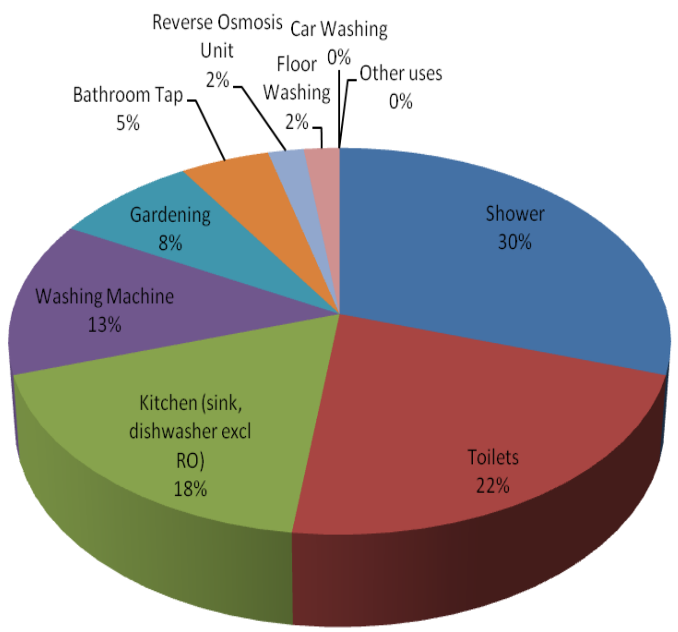

Figure 15.5: Classification of water use in Maltese households. Recycling of household grey-water can enable the re-use of shower water for toilet flushing purposes, thus potentially reducing the household water demand by around 22%

The implementation of the above identified measures are projected to incur a cumulative volumetric impact of around 10,000,000m^3 each year, achievable through the reduction of the national water demand and the increased efficient use of national water supply base through the introduction of recycling/reuse technologies and the optimised utilisation of rainwater runoff. It is thus envisaged that the implementation of these measures will substantially increase the resilience of the water sector in the Maltese islands to face the emerging challenges due to Water Scarcity and Droughts.

3 Flood Risk Management Plans

Directive 2007/60/EC on the assessment and management of flood risks aims to establish a framework for the assessment and management of flood risks, aiming at the reduction of the adverse consequences for human health, the environment, cultural heritage and economic activity associated with floods in the Community. To achieve its objectives, the Directive requires Member States to develop Flood Risk Management Plans to coordinate the implementation of flood management measures within identified flood risk areas.

The Flood Risk Management Plan for the Malta Water Catchment District has been integrated within the 2nd Water Catchment Management Plan. This section presents an outline of the measures in the 2nd WCMP intended to address the management of floods within the Catchment District.

3.1 Floods in the context of the Malta Water Catchment District

The implementation of the Floods Directive in the Malta Water Catchment District needs to consider the specific hydrological conditions of the Catchment District. During storm events, the dry valley channels adopt their natural function as a storm water culvert whereby the uncontrolled surface water runoff generated throughout the urban areas is conveyed downstream, for eventual discharge at the coastal zone. This flow of surface water runoff within the valley channel is limited to the main part of the valley channel which has been built up and this flow occurs for a very short period of time (in the order of a couple of hours) after the termination of the rainfall event. Therefore locally the term flooding is understood as the presence of uncontrolled surface water runoff which is located in urbanised valley channels which are not normally covered by water.

3.2 Identification of areas prone to flooding

The dry nature of Maltese water courses has throughout the island’s history led to urban development within the actual water course. In fact, urban areas have throughout the years extended on what was once the original valley floor. The flow of uncontrolled surface water runoff occurs through these areas for a short period of time following intense rainfall events. The depth of rainwater runoff in the urbanised segments of the valley channel does not always reach the levels of significance required to pose a risk to the population and the economic activities undertaken within these risk areas. For the purpose of the implementation of the Floods Directive, risk from flooding was considered to occur only in those parts of the valley channel in which storm water runoff reaches levels exceeding 30cm in depth.

Figure 15.6: Catchments that experience previous surface water flooding

3.3 Development of Flood Risk and Flood Hazard Maps

The identification of the Flood Hazard Zones undertaken for the 1st Article 6 report under the Flood Directive was based on the results of the modelling exercise carried out as part of the National Flood Relief Project (NFRP); the objective of which was to avert increases in risks to life and property and control damages caused by uncontrolled surface water runoff in the four priority catchment basins of Msida, Gzira, Qormi and Marsaskala. The modelling exercise provided information on the extent and depth of the floods based upon a 1 in 5 year event storm scenario and this provides the basis for the information presented in the Flood Hazard Maps. In the Flood Hazard Maps, the modelled water depth was categorised according to the following depths: 0 meters to 0.10 meters, 0.10 meters to 0.25 meters, 0.25 meters to 0.50 meters, 0.50 meters to 0.75 meters, 0.75 meters to 1 meter, 1 meter to 1.50 meters and areas with a modelled flood water depth greater than 1.50 meters.

The Flood Risk Maps indicate the zones which pose a significant flood risk to the residents and commercial activities located adjacent to the modelled flood risk areas. The identification of the flood risk areas was based on the water level derived from the modelling exercise produced as part of the National Flood Relief Project. For the purpose of the implementation of the Floods Directive areas with a water depth above 30cm are considered as significant flood risk areas.

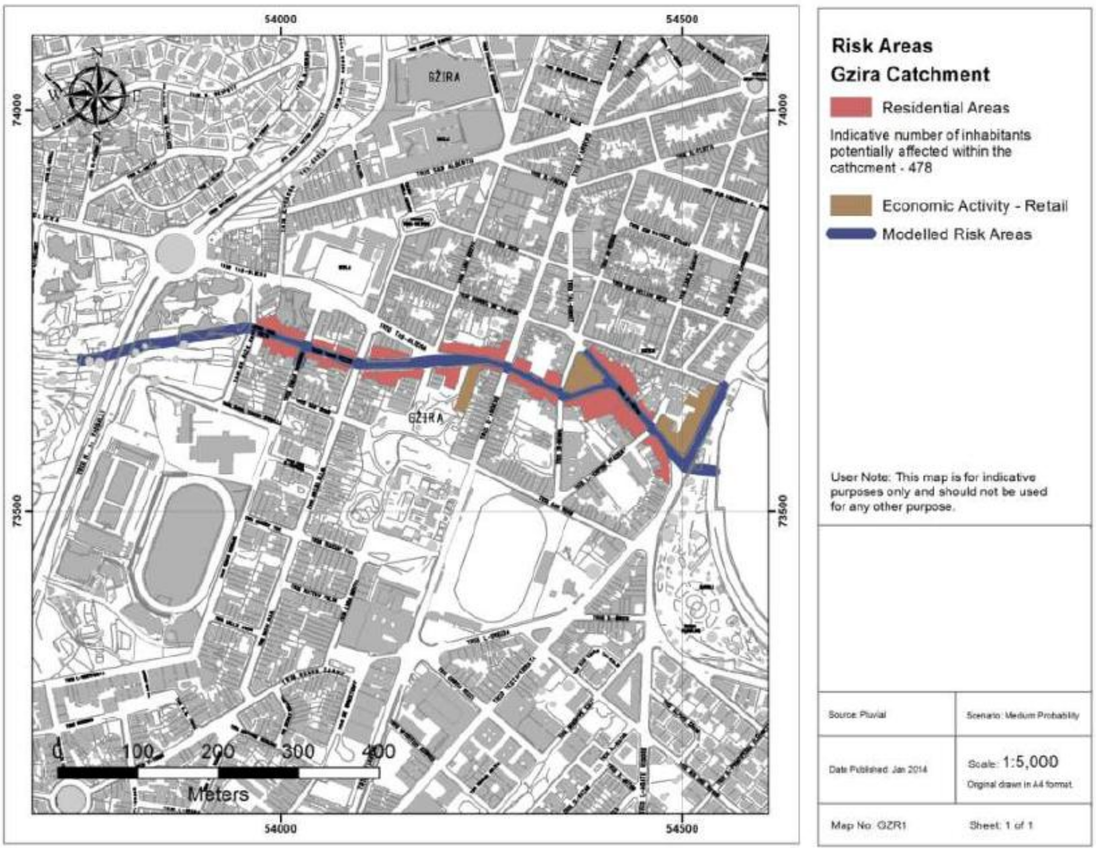

Figure 15.7: Flood Risk Areas in the Gzira Catchment

3.4 Establishment of Flood Management Objectives

The 1st Flood Risk Management Plan for the Malta Water Catchment District will seek to:

- develop a modeling framework the comprehensive assessment of the risk to flooding in all water catchment areas in the Maltese islands;
- focus on the reduction of the likelihood of flooding in identified 'at risk' catchments through the adoption of upstream water management measures such as Rainwater Harvesting and Sustainable Urban Drainage Systems; and
- introduce water level monitoring facilities in 'high risk' catchments to optimize the monitoring of flood events.

Through the flood risk management measures identified in the 2nd Water Catchment Management Plan, the development of 1.5 million m^3 of effective upstream storage and/or additional infiltration capacity will be sought in order to contribute to the reduction of flood risk.

3.5 Flood Management Measures

The Programme of Measures within the 2nd Water Catchment Management Plan includes a suite of Direct, Indirect and Supporting Measures aimed at achieving the objectives of the 1st Flood Risk Management Plan. The identified flood risk management measures are listed below.

Direct Measures

FLD1 – Modelling of the impact of the National Flood Relief Project on flood hazard and risk in identified catchments.

FLD2 – Flood Hazard and Risk Assessment in catchments not included in the National Flood Relief Project.

FLD3 – Comprehensive assessement for the inclusion of Sustainable Urban Drainage Systems and Natural Water Retention Measures to mitigate flood hazard and risk.
FLD4 – Implementation of Sustainable Urban Drainage Systems and Natural Water Retention Measures as identified under measure FLD3.

Indirect Measures
RWH1 – Survey of the status of existing rainwater runoff harvesting infrastructure, identification of potential users of rainwater harvested in these infrastructures, undertaking of rehabilitation works and development of a management framework to ensure the effective use of harvested rainwater runoff.
RWH6 – Rehabilitation of existing rainwater harvesting dam structures in valleys.
GWM4 – Development of Managed Aquifer Recharge schemes for aquifer management purposes.

Supporting Measures
GVN1 – Determination of the roles and responsibilities of all public sector agencies involved in the wider management of water resources.
RWH2 – Development of the administrative capacity required to ensure the effective implementation of current legislative requirements in relation to the development of rainwater harvesting facilities and associated secondary water conveyance systems.
MDM1 – Comprehensive upgrading of the hydrological cycle monitoring capacity.

3.6 Implementation of the Flood Risk Management Plan

The implementation of the measures outlined in the Flood Risk Management Plan is envisaged to start in 2016, with the identification of clear Roles and Responsibilities within the Water Management Sector for the implementation of the identified measures. The implementation of the respective measures is envisaged to be staggered over the six-year catchment management cycle. The implementation timeframe to be followed is presented in Table 1 below:

Implementation Start Date	Measure
2016	GVN1
2017	FLD1, RWH1, RWH2, RWH6, MDM1
2018	GWM4
2019	FLD3
2020	FLD4

Table 15.1: Implementation time-table for the identified flood management measures

3.7 Public Consultation Initiatives

The public consultation process supporting the development of the 1st Flood Risk Management Plan was undertaken within the development framework of the 2nd Water Catchment Management Plan, given that the development of the flood risk management measures was undertaken within the integrated framework considered for the 2nd WCMP's Programme of Measures.

Furthermore, through the collaboration of the Local Councils Associations, a number of public and stakeholder information meetings on the application of Sustainable Urban Drainage Systems in the Maltese islands were held throughout the development process of the 2nd WCMP. These meetings were organised as part of the Local Councils Association's participation in the EU funded E^{2}STORMED Project.

3.8 National Competencies

The National Competent Authority for the implementation of the EU Floods Directive is the Sustainable Energy and Water Conservation Unit (SEWCU). The development and implementation of the Flood Risk Management Plan for the Malta Water Catchment District is therefore being coordiniated by SEWCU in close collaboration with other involved entities including:

- Ministry for Transport and Infrastructure
- Ministry for Gozo
- Malta Environment and Planning Authority

ANNEX II

Specifications of the Water Flow Model

All the variables included in the Water Flow Diagram were identified and assigned a three-letter code as follows:

Seawater:	SWR
Precipitation:	PTN
Sub-surface discharge:	SSD
Groundwater MSL Aquifer:	GMS
Groundwater Perched & Coastal Aquifers:	GPC
Surface Runoff:	SRO
Evapotranspiration:	EVP
Municipal Water Production:	MWP
Private RO:	PRO
Real & Apparent Losses	RAL
Residential Consumers	RDC
Industry & Commercial Sectors:	ICS
Agricultural Sector:	AGS
Rainwater Harvesting:	RHV
Primary & Secondary Wastewater:	PSW
Tertiary Wastewater Treatment:	TWT
Artificial Groundwater Recharge:	MAR
Municipal RO:	MRO
Municipal GW:	MGW

The model water flows were extracted next and assigned a variable in the form of x_n as shown in Table 2 and Table 3. Table 2 illustrates the model water flows for the endogenous variables whilst Table 3 illustrates the exogenous variables.

From	to	Model Flows	Variable
		Mm3	
SWR	MRO	17	x1
SWR	PRO	1	x2
SSD	SWR	23	x3
PSW	SWR	10	x4
PTN	GMS	34	x5
PTN	GPC	14	x6
PTN	SRO	97	x7
GMS	SSD	23	x8
GMS	MGW	13	x9
GMS	RDC	1	x10
GMS	ICS	2	x11
GPC	GMS	3	x12
AGR	GMS	13.4	x13
AGR	GPC	1	x14
MWP	RAL	13.7	x15
MWP	RDC	10.6	x16
MWP	ICS	4.7	x17
PRO	ICS	1	x18
GMS	AGS	14.5	x19
MWP	AGS	1	x20
GPC	AGS	12	x21
RHV	AGS	2	x22
TWT	AGS	5	x23
RHV	RDC	2	x24
ICS	PSW	9	x25
RDC	PSW	8	x26
PSW	TWT	7	x27
TWT	AGR	2	x28
RAL	AGR	4.3	x29
RDC	AGR	1	x30
ICS	AGR	1	x31
AGS	AGR	6.1	x32
SRO	SWR	91	x33
SRO	RHV	5.5	x34

Table 15.2: Model flows covering Endogenous Variables

Base	Variable
13.6	RDC
1	x10
2	x24
7.7	ICS
1	x18
2	x11
34.5	AGS
2	x22
5	x23
0	x19
0	x21
0	x15
0	x9
8	x26
9	x25
7	x27
0	x32
0	x31
0	x30
0	x29
34	x5
14	x6
3	x12
23	x8

Table 15.3 – Model flows covering Exogenous Variables

Exogenous variables can be influenced by the user including numerical coefficients to reflect the effect of interventions.

Following the assignment of codes and model flows, a system of simultaneous equations is set up as shown below. Note that the bar sign over the variable refers to an exogenous variable.

1	$X_{16} = \overline{RDC} - \overline{X_{10}} - \overline{X_{24}}$	Domestic demand served by GWA and RWH, with MWP being residual to satisfy demand. Hence, projects can influence $\overline{X_{10}}$: use by GWA $\overline{X_{24}}$: use of RWH $\overline{RDC}$: total demand
2	$X_{17} = \overline{ICS} - \overline{X_{18}} - \overline{X_{11}}$	Similar approach for ICS
3	$X_{20} = 0.02\ \overline{AGS}$	Similar approach for AGS, but GWA is not fully exogenous
4	$X_{19} = \overline{AGS} - X_{20} - X_{21} - \overline{X_{22}} - \overline{X_{23}} + \overline{X_{19}}$	GWA by AGS is partly driven by demand, with a role for policy intervention through exogenous variables
5	$X_{21} = 0.26\ \overline{AGS} + \overline{X_{21}}$	
6	$X_{15} = 0.84\,(X_{16} + X_{17} + X_{20}) + \overline{X_{15}}$	RAL move in line with other demands for MWP, and can be influenced by measures through $\overline{X_{15}}$
7	$X_1 = X_{15} + X_{16} + X_{17} + X_{20} - X_9$	RO is residual between MWP and GWA
8	$X_{27} = 0.41\,(X_{25} + X_{26}) + \overline{X_{27}}$	Tertiary treatment is a proportion of primary and secondary, and a policy variable
9	$X_{28} = X_{27} - \overline{X_{23}}$	Tertiary treated water to artificial recharge is residual from agricultural use
10	$X_{32} = 0.13\ \overline{AGS} + \overline{X_{32}}$	Artificial recharge from AGS
11	$X_{31} = 0.13\ \overline{ICS} + \overline{X_{31}}$	Artificial recharge from ICS
12	$X_{30} = 0.07\ \overline{RDC} + \overline{X_{30}}$	Similar from RDC
13	$X_{29} = 0.31\ X_{15} + \overline{X_{29}}$	Recharge from RAL
14	$X_{13} = 0.94\,(X_{28} + X_{29} + X_{30} + X_{31} + X_{32})$	Recharge to GMS
15	$X_{14} = X_{28} + X_{29} + X_{30} + X_{31} + X_{32} - X_{13}$	Recharge to GPC
	$\overline{X_5}$	Recharge to GMS from precipitation
	$\overline{X_6}$	Recharge to GPC from precipitation
	$\overline{X_{12}}$	From GPC to GMS
	$\overline{X_8}$	From GMS to sub-surface discharge
16	Net MSL aquifer flow: $GMS = X_{12} + \overline{X_5} + X_{13} - X_8 - X_9 - \overline{X_{10}} - \overline{X_{11}} - X_{19}$	
17	Net GPC aquifer flow: $GPC = \overline{X_6} + X_{14} - X_{12} - X_{21}$	

Start Values of exogenous variables:	
$\overline{RDC} = 13.6$	$\overline{X_{25}} = 9$
$\overline{X_{10}} = 1$	$\overline{X_{27}} = 7$
$\overline{X_{24}} = 2$	$\overline{X_{32}} = 0$
$\overline{ICS} = 7.7$	$\overline{X_{31}} = 0$
$\overline{X_{18}} = 1$	$\overline{X_{30}} = 0$
$\overline{X_{11}} = 2$	$\overline{X_{29}} = 0$
$\overline{AGS} = 14.5$	$\overline{X_5} = 34$
$\overline{X_{22}} = 2$	$\overline{X_6} = 14$
$\overline{X_{23}} = 5$	
$\overline{X_{19}} = 0$	
$\overline{X_{21}} = 0$	All variables with zero values are influenced by policy. Other variables are state variables.
$\overline{X_{15}} = 0$	
$\overline{X_9} = 0$	
$\overline{X_{26}} = 8$	
$\overline{X_{12}} = 3$	
$\overline{X_8} = 23$	

The next step is to place all endogenous variables on the left hand side and exogenous on the right hand side of the equation.

1	$X_{16} = \overline{RDC} - \overline{X_{10}} - \overline{X_{24}}$
2	$X_{17} = \overline{ICS} - \overline{X_{18}} - \overline{X_{11}}$
3	$X_{20} = 0.02\ \overline{AGS}$
4	$X_{19} - X_{20} - X_{21} = \overline{AGS} - \overline{X_{22}} - \overline{X_{23}}$
5	$X_{21} = 0.26\ \overline{AGS} + \overline{X_{21}}$
6	$X_{15} - 0.84\,(X_{16} + X_{17} + X_{20}) = \overline{X_{15}}$
7	$X_1 - X_{15} - X_{16} - X_{17} - X_{20} + X_9 = 0$
8	$X_9 - 0.43\,(X_{15} + X_{16} + X_{17} + X_{20}) = \overline{X_9}$
9	$X_{26} = 0.59\ \overline{RDC} + \overline{X_{26}}$
10	$X_{25} = 1.17\,\overline{ICS} + \overline{X_{25}}$
11	$X_{27} - 0.41\,(X_{25} + X_{26}) = \overline{X_{27}}$
12	

	$X_{28} - X_{27} = X_{23}$
13	$X_{32} = 0.13\,\overline{AGS} + \overline{X_{32}}$
14	$X_{31} = 0.13\,\overline{ICS} + \overline{X_{31}}$
15	$X_{36} = 0.07\,\overline{RDC} + X_{30}$
16	$X_{29} - 0.31\,X_{15} = X_{29}$
17	$X_{13} - 0.94\,(X_{28} + X_{29} + X_{30} + X_{31} + X_{32}) = 0$
18	$X_{14} - X_{28} - X_{29} - X_{30} - X_{31} - X_{32} + X_{13} = 0$
19	$X_{12} - 0.2\,(X_{14}) = 0.2(\overline{X_6})$
20	$X_8 - 0.57(X_{12} + X_{13}) = 0.57(\overline{X_5})$
21	$GMS - X_{12} - X_{13} + X_8 + X_9 + X_{10} + X_{11} - \overline{X_{19}} = \overline{X_5} - \overline{X_{10}} - \overline{X_{11}}$
22	$GPC - X_{14} + X_{12} + X_{21} = \overline{X_6}$

The next step is to set up these equations in matrix form.

	x16	x17	x20	x19	x21	x15	x1	x9	x26	x25	x27	x28	x32	x31	x30	x29	x13	x14	x12	x8	GMS	GPC
x16	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
x17	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
x20	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
x19	0	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
x21	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
x15	-0.84049	-0.84049	-0.84049	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
x1	-1	-1	-1	0	0	-1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
x9	-0.43333	-0.43333	-0.43333	0	0	-0.43333	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
x26	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
x25	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
x27	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
x28	0	0	0	0	0	0	0	0	0	0	-1	1	0	0	0	0	0	0	0	0	0	0
x32	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
x31	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
x30	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
x29	0	0	0	0	0	-0.31387	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
x13	0	0	0	0	0	0	0	0	0	0	0	-0.93056	-0.93056	-0.93056	-0.93056	-0.93056	1	0	0	0	0	0
x14	0	0	0	0	0	0	0	0	0	0	0	-1	-1	-1	-1	-1	1	1	0	0	0	0
x12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
x8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
GMS	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	-1	0	-1	1	1	0
GPC	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	-1	1	0	0	1

The solution can be obtained through the use of matrix algebra as follows:

$a_1 x_1 + a_2x_2 + ……………+ a_nx_n = Z_1$
$b_1 x_1 + b_2x_2 + ……………+ b_nx_n = Z_2$

where: a_1 = coefficient, x_1 = endogenous variable and z_1 = exogenous variable

a_1 a_2 …. a_n	x1		Z_1
b_1 b_2 …. b_n	x2	=	Z_1
	Xn		Z_n
A	x	=	Z
	x	=	A^{-1} Z

Exogenous variables are inputted in accordance to a rate of growth as well as a power in accordance to project year starting from year 0 to year 25.

In order to find the value of the endogenous variable *x,* a matrix multiplication of the inverse of coefficients with that for the exogenous variables is undertaken. This value is obtained for each year till the end of the project life.

ANNEX III

	Tariff Structures and Average Rates for Drinking Water in Household and Industry			
	Tariff structure		Average rates (Eur/m^3)	
	Household	Industry	Household	Industry
England and Wales	Unmetered household charges: Fixed charge + charge based on the rateable value of the house	Standard charges for water: Non-household customers who use less than 50 million litres of water a year (250 million litres in Wales). Standing charge + volumetric charge per cubic metre for non-household customers who use more than 50 million litres	Unmetered household charges: Fixed charge: 69.6 EUR/year and charge based on the rateable value of the house: 75.7cents/EUR	Standard charges for water (example): Standing charge - possible ranges as applied by all different companies: (1) 12mm meter: between 20.4 and 59.4 EUR/Year (m), (2) 500 mm metre: between 29.6 and 1,213 EUR/Year, (3) Volumetric charge: 133.5 cents/m^3
	Metered household charges: Standing charge + volumetric charge per cubic metre (some water companies also apply some trial water charges, such as tariffs differentiated according to season and rising block tariffs)	Large and intermediate users: Standing charge + volumetric rate	Metered household charges: Standing charge: 35.5 EUR/year and Volumetric charge: 132.6 cents/m^3	
Scotland	Fixed rate (depending on Council Tax Band)	Fixed plus volumetric rate. Rates depend on size of the meter	Unmetered charges range from GBP 121.44 to GBP 364.32 per year, depending on Council Tax Band. Assuming an average consumption of 100 m^3 per household, this means EUR 1.51 to EUR 4.52 per cubic metre (unweighted average: EUR 3.02 per cubic metre).	For large users (meter size > 20 mm), the volumetric rate is GBP 0.7761 (EUR 0.96) per cubic metre
Netherlands	Mostly fixed rate per connection plus variable rate per cubic metre (no block tariffs)	Fixed + variable, or capacity tariff	EUR 1.43 (2010, net of taxes)	EUR 1.05 (2010, net of taxes)
France	Water tariff depends on the water volume consumed. For most municipalities, there is also a fixed part (all-in-price)	Water tariff depends on the type of water (drinking water, filtered water, etc,) the provider (public	EUR 1.55 (in 2009)	

		service, a specialised company, the industry by its own, etc,) and the volume		
Germany	Volumetric price and basic fee	Volumetric price and basic fee	1.65 EUR/m^3 , 65.60 EUR/Year	Industrial customers using 7,500 m^3 to 100,000 m^3 per year paid on average 1.73 EUR/m^3 in 2012
Slovenia	Mixed rate: fixed rate per connection plus variable rate per cubic metre Simple variable rate: variable rate per cubic metre	Mixed rate: same as household Simple variable rate: same as household	Between EUR 0.19 and EUR 1.48	Between EUR 0.19 and EUR 1.48
Spain	Varies according to location. The application of progressive tariffs (increasing block tariffs (IBT) is common in many urban areas of Spain. For instance, in the city of Barcelona, water supply services are managed using a hybrid model which encompasses a flat rate (service fee) coupled with increasing block rates	Similar pricing structure to that of the household sector Example: City of Barcelona	Spain: 0.85EUR/m^3; Catalonia: 1.14EUR/m^3;Barcelona(province): 1.18EUR/m^3	Spain:1.12EUR/m^3; Catalonia: 1.66EUR/m^3; Barcelona(province): 1.34EUR/m^3

Table 15.4: Tariff Structures and Average Rates for Drinking Water in Household and Industry

Sewage and Wastewater Treatment Tariff Structures and Average Rates in Household and Industry				
	Tariff structure		**Average rates (Eur/m^3)**	
	Household	**Industry**	**Household**	**Industry**
England and Wales	Unmetered household charges: Fixed charge + charge based on the rateable value of the house	Large user tariffs for foul sewage: A fixed charge + a standard volumetric rate for foul sewage discharged up to the threshold value for the tariff + a lower than standard volumetric rate for foul sewage discharged over the threshold value for the tariff (tariffs include charges for surface water drainage and highways drainage)	Unmetered household charges: Fixed charge: 42.3 EUR/year Charge based on the rateable value of the house: 133.5 cents/EUR	Standard charges for wastewater: (example): Standing charge- possible ranges as applied by all different companies: (1) 12mm meter: between 14 and 115.9 EUR/Year; (2) 500 mm metre: between 59.28 and 16,951.02 EUR/Year; (3) Volumetric charge: 153.3 cents/m^3
	Metered household charges: Standing charge+ volumetric charge per cubic metre	Trade effluent charges: Charges are based on the Mogden formula = fixed element + variable element based on the actual flow and loads discharged	Metered household charges: Standing charge: 75.3 EUR/year Volumetric charge: 160.3 cents/m^3	
		Infrastructure Charges: Fixed annual charge		
Scotland	Fixed rate (depending on Council Tax Band)	Fixed and volumetric rate. Rates depend on size of the meter	Unmetered charges range from GBP 140.94 to GBP 422.82 per year, depending on Council Tax Band. Assuming an average consumption of 100 m^3 per household, this means EUR 1.75 to EUR 5.25 per cubic metre (unweighted average: EUR 3.50 per cubic metre)	For large users (meter size > 20 mm), the volumetric rate is GBP 1.3097 (EUR 1.61) per cubic metre
Netherlands	Rates depend on household size (for sewage charge it differs by municipality)	Purification charge	EUR 310 per household (sewage charge plus purification charge) (given an average household use of 104.5 m^3, this means EUR 2.97 per cubic metre drinking water)	EUR 52.05 per pollution unit (2010) (this is the weighted average of the rates charged by all 26 water boards)

France	Wastewater treatment tariff depends on the wastewater volume. For most of the municipalities, there is also a fixed part (all-in-price)	Tariff depends on the volume of wastewater and on its quality (amount of pollutants, etc.)	EUR 1.54 (in 2009)	
Germany	Basic charge, unitary fee and fee for land area		EUR 2.36 (approx. 92 % of municipalities collect a volumetric charge)	
Slovenia	Mixed rate: fixed rate per connection plus variable rate per cubic metre. Simple variable rate: variable rate per cubic metre		Between EUR 0.089 and EUR 2.405	Between EUR 0.129 and EUR 2.436
Spain	Sewage charges are not always linked to levels of consumption. However, the tariff structure commonly comprises fixed and variable components, similar to the water supply structure. In the water bill, charges for sewage and wastewater treatment are commonly disaggregated from each other and from supply charges		Sanitation (sewage + wastewater treatment) Spain: 0.56 EUR/m^3 Catalonia: 0.72 EUR/m^3	Sanitation (sewage + wastewater treatment) Spain: 0.56 EUR/m^3 Catalonia: 0.84 EUR/m^3

Table 15.5: Sewage and Wastewater Treatment Tariff Structures and Average Rates in Household and Industry

Charges and /or tariffs for Irrigation Water in Selected EU Member States			
Country	**Water Type**	**Type of charge/tariff**	**Amount**
England and Wales	Water provided	No information	
	Water self-provided	Abstraction charge	Fixed annual charge + 0.0286 EUR/m^3
Scotland	Surface and groundwater	Abstraction charge	0.0033 EUR/m^3
Netherlands	Piped water	Water tariff	Fixed charge + 1.05 EUR/m^3
	Surface water	No charges	
	Groundwater	Abstraction charge	0.014 EUR/M3 (average, ranging from 0.008 to 0.025 EUR/m^3)
France	Water provided	Water tariff - Loire-Bretagne RBD	All-in-tariff: 0.09 EUR/m^3 ; Dual tariff (surface + volume): 81 EUR/ha = 0.06 EUR/m^3 ;Dual tariff (discharge + volume): 38 EUR/m^3/ha + 0.06 EUR/m^3
		Water tariff - Adour-Garonne RBD (C)	157 EUR/HA + 0.082 EUR/m^3
	Self-provision- surface water	Abstraction charge	In ZER* between 0.0015 and 0.03 EUR/m^3; Outside ZER: between 0.001 and 0.02 EUR/m^3
	Self-provision-groundwater	Abstraction charge	Between 0.002 and 0.003 EUR/m^3
Germany	Water provided	Water tariffs	Information not available
	Self-provision-surface water	Abstraction charge	0.005 EUR/m^3
	Self-provision-groundwater	Abstraction charge	0.025 EUR/m^3
Slovenia	Self-provision	Abstraction charge	0.0013 EUR/m^3
Spain	Water provided(Guadalquivir RBD)	Water tariff - Volumetric Charge	0.026 EUR/m^3
		Water fee -Flat rate	62.71 EUR/ha
Cyprus	Water provided	Water tariff	0.15-0.17 EUR/m^3
Greece	Water provided	Volumetric water tariff	0.02-0.07 EUR/m^3
		Water fee -Flat rate	73-210 EUR/ha
Italy	Water provided	Volumetric water tariff	0.04 -0.25 EUR/m^3
		Water fee -Flat rate	30-150 EUR/ha
Portugal	Water provided	Volumetric water tariff	0.002 EUR/m^3
		Water fee -Flat rate	120 EUR/ha

** ZER stands for zone de repartition des eaux, i.e. an area with inadequate water availability with respect to water needs*

Table 15.6: Charges and /or tariffs for Irrigation Water in Selected EU Member States