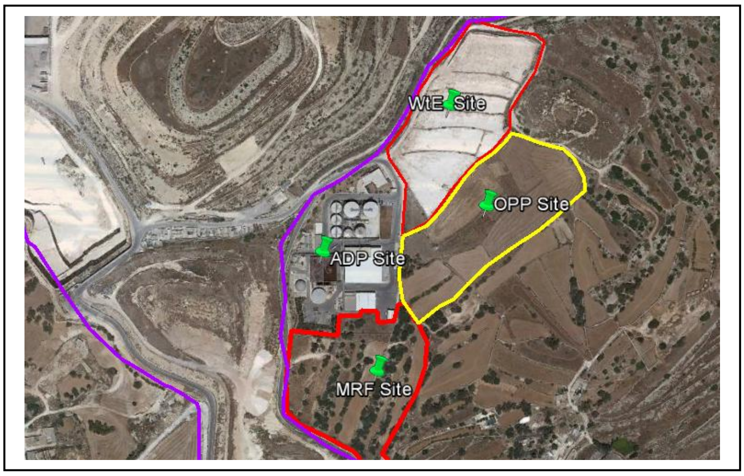
Environmental Impact Assessment

EA/00042/20:

Construction of a Material Recovery Facility (MRF)

at the Ecohive Complex,

Geology and Hydrology



Report Produced

by

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1.0 Introduction

1.1 The Waste Management Plan (WMP) for the Maltese Islands

The Waste Management Plan (WMP) for the Maltese Islands, 2021-2030, set out various measures to support more sustainable waste management systems in line with the objectives of the Circular Economy Package.

An essential sector of this circular economy is the construction of a Materials Recovery Facility (MRF) for the treatment of source-separated and co-mingled dry recyclables collected in Malta. The proposed development will form part of the ECOHIVE Complex and will operate in conjunction with the other waste management facilities at Magħtab (Figure 1).

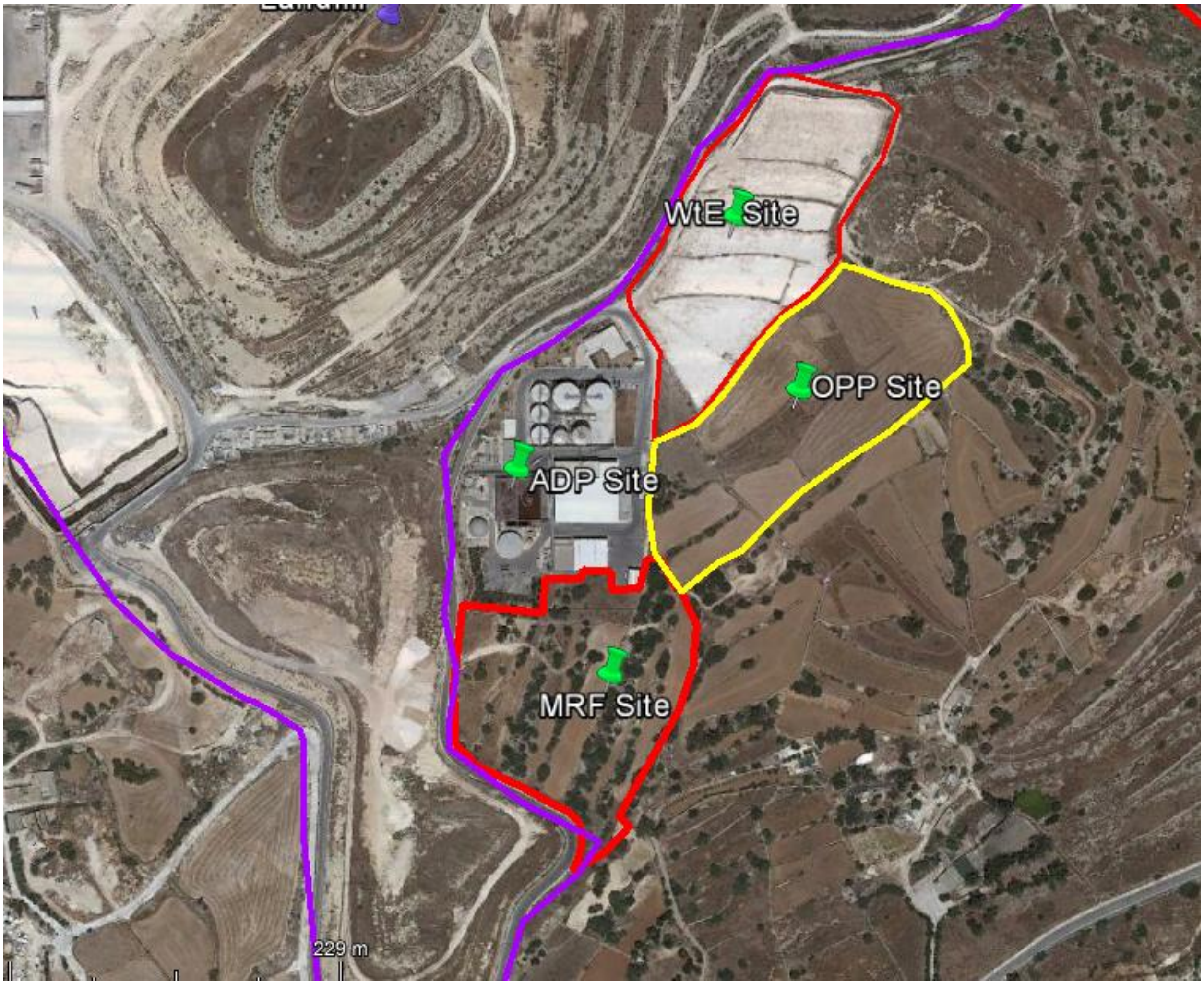


Figure 1: Location of the site (MRF Facility at Maghtab forming part of the EcoHive Complex)

Separated recyclable waste streams including paper, cardboard, plastics and metals were previously being received and processed at a Material Recovery Facility at the Sant' Antnin Solid Waste Treatment Plant in Marsascala. This MRF operated between February 2008 and May 2017 but was destroyed during a fire. In the absence of such a facility, processing of the aforementioned waste streams has been restricted to a manual sorting line. The Scheme is being proposed to manage such waste so as to meet the provisions of Malta's Waste Management Plan and achieve recovery and recycling targets stipulated in the Circular Economy Package.

The WMP 2021-2030 seeks to reduce the landfilling rate via the development of a Materials Recovery Facility amongst other facilities. Moreover, the MRF will contribute to reduce the proportion of waste that is being landfilled.

The adjacent waste management facilities forming part of the ECOHIVE Complex, include (see Figure 1):

- The Civic Amenity site,
- The Zwejra and Maghtab landfills;
- The Malta North Waste Treatment Plant
- The Anaerobic Digestion Plant (ADP)
- The Materials Recycling Facility (MRF) and
- The upcoming:
    - Waste-to-Energy Facility (WtE)
    - The Organic Processing Plant (OPP)
    - Thermal Treatment Facility (TTF)

1.2 Current receptors

The current receptors within the "Area of influence" of the proposed MRF Plant are:

- The adjacent waste management facilities forming part of the ECOHIVE Complex, including the Civic Amenity site, the Malta North Waste Treatment Plant, and the Zwejra and Maghtab landfills;
- Maghtab, and various residences to the west and the south;
- A private waste management facility to the south;
- Natural habitats in the vicinity of the Maghtab landfill that have been studied as part of previous Environmental Impact Assessments;
- Small farmhouses and ancillary buildings, including an adjacent cow farm;
- Roads, including access roads to the ECOHIVE Complex to the south, and the Coast Road to the east.

The Areas in the environs of the MRF site include the surrounding undeveloped areas, natural areas, mainly coastal steppe, and bare rock with limited pockets of maquis vegetation. Other areas are either disturbed land, or agricultural fields.

1.3 Natura 2000 Sites

The MRF site is surrounded by the following Natura 2000 sites:

- Zona fil-Baħar bejn il-Ponta ta' San Dimitri (Għawdex) u Il-Qaliet (MT 0000105) designated as an SCI (Site of Community Interest of international importance) via GN No. 682 of 2018, in accordance with the Flora, Fauna and Natural Habitats Protection Regulations, 2016 (S.L. 549.44), in a direct distance of approximately 0.5 km
- Is-Salini (MT 0000007) designated as an SAC (Special Area of Conservation) via GN No. 1379 of 2016, in accordance with the Flora, Fauna and Natural Habitats Protection Regulations, 2016 (S.L. 549.44), in a direct distance of approximately 1.7 km

- L-Għadira s-Safra (MT 0000008) designated as an SAC via GN No. 1373 of 2016, in accordance with the Flora, Fauna and Natural Habitats Protection Regulations, 2016 (S.L. 549.44)., in a direct distance of approximately 900m.

1.4 This Report

This Report represents the study on Geology, Geomorphology, hydrology, hydrogeology and Soils, to fulfil the Terms of Reference issued by ERA, in relation to the Environmental Impact Assessment (EIA) for the proposed construction of the Materials Recovery Facility (MRF) at Maghtab (see Figure 1).

2.0 Project Description

2.1 Size and extent of the Scheme

The Scheme covers a total area of 21,373m^2 and involves the development of a Materials Recovery Facility (MRF) for the treatment of source-separated and co-mingled dry recyclables collected in Malta.

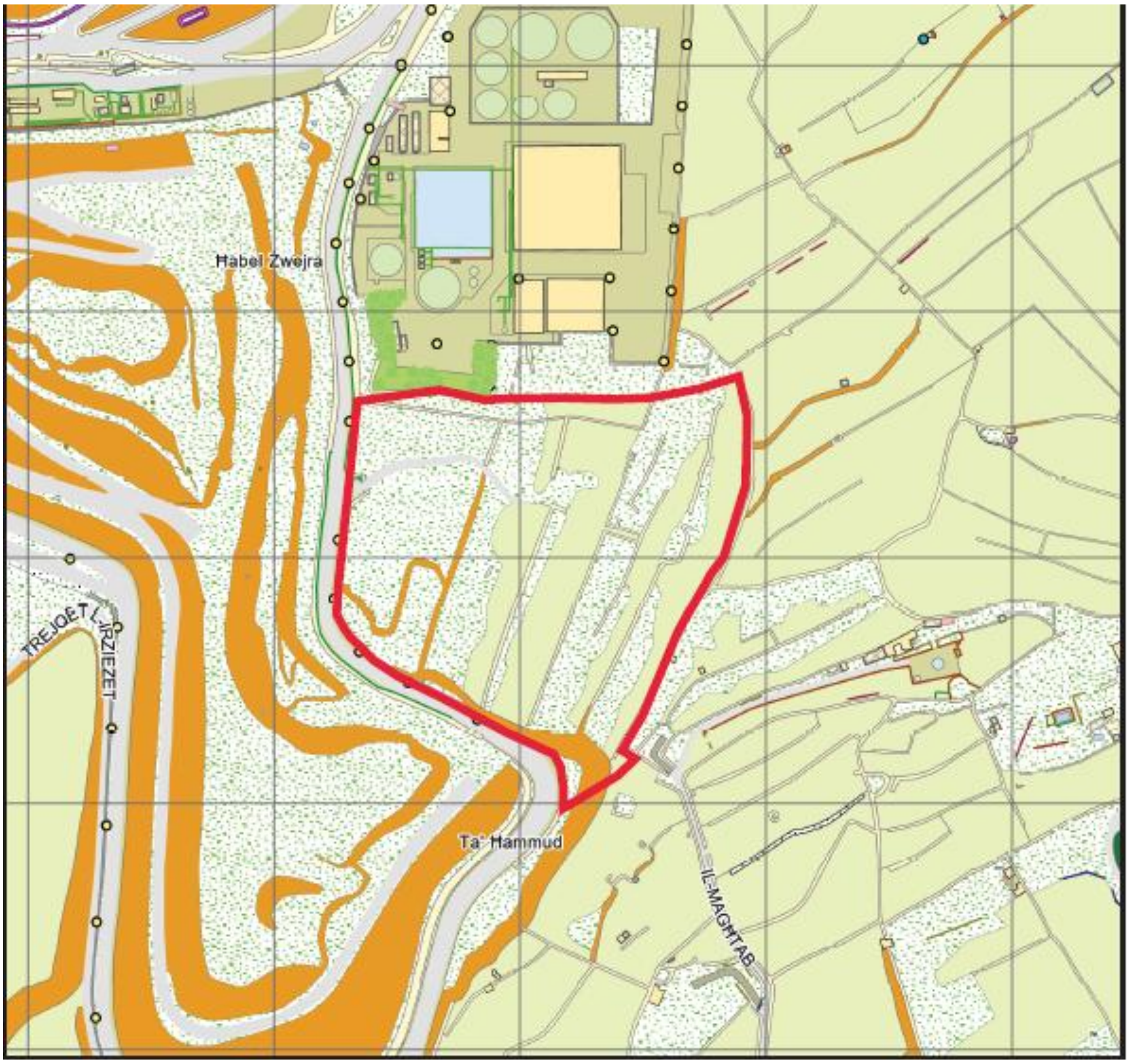


Figure 2: Survey Sheet (Part) showing the site being proposed for the MRF (Source PA)

The recyclables will be collected in two separate streams – fibre (cardboard, paper, magazines) and containers (plastic bottles, pots, tubs, trays, metal cans, plastic film, beverage containers). Glass will not be processed at the MRF.

The public is informed on household waste separation through campaigns by WasteServ Malta, instructing what is to be disposed of in the black (mixed municipal solid waste) and grey/green (mixed recyclables) bags.

The total processing capacity of the MRF plant is 70,000 tonnes per annum; 40,000 tonnes per annum for fibre and 30,000 tonnes per annum for container. The total processing capacity is more than double the amount that has been treated for recycling in the past, in a given year from 2016 to 2020.

Dock levellers will be used to load container and curtain side vehicles with limited lifting required. Input material will be loaded into the plant using loading shovels and a 360 excavator or material handler. Waste containing residue and mixed scrap metal will be partially segregated through a pre-sort cabin to filter out metal waste.

Two dust extractor systems will be installed in the processing area and will employ various modes of filtration systems (dry, wet, etc.) to prevent release of dust to the environment. The facility will be equipped with a generator, switch room and Heating, Ventilation, and Air Conditioning (HVAC) in welfare facilities and possibly in other areas.

Safety and maintenance strategy is envisaged to be planned, preventative and lean reliability centred. The design of the Scheme aims to achieve best practice above and beyond minimum standards. Full access to all areas of the Scheme is opted for to minimise downtime. The design life of the plant and buildings is to be based on 20 years. The Scheme will be required to operate independently from the other operations on site. All MRF functions will be located in a single covered building with appropriate fire compartmentalisation.

2.2 Construction Phase

2.2.1 Number of Employees

It is estimated that 30 to 40 persons will be required to construct the proposed Scheme, although this will depend on how the Construction Management Plan is set out by the winning works contractor.

2.2.2 Phasing

The construction target date for the Scheme is still tentative but the overall construction phase is anticipated to take up to 19 months as per contract. The construction of the Scheme is divided into phases, as listed below:

- **Phase 1**: The site will undergo preparation, hoarding will be added around the site, the vegetation within the area will be removed or redistributed, loose material will be cleared and excavation works will begin.
- **Phase 2:** Following Phase 1, the foundation will be set out and lower-level walls will be constructed at various points.
- **Phase 3:** Phase 3 involves further excavation and movement of backfill to be utilised to relevant areas. Moreover, engineering works of site with backfilling up to the relevant area will take place. Any backfill which will not be utilised will be removed from the site and will be subsequently landfilled.
- **Phase 4:** The next phase involves formalisation of landscaped areas with transplanted elements, inclusive of further hoarding.
- **Phase 5**: The area will then be landscaped with transplanted vegetation and a foundation will be constructed at various levels. The recommended species for transplanting are *Ceratonia siliqua* (Carob) and *Olea europaea* (Olive). Transplanting may also be feasible for *Pistacia lentiscus* (Lentisk).
- **Phase 6:** Construction phase of the proposed Scheme will commence in Phase 6.
- **Phase 7**: Commissioning of the proposed Scheme will take place prior to the operational phase.

2.3 Waste Output

According to Table 1 the waste material produced during the excavation phases of the proposed Scheme shall be about 51,500 m^3.

Table 1: Volumes of excavated material and backfilling

Work	Unit	Volume
Total excavation	m^3	-51,462.87
Backfilling to projected Ground Level	m^3	21,576.68
Net cut/fill	m^3	-29,886.19

3.0 A Description of the Site and its Surroundings

3.1 Location of the site

The project will take place wholly within the borders designated for the MRF facility (Figure 3) which has an approximate area of 21,373m^2. The Facility presently consists of fallow agricultural land subdivided into terraced fields bounded by rubble walls. At the time of writing this report, the terraced fields have been partly stripped of the soil cover (Figure 4 to Figure 7) for the archaeological study.

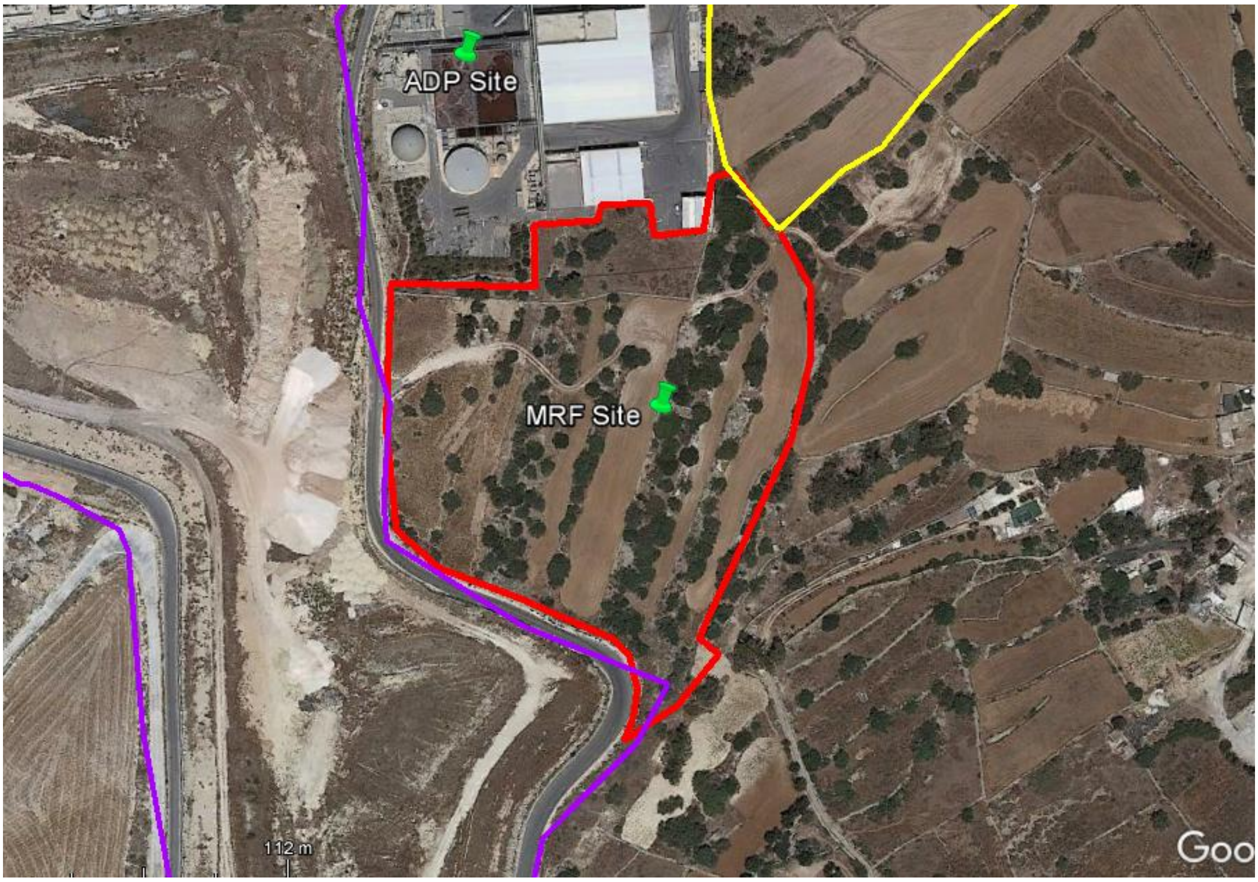


Figure 3: Google image showing approximate boundary of the site, presently made up of terraced fields. The plant in the north is the Anaerobic Digestion Facility (Source: Google Earth)

Figure 4: Photograph showing the present conditions at the west segment of the site as seen from the south, originally parcelled into terraced fields now being stripped of topsoil for the archaeological studies

Figure 5: Another Photograph showing the present conditions at the central sector of the site

Figure 6: Photograph showing the conditions of the east sector of the MRF site. Wall on the centre-left of the photograph marks the eastern margin of the site

Figure 7: Photograph showing freshly laid landfill on the boundary road marking the west margin of the site

To the north the boundary of the site is marked by the Anaerobic Digestion Plant which is nearing completion while to the west the site is bounded by the perimeter road and freshly laid landfill material (Figure 8).

Outside the landfill complex, the site and the surrounding land is a rounded hillslope which extends to the Bahar ic-Caghaq and Ghallis shoreline. Away From the landfill which covers an area of about 500,000m^2, land use is practically dictated by the geology which here is represented by Lower Globigerina Limestone and Lower Coralline Limestone. Lower Globigerina Limestone usually yields a soil layer and for this reason the area covered by this rock is terraced agricultural land. The remaining corridor extending to the coastline which is covered by Lower Coralline Limestone is represented by limestone Xaghra -that is bare rock. Lower Coralline Limestone is a pure limestone and does not usually produce a soil cover.

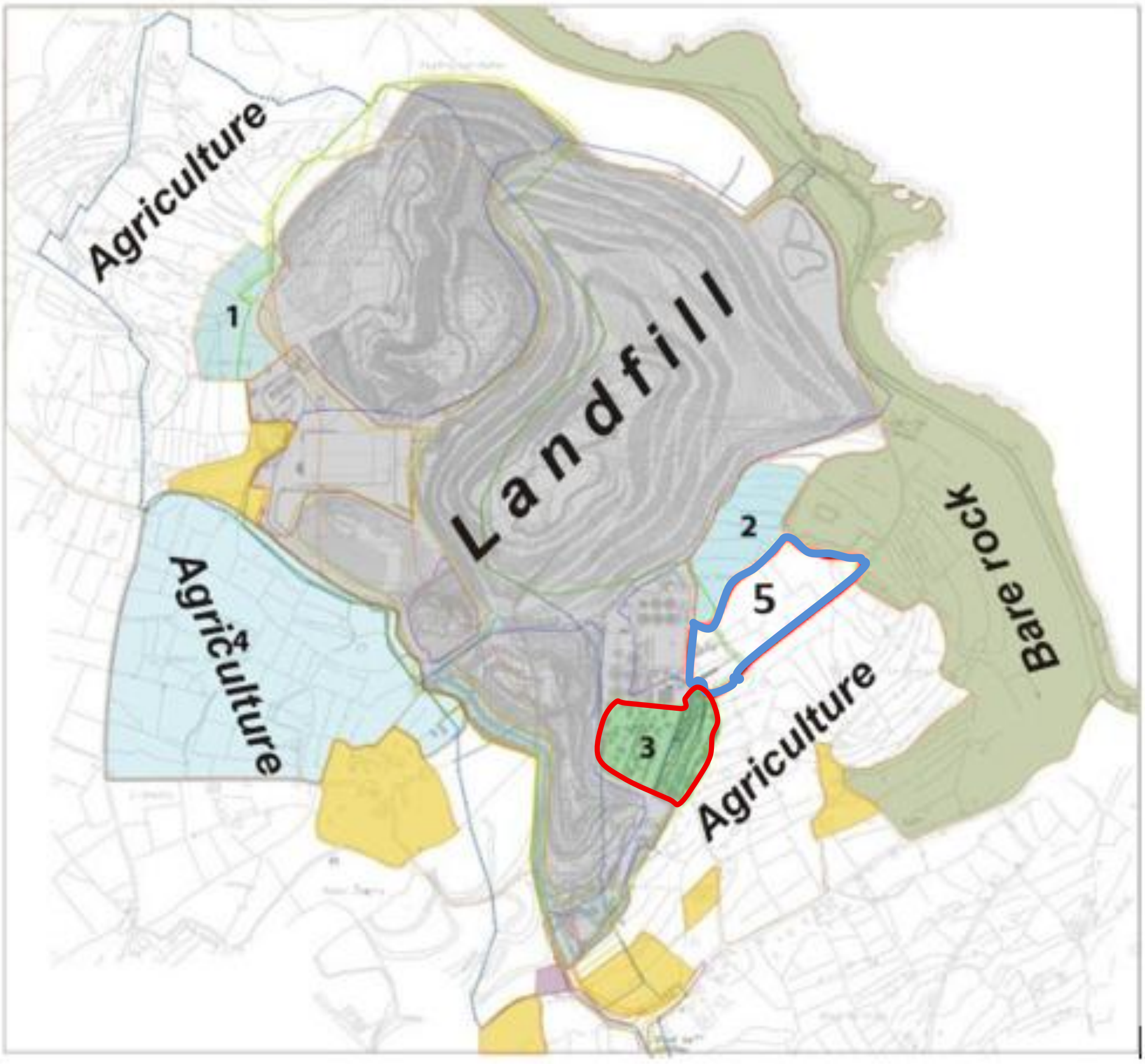


Figure 8: Land Use in the environs of the Maghtab Landfill. The proposed MRF site is labelled No 3 in green.

4.0 Terms of reference

4.1 A Description of the Site and its Surroundings (i.e. Environmental Baseline)

3.3 Geology, Geomorphology, Hydrogeology, and Soils

A comprehensive investigation of:
1. The geology and geomorphology of the site and its surroundings, including:
(i) existing geology, stratigraphy, structure, lithology, physiography and geomorphology features;
(ii) palaeontological features;
(iii) hydrogeological features; and
(iv) soil types.

Each feature shall be listed in a table, together with a short description and if any of the features are absent, this shall be stated. A scaled map, clearly depicting the feature occurrence within the area of influence, shall also be provided.
2. The geo-technical properties and considerations relevant to the site and its area of influence, including:
(i) land stability;
(ii) mechanical, erosional and structural properties of the terrain and land mass;
(iii) any relevant fissures, faults, hollows, or weak points;
(iv) the vulnerability of the site to natural forces such as wave action, erosive elements, landslides and mass movements; and
(v) any other considerations affecting the implications and risks posed by the proposed development or by any of its ancillary interventions such as site clearance, earth-moving, and excavations.

Each of the above shall be listed in a table along with a short description and if any of the features are absent, this shall be stated. A scaled map, clearly depicting the feature occurrence within the area of influence, shall also be provided.

3. The quality of the material that will be excavated (including soil, rock/mineral resource, and any existing fill material) and its potential for reuse.

4. The nature of the material to be excavated is to be adequately determined (i.e. whether it is contaminated and hazardous) prior to its management and disposal (guidance can be found in ERA's website: https://era.org.mt/topic/land-groundwater-investigation-waste-procedure/).

5. Sampling and testing should comply with the relevant standards (unless otherwise agreed, BS standards or other recognised equivalents should be used), and should extend to a sufficient depth below the deepest level of the proposed development (taking into consideration all proposed excavations and underground structures). Wherever the study involves the drilling of core samples, the number, depth and location thereof should also be submitted for ERA approval prior to carrying out of any in situ tests.

4.0 ASSESSMENT OF ENVIRONMENTAL IMPACTS AND ENVIRONMENTAL RISKS

All likely significant effects and risks posed by the proposed project on the environment during all relevant phases (including construction/excavation/demolition, operation and decommissioning) should be assessed in detail, taking into account the information emerging from Sections 1, 2 and 3 above. Apart from considering the project on its own merits (i.e. if taken in isolation), the assessment should also take into account the wider surrounding context and should consider the limitations and effects that the surrounding environmental constraints, features and dynamics may exert on the proposed development, thereby identifying any incompatibilities, conflicts, interferences or other relevant implications that may arise if the project is implemented.

4.1 Effects on the environmental aspects identified in Section 3

The assessment should thoroughly identify and evaluate the impacts and implications of the project on all the relevant environmental aspects identified in Section 3 above, also taking into account the various considerations outlined in the respective sections.
With regards to Section 3.4 and 3.5 above, the ecological status of the area in question is to be evaluated, taking into consideration the definition of status by relevant EU Policy, and assessing the extent to which the project will cause deterioration in status or compromise the achievement of good status in line with Article 4(7) of the EU Water Framework Directive.

4.3 Environmental risk

The assessment should also address, in sufficient detail, any relevant environmental risk (including major-accident scenarios such as contamination, emissions, explosions, blast, flooding, major spillages, etc.) likely to result in environmental damage or deterioration. The range of accident scenarios considered should exhaustively cover, as relevant:
1. one-time risks (e.g. during construction or decommissioning works);
2. recurrent risks during project operation; and
3. risks associated with extreme events (e.g. effect of earthquakes or natural disasters on the project).

The assessment should include, as relevant: a quantification of the risk magnitude and probability; and risk analysis vis-à-vis any hazardous materials stored, handled, or generated on site or transported to/from the site.

5.1 Mitigation Measures

A clear identification and explanation of the measures envisaged to prevent, eliminate, reduce or offset (as relevant) the identified significant adverse effects of the project during all relevant phases including construction, operation and decommissioning [see ***Section 1.2.3*** *above].*

5.2 Residual Impacts

Any residual impacts [i.e. impacts that cannot be effectively mitigated, or can only be partly mitigated, or which are expected to remain or recur again following exhaustive implementation of mitigation measures] should also be clearly identified.

5.3 Additional Measures

Compensatory measures (i.e. measures intended to offset, in whole or in part, the residual impacts) should also be identified, as reasonably relevant. Such measures should be not considered as an acceptable substitute to impact avoidance or mitigation.

Important features close to or below the site are:

- The mean sea level aquifer
- Areas designated as Special Area of Conservation as per Habitats Directive (94/43/EEC):
  - The adjacent marine areas Zona fil-Bahar fil-Grigal ta Malta;
  - L-Ghadira s-Safra has been designated as Special Area of Conservation. It lies at 650m from the site at its closest;

5.0 Methodology

5.1 Area of Influence

5.1.1 Geology, Geomorphology and soils

The area of influence for the geological and soils study shall be restricted to the site while the geomorphological study shall extend to a radius of about 500m to 600m from the site (Figure 9) to include the coastline.

5.1.2 Hydrology and Hydrogeology

The area of influence for the hydrology and hydrogeology study shall be the downstream part of the catchment of the site. There is no well-defined watercourse and the run-off generated on the Maghtab – Ghallis slopes will be discharged down the Ghallis slopes to Wied ta' Kieli as well as along the coastline in a diffuse manner (Figure 10).

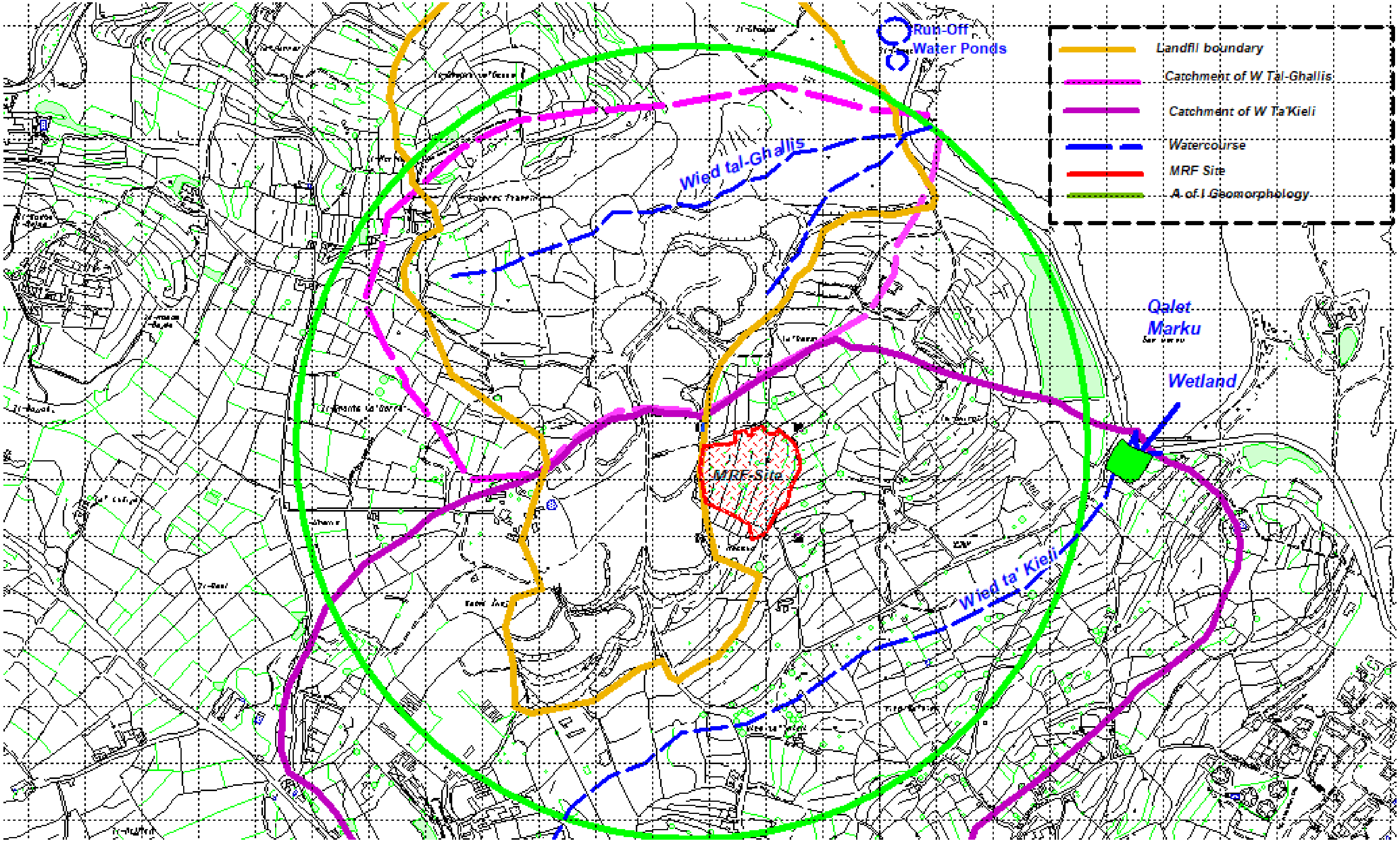


Figure 9: Map of the site and its environs showing area of influence for geomorphology. A of I for geology and soils is limited to the site. A of I for geomorphology is represented by the green circle

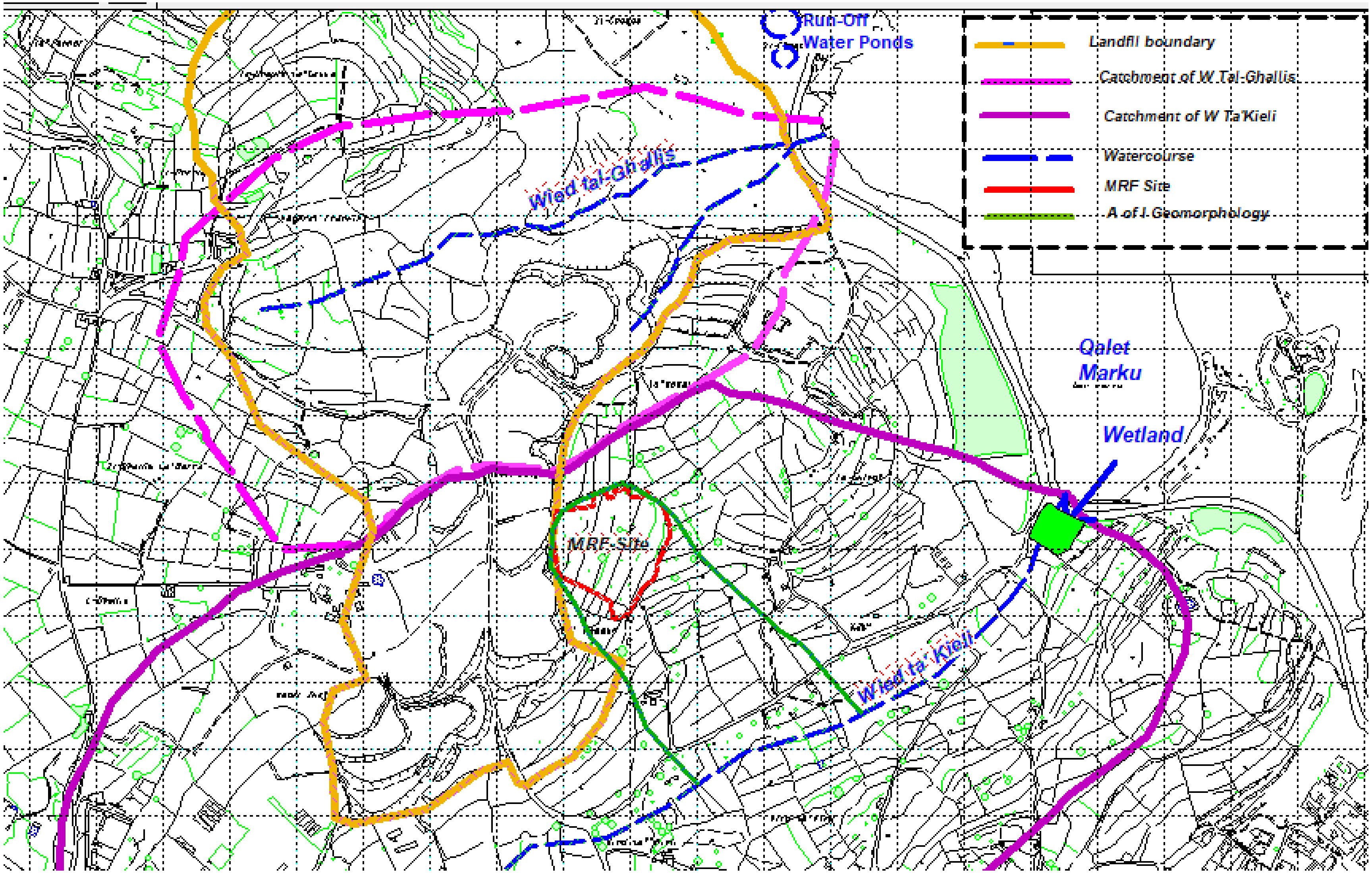


Figure 10: Survey sheet (part showing the Area of Influence for Hydrology -The Area downstream of the MRF Site-(For scale each grid square measures 100m by 100m)

5.2 Literature search

Previous studies in connection with the construction of the Coast Road next to the site were consulted especially with regards to the protected areas.

5.3 Geology, geomorphology and soils

A field survey was undertaken to determine the geology, geomorphology and soils of the site. For the geomorphological Study Area the geology shall be taken from the Geological Map of the Maltese Islands (Continental Shelf Department, 2022)

5.4 Hydrology and Hydrogeology

The catchment downstream of the site was drawn on a survey sheet during the desk study and subsequently controlled in the field during the field survey undertaken to map the hydrological features present in the area of influence for hydrology.

5.5 Geotechnical investigation for rock properties and reuse-including fissures faults and solution features and land stability.

In addition to the field survey, it is being proposed to use the exhaustive subsurface ground investigation undertaken in 2020 in connection with the construction of the Waste to Energy Facility, located in the vicinity of the site, for the proposed MRF facility (**Figure 11**).

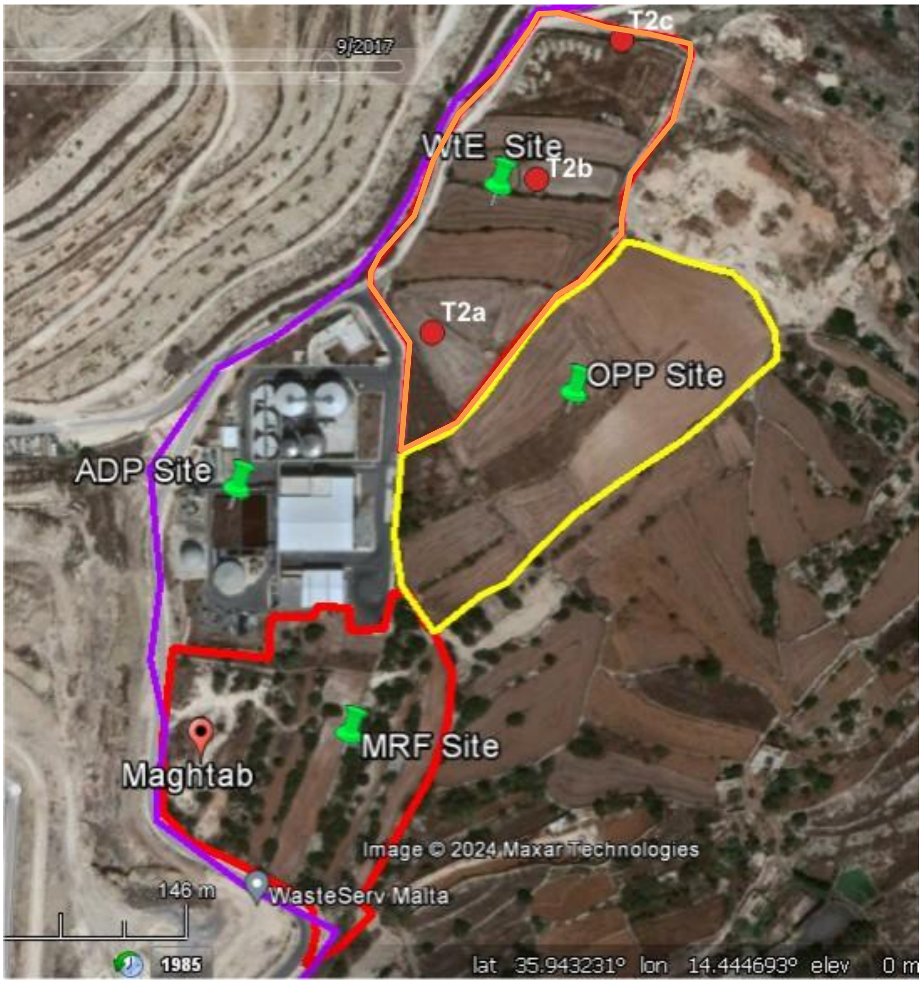


Figure 11: Plan showing the location of the boreholes drilled by continuous rock core sampling for the EIA for the WtE Facility.

The results of this ground investigation are considered valid for the proposed Materials Recovery Facility for the following reasons:

- The site for the MRF facility is very close to the WTE facility;
- The depth of the excavation for the MRF Facility is under 10m below ground level, while the depth of the holes drilled for the WTE Facility were 30m deep. They were drilled by continuous rock core sampling;
- The rock properties for Lower Globigerina Limestone do not change substantially over a such a short distance;
- The soil type present is similar to that of the WTE facility and the thickness of the overburden is therefore expected to be similar. This shall be verified during the field survey.
- Likewise, the rock unit present shall be verified during the field geological survey.

5.5.1 *The nature of the material to be excavated-Hazardous and /or Contaminated*

5.5.1.1 Past studies

An exhaustive chemical study of the nature of the material to be excavated, whether it is contaminated/hazardous or not, has already been undertaken in connection with the construction of the WtE Facility located next to the site. During this investigation a total of 30 samples, collected from 5 boreholes each 30m deep have been tested and none were revealed to be hazardous or contaminated. The 5 Borehole tested were BHT1B, BHT1C, BHT1D, BHT2A and BHT2B (**Figure 11**).

5.5.1.2 New Investigation at the MRF site

A reduced sampling effort at the MRF site, undertaken in December 2023, entailed sampling from four separate locations which represent the site's spatial extent and the degree of excavation proposed within it (**Figure 12**). Continuous core recovery and drilling with auger were carried out for land contamination testing at the four sampling boreholes.

Details of the proposed volume of material to be excavated are shown in Table 3.

Figure 12 and Table 4 indicate the proposed soil and rock sampling methodology to recover soil and rock samples for chemical analyses.

Table 2: Details of the proposed site excavation

Area Code	Projected Areas	Volume to be excavated (Cut)	Average Depth of excavation
A	3,111 m2	3,877.34m3	1.25m
B	3,364 m2	104.83 m3	0.03m
C	200 m2	0.00 m3	0.00m
D	2,535 m2	15,040.91 m3	5.94m
E	2,244 m2	7712.15 m3	3.44m
F	4,003 m2	20,968.74 m3	5.24m
G	557 m2	0.00 m3	0.00m
H	738 m2	0.00 m3	0.00m
J	1,289 m2	3,738.05 m3	2.90m
K	1,139 m2	0.00 m3	0.00m

L	6,855 m2	20.86 m3	0.01m

Figure 12: Map of the MRF site showing the location of the boreholes- at Area A, Area D, Area F and Area J

Depending on the proposed excavation a maximum of three in number (3) Soil and rock samples were collected from each location at the following depths:

- Sample No 1: <0.5m
- Sample No 2: at 1.5m /2.5m
- Sample No 3: 5.5m

From Areas A, D, F and J (Table 4).

Table 3: Soil and rock sampling protocol at the MRF site undertaken in December 2023

Area	Depth 1 (S)	Depth 2 (M)	Depth 3 (D)	No of Samples	Profile 2	Profile 3
Area A (A1)	<0.5m	1.5m	NA	2	2x 500g PET jar	1x 500g PET jar 2x 500g glass jar 2x Vials – fill only 1/10 of the capacity volume
Area D (D1)	<0.5m	2.5m	5.5m	2	2x 500g PET jar	1x 500g PET jar 2x 500g glass jar 2x Vials – fill only 1/10 of the capacity volume
Area F (F1)	<0.5m	2.5m	5.5m	2	2x 500g PET jar	1x 500g PET jar 2x 500g glass jar 2x Vials – fill only 1/10 of the capacity volume
Area J (J1)	<0.5m	2.5m	5.5m	2	2x 500g PET jar	1x 500g PET jar 2x 500g glass jar 2x Vials – fill only 1/10 of the capacity volume

Samples were taken at Area A, Area D, Area F and Area J since they represented the site's spatial extremities and the areas where significant excavation has been proposed to accommodate the scheme site. Area E, which encompasses an area of significant excavation (3.44m), has been scoped out from the sampling strategy due to the homogeneity of the site and because it lies in close proximity to Areas F and D. Consequently, the fate of the material to be excavated from Area E was determined by the results obtained from the samples taken at Area D.

The results of the chemical analyses were compared with the threshold levels recommended by the Italian: "**DECRETO LEGISLATIVO 3 aprile 2006, n. 152** Norme in materia ambientale. (GU Serie Generale n.88 del 14-04-2006 - Suppl. Ordinario n. 96)" also adopted by ERA for the local site contamination studies.

5.6 Standards and guidance

Geotechnical investigation undertaken in 2023 was in accordance to:

- BS 5930: 2015; Code of practice for geological site investigations;
- BS-EN 1997:2004 Geotechnical design- PART 1 General rules;
- BS EN 1997 - 2: 2007 Geotechnical Design – Part 2: Ground investigation and testing
- Uniaxial compressive strength tests shall be under taken were done according to BS 5930 and ISRM suggested methods.
- Chemical analysis for waste characterisation and water shall be as discussed above.

5.6.1 Standards and guidance EU Directives- Hydrology and Hydrogeology

Guidance shall be provided by:

- The Water Framework Directive
- Marine Strategy Framework Directive and related instruments
- Standards related to chemical analysis of groundwater and seawater
- Standards related to waste classification outline in Appendix 2 of the ERA terms of reference.
- "DECRETO LEGISLATIVO 3 aprile 2006, n. 152 Norme in materia ambientale. (GU Serie Generale n.88 del 14-04-2006 - Suppl. Ordinario n. 96)"

5.6.2 Strategic Plan for the Environment and Development (SPED)

The SPED replaces the previous Structure Plan (which was published in 1990 and adopted in 1992). The new Strategic Plan for the Environment and Development (SPED) provides a strategic spatial policy framework for environment and development up to 2020 complementing Government's economic, social and environmental objectives for the same period. The SPED covers the marine waters up to the extent of 25 nautical mile limit of the Fisheries Conservation Zone (adopted by Council Regulation EC No. 1967/2006).

The SPED provides the following guidance in the form of Specific objectives and arising issues listed in (Table 5).

Table 4: SEA Objectives and respective Issues (Strategic Plan for Environment and Development, Statement of adoption July 2015)

Theme	Issues
Biodiversity	Despite the legal protection biodiversity continues to be threatened by land development, invasive alien species, over-exploitation and climate change
Land	The small size of the Islands and high population density result in competing demands for land. There is a tendency towards inefficient use of land through over provision of development
Soil	Arising mainly from increased urbanisation, intensification of agricultural
Mineral resources	Resources Extraction practices lead to wastage of resource
Water resources including marine waters	Pollution and development that alters the hydromorphology of these waters.
Built heritage and archaeological remains	Demolition, inappropriate design and use of new and restored buildings which undermines street character as well as pilferage of underwater heritage remain a threat especially if these are not afforded legal protection.

Cultural landscape and coastal development,	Malta's cultural landscape is threatened by the extent of built up area, industrial taller buildings on urban fringes that obstruct views of historic centres, modern agricultural practices, increased vehicular access, litter, poor standards of design and work, and lack of maintenance.
Air quality	Malta's significant air pollutants are particulates and nitrogen dioxide mainly arising from traffic, industry and energy generation and ozone mainly from transboundary sources.
Noise	Heavy traffic is the main source of ambient noise in the Maltese Islands.
Use of Chemicals	Misuse, poor collection, storage and treatment of chemicals may lead to air, water, and sediment and soil pollution. Pesticides and biocidal products are considered to be of particular concern.
Solid waste management	Malta's solid waste management practice is heavily dependent on landfills with low levels of material recovery. Construction and demolition waste makes up a significant proportion of total solid waste generated and the associated impacts are land take up, pollution and nuisance related to transport and depletion of mineral resources.
Climate change	The Maltese Islands are vulnerable to the predicted impacts of climate change. A decrease in annual precipitation that may lead to episodes of drought, more intensive storm events leading to flooding and predicted changes in global sea levels are likely to affect ecological processes and consequently the socioeconomic activities and infrastructure which depend on them. Energy including transport is the main source of Greenhouse Gas Emissions. Targets for non ETS sector are challenging.

5.6.3 Strategic Environmental Assessment Regulations, 2010 (L.N. 497 of 2010)

These Regulations specify the cases in which a strategic environmental assessment must be carried out of certain plans and programmes which are likely to have significant effects on the environment. The aim is to provide for a high level of protection of the environment and to contribute to the integration of environmental considerations into the preparation and adoption of plans and programmes with a view to promoting sustainable development.

5.6.4 Soil Conservation

Wherever soil deposits will be affected, all planned activities must be in line with:

- Cap 549 Environment Protection Act;
- Cap 236 Fertile Soil Preservation Act;

and also:

- S.L. 236.01 List of Places where Fertile Soil may be deposited Notice; and
- S.L. 236.02 Preservation of Fertile Soil Regulations

The extracted material (soil/rock) shall be additionally examined paleontologically for fossils.

5.6.5 Rubble walls

Rubble walls are protected according to the Rubble Walls and Rural Structures (Conservation and Management) Regulations (S.L. 552.01). Any alteration may disturb the soil deposits the Preservation of Fertile Soil Regulations. (S.L. 362.02).

5.7 Impact Assessment

In terms of geology, geomorphology, hydrogeology, and soils, the geo-environmental impacts of the proposed construction are likely to arise from the excavation and construction of the proposed MRF facility. The impact of changes on the geology and geomorphology as a result of the proposed construction will mostly be restricted to the boundary of the site.

5.7.1 Impact Significance

For each of the identified potential impacts, the following information will be provided:

- Description of impact;
- Policy importance of impact (Local, National, International);
- Extent of effect;
- Duration of impact (temporary / permanent);
- Adverse or beneficial impact;
- Reversible / irreversible impact;
- Sensitivity of receptors;
- Probability of impact occurring (certain, likely, uncertain, unlikely, remote); and
- Scope for mitigation / enhancement (very good, good, none).

Based on the above criteria, a summary of the significance of the impact will be put forward in terms of whether the impact is considered not significant, of minor significance, of moderate significance, or of major significance:

- **Not significant**: little or no change to the geological, geomorphological and hydrogeological regime;
- **Minor significance**: changes to the geological, geomorphological and hydrogeological regime that may affect neighbouring properties but which may be offset by mitigation measures;
- **Moderate Significance:** changed to the geological regime that may be partly offset by mitigation measures (if negative) or may be partly enhanced by mitigation measures (if positive);
- **Major significance**: changes to the geological, geomorphological and hydrological regime that may affect neighbouring properties and which may not be offset by mitigation measures (if negative) or may be enhanced by mitigation measures (if positive).

Any mitigation measures envisaged to prevent, minimise and where possible offset any significant adverse effects on the environment of the project shall be included in the report. Any residual impacts expected following the implementation of the mitigation measures shall be described and quantified. A feasible monitoring programme will also be compiled, for the pre-, during and post-construction phases, including frequency of the proposed monitoring scheme. This monitoring programme will also incorporate measures to be considered during the decommissioning phase of the proposed development, as highlighted in the decommissioning plan that is being requested in the ToRs issued by ERA.

5.8 Output

The field survey results and subsurface investigation shall be presented in the form of:

- A Geological map
- A hydrological map
- Cross-sections
- Geological, Geomorphological, Hydrological and geotechnical Report
- Waste stone/soil material quality and characterisation
- Seawater quality
- Potential impacts and risks and impact Assessment
- Table summarising the impacts and risks of the proposed development.

6.0 Geology

6.1 Stratigraphy

The five Late Tertiary rock formations exposed on the Maltese Islands are, from top to base (Figure 13):

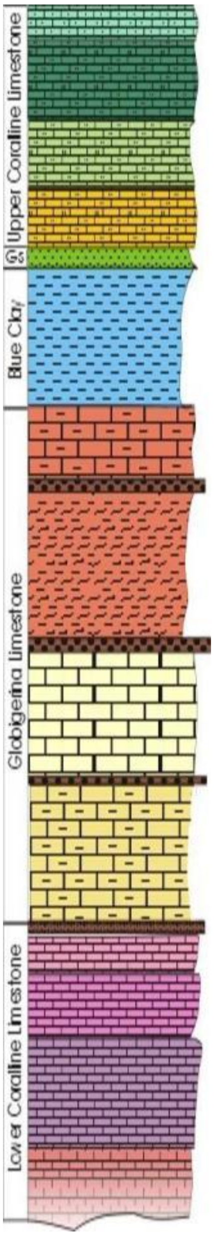


Figure 13:Lithostratigraphic column

- Upper Coralline Limestone Fm (Youngest)
- Greensand Fm
- Blue Clay Fm
- Globigerina Limestone Fm
- Lower Coralline Limestone Fm (youngest)

In addition to these formations, Quaternary continental deposits are also known to occur sporadically on the Maltese Islands. An unconformity and an erosional surface separate this unit from the underlying marine sedimentary succession.

The rock formations preserved in the Study Area are (Figure 14):

- Lower Coralline Limestone Formation
- Globigerina Limestone Formation –Lower Globigerina Limestone Mb

The overlying rock formations: Middle and Upper Globigerina, Blue Clay, Greensand and Upper Coralline Limestone have not been preserved in the Study Area.

At the site the exposed rock units are the Lower Globigerina Limestone Mb underlain by the Xlendi Mb and Attard Mb of the Lower Coralline Limestone Formation.

Some partly lithified red Quaternary slope deposits related to a local fault, have been identified on the hill slope east of the site close to the Coast Road.

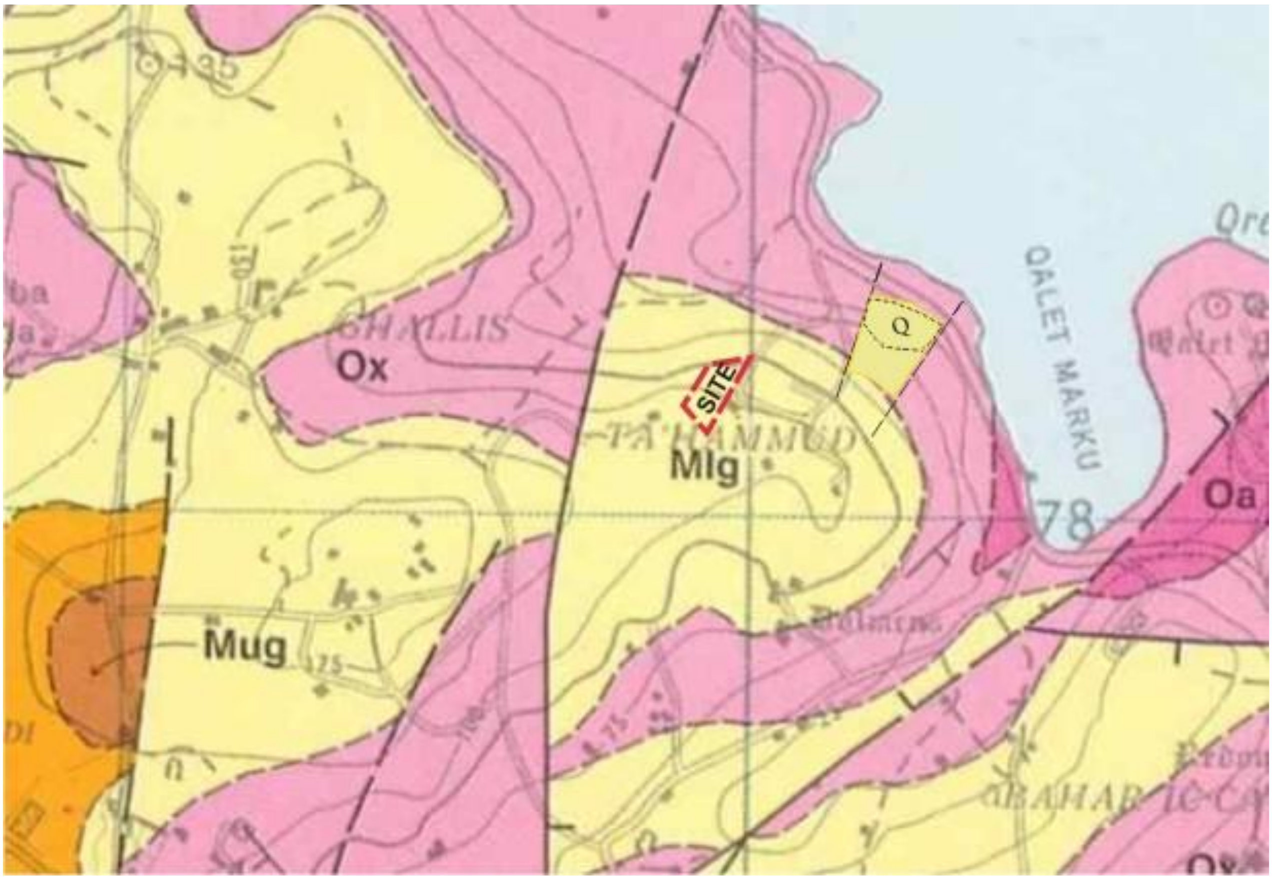


Figure 14: Geological map of Maghtab and il-Ghallis (Modified after OED,1993) Q: Quaternary slope scree; Mlg: Lower Globigerina Limestone Mb; Ox: Lower Coralline Limestone Fm-Xlendi Mb Oa: Attard Mb

6.1.1 Lower Coralline Limestone

As its name implies the Lower Coralline Limestone Formation is the lowermost rock formation exposed on the Maltese Islands. It outcrops some 400m to the east of the site.

The formation is known to be over 140m thick. Although the base of the formation is taken at sea level, it extends lower down below sea level. The contact with the overlying Globigerina Limestone Formation is sharp and is represented by a hard ground. This is best seen at about 1000m away from the site, along the Coast Road.

The Maltese name is Zonqor or Blat tal-Qawwi usually further classified as: First quality tal-Prima and second quality tas-Seconda.

SUB-DIVISIONS

The rock formation has been subdivided into four members as follows (Pedley, 1978):

- Wied Maghlaq Member (oldest)
- Attard Member
- Xlendi Member
- Il-Mara Member (youngest)

Of the four members only the top 3 rock unts are relevant to this project.

6.1.1.1 Attard Member

The Attard Member is predominantly composed of massive white algal limestone in 1m to 3m thick beds.

6.1.2 The Xlendi Mb

Of these members, the rock that dominates the area of influence is the Xlendi Member, which from past ground investigations in the area is known to be about 9m to 11m thick and is composed of brown or light brown very coarse bedded foraminiferal Limestone in wedge –shaped mega-forests beds of 20cm to about 80cm thick (Figure 16 and 16). The rock has a relatively high porosity but due to its non-homogeneous nature t is quite variable.

Figure 15: Coast Road cutting about 4m high exposing strata of the Xlendi Mb (Note the typical cross bedding)

Figure 16: Photograph showing Xlendi Mb with Karst conduits filled with terra rossa

6.1.3 Il-Mara Member

This rock unit is absent from north Malta. The Name il-Mara derives from the locality of il-Mara in eastern Malta where this member is best developed and was accessible in a Quarry cut in the cliff face and which now has been backfilled with fly ash. Best exposures lie along the Xghajra coastline. It is composed of massive bedded pale yellow limestone characterised by the giant foraminifera known as *Lepidocyclina.*

At the site this rock unit is represented by a condensed sequence composed of very hard brown bed about 0.5m thick. It is overlain by the Lower Globigerina Limestone (Figure 17).

6.1.4 Globigerina Limestone Formation

This rock formation is usually subdivided into (Rizzo1932):

- Lower Globigerina Limestone
- Middle Globigerina Limestone
- Upper Globigerina Limestone

Phosphate pebble bed or conglomerates mark the contact between the Lower and Middle Globigerina and the contact between the Middle and Upper Globigerina Limestone Members.

Of the three rock units that make up this rock formation, only the Lower Globigerina Limestone Mb is present in the Study Area.

6.1.4.1 Lower Globigerina Limestone Member

It consists of pale yellow brown to yellow fine to medium- grained weak, massive, often intensely bioturbated limestone. A thin phosphate pebble bed (Sometimes two) and scour surface is developed at the top of the Lower Coralline Limestone. The rock is composed of whole and fragmented tests of microforaminifera. The macrofossils usually present are echinoid spines and echinoid tests and whole or fragmented bivalve shells. Trace fossils are commonly represented by *Thalassinoides*.

This rock unit is marked by a series of terraced fields which are absent from Lower Coralline Limestone exposures. It Is now mostly buried under the Maghtab landfill.

6.1.5 Quaternary deposits

During the Field survey a red partly lithified slope scree exposure was observed along the coast road. The slope scree is associated with minor faulting which can be seen along the Coast Road (Figure 18).

Figure 17: Cutting in the Ghallis Land fill showing the contact between Lower Coralline Limestone and the overlying Lower Globigerina Limestone marked by two slightly darker yellow beds

Figure 18: Photograph showing a surface lithified layer of red Quaternary slope deposits underlain by Lower Globigerina Limestone. Such deposits are usually associated with faults

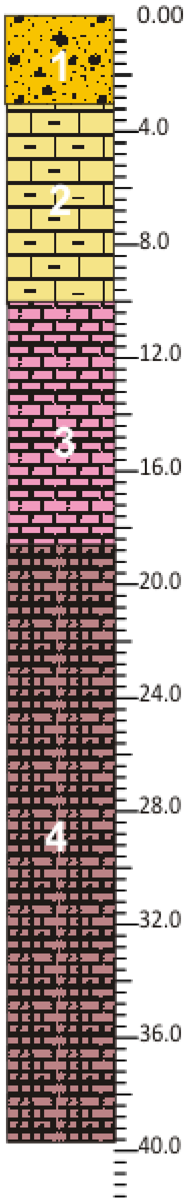
6.2 Structural Geology

In structural Geology the uplands adjacent to the site are known as the Ghallis high, as, despite their location on the hanging wall of the Victoria Lines Fault, the Lower Coralline Limestone rises way above sea level. The high is dissected by a radial drainage system of which, *Wied ta' Kieli* and Wied tal-Ghallis are the most relevant to this report.

One fault can be seen traversing the landfill (see Figure 15-Geological map) other minor faults can now be seen in the Coast Road cutting, exposing a thin bed of Lower Globigerina Limestone located in a shallow graben bounded by two normal faults having a throw of a few metres. This also explains the preservation of a thin Quaternary slope deposit within the graben.

Many Quaternary slope deposits are associated with such faults. In the absence of faults usually no Quaternary slope scree deposits are preserved. Tables listing and describing briefly the Geological, Geomorphological and Hydrological features are found in **Appendix 1**.

7.0 Assessment of the stone material to be excavated



An extensive ground investigation and testing has been undertaken in 2020 in connection with the Waste to Energy Facility, currently under construction. Considering that the WtE facility site lies close to the MRF site under study. The ground investigation of the former together with a field survey undertaken on 27 and 26 November 2022, has been utilised to assess the quality of the stone material that shall be extracted from the MRF site.

The subsurface is the lateral continuation of the rock beds from the WtE facility and the MRF site next to it.

The rock sequence at the site is described in Figure 19:

- (1) The topsoil on average is about 0.3 to 0.4m thick (seen during field survey) for the OPP and MRF sites; 3m were recorded in the WtE ground investigation.
- (2) The Lower Globigerina Limestone in exposures at the site, about 5m thick;
- The Lower Coralline Limestone (in the subsurface);
    - (3) Xlendi Mb: 9m to 11m thick;
    - (4) Attard Mb which, is about 22m thick, extends down to sea level.

Figure 19: General lithologic column of the surface and subsurface geology at il-Ghallis and Maghtab 1: Top soil; 2: Lower Globigerina Limestone; 3: Lower Coralline Limestone-Xlendi Mb ; 4: Lower Coralline Limestone –Attard Mb

7.1 Subsurface Ground investigation

7.1.1 Field work

Field work for the WtE facility was undertaken in May 2020 and comprised the drilling of 3 holes identified as T2a, T2b and T2c, drilled at the site with continuous core sample recovery from top of bedrock to 30m below ground level. The borehole locations are shown in Figure 11.

Drilling is summarised in **Table 6.** All samples recovered were composed of Lower Globigerina Limestone and Lower Coralline Limestone with a 0.5m to 1.0m thick overburden composed of topsoil and limestone rubble.

Table 5: Borehole drilling summary

Borehole Number	T2a	T2b	T2c
Date drilled	18/05/20	18/05/20	26/05/20
Overburden, m	0.0-1.30	0.0-0.5	0.0-5.0
Top Lower Globigerina, m	1.30	0.50	5.0
Top Lower Coralline Ls, m	17.8	22.3	17.4
Rock core sampling, m	1.5-30.0	1.3-30.0	0.0-30
Total Depth, m	30.0	30.0	30.0

7.2 Rock Quality

Table 7 below shows the values of the quality of the rock cores recovered from boreholes T2A, T2B and T2C; namely the Total Core Recovery (TCR), the Solid Core Recovery (SCR), the Rock Quality Designation (RQD) and the Fracture Index (S5930:2015). Photographs of typical rock core samples of Lower Globigerina Limestone and Lower Coralline Limestone recovered are shown in Figure 20 and Figure 21.

Figure 20: Photograph of Lower Globigerina Limestone core samples recovered from BHT2c Depth interval 6m to 12m below ground level

Figure 21: Photograph showing Lower Coralline Limestone core samples recovered from BHT2c Depth interval 18m to 24m below ground level

Table 6: Summary of the core recovery, Solid Core recovery and Rock Quality Designation

BH No.	Run No.	Depth (m)	TCR (%)	SCR (%)	RQD (%)	Rock Quality	Fracture Index (fractures/m)
BH T2a	1	1.30-2.00	100	100	90	Excellent	0/m
		2.00-3.00	100	100	90	Excellent	1/m
	2	3.00-4.00	100	100	68	Fair	0/m
		4.00-5.00	100	100	40	Poor	0/m (Highly weathered from 4.4m to 5.0m)
		5.00-6.00	100	100	95	Excellent	1/m
	3	6.00-7.00	95	95	80	Good	1/m
		7.00-8.00	100	100	94	Excellent	1/m
		8.00-9.00	100	100	82	Good	2/m
	4	9.00-10.00	100	100	92	Excellent	1/m
		10.00-11.00	100	100	98	Excellent	2/m
		11.00-12.00	100	100	70	Fair	1/m (Moderately weathered from 11.2m to 11.6m)
	5	12.00-13.00	100	100	97	Excellent	0/m
		13.00-14.00	100	100	98	Excellent	2/m
		14.00-15.00	100	100	100	Excellent	0/m
	6	15.00-16.00	87	87	87	Good	1/m
		16.00-17.00	80	80	80	Good	0/m
		17.00-18.00	100	100	95	Excellent	2/m
BH-T2c	1	1.30-2.00	61	61	53	Fair	0/m (Moderately weathered from 1.6m to 1.9m)
		2.00-3.00	85	85	66	Fair	1/m
	2	3.00-4.00	100	100	92	Excellent	0/m
		4.00-5.00	100	100	100	Excellent	2/m
		5.00-6.00	100	100	97	Excellent	0/m
	3	6.00-7.00	100	100	100	Excellent	0/m
		7.00-8.00	100	100	100	Excellent	1/m

BH No.	Run No.	Depth (m)	TCR (%)	SCR (%)	RQD (%)	Rock Quality	Fracture Index (fractures/m)
		8.00-9.00	100	100	98	Excellent	1/m
	4	9.00-10.00	100	100	100	Excellent	1/m
		10.00-11.00	100	100	100	Excellent	1/m
		11.00-12.00	100	100	100	Excellent	0/m
		28.00-29.00	100	100	100	Excellent	1/m
		29.00-30.00	100	100	100	Excellent	2/m

7.3 Laboratory testing

Twenty-Four (24) specimens of Lower Globigerina and Lower Coralline Limestone were selected from various depths along the recovered rock core from the three boreholes T2A, T2B and T2C for Unconfined Compressive Strength (UCS) testing. The rock specimens were tested according to the ISRM suggested method. The laboratory results are summarized in Table 7 below and are illustrated by a scatter chart shown in Figure 22**.**

Table 7: Unconfined compressive strength (UCS) of the limestone specimens.

BH No.	Run No.	Specimen No.	Depth (m)	Bulk Density (kg/m³)	Dry Density (kg/m³)	Water Content (%)	UCS (MPa)	Average UCS (MPa)
T2A	6	1	15.50	1940	1724	11.2	6.1	**6.6**
	6	2	16.85	1872	1568	16.2	8.8	
	6	3	17.75	1968	1696	13.8	5.0	
	9	4	25.20	2148	1956	8.9	4.7	**4.9**
	9	5	26.20	2182	1996	8.5	4.8	
	10	6	27.75	2115	1925	9.0	5.1	
T2B	2	7	3.45	2368	2265	4.4	17.6	**13.3**
	2	8	4.45	2158	1984	8.1	12.7	
	2	9	5.50	2020	1805	10.7	9.7	
	6	10	15.80	1848	1527	17.4	4.0	**4.1**
	6	11	16.90	1889	1531	18.9	4.3	
	6	12	17.85	1932	1517	21.5	4.0	
	10	13	27.5	1994	1739	12.8	4.3	**15.4**
	10	14	28.85	2136	1948	8.8	9.9	
	10	15	29.80	2349	2195	6.5	32.0	

BH No.	Run No.	Specimen No.	Depth (m)	Bulk Density (kg/m³)	Dry Density (kg/m³)	Water Content (%)	UCS (MPa)	Average UCS (MPa)
T2C	2	16	9.55	2068	1817	12.2	12.8	**12.9**
	2	17	10.60	2050	1760	14.2	14.9	
	2	18	11.80	1976	1725	12.7	10.9	
	3	19	12.25	1914	1641	14.3	9.8	**10.9**
	3	20	13.55	2028	1717	15.3	15.3	
	3	21	14.5	1943	1525	21.5	7.5	
	6	22	22.55	1944	1672	14.0	6.6	**4.5**
	7	23	26.35	1930	1630	15.5	3.6	
	8	24	29.60	1915	1590	17.0	3.4	

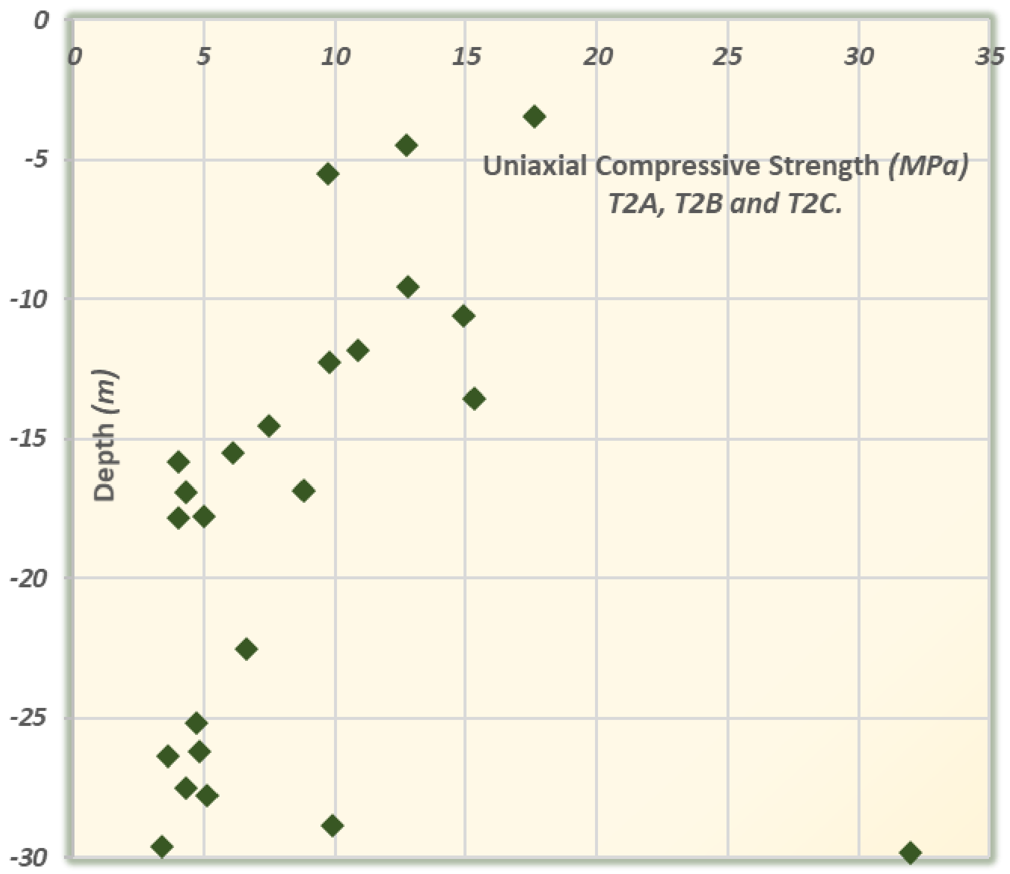


Figure 22: Uniaxial, Unconfined Compressive Strength Scatter chart

From Figure 22 it is at once evident that the top layers (Lower Globigerina Limestone) are stronger than the deeper beds (Lower Coralline Limestone).

- Top layers – Lower Globigerina Limestone (Approximate) average strength= 13Mpa
- Deeper beds –Lower Coralline Limestone (Approximate) average strength= 7Mpa
- High water content in both rock units

8.0 Use of the Material to be Excavated

Kindly refer to separate technical report containing information on material characterisation and ground contamination tests.

8.1 Use of Material to be excavated

8.1.1 Topsoil

Topsoil should be preserved for later use in agriculture and also to embellish the Materials Recovery Facility

8.1.2 Lower Globigerina Limestone

Lower Globigerina Limestone would not find use as a building stone as it is fractured. Fracture frequency was of the order of 1.5/m which would not permit dimension stone extraction without the generation of a high volume of waste material.

Furthermore, presently the use of Lower Globigerina Limestone is very limited, as with the current status of the building industry the cement brick has taken over.

If excavated it could be used as screed and in mass concrete as well as in the sub-base for road construction and for building rubble walls.

8.1.3 Lower Coralline Limestone

The depth to the top of the Lower Coralline Limestone is about 17m. Excavation for the MRF facility is under 10m.

No Lower Coralline Limestone material shall be extracted from the MRF site.

8.2 Rock Slope stability

Subsurface investigation has revealed that the rock mass is dissected by fissures. Any excavation undertaken will lie in Lower Globigerina Limestone. Monitoring of the walls of the excavation as deepening proceeds is recommended.

8.3 Note on excavation monitoring

8.3.1 Excavation in rock

If any excavation is undertaken it is recommended to monitor the walls of the excavation, preferably by an experienced geologist due to presence of potentially unstable rock wedges or slabs created due to daylighting of particular joints as the excavation proceeds (Figure 23). This is required for health and safety reasons and to safeguard 3rd party property on the margins of the site.

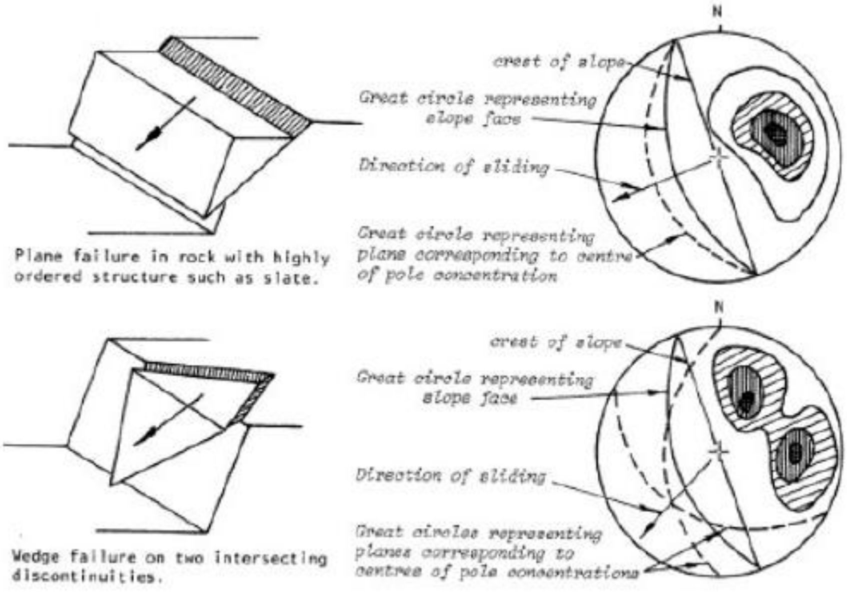


Figure 23: Potential rock wedge and rock prism modes of failure (Hoek E., 2023), Practical Rock Engineering

8.3.2 Shallow Horizontal Discontinuities

The presence of shallow horizontal discontinuities like bedding planes may cause block detachment during excavation and consequent damage to 3rd party foundations or 3rd party property (Figure 24). This may be due to the vibrations caused by the excavator or else due to settlement as the block is detached by the excavator (Hammer or saw) from the rest of the stratum.

8.3.3 Strongly weathered Limestone

Surface strongly weathered limestone beds are often characterised by the presence of veins and lenses of terra rossa and /or caliche which may deteriorate on exposure. These geological conditions may lead to eventual collapse of exposed weathered limestone layer.

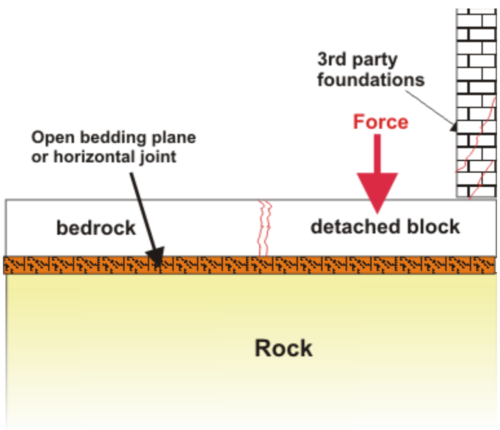


Figure 24: Rock block detachment caused by Shallow horizontal or low angle discontinuities

8.4 Landfill Slope stability

8.4.1 Landfill Slope stability.

A road runs along the north-western boundary of the MRF site and separated the site from the freshly deposited landfill. The toe of the landfill is protected by a thick concrete gravity wall. The landfill itself is loose and its slope has assumed the natural angle of repose.

Figure 25: Freshley laid landfill composed of excavation and construction material west of the road skirting the MRF site

Further north close to the site for the WtE facility the slope is terraced and set in benches each about 15m high with a 5m wide step for every 15m increase in altitude.

Measured average slope = 1:3 or 18.4Degrees

The average slope angle for the steepest segment of the landfill is about 18 Degrees (Figure 28). The angle of repose for landfill material is usually of the order of 45Deg (Table 8). This setup of the slope renders it quite stable. In fact, no land slip has ever been recorded at the Maghtab-Ghallis landfill.

8.4.2 Overburden stability

Clearance of the top soil for archaeological studies in connection with the WtE site and OPP site shows that the thickness of the overburden is under 0.5m. Moreover, the topsoil is being removed for later reuse at the site. The topsoil does not present any stability hazards. The overburden does not pose any stability hazards.

8.4.3 Excavation in rock

The face of the excavation should be monitored for potential formation of unstable rock wedges that may arise due to intersecting fissures, that may daylight in the rock face during excavation. These should be stabilized by rock bolting.

Figure 26: View of the eastern sector of the landfill as seen from the proposed WtE site (2020). Presently this site is an excavation about 5m deep. The moderate slope of the landfill is evident

Figure 27: View of the western sector of the landfill as seen from the margin of the proposed WtE Facility (2020)

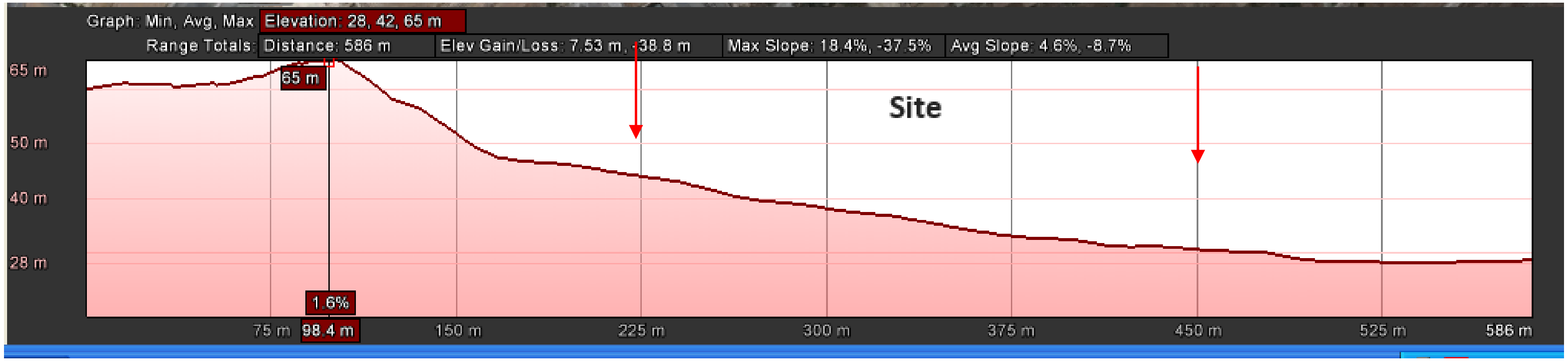


Figure 28: W-E Topographic Profile across the Ghallis Maghtab Landfill (Purple line). Line of section is the red line shown in the Google Image.

Furthermore, the landfill has been in existence for over 20 years and no landslip has ever been recorded.

Table 8: Angle of repose of some natural materials-Crushed stone has a value of 45Degrees-Terzaghi-Peck,1996 Sol Mechanics n Engineering Practice

Material (condition)	*Angle of Repose* (degrees)
Sand (wet)	45°
Sand (water filled)	15–30°
Sand (dry)	34°
Gravel (natural w/ sand)	25–30°
Gravel (crushed stone)	45°
Granite	35–40°
Earth	30–45°

9.0 Geomorphology and soils

9.1 Geomorphology

The area under study is a low and broad spur of agricultural land at the foot of the landfill hill, which from the site at about 40m above sea level rises to about 60m to reach a height of 100m above sea level. The proposed MRF site shall be developed on Lower Globigerina Limestone. The Lower Coralline Limestone (Xlendi Mb and Attard Mb) weathers only by solution as it is almost pure Calcium Carbonate. For this reason, no substantial soil thickness is developed on this rock formation. Such limestone pavement is usually designated as "*Xaghra*". In other areas exposures of the Xlendi Mb are mostly bare. The soil covering rock exposures of the Xlendi MB below the site must have been transported.

The geomorphological features that once could be seen in the Study Area are listed below (Figure 29):

- Saddle at Ta' San Pietru
- The Il-Qadi –Ta'Hammud Uplands flanked by:
- Il-Qadi - Ta' Hammud Uplands
- Wied Ghallis Valley
- Wied ta'Kieli Valley
- The pocket beach of Qalet Marku
- The Bahar ic-Caghaq – Ghallis rocky coastline

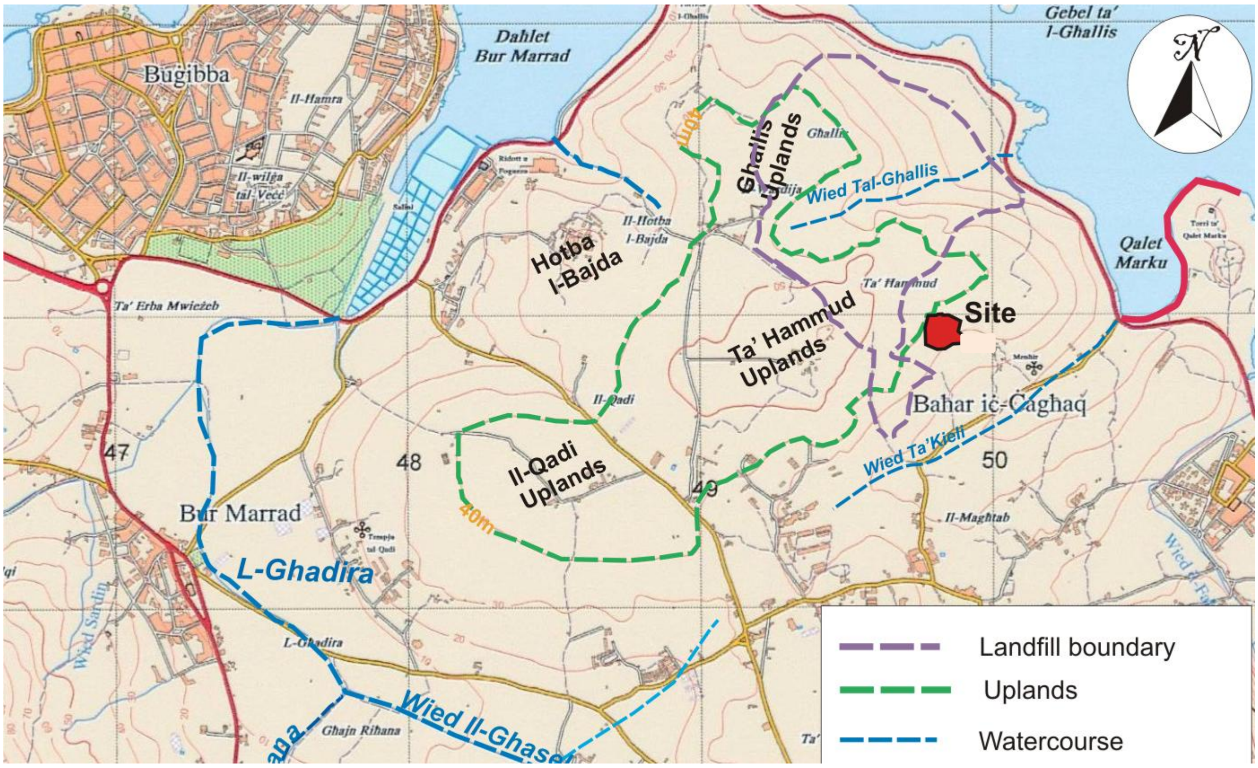


Figure 29: Map showing area of influence for geomorphology. For scale grid squares measure 1000m by 1000m

Most of these features are now buried beneath the Maghtab and Ghallis Landfill and what remains are:

- ***Wied Ta Kieli:*** *a primarily agricultural tenement parcelled into terraced fields. No watercourse is developed except at the coastline (*Figure 30*).*

Figure 30: Photograph showing typical terracing in Wied ta'Kieli

- **The eastern slopes of Ta Hammud Uplands**. The upper sector of these rounded slopes is terraced and covered by a topsoil while the lower part which exposes Lower Coralline Limestone constitutes mainly a limestone pavement as inland exposures of Lower Coralline Limestone, being a pure limestone, are barren and form a limestone pavement locally known as *Xaghra*.
- **The Qalet Marku and Ghallis Coastline** is set on the Xlendi mb of the lower coralline limestone formation. The coastal belt that forms a corridor between the Coast Road and the coastline is characterised by its serrated character and rugged marine karst landscape forming a dense network of rock pools up to about 5m in diameter (Figure 32 and Figure 33). It is a rugged bare shore platform with scattered ponds best represented by Ghadira S-Safra. Shallow embayments form the offshore extension of the valleys mainly represented by Bahar Ic-Caghaq and Qalet Marku.

Owing to the high resistance to erosion of the limestone exposures along the coastline, only a small pocket cobble beach is developed at Qalet Marku.

Figure 31: Photograph of the eastern slopes il- Ghallis showing the pocket beach at Qalet Marku and the rocky (Xaghra) nature of the slopes.

Figure 32: Photograph of Qalet Marku as seen from the west

Figure 33: Typical rock pool morphology of the coastline as seen along the Ghallis coast road during the rainy season

9.2 Geomorphology and structural geology

In structural geological terms these uplands are known as the Ghallis high as despite their location on the hanging wall of the Victoria Lines Fault, the Lower Coralline Limestone rises way above sea level. The high is dissected by a radial drainage system of which, Wied ta' Kieli and Wied tal-Ghallis are the most relevant to this report.

The site is located next to broad spur roughly oriented North South and forms part of the Ghallis structural high. This High is marked by a well-developed Lower Coralline Limestone with a reduced thickness of the Globigerina Limestone. Past ground investigation at the WtE facility, now in execution phase, has revealed that the Lower Globigerina Limestone is about 17m to 22m thick.

10.0 Soils

10.1 Soils of The Maltese Islands Classification–General Introduction

SOIL COMPOSITION - The most striking characteristic of the soil of the Maltese islands is their high carbonate content along the whole soil profile. For example, it is of the order of 50 % to 80% near the surface of the pale brown soils (Xerorendzinas) and in the white raw carbonate soils and is found to increase down the soil profile, whereas in the terra rossa soils (red) it ranges from 25% to 60% and decreases with depth.

SOIL DEPTH - The depth of soil or soil-like material is very variable and is found to be highly dependent on the morphology of the area under consideration as well as on the underlying bedrock itself. Generally, its depth is very shallow on ridges plateaus and pavements formed of hard limestones, (erosional surfaces) such as the Lower Coralline Limestone. It usually ranges in depth from less than 20cm to 60cm with the exception of isolated pockets, where it could be deeper. However, very often the hard Coralline limestones are exposed as a bare highly karstified surface.

On the other hand, in erosional and structural valleys the soils were developed over slope taluses and alluvial deposits which have been weathered to varying degrees under the influence of past climatic regimes and usually are very thick and often exceed 150cm.

The soils or soil material on talus deposits and Blue Clay outcrops are usually deep as the parent material is soft and can be readily disintegrated into a soil which is barely distinguishable from the humus deficient soil itself which is commonly only about 75cm deep.

10.1.1 Terracing and other human interference

Under the local climatic regime of a long dry summer and a short-wet season with frequent heavy showers soils are usually easily eroded. However, this has been prevented by terracing. In fact, over the years, in order to preserve his scanty soil resource, the local farmer has actually remodelled the land surface especially the hill slopes by terracing and building of rubble walls to protect the soil from the agents of erosion. The only areas which have escaped profound human intervention are the nearly level areas of deep soil in the erosional and structural valleys as well as the hard limestone plateaux where the principal human intervention was the construction of rubble walls. However, even here man has re-sculptured the land surface. In these areas the soil was carefully removed, the irregular and usually sloping rock outcrop was hewn and levelled and the soil material was carefully and regularly spread over the entire surface. The excess material was usually disposed off by building rubble walls which act as wind breakers as well as preventing run-off water from eroding the soil.

Such terracing has been even more drastic in the globigerina areas as the limestone is very soft and hence man could cut even deeper thus giving rise to terraces separated by a depth interval which could be a metre or two. In these circumstances the scarce soil material has been supplemented by fine rock fragments and rock flour produced during terracing of the hill slopes as well as during the excavation of water reservoirs and building stone quarrying.

Soil material has always been recognised as a scarce resource and the literature refers to the transport of ship- loads of red soil from Sicily for the construction of the Maltese fields during the early days. However, this is very unlikely, the only material that could have been imported was ballast for the ships.

10.1.2 Classification

The soils found distributed in the Maltese Islands have been classified into three groups (Lang 1962). These are:

- Terra Rossa
- Xerorenzina
- Carbonate raw Soils

This classification basically corresponds to the local popular names of red, brown and white soils.

10.1.2.1 Terra Rossa

The red Terra Rossa soils are highly decalcified and are rich in humus. The brown Xerorenzina soils are only slightly decalcified and humus enriched. The whitish Carbonate Raw Soils are essentially physically disintegrated parent rock; they are highly calcareous and humus deficient. Within this broad soil classification there exists a wide range in variation due to local natural processes such as mixing of the parent material with products of erosion and deposition by runoff water and soil creep as well as due to local lithological variation within a given formation such as the three members composing the Globigerina Limestone as well as due to lithological variations that occur within each member. These differences are further complicated by human interference such as in manmade soils, terracing and addition of soil coming from other parts of the island.

Considering the local particular conditions, the three classes of soils referred to above have been further subdivided as follows:

10.1.2.2 XERORENZINA

- San Biagio
- Alcol
- Tal-Barrani

10.1.2.3 TERRA ROSSA

- Tas-Sigra
- Xaghra

Furthermore, one association and three soil complexes have also been identified as follows:

- Rdum sequence: a lithosequence occurring on scarp slopes.
- Armier complex: a natural soil complex produced by mixed parent material.
- L'inglin complex: a man-made complex arising from terracing on steep slopes.
- Tad-Dawl complex: a man made complex in quarries.

10.1.3 The soil at the site

The proposed site is set on a number of terraced fields underlain by Lower Globigerina Limestone. The soil associated with such a geomorphological setting is the L-Inglin man-made complex associated with terraced slopes exposing Lower Globigerina Limestone (Figure 34).

A typical profile of the soil that has been exposed at the site during the archaeological survey is shown in Figure 35.

10.1.4 Xaghra Series

Lower Coralline Limestone exposures are bare of any soil or it occurs in pockets and is very thin and is termed the Xaghra Soil Series. In Maltese the word Xaghra indicates bare rock.

XAGHRA SERIES (Terra Rossa) - This soil series is represented by very shallow to very deep, red, heavy textured (clay and clay loam) decalcified soils with a strong subangular to angular blocky structure and occurs intermittently among hard limestone outcrops on the karst landscape. The soils are strongly decalcified, with humus-enriched surface and possess an A C D profile on an almost completely decalcified B horizon soil material formed during an earlier climate.

This soil series is invariably associated with the karst type of landscape. The principal areas of distribution are on the Rabat-Dingli plateau the coastal hills between Sliema and Salina and other areas associated with Lower and Upper Coralline Limestone Formations, and the Franka layer of the Lower Globigerina.

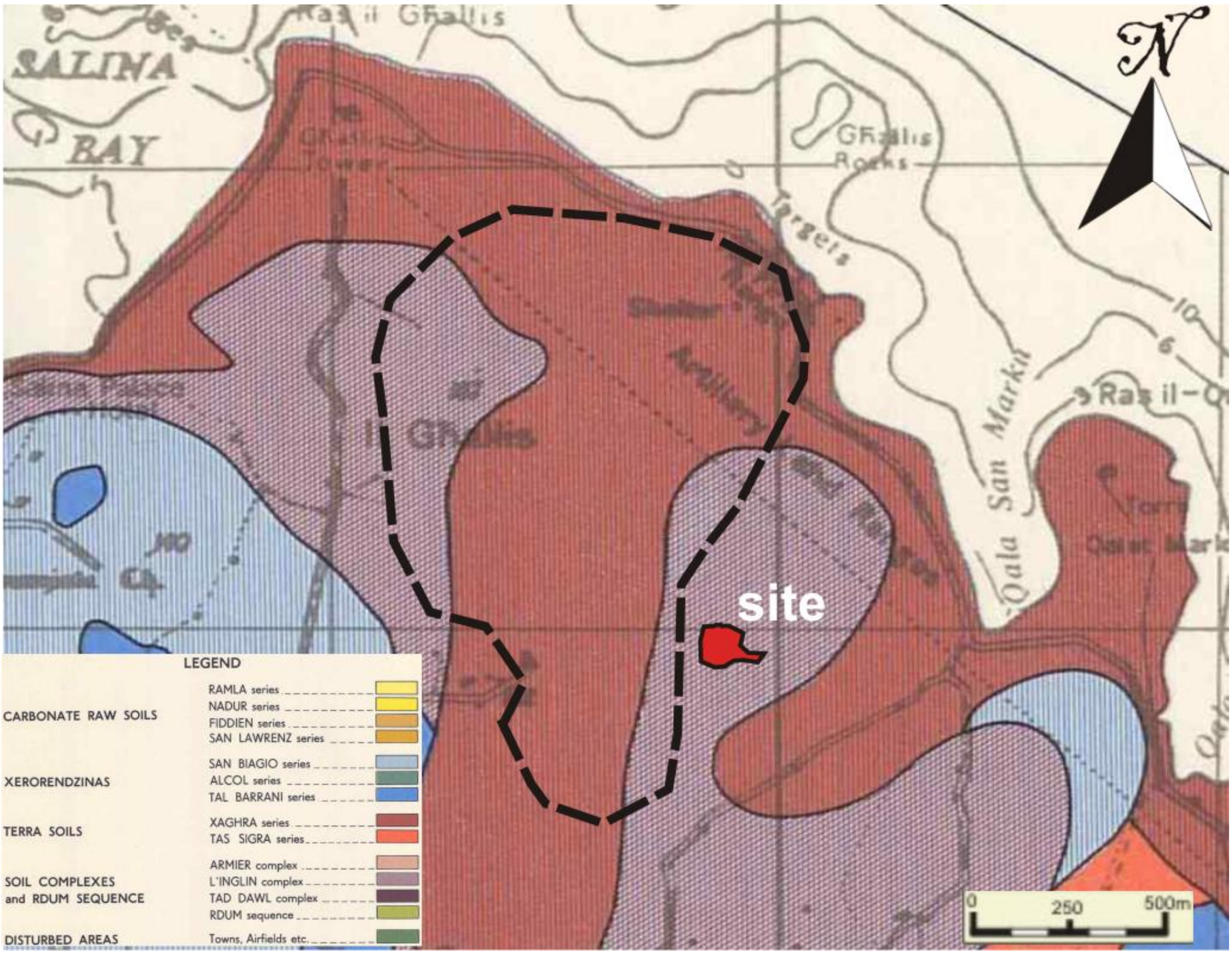


Figure 34: Soil map of the environs of the site from Lang 1962. Black line indicates the approximate extent of the land fill

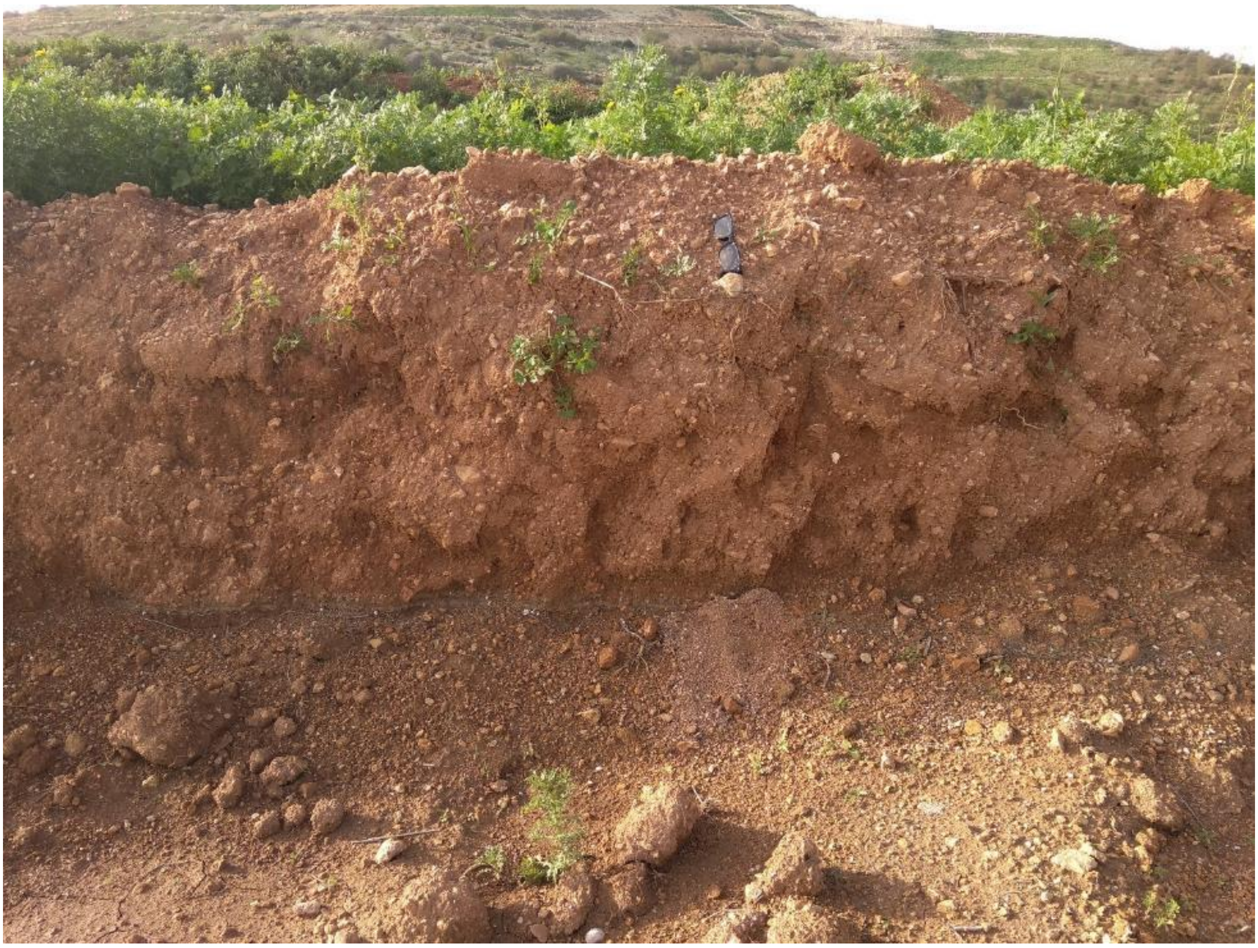


Figure 35: Photograph of a typical soil profile at the OPP site about 0.4m thick

11.0 Hydrology and Hydrogeology

11.1 The Water Protection Zone

The site is underlain by the lower coralline limestone which constitutes the Mean Sea Level Aquifer but it does not lie within the boundary of the water protection zone (Figure 36).

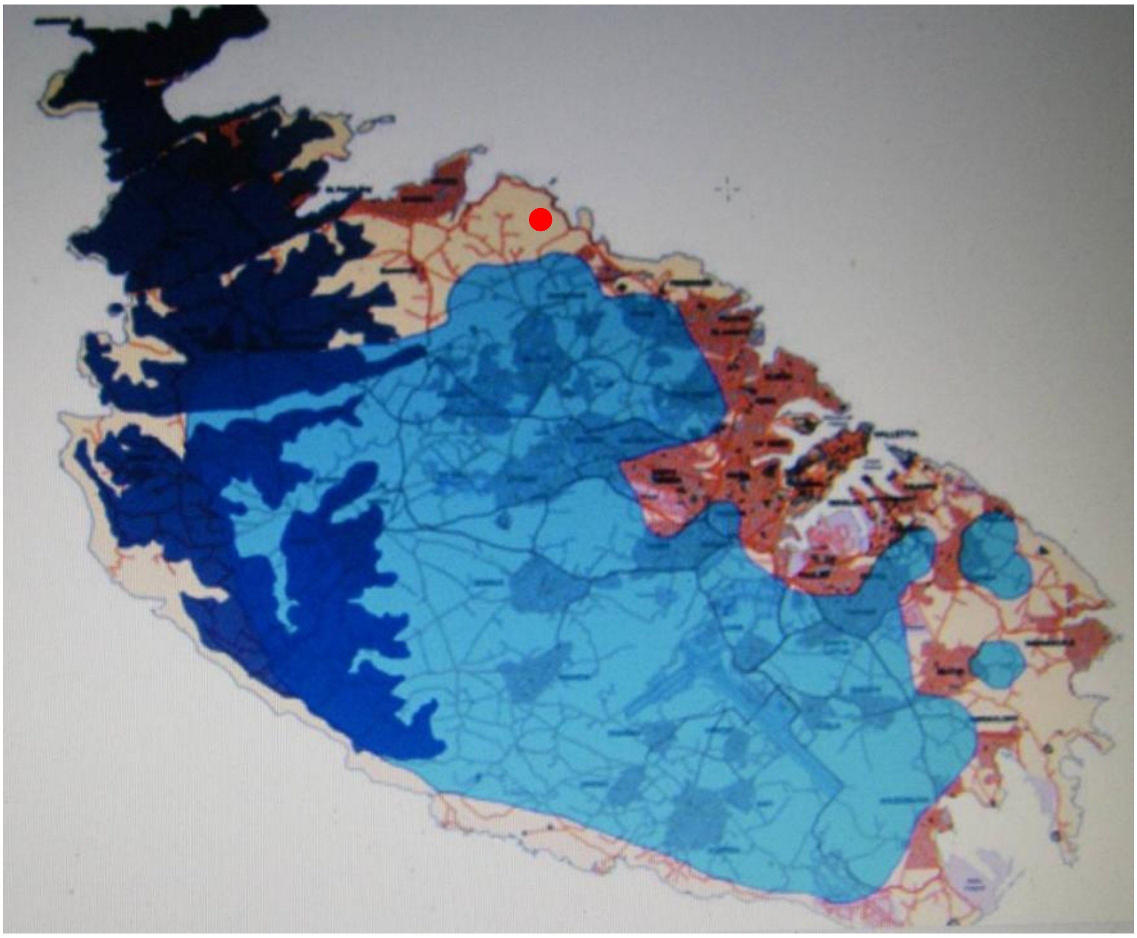


Figure 36: Map showing the water protection zone extending over the island. The approximate location of the site is shown by a red circle.

11.2 Hydrology and Hydrogeology

The site falls within the catchment of Wied tal-Ghallis (part), Wied ta'Kieli and partly diffuse (Figure 37). The water shed of this watercourse passes just north of the site as shown in the map.

The hydrogeological and hydrological features close to the site are shown in Figure 37 and are listed below:

- Wied tal-Ghallis: a shallow valley covered by landfill and limestone pavement in which no watercourse is developed suggesting scarce run-off events.
- Wied ta'Kieli drainage system which discharges into Qalet Marku;

- The catchment of the site. The site lies partly within the catchment of Wied ta'Kieli about 15% of the area within the catchment of Wied Tal-Ghallis and approximately about 15% is diffuse;
- The catchment of the site is represented by its boundary and has an area of approximately 21,373m^2;
- The Mean Sea Level Aquifer represented by Lower Coralline Limestone;
- Water Services Corporation (WSC) and private boreholes;
- Wetlands.

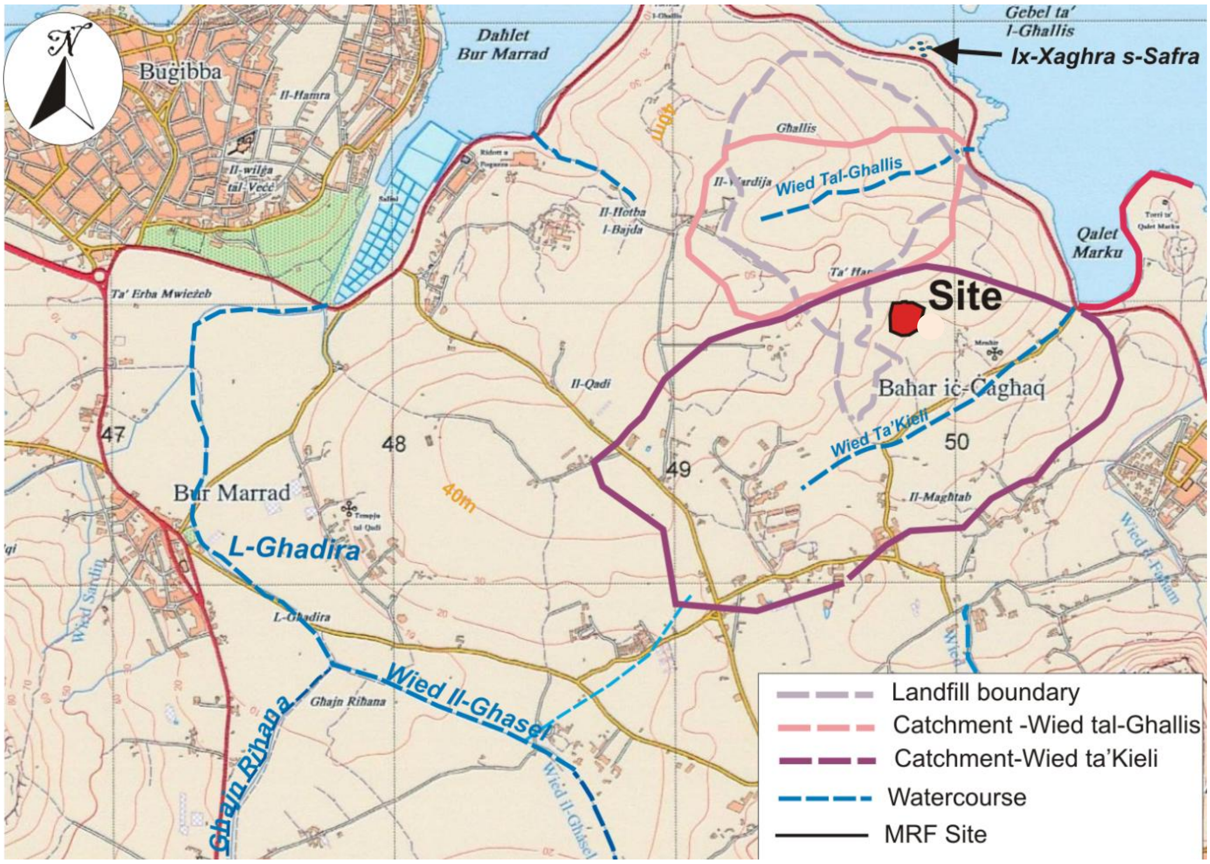


Figure 37: Map showing hydrological features including the catchments of Wied tal-Ghallis and Wied ta'Kieli

11.2.1 The Mean Sea Level Aquifer

Field survey as well as the geological map of the site has revealed that at the site or within its catchment, there are no impermeable beds above sea level such as marly or Clay beds. No perched aquifer is therefore, developed beneath the site. The only aquifer beneath the site that may be developed is the mean sea level water table, which lies some 30m to 45m below ground level. This also represents the hydrogeological feature closest to the site.

The mean sea level water body is a lens-shaped water body reaching some 2.5m above sea level in central Malta and thins out to zero thickness at the coastline (Figure 38).

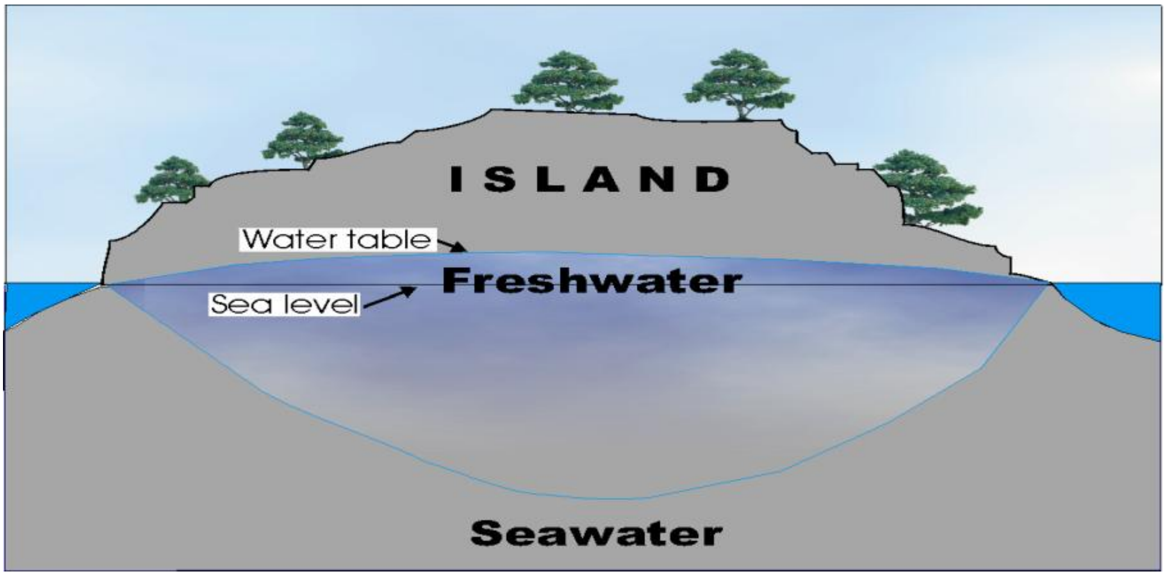


Figure 38: Schematic representation of the mean sea level aquifer developed beneath an island

11.2.2 Water Boreholes – Water Services Corporation

The area under study lies outside the Mean Sea Level Aquifer protection zone. The WSC hydrological feature closest to the site are two boreholes in Wied ta'Kieli (Appendix 2).

11.2.3 Wetlands

A field at the discharge point of Wied Ta'Kieli is covered by vegetation usually associated with wetlands. This site behaves as a semi-permanent wetland due to temporary flooding during heavy rain events which generate runoff and water appears to linger for some time before drying or discharging at sea (Figure 39).

Figure 39: Photograph showing a field along Triq Tull il-Kosta at the discharge point of Wied ta'Kiieli which appears to form a temporary wetland

11.3 The Water Cycle

Figure 40 shows the partition of rainwater on reaching the ground into:

- run-off, and
- infiltration water (recharge) which recharges the mean sea level aquifer during the rainy season
- evapotranspiration

Rainfall upon reaching the ground is partly led to the sea as run-off through the surface drainage system, which for fallow land is taken as 10% of the average rainfall. Part of the rainwater percolates into the ground and goes to recharge the mean sea level aquifer (27%). The rest of the water is returned to the atmosphere by evapotranspiration.

Owing to the long, hot and dry season of the Maltese Islands, this is very high and is usually taken as 63% (2nd WCMP-2015-2020) (Figure 41). Figure 42 illustrates the breakdown of groundwater extraction.

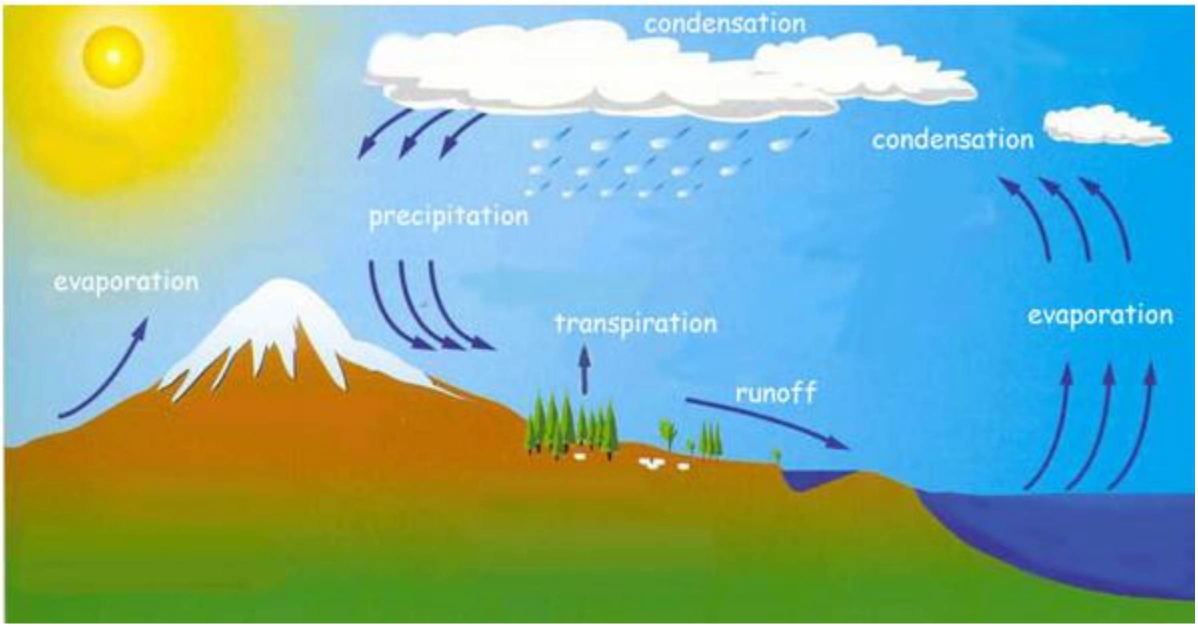


Figure 40: Schematic representation of the water cycle (http://coastgis.marsci.uga.edu/summit/watercyclegen.htm)

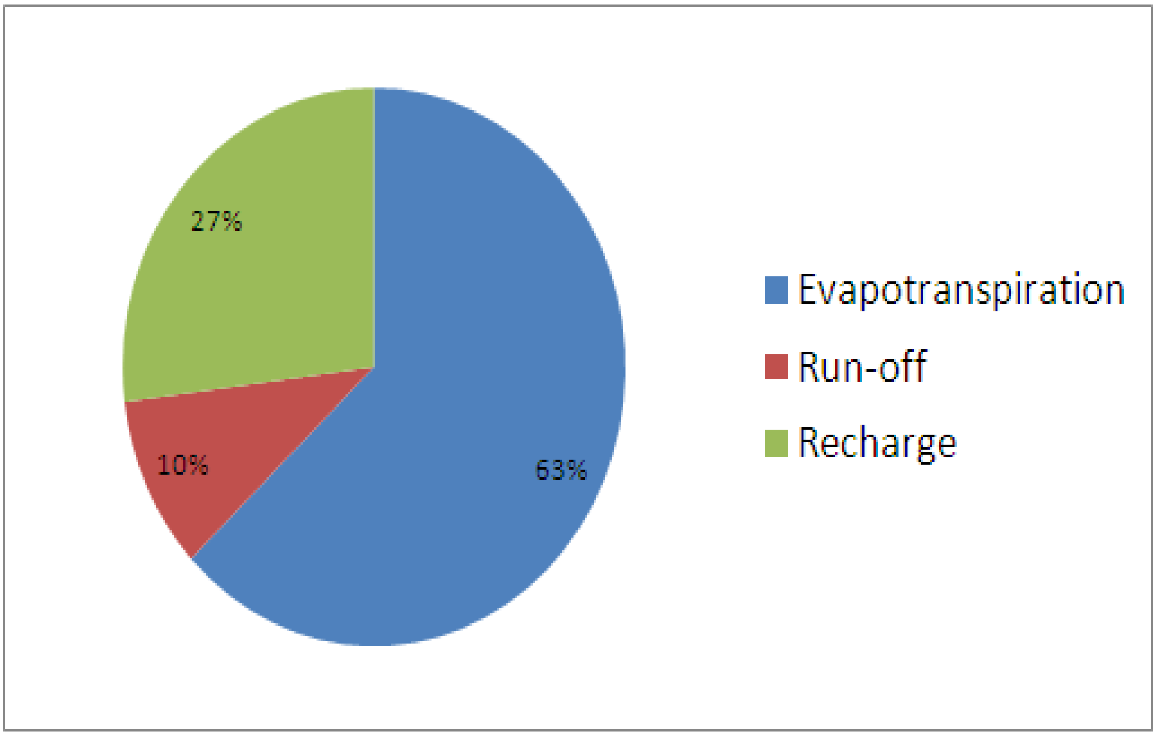


Figure 41: The water balance (Source for Evapotranspiration WCMP 2015-2020)

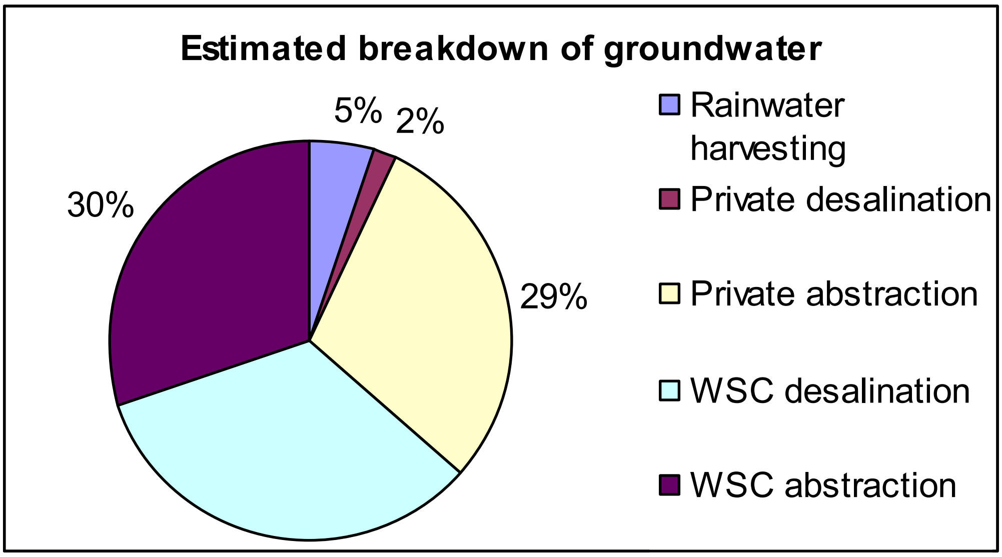


Figure 42: Breakdown of the freshwater production

11.3.1 Surface Run-Off Estimates

Area of the site 24,000m² (approximately)

• Area of site:	21,373m^2
• Average yearly rainfall for the Maltese Islands:	550mm
• Average Percolation:	27%

Average before MRF development:

• Average annual Run-off at the site @10%	1,320m^3
• Aquifer recharge @27%	3,564m^3

Average after MRF development:

• Run-off % 95%	12,500m^3
• Aquifer recharge:	Practically Nil

It is to be noted that, if not harvested, the entire run-off will run down to the coastline. It is important to note that the harvesting of rainwater offers a renewable alternative to other more costly sources of supply (SWCMP-2015).

11.3.2 Storm water collection during operation

The site footprint (excluding circulation and landscaping areas) shall be entirely paved and rendered impermeable. Storm Water will be collected separately from the roofs and from the roads and other paved areas. Both streams will be collected in the respective underground water tanks (5,000m^3 and 6,500m^3). The overflow of the roof water will be discharged in the adjacent southern site.

12.0 Potential Impacts and Risks

As reiterated in the Project Description Statement, the facility shall be designed in such a way to ensure that any emissions and environmental impacts arising from operations are in conformity with the requirements and standards stipulated in the EU Industrial Emissions Directive 2010/75/EU (IED).

Directive 2010/75/EC on industrial emissions (integrated pollution prevention and control) The IED is the successor of the IPPC Directive and in essence, it is about minimising pollution from various industrial sources throughout the European Union.

12.1 Potential Impacts and Risks During Construction

During the construction phase the site is considered to be like many other large building sites scattered all over the island. Incidents involving contamination coming from a building site normally do not happen. Dust emissions could emerge during excavation works on dry windy days in particular, with a negative impact on the coastline, coastal waters and l-Ghadira S-Safra. The site shall be excavated and thus it shall be a closed system and there shall be no runoff beyond the excavation boundary.

The landfill has altered the geomorphology of the entire area and for this reason the new excavation will only exacerbate what has already been destroyed beyond recovery.

Impact on the geo-environment is envisaged. There is a potential risk of spillage of fuel and lubricants. This is avoided by storing fuels and lubricating oils in appropriate containers and bunded areas. Lubricants in a construction site, during the excavation phase in particular, if spilled could easily find their way into the coastal waters through open fissures.

Stone material could be spilled during haulage. For this reason loaders should not be filled to the brim. Besides, a protective cover should be used to prevent dust emissions, especially on dry windy days.

Slope stability. The construction phase envisages a large but rather shallow excavation which could potentially present stability issues, mainly due to the presence of intersecting joints that produce rock wedges that may be unstable when they daylight in the excavation.

Dust emissions. During the **early stage** of the construction the likely impacts may be due to excavated stacked material being washed away by run-off and degrading the rocky coastal platform and coastal waters. Secondly, this could also happen by wind-blown dust during windy days. Finally, spillage of hazardous materials associated mainly with the excavation and haulage equipment. When the **excavation goes down below ground level** the site will be a closed system and only dispersion of dusts may potentially occur. Excavation material needs to be carted away in covered trucks to prevent spillage or generation of wind-blown dust.

Mitigation

The site lies close to the coastline. Water in the subsurface is brackish or saline.

The sea level aquifer is developed beneath the site but is brackish. Moreover, the site lies outside the drinking water protection zone.

Rock face instability will be mitigated by monitoring of the excavation and timely action if unstable conditions are anticipated.

To mitigate these impacts, it's essential for construction projects to adhere to environmental regulations and best practices. This might include proper sediment and erosion control measures, the use of silt fences, managing stormwater runoff, and ensuring that construction sites are adequately managed to prevent pollution. Environmental impact assessments are required to assess the potential effects of this and similar construction projects on water bodies and ecosystems, and appropriate mitigation measures should be put in place.

Local authorities, environmental agencies, and construction companies need to work together to minimize the negative impact of construction activities on water bodies and preserve the environmental integrity of the aquatic ecosystems.

12.2 Potential Impacts and Risks During Operation

12.2.1 Leakages

During operation there could be accidental leakage of sewer or other discharges which may find their way to the bay water. Regular inspection of effluents will mitigate such incidence. Haulage of waste material could be accompanied by accidental spillage.

13.0 Impact Assessment

13.1 Potential Impacts

The potential impacts arising from the construction and operation of the proposed development on the sensitive receptors could include:

- Contamination of the Mean Sea Level Aquifer;
- Removal/degradation of stone beds containing important palaeontological features;
- Degradation of the geomorphology
- Degradation of the coastline
- Degradation of the coastal waters
- Loss of mineral resources
- Degradation of the geomorphology due to dust emissions

13.2 Impact Significance

This section includes, for each potential impact the following information:

- Description of impact;
- Policy importance of impact (Local, National, International);
- Extent of effect; and duration of impact (temporary/permanent);
- Adverse or beneficial impact and reversible/irreversible impact;
- Sensitivity of receptor (residential dwelling, business outlets, farmers etc.);
- Probability of impact occurring (certain, likely, uncertain, unlikely, remote); and
- Scope for mitigation/enhancement (very good, good, none).

Based on the above criteria, a summary of the significance of the impact will be considered:

- **Insignificant** – little or no change to the hydrologic regime or geological / geomorphological regime;
- **Minor significance -**change to the geological/ hydrological/hydrogeological regimes with scope for mitigation
- **Moderate Significance:** changed to the geological regime that may be partly offset by mitigation measures (if negative) or may be partly enhanced by mitigation measures (if positive);
- **Major significance:** changes to the geological, geomorphological and hydrological regime that may affect neighbouring properties and which may not be offset by mitigation measures (if negative) or may be enhanced by mitigation measures (if positive).

13.3 During Construction

The site will be of relatively limited extent. During construction this will be more or less similar to a large building site with use of heavy excavation and construction equipment.

Demolition and excavation works are expected to generate fine dust that may be transported by wind, by surface runoff following rainfall and by downslope slumping when these activities take place on sloping ground. Fine material stored in stockpiles can be subject to transport during windstorm events.

Windblown dust is dependent on the time of year during which excavation is carried out. Particulate generated during the wet-season predominant northwest winds would be expected to transport dust in a predominantly south-easterly direction, towards inland areas. During the rainy season rock is saturated with water and is less prone to generate dust.

During the dry-season excavation, southernly winds would generate dust that may predominantly be transported in a northerly direction.

Potential Impact of Stockpiles. Every effort should be made not to allow stockpiles of excavated materials on site.

Temporary storage of excavation and construction material on the site may provide opportunities for dust generation. Unprotected stockpiles would provide surfaces exposed to redistribution of dust by wind and by surface runoff.

Several dust-suppression measures may be considered to minimize wind-blown dispersion. These include use of silt fences, collection of fine particulates generated during any on-site working of stone, covering of stored material, and controlled water-spraying of active areas.

13.4 During Operation

The main emissions during operation are emissions from plant during waste acceptance and possibly waste water generated during operation.

The significance of likely impacts on the geo-environment are listed in **Table 12** to **Table 17** below.

Table 9: Significance of likely impacts on Geology and Palaeontology

Significance of likely impacts on Geology and Palaeontology Policies RCO11 and RCO12	
Level of significance	**Criterion**
High	Removal/degrading of sites of scientific importance - Rural conservation Policies RCO11 and RCO12 without any possible scope for mitigation
Moderate	Removal of substantial quantities of strata from sites of no scientific importance involving extensive excavation works or removal of important strata with scope for mitigation
Low	Development involving removal of minor amounts of rock strata

Insignificant	Development that requires no excavation

Adverse/Beneficial -Geology and Palaeontology	
Assessment	**Criterion**
Highly beneficial	Developments that will protect or enhance sites of scientific importance such as nature trails or geological parks
Beneficial	Developments that will protect or enhance geological sites not necessarily of scientific importance
Neutral	Developments that do not involve removal of geological strata
Adverse	All developments that involve removal of strata are adverse even though they might be small and may seem to be insignificant. The cumulative effect of the construction will lead to removal of extensive quantities of geological strata (e g Construction of a new neighbourhood or town).

Table 10: Significance of likely impacts on geomorphology

Significance of likely impacts on Geomorphology Policies RCO11 and RCO12	
Level of significance	**Criterion**

High	Removal of sites of scientific importance - Rural conservation
High	Visibly Impairing geomorphological features of high landscape value, such as hill slopes, valleys or watercourses or cliffs or limestone pavements or karst features by burial or the removal of rock strata. Cumulative effect of a number of sites added together.
High	Developments leading to instability of Blue Clay slopes or to the cliff margins overlying the contact Blue Clay /Upper Coralline Limestone
Moderate	Removal of substantial Quantities of strata from sites of no scientific importance involving extensive excavation works but in low lying planar features
Low	Development involving removal of minor amounts of rock strata from sites of no landscape value or removal of strata with scope for mitigation
Insignificant	Development that do not bury surface geomorphological features and do not require any excavation

Adverse/Beneficial	
Assessment	**Criterion**
Highly beneficial	Developments that will protect or enhance sites of scientific importance such as nature trails or geomorphological/geological parks
Beneficial	Developments that will protect or enhance geomorphological /geological sites not necessarily of scientific importance
Neutral	Developments that do not involve removal of geological strata
Adverse	All developments that involve removal of strata are adverse even though they might be small and may seem to be insignificant. The cumulative effect of the construction will lead to removal of extensive quantities of geological strata (e g Construction of a new neighbourhood) and total obliteration of the geomorphology.

Table 11: Significance of likely impacts on soils

Significance of likely impacts on Soils (Policy AHF4, Policy RCO 29)	
Level of significance	**Criterion**
High	Removal or contamination of sites of scientific importance - Rural conservation Policies RCO11 and RCO12 – accelerated soil erosion
High	Removal and burial or dispersal of substantial quantities of soil without any scope of later remediation
Moderate	Removal and burial or dispersal of small quantities of soil without any scope of later remediation
Low	Development involving removal of minor quantities of soil from sites of no landscape value
Insignificant	Development that do not require the removal of soil

Adverse/Beneficial -Soils	
Assessment	**Criterion**
Highly beneficial	Developments that will protect or enhance sites of scientific importance such as nature trails or geomorphological/geological parks
Beneficial	Developments that will inhibit soil erosion such as the construction of Rubble Walls or terracing
Neutral	Developments that do not involve removal of soil
Adverse	All developments that involve removal of soil are adverse even though they might be small e.g. clearing for the construction of a new house. The cumulative effect of the construction of a new neighborhood will lead to removal of extensive quantities of soil with a high risk of dispersal without any possibility of recovery.

Table 12: Significance of likely impacts on hydrology and hydrogeology

Significance of likely impacts on Hydrology/hydrogeology (Framework Directive 2000/60/EC)	
Level of significance	**Criterion**
Very High	Contamination of the aquifer with liquid fuels. Liquid fuels are very hard to remove from the pores of the aquifer
High	Alteration of the hydrological regime by increase or decrease of run-off which do not reflect the seasonal changes in the hydrological cycle leading to loss in infiltration and percolation of groundwater (Framework Directive 2000/60/EC)
High	Alteration of the hydrological regime of the catchment basin leading to increase of run-off and accelerated hill slope erosion –silting of watercourse
High	Destruction of karst features that promote percolation of run-off
Moderate	Alteration of the hydrological regime of the catchment basin leading to increase of run-off with MRFortunity for mitigation of likely impacts
Low	Development involving minor changes in run-off of a catchment
Insignificant	Development that requires no excavation and/or paving. Excavation may reduce run-off while paving has the opposite effect.

Adverse/Beneficial -- Hydrology/hydrogeology	
Assessment	**Criterion**
Highly beneficial	Developments that will protect or enhance watercourses and catchment basins
Beneficial	Developments that will enhance infiltration
Neutral	Developments that do not involve any changes in the hydrological cycle
Adverse	All developments that involve paving of any type are adverse even though they might be small e.g. excavation for a garage or basement which might seem to be insignificant. The cumulative effect of the construction of a new neighborhood will lead to flooding in the lower reaches of the watercourse

Table 13: Significance of likely impacts on Water Quality

Significance of likely impacts on Water Quality (Framework Directive 2000/60/EC)	
Level of significance	**Criterion**
High	Alteration of the run-off characteristics leading to contamination of surface or groundwater e.g. major oil spills –contamination with organo-metallic compounds such as pesticides, nitrate contamination or contamination involving any other poisonous substance
High	Irreversible contamination of the aquifer
Moderate	Contamination with scope for mitigation
Low	Contamination of groundwater by minor spillages with scope for easy mitigation
Insignificant	Developments where no kind of contaminant is handled

Adverse/Beneficial - Water Quality	
Assessment	**Criterion**

Highly beneficial	Developments for the treatment of run-off or groundwater
Beneficial	Natural Processes that are intended to purify run-off or groundwater such as reed beds.
Neutral	i) Developments that require the catchment of water and recirculation such as turf grass cultivation with underlying membrane to catch excess irrigation water to be recycled. ii)Spillage of freshwater say from a water bowser
Adverse	All spillages/leakages change the quality of groundwater normally by contaminating it and therefore are adverse

Table 14: Significance of likely impacts on Mineral resources

Significance of likely impacts on Mineral resources (Policies Min 1, MIN5 and MIN 6, subject plan Policies HS 3, HS 4, HS 5, HS 6, HS 7 and HS 8, DC1 to DC 22)	
Level of significance	**Criterion**
High	Major excavations that will produce large quantities of mineral resources such as hardstone or the destruction of large reserves of good quality soft stone
High	Sterilisation of large amounts of mineral resources
High	Excavation next to 3rd party property or other interests
Moderate	Excavation /sterilisation of moderate amounts of mineral resources
Low	Excavation /sterilisation of small amounts of mineral resources
Insignificant	Development that requires no excavation/sterilization of mineral resources
Adverse/Beneficial - Mineral resources	
Assessment	**Criterion**

Highly beneficial	Developments that will protect or enhance mineral deposits for posterity
Beneficial	Developments that will recycle mineral resources
Neutral	1a) Developments that do not involve removal of geological strata b)Excavations (moderate) with possibility to fully recycle moderate amounts of stone material
Adverse	a) Sterilisation of mineral resources b) Production of excessive amounts of mineral resources c) Destruction of mineral resources such as conventional excavations in good franka stone d) Production of waste stone material with no scope for recycling

A tabulated summary of the impacts and risks of the proposed development in Maghtab is presented in a tabulated form in **Appendix 3**.

13.5 Monitoring

13.5.1 During Construction

The most important monitoring during excavation is the stability of the walls of the excavation. It is recommended that this be done by an experienced geologist in order to be able to anticipate unstable situations before they occur.

13.5.2 During Operation

Periodic checks of effluents and second class water effluents and other waste disposal systems would ensure that no harmful substances are leaked to the ground. The Groundwater analysis, undertaken as part of the baseline study will constitute a baseline water quality which would serve as a base for future monitoring of the water quality.

13.6 Waste Management Plan (WMP)

In view of the waste stone material that will be generated (44,500m^3), a waste management plan is made available for the construction phase (in particular) and operation phase of the site to cater for the wastes generated during construction and operation of the site.

13.7 Residual Impacts – The Cumulative Effect

Although a development site might be considered to have little impact on each of the components of the Geo-Environment: Geology including mineral resources, geomorphology, palaeontology, geomorphology, soils, hydrology and hydrogeology - the residual impact is always present.

The building of a house or even perhaps a larger development site, nowadays accompanied by excavation for a basement will always be accompanied by:

- Loss in reserves of mineral resources
- Increase in waste stone material
- Loss of geological strata
- Loss of geomorphology
- Loss of soil
- Increase in run-off or decrease depending on availability of storm water storage reservoir/s
- loss of recharge
- loss of groundwater quality - leakage of sewers pollution of run-off e.g. traffic or acid rain
- loss of recharge to the aquifers

All these impacts, arising from a single building or larger development site, might be very small indeed and would cause no significant change to the Geo-Environment when taken on a one –by-one basis. But, collectively they would produce a large complex or a town with all the accompanying cumulative negative impacts on the geo-Environment that are usually associated with towns and large villages.

13.8 Mitigation

13.8.1 Environmental risks and mitigation measures during construction phase

Relevant risks and mitigation measures during the construction phase are listed in table 10 of the Project description statement and are reproduced in Table 15 below.

Table 15: Risks and mitigation measures during Construction

Risk	Mitigation measure
Generation of dust	• Using water or pre-soaking to control dust generation • Removing accumulations of dust on site and on roads accessing the site • Preventing dust and particulates from coming into contact with storm waters • Using barriers and containment over areas where sanding or blasting may be applied • Using blasting and sanding equipment that is equipped with appropriate dust extraction and recovery
Contamination of water	Management of any storm waters accumulating on site during works; avoiding all off-site discharges.

13.8.2 Environmental risks and mitigation measures

Relevant risks and mitigation measures during the construction phase are listed in Table 8 of the Project Description Statement and are listed below.

Table 16: Risks and Mitigation measures during operation

Geology, Geomorphology, Palaenthology, Hydrology, Hydrogeology	**Moderate Adverse** A geological fault traverses across the Scheme site which may cause geotechnical issues during excavations.	Geotechnical borehole testing
	Moderate Adverse Excavation works may require the removal of good quality rock minerals.	Any removed rock minerals should be reused and recycled for backfilling of the site or other projects to minimise loss of mineral resources. If Lower Coralline Limestone is present, it could be used for the production of concrete.

Periodic monitoring of effluents will ensure that there are no losses into the subsurface and eventually into the mean sea level water table.

REFERENCES

- BRGM Study of the Freshwater resources of Malta (1991)
- ATIGA Consortium Wastes Disposal and Water Supply Project Malta **(1972)**
- Continental Shelf Department 2022: Revised Geological Map on scale of 1:10,000
- ERA 2015. The new Strategic Plan for the Environment and Development (SPED)
- J. Edelmann The Conservation of Runoff Water (1968)
- MRA 1999-2000: Annual report
- MRA 2003-2004: Annual report
- MRA 2004, On the Development of "A Water Policy for the Future"
- Lorenz, W. and Gwosdz, W, 2003. Manual on the Geological Technical Assessment of Mineral Construction Materials. Geol. Jb. Sonderhefte, SH15, 498p, 103 figs, 301 tables.
- Malta Environment and Planning Authority 2004, Structure Plan Review Public Consultation
- Hoek E., 2001 Practical Rock Engineering
- Rockscience 2004, DIPS 5 Interactive analysis of orientation based geological data.
- Planning Authority 1990, Structure Plan for the Maltese Islands
- 1996, Mineral resource Assessment
- The 2nd Water Catchment Management Plan for the Malta Water Catchment District, 2015 – 2021 . Sustainable Energy and Water Conservation Unit Environment and Resources Authority
- SEWCU: 2nd Run-of Water Management plan 2015-2020.

14.0 Appendix 1: Table of Geological, Geomorphological and Hydrological Features

Each feature described in this report is listed in a table, together with a short description and if any of the features are absent, this shall be stated

Geological Features		
Feature	Description	Remarks
Lower Globigerina Limestone Mb	Fine pale yellow massive Limestone. Phosphate beds mark its boundary with the overlying Upper Globigerina Limestone and the lower Coralline Limestone below.	
Lower Coralline Limestone	Xlendi Mb: Brown to light brown very coarse Limestone	
	Attard Mb: White very coarse algal limestone	
Quaternary Deposits	Consolidated brown slope scree composed of limestone clasts in a brown soil matrix	
Paleontological features	No particular paleontological deposit exists in the area of influence of the MRF site. Limestones are composed entirely of calcareous fossil flora and fauna.	

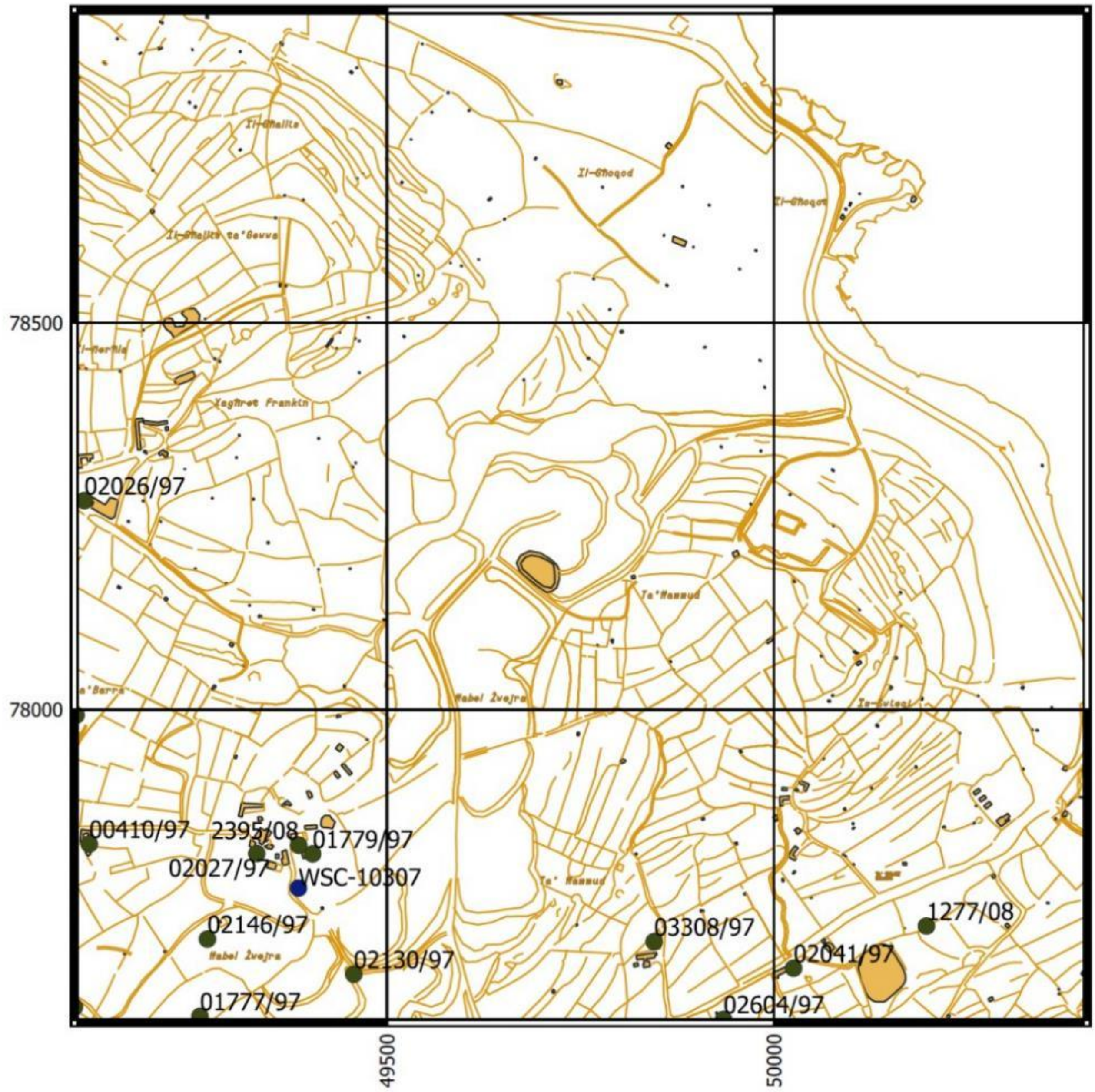
Geomorphological Features		
Feature	**Description**	**Remarks**
Ghallis Uplands	A low hill at il-Ghallis rising above the surrounding lowlands	
Ta Hammud Uplands	A low hill at Ta'Hammud rising above the surrounding lowlands	

Hill slopes	The hill slopes descend to the coastal plain on which the Coast Road is built. The upper sectors are terraced and exposed Lower Globigerina Limestone covered by a thin brown soil bed. The lower reaches of the hillslope expose lower Coralline Limestone and are mostly compose d of bare rock with scattered soil pockets.	
Valleys	The only valley in the area of influence of the MRF site is Wied ta' Kieli which is a broad low valley cut into parcels by rubble walls. No real watercourse exits.	
Rocky Coast-foreshore	The foreshore consists of a low shore platform exposing lower Coralline Limestone. It is rugged and dotted with rock pools the site of a flourishing unique flora and fauna as it has freshwater influence during the rainy season and sea water during storm events.	
Soils	Soil is the loose surface material that covers most land. It consists of inorganic particles and organic matter. Soil provides the structural support to plants used in agriculture and is also their source of water and nutrients. Soils vary greatly in their chemical and physical properties	

Hydrological features		
Feature	**Description**	**Remarks**
Msla	The msla is represented by the lower Coralline Limestone which outcrops on the margins of the Maghtab-Ghallis landfill. An aquifer is a porous and permeable rock that can store and transmit groundwater.	
Wied ta Kieli	The only valley in the area of influence of the MRF site is Wied ta' Kieli which is a broad low valley, cut into parcels by rubble walls. No real watercourse exits.	

Ponds	Two artificial ponds about 50m in diameter are found at the northern exit of the landfill. These fill by runoff from the eastern slopes of the landfill	
Catchment area	The catchment area of a watercourse is the area from which a watercourse collects is runoff. the boundary of the area is called the divide.	
WSC and private wells	Private wells are the boreholes that extract freshwater from the MSLA.	

15.0 Appendix 2 –WSC and Private Boreholes



16.0 Appendix 3- Summary of Impact And Risks During Construction & Operation Of The Organic Processing Facility

Impact type and source			Impact receptor		Effect & Scale							Probability of impact occurring (Inevitable/ Likely/ Unlikely/ Remote/ Uncertain	Overall impact significance	Proposed mitigation measures	Residual impact significance	Other requirements
Impact type	**Specific intervention leading to impact**	**Project phase (construction/ operation/ decommissioning)**	**Receptor type**	**Sensitivity toward impact**	**Direct/ Indirect/ Cumulative**	**Beneficial/ Adverse**	**Severity**	**Physical/ geographic extent of impact**	**Short-/ Medium- / Long-term**	**Temporary (indicate duration)/ Permanent**	**Reversible (indicate ease of reversibility)/ Irreversible**					
Geology: loss of rock strata	Excavation	Construction	Mineral resources	Low	Direct and cumulative	Adverse	High	Localised	Long term	Permanent	Irreversible	Inevitable	Major	Reuse and recycle	Moderate	
Geomorphology: degradation /destruction of surface features	Excavation	Construction	Landscape	Low	Direct and cumulative	Adverse	High	Localised	Long term	Permanent	Irreversible	Inevitable	Moderate	Landscaping of the site/already degraded by landfill	Minor	
Dust Emissions	Excavation	Construction	Landscape	Low	Direct and cumulative	Adverse	Moderate	Localised	Short term	Temporary	Reversible	Unlikely	Minor	Haulage of excavated material in covered trucks	Minor	
Soils	Excavation	Construction	Agriculture and landscape	High	Direct and cumulative	Adverse	High	Localised	Long term	*Temporary- lifetime of MRF plant until site is returned to its original state*	Reversible	Inevitable	Minor	Soil already degraded by landfill	Minor	
Mineral resources	Excavation	Construction	Limestone resources	High	Direct and cumulative	Adverse	High	Localised	Short term	Permanent	Irreversible	Inevitable	Minor	Reuse and recycle	Minor	
Stability of the walls of the excavation	Excavation	Construction	Operatives and 3rd party property	High	Direct	Adverse	High	Localised	Short term	Temporary	Reversible	Uncertain	Major	Monitor closely during excavation and stabilize if necessary	Minor	
Dust Generation	Excavation	Construction	Rock pools and coastal waters	High	Direct	Adverse	Low	Localised	Short term	Temporary	Reversible	Remote	Minor	There should be no stacked excavation material that could be washed away by run-off during the rainy season	Minor	
Silting	Excavation	Construction	coastal waters	High	Direct	Adverse	Low	Localised	Short term	Temporary	Reversible	Remote	Minor			
Spillage due to a major incident during loading/unloading and transport by run-off	Operation of the MRF plant	Operation	Groundwater and coastal waters	Low	Direct	Adverse	Moderate	Localised	Short term	Temporary	Reversible	Unlikely	Moderate	Care during operation of the plant-employ experienced operatives	Minor	
Seawater intrusion due to loss of recharge from the paving of the site	MRF Plant	Operation	Groundwater	Low	Direct	Adverse	High	Localised	Long term	Temporary	Reversible	Unlikely	Moderate	Groundwater beneath the site is brackish. The paved area compared to the potential recharge area is relatively small. Use of 2nd class water for irrigation may indirectly mitigate recharge.	Minor	