TERMS OF REFERENCE ON THE CLOSURE, AFTERCARE AND REHABILITATION OF LANDFILLS AND EXCAVATION VOIDS

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Guidelines on the Closure, Aftercare and Rehabilitation of Landfills and Excavation Voids

May 2021

Report for: **Environment & Resources Authority**

Revision Schedule

Rev	Date	Details	Written by:	Checked by:	Approved by:
00	Dec. 2020	First draft	**Dr Pat Collison** Waste management specialist	**Rachel Decelis** Senior Consultant	**Adrian Mallia** Director
01	Feb. 2021	Final draft	**Dr Pat Collison** Waste management specialist	**Rachel Decelis** Senior Consultant	**Adrian Mallia** Director
02	May 2021	Groundwater updates	**Dr Pat Collison** Waste management specialist	**Rachel Decelis** Senior Consultant	**Adrian Mallia** Director

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Kappara Business Centre
113 Triq Birkirkara
San Gwann SGN 4197
MALTA

Tel. / Fax: 21378172 - 77

Email: info@adi-associates.com
Web: www.adi-associates.com

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EXECUTIVE SUMMARY:

The Environment and Resources Authority (ERA) participated in an Interreg Europe project bearing the name COCOON, and such a project aims to improve regional policy on landfill management through an exchange of best practices and information between participating countries.

Landfills are considered as dynamic stocks of resources (landfill gas, water, other) that can be integrated into the economy, while landfill management (LfM) supports reclaiming land and avoids remediation and aftercare costs. The COCOON objective is to develop, integrate and improve relevant policy instruments, while increasing subsidies through operational programmes (OPs) for LfM projects. COCOON brings together distinct EU regions to share and capitalise on regional good practices.

By applying lessons learnt from other partners concerning the rehabilitation of closed landfills, ERA has developed the first national terms of reference for landfill operators on best practices and procedures to follow for the rehabilitation of landfills (hereafter referred to as ToRs). ERA engaged consultants (ADI Associates Environmental Consultants Ltd.) to assist in the drafting of these ToRs.

Such ToRs are intended to be imposed by ERA in the environment/IPPC permit of the operators issued by ERA or when consulted by the Planning Authority on relevant project or plants, on landfill operators.

These ToRs aim at covering the whole process from closure and after-care of a landfill as well as their rehabilitation, including the following, amongst others:

- Monitoring (*including parameters to be monitored, frequency of monitoring, and the timeframe for monitoring after the closure)* and thresholds;
- Minimum and mandatory landfill cover and capping system to be installed *(which takes into consideration the type of waste disposed of & the landfill dynamics in place since closure);*
- The minimum requirements and conditions to be applied in the rehabilitation of old dumpsites *(i.e. non-engineered landfills and pre-accession to EU landfills); and*
- Criteria for the identification of sites and their possible after-use.

The above were drafted after a review of the methodologies for derivation of threshold and trigger levels for leachate, landfill gas and surface water, taking into consideration the location of the landfill and the wastes accepted, as well as the statutory requirements for landfill cover and surface sealing under the Landfill Directive (1999/31/EC, transposed into national legislation into the Waste Management (Landfill) Regulations, S.L. 549.29), as well

as the monitoring requirements.

Sources of information on historical landfills and known dumpsites in the Maltese Islands, namely information in the historical State of the Environment Reports, were also reviewed.

In addition, guidance, best practice and examples shared through the Interreg Europe COCOON project, on remediation and rehabilitation of landfills closed before accession to the EU or the date of transposition of the Landfill Directive were also reviewed, placing emphasis on best practices and examples which are considered most appropriate in the context to the Maltese Island with respect to criteria including, but not exclusively, climate, geological and hydrogeological setting and proximity to inland surface waters, protected areas and urban/suburban centres of population.

Practical criteria for the identification and characterisation of landfills/dumpsites are also included, together with a framework for identifying potentially suitable after-use classes, based on a risk-based approach. Such an approach takes into consideration the type of waste disposed of (i.e. whether the site contains hazardous waste), landfill dynamics (i.e. evaluation of risk of landfill gas, and stability), and locality criteria (i.e. risk to surface/ground water).

DRAFT TERMS OF REFERENCE

INTRODUCTION

1. This document sets out draft Terms of Reference on the closure, aftercare and rehabilitation of landfills and excavation voids in Malta.

2. These Terms of Reference have been requested by the Environment and Resources Authority (ERA), which is participating in an EU Interreg-funded project called COCOON[1]. As part of Malta's Action plan for the COCOON project, ERA will apply lessons learnt from other partners concerning the rehabilitation of closed landfills into actions by developing the first national terms of reference for landfill operators on best practices and procedures to follow for the rehabilitation of landfills.

3. It is intended that the ERA will apply such terms of reference through:

   - a specific requirement to be included in the environmental / IPPC permit of the operators, issued by ERA; and

   - a condition imposed by ERA referred to the Planning Authority to be included in the development permit under the conditions imposed and enforced by external entities.

Background

4. Since the 1950s Europe has been disposing vast amounts of waste in landfills. Estimates have revealed that 90% of Europe's 500,000+ landfills are "non-sanitary" landfills, which predate the EU Landfill Directive (Council Directive 1999/31/EC as amended) and have limited environmental protection technologies.

5. The European Commission has acknowledged that a vision for managing Europe's landfills is urgently required. Landfills are to be considered as dynamic stocks of resources (such as landfill gas) that can be integrated into the economy, while landfill management (LfM) supports reclaiming land and avoids astronomic remediation and aftercare costs. Although many EU regions are already implementing LfM, no targeted, specific European LfM legislation currently exists. Nor are existing Waste Management and Soil Protection policies integrated into an overarching circular economy framework.

6. Therefore, the COCOON objective is to develop, integrate and improve relevant policy instruments, while increasing subsidies through operational programmes (OPs) for LfM projects. COCOON brings together distinct EU regions to share and capitalise on regional good practices. The targeted policy instruments include:

   - the Soil Remediation Decree in Flanders (Belgium);

[1] COCOON Interreg Europe. https://www.interregeurope.eu/cocoon/.

- the Environmental Protection Act in the Netherlands; and
- funding of LfM projects through the OPs in Andalucía (Spain), Brandenburg (Germany), Cyprus and Malta.

7. As a result of LfM projects, the recovery of resources (landfill gas and water first, other resources later), as well as land recovery is increased while future environmental hazards can be avoided. LfM projects generate economic development opportunities and create new (local) jobs, all within the context of an EU-wide transition to a resilient, low-carbon, circular economy. It is anticipated that the governments of the partner regions directly benefit from the improved policy. Additionally, as LfM contributes to a safe environment and more resource efficiency, other public bodies also benefit from the project, as will companies, knowledge institutes and civilians.

Terms of Reference

8. The Terms of Reference (ToR) for these Terms of Reference are outlined in ERA's call for quotations dated 26th June 2020, as described below:

> *The guidance document should cover the whole process from closure to after-care of a landfill, as well as their rehabilitation, including the following actions which landfill operators must carry out, among others:*
>
> - *Initial baseline tests;*
> - *Monitoring (including parameters to be monitored, frequency of monitoring, and the timeframe for monitoring after the closure) and thresholds;*
> - *Minimum and mandatory landfill cover and capping system to be installed (which takes into consideration the type of waste disposed of & the landfill dynamics in place since closure);*
> - *The minimum requirements and conditions to be applied in the rehabilitation of old dumpsites (i.e. non-engineered landfills and pre-accession to EU landfills). These conditions and requirements are to be elaborated by the consultant; and*
> - *Criteria for the identification of sites and their possible after-use.*
>
> *The consultant must make reference to the good practices shared throughout the Interreg Europe COCOON project. These can be acquired from https://www.interregeurope.eu/cocoon/good-practices/.*
>
> *All the information provided in the guidance document must be in line with the Landfill Directive and any other relevant legislation.*

Methodology

9. A review has been carried out of:

- Statutory requirements for landfill monitoring under the Landfill Directive; and
- Published guidelines and best practice documents, including parameters to be monitored, frequency and timeframe for baseline and post-closure conditions.

10. This review focuses on, but is not restricted to, parameters including landfill gas, leachate, surface and ground water and settlement behaviour of the landfill body.

11. In preparing these draft terms of reference, a review has been carried out of:

- Methodologies for derivation of threshold and trigger levels for leachate, landfill gas and surface water, taking into consideration the location of the landfill and the wastes accepted;
- Statutory requirements for landfill cover and surface sealing under the Landfill Directive; and
- Sources of information on historical landfills and known dumpsites in the Maltese Islands. Where possible, these have been characterised according to size and range of wastes accepted. The documents reviewed have included historical State of the Environment Reports and other reports made available by ERA.

12. Published guidance, best practice and examples shared through the Interreg Europe COCOON project, on remediation and rehabilitation of landfills closed before accession to the EU or the date of transposition of the Landfill Directive were also reviewed. Particular emphasis has been given to those methodologies considered most appropriate to the Maltese Island context with respect to criteria including, but not exclusively, climate, geological and hydrogeological setting and proximity to inland surface waters, protected areas and urban / suburban centres of population.

13. Practical criteria for the identification and characterisation of landfills / dumpsites are put forward, and a framework for identifying potentially suitable after-use classes adopting a risk-based approach to take into account consideration of the type of waste disposed, landfill dynamics and locality criteria, are developed. These criteria are generic, rather than site-specific.

THE MALTESE ISLANDS CONTEXT

Historical Landfills

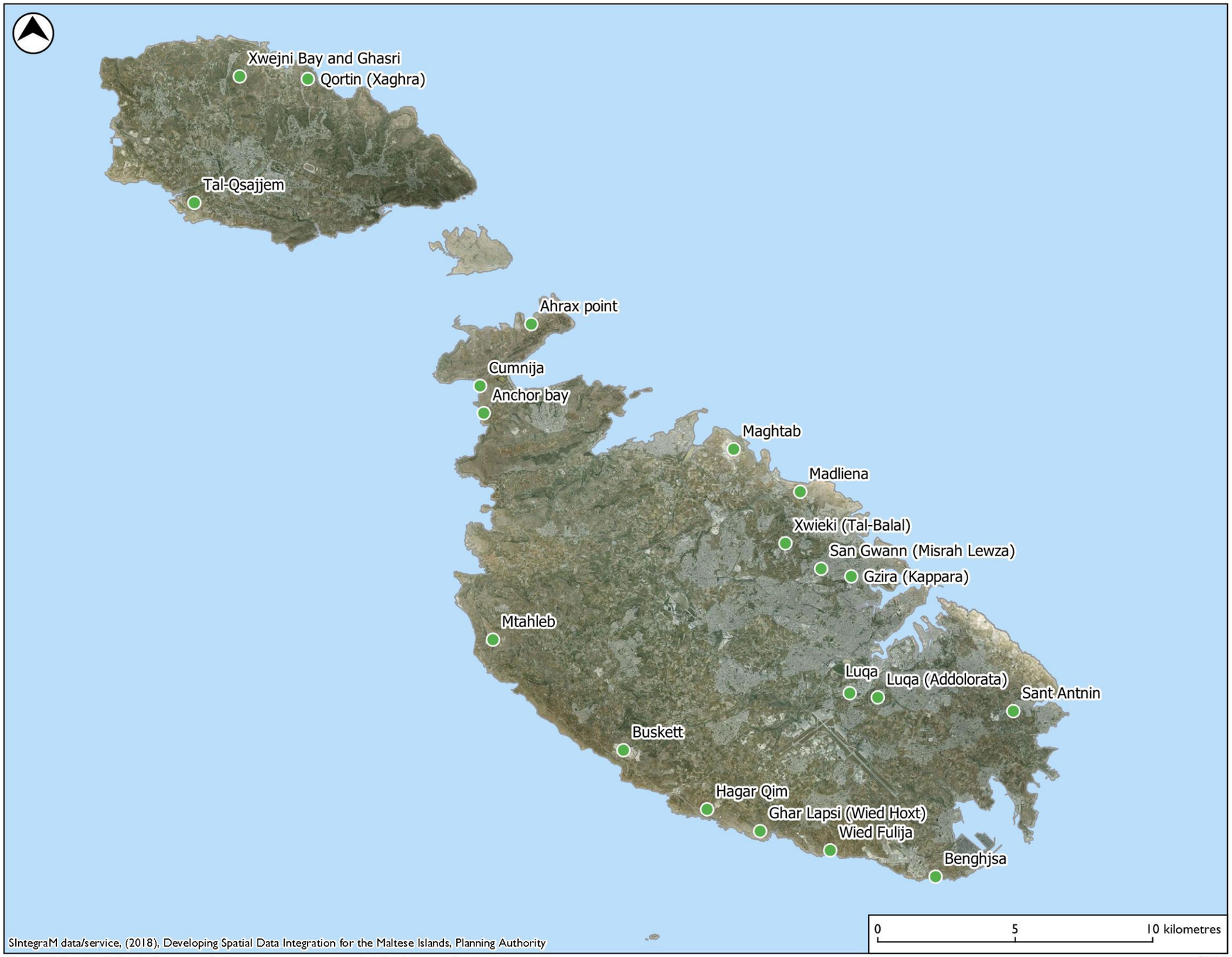
14. The State of the Environment Report for Malta 1998[2] (SOER 1998) highlighted that landfilling has been the traditional way of disposing of waste in the Maltese Islands and identified a number of sites that have served as landfills and for which there exist records. The report stated that most of these sites have been closed down and have either been converted into agricultural land, built upon or just abandoned, such as the Bengħisa site, which served to dump power station fly ash up to 1995,

[2]Axiak V, Mallia E, Gauci V, Schembri P, Mallia A, Vella A. (1999) *State of the Environment Report for Malta 1998.* Environment Protection Department.

the Luqa site, and the Wied Fulija site.

15. The report also stated that a number of unofficial dumps exist around the islands, all of which serve to degrade the landscape and cause all sorts of environmental problems associated with odours, fires, noxious fumes, vermin, and dust. It was reported that dumps include the ones at Iċ-Ċumnija, Anchor Bay, Aħrax Point, between Xwejni bay and Għasri, and at Tal-Balal "among others". Sites known to have served historically as landfills are identified in **Figure 1** and **Table 1**.

Figure 1: Approximate location of historic landfills / dumpsites



Historic landfills / dumpsites

Legend

- Historic landfills / dumpsites

Guidelines on landfill rehabilitation

Map by:

ADI ASSOCIATES

Client: ERA
Ref: ERA002
Date: 12 / 2020

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Table 1: Non-exhaustive list of historic landfills / dumpsites[2,3,4]

Location	Opened-Closed	Main waste types[5]	Area (m^2) in 1998
Luqa	pre-1938 to 1974	M/C, C&D	90,000
Luqa (Addolorata)	?	C&D	?
Ċumnija	pre-1938 to 1990	?	20,300
Gżira (Kappara)	pre-1938 to1958	?	?
San Ġwann (Misraħ Lewża)	pre-1938 to 1960	?	?
Qortin (Xagħra), Gozo	1968 to 2004	M/C, C&D, IND	50,700
Xwieki (Tal-Balal)	1974 to 1976	C&D	Cleared
Sant' Antnin	1974 to 1979	M/C, C&D	?
Ġnien San Pawl	1976 to 1977	C&D	?
Magħtab	1977 to 2004	M/C, C&D, IND	600,000 (in 1997)
Ħaġar Qim	1977 to 1978	C&D	?
Wied Fulija	1979 to 1996	C&D	85,400
Buskett	1979 to 1979	C&D	?
Mtaħleb	1982 to 1985	C&D	?
Għar Lapsi (Wied Ħoxt)	1982 to 1985	?	?
Bengħisa	1995	Power station ash	?
Aħrax point	?	?	13,000 (cleared)
Anchor bay	?	C&D (excavation)	30,000
Xwejni bay / Għasri, Gozo	?	C&D	?
Tal-Qsajjem, Gozo	?	C&D	(Post-1998)

16. Investigations carried out at the Luqa site, and reported[6] as part of development plans for the site, identified significant limestone fill overlying waste fill comprising possibly domestic waste mixed with construction waste or inert fill. This is indicative that, historically, construction and demolition waste comprised a significant proportion of waste deposited in old landfills. The characterisation study of the main body of the Luqa landfill concluded that the fill has been subjected to fires over the years, but that no subterranean temperature or landfill gas were detected at the time of the investigation in 2015.

17. Two official landfill sites were available at the time of the 1998 and 2002[7] SoERs for the landfilling of mixed wastes:

- The Magħtab landfill in Malta (which started operation in 1977); and
- The Qortin landfill in Gozo (which started operation in 1968).

18. However, both the Magħtab and the Qortin landfill remained largely "uncontrolled" landfills, due amongst others to a lack of sufficient control of materials accepted at the site, lack of proper cover material, the absence of surface

[3] Spiteri M (2019). *The Evolution of Landfills in Malta*. COCOON 6th Thematic event in Malta, November 2019.
[4] Other information has been compiled from in-house knowledge.
[5] M/C: Municipal / commercial; C&D: Construction & demolition (may include excavation); IND: Industrial.
[6] Landmark Architects (2109). *Luqa Dump Regeneration Project. Project Description Statement.*
[7] Axiak V, Gauci V, Mallia A, Mallia E, Schembri P, Vella A, Vella L. (2002). *State of the Environment Report for Malta 2002*. Ministry for Home Affairs and the Environment.

runoff and leachate and landfill gas management, and the lack of site rehabilitation plans.

19. The SOER 1998 identified that the Magħtab site accepted a significant proportion of construction and demolition waste, reportedly 744,000 tonnes or 80% of all solid wastes accepted at the site in 1997, increasing to 939,584 tonnes in 2001 (SoER, 2002[8]). A drive to divert construction and demolition waste from the Magħtab site is reported to have resulted in insufficient material to cover putrescible and other waste.

20. Building contractors were responsible for disposing of their waste and, with much of the waste being generated in the north of Malta, this led to the popularity of the Magħtab landfill. In the effort to divert construction and demolition waste from Magħtab a number of disused quarries were identified that could be dedicated to the deposition of construction waste. Eleven disused quarries in Malta and Gozo were licensed for the recycling or deposit of inert wastes in accordance with Legal Notice 128 of 1997, the *Deposit of Wastes and Rubble (Fees) Regulations*. Data provided by licensees indicates that approximately 400,000 tonnes of "mainly" excavation waste were deposited at these sites in 2001 (SoER 2002). Despite this, the SoER 2002 report identified that a number of disused quarries (most in the Siġġiewi / Mqabba area) still operated illegally as dump sites. The SOER 1998 report stated that no data existed regarding the composition of construction and demolition waste, although "visual observation" suggests that its major component (probably more than 90%) was limestone. No reference was made to the remaining fraction and given the apparent lack of regulation, the deposition of a wide range of other wastes, including asbestos-containing building wastes, cannot be ruled out.

21. The Qortin landfill, in common with similar facilities in Malta, was not equipped with leachate collection or gas monitoring and collection facilities. However, a much lower quantity of construction and demolition waste was accepted at this site than at Magħtab, with nearly 50,000 tonnes deposited at the site in 2001 (SoER 2002). It was estimated that 250,000 tonnes of construction and demolition waste per year was generated in Gozo, and this was for the most part fly-tipped. In the 1998 SOER, a quarry at Tal-Qsajjem was identified for immediate use for the disposal of construction and demolition waste, but this did not feature in the list of landfills identified in the 2002 report. In fact, this quarry was permitted but was infilled very quickly.

22. The SoER 2005[9] reported that construction and demolition waste was no longer going to landfill, that a five-year contract had been awarded to rehabilitate disused quarries by infilling with this material, and that between May 2003 and May 2005, 3.3 million tonnes of this material had been deposited in 14 quarries. This was

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[8] Axiak, V. and Debono, H, Gauci, V. (2002). Solid and Liquid Wastes. In: *State of the Environment Report for Malta, 2002*. Ministry for Home Affairs and the Environment.
[9] Malta Environment & Planning Authority (2005). *State of the Environment Report 2005*.

reiterated in the Environment Report 2008[10], which stated that since 1997, construction and demolition waste had been disposed of in various licensed or otherwise disused quarries for the rehabilitation of those quarries, a process stepped up in 2003.

23. It is worth noting here that investigations at the Wied Fulija, Magħtab and Qortin landfills (carried out by Scott Wilson[11]) and into the Luqa landfill (reported by Landmark Architects[12]), identify either existing sub-terranean fires or evidence of previous fires. It is also noteworthy that in none of the investigations to these landfills was free leachate identified. Scott Wilson attributed this to be likely related to high temperatures limiting free leachate generation, sporadic leachate generation related to intense rainfall events and any leachate generated leaving the landfill into the underlying fractured and fissured bedrock. However, Scott Wilson also noted a lack of impacts on groundwater quality, whilst recognising that the investigations reported were carried out during a very dry period and leachate is likely to be generated in the winter season; therefore impacts on groundwater could be seasonal.

Remedial Works

24. Remedial works have been carried out at some sites. he Xwieki site was cleared in 1999 (Spiteri, 2019) and the Aħrax point unauthorised site was reportedly cleared in 2001(SoER 2002); both sites were formerly quarries. It has been reported that the latter site was also used by the Beach Cleaning Section of the Government of Malta for dumping of sea-grass banquettes debris and other material collected from the sandy beaches in the north of Malta. Site investigations[13] carried out in 2017 indicated that the material on site at the time mainly consisted of sand and sea-grass debris, soil and stones / masonry. This study was concluded that the site has not been used for dumping of hazardous material. The site is proposed for re-development for motorsport use, whereas it has been agreed with ERA that a surface clean-up of fly-tipped waste will be carried out. The seagrass debris / sand will be retained on site, and will be used for re-contouring purposes. Additional material will be introduced on site so as to grade and level areas so that through compaction, sufficient stability is achieved in order to withstand stress from vehicles in line with international motorsport guidelines.

25. The ash dump at Bengħisa had reportedly been covered with poor quality topsoil from excavations at the Freeport to reduce dust emissions (SoER 2002) and

[10] Malta Environment & Planning Authority (2008). *The Environment Report 2008.*
[11] Scott Wilson (2004). *Development of Rehabilitation Strategies Maghtab, Qortin and Wied Fulija Landfills.*
[12] Landmark Architects (2019). *Luqa Dump Regeneration Project. Project Description Statement.*
[13] Adi Associates Environmental Consultants Ltd, 2018. PA 02926/16: *Re-Development of Disused Quarry for Motorsport Use at Barriera ta' l-Aħrax, Mellieħa, Malta. Site Report.* San Gwann, December 2018; iii + 15 pp.

subsequently has been rehabilitated for use as a solar farm park.[14,15]

26. It is understood that rehabilitation works have also been carried out at the Magħtab and Qortin non-engineered landfills, which includes capping, slope stabilisation and surface water control measures.[16] Mixed landfill gases are collected from the Magħtab and adjacent Żwejra landfills (see below) and are mixed with fresh air in order to retain a composition suitable for a regenerative thermal oxidiser. The Qortin landfill has a landfill gas extraction system with a flare unit to treat the gas stream. It is also understood that the Magħtab and Qortin landfills have been planted with indigenous Maltese vegetation.[17,18] The Sant' Antnin landfill has been rehabilitated as a family park with passive landfill gas venting. It is understood that 6.5 hectares of the Wied Fulija landfill are undergoing rehabilitation, including surface water management infrastructure, landscaping, planting with indigenous species and paved access for the public to provide access to cliff-top views.

Current Sites

27. Two engineered landfills have been operated since accession to the EU, both within the Magħtab environmental complex. The Ta' Żwejra landfill has been operational from 2004 and the Għallis landfill has been operational since 2006.[19] It is understood that both are still operational and are operated under IPPC permits,[20] although the Ta' Żwejra landfill is nearly full.

28. As of 6 November 2020, there are 36 current permits issued for the backfilling of clean inert wastes, including five valid permits issued under pre-accession legislation (LN 128 of 1997, now S.L.549.07).

Climate

29. The Maltese Islands' climate is summarised in the Malta Water Resources Review[21] (MWRR). The climate is influenced by the regional weather patterns in the Central Mediterranean, and the influence from the surrounding sea, which has a warming

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[14] Spiteri M (2019). *The Evolution of Landfills in Malta*. COCOON 6th Thematic event in Malta, November 2019.
[15] MaltaToday (2020). *Solar farm at Benghisa operating at full capacity, powering 760 household* https://www.maltatoday.com.mt/environment/energy/105241/maltas_first_solar_farm_at_benghisa_operating_at_full_capacity#.X9zCp9hKg2w.
[16] WasteServ (1999). *Landfill Gas Management in the Maltese Islands*. COCOON 7th Interregional meeting in Potsdam, Germany. February 2019.
[17] Sciberras, L. *Good practice: Qortin Landfill Rehabilitation in Gozo*. https://www.interregeurope.eu/policylearning/good-practices/item/1901/qortin-landfill-rehabilitation-in-gozo/.
[18] WasteServ. *Rehabilitated Landfills*. https://www.wasteservmalta.com/en/rehabilitated-landfills.
[19]European Commission. *Factsheet – Malta*. https://ec.europa.eu/environment/waste/framework/pdf/facsheets%20and%20roadmaps/Factshee_Malta.pdf .
[20] ERA. *Waste Management Facilities Permitted to Accept Waste*. https://era.org.mt/topic/permitted-waste-management-facilities/.
[21] Food and Agriculture Organization of the United Nations. (2006). *Malta Water Resources Review*.

influence in winter and a cooling influence during the summer. The climate is typically Mediterranean with mild wet winters and hot, dry summers dominated by high-pressure systems.

30. Precipitation is in the form of rain, hail, dew and soft rime. The long-term (1900-2000) average precipitation rate is approximately 550 mm annually with a high seasonal and inter-annual variability (27 co-efficient of variation), with annual rainfall of 300 mm more or 250 mm less than the average being common. The majority of rainfall takes place between October and February. Rainfall events are typically characterised by single storms of relatively short duration. This often results in runoff taking place over a short period, during and immediately following the storm event, and surface water flows in the beds of major valleys occurs for a few days only.

Geology and Hydrogeology

31. The geology is also summarised in the MWRR. The formations comprise Tertiary and Quaternary deposits. The islands are mainly composed of two porous and fissured limestone units: the Lower Coralline Limestone and immediately overlying Globigerina Limestone (which underlie the majority of the islands), and the Upper Coralline Limestone (which occupies the higher ground on the west of Malta and east of Gozo). The two units are considered aquifers, separated by the thin Greensand and thicker Blue Clay, which acts as an aquitard, although it is considered that karstic development and faulting reefs allow leakage from the Upper Coralline Limestone to the Globigerina / Lower Coralline Limestone aquifer below.

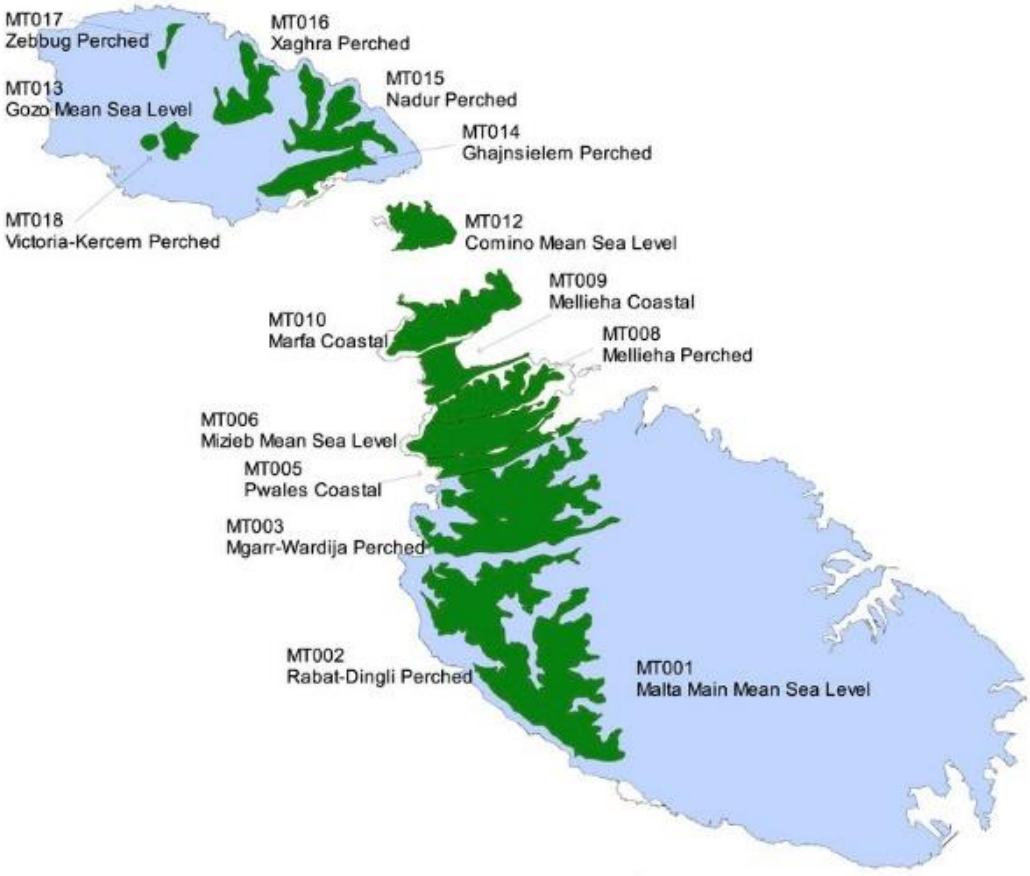
32. The Lower Coralline aquifer is in lateral and vertical contact with sea water, but lower density freshwater forms a lens above saltwater, referred to as the mean sea level aquifer. This aquifer is a lens-shaped water body reaching some 2.5 m above sea level in central Malta and thinning out to zero thickness at the coastline. Infiltration to the mean sea level aquifer is predominantly through fissures in the overlying Globigerina Limestone, which functions only as an aquifer where highly fractured.

33. Northeast-southwest faulting in the northern part of Malta leads to the formation of different aquifer units largely independent of each other, with limited groundwater yield.

34. In the islands of Gozo and Comino, the Lower Coralline Limestone aquifer sustains a sea level aquifer over the whole island except for a small region around the harbour of Mgarr in the south-eastern part Gozo. The Upper Coralline Limestone outcrops in geographically separate areas of Gozo, giving rise to separate aquifer blocks sustaining distinct bodies of groundwater. Essentially, the entire Maltese Islands are underlain by aquifers.

35. Malta's 2nd Water Catchment Management Plan (WCMP)[22] identifies 15 bodies of groundwater in the Maltese Islands, as shown in **Figure 2**.

Figure 2: Groundwater bodies in the Malta River Basin District[23]



36. The Water Policy Framework Regulations identify as 'protected areas' those bodies of water that are utilised for the abstraction of water intended for human consumption. In the Malta Water Catchment District the bodies of water used for such purpose are shown in **Figure 3**.

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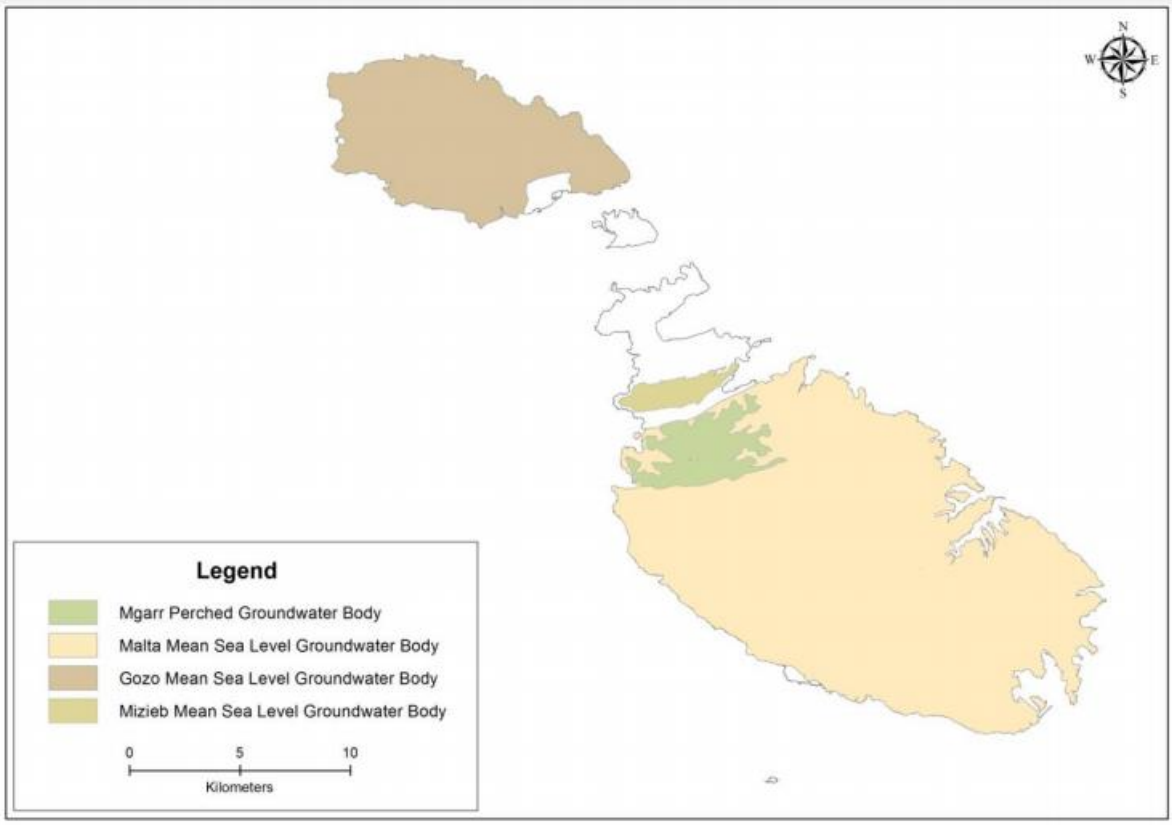
[22] Sustainable Energy and Water Conservation Unit, Environment and Resources Authority. *The 2nd Water Catchment Management Plan for the Malta Water Catchment District 2015 – 2021*. https://era.org.mt/wp-content/uploads/2019/05/2nd_Water_Catchment_Management_Plan-Malta_Water_in_Maltese_Islands-3.pdf.

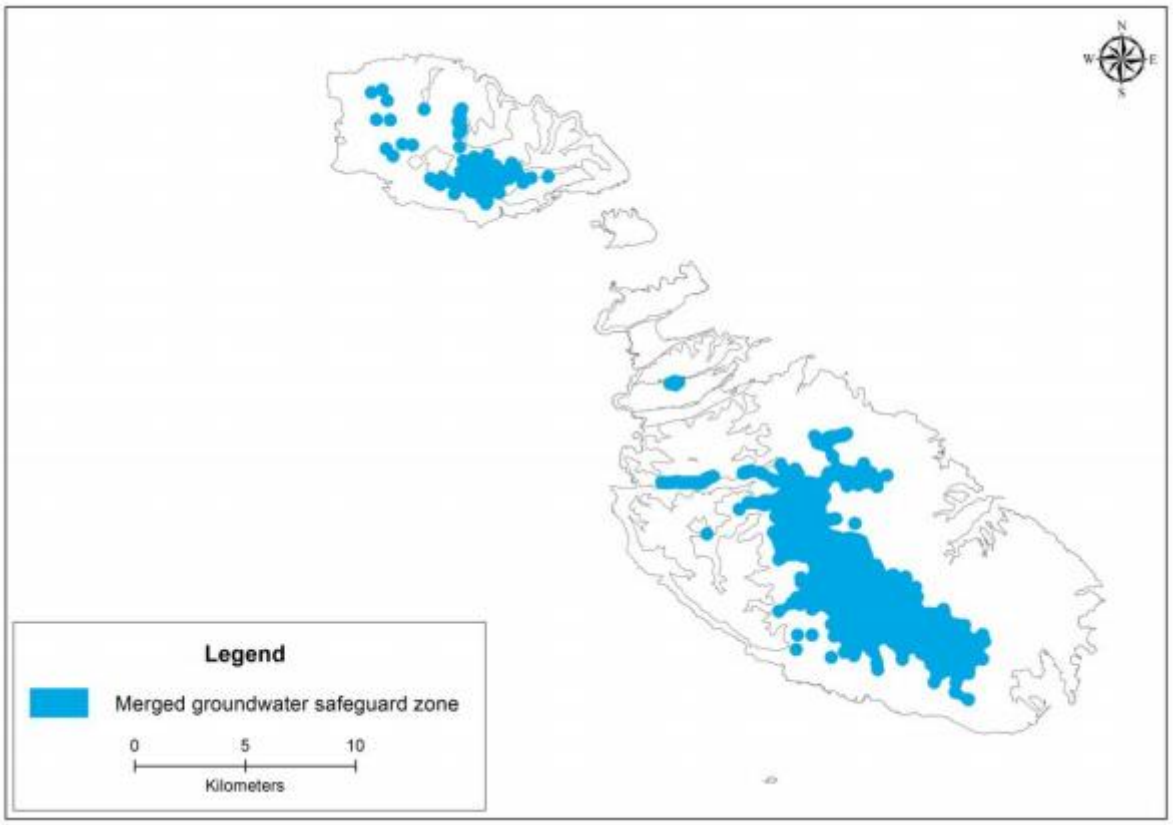
[23] Adapted from: Spiteri D, Valdramidis VP, Scerri, C (2015). *The Current Situation for the Water Sources in the Maltese Islands*. Journal of Health Sciences 2(1):22-25 https://www.researchgate.net/publication/281006114_THE_CURRENT_SITUATION_FOR_THE_WATER_SOURCES_IN_THE_MALTESE_ISLANDS.

Figure 3: Groundwater bodies used for the abstraction of water intended for human consumption



37. Under the *Water Policy Framework Regulations*, S.L.549.100, the Ministry for Energy, Enterprise and Sustainable Development is responsible for implementing measures to prevent the deterioration of the status of water bodies and for establishing drinking water safeguard zones insofar as inland water is concerned. Inland water is defined as "*all standing or flowing water on the surface of the land, and all groundwater on the landward side of the baseline from which the breadth of territorial waters is measured*." It is noted that the Regulations distinguish between "protected areas", which include whole groundwater bodies, and "safeguard zones", which are specific areas of the groundwater bodies where protection measures are more focused. Malta's 2nd WCMP identifies a safeguard area established by defining a 300 m radius from public groundwater abstraction sources, as shown in **Figure 4**. All developments located within the 300 m of the merged safeguard zones are required to implement additional pollution protection measures, such as the additional lining of waste management facilities to limit accidental discharges.

Figure 4: Groundwater safeguard zone[22]



LEGAL REQUIREMENTS

Legislation relevant to Pre-Accession Non-Engineered Landfills, Void Spaces of Excavated Sites and Inert Landfills

38. Prior to 1997, the only controls of note with respect to waste management were:

- the Development Planning Act 1992, which introduced a formal development control and the issuing of planning permission, thus indirectly controlling the siting and design of waste management facilities; and
- the Environmental Protection Act 1991 (Act V of 1991), which required an environmental impact assessment of developments "*of an industrial or any other nature*" and enabled the Minister to "*grant special permits under particular conditions for the disposal and dumping on land of certain substances*", without specifically mentioning waste.

39. The State of the Environment Report for Malta (1998) concluded that:

> *"Waste practices in Malta cannot be referred to as waste management, as this term has come to be defined in developed countries. Such practices in the Maltese Islands are unsustainable in so far that material and land resources are not being conserved, and future generations are being burdened with waste-related problems created by this generation.*

Current legislation does not reflect corresponding state-of-the-art environmental legislation in developed countries. The main shortcomings are as follows:

- *archaic and fragmented legislation*
- *lack of effective incentives to encourage preferred waste management options, rather than landfilling*
- *any controls that exist are incidental and not conducive to the sustainable management of waste".*

40. The Deposit of Wastes and Rubble (Fees) Regulations, 1997[24] (now S.L. 549.07) prohibited the deposit of rubble, waste or hazardous waste in any site unless it is a waste deposit site, and any person who is the owner of a site used for the deposit of such waste must be in possession of a licence. The Regulations also required the licence holder to be covered by an insurance policy against environmental damage, with the cover decided according to the vulnerability of the aquifer where the waste is deposited.

41. The Waste Management (Permit and Control) Regulations, 2001[25] under the Environment Protection Act (Cap. 435), introduced after-care obligations on permit holders following the cessation of waste management sites. Upon closure or ceasing operations, the competent authority shall assess the site, particularly in relation to physical stability, any contamination, the presence of any residues and the presence of any discharges that require management. Following that assessment, the competent authority could confirm and bring into effect after-care obligations and require the permit holder to take such additional measures, rehabilitation and monitoring, with the permit holder bound by the after-care obligations "*for such a period as it may stipulate, notwithstanding that the permit holder has ceased to operate or he no longer holds the permit*". These obligations are transferred to the new owner in the event of a change in ownership.

42. The Waste Management (Landfill) Regulations, 2002 (LN 168 of 2002, now S.L.549.29) reinforced aftercare and monitoring requirements for landfill gas, leachate and ground and surface water regime as long as the competent authority considers that a landfill is likely to cause a hazard to the environment. Although introduced prior to EU accession, the Regulations introduced elements of the EU Landfill Directive, introducing requirements for geological barriers and leachate and landfill gas control, and specifying monitoring requirements including the concept of trigger levels for considering adverse changes in groundwater quality (discussed in the next section).

43. The Prevention and Remedying of Environmental Damage Regulations 2015

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[24] LN 128 of 1997 under the Environment Protection Act 1991 Fees Ordinance (Cap. 35) and Water services Act 1991, Deposit of Wastes and Rubble (Fees) Regulations, 1997, as amended.
[25] LN 337 of 2001, revoked by the Waste Regulations, S.L.549.63.

(S.L.549.97) implement Directive 2004/35/CE[26] on environmental liability with regard to the prevention and remedying of environmental damage. These Regulations apply to waste management operations, including the collection, transport, recovery and disposal of waste and hazardous waste, including the supervision of such operations and after-care of disposal sites subject to permit or registration under the Waste Regulations, operation of landfill sites under the Waste Management (Landfill) Regulations and the management of extractive waste pursuant to the Waste Management (Management of Waste from Extractive Industries and Backfilling) Regulations. The Regulations do not apply to:

- damage caused by an emission, event or incident that took place before the 30th April 2007;
- damage caused by an emission, event or incident that takes place subsequent to the 30th April 2007 when it derives from a specific activity that took place and finished before the said date; or
- damage, if more than thirty (30) years have passed since the emission, event or incident resulting in the damage occurred.

44. Significantly, these exclusions apply to most of the former landfills / dumpsites identified previously.

45. Where environmental damage has occurred, the competent authority can require the operator to bear the cost of restoring the damaged natural resources and, or services to, or towards, baseline condition. The operator may not be liable for the cost where he demonstrates that he was not at fault or negligent and that the environmental damage was caused by an emission or event expressly authorised by, and fully in accordance with the conditions of, an authorisation conferred by or given under relevant laws and regulations. The operator may also not be liable for costs for an activity that the operator demonstrates was not considered likely to cause environmental damage according to the state of scientific and technical knowledge at the time when the emission was released, or the activity took place.

46. The Action on Illegal Deposit of Material on Land and Illegal Reclamation of Land Regulations 2019 (S.L.552.29) apply to any land subject to enforcement action under CAP. 552 (the Development Planning Act 2016), relating to, inter alia, the illegal deposit, dumping or tipping of any material on land that appears on the Planning Authority's aerial photographs of 2012, but not appearing on aerial photographs of 1994. The regulations make provision for the Environment and Resources Authority to identify the most suitable regeneration method for land subject to enforcement action. The regulations require the person subject to the enforcement to submit a method statement describing, *inter alia*, how the offending material is to be removed from site and any mitigation measures to contain as

[26] Directive 204/35/CE of the European Parliament and of the Council of 21 April 2004 on environmental liability with regard to the prevention and remedying of environmental damage.

much as possible the pollution of terrestrial, underground or marine water bodies.

47. In respect of inert waste deposited in quarries, until the introduction in Malta of the planning system in the early 1990s, the control of quarries rested with the Police Licencing system. Such Licences included few conditions and no provision for effective site restoration (although it is noted that the generation of excavation waste was uncommon at the time, since many developments did not include significant excavation). From 1992, many quarries started to be brought within the control of the then Planning Authority (later the Malta Environment and Planning Authority (MEPA)), and new development permits provided for comprehensive controls. However, the restoration standards applied to sites being issued with new development permits did not apply to the older sites. However, general conditions applicable to all quarries were introduced at this time through the police licensing mechanism. These conditions included a requirement for site restoration once the minerals in the quarry are exhausted.

Legislation Relevant to Post-Accession Sites

48. Following accession, Council Directive 1999/31/EC of 26 April 1999[27] on the landfill of waste were brought into force by the Waste Management (Landfill) Regulations 2002 (S.L.549.29).

49. Landfills, as defined in the Waste Management (Landfill) Regulations, receiving more than 10 tonnes of waste per day or with a total capacity exceeding 25,000 tonnes (excluding landfills of inert waste) are further covered by the Industrial Emissions (Integrated Pollution Prevention and Control) Regulations 2013 (S.L.549.77), herein referred to as 'the IPPC Regulations'.

50. The Għallis and Ta' Żwejra landfills fall within these legal requirements, and are permitted by IPPC permits IP 0001/06/C and IP 0001/05/C respectively.

51. The IPPC Regulations require that, where the activity involves the use, production or release of hazardous substances, the operator must prepare a baseline report before starting operation of an installation (or before a permit for an installation is updated for the first time after 7 January 2013), having regard to the possibility of soil and groundwater contamination at the site.

52. The IPPC Regulations require the permit to include conditions for the regular maintenance and surveillance of measures taken to prevent emissions to soil and groundwater and appropriate requirements concerning the periodic monitoring of soil and groundwater in relation to relevant hazardous substances likely to be found on site, having regard to the possibility of soil and groundwater contamination. The approved Environmental Monitoring Programme for Għallis and Ta' Żwejra includes a requirement for regular monitoring of soil and groundwater; it is noted that the Għallis and Ta' Żwejra landfills are only authorised to accept non-hazardous waste.

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[27] Directive 1999/31/EC of the European Council of 26 April 1999 on the Landfill of Waste.

53. The IPPC Regulations also require the operator, upon definitive cessation of the activities, to assess the state of soil and groundwater contamination by relevant hazardous substances used, produced or released by the installation. Where the installation has caused significant pollution of soil or groundwater by relevant hazardous substances compared to the state established in the baseline report, the operator shall take the necessary measures to address that pollution so as to return the site to that state. Where the contamination of soil and groundwater at the site poses a significant risk to human health or the environment as a result of the permitted activities, the operator shall take the necessary actions aimed at the removal, control, containment or reduction of relevant hazardous substances, so that the site, taking into account its current or approved future use, ceases to pose such a risk.

54. The competent authority may also require the provision by the operator of a suitable financial guarantee to secure the obligations under the permit or registration, before the permit or registration is issued. The financial guarantee may be tied to specific requirements in the permit.

55. The backfilling of inert waste generated by the construction industry in depleted quarries is regulated under the Waste Management (Management of Waste from Extractive Industries and Backfilling) Regulations 2009 (S.L.549.50) – Part VII (Backfilling Into Excavation Voids), and the Waste Regulations, 2011 (S.L.549.63). The permits also provide for a number of monitoring obligations, which operators are to fulfil throughout the validity of the permits.

56. The waste authorised to enter these sites is restricted to the European Waste Catalogue (EWC) codes listed in **Table 2**.

Table 2: Inert waste that may be accepted in quarries[28]

EWC code	Description
01 01 02	Waste from mineral non metalliferous excavation
01 04 08	Waste gravel and crushed rocks except those mentioned in 01 04 07 (wastes containing dangerous substances from physical or chemical processing of non-metalliferous minerals)
01 04 09	Waste sand and clays
01 04 13	Wastes from stone cutting and sawing except those mentioned in 01 04 07
17 01 01	Concrete
17 01 02	Bricks
17 01 03	Tiles and ceramics
17 01 07	Mixtures of concrete, bricks, tiles and ceramics other those mentioned in 17 01 06
17 02 02	Glass
17 05 04	Soil and stones (excluding topsoil, peat; excluding soil and stones from contaminated sites)

57. The Waste Management (Activity Registration) Regulations (SL 549.45) grant permission for certain classes of activities not covered by other legislative

[28] ERA (2020). *Quarries*. https://era.org.mt/era-topic-categories/quarries/.

provisions. Amongst the classes permitted is the reclamation of derelict land, subject to a development control permit, by the spreading of waste consisting of soil and rock on any land in connection with the reclamation or improvement of that land, if:

- by reason of industrial or other development the land is incapable of beneficial use without treatment;
- the spreading results in benefit to agriculture or ecological improvement; and
- the waste is spread at a depth of no more than two metres.

MONITORING REQUIREMENTS

Pre-Accession Non-Engineered Landfills, Void Spaces of Excavated Sites, and Inert Landfills

58. There are no monitoring requirements set down under the Deposit of Wastes and Rubble (Fees) Regulations 1997, and Police Licences for quarries did not set monitoring requirements for backfilling either. However, the Regulations require the applicant for a waste deposit to be covered by an insurance policy for environmental damages resulting from the deposit of rubble, waste or hazardous waste by whatever means, with the proviso that if the aquifer is damaged and the damages exceed the sum covered by the insurance policy the applicant is responsible for the additional costs. Damages would be estimated also on the loss of production of water as well as on all remedial works to reverse the damage.

59. Guidance from the UK Environment Agency[29] on surrender of environmental permits considers monitoring and completion criteria for sites that were operational before the implementation of the Landfill Directive and contain wastes that pose a lower risk to the environment, which were historically called "inert wastes". The guidance recognises that definitions of "inert" have changed across different regulatory regimes but describes low-risk sites as having low leaching potential and low gassing potential. For those sites in non-sensitive environmental settings and having strong evidence that the waste types are inert and have not accepted significant quantities of biodegradable or leachable wastes, no further testing may be required.

60. If following a review of the existing waste records, it cannot satisfactorily be demonstrated that the waste has a low leaching or gassing potential, samples of the waste from the site can be taken for analysis to demonstrate that it has a low leaching or low gassing potential. Sampling must extend throughout the site, both across its full area and through the entire depth of the waste; the number and the extent of samples must be collected according to a programme designed to ensure that the samples are representative of the contents of the site.

[29] Environment Agency (2012). EPR 5.02 *Landfill and other permanent deposits of waste. How to surrender your environmental permit. V2*.

61. The Environment Agency guidance states for that for sites that have good records of having accepted wastes only with a low leaching and gassing potential, but which are located on a principal aquifer, in a source protection zone, less than 100 m from a surface water course or are less than 250 m from a potential landfill gas receptor it is recommended that monitoring to assess the impact from leachate is carried out quarterly, for a minimum of two consecutive years, and monitoring to assess the impact from landfill gas should be undertaken at least monthly for a period of 6 months. The Environment Agency definition of principal aquifers is those aquifers providing significant quantities of drinking water and water for business needs. The Malta Water Policy Framework Regulations do not differentiate between principal and secondary aquifers, but as described above and shown in **Figure 4** establishes ground water safeguard zones (GSZ). It is proposed that the criteria above be applied to sites lying within a GSZ, within 100 m of a watercourse or to habitats directly depending on water.

62. For sites where there is uncertainty on the waste types based on available records, and the site lies on protected areas, i.e. all those areas shown in **Figure 3**, or more than 250 m from a landfill gas receptor, the site should be subject to a site investigation to assess the leaching or gas potential of the waste, or demonstrate by risk assessment that there is a suitable barrier to prevent pollution or deterioration of the status of water bodies. Samples of the waste should be taken from throughout the site, both across its full area and through the entire depth of the waste. To characterise the deposited waste, the guidance recommends a combination of:

- visual inspection of the waste;
- an assessment of the odour of the waste, to check for the presence of organic pollutants; and
- chemical analysis for the concentration of the common pollutants within soils including metals, salts, and organic substances.

63. The components listed in **Table 3** are recommended as a basis for the assessment.

Table 3: List of potential pollutants

Metals (1)	**Other**(1)	**Organic (indicators)**(2)
Antimony (Sb) Arsenic (As) Barium (Ba) Cadmium (Cd) Chromium (Cr) Copper (Cu) Lead (Pb) Mercury (Hg) Molybdenum (Mo) Nickel (Ni) Selenium (Se) Zinc (Zn)	Chloride (Cl) Fluoride (F) Sulphate (SO_4) Total dissolved solids (TDS) Dissolved organic carbon (DOC) Phenol index	Total Organic Carbon (TOC) BTEX (Benzene, toluene, ethylbenzene and xylenes) Polychlorinated biphenyls (PCBs) Mineral oil (C10 to C40) Polycyclic aromatic hydrocarbons (PAHs)
From the Council Decision 2003/33/EC, Annex, paragraph 2.1.2 (1) Leaching limit values BS EN 12457:2002 (2)Total concentration		

Due to the high proportion of construction and demolition waste in historical landfills, it is also recommended here that an asbestos screen is carried out on samples.

64. For sites where there is uncertainty on the waste types deposited based on available records, or it cannot be demonstrated that the waste is of low leachate or gas potential and the site lies less than 250 m from a potential landfill gas receptor, it is recommended that landfill gas should be monitored for a minimum of two consecutive years with at least two occasions when the atmospheric pressure is below 1000 mb and falling. Gas monitoring must represent the full depth of the waste that has a potential to produce gas. Landfill gas monitoring should be undertaken from permanent monitoring points installed within the waste at a frequency of no less than two boreholes per hectare, with a minimum of four boreholes per site. If the site is located in a GSZ or lies less than 100 m from a surface water course or habitats directly depending on water, monitoring of the groundwater and any surface waters both up gradient and down gradient of the site is recommended for a minimum of two consecutive years to assess the risk to water from leachate. The 2011 Water Catchment Management Plan considered pollutants that threshold values should be set for and included chloride, sulphate, ammonium, lead, arsenic and conductivity, with a recommendation for copper and zinc to be considered. Fluoride is naturally present in the mean sea level aquifer and not typically found in significant concentrations in leachate, so is not considered appropriate as an indicator. Additionally, threshold values are set on a risk-based approach and can be revised following the undertaking of the 6-yearly surveillance monitoring programme as well as the pressures and impacts assessments as part of the River Basin Management Plan (RBMP) process. Hence monitoring frameworks might need to be revised according to developments in the RBMPs. The WPF requires the monitoring of core parameters pH, oxygen content and nitrate in addition to conductivity and ammonium. The Landfill Regulations (S.L.549.29) recommend pH, Total Organic Carbon (TOC), phenols, heavy metals, fluoride, arsenic, and oil / hydrocarbons as indicator parameters.

65. Taking into account the Landfill Regulations, the Water Catchment Management Plan and the Protection of Groundwater Against Pollution and Deterioration Regulations (S.L.549.53) it is recommended here that parameters for groundwater monitoring and investigations should include, at a minimum, pH, chloride, conductivity, sulphate, ammonium, arsenic, cadmium, chromium, copper, nickel, lead and TOC. However, it is also recommended that a risk-based approach be adopted taking into account additional indicator parameters following characterisation of the wastes.

66. Where historic monitoring data are absent or inadequate, characterisation monitoring may need to be carried out, using monitoring locations representative of conditions unaffected by the landfill.

67. The length and gradient of slopes at the site should be reviewed to determine the likelihood of failure using an appropriate stability assessment for the level of risk posed by the slope. A slope stability analysis is not required for shallow slopes.

Post-Accession Landfills

68. Environmental permits for inert wastes issued under the Environmental Protection Act in accordance with the Waste Management (Management of Waste from Extractive Industries and Backfilling) Regulations, include a condition requiring the Permit Holders to conduct any monitoring programme/s "*as may be required by the Authority after consultation with the Malta Resources Authority*" to ensure that the quality of groundwater in the area is not compromised in the event of an environment hazard. A further condition requires, when the Authority deems it necessary, that prior to the cessation or closure of the site, the Permit Holder must carry out any monitoring tests as indicated by the Authority, which will determine whether the Permit Holder can be released from the obligation of the permit. However, no monitoring requirements are presented in the permits.

69. The Waste Management (Landfill) Regulations require the operator of a non-hazardous or hazardous waste landfill to carry out a control and monitoring programme in the operational phase of a landfill and in the post-closure period as long as the competent authority considers the landfill is likely to cause a hazard to the environment. The minimum requirements are as shown in **Table 4.**

Table 4: Emission data: water, leachate and gas control

Parameter	**Operation phase**	**After-care phase(2)**
Leachate volume (only where leachate collection takes place)	Monthly (1)(2)	Every six months
Leachate composition(3) (only where leachate collection takes place)	Quarterly(2)	Every six months
Volume and composition of surface(4) water	Quarterly (2)	Every six months
Potential gas emissions and atmospheric pressure(5) (CH_4, CO_2, O_2, H_2S, H_2, etc.)	Quarterly(2) (6)	Every six months(7)

(1) The frequency of sampling could be adapted on the basis of the morphology of the landfill waste in tumulus, buried, etc. This has to be specified in the permit.

(2) If the evaluation of data indicates that longer intervals are equally effective, they may be adapted. For leachates, conductivity must always be measured at least once a year.

(3) The parameters to be measured and the substances to be analysed vary according to the composition of the waste deposited; they must be laid down in the permit document and reflect the leaching characteristics of the waste.

(4) On the basis of the characteristics of the landfill site, the competent authority may determine that these measurements are not required.

(5) These measurements are related mainly to the content of organic material in the waste.

(6) CH_4, CO_2, O_2 regularly, other gases as required, according to the composition of the waste deposited, with a view to reflecting its leaching properties.

(7) Efficiency of the gas extraction system must be checked regularly.

Protection of Groundwater

70. Monitoring is required of groundwater likely to be affected by the discharge of waste, with at least one measuring point upstream and two downstream of the site. The selection of parameters to be monitored should take into account site-specific conditions such as expected leachate composition, groundwater quality in the area and mobility in the groundwater zone, with recommended parameters in the Waste Management (Landfill) Regulations of pH, TOC, phenols, heavy metals, fluoride, arsenic and oils / hydrocarbons. The information from these investigative monitoring networks should also be reported under the Water Framework Directive (in the RBMPs).

71. UK guidance on monitoring of leachate, groundwater and surface water[30] takes into account the Landfill Directive. The guidance describes the use of:

- Indicator parameters, to provide more frequent monitoring of measurements specified for compliance purposes, with parameters selected from the results of initial characterisation monitoring, and including parameters capable of indicating impacts of leachate, such as ammoniacal nitrogen, chloride and total organic carbon (TOC); and

- Ongoing characterisation measurements: a periodic repeat of the same parameters but at a lower frequency.

72. To provide consistency with threshold values for groundwater quality discussed in paragraph 63 above and in the final section below, it is recommended here that the minimum range of parameters for groundwater monitoring should include, pH, chloride, conductivity, sulphate, ammonium, arsenic, cadmium, chromium, copper, nickel, lead and TOC, together with any additional indicator parameters on a risk based approach following characterisation of the wastes.

73. The minimum frequency identified in the Waste Management (Landfill) Regulations is given in **Table 5**.

Table 5: Groundwater monitoring

Parameter	Operation phase	After-care phase
Level of groundwater	Every six months(1)	Every six months(1)
Groundwater composition	Site-specific frequency(2)(3)	Site-specific frequency(2)(3)

(1) If there are fluctuating groundwater levels, the frequency must be increased.

[30] Environment Agency (2003). *LFTGN02: Guidance on Monitoring of Landfill Leachate, Groundwater and Surface Water*.

(2) The frequency must be based on possibility of remedial actions between samplings if a trigger level is reached, i.e. the frequency must be determined on the basis of knowledge and the evaluation of the velocity of groundwater flow.

(3) When a trigger level is reached, verification is necessary by repeating the sampling. When the level has been confirmed, a contingency plan (laid down in the permit) must be followed.

74. The Landfill Regulations require sampling to be carried out in at least three locations before filling operations to establish reference values for future sampling. UK guidance recommends that samples taken for this purpose are to be taken from at least one upstream and two downstream locations.

75. Furthermore, the IPPC Regulations 2013 require that, where the activity in an IPPC site involves the use, production or release of relevant hazardous substances and having regard to the possibility of soil and groundwater contamination at the site of the installation, the operator must prepare and submit to the competent authority a baseline report before starting operation of an installation (or before a permit for an installation is updated for the first time after 7 January 2013). The baseline report must contain the information necessary to determine the state of soil and groundwater contamination so as to make a quantified comparison with the state upon definitive cessation of activities.

76. For non-inert post-accession landfills in Malta, monitoring regimes for landfill gas, leachate, groundwater, surface water and other emissions are established and regulated by the site's IPPC permit.

Topography of the Site: Data on the Landfill Body

77. To ensure the placement of waste on the site takes place in such a way as to ensure stability of the mass of waste and associated structures, particularly in respect of avoidance of slippages, the Waste Management (Landfill) Regulations require the minimum monitoring regime in **Table 6**.

Table 6: Landfill body monitoring

Parameter	**Operation phase**	**After-care phase**
Structure and composition of landfill body (1)	Yearly	
Setting behaviour of the level of the landfill body	Yearly	Yearly reading
(1) Data for the status plan of the concerned landfill: surface occupied by waste, volume and composition of waste, methods of depositing, time and duration of depositing, calculation of the remaining capacity still available at the landfill		

CAPPING AND COVER REQUIREMENTS

Review of Cover Systems and Remediation Strategies for Pre-Accession Landfills / Dumpsites

78. There are no legal requirements specifying cover for pre-accession landfills.

79. Whilst it is acknowledged that the requirements of the Prevention and Remedying of Environmental Damage Regulations will not apply to many former dumpsites due to temporal limitations, the criteria for remedial measures within those Regulations are worthy of note, namely:

> *"The necessary measures shall be taken to ensure, as a minimum, that the relevant contaminants and emissions are removed, controlled, contained or diminished so that the contaminated land, taking account of its current use or approved future use at the time of the damage, no longer poses any significant risk of adversely affecting human health or the environment. The presence of such risks shall be assessed through risk-assessment procedures taking into account the characteristic and function of the soil, the type and concentration of the harmful substances, preparations, organisms or micro-organisms, their risk and the possibility of their dispersion."*

80. It is reasonable, therefore that the requirement for, and specification of, capping requirements for pre-accession landfills or dumpsites should be determined by risk assessment consistent with the spirit of the Regulations, notwithstanding they may not be enforceable due to temporal limitations. The Regulations go on to specify the criteria to be taken into account in the choice of remedial options (which could include cover requirements). The Regulations state that remedial options should be evaluated, using best available technologies, based on the following criteria:

> *(a) the effect of each option on public health and safety,*
>
> *(b) the cost of implementing the option,*
>
> *(c) the likelihood of success of each option,*
>
> *(d) the extent to which each option will prevent future damage, and avoid collateral damage as a result of implementing the option,*
>
> *(e) the extent to which each option benefits to each component of the natural resource and, or service,*
>
> *(f) the extent to which each option takes account of relevant social, economic and cultural concerns and other relevant factors specific to the locality,*
>
> *(g) the length of time it will take for the restoration of the environmental damage to be effective,*
>
> *(h) the extent to which each option achieves the restoration of site of*

the environmental damage,

(i) the geographical linkage to the damaged site.

81. The possibility of natural recovery is also to be taken into consideration, and the decision should be taken to undertake no further remedial measures if the cost of the remedial measures that would need to be taken to reach baseline conditions (or similar levels) would be disproportionate to the environmental benefits to be obtained.

82. As pointed out by the Swedish Environmental Protection Agency[31], the contents of a landfill are often extremely heterogeneous. The waste can vary both between different parts of the landfill and within the same part. Different contaminants can occur in different parts of the landfill. The particle size can also vary from fine-grained ashes and filter dust to large building components and different processes can run at different speeds in different landfills and within different parts of a landfill. The heterogeneous properties of the waste must therefore always be taken into account in risk assessments.

83. As identified previously, common practice in the Maltese Islands was to deposit mixed wastes along with a high proportion of construction wastes. Over time, deposits of biodegradable wastes are likely to have compacted due to a combination of degradation, fires and 'self-compaction' as a result of overlying construction and demolition wastes. For smaller sites and those sites situated in high-value land locations, removal of all or part of the wastes may be physically and economically viable and this approach has been proposed for the Luqa landfill, which is located in an industrial area. A support tool is currently under development in Belgium to aid decision making in landfill enhanced mining projects[32]. However, for larger former landfills, smaller sites in rural areas with lower land values, and those where the environmental risks can be mitigated by remediation *in situ*, landfill mining is less likely to be viable, and the cost and environmental impacts associated with landfill mining may outweigh the benefit. Studies in the Netherlands[33] concluded that landfill mining does not improve soil quality and does not significantly reduce costs for monitoring and aftercare; this is based on the Dutch philosophy of risk reduction and that installation of clean cover materials meets the legal requirements whilst enabling interim land-uses such as solar parks before completion criteria are met.

84. Remedial options involving minimum disturbance of the wastes will be subject to risk assessment, discussed in the next section, but, depending on the nature of the waste and the site locality, may include grading and installation of some form of cap and surface water run-off control to minimise infiltration (hence leachate

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[31] Swedish Environmental Protection Agency (2011) *Basis for guidance regarding inventory, investigation and risk classification of old landfills*. 2-0902-0098.
[32] Van Raemdonck M (2019) *Cedalion and Orion, a decision support tool for dynamic landfill management. COCOON Good Practices.*
[33] Mars JF (2019) *NAVOS: Remediation Strategies for Former Landfills in the Netherlands. COCOON Good Practices.*

generation), and landfill gas control. The Landfill Directive recommendations for capping (see below) include an 'impermeable mineral layer' for non-hazardous landfills (if a landfill does not meet inert waste criteria and generates landfill gas, albeit at low concentrations, it is reasonable to assume it can be considered as, at least, non-hazardous). However, as the Scottish Environment Protection Agency (SEPA) points out[34], mineral layers cannot be impermeable but will have a certain permeability depending on the mineral used and the field conditions. It goes on to say that capping systems design should be based on quantified calculation of the infiltration characteristics over the full life cycle of the landfill in context with the meteorological conditions and other aspects of engineered control systems including gas management.

85. Scott Wilson reviewed potential capping systems as part of the development of rehabilitation strategies for the Magħtab, Qortin and Wied Fulija landfills on behalf of WasteServ Malta[35]. They considered three types of mineral liner: clay caps, bentonite enhanced sand (BES) and geosynthetic clay liners (GCL). They concluded that whilst these would be effective in reducing infiltration and potential impacts on groundwater from leachate production, each have limitations. With respect to clay caps, they noted the scarcity of locally derived clay (restricted to Blue Clay), and that the potential for drying out and fissure formation in the semi-arid climate could allow landfill gas emissions and air and water ingress. Similar concerns were raised regarding BES and GCL. In the absence of suitably derived clay minerals, the costs associated with importation of suitable materials was also a factor. Synthetic caps such as flexible membrane liners (FML) were also considered, but it was considered they could be compromised by the occurrence of near surface heating due to subterranean fires, and steep slopes would prevent the installation of restoration materials over the cap without significant reprofiling to reduce the slope angles.

86. A compacted cap formed from suitable waste materials (limestone waste) was also considered by Scott Wilson, either by processing and replacing or *in-situ* compaction using heavy mobile plant. The efficacy of this to minimise air ingress and rainfall infiltration is uncertain, as it would depend on the nature of the materials available. Environmental impacts associated with either excavating or processing materials, and compaction equipment would also have to be taken into account.

87. The use of an evapotranspiration cap was also considered by Scott Wilson, comprising thick restoration soils and abundant planting to minimise infiltration. This could also increase the potential for oxidation of methane from the waste. However, this would entail significant quantities of restoration soils which may be difficult to source. Other authors[36] have suggested the practice may be particularly suited to southern Europe, where precipitation is low, but also identified that the

[34] SEPA (2003). *Interim Technical Guidance Note. Capping for Landfill Sites.*
[35] Scott Wilson (2004) *Development of Rehabilitation Strategies Magħtab, Qortin and Wied Fulija landfills. Doc No D100242/WM/43*
[36] Stock U (2019). *Evapotranspiration-optimized Capping Systems.* COCOON Good Practices.

requirement for good quality soil to a thickness of >1.5 m is likely to be a constraint.

88. Capillary-interrupting surface sealing systems have also been suggested.[37] These comprise a two-layer system with coarse-grained soil beneath and sand on top, in which the water is held due to the matrix potential, resulting in the pores in the upper layer being partially filled with water with no water in the coarse-grained material. The hydraulic conductivity in the unsaturated state is much higher in the upper layer and, with suitable gradients, the water flows to the edge of the landfill drainage system. It is suggested that this technique may be most appropriate in southern European regions with low precipitation rates and smaller landfills containing non-hazardous wastes. However, ISWA[38] point out that filter stability is important, that the two materials should have a distinct particle size distribution, and that no particles should intrude into the capillary block or it would impair the functioning (which is likely to impact on cost and constructability). In addition, the distribution of precipitation and corresponding conditions in the soil must be considered, and the system must be covered with a minimum 1 m of restoration soils. Whilst coarse-grained materials may be available in the Maltese Islands context and may even be derived by processing materials from the site, the availability of suitable sand and thick restoration soils may limit opportunities. Generation of topsoil by incorporation of compost derived from waste materials into subsoils has been suggested, but this will require careful quality control to ensure that the material is free from foreign matter such as plastics, that the composting process is complete, and the nutrient content and demand will need to be determined to avoid nutrient leaching[39].

89. The requirements for landfill gas control will be dependent on the composition of gases and the rate of generation. Low permeability caps can be effective in reducing surface methane emissions and odours associated with landfill gas, and reducing air ingress where active gas extraction is carried out. However, as Golder Associates[40] point out, hazards associated with lateral gas migration are likely to be most significant from unlined sites in close proximity to residential receptors when low permeability capping has been installed with no effective gas collection system installed. In assessing best available techniques, Golder Associates concluded that control of emissions by oxidation or biofiltration may be the most appropriate technique where methane concentrations are below 10% to 15%. Gebert[41] promotes biological methane oxidation systems incorporated into the cap where landfill gas generation is too low for economically viable technical gas treatment, although it is also suggested that this may be less sustainable in regions with low

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[37] Abel S (2019). *Capillary-interrupting Surface Sealing Systems on Landfills.* COCOON Good Practices.
[38] ISWA (2019). *Landfill Operations Guidelines*. 3rd Edition.
[39] Abel S (2019). *Surface Capping: Construction of Topsoil by Incorporation of Compost.* COCOON Good Practices.
[40] Golder Associates (2011) *Management of Low Levels of Landfill Gas*. Prepared for the Irish Environmental Protection Agency.
[41] Gebert J (2019). *Methane Oxidation Systems for the Biological Treatment of Weak Gas*. COCOON Good Practices.

precipitation and long dry seasons. The Environment Agency[42] also identified preventing drying of packed beds, which results in biofilm die-off and loss of gas treatment, as a significant issue in biofilters. They suggest that, whilst this can be avoided by wetting the gas fed into the filter, because of the careful control required for optimum gas treatment, biofilters are regarded as high maintenance systems.

Post-Accession Landfill Requirements

90. The Landfill Regulations make provision for the competent authority to prescribe a surface sealing, if it finds that the prevention of leachate formation is necessary after consideration of the potential hazards to the environment. Recommendations for the surface sealing are as shown in **Table 7**.

Table 7: Recommended surface sealing

Landfill category	**Non-hazardous**	**Hazardous**
Gas drainage layer	Required	Not required
Artificial sealing liner	Not required	Required
Impermeable mineral layer	Required	Required
Drainage layer greater than 0.5 m	Required	Required
Top soil cover greater than 1m	Required	Required

91. The Regulations also require that measures be taken to control the accumulation and migration of landfill gas and that landfill gas must be collected from all landfills receiving biodegradable waste. It can be implied from this that capping is required to control the migration of landfill gas.

92. However, there is no recommendation for surface sealing for inert landfills. In addition, the competent authority may decide, on the basis of an assessment of environmental risks, that collection and treatment of leachate is not necessary or, if it has been established that the landfill poses no potential hazard to soil, groundwater or surface water, the requirements above may be reduced accordingly. The Regulations are consistent with the Landfill Directive.

[42] Browell D, Georges M, Pawson D, Shughnessy J (2009). *Control of Landfill Gas Containing Low Concentrations of Methane*. Environment Agency Science Report SC030305/SR2.

CRITERIA FOR CHARACTERISATION OF SITES AND THEIR POSSIBLE AFTER-USE

Criteria Considered for Site Identification and Characterisation

93. A system for the classification of landfills in rural areas has been adopted in Brandenburg, Germany,[43] using parameters including the kind of waste, the area and volume of the waste deposit, and whether the site is in a drinking water protection area. The classification scheme gives rise to four classes: A1, A2, B1 and B2, with A1 being the least potentially polluting, with sub-classes for class A2 based on waste volumes (the smallest class being <25,000 m^3), drinking water protection area classification and the presence of sensitive uses. Broad remediation guidelines are proposed for each category, ranging from the minimum of collecting scrap and bulky waste from the surface, profiling the surface to aid run-off and installing a recultivation layer, through to full compliance with the Landfill Directive.

94. The Environment Agency guidance EPR 5.02 also considers criteria for surrender of permits for low-risk landfills. The guidance considers that for Landfill Directive-compliant inert waste landfills, surrender can be accepted where it can be demonstrated that waste acceptance controls have been complied with during the life of the site. For Landfill Directive-compliant landfills for inert waste from a single source, such as mining or quarry waste, demonstration of the inert nature of the waste at source may be adequate. For pre-Landfill Directive inert waste landfills, an assessment of the leaching and gassing potential is necessary, with:

- Type A being those sites with well-characterised waste and strong evidence that the waste types in the site are inert, such as inert uncontaminated soils, clean minerals and single source wastes with known low biodegradable or leachable content; and

- Type B sites being those where the waste is poorly characterised, having come from various sources over a long period before the Landfill Directive definition of inert waste, and including construction and demolition waste.

95. The second part of the surrender assessment considers the site sensitivity. Where a Type A site is located on a groundwater safeguard zone or less than 250 m from a landfill gas receptor, the leaching and / or gassing potential of the waste must be considered. If the waste can be demonstrated to be of low leaching potential and / or gas concentrations in the waste can be demonstrated to be below 5% carbon dioxide and 1.5% methane, surrender can be considered.

96. For Type A sites in a groundwater source protection zone, or Type B sites lying on groundwater safeguard zone or greater than 250 m from a landfill gas receptor, it must be demonstrated by risk assessment that there is a suitable barrier to prevent pollution. Alternatively, the results of groundwater monitoring must demonstrate

[43] Stock U (2109). *Brandenburg Policy: Classification of Closed Landfills with Small Volume in a Rural Area*. COCOON Good Practices.

that ground and surface waters are not being impacted by leachate, and / or landfill gas concentrations are similar to background levels, below 5% carbon dioxide and 1.5% methane, or between 5% and 10% carbon dioxide and 1.5% and 5% methane with a maximum gas flow rate of 0.7 litres/hour, for surrender to be accepted.

97. For Type B sites lying on a groundwater safeguard zone or source protection zone, or within 100 m of a surface water course, or less than 250 m from a landfill gas receptor, a comprehensive investigation must be carried out on ground water quality upstream and downstream of the site, to confirm the site is having no impact on ground or surface water quality. Landfill gas must also be monitored to demonstrate it fits the criteria outlined previously.

98. Any site falling outside the above criteria is considered as higher risk and standard surrender conditions are required. It is necessary to demonstrate from the results of monitoring that the conditions are stable and that control measures for leachate, landfill gas and settlement are no longer necessary.

Proposed Risk-Based Framework for Site Classification in the Maltese Islands

99. From the review of historical pre-accession landfills in Malta, it is considered that many accepted a high proportion of construction and demolition wastes, often comprising waste stone, although the co-deposit of organic wastes and demolition materials potentially contaminated with asbestos cannot be ruled out. Where organic materials have been deposited, degradation and combustion are likely to have taken place, with, as a generalisation, the older sites most likely to have undergone most stabilisation, although, again, site-specific conditions, such as depth of deposit, will impact on the ingress of air, which will speed up degradation. Additionally, at some sites (e.g. Magħtab, Bengħisa), hazardous waste is known to have been accepted.

100. Bearing the above in mind and taking into account the Maltese Islands' context, the following route to classification of pre-accession landfills is suggested, although a degree of caution and 'common' sense is to be applied in interpretation. The below is intended as a framework or guide rather than as a 'rule-based' procedure; if there are grounds for concern in respect of a particular site, then a more cautious risk-based approach should be taken, which also weighs the environmental benefits of taking a more conservative approach against the costs of doing so.

101. It is noted that these criteria are applicable to pre-accession landfills, as well as any quarry fill sites that had waste deposited in them post-accession (2004), before they were regulated under the Waste Management (Management of Waste from Extractive Industries and Backfilling) Regulations 2009 (S.L.549.50), or the Waste Regulations 2011 (S.L.549.63), or a site-specific environmental permit. However, the below criteria do not apply to IPPC sites, as they are governed both by the requirements of the Landfill Directive and post-closure requirements under their permits, together with planning conditions relating to their restoration and aftercare.

102. The proposed framework for site classification in the Maltese Islands is summarised

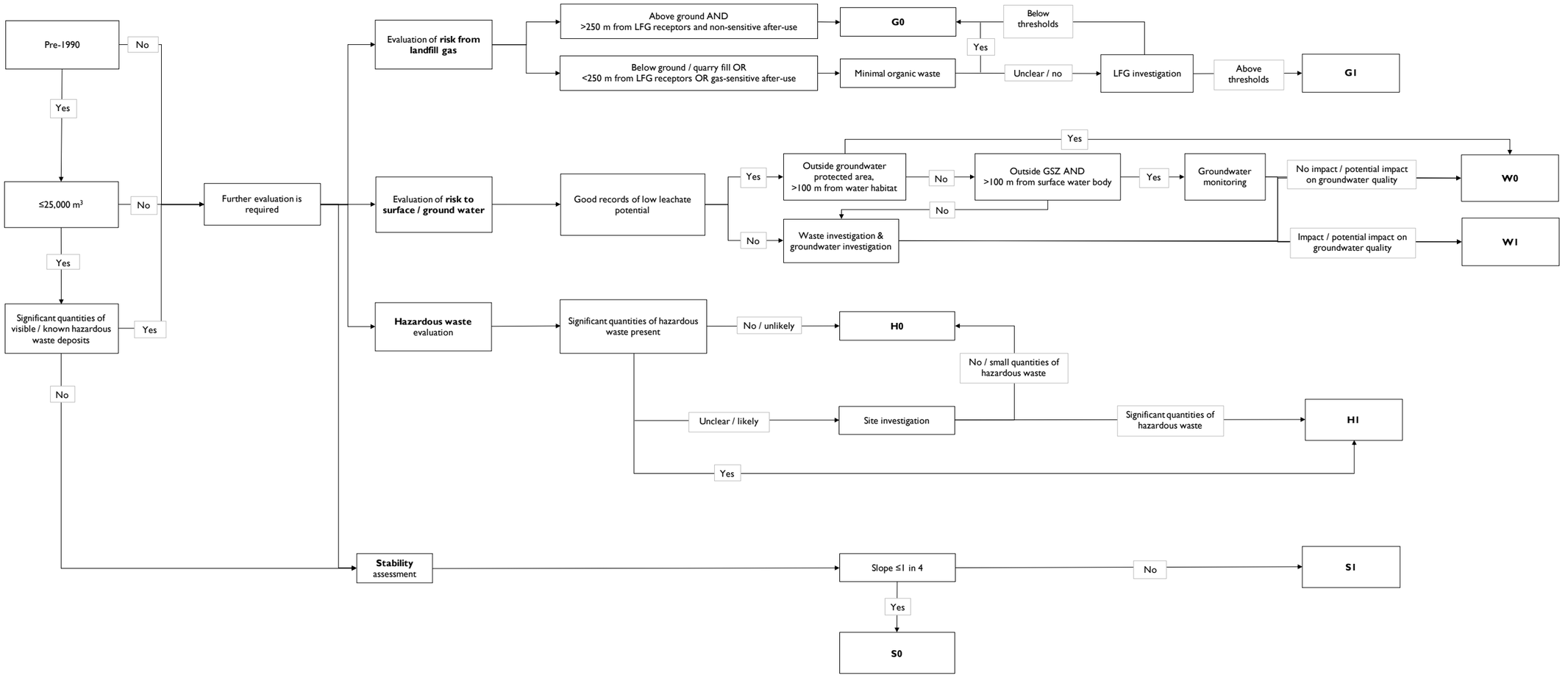
in **Figure 5**.

103. The decision-making process takes into account the following criteria:

- The source term including:
    - The nature of the deposited waste;
    - The age of the deposit;
    - The current polluting potential or impact;
    - The volume of waste deposited;
    - The characteristics of the deposit site (above / below ground); and
    - The landform;
- The sensitivity of the environment:
    - Whether located in a groundwater safeguard zone (GSZ) or within 100 m of a watercourse or habitats directly depending on water;
    - Proximity of the site to landfill gas-sensitive receptors[44]; and
    - Potential after-use of the site.

[44] Landfill gas-sensitive receptors include residences, vegetation, and underground surfaces where landfill gases could accumulate (such as wells, covered reservoirs, and other confined spaces).

Figure 5: Proposed decision tree for site classification



N.B. A landfill may be classified under more than one category (e.g. Both G1 and W1), therefore more than one type of remedial action may be required.

Lowest-Risk Sites

104. Consistent with a risk-based approach, this framework identifies a category of lowest-risk sites, consisting of sites that:

- Did not receive waste after 1990; this year was selected as the cut-off date due to: the likelihood of degradation of most of the non-hazardous organic waste having taken place after 30+ years, and for consistency with the Prevention and Remedying of Environmental Damage Regulations 2015 (S.L.549.97) which do not apply if more than 30 years have passed since the emission, event or incident resulting in the damage occurred;
- Do not have more than 25,000 m^3 of deposited waste; and
- Do not contain significant quantities of hazardous waste.

105. Therefore, where it can be identified with reasonable confidence that the waste materials were deposited before 1990, for example by records, comparison of topographic surveys or aerial photography, an estimate of the volume of waste should be made. If the volume of waste is not more than 25,000 m^3, then a visual inspection of the site surface should be undertaken to confirm that no large quantities of hazardous waste have been deposited.

106. For sites that do not meet each of the above criteria, further assessment is required, comprising the evaluation of all of the following aspects, as described in detail further on:

- Risk from landfill gas;
- Risk to surface water and groundwater;
- The presence of hazardous waste; and
- Stability of the landfill.

107. However, for sites meeting all three criteria to be classified as lowest-risk sites, the only assessment required would be an evaluation of the stability of the site.

Evaluation of Risk from Landfill Gas

108. For sites that are not classified as having the lowest risk, if it can be demonstrated, again by desk study or by limited investigation (such as a walkover survey, with possible limited trial pit excavation to demonstrate the depth of fill) and topographic survey, that:

- the waste was deposited 'above ground', rather than into former quarries or topographic lows such as valleys; and
- there are no properties or other landfill gas-sensitive receptors within 250 m of the site boundary, and the site is not proposed for a landfill gas-sensitive use;

then the site may be classified as G0, and only minimal remedial action is required in order to prepare the site for its after-use. This could include collecting scrap

material and bulky waste from the surface, and removal of any material / waste that could interfere with the planned after-use of the land.

109. However, if the waste was deposited below ground (or within a quarry), or the site lies within 250 m of a landfill gas sensitive receptor, or the intended use is sensitive to landfill gas, then further investigation or records will be required to satisfy that the wastes are not producing, or likely to produce landfill gas. In the case of those sites with a permit for inert wastes, comprehensive records may suffice, and the site can be classified as G0. In other cases, investigation of the wastes and landfill gas monitoring will be required.

110. If the investigation of landfill gas demonstrates the concentration of carbon dioxide is consistently less than 5% and the concentration of methane consistently less than 1.5% (for example adopting the criteria in Environment Agency EPR 5.02),[45] or below background levels in the surrounding strata, the site may also be classified as G0. If the hazardous gas (i.e. methane and CO_2) concentrations are above that, but less than 10% carbon dioxide and less than 5% methane and the maximum hazardous gas flow rate is 0.7 litres/hour (as defined by BS8485:2007) and the maximum total gas[46] flow rate in any borehole is less than 70 L/h, the site may, again, be classified as G0.

111. If the landfill gas concentrations exceed the thresholds described above, the site should be classed as G1 and measures must be incorporated into the remediation programme to control landfill gas emissions and, in particular, minimise the potential for lateral landfill gas migration. In addition, it is recommended that landfill gas monitoring boreholes be installed between the site boundary and any sensitive receptor, and a programme of routine monitoring initiated.

Evaluation of Risk to Surface Water and Groundwater

112. For sites that are not classified as having the lowest risk, if there are good records of wastes only of low leaching potential and the site lies outside a groundwater protected area and greater than 100 m from a habitat depending directly on groundwater, the site may be classified as W0, requiring only surface treatment to encourage surface water run-off and drainage measures to direct surface water away from the waste mass; these measures serve to reduce the likelihood of contamination of the surface water, and avoid erosion of the surface by heavy rain.

113. For sites with good records of wastes of low leaching potential that lie within a groundwater protection area, but outside a Groundwater Safeguard Zone (GSZ), and lie more than 100 m from a surface water body (including seasonal and ephemeral), groundwater monitoring should be carried out for a minimum of two consecutive years. If the results of the investigation demonstrate no significant likelihood or actual impact on ground water quality, the site may be classified as W0 with respect

[45] Environment Agency (2012) *Additional guidance for Landfill (EPR 5.02) and other permanent deposits of waste: How to surrender your environmental permit.*
https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/321656/LIT_5144.pdf

[46] Including other gases such as nitrogen and oxygen.

to groundwater.

114. For sites for which there are inadequate records to demonstrate that only wastes of low leaching potential have been deposited, or if the site lies within a GSZ or 100 m of a surface water body (including seasonal and ephemeral), it will be necessary to demonstrate by site investigation that the wastes deposited are of low leaching potential, and groundwater monitoring should be carried out for a minimum of two consecutive years to demonstrate the site is not causing an impact on groundwater quality. If the results of the investigation demonstrate no significant likelihood or actual impact on ground water quality, the site may be classified as W0 with respect to groundwater.

115. If the above investigation identifies the site has the potential or is having an impact on groundwater quality when compared with threshold values, the site should be classified as W1 and measures should be incorporated in the remediation scheme to limit leachate production and migration.

116. The 2nd Water Catchment Management Plan (2016) considered that threshold values should be set for chloride, sulphate, ammonium, lead, arsenic and conductivity, with a recommendation for copper and zinc to be also considered. Fluoride is naturally present in the mean sea level aquifer and not typically found in significant concentrations in leachate, so it is not considered appropriate as an indicator. As mentioned previously, the Groundwater Regulations recommend monitoring of pH, TOC, phenols, heavy metals, fluoride, arsenic and oils / hydrocarbons in groundwater.

117. The recommended parameters for W1 investigations, taking into account the two sets of monitoring requirements are therefore: pH, chloride, conductivity, sulphate, ammonium, arsenic, cadmium, chromium, copper, nickel, lead and TOC. In considering trigger levels for the Għallis and Żwejra non-hazardous landfills, Adi Associates[47] adopted Maltese and Italian Drinking Water Criteria Values, consistent with the approach taken in the 2nd Water Catchment Management Plan[48]. Threshold values for sea-level groundwater bodies, perched groundwater bodies and coastal groundwater bodies have been established as part of the 2nd Water Management Catchment Plan taking into account the background quality and use for different aquifer units (either drinking water standards or criteria values for irrigation water) and are presented in **Table 8**.

Table 8: Groundwater threshold values in Malta

Groundwater Body	Threshold Values
Sea-Level Groundwater Bodies	
MT001 Malta Mean Sea Level MT006 Mižieb Mean Sea Level MT012 Kemmuna Mean Sea Level	Chloride: 1000 mg/L Sodium: 450 mg/L Boron: 0.6 mg/L

[47] Adi Associates Environmental Consultants Ltd, 2020. *Ghallis & Zwejra Non-Hazardous Landfills, Malta North Waste Treatment Plant.* Environmental Monitoring Programme. San Gwann, November 2020; vi + 75 pp. + 4 Appendices.

[48] SEWCU, ERA. *The 2nd Water Catchment Management Plan for the Malta Water Catchment District*.

Groundwater Body	Threshold Values
MT013 Gozo Mean Sea Level	Sulphate: 475 mg/L Conductivity: 4500 µS/cm
Perched Groundwater Bodies	
MT002 Rabat Dingli Perched MT003 Mgarr-Wardija Perched MT008 Mellieħa Perched MT014 Għajnsielem Perched MT015 Nadur Perched MT016 Xagħra Perched MT017 Żebbug Perched MT018 Victoria-Kerċem Perched	Chloride: 210 mg/L Sodium: 160 mg/L Boron: 0.5 mg/L Sulphate: 190 mg/L Conductivity: 2000 µS/cm
Coastal Groundwater Bodies	
MT005 Pwales Coastal MT009 Mellieħa Coastal MT010 Marfa Coastal	Chloride: 500 mg/L Sodium: 450 mg/L Boron: 1 mg/L Sulphate: 475 mg/L Conductivity: 3000 µS/cm
All groundwater bodies in the Maltese River basin District	Lead: 10 µg/L Copper: 2 mg/L Zinc: 3 mg/L

118. It should be noted that threshold values are not published for all the parameters suggested in the previous paragraph. As identified in guidance published by the UK Environment Agency[49], in these circumstances, an appropriate environmental assessment level should be developed having regard to baseline groundwater chemistry; this approach has the advantage of taking into account the existing local pressures on groundwater, compared to the approach of using reference values from other countries such as Italy. It is not possible for historical landfills to determine baseline groundwater quality, if baseline measurements were not undertaken. The assessment must therefore either take into account previously published baseline data from the same aquifer unit (bearing in mind that groundwater deterioration has occurred throughout the Maltese Islands[50] irrespective of potential contamination from landfills), or current data from a borehole located upstream of the site with respect to the anticipated groundwater flow direction. Where upstream groundwater quality is established as being above the threshold value due to other sources of contaminants, this must be taken into account when assessing the impact of the landfill.

119. With the exception of landfill mining to remove the source, and those sites meeting the Landfill Directive criteria with basal and side engineered barriers, there is little scope for the prevention of leachate escape from the base of the waste deposits, and the remediation options are likely to be limited to minimising infiltration. If the impact is significant, a low permeability capping system may be required, but, as discussed previously, there are limited natural sources of low permeability materials likely to be available. If the impact / potential impact is low, a remediation scenario focussed on

[49] Environment Agency (2003). *LFTGN01: Hydrological Risk Assessments for Landfills*.
[50] Hartfiel, L, Soupir, M. Kanwar, R.S. (2020). Malta's Water Scarcity Challenges: Past, Present, and Future Mitigation Strategies for Sustainable Water Supplies, *Sustainability*, MDPI, 12, 1-17.

achieving a landform to achieve adequate gradients to encourage run-off (between 1:20 and 1:3 slopes) and drainage systems designed to direct water away from the waste mass, together with revegetation of the surface with native species to encourage evapotranspiration may be considered.

Hazardous Waste Evaluation

120. A walkover of the site and a review of available records are to be carried out to assess whether the site is likely to have accepted significant quantities of hazardous waste, such as asbestos cement products, fly ash, used grit, or industrial sludge. If the conclusion is that the no disposal of significant quantities of hazardous waste occurred at the site, or that such disposal would have been unlikely, then the site is classified as H0, requiring only minimal intervention to prepare the site for its after-use (as per G0).

121. However, if it is unclear whether (or even likely) that the site accepted significant quantities of hazardous waste, then a site investigation would need to be carried out to confirm this or otherwise. Depending on the type and quantities of waste suspected to have been disposed of at the site, the nature of the investigation could range from a simple trenching exercise (using a grab excavator or similar), to coring and testing for the analytes identified in a conceptual site model.

122. If the site investigation reveals no / small quantities of hazardous waste (e.g. incidental and easily visually recognisable waste, such as occasional pieces of bonded asbestos in demolition waste), then the site may also be classified as H0.

123. However, if the site investigation reveals significant quantities of hazardous waste, the site is classified as H1. In such cases, an options appraisal on the way forward would need to be carried out, where the most appropriate option would be identified depending on the type and quantities of hazardous waste identified, and the associated risk. The possibilities to be considered in this appraisal could include the following, as well as others:

- Site sealing, with capping and surface water control, and a ban on excavation in the after-use phase of the site;
- Removal of all or part of the waste for disposal / recovery at a licensed facility (particularly if excavation, or remodelling of the topography, is required for further development); and
- Soil washing or stabilisation.

124. If the site is known to have accepted significant quantities of hazardous waste (for instance if this is immediately visible, or if records indicate that the site was used for the disposal of hazardous waste), then the site may be classified as H1 without necessarily undertaking a site investigation.

Stability Assessment

125. The final criteria to be applied in the classification of sites relate to the stability of the wastes. For most pre-accession landfills, with the exception of those known to accept significant quantities of household and other organic wastes (particularly

Magħtab and Qortin landfills), it is likely that further settlement will be minimal and annual monitoring as recommended under the Landfill Directive is unlikely to identify discernible changes. However, further investigation of engineering properties may be necessary, dependant on the proposed after-use. Given that few pre-accession landfills and more recent inert landfills will have little in the way of pollution control or monitoring facilities at risk from instability settlement of the waste mass, the important aspect of the landform is that of safety to neighbouring properties and users (particularly if operating machinery such as vehicles), whether 'official' or casual.

126. It is recommended that as a 'rule of thumb' a maximum acceptable slope gradient of 1 (vertical) in 4 (horizontal) be applied,[51] with any site meeting that criteria being classed as S0. In such cases, only minimal remedial action is required in order to prepare the site for its after-use. Same as G0 and H0, this could include collecting scrap material and bulky waste from the surface, and removal of any material / waste that could interfere with the planned after-use of the land.

127. Sites with any slope greater than 1 in 4 should be classed as S1, requiring further investigation or remediation. In addition to the potential for slopes such as these to fail, which should be assessed by qualified engineers using recognised slope stability analysis techniques, the potential for spalling of materials from the slopes and erosion is significant and safe access for agricultural machinery may be limited. Where it is not possible to reduce the slopes due to access or safety considerations, alternative methods to minimise the likelihood of slope failure or movement of surface materials should be considered.

128. A summary of the classification of pre-accession landfills is presented in **Table 9**.

[51] DoE (1995). *Landfill Design, Construction and Operational Practice.* Waste Management Paper 26B.

Table 9: Site classification summary

Assessment type	Criteria	Evidence	Further investigation	Classification	Remedial action
Identification of lowest-risk sites	Pre-1990 <25,000 m^3 No significant quantities of visible hazardous waste deposits	Records Topographic surveys Aerial photography Walkover survey	Stability assessment	-	-
Evaluation of risk from landfill gas	Above ground >250 m from landfill gas (LFG)-sensitive receptors Non gas-sensitive after-use	Records Topographic surveys Aerial photography Mapping Limited investigation	None	G0	Minimal
	Below ground / quarry fill <250 m from gas receptors OR gas-sensitive after-use	Records Topographic surveys Aerial photography Mapping	Detailed records of wastes deposited and / or investigation for landfill gas	G0 if survey results demonstrate: <5% CO_2, <1.4% CH_4 OR <10% CO_2, <5% CH_4 AND <0.7 L/h AND total gas flow <70 L/h in any borehole	As per G0
				G1 if landfill gases exceed criteria	Landfill gas remediation / control measures
Evaluation of risk to surface / ground water	Outside groundwater protected area AND >100 m from surface water body, good records demonstrating low leaching potential	Records Topographic surveys Aerial photography Mapping	None	W0	Surface water control
	Within groundwater protected area, outside groundwater safeguard zone (GSZ) AND >100 m from surface water body, good records demonstrating low leaching potential	Records Topographic surveys Aerial photography Mapping	Groundwater monitoring for at least 2 years	W0 if no / unlikely impact on groundwater	As per W0
				W1 if there is actual / potential impact on groundwater	Low impact: Landform to encourage runoff, surface water control measures, revegetation High impact: Capping and surface water control measures
	Within GSZ OR ≤100 m from surface water body, OR inadequate records to demonstrate low leaching potential	Records Topographic surveys Aerial photography Mapping	Waste investigation to demonstrate leaching potential, and groundwater monitoring for at least 2 years	W0 if no / unlikely impact on groundwater	As per W0
				W1 if there is actual / potential impact on groundwater	Low impact: Landform to encourage runoff, surface water control measures, revegetation High impact: Capping and surface water control measures
Hazardous waste evaluation	No / minor quantities of hazardous waste	Records Walkover survey	Site investigation (if required)	H0	Minimal
	Significant quantities of hazardous waste	Records Walkover survey	Site investigation (if required)	H1	Options appraisal
Stability assessment	Landform slopes ≤1 in 4	Topographic survey	None	S0	Minimal
	Landform slopes >1 in 4	Topographic survey	None	S1	Reprofile to <1 in 4 or slope stability analysis and / or alternative measures

Framework for Assessing Potential After-use in the Maltese Islands

129. A framework for assessing potential after-uses follows from the criteria discussed previously, in particular:

- The site characteristics:
    - The current polluting potential or impact, particularly landfill gas generating potential, and contamination by hazardous waste;
    - The compatibility with remedial control measures required; and
    - The landform;
- The sensitivity of the environment:
    - Proximity of the site to sensitive landfill gas receptors, including in the post-remediation phase; and
    - The potential for the development to change the landfill dynamics.

Risk-based Criteria for Remediation / Potential After-Use of Pre-accession Landfills / Dumpsites

130. This section proposes risk-based criteria for remediation scenarios for, and potential after-use of, pre-accession landfills / dumpsites, taking into consideration site characteristics.

131. Potential uses of former landfills will depend on the characteristics of the site and surrounding land-uses, which will impact on the viability of the remedial measures with respect to the value of the land. For example, the fact that a costly remediation such as landfill mining with soil washing is being considered for the Luqa landfill is likely related to its location in a thriving and expanding industrial area, hence land values are relatively high.

132. In general terms, sites in rural or semi-rural areas are likely to be most suited to some form of rural after use, such as forestry or agriculture, dependant on the availability of restoration soils. Sites falling under classifications G0 / H0 / S0, which require minimal intervention may, in what are likely to be rare cases, represent a 'do nothing' scenario, consistent with the provisions of the Prevention and Remedying of Environmental Damage Regulations. In some cases, natural revegetation and 'wilding' may have led to the development of informal nature reserves. However, even if this is acceptable or even desirable, from a land use planning perspective, it is likely that some management will be required, such as removal of invasive or non-native species. In most cases, it is likely that removal of fly tipped rubbish will be necessary.

133. In most cases falling under G0 / H0 / S0 classes, some minimal remediation may be required, limited largely to removal of surface rubbish and/or large or obstructive debris such as large masonry pieces or reinforcing bar that could impact on restoration or construction / maintenance machinery, together with site profiling and drainage measures. The soil requirement will be determined by the chosen after-use, with native arid tolerant species requiring lower quality soils than commercial crops

cultivation. Alternative, essentially 'open air' commercial uses such as solar energy parks, such as that being developed at Benghisa, or open storage areas, are low-risk as the potential for landfill gas accumulation in confined spaces is low, although the siting of underground services must also be taken into consideration. Hard development may be suitable, such as buildings or paving for vehicle parking and distribution centres, subject to geotechnical investigation for foundation design. As a precaution, where any building is proposed, an investigation for landfill gas is recommended, irrespective of the outcome of the classification outlined here. In all cases involving groundworks leading to the disturbance of construction and demolition materials, it is recommended that an assessment for the potential presence of asbestos is carried out as a precaution; its presence may require an alternative design strategy.

134. Sites falling under classification G1 are considered higher risk and suitable for open air after-uses unless it is demonstrated by investigation with a high degree of confidence that they can be classified as G0. The risks associated with 'hard development' fall into two categories, those that pose potential risks to the new users and those associated with off-site receptors. Hard development such as buildings constructed over fill must take into account the potential for landfill gas accumulation and the design incorporated measures to prevent landfill gas entry into the building. The potential for the accumulation of landfill gas in other commercial development such as greenhouses / polytunnels must also be carefully considered with the potential for methane accumulation with associated fire / explosion risks, as well as asphyxiation due to displacement of oxygen. With respect to off-site receptors, installation of hard cover such as buildings and paved surfaces, as in the case of parking or distribution yards, will restrict the potential for escape of gases to the atmosphere; hence encouraging lateral migration, reinforcing the requirement for investigations with a high degree of confidence where there are sensitive receptors within 250 m.

135. Those sites falling under classification G1 must be considered in the highest risk category with respect to landfill gas hazards. These sites should be considered only for open air after-uses unless carefully designed and constructed remedial measures are implemented. Remedial measures could include any, or a combination, of passive gas venting, biological oxidation or active extraction depending on the specific degree of gas production and site characteristics. It is likely that hard development will be possible only by incorporating extensive gas protection measures in the design of on-site buildings coupled with a robust landfill gas monitoring regime between the site and neighbouring receptors. This is also the case where the site falls into category W1 if a landfill cap is proposed to minimise infiltration, as that will have the effect of reducing gas venting to the atmosphere; thereby increasing the likelihood of lateral migration.

136. Sites falling under classification W0 pose no restriction on their use with respect to ground and surface water beyond those associated with any development. However, the development should not lead to enhanced infiltration.

137. Sites falling into category W1 may benefit from hard development in that the hard development surfaces such as roofs and hard paving are likely to inhibit infiltration,

subject to the installation of good surface drainage. Soakaways for drainage should not be allowed and drainage should be directed away from the waste body. However, it is likely that those sites falling within W1 may also have a high landfill gas potential and this must be taken into account in assessing the suitability for hard development. Hard development may also alleviate the need for slopes to the landform if drainage is incorporated. On those sites falling in W1 where a cap is installed, the after-use must be taken into consideration with respect to the integrity of the cap. Vegetation should be restricted to shallow rooting species with adequate soils placed over the cap to avoid root penetration, which could impact the integrity of the cap. Any hard development must take into account the need to avoid foundations penetrating the cap.

138. For sites classified under H1, the appropriate after-use would need to take into account the outcome of the options appraisal, which as mentioned is dependent on the type and quantities of hazardous waste identified, and the risk.

139. For sites classified under S1, provided no remediation is required under other classifications, once slopes in excess of 1 in 4 have been stabilised, there is no constraint on after-use, beyond those engineering constraints of the proposed development and the landfill characteristics. Steeper slopes are most likely to be suitable for revegetation, which will further benefit in stabilising the slopes and slowing down run-off.