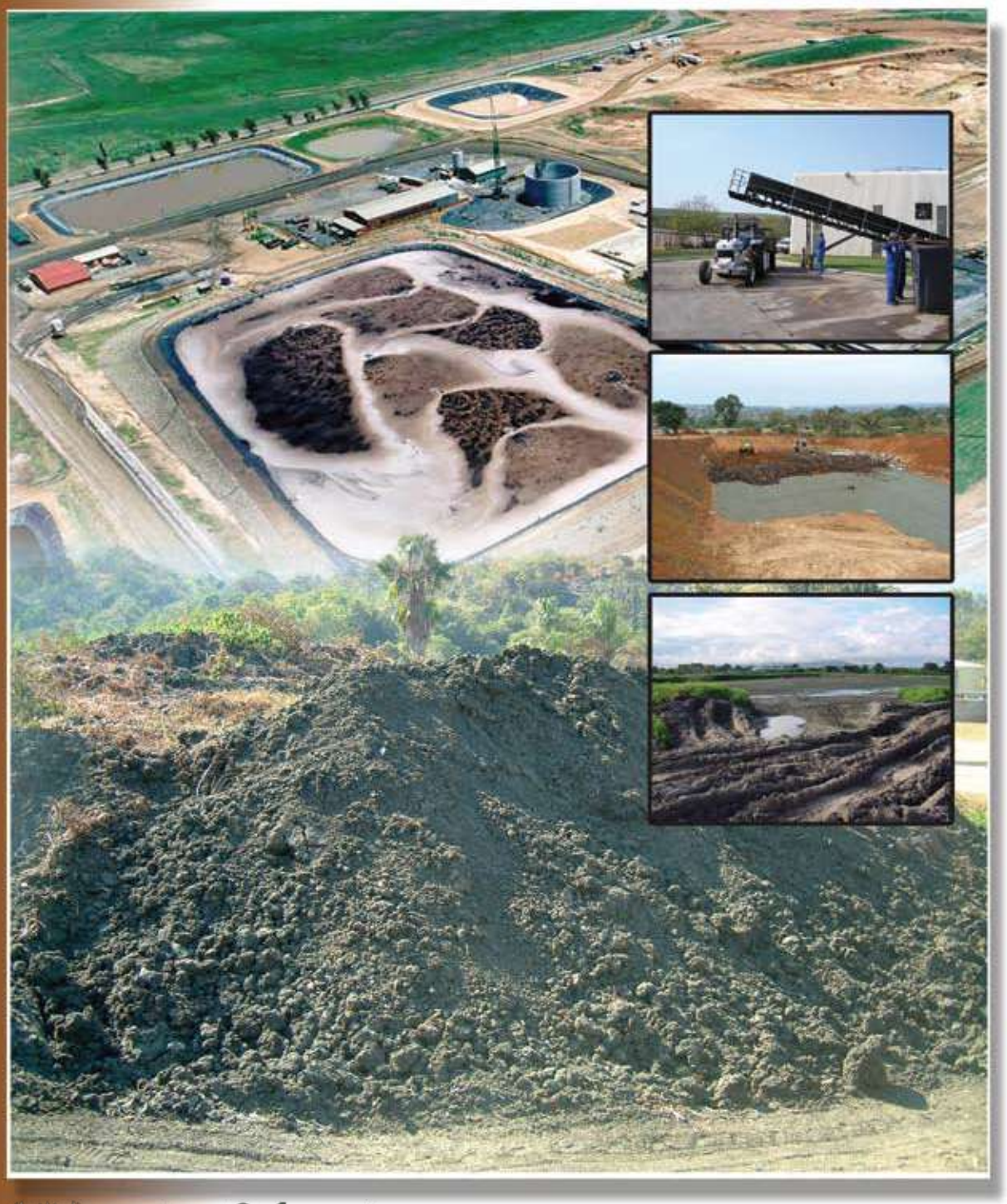
GUIDELINES FOR THE UTILISATION AND DISPOSAL OF WASTEWATER SLUDGE

Volume 3 of 5

Requirements for the on-site and off-site disposal of sludge



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TT 349/09
Water Research Commission

GUIDELINE VOLUMES

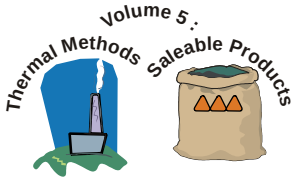
These Guidelines were developed to encourage the beneficial use of wastewater sludge but it should be recognized that beneficial use is not always feasible. Rather than trying to develop a single guideline to address the range of management options dealing with beneficial and non-beneficial uses, a separate Guideline Volume deals with each of the management options. This Volume deals with the management, technical and legislative aspects associated with on-site and off-site disposal of sludge as well as the characterisation and monitoring requirements for each disposal option.

Volume 1: Selection of management options

Volume 2: Requirements for the agricultural use of sludge

Volume 3: Requirements for the on-site and off-site disposal of sludge

Volume 4: Requirements for the beneficial use of sludge at high loading rates



Volume 5: Requirements for thermal sludge management practices and for commercial products containing sludge

THESE VOLUMES ARE AVAILABLE FROM:

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Guidelines for the Utilisation and Disposal of Wastewater Sludge

Volume 3: Requirements for the on-site and off-site disposal of sludge

Prepared for the
Water Research Commission
by

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Golder Associates Africa

WRC Report No. TT 349/09
June 2009

The publication of this report emanates from a project entitled: D*evelopment of the South African wastewater sludge disposal guidelines dealing with land and ocean disposal, beneficial use, use in commercial products and thermal treatment*
(WRC Project No. K5/1622)

ISBN 978-1-77005-709-8
Set No. 978-1-77005-420-0

Printed in the Republic of South Africa

FOREWORD

Traditional practices related to wastewater sludge management include dedicated land disposal, waste piling, landfill disposal and to a lesser degree use in agricultural practices. However, due to varying reasons, on-site land disposal and waste piling have become the standard management option for many wastewater treatment plants in South Africa today. With sludge production increasing on a daily basis, it has however become apparent that current practices are unsustainable with sludge management becoming a problem for many municipalities in South Africa. Innovative solutions need to be sought to create opportunities that provide a wide spectrum of options to the management of wastewater sludge.

Seeking innovative solutions requires a paradigm shift in our perception and understanding of wastewater sludge from a waste product to one of a resource. Such a shift creates an opportunity for local authorities and municipalities to generate a range of economic and social spin-offs to the benefit of their communities thereby taking a small step towards achieving the goal of sustainable development.

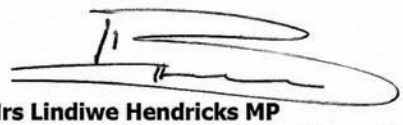
Volumes 2, 3, 4 and 5 of the Sludge Guidelines Series aim to provide options and opportunities for this innovation and to encourage the beneficial use of wastewater sludge. However, it is recognised that not all sludge can be used beneficially and where the wastewater sludge cannot be used as a resource, the guidelines provide for its disposal in a responsible manner.

It is for this reason that one Volume of the Guideline Series, Volume 3 (this document) is dedicated to disposal options. The sludge generator is still encouraged to investigate the feasibility of beneficial uses by changing the quality of the sludge through source control or to consider alternative beneficial uses. Sludge disposal must be controlled effectively and monitored for the protection of human and animal health, protection of water resources and land quality in general. This Guideline Volume has specifically been developed to minimise the detrimental effect of sludge disposal to land, the water resource and the marine environment.

Sludge is normally regarded as a waste but when used beneficially it becomes a resource. Waste disposal in SA is guided by the latest published edition of the Minimum Requirements and the same principles contained herein have been adopted for sludge disposal on land. This guideline also highlights the fact that according to the *Operational Policy for the Disposal of Land-derived Water Containing Waste to the Marine Environment of South Africa* (DWAF, 2004) marine disposal of sludge is not favorably considered. While the value and guidance provided by the above-mentioned documents are paramount, their specific content in terms of the regulation of sludge is limited as they deal with a wide range of waste. Sludge is a sector-specific waste with unique characteristics and concurrent handling requirements and impacts on the receiving environment. The Sludge Guidelines series therefore addresses the requirements pertaining only to sludge with regard to its management and disposal. The Minimum Requirements and Volume 3 of the Sludge Guidelines should not be seen as independent documents and should be consulted concurrently.

The Guidelines were developed as a user-friendly document for regulatory authorities, managers, practitioners and operators responsible for sludge management. The development of the Sludge Guidelines were also supported by an extensive stakeholder consultation process (two consultative workshops and a training workshop in each province) which included sector stakeholders, regulatory authorities, government departments, industry experts, professional service providers, and interested individuals whose inputs significantly enhanced the final product. In the interest of transparency, the scientific basis, assumptions, thought processes and stakeholder consultation were documented as separate documents available from the Water Research Commission (WRC).

The Sludge Guidelines are living publications, and will be reviewed periodically based on comments received on the current requirements and approaches. All users are urged to take a critical view regarding the Guidelines in terms of usefulness and appropriateness. It is believed that valuable feedback will ensure continual improvement. Comments should be directed to the Director: Resource Protection and Waste, Department of Water Affairs and Forestry, Private Bag X313, Pretoria, 0001.



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ACKNOWLEDGEMENTS

The guidelines in this Volume emanated from a project jointly funded by the Water Research Commission and the Department of Water Affairs and Forestry entitled:

"DEVELOPMENT OF THE SOUTH AFRICAN WASTEWATER SLUDGE DISPOSAL GUIDELINES DEALING WITH LAND AND OCEAN DISPOSAL, BENEFICIAL USE, USE IN COMMERCIAL PRODUCTS AND THERMAL TREATMENT"

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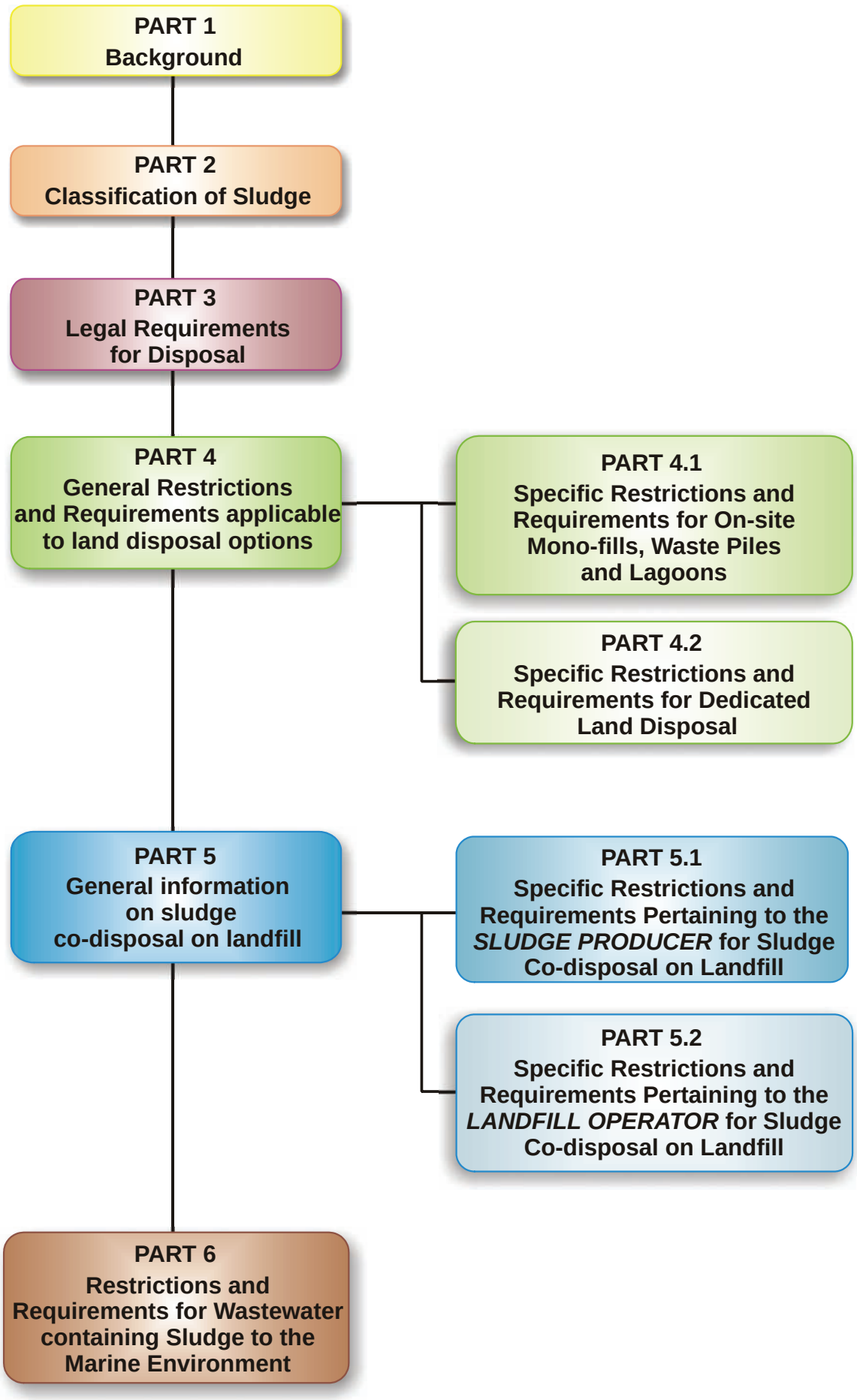
The financing of the project by the Water Research Commission and the Department of Water Affairs and Forestry as well as the contribution of the members of the Reference Group and all Stakeholders are gratefully acknowledged.

The project team also want to acknowledge Tiaan van Niekerk (cover page design) and Beulah Sanders (graphics design) for their assistance.

STRUCTURE OF THIS GUIDELINE VOLUME



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LIST OF ACRONYMS

AE	Acceptable Exposure
DEAT	Department of Environmental Affairs and Tourism
DLD	Dedicated land disposal
DWAF	Department of Water Affairs and Forestry
ECA	Environment Conservation Act 73 of 1989
EEC	Estimated Environmental Concentration
EIA	Environmental Impact Assessment
G:B^+	General landfill with leachate generation (rainfall exceeds evaporation)
G:B^-	General landfill without leachate generation (evaporation exceeds rainfall)
H:H / H:h	Hazardous landfill site
MPL	Maximum Permissible Level
NEMA	National Environmental Act, No. 107 of 1998
NWA	National Water Act 36 of 1998
RoD	Record of Decision
TCLP	Toxicity Characteristic Leaching Procedure
TTV	Total Trigger Value
WWTP	Wastewater treatment plant

INTRODUCTION

These Guidelines were developed to encourage the beneficial use of wastewater sludge. However, it is recognised that beneficial use is not always possible. In these cases disposal options may be considered. The sludge generator is still encouraged to investigate the feasibility of beneficial uses by influencing the quality of the sludge through source control or considering alternative beneficial uses. Disposal options should only be considered when all other options have been found to be unfeasible.

According to the Minimum Requirements[1] wastewater sludge is considered a waste under circumstances. It states: "Sewage sludge disposed of at a site other than that of the sewage works itself, (provided the water use authorisation has been issued for the sewage works) **would** fall under the definition of waste, as stipulated in Section 1 of the Environmental Conservation Act, 1989". The same principle can be applied for on-site sludge disposal. Therefore, when disposal of sludge is considered, sludge is classified and legally viewed as a "waste" and should be managed as such. This view changes when sludge is used beneficially.

The principles of the Minimum Requirements which govern waste disposal in South Africa have been adopted for all land sludge disposal options, both on-site and off-site. The Minimum Requirements are updated periodically and the reader is referred to these documents, or any future updates of the documents, where necessary. However, this volume was developed recognising that the wastewater industry is not necessarily familiar with waste handling practices and the legal requirements thereof. Therefore, the basic principles of the Minimum Requirements were adopted for sludge disposal and included in Volume 3 of the Sludge Guidelines to enable the wastewater industry to familiarise themselves with waste handling practices and, at the same time, comply with the waste disposal requirements.

PURPOSE OF THIS VOLUME

The purpose of this Volume is:

- To give guidance on how to select appropriate on-site and off-site disposal options;
- To create an understanding of the operational and legal requirements of the different disposal options; and
- To present guidelines for the monitoring of on-site and off-site sludge disposal sites.

[1] Department of Water Affairs and Forestry. Waste Management Series (Latest edition). Document 1: Minimum Requirements for the Handling, Classification and Disposal of Hazardous waste.

INTRODUCTION

On-site disposal is the disposal of sludge within the boundaries of the wastewater treatment plant (WWTP) and include:

- Mono disposal (mono-fill, waste piles, lagoons)
- Dedicated land disposal (DLD) where the disposal site is within the boundaries of the WWTP

Off-site disposal is the disposal of sludge outside the boundaries of the WWTP and include:

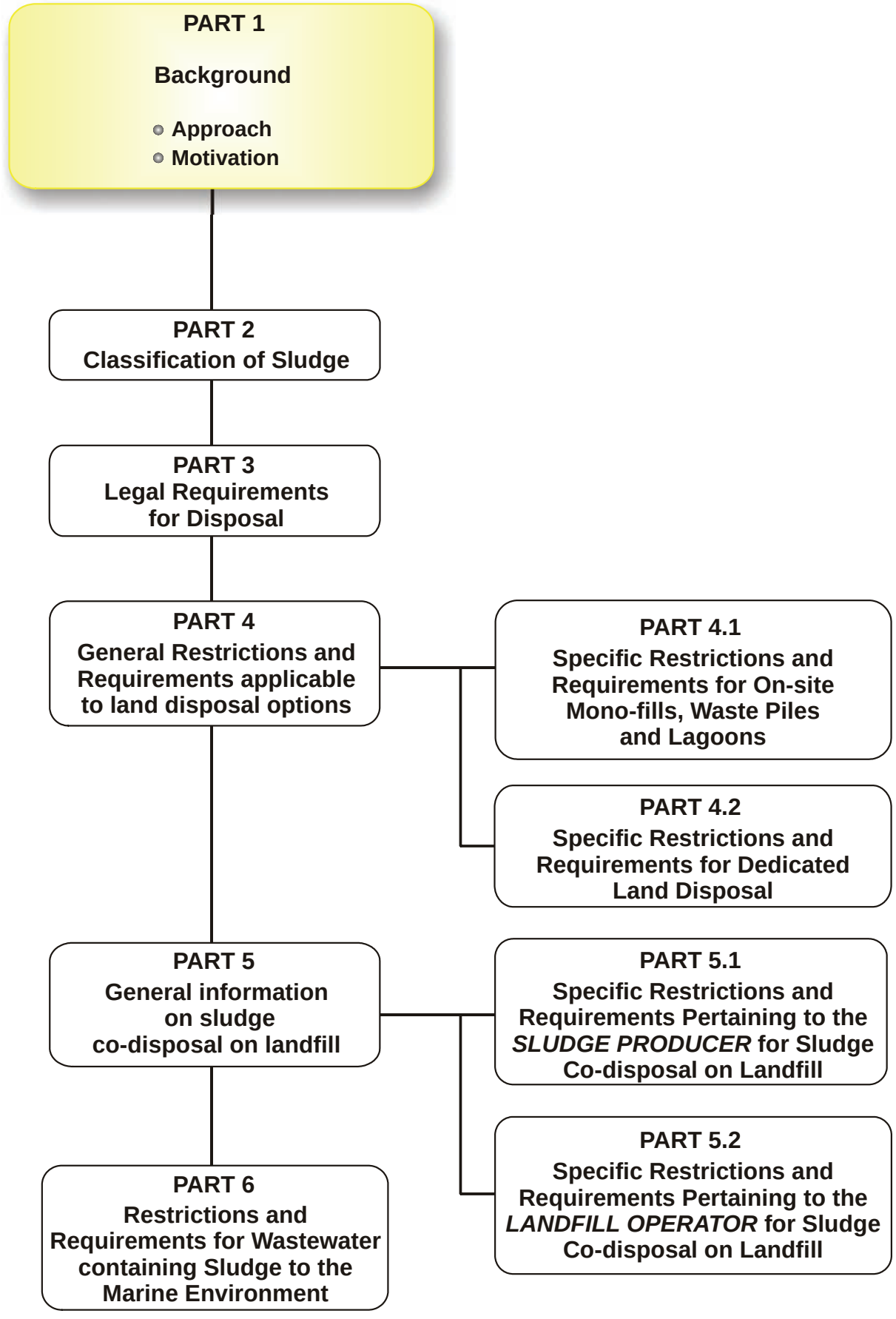
- Dedicated land disposal (DLD) where the disposal site is not within the boundaries of the WWTP
- Co-disposal on landfill
- Marine disposal

WHO SHOULD USE THIS VOLUME?

Volume 3 was developed to ensure the safe disposal of sludge while minimizing the effect on the receiving environment. Any person who effectively applies the Guidelines will comply with all the environmental and regulatory requirements. This Guideline was developed for:

- **Wastewater treatment plant operators** – to implement acceptable good practice pertaining to on-site and off-site disposal of sludge.
- **Wastewater treatment service providers** – to manage the on-site and off-site disposal of sludge to reduce the environmental impact.
- **Local authorities and town/city councils that own and operate wastewater treatment plants** – to design, operate and maintain a sludge disposal strategy that would not negatively impact on the receiving environment.
- **Landfill site owners/operators** – to manage the wastewater sludge accepted on the site.
- **Wastewater engineers/scientists** – to design appropriate on-site and/or off-site disposal facilities and associated monitoring plans.
- **Technical advisors** – to provide appropriate advice on the on-site and off-site disposal options of sludge.
- **Legislators** – to assess compliance in cases where the Sludge Guideline Volumes have been included in a water use authorisation or waste disposal site permit.
- **Educators** – to build capacity and create awareness

DOCUMENT ROADMAP



PART 1:

BACKGROUND

In cases where sludge cannot be used beneficially and all reasonable alternatives have been exhausted, disposal can be considered. This Volume deals specifically with the on-site and off-site disposal of sludge including the management, technical and legislative aspects, as well as monitoring requirements. General and specific restrictions and requirements for different types of disposal are presented with the aim of protecting the receiving environment.

APPROACH FOLLOWED TO DEVELOP VOLUME 3

The South African waste management legislative systems and implementation of responsible waste management practices is well advanced. This Volume was developed to **complement** the existing suite of waste management guidelines and documents outlining good management processes. During the development of this Volume, the waste management function was transferred from the Department of Water Affairs and Forestry (DWAF) to the Department of Environmental Affairs and Tourism (DEAT). The project team attempted to incorporate the regulatory requirements from both departments and at the same time follow internationally accepted protocols which are scientifically justified.

The Guidelines for the on-site and off-site disposal of sludge is therefore based on the following information:

- National and international research findings
- National legislative and guideline documents
- International guidelines and legislative trends
- The results of the risk assessment
- Practical considerations

The scientific premise for this Volume was based on a risk assessment and risk management process. All the potential risks associated with the disposal of sludge were identified and evaluated. The process identified which potential receptors could be affected and methods/limits were developed to protect these receptors.

It was assumed that the workers comply with the provisions of the Occupational Health and Safety Act (OSH Act) and are equipped with personal protective equipment (PPE). The impact of the sludge on workers would therefore be covered by this Act and is not considered to be a sludge disposal issue.

The following constituents and properties of sludge received particular attention due to their potential negative effects on one or more receptors:

- Nutrients – soil, surface and groundwater should be monitored to ensure that the disposal of sludge does not increase the concentrations of nutrients in these receptors or that the maximum nitrogen level for surface and groundwater is not exceeded.

- Metals – maximum permissible levels (MPL) were developed for sludge and the receiving soil and water environment. These metal limits are designed to protect the receiving environment.
- Odours – odours and vector attraction affect the public negatively (and could affect public health), therefore the stability of sludge, the reduction of odours and vector attraction potential received attention in these Guidelines.
- Pathogens – no limits were placed on the pathogen content of sludge destined for disposal but additional restrictions should be implemented to protect the receiving environment.

The potential negative effects were managed by specifying management requirements to isolate the potential receptors from the potential risk (such as implementing access restrictions and buffer zones to protect the general public).

Some disposal options such as the co-disposal of sludge with domestic solid waste need to comply with the Minimum Requirements[2] and other existing documents. In these cases, additional guidance is provided that could assist the user to simplify the process required. Therefore, Volume 3 expands on the existing requirements. The conceptual thinking, development process and assumptions are presented in separate documents which are available from the WRC[3 & 4].

MOTIVATION FOR DEVELOPING GUIDELINES FOR SLUDGE DISPOSAL

The beneficial use of sludge is encouraged through the Sludge Guidelines to ensure sustainable sludge management. However, not all the sludge produced in South Africa is of such quality that it can be used beneficially, which leaves disposal as the only feasible option.

Sludge is an industry specific waste with specific characteristics and properties pertaining to it. The Minimum Requirements focus on the management of domestic and industrial solid waste and dedicates a small section to the disposal and co-disposal of sludge. The Policy on the disposal of land-derived water containing waste to the marine environment[5] essentially prohibits (by definition) the disposal of sludge to the marine environment. In addition, there are practices such as dedicated land disposal (DLD) which is not addressed in these guiding documents.

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[2] Department of Water Affairs and Forestry. Waste Management Series (Latest edition)
Minimum Requirements for Waste Disposal by Landfill.
Minimum Requirements for Water Monitoring at Waste Management Facilities.

[3] Herselman, J.E. and Snyman, H.G. 2008. Guidelines for the utilisation and disposal of wastewater sludge: Literature review and technical support document for Volumes 3-5. WRC Report 1622/1/09, 1622/2/09 ans 1622/3/09.

[4] Snyman, H.G. and Moodley, P. 2008. Guidelines for the utilisation and disposal of wastewater sludge: Legal review. WRC Report 1622/4/09.

[5] Department: Water Affairs and Forestry. 2004. Water Quality Management series, Sub-series No. MS 13. Operational Policy for the disposal of land-derived water containing waste to the marine environment of South Africa. Edition 1

The nature and characteristics of sludge compared to other wastes warrants the need for sector specific guidelines to ensure its responsible management. The reality is that many WWTPs use on-site waste piles and lagoons as sludge management and final disposal options. These facilities are not designed as waste disposal facilities and do not comply with the Minimum Requirements. This Volume attempts to form the "bridge" between the waste management industry and the wastewater industry.

Lastly, the wastewater industry is generally not accustomed to the complex waste management requirements in South Africa, but rather to the legislation and requirements of DWAF. This Volume aims to consolidate all the requirements of managing sludge as a waste in one document.

DESCRIPTION OF SLUDGE DISPOSAL OPTIONS

The sludge disposal options include the following:

- Disposal to a **Mono-fill**
- Disposal on **Waste piles**
- Disposal to **Lagoons**
- Disposal on **Dedicated Land Disposal Sites**
- Co-disposal to **Landfill**
- Discharge to the **Marine Environment**

Each of the disposal options are described below.

A **mono-fill** is a landfill where only one waste type, in this case sludge, is disposed of. It is usually dewatered sludge that is deposited in depressions within the land or on the land surface in a **regulated manner** with containment of the contents (Figure 1).

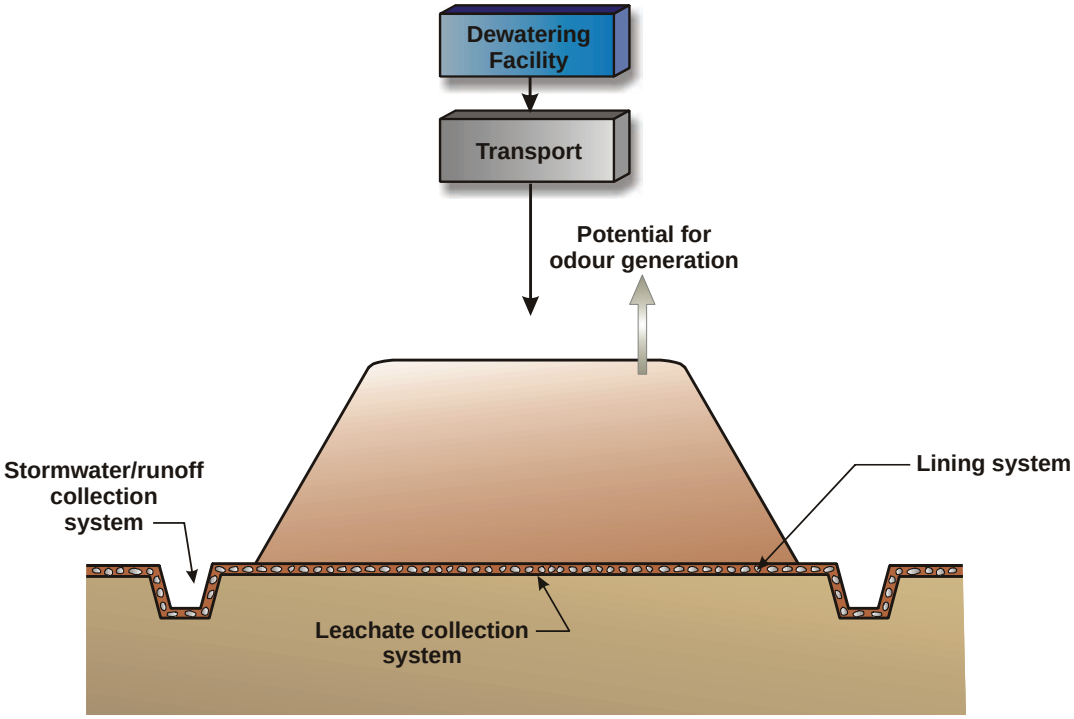


Figure 1: Illustration of a typical on-site mono-fill

Waste piles are simply mounds of dewatered sludge (sludge stockpiles) placed on the land surface for final disposal without daily or final cover. These are on-site disposal options and can be lined or unlined facilities. The existing waste piles in South Africa are typically unlined (Figure 2).

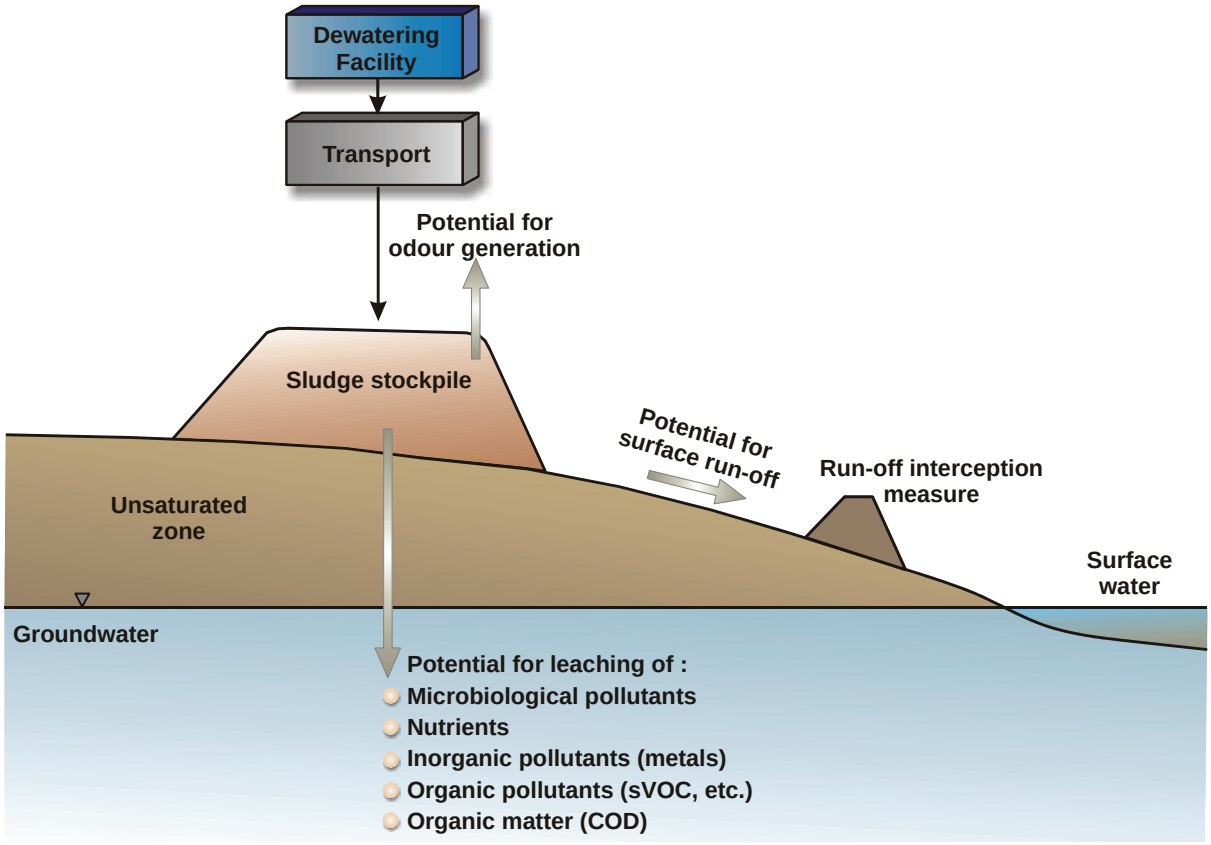


Figure 2: Illustration of a typical unlined waste pile

Lagoons are disposal sites where sludge with high water content is placed in an open excavated area, normally on-site. Ideally these facilities should be lined with an appropriate leachate collection system, but the existing sludge lagoons in South Africa are typically unlined facilities (Figure 3).

These facilities may also serve as deep drying beds where sludge is left to dry and then removed for final disposal. When the lagoons are lined, the liners are often damaged when dried sludge is removed.

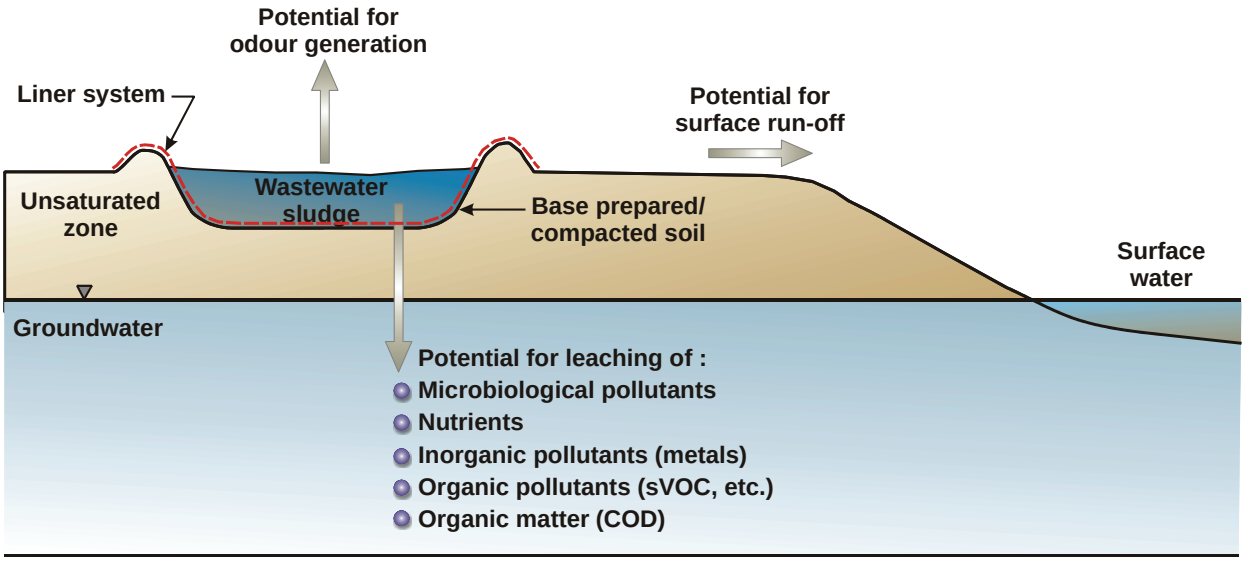


Figure 3: Illustration of a sludge lagoon

At **dedicated land disposal (DLD)** sites sludge is applied to the surface of the land on a routine basis where the objective is sludge disposal rather than sludge utilization. The sludge can be applied as liquid (Figure 4) or dewatered sludge (Figure 5).

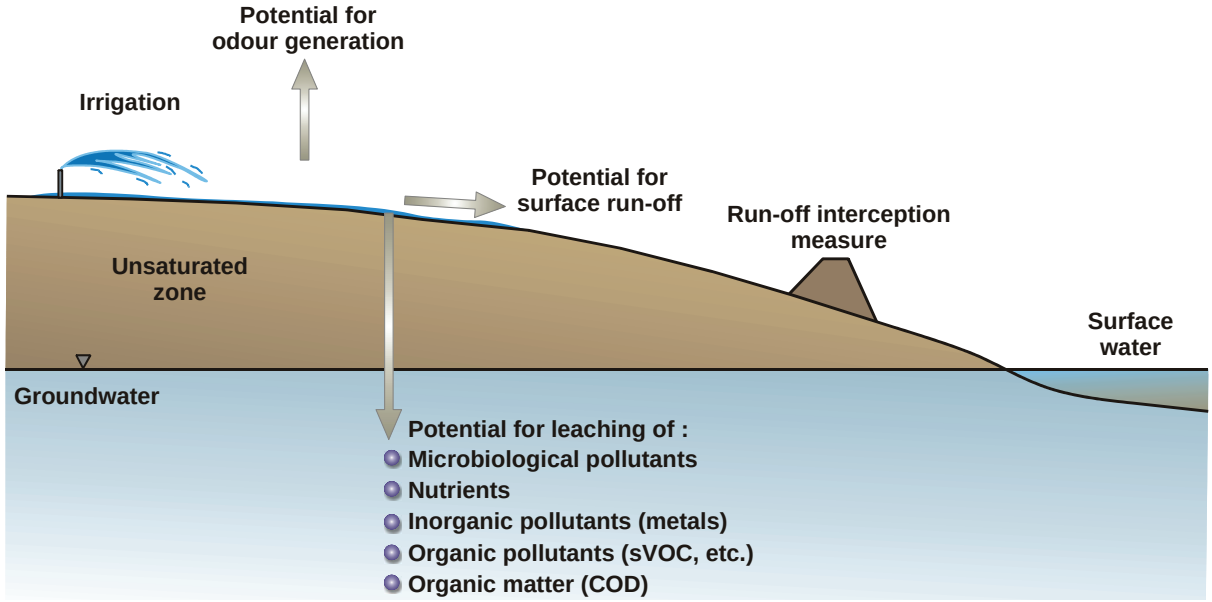


Figure 4: Illustration of liquid sludge application on a DLD site

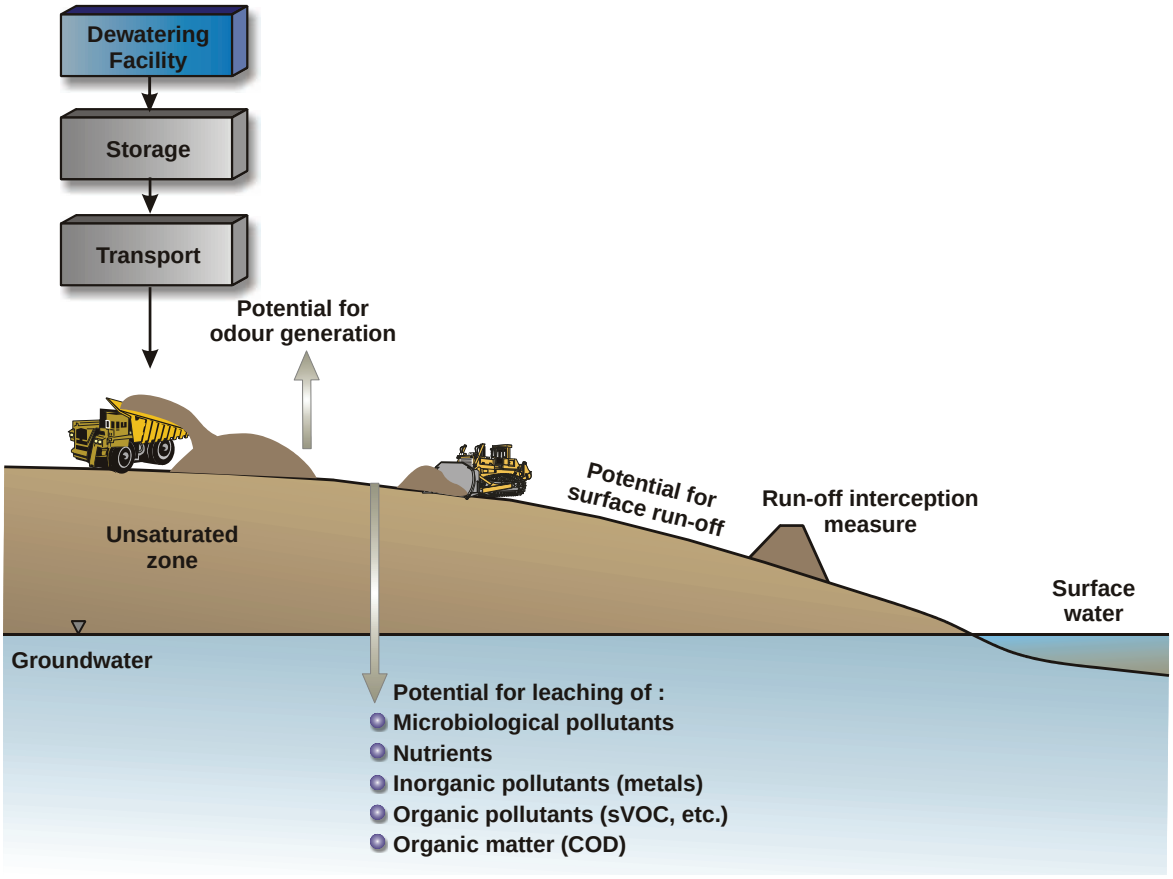


Figure 5: Illustration of dewatered sludge disposal at a DLD site

Landfill is understood as the disposal of material into a natural depression or into an excavation in the ground. **Co-disposal** sites are those where sludge is accepted for disposal with wastes from other sources, e.g. municipal solid waste (Figure 6), usually off-site.

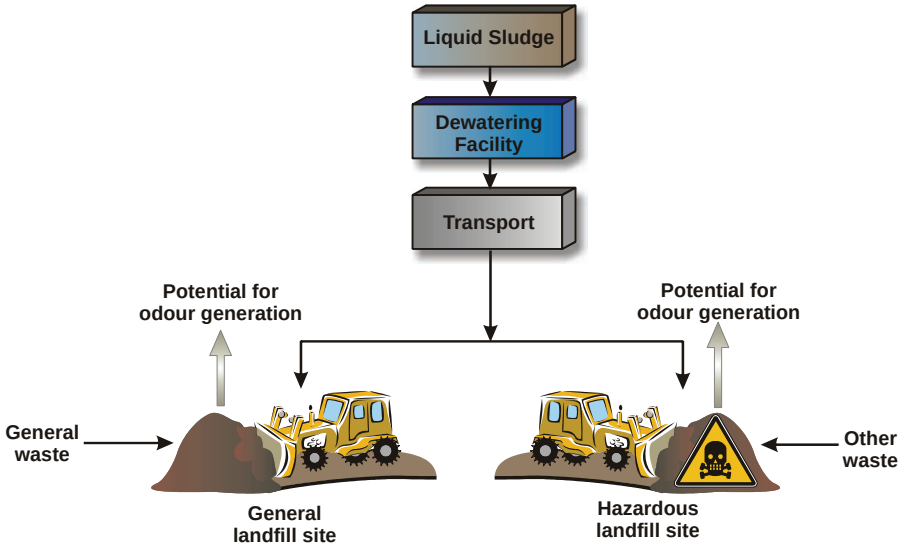


Figure 6: Illustration of sludge co-disposal at off-site landfill sites

Marine discharge/disposal entails the discharge of wastewater to the marine environment. The disposal of wastewater containing sludge is only permissible via a marine outfall which consists of a submarine pipeline originating on shore, which conveys wastewater from the head of works to a submerged discharge location on or near the seabed beyond the surf zone (Figure 7). It is also referred to in the literature as a deep sea outfall/pipeline. At the time of this publication no new pipelines designed for the disposal of raw wastewater (without primary treatment) to the marine environment would be authorised. All new deep sea outfalls will require primary treatment of wastewater.

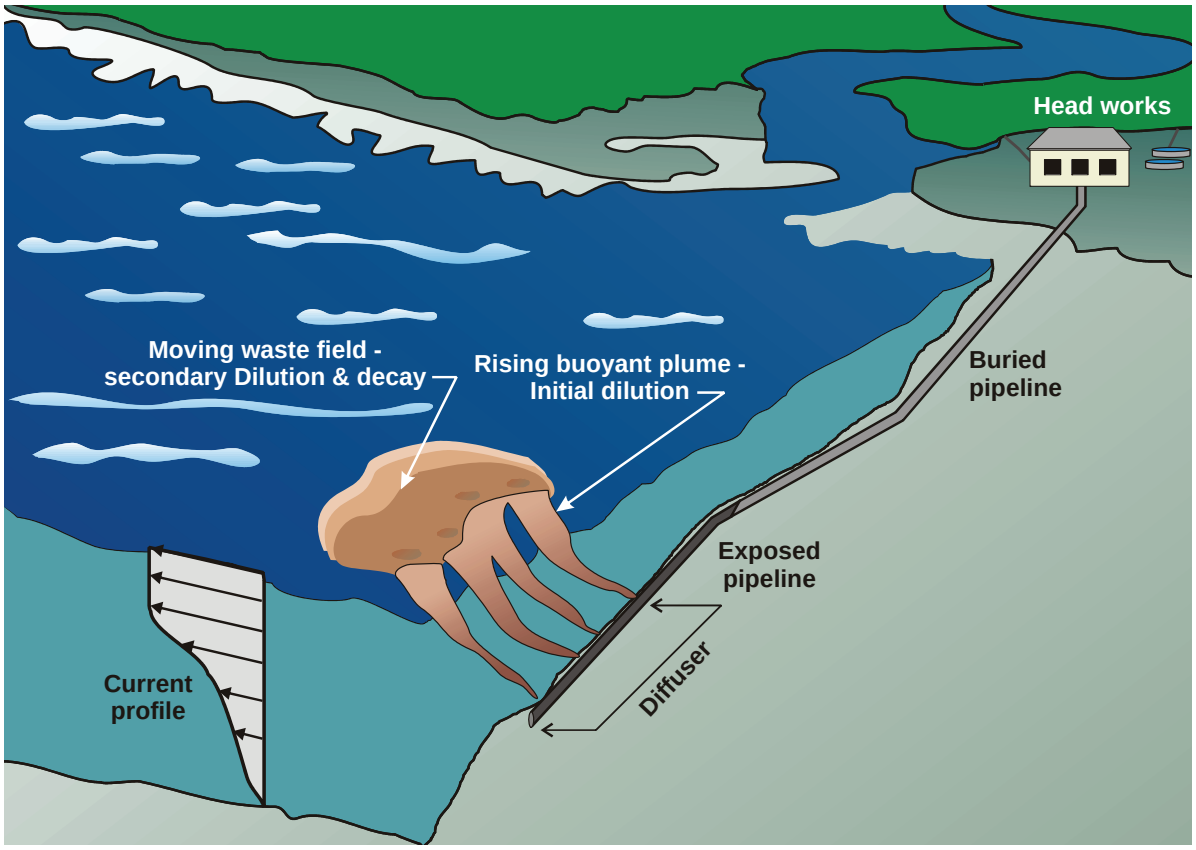
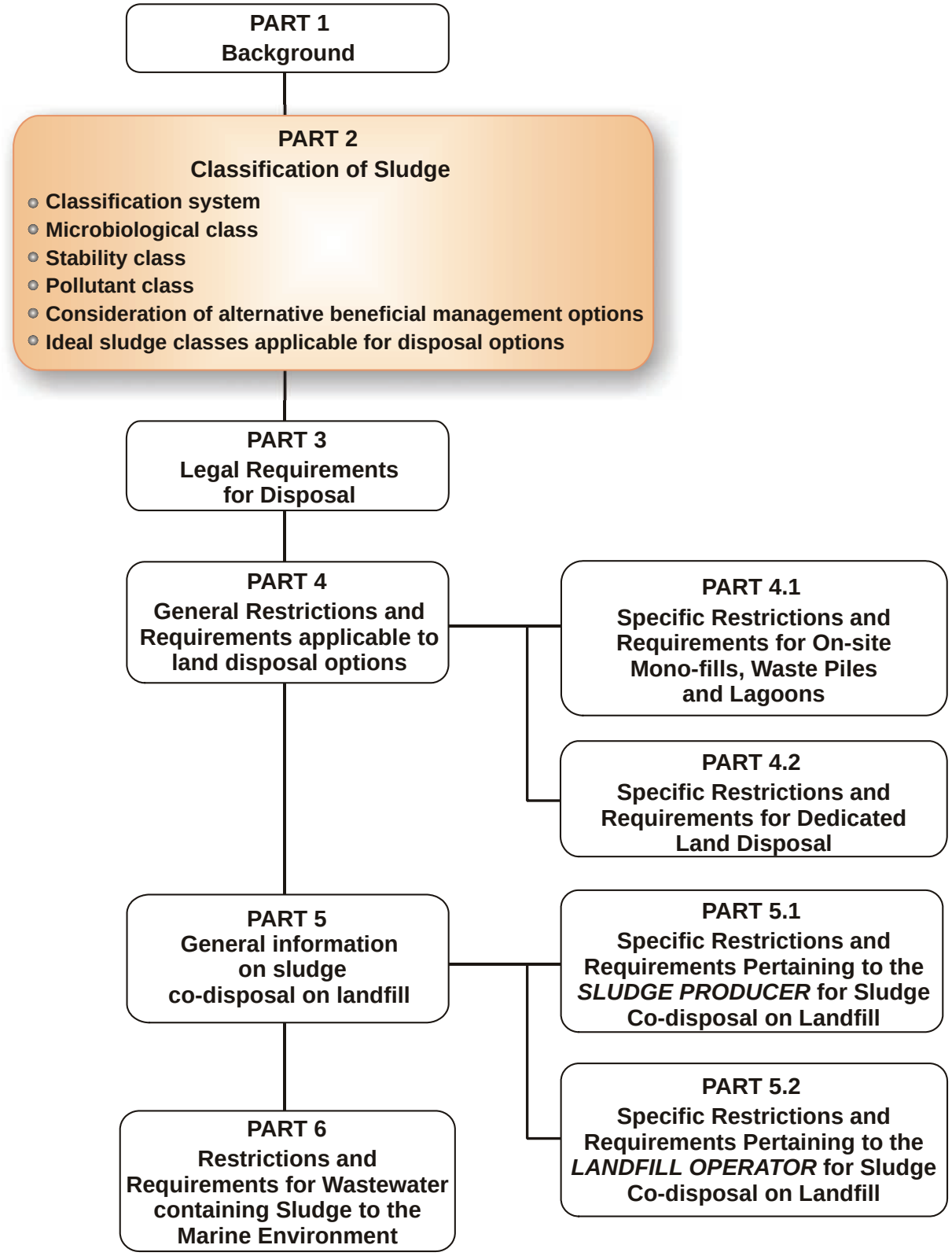


Figure 7: Illustration of wastewater disposal via a pipeline (adopted from DWAF, 2004)

DOCUMENT ROADMAP



PART 2:

CLASSIFICATION OF SLUDGE

A preliminary classification is stipulated in Volume 1 of the Guidelines to select applicable sludge management options. All sludge producers considering disposal must repeat the Pollutant class classification because a different analytical method is recommended.

CLASSIFICATION SYSTEM

The South African Wastewater Sludge Classification System must be applied to classify the sludge intended for on-site and off-site disposal. The classification system is defined in Table 1.

TABLE 1: CLASSIFICATION SYSTEM FOR SLUDGE

Microbiological class	**A**	**B**	**C**
Stability class	**1**	**2**	**3**
Pollutant class	**a**	**b**	**c**

The characterisation and classification should be repeated if any major sludge production or processing changes occur that could affect the classification. This could include:

- When major upgrades or extensions are implemented at the wastewater treatment plant.
- When major operational changes are made at the wastewater treatment plant.
- When the raw influent quality to the wastewater treatment plant changes in such a way that the sludge quality could be affected. In other words, when any major new wastewater contributor starts/ceases to discharge to the plant.

The sampling procedure (number of samples, sampling frequency and sample location) for the classification of sludge is the same as for the monitoring of the sludge. This is discussed in Part 4, “Monitoring Requirements for land disposal: Sludge Monitoring”. The laboratory analyses and methods required for sludge classification are detailed in Appendix 1.

Microbiological classification

The results of the microbiological analyses of the sludge samples can be used to determine the Microbiological class (Table 2). The recommended new analytical method for determination of viable helminths ova is detailed in Appendix A.

TABLE 2: COMPLIANCE AND CLASSIFICATION CRITERIA: MICROBIOLOGICAL CLASS

Microbiological class	Unrestricted use quality		General use quality		Limited use quality
	A		B		C
	Target value	Maximum permissible value	Target value	Maximum permissible value	
Faecal coliform (CFU/g_{dry})	< 1 000 (5 log reduction)	10 000 (4 log reduction)	$< 1x10^6$ (2 log reduction)	$1x10^7$ (1 log reduction)	$> 1x10^7$ (no reduction)
Helminth ova (Viable ova/g_{dry})	< 0.25 (or one ova/4g)	1	< 1	4	> 4
Compliance requirements					
Requirements for classification purposes (Minimum 3 samples)	All the samples submitted for classification purposes must comply with these requirements	Not applicable	Two of the three samples submitted for classification purposes must comply with these requirements	The sample that failed may not exceed the Minimum Permissible Value	Not applicable
Requirements for monitoring purposes	90% compliance	The 10% (maximum) of samples that exceed the Target Value, may not exceed the Maximum Permissible Value	90% compliance	The 10% (maximum) of samples that exceed the Target Value, may not exceed the Maximum Permissible Value	Not applicable

Note: Microbiological testing results require 90% compliance for the monitoring programme. Some plants such as those producing < 1 t dry sludge/day are required to collect only three samples once a year. These plants will therefore only be able to prove 90% compliance after a few years. Larger plants will be able to prove compliance on an annual basis.

Stability classification

The Stability class can be determined analytically and/or by complying with a vector attraction reduction requirement. A sludge producer is required to prove compliance to at least one of the vector attraction reduction options at any stage during operation. The different vector attraction reduction options are listed in Table 3 and described in detail in Appendix 2.

Note: The Stability class indicates the stability of the sludge and not the stability of the disposal site.

The achievement of a Stability class is especially important during the operational stages of a wastewater treatment plant. It is more important to consistently comply with a vector attraction reduction option, than the actual initial Stability classification. Confirm the Stability class of the sludge by selecting at least one of the vector attraction reduction options in Table 3.

TABLE 3: DETERMINING THE STABILITY CLASS

Stability class	1	2	3
	Comply with one of the options listed below on a 90 percentile basis.	Compy with one of the options listed below on a 75 percentile basis.	No stabilisation or vector attraction reduction options
Vector attraction reduction options (Applicable to Stability Class 1 and 2 only)			
Option 1	Reduce the mass of volatile solids by a minimum of 38 percent		
Option 2	Demonstrate vector attraction reduction with additional anaerobic digestion in a bench-scale unit		
Option 3	Demonstrate vector attraction reduction with additional aerobic digestion in a bench-scale unit		
Option 4	Meet a specific oxygen uptake rate for aerobically treated sludge		
Option 5	Use aerobic processes at a temperature greater than 40°C (average temperatures 45°C) for 14 days or longer (eg during sludge composting)		
Option 6	Add alkaline material to raise the pH under specific conditions		
Option 7	Reduce moisture content of sludge that do not contain unstabilised solids (from treatment processes other than primary treatment) to at least 75 percent solids		
Option 8	Reduce moisture content of sludge with unstabilised solids to at least 90 percent solids (like primary treatment)		
Option 9	Applicable to Dedicated disposal and other land disposal options. Inject sludge beneath the soil surface within a specified time, depending on the level of pathogen treatment		
Option 10	Applicable to Dedicated disposal and other land disposal options. Incorporate sludge disposed on the land surface within a specified time after disposal.		
Option 11	Applicable to landfill option only. The sludge should be covered on a daily basis.		

Note: Vector attraction reduction options 1-8 are applicable to all on-site and off-site disposal options, options 9 and 10 are applicable to all land disposal options and option 11 is applicable to co-disposal on landfill only.

Pollutant classification

The Pollutant class determination of sludge in Volumes 1 and 2 was based on the total metal content (*aqua regia* digestion) of the sludge. In this Volume the Pollutant class is based on the Toxicity Characteristic Leaching Procedure (TCLP) test (Appendix 1). The results of the sludge analyses can be employed to determine the Pollutant class as defined in Table 4.

TABLE 4: DETERMINING THE POLLUTANT CLASS FOR SLUDGE DISPOSAL OPTIONS

TCLP extractable metals	Pollutant class		
	a	b	c
	<AE mg/l	≥AE and ≤ 10*AE mg/l	>10*AE mg/l
Arsenic (As)	<0.38	0.38 - 3.8	>3.8
Cadmium (Cd)	<0.031	0.031 - 0.31	>0.31
Chromium (Cr III))	<4.7	4.7 - 47	>47
Chromium (Cr VI)	<0.02	0.02 - 0.2	>0.2
Copper (Cu)	<0.13	0.13 - 1.3	>1.3
Lead (Pb)	<0.12	0.12 - 1.2	>1.2
Mercury (Hg)	<0.022	0.022 - 0.22	>0.22
Nickel (Ni)	<0.75	0.75 - 7.5	>7.5
Zinc (Zn)	<0.7	0.7 - 7	>7

AE : Acceptable exposure

Note: Pollutant class determination requires the analyses of eight (8) potentially toxic metals and elements. The metals listed in Table 4 were specifically chosen as they are typically the elements that might be of concern. However, the sludge produced at a specific wastewater treatment plant could contain elevated concentrations of other elements due to unique circumstances. A full total elemental analysis including a number of other trace metals and elements is required for the preliminary classification as detailed in Volume 1. The results of those analyses need to be consulted to determine if any other element is of concern. In cases where additional element(s) were identified, these also need to be included in the analyses for classification and monitoring purposes.

Sludge producers are encouraged to improve the sludge quality to protect the receiving environment during disposal.

Sludge classified as **Pollutant class a** (TCLP metal concentration ≤ AE) could be disposed on land with minimal restrictions. When the analytical results of the TCLP test indicate **Pollutant class b** sludge, the sludge should be limed (CaO) at a recommended dosage of 25 $kg_{lime}/ton_{wet\ sludge}$. Specific liming tests can be conducted to determine the liming requirement to immobilize metals. The TCLP test should be repeated on the sludge after liming. If the new results indicate **Pollutant class a** sludge, the sludge could be disposed on land as **Pollutant class a** sludge. In cases where the analytical results after liming still

indicate **Pollutant class b** sludge, the load principle should be applied where the maximum load for the disposal area is calculated based on the TCLP concentration of the constituents of concern and more stringent management requirements will apply. DWAF/DEAT need to be informed of the situation and the disposal site owner/operator should provide the authority with the analytical results.

Land disposal of Pollutant class c sludge will only be allowed with very strict restrictions and monitoring requirements. Specific liming tests are recommended to achieve at least a Pollutant class b classification. A schematic presentation of the procedure to improve the Pollutant class is detailed in Figure 8.

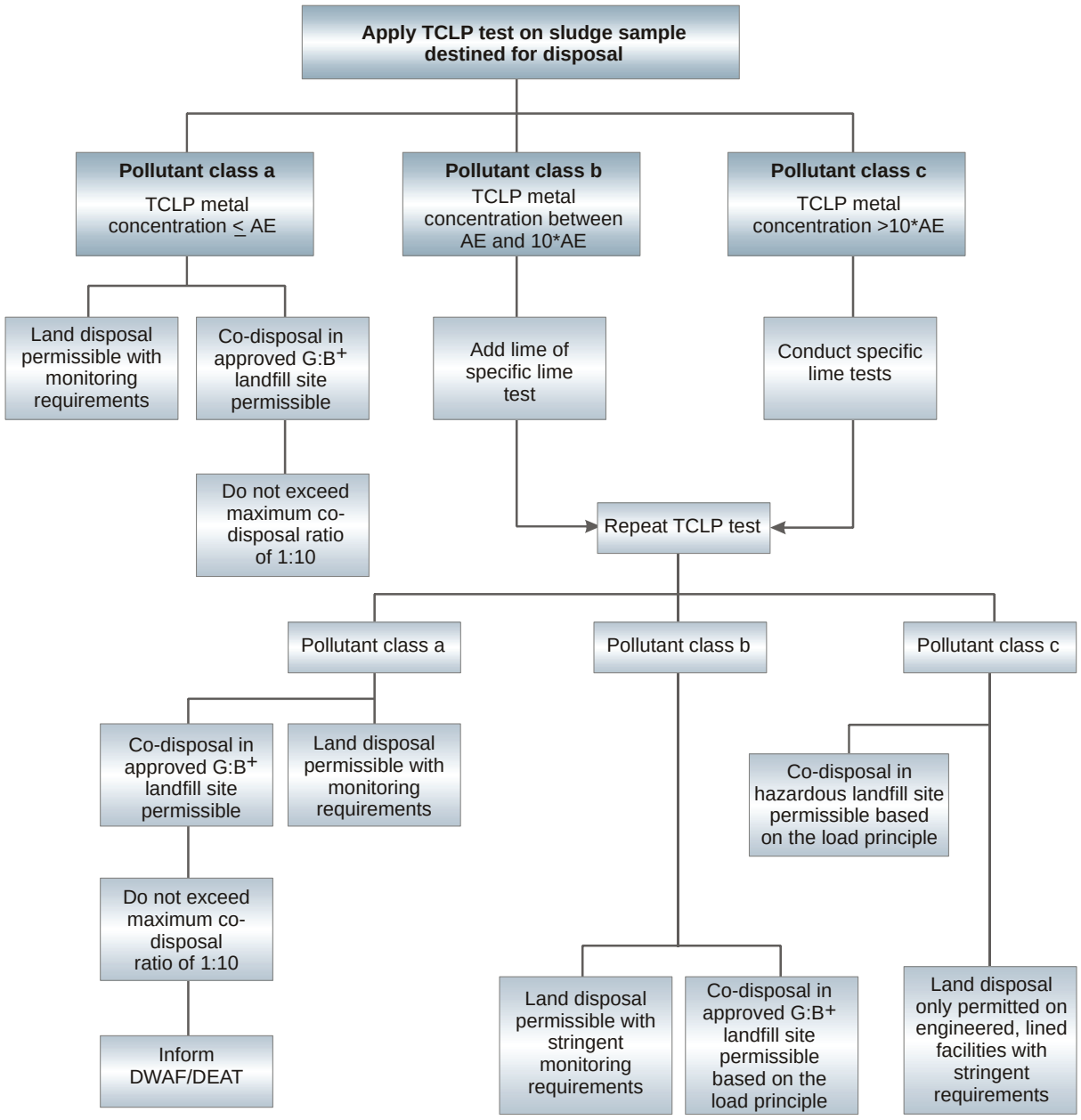


Figure 8: Schematic presentation of procedure to improve Pollutant class classification

Consideration of alternative beneficial management options

The White Paper on Integrated Pollution and Waste Management for South Africa (2000) defines government's "cradle to grave" approach to the management of waste (see Figure 9). This is a holistic and integrated management approach extending from the feasibility and planning stages of a project, through waste prevention and minimisation, as well as the generation, storage, collection, transportation, treatment and to the final disposal of waste. Therefore, the beneficial use of wastewater sludge is encouraged and sludge disposal should be a last resort. Sludge producers will have to proof that alternative options were considered and that disposal is the only option. A detailed report on the consideration of alternatives and motivations should be addressed as part of the record-keeping requirements (addressed in Part 4). In cases where the sludge quality is hampering the beneficial use of sludge, details should be provided on what efforts have been made to improve the sludge quality (also refer to Volume 1, Part 3). This document will also be required for the Environmental Impact Assessment (EIA) process (see Appendix 3) as the consideration of alternatives form part of the process.

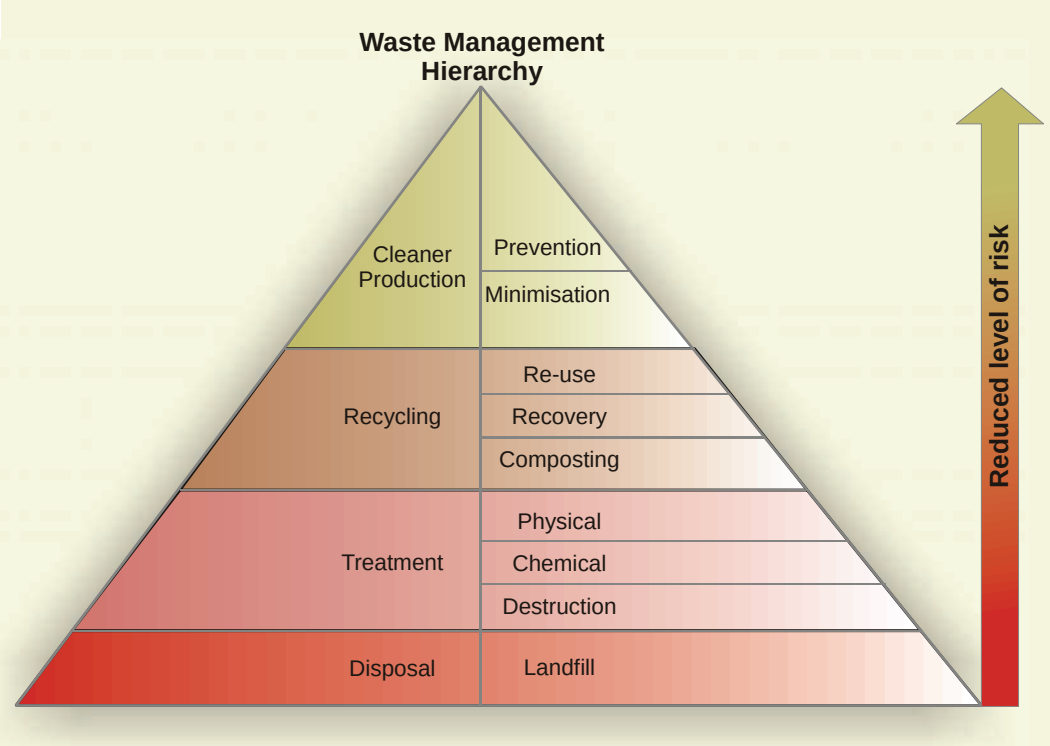


Figure 9: Waste hierarchy approach for integrated waste management

Ideal sludge classes applicable for different disposal options

Table 5 shows the colour coded index that can be used to assess the appropriateness of a disposal option based on the Microbiological class, Stability class and Pollutant class of a specific sludge as discussed in Volume 1 of the Sludge Guidelines.

Table 6 provides an indication of the probability of sludge disposal based on its applicable sludge class. The restrictions and management requirements become more onerous with deteriorating sludge quality. For example, due to the presence of pathogens in Microbiological class C, this class must be covered at the disposal site on a daily basis in order to adequately protect the public and workers.

TABLE 5: COLOUR CODED INDEX TO ASSESS APPROPRIATENESS OF SELECTED DISPOSAL OPTIONS

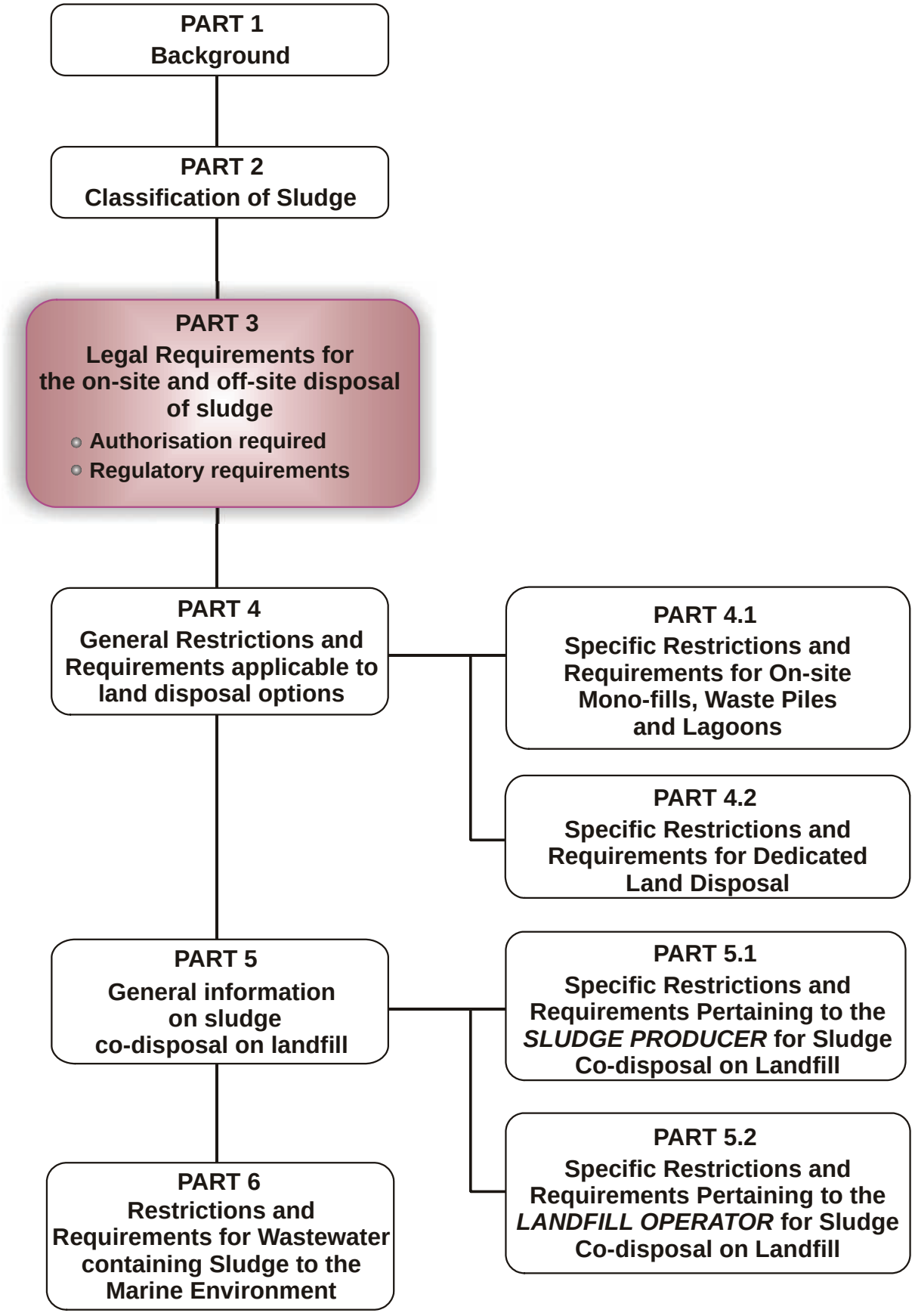
(i)	Yes	Recognising that no management option can ever truly be applied without any restrictions, these options only have minor restrictions.
(ii)	Qualified yes	The restrictions that apply do not have major complications and can be managed using good management practices.
(iii)	May be	This can only be effectively applied under strict conditions and major management and cost implications apply.
(iv)	Qualified no	Only under unique conditions can this management option be applied for this class of sludge
(v)	No	This management option should not be considered for this class of sludge.

TABLE 6: PERMISSIBLE DISPOSAL OPTIONS BASED ON THE SOUTH AFRICAN SLUDGE CLASSIFICATION SYSTEM

South African Sludge Classification		Is disposal an option?	Notes
Microbiological Class	A	Maybe (iii)	Disinfection technologies are costly and this management option therefore represents wasting of potential resource recovery.
	B	Maybe (iii)	It could potentially be used beneficially.
	C	Yes (i)	General restrictions/requirements as well as stringent monitoring requirements will apply.
Stability Class	1	Yes (i)	General restrictions/requirements apply.
	2	Qualified yes (ii)	Depending on the reliability of the vector attraction reduction measures implemented, additional management systems may be required.
	3	Qualified no (iv)	Unstable sludge will not be accepted at landfill sites and land disposal would not be permissible. At least one vector attraction reduction option should be implemented.
Pollutant Class	a	Qualified no (iv)	Beneficial use is recommended.
	b	Maybe (iii)	Delisting according to Minimum Requirements is required.
	c	Maybe (iii)	Disposal of Pollutant class c sludge will only be allowed on hazardous landfills. Stringent restrictions, management and monitoring requirements will apply for land disposal.

Note: Beneficial use of sludge is encouraged and disposal should be the last resort. When the sludge quality is of a high enough standard to be used beneficially, the sludge producer must prove to the authorities which beneficial use option were investigated and why they were not feasible, before disposal will be allowed.

DOCUMENT ROADMAP



PART 3:

LEGAL REQUIREMENTS FOR THE ON-SITE AND OFF-SITE DISPOSAL OF SLUDGE

According to the Minimum Requirements waste is defined as: "*An undesirable or superfluous by-product, emission, or residue of any process or activity, which has been discarded, accumulated or stored for the purpose of discarding or processing. It may be gaseous, liquid or solid or any combination thereof and may originate from a residential, commercial or industrial area.*"

The South African environmental legislative environment is complex and regulation by more than one Government Department needs to be considered for on-site and off-site disposal of sludge (see Appendix 3). The Department of Water Affairs and Forestry (DWAF) and Department of Environmental Affairs and Tourism (DEAT) are the lead regulatory authorities for sludge disposal. The location of the disposal site relative to the WWTP determines the lead authority in the regulation process and the type of authorisation required. It is therefore important for the sludge producer to understand the definition of on-site and off-site to determine the applicable legal authorisation required:

On-site disposal is the disposal of sludge within the boundaries of the wastewater treatment plant (WWTP), i.e. **within the co-ordinates of the WWTP** as defined in the water use authorisation for the treatment plant. On-site disposal includes:

- Mono-disposal (mono-fill, waste piles, lagoons)
- Dedicated land disposal (DLD) where the disposal site is within the boundaries of the WWTP

Off-site land disposal is the disposal of sludge outside the boundaries of the WWTP, i.e. **outside the co-ordinates of the WWTP** as defined in the water use authorisation for the treatment plant. Off-site disposal includes:

- Dedicated land disposal (DLD) where the disposal site is outside the boundaries of the WWTP
- Co-disposal on landfill

Off-site marine disposal is the disposal of sludge to the marine environment, i.e. **outside the co-ordinates of the WWTP** as defined in the water use authorisation for the treatment plant.

AUTHORISATION REQUIRED

The authorisation/s required for sludge disposal is/are as follows:

- **On-site disposal** – Water Use Authorisation in terms of Section 40 of the National Water Act (Act No. 36 of 1998). On site disposal of sludge is usually included in the water use authorisation for the WWTP, and does not necessarily require a separate authorisation. The authorisation may be in the form of a water use licence, general authorisation or an existing lawful use.
- **Off-site land disposal** – Waste Permit in terms of Section 20 of the Environment Conservation Act (Act No. 73 of 1989)

- **Off-site marine disposal** – Water Use Authorisation in terms of Section 40 of the National Water Act (Act No. 36 of 1998). However, at the time of this publication changes in the legislation were being proposed in terms of the Integrated Coastal Management Bill[6] that may influence this disposal option.

REGULATORY REQUIREMENTS

The relevant regulatory requirements applicable to the on-site and off-site disposal of sludge are listed in Table 7. The responsible authority (DWAF or DEAT) may require an Environmental Impact Assessment (EIA) to be carried out before a waste permit or water use authorisation is issued (refer to Appendix 3 for the EIA process).

While the regulatory instrument may be either a waste permit (DEAT) or water use authorisation (DWAF), the supporting authority still has to approve the activity and/or impacts before either authorisation is issued. For example, DWAF may require a positive Record of Decision (RoD) for an EIA from DEAT in order to issue a water use licence. Similarly DEAT will require a RoD from DWAF to approve water use impact aspects before a waste permit is issued. The different departments have committed to co-operative governance and to improve inter-departmental communication, which should simplify the regulatory process. Similarly, the lead authority will also consult with the other national and provincial departments that could have regulatory requirements that must be taken into consideration.

The sludge producer must also be aware of local municipal by-laws that relate to sludge management and practices that must be complied with. This could relate to odours or other nuisances.

[6] Integrated Coastal Management Bill. GN 1829, GG 29476, 14 December 2006.

TABLE 7: REGULATORY REQUIREMENTS APPLICABLE FOR THE ON-SITE AND OFF-SITE DISPOSAL OF SLUDGE

Disposal Option	On-site disposal (Within co-ordinates of WWTP)	Off-site land disposal (Outside co-ordinates of WWTP)	Off-site marine disposal (Outside co-ordinates of WWTP)
Applicable Act Governing Practice	National Water Act (Act No. 36 of 1998)	Environmental Conservation Act (Act No. 73 of 1989) Natural Environment Management - Waste Management Act	National Water Act (Act No. 36 of 1998)
Authorisation Required	Water Use Authorisation	Disposal Site Permit or Water Use Authorisation (irrigated sludge)	Water Use Authorisation
Lead Authority	DWAF	DEAT DWAF (irrigated sludge)	DWAF
Regulatory Instrument	Water use licence (Or general authorisation or existing lawful water use)	Disposal Site Permit	Water use licence
Regulatory Guidelines	Sludge Guidelines (Volume 3) and Minimum Requirements (latest version)		Operational Policy for the disposal of land-derived water containing waste to the marine environment of South Africa

Note: At the time of this publication changes in the legislation with regard to Marine disposal were being proposed in terms of the Integrated Coastal Management Bill that may influence the legal requirements of this disposal option.

A summary of the relevant legislation governing practices that are applicable to the on-site and off-site disposal of sludge are included in Appendix 3.

The Departments of Water Affairs and Forestry and Environmental Affairs and Tourism have indicated the **minimum legal requirements** for sludge producers as follows:

Legal requirements for sludge producers (individual/entity producing sludge)

- For on-site disposal of dewatered sludge or liquid sludge
  - The producer must have an authorisation for such a water use (i.e. a general authorisation, a water use licence or it should be an existing lawful use) which would include a condition to comply with the latest sludge guidelines, in this case Volume 3.
- For off-site DLD
  - For disposal of dewatered sludge the producer and the disposal site owner/operator must have an authorisation for the waste disposal (i.e. a disposal site permit) and must comply with Volume 3 of the Sludge Guidelines and the latest edition of Minimum Requirements (Waste Management Series).
  - For irrigation with liquid sludge the disposal site owner/operator must have an authorisation for such an activity, which could be either a water use authorisation (i.e. either a general authorisation, a water use licence or it should be an existing

lawful use) or a disposal site permit, either of which would include a condition to comply with Volume 3 of the Sludge Guidelines and/or the latest edition of Minimum Requirements (Waste Management Series).

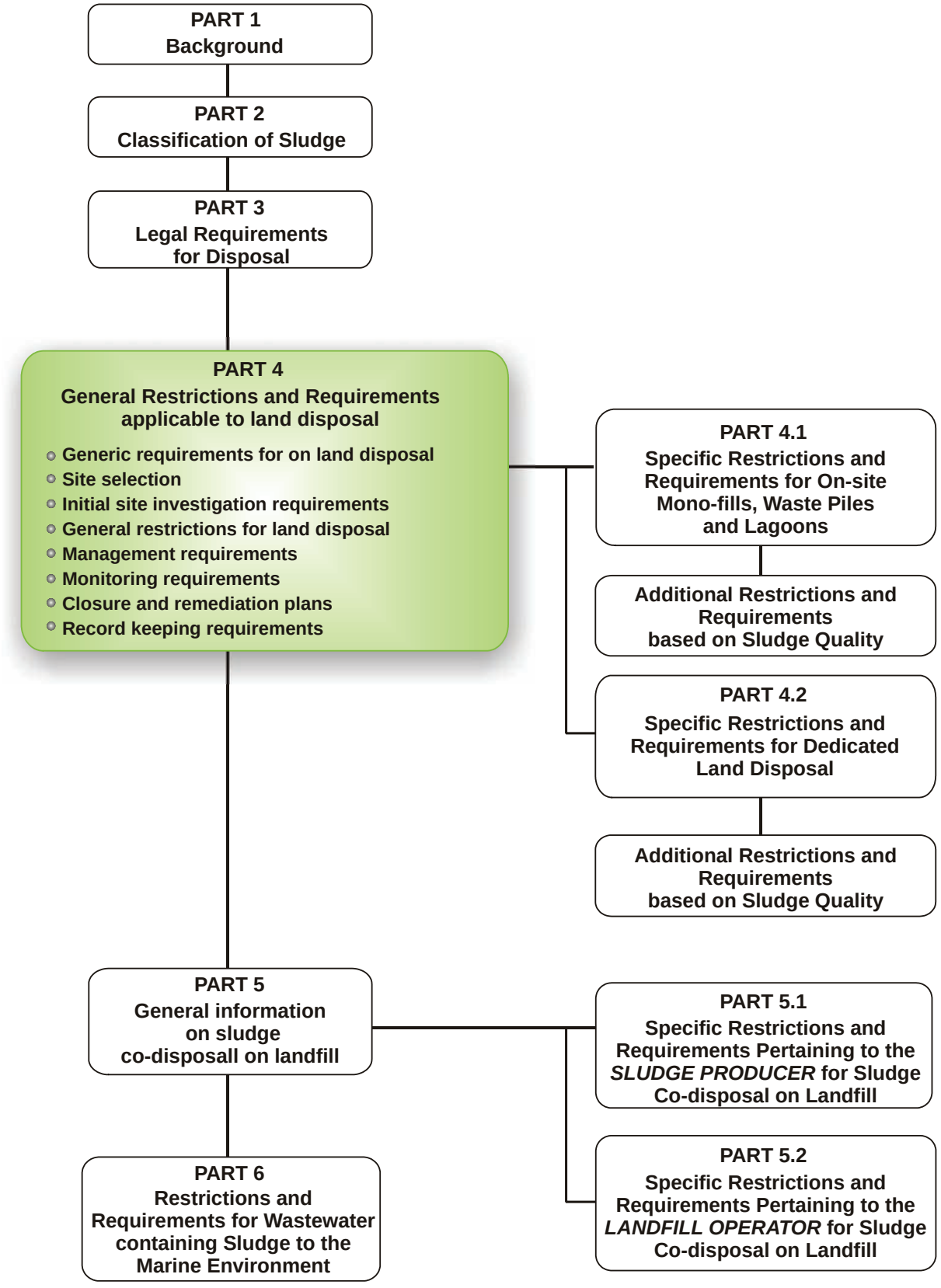
- For off-site co-disposal at a general or hazardous landfill site

  - The landfill owner/operator must obtain a disposal site permit and must, together with the sludge producer, comply with Volume 3 of the Sludge Guidelines and the latest edition of Minimum Requirements (Waste Management Series).

- For marine disposal

  - The producer must obtain a water use authorisation and must comply with Volume 3 of the Sludge Guidelines and the Operational Policy for the disposal of land-derived water containing waste to the marine environment of South Africa.

DOCUMENT ROADMAP



PART 4:

GENERAL RESTRICTIONS AND REQUIREMENTS APPLICABLE TO LAND DISPOSAL OPTIONS

GENERIC REQUIREMENTS FOR LAND DISPOSAL

Some generic requirements apply irrespective of the classification or disposal option selected. Table 8 summarises the generic requirements that apply to land disposal of sludge. Each of these requirements is discussed in more detail in the sections that follow.

TABLE 8: GENERIC REQUIREMENTS FOR LAND DISPOSAL OPTIONS

Legend: L = lined U = unlined NA = not applicable ✓ = applicable	Disposal Option							
	On-site disposal (Part 4.1)						DLD (Part 4.2)	
	Mono-fill		Waste piles		Lagoons		Liquid sludge	Dewatered sludge
	L	U	L	U	L	U		
Initial site investigation and site selection requirements:								
Topography	✓	✓	✓	✓	✓	✓	✓	✓
Soil	✓	✓	✓	✓	✓	✓	✓	✓
Surface water	✓	✓	✓	✓	✓	✓	✓	✓
Groundwater	✓	✓	✓	✓	✓	✓	✓	✓
General requirements:								
Eliminate sensitive areas	✓	✓	✓	✓	✓	✓	✓	✓
Buffer zones	✓	✓	✓	✓	✓	✓	✓	✓
Management requirements:								
Odour control	✓	✓	✓	✓	✓	✓	✓	✓
Run-off collected	✓	✓	✓	✓	NA	NA	✓	✓
Leachate collected	✓	NA	✓	NA	✓	NA	✓	NA
Limits on methane concentration	✓	✓	✓	✓	✓	✓	NA	NA
No crops grown on-site	✓	✓	✓	✓	✓	✓	✓	✓
No grazing animals on-site	✓	✓	✓	✓	✓	✓	✓	✓
Public access control	✓	✓	✓	✓	✓	✓	✓	✓
Monitoring requirements:								
Surface water	✓	✓	✓	✓	✓	✓	✓	✓
Groundwater	✓	✓	✓	✓	✓	✓	✓	✓
Soil	NA	✓	NA	✓	NA	✓	✓	✓
Air	✓	✓	✓	✓	✓	✓	✓	✓
Closure remediation plan:	✓	✓	✓	✓	✓	✓	✓	✓
Record keeping:	✓	✓	✓	✓	✓	✓	✓	✓

Note: Sludge should have a minimum of 12% solids to classify as dewatered sludge

PART 4: GENERAL RESTRICTIONS AND REQUIREMENTS APPLICABLE TO LAND DISPOSAL OPTIONS

SITE SELECTION

It is economically sound practice to establish the disposal site as close to the generation area as possible to minimise transport costs. It is recognized that most existing on-site disposal sites are confined to the boundaries of the WWTP which were delineated some time ago. In general, WWTPs were not developed in the most suitable areas for waste disposal (near rivers, dwellings etc.).

For existing sludge disposal sites the following site selection procedure is recommended:

- Ensure that the disposal site is not located in a sensitive area where disposal is not permissible (see "General restrictions for land disposal: Areas where sludge disposal is not permissible")

- Ensure that the sludge disposal site is located as far as possible from the area where the final effluent is discharged to limit possible contamination of the final effluent, as well as to limit possible contribution of contaminants to the water resource.

- Allow for the maximum buffer zones (see "General restrictions for land disposal: Buffer zones")

For new disposal sites an Environmental Impact Assessment (EIA) will be required to obtain a Record of Decision (RoD) from DEAT (see Part 3: Legal Requirements).

INITIAL SITE INVESTIGATION

Initial site investigation is necessary to collect background/baseline data which could be used to assess the impact of the disposal practices over time. In cases where a new site is selected as part of a new WWTP or major extension, the initial site investigation will form part of the EIA that will be required to obtain a RoD from DEAT. The EIA process might require a more detailed investigation. The site investigation for existing and new sites should include (as a minimum):

- **Topography**
  - The slope of the disposal site should be considered to minimise run-off, erosion and ponding.
  - The disposal site should not be within the 1:100 year flood line.
- **Soil properties**
  - The soil structure, permeability and cation exchange capacity (CEC) will indicate whether the soil will act as a "natural liner/barrier" to minimise the leaching of contaminants.

    Note: Soils with clay content <20% should not be considered for land disposal unless the site is to be lined

  - The soil pH will indicate whether acidic conditions could cause metals to leach through the soil profile.

    Note: Soil pH(H_2O)>6.5 should be maintained at all times to limit the mobility of metals

- The concentration of nutrients, trace elements and metals will give baseline concentrations to determine the incremental effects of disposal on the soil.

- **Surface water**

  - Possible surface water resources should be identified and the distance and likelihood that they could be affected, documented.
  - Where surface water resource contamination is a possibility, background water quality sampling is required to determine the baseline values which can be used for comparative purposes in future.
  - Where surface water resource contamination is expected at existing sites, water samples should be analysed and compared to the relevant standards to assess compliance.

- **Groundwater**

  - Aquifer classification (determine yield, depth, strategic value) (Table 9). Sludge disposal will not be allowed within 200 m of the recharge zone of major aquifers, sole-source aquifers or other strategic aquifers.

TABLE 9: TYPES OF AQUIFERS DIFFERENTIATED FOR GROUNDWATER QUALITY MANAGEMENT

Aquifer Type	Description
Sole-source aquifer	An aquifer used to supply 50% or more of urban domestic water for a given area and for which there are no reasonable available alternative sources of water.
Major aquifer	A high-yield aquifer system of good quality water.
Minor aquifer	A moderate-yield aquifer system of variable water quality.
Poor aquifer	A low- to negligible-yield aquifer system of moderate to poor water quality.
Special aquifer	An aquifer system designated as such by the Minister of Water Affairs and Forestry, after due process.

  - The hydraulic gradient should be determined to assess the position of the monitoring boreholes
  - Groundwater quality (up gradient and down gradient) will give baseline information to assess future impact of disposal on groundwater quality.
  - Where groundwater contamination is expected at existing sites, water samples should be analysed and compared to the relevant standards to assess compliance.
  - A qualified person should confirm cases where groundwater impact is unlikely due to depth of water table or other circumstances.

PART 4: GENERAL RESTRICTIONS AND REQUIREMENTS APPLICABLE TO LAND DISPOSAL OPTIONS

GENERAL RESTRICTIONS FOR LAND DISPOSAL

Areas where sludge disposal is not permissible:

- Areas within the 1 in 100 year flood line (wetlands, vleis, pans and flood plains) to minimize water pollution.
- Unstable areas (fault zones, seismic zones and dolomitic or karst areas where sinkholes and subsidence are likely).
- Areas characterised by steep gradients where slope stability could be a problem and soil erosion would be prevalent.
- Areas of groundwater recharges on account of topography and/or highly permeable soils to minimise groundwater pollution.
- Areas immediately upwind of a residential area in the prevailing wind direction(s).
- Natural habitat of endangered plant and/or animal species.

Buffer zones:

- Depth to aquifer:
  - Dewatered sludge application must be >5 m (mono-fills, waste piles and dewatered DLD)
  - Liquid sludge application must be >10 m (lagoons and liquid DLD).
- Distance from surface water/borehole must be >400 m.

Note: These buffer zones may be relaxed on condition that proof is provided that the groundwater and surface water is adequately protected. An increase in buffer zones may also be required depending on site conditions.

MANAGEMENT REQUIREMENTS FOR LAND DISPOSAL

Odour control

One of the vector attraction reduction options (Table 3) must be applied to minimise the production of odours.

Minimum solids content

Sludge should be dewatered to at least 20% solids before it can be disposed of on mono-fills, waste piles or landfill to ensure pile stability.

Run-off collection

Run-off includes rainwater and other liquid that drains over the land and runs off the land surface. Run-off may be contaminated by sludge and must be collected and disposed of according to the licence requirements. In some disposal practices like existing, unlined lagoons, this is not possible. In these cases, a stringent monitoring program should be adopted.

Leachate collection

Leachate is liquid originating from excess moisture in the sludge or from rainwater percolating through the disposal site. If the disposal site has a liner and a leachate collection system and/or a toe drain:

- The leachate collection system must be maintained and checked on a regular basis;
- Any leachate should be re-cycled to the WWTP for treatment or treated separately in an evaporation pond or alternative appropriate treatment system.

If the site does not have a liner and leachate collection system, the leachate will move through the soil profile, taking along the mobile elements. At these sites the soil profile on the footprint of the disposal site will have to be monitored.

Surface water protection

Surface water resources near the disposal sites need to be protected against contamination by constituents from the waste disposed of at the site. This could be achieved by:

- Constructing cut-off trenches or bund walls down-gradient of the disposal site to intercept run-off;
- Increasing the distance between the waste disposal site and the water body to ensure no run-off will reach the water body;
- Planting non-edible crops/plants/trees with a high water demand that will intercept run-off.

Groundwater protection

Groundwater is a valuable resource in the South African context and sludge placed on land should not contaminate the aquifer. Nitrate (NO_3) present in sludge could leach through the soil profile into the aquifer. The South African Water Quality Guidelines for NO_3 in water for domestic use is presented in Table 10. It is recommended that the groundwater quality should not deteriorate more than 1 class (for example from acceptable to tolerable) due to sludge disposal with a **maximum permissible NO_3-N concentration of 20 mg/ℓ** . If there is any possibility that the groundwater may be used for **drinking purposes**, **the maximum tolerable level for NO_3-N must not exceed 10 mg/ℓ .**

TABLE 10: SOUTH AFRICAN WATER QUALITY GUIDELINE FOR NITRATE (DOMESTIC USE)

	Target Water Quality Guideline	Acceptable	Tolerable	Unacceptable
NO_3-N (mg/l N)	6	10	20	> 20

If the background NO_3 concentration in the groundwater is >20 mg/ℓ, specialist studies should be conducted to ensure that the groundwater resource will be protected against further deterioration due to sludge disposal. The owner/operator should provide proof that groundwater is not contaminated by means of:

- Implementing a groundwater monitoring programme;
- Monitoring of the transmission zone at regular intervals (every 3 years);
- Proof that groundwater monitoring is not required based on a detailed study by a qualified person, either because of the depth of the water table, the amount of sludge disposed or other site specific factors.

Liner requirements

A liner is a low permeability layer placed beneath a land disposal site, designed to direct leachate to a collection drain or sump, or to contain leachate. It may comprise natural materials, synthetic materials, or a combination thereof.

Appropriate liners will be required under the following circumstances:

- Soil clay content <20%;
- $G:B^-$ landfills engineered as $G:B^+$ sites in order to receive sludge for co-disposal;
- Sites receiving Pollutant class c sludge.

For more information on liner design requirements, consult the latest edition of the *Minimum Requirements for Waste Disposal by Landfill.*

Soil quality

Total trigger values (TTV) and maximum permissible levels (MPL) for metals in the receiving soil (Table 11) have been set to ensure that the soil quality in unlined facilities does not degrade to such an extent that major intervention is required to restore soil functionality.

When the total metal content (*aqua regia* digestion, Appendix 1, Table 1D) of the soil exceeds the TTV the producer should be aware that the capacity of the soil to receive sludge at high loading rates is approaching its limit and that additional management requirements should be implemented. These management requirements could include additional liming to ensure immobility of metals in the soil profile (especially at existing land disposal sites with soil pH<6.5) and/or source control to improve sludge quality. The monitoring requirements are explained in the “Soil monitoring” section. Sludge disposal on the site should cease (no remediation needed) when the soil metal concentration reach the MPL. At existing sites, the soil metal concentration may be higher than the MPL in which case a remediation plan should be implemented.

TABLE 11: METAL LIMITS FOR SOIL AT UNLINED SLUDGE DISPOSAL SITES

Elements	Total trigger value (TTV) mg/kg	Maximum permissible level (MPL) mg/kg
Arsenic (As)	2	20
Cadmium (Cd)	3	5
Chromium (Cr)	350	450
Copper (Cu)	120	375
Lead (Pb)	100	150
Mercury (Hg)	1	9
Nickel (Ni)	150	200
Zinc (Zn)	200	700

Methane gas

Methane is an odourless and highly combustible gas generated at disposal sites when sludge is covered by soil or other material. At these sites the air quality must be continuously monitored for methane gas and must meet the limits on the concentration of methane in the air as presented in Table 12.

TABLE 12: RECOMMENDED METHANE LIMITS AT DISPOSAL SITES

	Methane level	Mitigation required
Inside buildings	0,1% - 1% in air (i.e., 2% - 20% of the LEL)	Regular monitoring must be implemented.
	> 1% in air (i.e., 20% of LEL)	Building must be evacuated and trained personnel consulted.
Disposal site property line	0,5% - 5% in air (i.e., 10% of LEL)	Regular monitoring of the boundary must be implemented.
	> 5% in air (i.e., the LEL)	Monitoring should be initiated and an investigation to determine lateral migration.
LEL = Lower explosive limit - the lowest % (by volume) of methane gas in air that supports a flame @ 25^{0}C and atmospheric pressure.		

Restrictions on crop production

No **edible crops** (grain, fruit and vegetables) may be grown on disposal sites (during operation and after closure) unless the owner/operator at the disposal site can demonstrate to the permitting authority that public health and the environment are protected from reasonably anticipated adverse effects of certain pollutants present in the sludge. If the owner/operator wishes to grow crops on the site, “Volume 4: Requirements for the beneficial use of sludge” will apply. The site is then managed as a beneficial use site at high application rates.

PART 4: GENERAL RESTRICTIONS AND REQUIREMENTS APPLICABLE TO LAND DISPOSAL OPTIONS

Public access restrictions

Public access must be restricted at all disposal sites while the site is in operation and 3 years after closure. This management practice minimises public contact with pollutants, including pathogens that may be present in the sludge.

Restrictions on grazing animals

No grazing animals are allowed on disposal sites unless the owner/operator at the disposal site can demonstrate to the permitting authority that public health, health of the animals and the environment are protected from reasonably anticipated adverse effects of certain pollutants present in the sludge. If the owner/operator wishes to graze animals on the site, "Volume 4: Requirements for the beneficial use of sludge" will apply and a condition will be included as such in the relevant authorisation.

MONITORING REQUIREMENTS FOR LAND DISPOSAL

The analytical data collected during monitoring must be interpreted by the sludge producer. If any problems are identified it must be communicated to the relevant Authority.

Sludge monitoring

Sludge monitoring is recommended to determine whether sludge quality increased or decreased with time. Sludge management options may be re-evaluated if the sludge quality increases. Table 13 indicates the frequency of sampling and analyses needed for monitoring purposes.

Groundwater monitoring

Monitoring boreholes should be located to intersect groundwater moving away from a disposal site. The number and location of boreholes have to be determined by a responsible person.

- Boreholes should be located on either side of the disposal site in the direction of the groundwater flow (up-stream and down-stream).
- Site monitoring boreholes must be such that the section of the aquifer most likely to be polluted first is monitored.
- Groundwater levels must be recorded on a regular basis to detect any changes or trends.
- The frequency of sampling will depend on the disposal option and type of sludge (liquid or dewatered).
- Water sampling, preservation and analyses should be done according to prescribed procedures (Table 14).
- If the sludge producers adhere to all the requirements in this guideline, groundwater should be adequately protected. However, it is recognised that in some unforeseen circumstances groundwater contamination may be observed for which a closure and remediation plan is required.

TABLE 13: SLUDGE SAMPLING AND ANALYSES FOR MONITORING

<table>
<tr><td>What should be monitored ?</td><td colspan="3">Microbiological quality
Physical characteristics
Chemical characteristics</td></tr>
<tr><td rowspan="6">How often should samples be taken ?</td><td colspan="2">Amount of sludge produced (t _{dry weight})</td><td rowspan="2">Monitoring frequency</td></tr>
<tr><td>Daily average</td><td>Yearly average</td></tr>
<tr><td><1</td><td><365</td><td>Once per year</td></tr>
<tr><td>1 - 5</td><td>365 - 1 825</td><td>4 times per year</td></tr>
<tr><td>5 - 45</td><td>1 825 - 16 500</td><td>6 times per year</td></tr>
<tr><td>>45</td><td>>16 500</td><td>Monthly</td></tr>
<tr><td>Type of samples</td><td colspan="3">Grab samples of pathogens and composite samples for metals.</td></tr>
<tr><td>How many samples should be taken?</td><td colspan="3">At least 3 samples of each sludge stream destined for disposal.</td></tr>
<tr><td>When to sample ?</td><td colspan="3">Before disposal</td></tr>
<tr><td rowspan="6">Where to collect samples ?</td><td>Anaerobic digested</td><td colspan="2">Collect from sampling valves on the discharge side of sludge pumps</td></tr>
<tr><td>Aerobic digested</td><td colspan="2">Collect from sampling valves on the discharge side of sludge pumps</td></tr>
<tr><td>Thickened</td><td colspan="2">Collect from sampling valves on the discharge side of sludge pumps</td></tr>
<tr><td>Heat treated</td><td colspan="2">Collect from sampling valves on the discharge side of sludge pumps</td></tr>
<tr><td>Mechanical dewatered</td><td colspan="2">Collect from discharge point</td></tr>
<tr><td>Dewatered in drying beds</td><td colspan="2">Divide bed into quarters, sample from each quarter and combine samples</td></tr>
<tr><td>Sample sizes</td><td>At least 500g _{dry mass}</td><td colspan="2"></td></tr>
<tr><td>Analytical methods</td><td colspan="3">See volume 1 - Appendix 2 (Faecal coliform), Volume 3 - Appendix 1 (Helminth ova and TCLP test for metals).</td></tr>
</table>

TABLE 14: GROUNDWATER SAMPLING AND ANALYSES FOR MONITORING

<table>
<tr><td>What should be monitored?</td><td colspan="2">• pH, EC, PO_4, NH_4 NO_3, COD
• Faecal coliforms and/or e coli depending on sludge quality</td></tr>
<tr><td>How often should samples be taken?</td><td colspan="2">Depend on disposal option and type of sludge. For monitoring frequency refer to:
• Table 19: Mono-fills, waste piles and lagoons
• Table 21: Dedicated Land Disposal</td></tr>
<tr><td>What sampling equipment should be used?</td><td colspan="2">Plastic bottles with a plastic cap and no liner within the cap is required
Glass bottles are required if organic constituents are to be tested</td></tr>
<tr><td>How should samples be taken?</td><td colspan="2">See Volume 3 - Appendix 3 (sampling procedures)</td></tr>
<tr><td rowspan="2">How should samples be preserved?</td><td>For pH, EC, PO_4 analyses</td><td>For NH_4, NO_3, COD analyses</td></tr>
<tr><td>No additives, refrigerate and analyse as soon as possible</td><td>Add H_2SO_4 to pH<2</td></tr>
<tr><td>How many samples should be taken?</td><td colspan="2">At least 2 samples from each borehole, 1 sample for pH, EC and PO_4 analyses and 1 sample for NH_4, NO_3 and COD analyses</td></tr>
<tr><td>Sample sizes</td><td colspan="2">At least 100 ml for each sample would be needed</td></tr>
<tr><td>Analyses methods</td><td colspan="2">See volume 3 - Appendix 1 (Analytical methods)</td></tr>
</table>

Surface water monitoring

Surface water should be monitored to ensure that surface water bodies are not contaminated by sludge disposal practices. Surface water monitoring includes run-off monitoring.

- Water sampling, preservation and analyses should be done according to prescribed procedures (Table 15 and Appendix 3).
- Run-off should be collected on a daily basis and analysed before discharge. No analyses are needed when run-off is re-cycled into the treatment system.

TABLE 15: SURFACE WATER SAMPLING AND ANALYSES FOR MONITORING

What should be monitored?	• pH, EC, PO_4, NH_4 NO_3, COD	
How often should samples be taken?	Monthly from water courses upstream and downstream of the disposal site (20 - 50m down stream)	
What sampling equipment should be used?	Plastic bottles with a plastic cap an no liner within the cap is required for most sampling exercises Glass bottles are required if organic constituents are to be tested (see Appendix 3)	
How should samples be taken?	See Volume 3 - Appendix 3 (sampling procedures)	
How should samples be preserved?	**For pH, EC, PO_4 analyses**	**For NH_4, NO_3, COD analyses**
	No additives, refrigerate and analyse as soon as possible	Add H_2SO_4 to pH<2
How many samples should be taken?	At least 2 samples from each water course, 1 sample for pH, EC and PO_4 analyses and 1 sample for NH_4, NO_3 and COD analyses	
Sample sizes	At least 100 ml for each sample would be needed	
Analyses methods	See volume 3 - Appendix 1 (Analytical methods)	

Soil monitoring

Soil monitoring is only required at unlined disposal sites. Soil monitoring will serve as an early warning system on the mobility of constituents of concern in the soil profile and the potential for groundwater contamination.

- Frequency of monitoring will depend on:
  - The disposal option and the sludge type (liquid or dewatered);
  - Soil pH; and
  - Soil clay content.
- Soil sampling and analyses should be done according to described procedures (Table 16; Appendix 3). Soils should be sampled at 100 mm intervals to a depth of at least 500 mm.

TABLE 16: SOIL SAMPLING AND ANALYSES FOR MONITORING

What should be monitored?	pH, nutrients (total N, P and NO_3-N) and 8 metals (total) specified in classification
How often should samples be taken?	Depend on disposal option, type of sludge, soil pH and soil clay content. For monitoring frequency refer to: • Table 19: Mono-fills, waste piles and lagoons • Table 21: Dedicated Land Disposal
How to sample?	Sample at 100mm intervals to at least 500mm See Volume 3 - Appendix 3 (sampling procedures)
How many samples should be taken?	At least 2 composite samples of each disposal area at each depth
Sample sizes	At least 1kg
Analyses methods	See volume 1 - Appendix 2

Methane monitoring

A methane monitoring system must be implemented at disposal sites where sludge is covered with soil or other material. A methane monitoring device must be installed to continuously measure methane concentrations in the air inside the property. Any individual entering the premises must be able to read the measurement. The prevailing wind direction should be considered when installing the measuring device.

CLOSURE AND REMEDIATION PLANS FOR LAND DISPOSAL

Once the operation has ceased, aftercare is necessary to ensure sustained acceptability of the disposal site. A remediation and closure plan for all disposal sites is required and should be developed by a responsible person.

Aspects that should be addressed include:

- Remedial design to address identified problem areas (or future problems)
- Final landscaping and re-vegetation
- Permanent storm water diversion measures, run-off control and anti-erosion measures
- Post-closure monitoring plan and implementation.

Remediation

The remediation of a disposal site will ensure that the final condition of the site is environmentally acceptable and that there will be no adverse long-term effects. It should include final cover/capping and/or vegetation. Any long-term leachate, gas, storm water and erosion control systems required should be in place before closure. The remediation plan should be developed by a responsible person.

The extent of the remediation plan will depend on several factors, including:

- Size of the disposal site (localised waste pile or large area irrigated with sludge);
- Extent of pollution – sites where metals have not migrated down the soil profile will require a less complicated rehabilitation plan than sites where groundwater contamination has already occurred; and
- Future land-use.

RECORD KEEPING REQUIREMENTS FOR LAND DISPOSAL OPTIONS

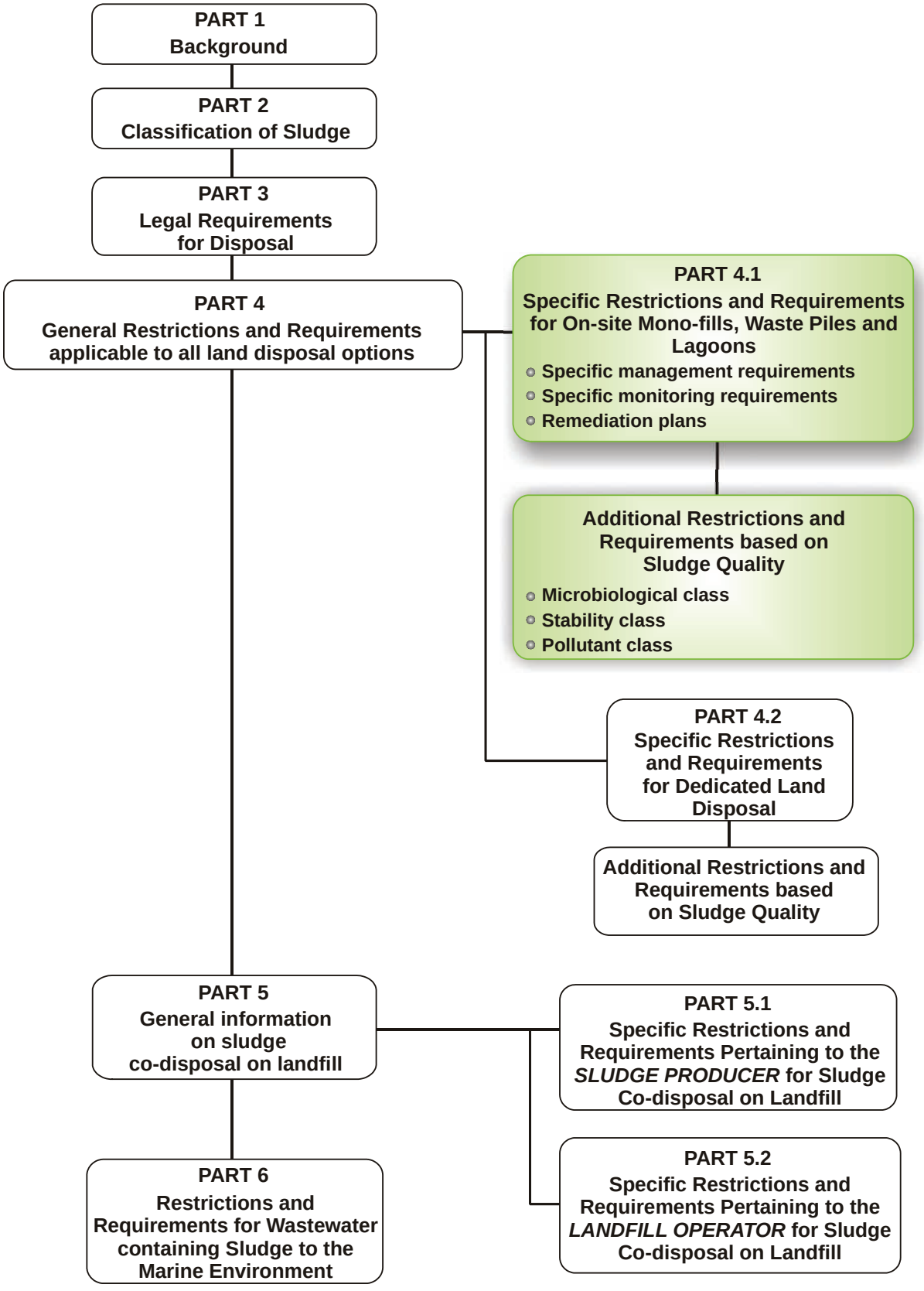
Once the applicable permits and authorisations have been granted, sludge disposal areas essentially become self-regulatory. This implies that certain records must be kept by the sludge producer and disposal site owner/operator.

Table 17 summarises the general record keeping requirements for the producer (irrespective of the class of sludge produced). It must be noted that the conditions specified in an authorisation may require additional record-keeping. It is the responsibility of the producer to obtain the necessary data from the disposal site owner/operator as per their contract.

TABLE 17: RECORD KEEPING REQUIREMENTS FOR THE SLUDGE PRODUCER

	Description of records to be kept
1	Report on the consideration of alternative, beneficial use options and feasibility studies
2	A copy of the applicable permits and licences
	Sludge records
3	Mass, solids content and volume of each sludge stream produced and a supporting wastewater treatment plant mass balance
4	Detailed description of sludge management process
5	Classification of each sludge stream that leaves the plant
6	Results supporting initial classification of sludge in terms of the: • Microbiological class • Stability class • Pollutant class (total and TCLP)
7	The original or certified copy of the contract between the sludge producer and the disposal site owner/operator (if applicable)
8	Operational problem register
9	Complaints register
	Initial site investigation and site selection records
10	Groundwater data including: • Aquifer classification (yield, depth, strategic value) • Hydraulic gradient • Groundwater quality (up gradient and down gradient)
11	Surface water quality data
12	Soil data including: • Soil structure, pH, clay content, permeability and cation exchange capacity (CEC) • Soil classification and soil map of the area • Concentration of nutrients, trace elements and metals (total)
	Monitoring records
13	Sludge data pertaining to the: • Microbiological class • Stability class • Pollutant class
14	Groundwater data including: • Groundwater levels • Groundwater monitoring data (chemistry and microbiology if applicable)
15	Surface water data including: • Run-off volumes and quality (if applicable) • Water quality from nearby water course
16	Soil data including: • Soil pH • Nutrient status with depth • Metal content of the soil with depth (total)
17	Methane gas data

DOCUMENT ROADMAP



PART 4.1:

SPECIFIC RESTRICTIONS AND REQUIREMENTS FOR ON-SITE MONO-FILL, WASTE PILES AND LAGOONS

Part 4.1 deals with the specific restrictions and requirements for the on-site disposal of sludge in mono-fills, waste piles and lagoons. The major difference between a mono-fill and a waste pile is that a monofill is a constructed waste site while waste piles are simply mounds of dewatered sludge on the soil surface. Lagoons are constructed areas (lined or unlined) where liquid sludge is left to dry. Occasionally the dried sludge is removed from the lagoon and disposed on waste piles or used beneficially.

SPECIFIC RESTRICTIONS AND REQUIREMENTS BASED ON SLUDGE QUALITY

Table 18 lists the specific restrictions and requirements based on sludge quality. These restrictions and requirements include additional treatment and/or management options that should be implemented and/or more stringent monitoring requirements that are required with deteriorating sludge quality.

TABLE 18: SPECIFIC RESTRICTIONS FOR ON-SITE MONO-FILLS, WASTE PILES AND LAGOONS BASED ON SLUDGE QUALITY

<table>
<tr><th colspan="2">South African Sludge Classification</th><th>Lined land disposal sites</th><th>Unlined disposal sites</th></tr>
<tr><td rowspan="3">Microbiological Class</td><td>A</td><td>None</td><td>None</td></tr>
<tr><td>B</td><td>None</td><td rowspan="2">Surface and Groundwater monitoring should include faecal coliforms and E. Coli analyses</td></tr>
<tr><td>C</td><td>None</td></tr>
<tr><td rowspan="3">Stability Class</td><td>1</td><td colspan="2">None</td></tr>
<tr><td>2</td><td colspan="2">Depending on the reliability of the vector attraction reduction measures implemented, additional management systems may be required.</td></tr>
<tr><td>3</td><td colspan="2">Disposal of raw, primary sludge will not be allowed</td></tr>
<tr><td rowspan="3">Pollutant Class</td><td>a</td><td>None</td><td>None</td></tr>
<tr><td>b</td><td>Possible liner design requirements</td><td>Lime treatment
Soil restrictions</td></tr>
<tr><td>c</td><td>Liner design requirements</td><td>Disposal will only be allowed on properly engineered disposal sites with appropriate liners and leachate collection systems</td></tr>
<tr><td colspan="4">Note: The restrictions on Pollutant class refer to the TCLP extractable metal content of the sludge, (Table 4), not the other potential pollutants such as nutrients</td></tr>
</table>

PART 4.1: SPECIFIC RESTRICTIONS AND REQUIREMENTS FOR ON-SITE MONO-FILL, WASTE PILES AND LAGOONS

SPECIFIC MANAGEMENT REQUIREMENTS FOR MONO-FILLS, WASTE PILES AND LAGOONS

All management requirements described in Part 4 apply to all existing and new on-site land disposal facilities. The management requirements discussed in the following section is specifically for on-site mono-fills, waste piles and lagoons.

Run-off collection

Where bund walls or cut-off trenches have been constructed around/down slope of mono-fills and waste piles, run-off should be collected, contained and treated or recycled and discharged in a responsible manner depending on the water quality.

SPECIFIC MONITORING REQUIREMENTS FOR MONO-FILLS, WASTE PILES AND LAGOONS

All monitoring requirements described in Part 4 apply. Only monitoring requirements pertaining specifically to mono-fills, waste piles and lagoons will be discussed in the sections that follow. Table 19 lists the minimum frequency of monitoring for mono-fills, waste piles and lagoons. Unlined disposal sites need to be monitored more frequently to assess the impact on soil and groundwater

TABLE 19: MINIMUM FREQUENCY FOR MONITORING OF MONO-FILLS, WASTE PILES AND LAGOONS

	Mono-fill		Waste pile		Lagoon	
	L	U	L	U	L	U
Groundwater chemistry	y	6m/3m*	y	6m/3m*	6m	3m/3m*
Groundwater microbiology	NA	6m#/3m##	NA	6m#/3m##	NA	6m#/3m##
Surface water quality‡	m	m	m	m	m	m
Soil quality	NA	y/6m**	NA	y/6m**	NA	6m/3m**

Legend: L = lined; U = unlined; NA = not applicable; y = yearly; m = monthly; 3m = 3-monthly; 6m = 6 monthly; BD = Before Design

* For existing disposal sites where the water table is <5m and the lagoons where water table is <10m

\# Microbiological class B

\## Microbiological class C

** For existing sites with soil pH <6.5 and/or clay content <20%

‡Only applicable during the rainy season, including chemistry and microbiology (if applicable)

Note: The monitoring frequency can be relaxed or increased by the regulating Authority based on the results of the monitoring data.

PART 4.1: SPECIFIC RESTRICTIONS AND REQUIREMENTS FOR ON-SITE MONO-FILL, WASTE PILES AND LAGOONS

Groundwater monitoring

For more detailed descriptions on groundwater sampling procedures, see Appendix 4.

- At existing sites where the water table <5 m the monitoring frequency should increase to 3-monthly monitoring (mono-fills and waste piles) or monthly monitoring for lagoons where the water table is <10 m.
- Groundwater analyses should include:
  - Groundwater chemistry; and
  - Groundwater microbiology.

Note: The monitoring frequency and/or number of determinants for groundwater monitoring could be relaxed for unlined mono-fills and waste piles under the following circumstances:

- Water table >10 m;
- Soil clay content >35%;
- On application to the relevant authority with an appropriate technical motivation: the applicant must demonstrate a history of compliance.

Surface water monitoring

For more detailed descriptions on water sampling procedures, see Appendix 4.

- Run-off water quality monitoring is not applicable when the run-off is recycled in the treatment process.
- Surface water quality should be monitored monthly during the rainy season or whenever there is a flow, 20-50 m upstream and downstream of the disposal site.
- Analyses should include:
  - Surface water chemistry; and
  - Surface water microbiology.

Soil monitoring

For more detailed descriptions on soil sampling procedures, see Appendix 4.

- Unlined mono-fills and waste piles –
  - Sample the footprint of the disposal area;
  - Increase the sample frequency when the soil pH<6.5 and/or soil clay content <20%;
  - Take at least 3 soil samples from each disposal area on site;
  - Sample at 100 mm depth increments up to 500 mm (3 replicates of each);
  - Analyse samples for nutrients and metals and determine the pH.

- Unlined lagoons –
  - Sample down slope and as near as possible to the lagoon;
  - Increase the sample frequency when the soil pH<6.5 and/or soil clay content <20%;
  - Take at least 3 samples from each lagoon on site;
  - Sample at 100 mm depth increments up to 500 mm (3 replicates of each);
  - Analyse samples for nutrients and metals and determine pH.

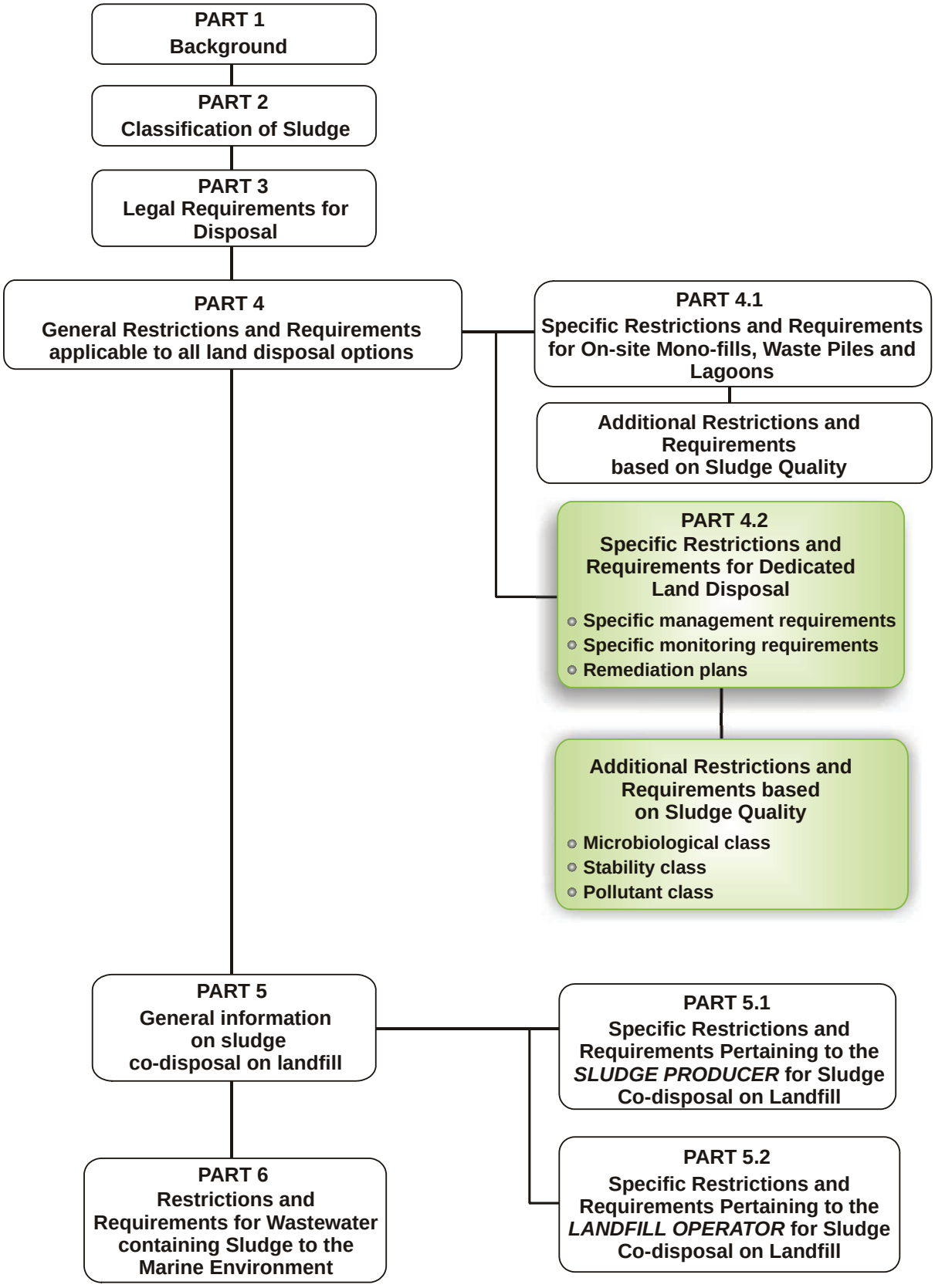
REMEDIATION PLANS FOR ON-SITE LAND DISPOSAL

When the interpretation of the monitoring data leads to the identification of potential contamination of the water resources or soil, the sludge producer must appoint a responsible person to develop a remediation strategy for the specific site. A report, including the interpreted data and the remediation plant must be submitted to the relevant Authority to be approved for implementation.

A site remediation plan should be developed by a responsible person when:

- Groundwater quality starts to deteriorate due to sludge disposal; or
- Surface water quality is affected due to sludge disposal; or
- The total soil metal content exceeds the MPL; or
- Mobility of metals and nutrients in the soil profile is observed.

DOCUMENT ROADMAP



PART 4.2:

SPECIFIC RESTRICTIONS AND REQUIREMENTS FOR DEDICATED LAND DISPOSAL OF SLUDGE

Part 4.2 deals with specific restrictions and requirements for dedicated land disposal (DLD) of sludge. DLD sites are usually close to, but not within the premises of the WWTP. The area that receives sludge can be several hectares, depending on the land available for disposal. The potential pollution area is substantially larger than in the case of mono-fills, waste piles and lagoons, but the impact per unit surface area is smaller.

SPECIFIC RESTRICTIONS AND REQUIREMENTS BASED ON SLUDGE QUALITY

Table 20 lists the additional restrictions and requirements for DLD based on the sludge quality. These restrictions and requirements include additional treatment options that should be implemented and/or more stringent monitoring requirements with deteriorating sludge quality.

TABLE 20: RESTRICTIONS AND REQUIREMENTS FOR DLD BASED ON SLUDGE QUALITY

South African Sludge Classification		Restrictions / Requirements
Microbiological Class	A	None
	B	Surface and Groundwater monitoring should include faecal coliforms
	C	Surface and Groundwater monitoring should include faecal coliforms and *E. Coli* analyses
Stability Class	1	None
	2	Depending on the reliability of the vector attraction reduction measures implemented, additional management systems may be required.
	3	Disposal of raw, primary sludge will not be allowed
Pollutant Class	a	None
	b	Lime treatment Soil restrictions
	c	Specific lime treatment tests Soil restrictions Frequent monitoring (soil and groundwater)

Note: The restrictions on Pollutant class refer to the TCLP extractable metal content of the sludge, (Table 4), not the other potential pollutants such as nutrients

PART 4.2: SPECIFIC RESTRICTIONS AND REQUIREMENTS FOR DEDICATED LAND DISPOSAL OF SLUDGE

SPECIFIC MANAGEMENT REQUIREMENTS FOR DLD SITES

All management requirements described in Part 4 apply to DLD sites. The management requirements discussed in the following section are specifically for DLD sites for both liquid and dewatered sludge application.

Odour control

Appropriate odour control measures should be implemented to reduce odours and vector attraction.

Run-off collection

Run-off should be collected from cut-off trenches or where bund walls were constructed around/down slope of DLD sites. The water must be contained and treated/recycled/discharged depending on the water quality.

Restrictions on crop production

The DLD site owner/operator should ensure that no edible crops grow on the site that could serve as a food source to the general public. Adequate signposts should be erected to warn the public that no crops may be harvested at the DLD site.

Restrictions on grazing animals

The DLD site owner/operator should ensure that no animals are allowed to graze on the site. Adequate signposts should be erected to warn the public that no grazing animals are allowed on the DLD site.

Public access restrictions

Due to the potentially high pathogen and metal content of the sludge and its instability, public access to the disposal site should be restricted. Adequate signposts should be erected to warn the public that the DLD site might be hazardous.

SPECIFIC MONITORING REQUIREMENTS FOR DLD SITES

All monitoring requirements described in Part 4 apply. Only monitoring requirements pertaining specifically to on-site land disposal will be discussed in the sections that follow. Table 21 lists the minimum frequency for monitoring of DLD sites.

Note: The monitoring frequency can be relaxed or increased by the regulating Authority based on the results of the monitoring data.

TABLE 21: MINIMUM FREQUENCY OF MONITORING OF DLD SITES

	Dewatered sludge	Liquid sludge
Groundwater chemistry	6m/3m*	3m/m*
Groundwater microbiology	6m#/3m##	3m#/m##
Surface water quality‡	m	m
Soil quality	y/6m**	6m/3m**

Legend: y = yearly; m = monthly; 3m = 3-monthly; 6m = 6 monthly;

* Existing DLD sites where the water table is <5m (dewatered) and <10 (liquid)

\# Microbiological class B

\## Microbiological class C

** For existing DLD sites with soil pH <6.5 and/or clay content <20%

‡Only applicable during the rainy season, including chemistry and microbiology (if applicable)

Groundwater monitoring

For more detailed descriptions on groundwater sampling procedures, see Appendix 4.

- At existing sites where the water table <5 m the monitoring frequency should increase to 3-monthly monitoring for dewatered sludge application or monthly monitoring for liquid sludge disposal.
- Groundwater analyses should include:
  - Groundwater chemistry;
  - Groundwater microbiology.

Note: The monitoring frequency for groundwater monitoring could be relaxed for DLD sites under the following circumstances:

- Water table >10 m (dewatered sludge disposal) or >20 m (liquid sludge disposal);
- Soil clay content >35%;
- On application to the relevant authority with an appropriate technical motivation: the applicant should be able to demonstrate a history of compliance.

Surface water monitoring

For more detailed descriptions on surface water sampling procedures, see Appendix 4.

- Run-off water quality monitoring is not applicable when the run-off is recycled in the treatment process.

- Surface water quality should be monitored monthly during the rainy season, 20-50 m upstream and downstream of the disposal site.
- Analyses should include:
  - Surface water chemistry;
  - Surface water microbiology.

Soil monitoring

For more detailed descriptions on soil sampling procedures, see Appendix 4.

- Sample the footprint of the disposal area according to different soil types (if applicable).
- Increase the sample frequency when the soil pH<6.5 and/or soil clay content <20%.
- Sample at 100 mm depth increments up to 500 mm.
- Collect numerous samples, mix well and submit at least three composite samples for each depth increment for every hectare of the DLD site.
- Analyse samples for nutrients and metals and determine soil pH.

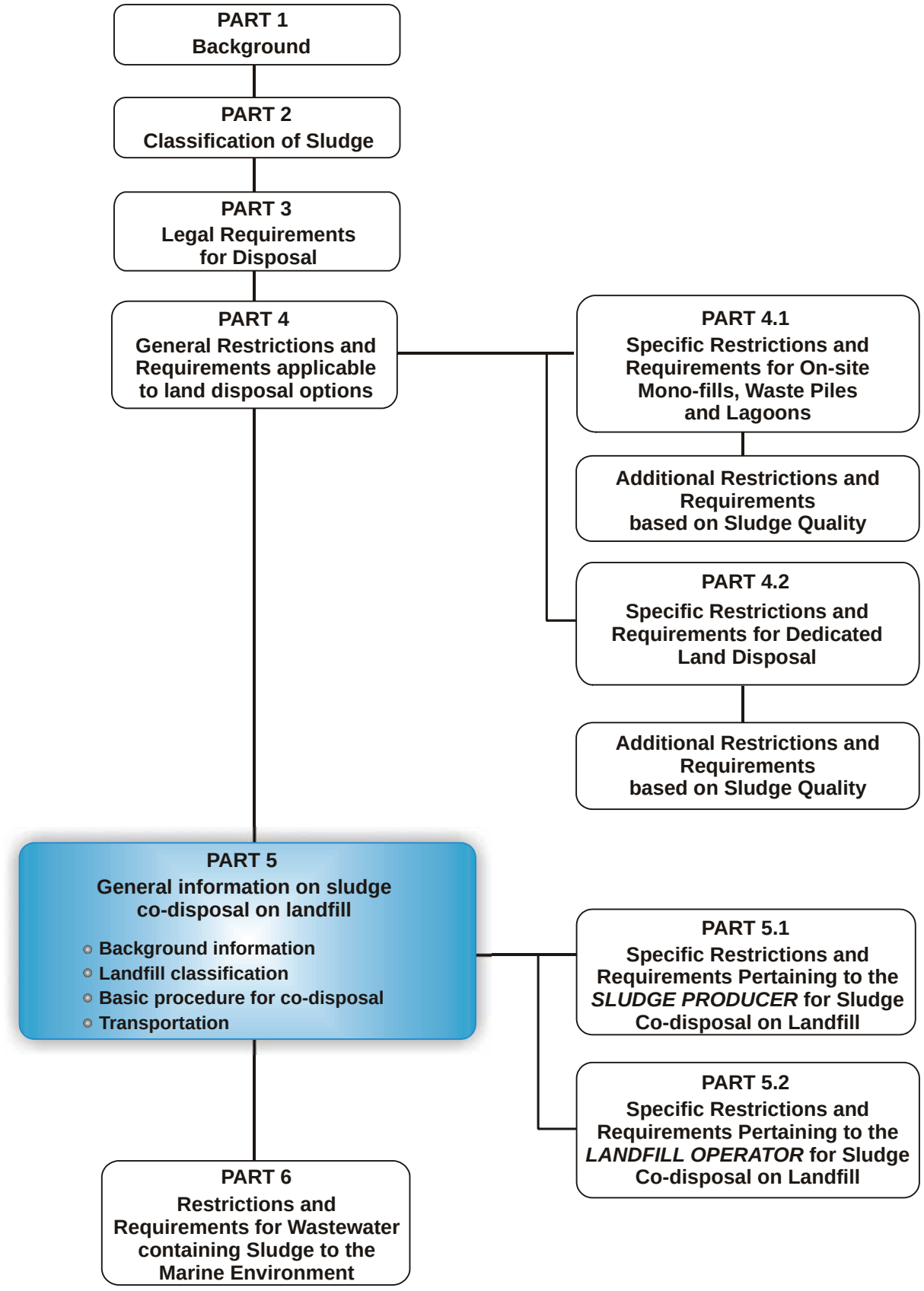
REMEDIATION PLANS FOR DLD SITES

If any potential pollution problems are identified during the interpretation of the monitoring results, a site remediation strategy must be developed by a responsible person. The site remediation plant must be approved by the relevant Authority before implementation.

A site remediation plan should be developed by a responsible person when:

- Groundwater quality deteriorates due to sludge disposal; or
- Surface water quality is affected due to sludge disposal; or
- The total soil metal content exceeds the MPL; or
- Mobility of metals and nutrients in the soil profile is observed.

DOCUMENT ROADMAP



PART 5:

GENERAL INFORMATION ON SLUDGE CO-DISPOSAL ON LANDFILL

Part 5 deals with specific restrictions and requirements for sludge co-disposal on a General or Hazardous landfill. The co-disposal of sewage sludge with municipal solid waste on landfills in South Africa is dealt with in the *Minimum Requirements for the Handling, Classification and Disposal of Hazardous waste* and *Minimum Requirements for Waste Disposal by Landfill*. All actions required in the design, operation, monitoring and closure of landfill sites in South Africa are described in these publications. Volume 3 of the Sludge Guidelines (this document) presents procedural guidelines for co-disposal of sludge on landfill.

BACKGROUND INFORMATION

The following apply for wastewater sludge:

- sludge disposed at a site other than the WWTP itself, falls under the definition of waste as stipulated in Section 1 of the Environmental Conservation Act, 1989
- sludge falls under the definition of a high volume/low hazard waste.

Sludge co-disposal in general landfill has the following benefits:

- sludge increase the moisture storage in the landfill and therefore reduce the leachate volumes;
- sludge decrease the mobility of metals due to an increase in pH and precipitation of metals, and;
- sludge increase the compaction density achieved in a landfill.

These benefits also apply to the use of sludge as landfill cover (described in Volume 4) and therefore the beneficial use option should rather be considered.

Sludge co-disposal methods

Area method: Spread sludge as a thin layer on the waste body, cover with a relatively thin layer of waste and compact with a landfill compactor (Figure 10).

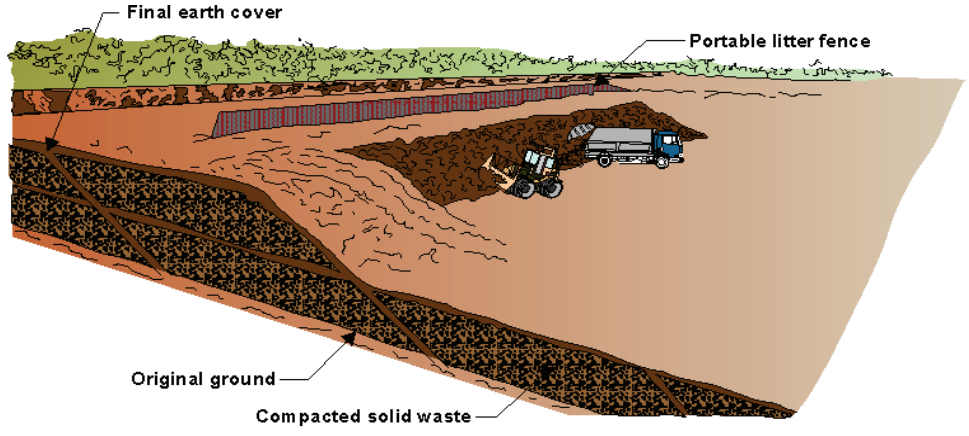


Figure 10: Illustration of the area method of sludge co-disposal on landfill

Toe method: Spread the sludge in a layer at the toe of an advancing cell. Waste is placed at the top of the slope and compacted down the slope to cover the sludge (Figure 11).

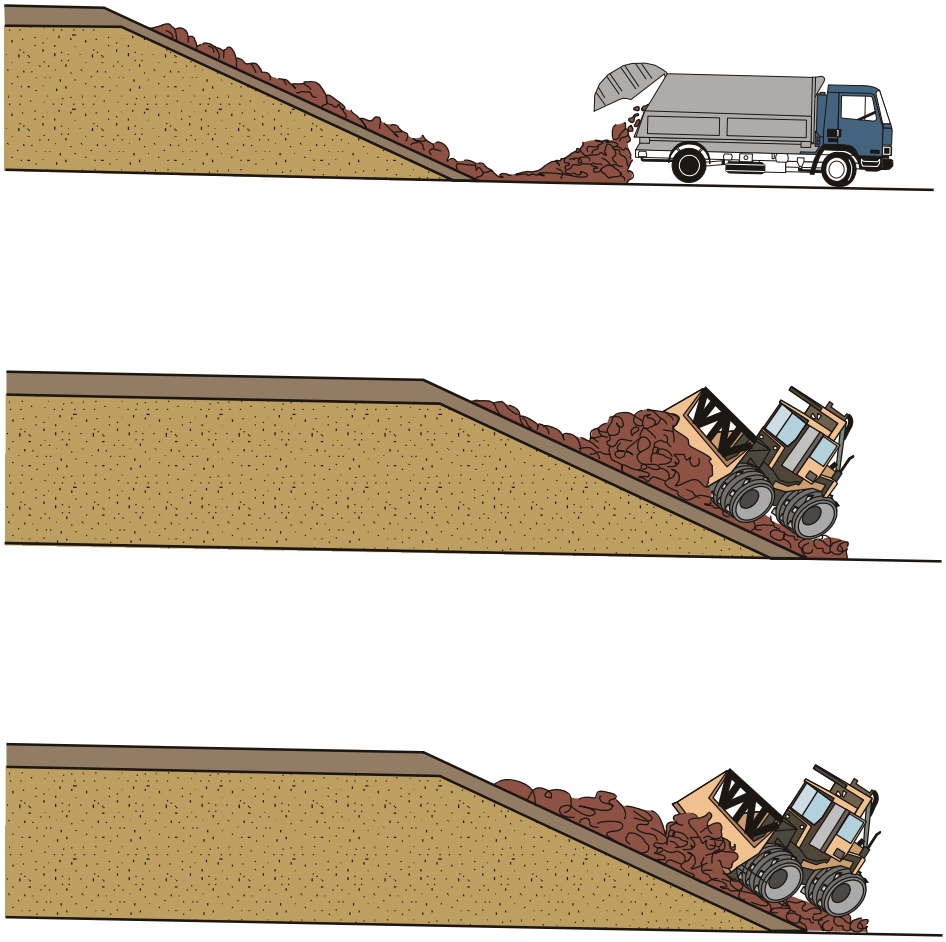


Figure 11: Illustration of the toe method of sludge co-disposal on landfill

Trenching: Sludge is deposited in trenches and filled over with waste immediately after filling (Figure 12).

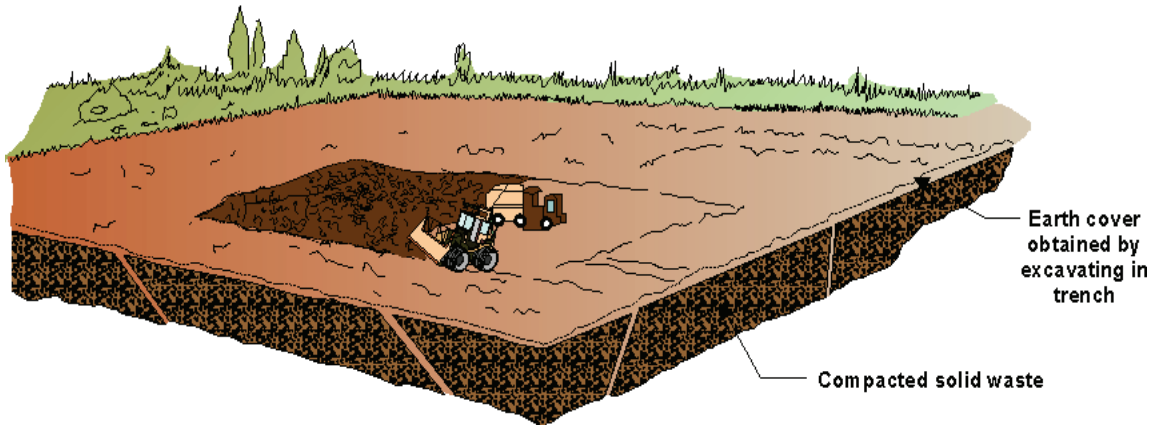


Figure 12: Illustration of the trench method of sludge co-disposal on landfill

Alternative method: This co-disposal option has been researched in SA and found to be a good alternative to other methods. A pile of waste is placed at the toe of the slope. A pile of sludge is then placed against this. A second pile of refuse is then placed against the sludge (i.e. the sludge is sandwiched between two piles of refuse). The compactor then moves these piles up the working face. The advantages of this method are that good mixing is achieved and the compactor does not slip on or sink into the sludge (Figure 13).

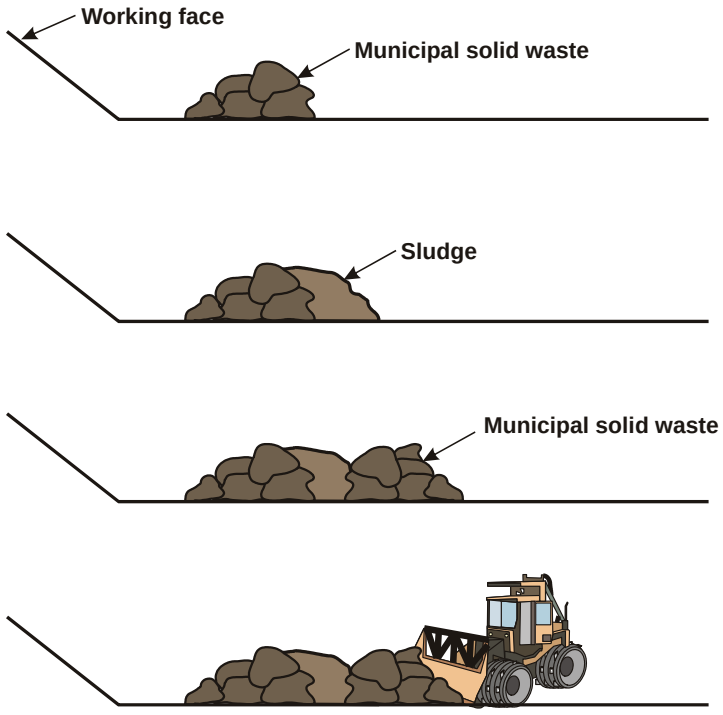


Figure 13: Proposed alternative method for sludge co-disposal on landfill

LANDFILL CLASSIFICATION

The Minimum Requirements detail landfill designs based on the specific landfill classification. Waste type, waste volumes and the water balance determine the landfill classification.

- General waste can be disposed of at general landfill sites denoted G;
- Hazardous waste site are denoted H.

Based on waste volumes, landfills are classed as:

- Communal (C) – sites designed to receive <25 t/day;
- Small (S) – sites designed to receive 25-150 t/day;
- Medium (M) – sites designed to receive 150-500 t/day;
- Large (L) – sites designed to receive >500 t/day.

Climatic and/or site specific water balances are used to determine whether a site has a positive ($\mathbf{B^+}$; precipitation exceeds potential evaporation) or negative water balance ($\mathbf{B^-}$; evaporation exceeds potential precipitation). Sites accepting general waste (municipal and delisted hazardous waste) have a classification describing these three aspects.

Example: GLB$^+$ landfill – receives more than 500 tons per day of general waste and is expected to generate leachate more than one year out of five.

Sludge co-disposal affects the classification of proposed landfills, and may only be practised at GMB$^+$ and GLB$^+$ sites provided that the site is equipped with an appropriate leachate management system. When sludge co-disposal is planned at a B$^-$ site, the site should be engineered as a B$^+$ site with the appropriate liners and leachate collection system.

Note: These restrictions may be relaxed in certain areas on a site specific basis, if adequate proof is provided to the authorities that no leachate will be generated at the landfill site.

BASIC PROCEDURE FOR CO-DISPOSAL

The **basic procedure** followed for co-disposal is as follows:

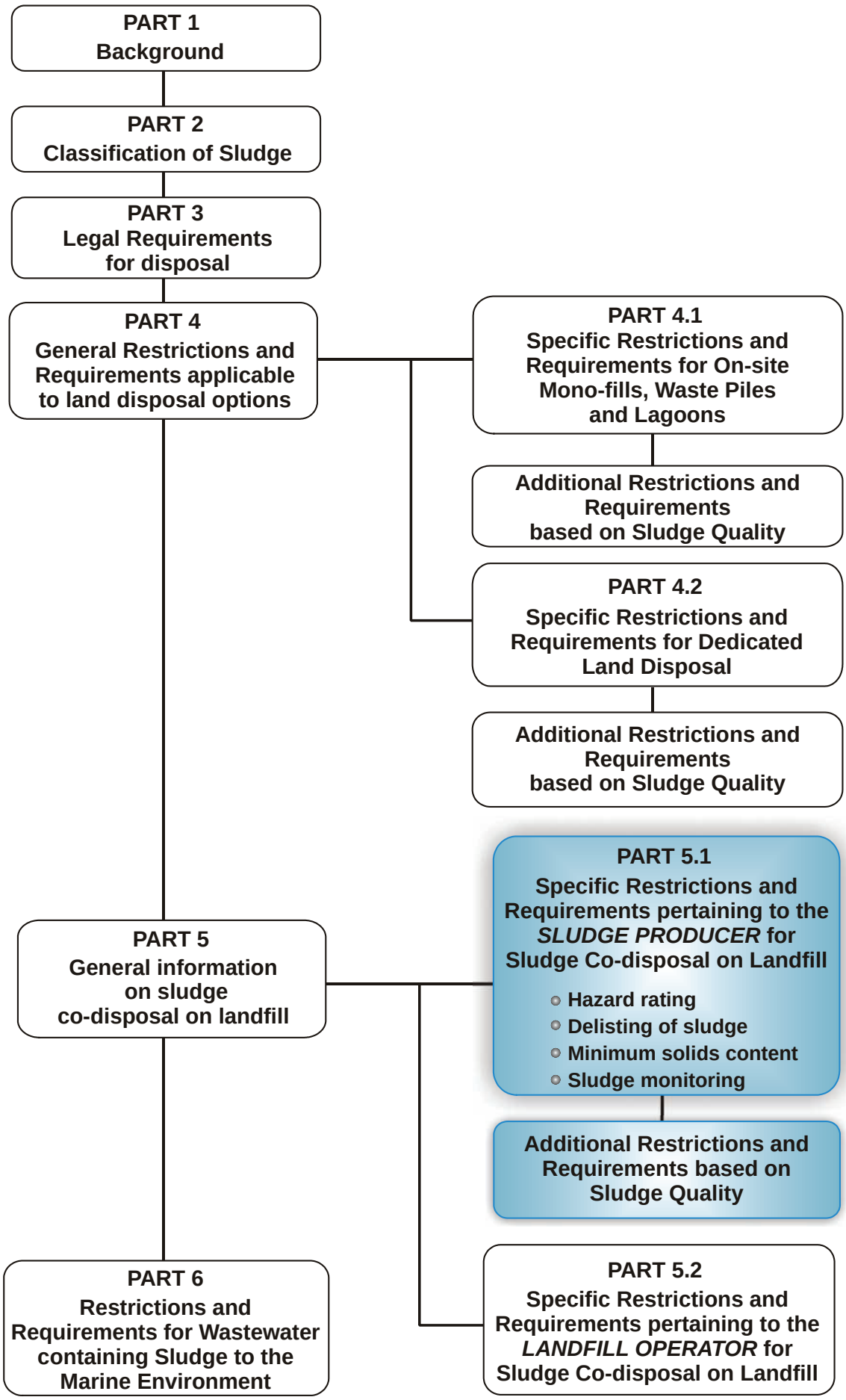
1. Classify the waste;
2. Obtain a hazard rating using test results (in the case of sludge it is the TCLP test);
3. Find the LD_{50}s and LC_{50}s for the compounds required (Acceptable Exposure; AE);
4. Calculate the Estimated Environmental Concentration (EEC) and total load; and
5. Determine the hazard rating (HR) and the potential to delist the sludge to a lower HR;
6. HR2 – HR4 waste may be delisted and disposed on a GLB$^+$ or GMB$^+$ site
7. HR1 waste should be disposed on H:H or H:h sites.

TRANSPORTATION OF SLUDGE

Due to the potentially high microbiological content of sludge, it should be handled as a hazardous waste (containing infectious substances) during transportation. The following aspects should receive attention during the transportation of the sludge from the WWTP to the off-site disposal site:

- Identification of waste – the transporters must be provided with accurate information about the nature and properties of the load.
- Documentation – the transport operator must be provided with the relevant transportation documentation.
- Hazchem placard – the transport operator must be supplied with the appropriate Hazchem placards which should be properly fitted to the vehicle.
- Protection against the effect of an accident – the sludge generator – or his representative, i.e. transporter – must ensure that adequate steps are taken to minimise the effect an accident or incident may have on the public and on the environment.
- Notification – all road accidents must be reported to the Department of Transport on the prescribed documentation and a full report should be sent to the Local Authorities, the Competent Authority and the Department of Water Affairs and Forestry.

DOCUMENT ROADMAP



PART 5.1:

SPECIFIC RESTRICTIONS AND REQUIREMENTS PERTAINING TO THE *SLUDGE PRODUCER* FOR OFF-SITE CO-DISPOSAL OF SLUDGE ON LANDFILL

The specific restrictions and requirements pertaining to the sludge producer are described in this section. The sludge producer needs to comply with these restrictions and requirements before the sludge leaves the WWTP.

HAZARD RATING

The toxicity of the sludge must be determined before disposal. This is called Hazard Rating. Hazard Rating for disposal takes into account the toxicity (LD_{50}), ecotoxicity (LC_{50}), carcinogenicity, mutagenicity, teratogenicity, persistence, environmental fate and Estimated Environmental Concentration (EEC) of the waste. The Hazard Rating indicates the risk posed to humans and the environment by the disposal of the waste. The Hazard Rating differentiates between a Hazardous Waste that is fairly or moderately hazardous and one that is very or extremely hazardous. The Hazard Rating also indicates the class of Hazardous Waste landfill at which the waste may be disposed (Table 22).

TABLE 22: DIFFERENT HAZARD RATINGS AND THE APPROPRIATE LANDFILLS FOR DISPOSAL

H:H landfill	H:H or H:h landfill
Hazard Rating 1 - extreme risk	Hazard Rating 3 - moderate risk
Hazard Rating 2 - high risk	Hazard Rating 4 - low risk

- Sludge with Hazard Rating 1 must be disposed of at an **H:H** site. In exceptional cases, it may be disposed of on an **H:h** site, with written permission from the Competent Authority. An H:H site is more stringently designed, operated and monitored than an H:h site. This permission will specify volumes and other necessary parameters.

- If sludge is to be co-disposed at an **H:H** landfill site, the sludge is to be regarded as hazardous waste and treated in the same way.

Note: Sludge originating from domestic WWTP is a high volume, low hazard waste. This implies that, although the sludge may contain highly toxic substances like mercury (Hg), the concentrations are usually low. The organic nature of domestic wastewater sludge is conducive to the adsorption of toxic elements and metals. It is for these reasons that a predictive leaching test show that only small concentrations is in the soluble form and will typically not leach under normal landfill conditions. It is recommended that all sludge be tested using the TCLP test to determine the potential for delisting to a lower HR.

PART 5.1: SPECIFIC RESTRICTIONS AND REQUIREMENTS PERTAINING TO THE SLUDGE PRODUCER FOR OFF-SITE CO-DISPOSAL OF SLUDGE ON LANDFILL

DELISTING OF SLUDGE

All sludge types may be disposed of at appropriately lined GMB^+ and GLB^+ landfills, provided that it passes through the delisting process. A schematic presentation of the delisting process is shown in Figure 14. Although sludge may not be co-disposed on $G:B^-$ landfill sites under normal circumstances, the sludge producer could apply for relaxation from the authorities if proof is provided that no leachate will be generated due to the co-disposal of sludge.

Delisting is based on the estimated environmental concentration (EEC) and the acceptable exposure (AE) of a particular pollutant. The determination of EEC establishes potential exposure to target populations or organisms. A TCLP analysis of the sludge should be done before delisting. The TCLP method is presented in Appendix 1.

The EEC is the concentration of a hazardous substance that may migrate from the disposal site, based on the assumption that the total mass of the hazardous substance disposed of on one hectare of a disposal site will leach into one hectare of groundwater with a depth of 15 centimeters underlying the disposal site within one month. The EEC of the substance in the waste is calculated in grams disposed of per hectare per month multiplied by a factor of 0.66.

Therefore, **EEC** (ppb) = g/ha/month x 0.66

A waste may delist if the EEC of a substance is equal to or less than one tenth of the LC_{50} for that specific substance. The LC_{50} or acute eco-toxicity is the concentration at which a substance would kill 50 per cent of organisms if it were disposed of directly into a body of water. If the concentration of the hazardous substance does not exceed ten percent of the LC_{50}, it represents an Acceptable Exposure (AE) to the environment (also called the Acceptable Risk Level or ARL) that would cause a mortality incidence of one in three hundred thousand (1:300 000) in the aquatic environment.

Delisting is regulated by the most hazardous contaminant in a waste stream. The EEC of such a contaminant must be compared to the AE to determine whether such a waste stream will delist or not. The EEC may also be used to determine the total amount, i.e. **Total Load**, of a hazardous substance that may be accepted at a certain landfill site.

Since a single substance can determine the Hazard Rating, treatment can be used to reduce the hazardousness of the substance. Thereafter, the next most hazardous substance will determine the Hazard Rating. Treatment (liming) can thus be used to delist a waste to a lower Hazard Rating or to allow a waste to be disposed of as a general waste. Note, however, that the treated waste will have to be tested and analysed once more to confirm the efficacy of the treatment.

Examples of sludge delisting for co-disposal on landfill are presented in the latest edition of the *Minimum Requirements for the Handling, Classification and Disposal of Hazardous Waste*.

MINIMUM SOLIDS CONTENT

General landfill sites may not accept sludge with a solids content <20% mass per mass. This requirement could be relaxed based on site specific investigation or increased depending on the specific landfill site requirements.

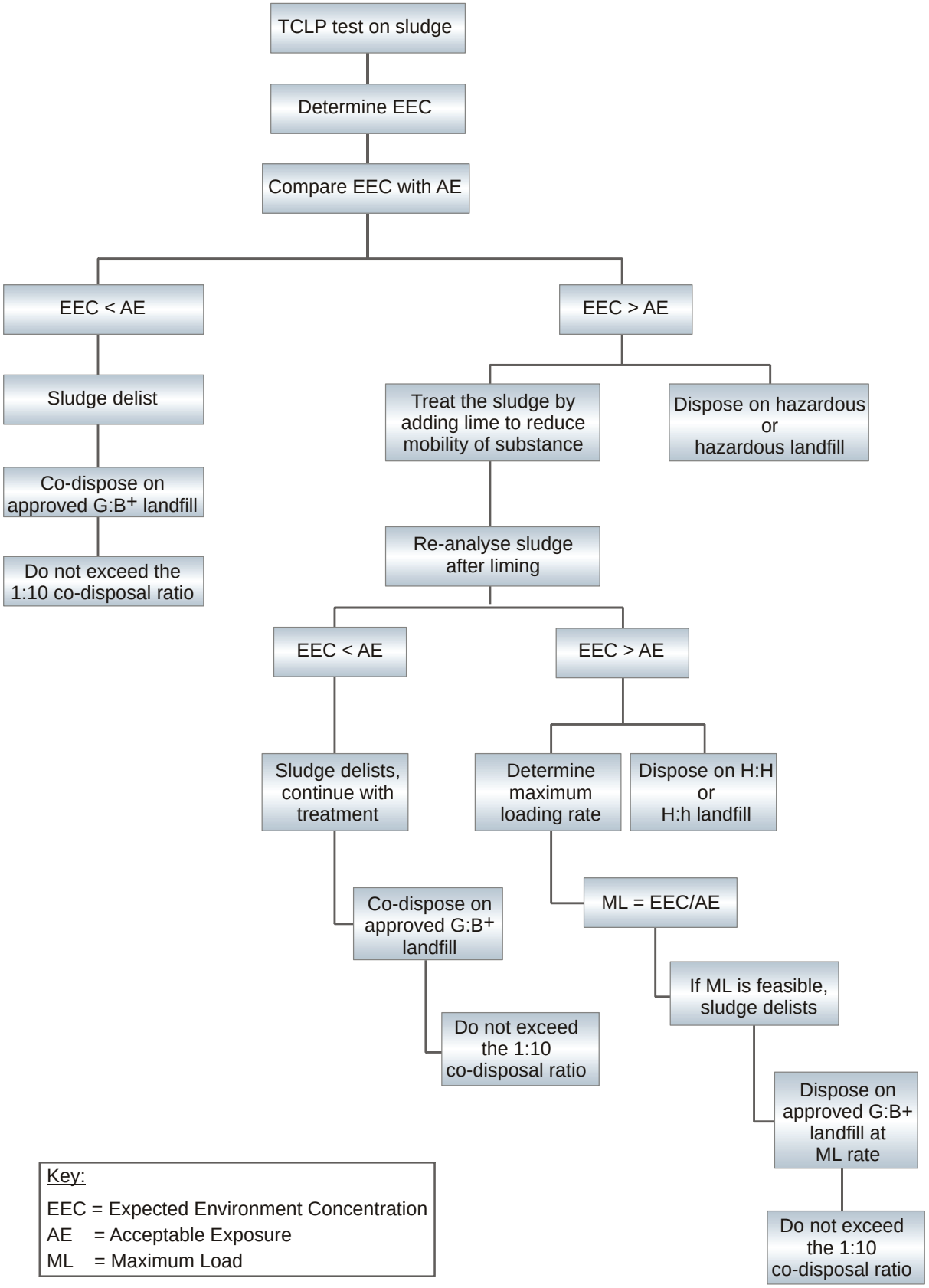


Figure 14: Schematic presentation of delisting process

PART 5.1: SPECIFIC RESTRICTIONS AND REQUIREMENTS PERTAINING TO THE SLUDGE PRODUCER FOR OFF-SITE CO-DISPOSAL OF SLUDGE ON LANDFILL

SLUDGE MONITORING

Sludge should be monitored on a regular basis to ensure that the quality stays within the limits required for co-disposal to landfill. The same sampling analyses and frequency apply as for on-site and off-site land disposal (Table 13). The sampling frequency for monitoring purposes depends on the amount of sludge produced and can be summarised as follows:

- <1 t $_{\text{dry weight}}$/day – yearly;
- 1-5 t $_{\text{dry weight}}$/day – quarterly;
- 5-45 t $_{\text{dry weight}}$/day – biannually;
- >45 t $_{\text{dry weight}}$/day – monthly;

However, the landfill operator may require additional monitoring, especially in the case of Pollutant class b and c sludge that needs to be treated before it can be delisted for co-disposal.

SPECIFIC RESTRICTIONS AND REQUIREMENTS BASED ON SLUDGE QUALITY

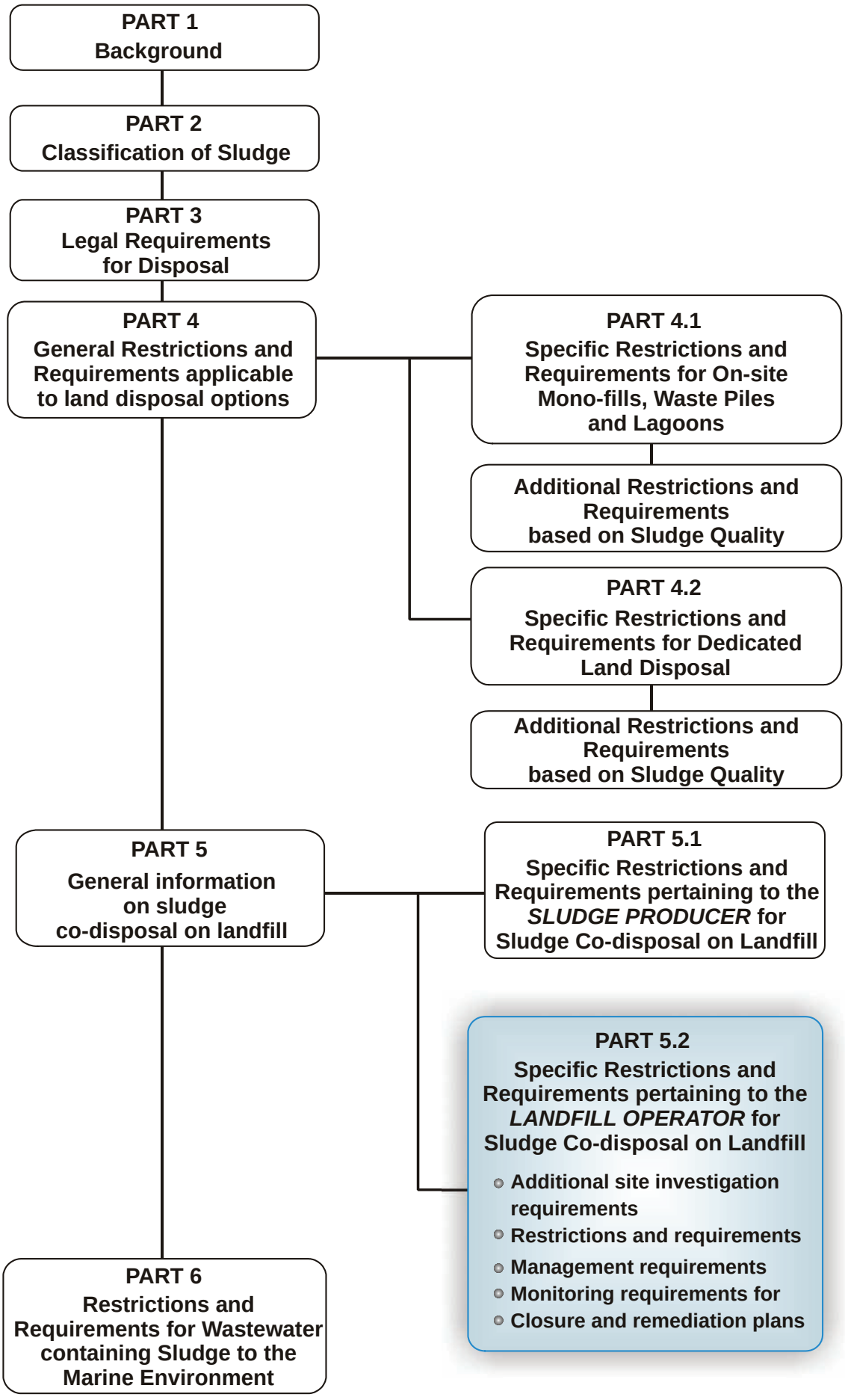
Table 23 lists the additional restrictions and requirements for co-disposal on landfill based on the sludge quality.

TABLE 23: ADDITIONAL RESTRICTIONS FOR CO-DISPOSAL BASED ON SLUDGE QUALITY

South African Sludge Classification		Additional restrictions and requirements	
		General landfills	Hazardous landfills
Microbiological Class	A	None	
	B	None	
	C	None	
Stability Class	1	None	
	2	Depending on the reliability of the vector attraction reduction measures implemented, additional management systems may be required.	
	3	Disposal of raw, primary sludge will not be allowed	
Pollutant Class	a	None	
	b	Lime treatment Max load principle	None
	c	Specific lime treatment studies Max load principle	None

Note: The restrictions on Pollutant class refer to the TCLP extractable metal content of the sludge, (Table 4), not the other potential pollutants such as nutrients

DOCUMENT ROADMAP



PART 5.2:

SPECIFIC RESTRICTIONS AND REQUIREMENTS PERTAINING TO THE *LANDFILL OPERATOR* FOR OFF-SITE CO-DISPOSAL OF SLUDGE ON LANDFILL

Part 5.2 deals with the specific restrictions and requirements pertaining to the landfill operator, should the landfill be permitted to receive sludge for co-disposal.

ADDITIONAL SITE INVESTIGATION REQUIREMENTS

The initial site selection and investigation should be conducted according to the *Minimum Requirements for Waste Disposal by Landfill.* The following components should receive particular attention:

Specific water balance studies

A site specific water balance should be undertaken for landfill sites where co-disposal is proposed. Operators of landfill sites with a negative water balance must prove that no leachate will be generated due to sludge co-disposal.

Site stability assessment

- Site stability assessments are essential to the landfill design. Stability assessments must be done by a professional engineer at sites where sludge co-disposal is practised.

- The spacing and orientation of trenches must be considered in 6-monthly stability assessments. As a precautionary principle the shear strength of sludge should be assumed to be zero.

- As a general rule, trench orientation should be perpendicular to the crest of a landfill and no trenching should occur within 30 m of the crest.

- The effective degree of mixing that is achieved with trenching should be taken into account when calculating an acceptable co-disposal ratio in terms of leachate generation.

MANAGEMENT REQUIREMENTS FOR CO-DISPOSAL

All the management requirements as specified in the *Minimum Requirements for Waste Disposal by Landfill: Landfill Operation* (Latest edition) should be adhered to. Only the requirements specific to sludge co-disposal will be discussed in this section.

Sludge analyses/monitoring information

Since the sludge quality is fundamental in the management of the landfill site, the landfill operator should be certain of the sludge quality. This is especially important in cases where the sludge needs to be treated (limed) before it delists. The landfill operator should regularly receive the sludge analyses results and/or monitoring information. Small WWTPs may only be required to monitor on an annual or quarterly basis and this may not be sufficient for the landfill operator in terms of the permit conditions. Therefore, landfill operators may require additional sludge quality data.

PART 5.2: SPECIFIC RESTRICTIONS AND REQUIREMENTS PERTAINING TO THE LANDFILL OPERATOR FOR OFF-SITE CO-DISPOSAL OF SLUDGE ON LANDFILL

Co-disposal ratio

- The co-disposal ratio **may not exceed 1:10** (mass of wet sludge to mass of waste)
- Metal concentrations must be considered in the determination of an appropriate co-disposal ratio and based on these, the co-disposal ratio may need to be lower than 1:10

The ratio of 1:10 is an absolute maximum but sludge specific conditions may require a lower ratio (e.g. 1:20 or even lower) depending on the metal levels in the sludge. This possibility must be assessed by carrying out leaching tests according to the TCLP methodology outlined in Appendix 1

The procedure for calculating co-disposal ratios for sludge co-disposal is explained in the Scientific premise document available from the WRC (Report number 1622/1/09).

Note: The limit of a minimum of 20% solids for sewage sludge could be waived on a case-specific basis. However, achieving the higher solids content should be encouraged, although the maximum sludge co-disposal ratio of 1:10 will be retained.

Public access restrictions

No salvaging is permitted at any hazardous waste site or the cell of the general landfill where co-disposal of sludge is practised.

Run-off collection and management

- Run-off and storm water must always be diverted around one or both sides of the waste body, by a system of berms and/or cut-off drains.
- Water contaminated by contact with waste, as well as leachate, must be contained within the site. If it is to be permitted to enter the environment, it must conform or be treated so as to conform to the water quality limits specified in terms of the Permit.
- The basis of trenches and cells must be so designed that water drains away from the deposited waste.
- The contaminated run-off from the landfill must be stored in a sump or retention dam. It may be pumped from the dam and disposed of if it conforms to the water quality limits specified and stipulated in the Permit.
- A 0,5 m freeboard, designed for the 1 in 100 year flood event, must always be maintained in the case of contaminated water impoundments and drainage trenches.
- All temporarily and finally covered areas must be graded and maintained to promote run-off without excessive erosion and to eliminate ponding or standing water.
- Clean, uncontaminated water, which has not been in contact with the waste, must be allowed to flow off the site into the natural drainage system, under controlled conditions.
- All drains must be maintained. This involves ensuring that they are not blocked by silt or vegetation.

PART 5.2: SPECIFIC RESTRICTIONS AND REQUIREMENTS PERTAINING TO THE LANDFILL OPERATOR FOR OFF-SITE CO-DISPOSAL OF SLUDGE ON LANDFILL

SPECIFIC MONITORING REQUIREMENTS FOR CO-DISPOSAL

Monitoring serves to quantify any effect of the operation on the environment, especially the water regime, and act as an early warning system, so that any problems that arise can be identified and rectified. Such problems would include:

- malfunctioning drainage systems,
- cracks in the cover,
- leaking liners, and
- surface or groundwater pollution.

Note: The monitoring requirements in *"Landfill Operation Monitoring"* and *"Water Quality Monitoring" (Minimum Requirements for Waste Disposal by Landfill (Latest edition))* should be complied to.

Operational monitoring

The general objective of operational monitoring is to verify that all aspects of the disposal site, including any leachate management and treatment systems, conform to the required standards and the site Permit conditions. More specific objectives are:

- To ensure that the accepted site design is properly implemented
- To function as a control measure to ensure that the operation conforms to the required standards
- To quantify any effect that the operation has on the environment and, in particular, any effect on the water regime
- To serve as an early warning system, so that any problems that arise can be *timeously* identified and rectified.

The extent and frequency of monitoring will depend on the site classification and will be indicated in the Permit.

For further information see: *Minimum Requirements for Waste Disposal by Landfill (Latest edition), "Landfill Operation Monitoring".*

Leachate and water quality monitoring

The Permit Holder must ensure regular sampling and analysis of ground and surface water, leachate, the effluent, sludge or concentrates from any treatment system. The Permit Holder must also ensure interpretation of the findings. Records must be maintained of any impact caused by the disposal operation on the quality of the water regime in the vicinity of the site**. This is required in terms of the Permit conditions**. Additional samples may be necessary (Table 24).

TABLE 24: MINIMUM FREQUENCY OF WATER QUALITY MONITORING AT CO-DISPOSAL SITES

Leachate	m (if applicable)
Run-off water quality	d
Surface water quality	m
Groundwater chemistry	3m
Legend: m = monthly; 3m = 3 monthly; d = daily	

Methane monitoring

Landfill gas is a potential explosion hazard, where methane gas reaches concentrations of between 5% and 15% by volume of atmospheric gas composition. The risk of gas explosion must therefore be continually monitored. If monitoring indicates that there is any safety risk on account of landfill gas accumulation and/or migration, controls must be considered in consultation with the Relevant Authority.

Air quality monitoring

There is some risk of dust and the escape of contaminants by wind action. Hazardous air pollutants may therefore be dispersed from a landfill site as dust, or as gaseous substances. These have to be monitored separately.

CLOSURE OF CO-DISPOSAL SITES

Note: The section on "*Rehabilitation, closure and end-use" (Minimum Requirements for Waste Disposal by Landfill (Latest edition))* applies.

The objectives of disposal site closure are:

- To ensure public acceptability of the implementation of the proposed End-use Plan.
- To remediate the site to ensure that it is environmentally and publicly acceptable and suited to the implementation of the proposed end-use.

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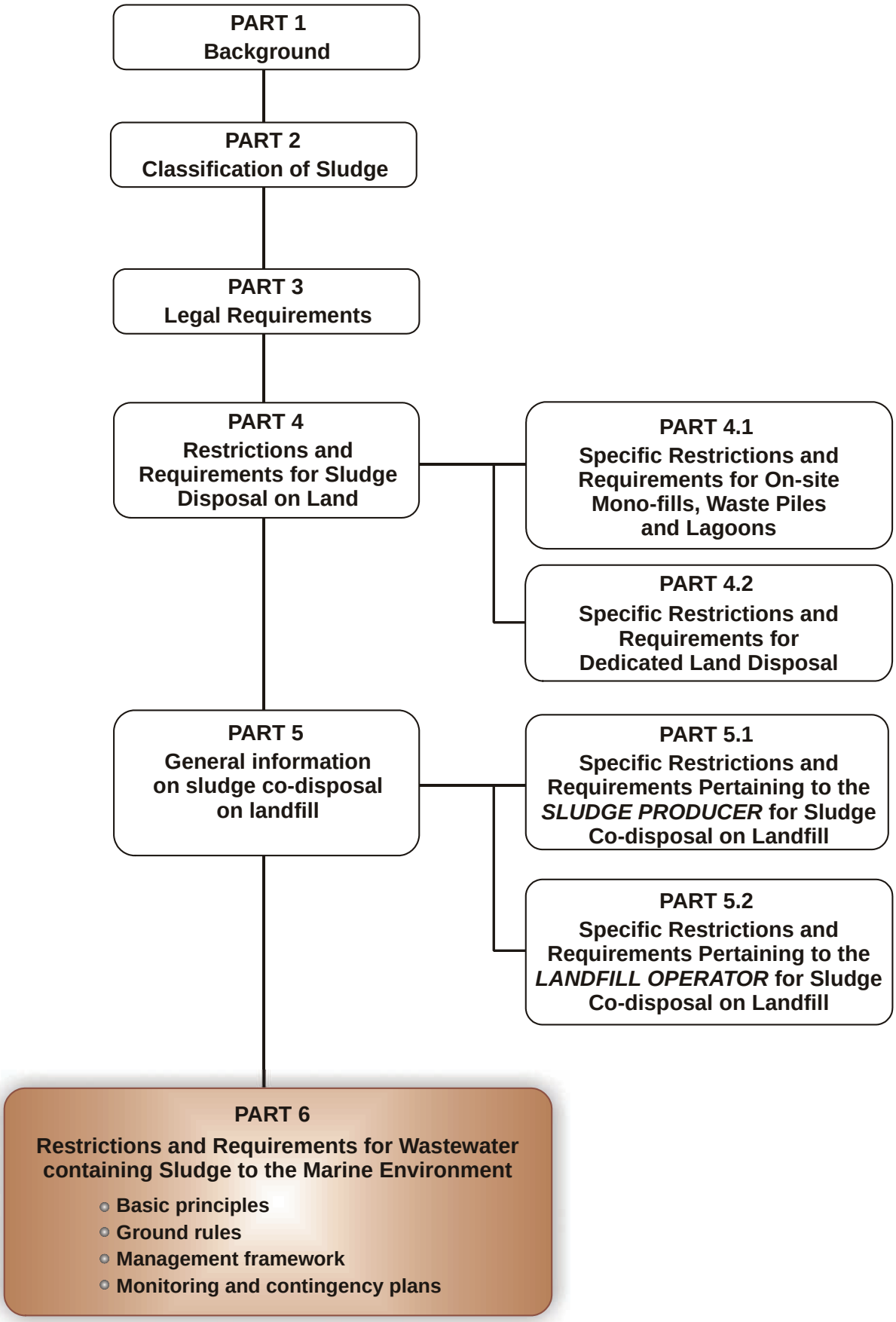


PART 6:

RESTRICTIONS AND REQUIREMENTS FOR DISPOSAL OF WASTEWATER CONTAINING SLUDGE TO THE MARINE ENVIRONMENT

While the sea is the ultimate natural sink for many of the wastes generated on land, it is becoming increasingly evident and more widely recognised that it has limitations in its assimilative capacity. Careful management is required to ensure that this capacity is not exceeded and that the vital resources of the sea are not compromised. At the same time it may well be prudent to make use of the ocean's capacity to assimilate wastes in situations where this represents the best practicable environmental option. Achieving a sensible compromise is an ongoing challenge for scientists and coastal managers. South Africa has never seriously considered this route for sludge disposal and it is unlikely that it presents an economically viable or environmentally acceptable option.

Note: Disposal to the marine environment is **NOT** the 'default' option in coastal areas.

The document *"Operational policy for the disposal of land-derived water containing waste to the marine environment of South Africa"* (DWAF, 2004) which was drawn up after extensive consultation amongst competent authorities and stakeholders, and with detailed reference to global experience, outlines DWAF's and DEAT's new thinking on sea discharges. The basic principles and ground rules together with a management framework are presented in the document. A major shift in approach is signalled by the change from an effluent standards approach (i.e. enforcing compliance with effluent standards) to an approach that focuses on receiving water quality objectives which support the maintenance of fitness for use.

Note: Where municipal wastewater receives **preliminary treatment**, sludge is not yet separated from the effluent and thus discharged according to the discharge standards prescribed in the licence. In instances where the receiving environment can absorb such inputs, sludge disposal is essentially taken care of.

However, where effluents receive **primary (partly separated) or higher treatment**, solids are separated from the effluent and need to be dealt with separately. Sludge removed from the wastewater during primary or higher treatment must be disposed of on land according to the relevant Sludge Guideline Volumes or the Minimum Requirements (latest edition) for co-disposal on landfill.

BASIC PRINCIPLES

The Basic Principles provide the broad reference framework or direction within which the ground rules for the disposal of land-derived wastewater to the marine environment, as well as the management thereof, were developed. The basic principles pertaining to the *Operational policy for the disposal of land-derived wastewater to the marine environment of South Africa* (2004) are listed below.

Principle 1: Pollution prevention, waste minimisation and precautionary approach

- Pollution prevention aims at preventing waste production and pollution wherever possible

- Minimisation of pollution and waste at source aims at minimising unavoidable wastes through technical interventions

- Responsible disposal aims at minimising environmental impact through applying the precautionary approach

Principle 2: Receiving water quality objectives approach

The requirements of the aquatic ecosystem, as well as the requirements of the beneficial uses of the water resource, will determine the objectives to be met (rather than following a uniform effluent standard approach as was the case with the General and Special Standard under the previous Water Act 54 of 1956). This principle applies to the marine environment as well.

Principle 3: Integrated assessment approach

The operational policy will adhere to the principles of Integrated Environmental Management, taking cognisance of concepts such as Strategic Environmental Assessment, and Environmental Impact Assessment.

Principle 4: Polluter pays principle

The responsibility for environmental costs incurred for rehabilitation of environmental damage and the costs of preventive measures to reduce or prevent such damage will be shifted to the impactors through, for example, the implementation of a waste discharge charge system.

Principle 5: Participatory approach

Transparent stakeholder participation will be required, not only as part of the decision making, but also through ongoing transparent and open communication on the status quo during design, construction and operations.

GROUND RULES RELATED TO MUNICIPAL WASTEWATER

Ground Rules are derived within the broader context of the Basic Principles and provide more specific rules that will be applied by Government when considering licence applications to dispose of land-derived wastewater to the marine environment. The ground rules discussed below have specific significance for municipal wastewater.

Ground Rule No. 14 – Master plan for water supply/demand and wastewater treatment

South Africa is a water scarce country. Marine disposal of land-derived municipal wastewater (particularly freshwater) will therefore only be considered where it has been evaluated in terms of the Water Services Development Plan for a particular municipal area. This requirement supports the concept of a 'Master Plan for water supply/demand and wastewater treatment', supporting the principles of pollution prevention, waste minimization and the precautionary and integrated assessment approach.

Ground Rule No. 15 – Industrial wastewater management plan

Municipal WWTP receiving industrial effluent will be subject to the Ground Rules for Industrial Wastewater. Service Providers or Local Authorities operating such treatment works will be required to prepare Industrial wastewater management plans.

PART 6: RESTRICTIONS AND REQUIREMENTS FOR DISPOSAL OF WASTEWATER CONTAINING SLUDGE TO THE MARINE ENVIRONMENT

Ground Rule No. 17 – DWAF Policy regarding Marine outfalls

The new DWAF policy regarding municipal wastewater disposal to sea is clearly stated in Ground Rule No. 17:

- Marine outfalls authorised after 31 May 2004

  primary treatment will be required as a minimum for disposal of municipal wastewater to the offshore marine environment.

- Marine outfalls that were already authorised by 31 May 2004

  - **preliminary treatment** will be accepted as a minimum requirement, provided that the receiving environment is suitable for this marine disposal and that the environmental (or resource) quality objectives are met.

  - future expansions or upgrades to such existing marine outfalls will require **primary treatment** of the wastewater prior to discharge unless it can be proven that key socio-economic factors require otherwise. Nevertheless, environmental (or resource) quality objectives must still be met.

Ground Rule No. 18 – Sludge disposal according to Minimum Requirements

The disposal of sludge arising from wastewater treatment facilities (e.g. primary, secondary and tertiary) must be in accordance with the Minimum Requirements for Waste Disposal by Landfill and the appropriate 'Sludge Guidelines Volume' or any future updates of such policies or guidelines.

Ground Rule No. 20 – Detailed description of the waste stream

An industry, discharging wastewater to a municipal WWTP or directly to the marine environment, will be required to provide a detailed description of the waste stream in terms of both volume (quantity) and quality (i.e. listing all substances present and their concentrations and loads). Where industries discharge wastewater to a WWTP, the water services provider is responsible for obtaining this information from the industry concerned. The DWAF or local authority may also require a detailed inventory of the raw materials, as well as process material, used by an industry.

It will be the responsibility of an industry to supply a detailed description of their effluent to the DWAF. Such information is crucial to the authorisation process both in terms of evaluating potential impacts appropriately, and of evaluating alternative wastewater treatment options.

Toxicity testing will not be considered as a substitute where detailed description of the composition of the wastewater is not available. However, these tests are valuable techniques to be used as supplementary tools for verifying impact assessment studies based on the detailed wastewater composition.

Ground Rule No. 21 – Pre-treatment

Industrial wastewater discharged to a municipal WWTP disposing to the marine environment, will be subject to appropriate pre-treatment. It is the responsibility of the local authority operating the WWTP to ensure compliance in this regard. Appropriate pre-treatment is required to ensure that:

• The WWTP and associated equipment are not damaged;

• Operation of the WWTP and the treatment or re-use of sludge are not impeded;

• Discharge from the WWTP does not adversely affect the marine environment.

MANAGEMENT FRAMEWORK

The **Management Framework** provides the generic and structured approach within which the management and control of the disposal of land-derived wastewater to the marine environment of South Africa, needs to be conducted.

Management institutions and administrative responsibilities

The disposal of land-derived wastewater to the marine environment is currently governed by the DWAF under the National Water Act 36 of 1998. The DWAF works in consultation with other government departments. In the context of this operational policy, water use authorisation under section 21 of the NWA will be required for:

- New applications to dispose of land-derived wastewater to the marine environment;
- Existing discharges of land-derived wastewater to the marine environment that are not considered to be existing lawful water use in terms of Section 32 of the NWA;
- Upgrades, extensions of existing WWTP or industries discharging to the marine environment that were not approved in terms of the original authorisation;
- Change in effluent volume or composition (a licence is issued based on a specific effluent volume and composition, therefore if these change, the discharger legally must re-apply).

Note: Further information on local management institutions is provided in *Operational policy for the disposal of land-derived water containing waste to the marine environment of South Africa: Guidance on Implementation, Section 3* (DWAF Water Quality Management Sub-Series 13.3).

Environmental quality objectives

The area within which this management framework is applied must be determined, taking into account the anticipated influence of the proposed discharge, both in the near and far fields (e.g. an entire bay or ecosystem).

Note: Guidance on procedures to be followed to determine the area boundaries, important ecosystems, beneficial uses and associated environmental quality objectives is provided in *Operational policy for the disposal of land-derived water containing waste to the marine environment of South Africa: Guidance on Implementation, Section 4* (DWAF Water Quality Management Sub-Series 13.3).

Activities and associated waste loads

To ensure that possible cumulative and synergistic effects are taken into account, the waste loads of the activities under investigation, as well as those of existing waste inputs to the study area (both in terms of quantity and quality), need to be defined.

PART 6: RESTRICTIONS AND REQUIREMENTS FOR DISPOSAL OF WASTEWATER CONTAINING SLUDGE TO THE MARINE ENVIRONMENT

Note: Guidance on determining the specification for different types of wastewater is provided in *Operational policy for the disposal of land-derived water containing waste to the marine environment of South Africa: Guidance on Implementation, Section 5* (DWAF Water Quality Management Sub-Series 13.3).

Scientific and engineering assessment

The objective of this component of the management framework is to refine the environmental quality objectives for a particular marine receiving environment and to establish whether a waste disposal practice that will comply with such environmental quality objectives can be designed.

Note: Guidance on the procedures to be followed in the scientific and engineering assessment of land derived wastewater disposal to the marine environment is provided in *Operational policy for the disposal of land-derived water containing waste to the marine environment of South Africa: Guidance on Implementation, Section 6* (DWAF Water Quality Management Sub-Series 13.3). Where appropriate, a distinction is made between requirements for a pre-assessment and a detailed investigation as specified within the licence authorisation process, discussed in detail in *Section 3 of that document*.

Monitoring requirements

Long-term monitoring plans need to be designed and implemented to enable the continuous evaluation of:

- The effectiveness of management strategies and actions to comply with the licence conditions and design criteria
- The trends and status of changes in the environment in terms of the health of important ecosystems and designated beneficial uses.

Monitoring programs typically become part of the licence issued by the DWAF for a particular discharge under Section 21 of the NWA. Monitoring data must be evaluated against predetermined objectives (Table 25).

Note: An industry, discharging to a WWTP or directly to the marine environment, will be required to provide a detailed description of the waste stream both in terms of volume and quality. Where industries discharge into a WWTP, the WWTP authority is responsible for obtaining this information from the industry concerned.

TABLE 25: MONITORING REQUIREMENTS FOR MARINE DISPOSAL

Compliance Monitoring	
Flow	Wastewater volume
Composition of wastewater	BOD/COD, total suspended solids, particulate organic carbon and nitrogen, inorganic nitrate and nitrite, total ammonia and dissolved reactive phosphate Any other constituents present in the sludge/wastewater that could impact negatively on the receiving environment
Toxicity testing	The frequency of toxicity testing of the wastewater will depend on the actual variability in the wastewater composition
System Performance Monitoring	
Physical inspection of the outfall system (for marine outfalls)	
Hydraulic performance	
Environmental Monitoring	
Setting clear monitoring objectives	Site-specific and dependent on the type of wastewater discharge and the variability in its waste loads, as well as the site-specific physical, biogeochemical and ecological characteristics of the receiving environment and the variability thereof

Contingency plans and mitigating actions

Contingency plans and mitigating actions are required to minimize the risks to the environment in the event of malfunctioning, both during construction and operation. Decommissioning of a wastewater disposal scheme is also addressed.

Note: Guidance on procedures to be followed in the design and implementation of monitoring programs and contingency plans is provided in *Operational policy for the disposal of land-derived water containing waste to the marine environment of South Africa: Guidance on Implementation in Section 7 and 8, respectively* (DWAF Water Quality Management Sub-Series 13.3).

CONCLUSION

The principles of the Waste Management Series (Latest edition) comprising of the *Minimum Requirements for the Handling, Classification and Disposal of Hazardous Waste, Minimum Requirements for Waste Disposal by Landfill* and *Minimum Requirements for the Monitoring of Water Quality at Waste Management Facilities* have been adopted for sludge disposal on land in Volume 3 of the Sludge Guidelines. Since sludge is an industry-specific waste, not all the requirements in the above-mentioned documents are applicable to land disposal of sludge. Therefore, only the requirements relevant to sludge disposal were included in Volume 3.

The disposal of sludge to the marine environment is still debated nationally and internationally and the principles of the *Operational policy for the disposal of land-derived water containing waste to the marine environment of South Africa (DWAF, 2004)* have been adopted in Volume 3 for sludge disposal to the marine environment.

Volume 3 of the Sludge Guidelines informs the reader regarding the legal requirements for sludge disposal on land (both on-site and off-site), co-disposal on landfill and disposal to the marine environment. It also states clearly that beneficial use of sludge is encouraged and that sludge disposal would be considered as a last resort. Therefore, sludge producers would need to provide proof of the beneficial use options considered, feasibility studies to implement these options and efforts to improve the sludge quality, should that be the limiting factor for beneficial use.

Should disposal be the only alternative management option for sludge, it becomes a 'waste' by definition and restrictions and requirements should be applied to protect the receiving environment. These restrictions and requirements become more stringent with deteriorating sludge quality and the vulnerability of the receiving environment. Especially at existing disposal sites where the necessary criteria for disposal sites are not met, the management and monitoring requirements increase substantially. The development of closure and remediation plans is introduced to ensure sustained acceptability.

It is recognized that new information is constantly generated and it has been recommended that the Sludge Guidelines be revised every 5 to 10 years. This will allow the South African wastewater industry sufficient time to implement these Guidelines and highlight shortcomings, constraints and operational difficulties. Furthermore, by implementing the monitoring requirements stipulated in these Guidelines, case-specific data will be generated that will enrich our local knowledge base.

APPENDIX 1: PARAMETERS AND ANALYTICAL METHODS REQUIRED FOR CLASSIFICATION OF SLUDGE AND MONITORING OF SLUDGE, WATER AND SOIL SAMPLES

Appendix 1.1: Analyses required for classification and characterization of sludge

Characteristic	Parameter	Guidance on methodology and/or recommended extraction method
Physical characteristics	pH	Direct measurement pH on saturated paste or solution
	Total solids (TS)	Standard method 2540B[1]
	Volatile suspended solids (VSS)	Standard method 2540E[2]
	Volatile Fatty Acids (VFA)	Adapted from Standard methods. The full method is detailed in Volume 1, Appendix 2.
Nutrients	Total Kjeldahl Nitrogen (TKN)	The suggested method description has been attached in Volume 1, Appendix 2.
	Total Phosphorus (TP)	The suggested method description has been attached in Volume 1, Appendix 2.
	Potassium (K)	The suggested method description has been attached in Volume 1, Appendix 2.
Metals and micro-elements	Arsenic Cadmium Chromium Copper Lead Mercury Nickel Zinc (Any other metal or element identified during the comprehensive characterisation detailed in Volume 1)	For land disposal the TCLP test is recommended US EPA Method 1311, 1992 Note: A semi-quantitative ICP scan would give concentrations for all mentioned metals. Remind the laboratory to manage the interferences on the ICP appropriately, especially for compounds such as Arsenic.
Microbiological quality	Faecal coliforms	Membrane filter/ m-FC medium
	Total viable Helminth ova	See recommended new method further on in this Appendix

[1,2] Standard Methods for the Examination of Water and Wastewater, 20th edition (1998) or latest, by Leonore S. Clesceri, Arnold E. Greenbert and R. Rhodes Trussell.

Appendix 1.2: Sludge analyses required for monitoring purposes

Characteristic		Parameter	Guidance on methodology and/or recommended extraction method
Physical characteristics		pH	Direct measurement pH on saturated paste or solution
		Total solids (TS)	Standard method 2540B[1]
		Volatile suspended solids (VSS)	Standard method 2540E[2]
		Volatile Fatty Acids (VFA)	Adapted from Standard methods. The full method is detailed in Volume 1, Appendix 2.
Chemical characteristics	Nutrients	Total Kjeldahl Nitrogen (TKN)	The suggested method description has been attached in Volume 1, Appendix 2.
		Total Phosphorus (TP)	The suggested method description has been attached in Volume 1, Appendix 2.
		Potassium (K)	The suggested method description has been attached in Volume 1, Appendix 2.
	Metals and micro-elements	Arsenic Cadmium Chromium Copper Lead Mercury Nickel Zinc (Any other metal or element identified during the comprehensive characterisation detailed in Volume 1)	For land disposal the TCLP test is recommended US EPA Method 1311, 1992 Note: A semi-quantitative ICP scan would give concentrations for all mentioned metals. Remind the laboratory to manage the interferences on the ICP appropriately.
Microbiological quality		Faecal coliforms	Membrane filter/ m-FC medium
		Total viable Helminth ova	See recommended new method further on in this Appendix

[1,2] Standard Methods for the Examination of Water and Wastewater, 20th edition (1998) or latest, by Leonore S. Clesceri, Arnold E. Greenbert and R. Rhodes Trussell.

Appendix 1.3: Surface and groundwater analyses required for monitoring purposes

Characteristic	Parameter	Guidance on methodology and/or recommended extraction method
Water chemistry	pH	Direct measurement
	EC	Direct measurement
	PO_4	Standard method 4500-P[1]
	NH_4	Standard method 4500-NH_4[1]
	NO_3	Standard method 4500-NO_3[1]
	COD	Standard method 5220D[1]
Water microbiology	Faecal coliforms	Membrane filter/ m-FC medium[1]
	E Coli	Standard method 9221B[1]

[1] Standard Methods for the Examination of Water and Wastewater, 20th edition (1998) or latest, by Leonore S. Clesceri, Arnold E. Greenbert and R. Rhodes Trussell

Appendix 1.4: Soil analyses required for monitoring purposes

Characteristic	Parameter	Guidance on methodology and/or recommended extraction method
Nutrients	Total Kjeldahl Nitrogen (TKN)	The suggested method description has been attached in Volume 1, Appendix 2.
	Total Phosphorus (TP)	The suggested method description has been attached in Volume 1, Appendix 2.
Metals to assess compliance in terms of the TTV and MPL	Arsenic Cadmium Chromium Copper Lead Mercury Nickel Zinc (Any other metal or element identified during the comprehensive characterisation detailed in Volume 1)	Extraction of trace elements soluble in *aqua regia* solution (see Volume 1, Appendix 2). International Standard ISO 11466 Method Reference number: ISO11466:1995 (E) Note: A semi-quantitative ICP scan would give concentrations for all mentioned metals. Remind the laboratory to manage the interferences on the ICP appropriately.

Appendix 1.5: Recommended new procedure to determine Helminth ova in wastewater sludge

Note: This is a new method which was developed after Volume 1 of the New Sludge Guidelines has been published and differs from the method published in Volume 1.

Method for analyses of sludge

Note: It is always preferable to work with small sub-samples as eggs may not be as easily released from a large sample to float out of the sludge when doing the $ZnSO_4$ flotation technique. Rather increase the number of sub-samples than overload each test-tube in order to keep the number of tubes down.

The number of sub-samples will also be dependent on the helminth ova load expected. This will require knowledge of the epidemiology of helminths in the particular area in South Africa. Consequently, more sub-samples must be done in an area of low endemicity and less in a highly endemic area.

1. Mix the sludge sample well by swirling and stirring with a plastic rod. From the total sample take 4 x 15 mℓ sub-samples and place them into 4 x 50 mℓ test tubes. (If the solid content is high this should be sufficient sample. If it is low, take more 15 mℓ sub-samples).

2. Add either a few millilitres of 0.1% Tween80 or AmBic solution to the samples, vortex and add more wash solution. Repeat this procedure until the tubes are filled to approximately a centimetre from the top.

3. Place the 150 µm sieve in a funnel in a retort stand with a plastic beaker underneath to catch the filtrate. Filter the well-mixed contents of the tubes one at a time, rinsing out each tube and washing this water through the sieve as well.

4. Pour the filtrate into test tubes and centrifuge at 1389 g (±3000 rpm) for 3 minutes. Suction off the supernatant fluids and discard. Combine the deposits into a suitable number of tubes so that there is not more than 1 mℓ in a 15 mℓ tube or 5 mℓ in a 50 mℓ tube

5. Re-suspend each of these deposits in a few millilitres of ZnSO and vortex well to mix. Keep adding more $ZnSO_4$ and mixing until the tube is almost full.

6. Centrifuge the tubes at 617 g (±2000 rpm) for 3 minutes. Remove from the centrifuge and pour the supernatant fluids through the 20 µm filter, washing well with water.

7. Collect the matter retained on the sieve and wash it into test tubes.

8. Centrifuge the tubes at 964 g (±2500 rpm) for 3 minutes; remove & discard the supernatant fluid. Combine the deposits into one test tube, using water to recover all the eggs from the other tubes. Then centrifuge again at 964 g for 3 minutes to get one deposit.

9. Once there is one final deposit, remove all of it using a plastic Pasteur pipette and place it onto one or more microscope slides. Place a coverslip over each deposit and examine microscopically using the 10x objective and the 40x objective to confirm any unsure diagnoses.

10. Each species of helminth ova is enumerated separately and reported as eggs per gram of sludge.

Note: Samples may be examined slightly differently from that described in step No. 10 above by doing the following:

The deposits are filtered through a 12 µm ISOPORE membrane, which is then rinsed with distilled water. The membrane is air-dried, cut in half and placed on a microscope slide. Immersion oil is used to clear the membrane before examining under the microscope.

To test for viability:

Perform steps 1 to 8 of the procedure above and continue as follows:

9. Once there is a final deposit in the test tube, re-suspend it in 4 mℓ of 0.1 H_2SO_4. Before incubating mark the test tube with the level of liquid and incubate at a temperature of 26ºC for three to four weeks. Check the level of liquid in each one of the test tubes and add the reagent every time that is necessary, compensating for any evaporation that may occur.

10. Once the incubation time is over, homogenize the deposit and proceed to quantify the eggs. Remove all of the deposit using a plastic Pasteur pipette and place it onto one or more microscope slides. Place a coverslip over each deposit and examine microscopically using the 10x objective and the 40x objective to confirm any unsure diagnoses. Only those ova where the larva is observed are considered viable.

Equipment required and related information

1. A centrifuge with a swing-out rotor and buckets that can take 15 mℓ and/or 50 mℓ plastic conical test tubes.
2. Vortex mixer.
3. Retort Stand with at least 2 clamps on it.
4. Large plastic funnels to support the filters (±220 mm diameter).
5. Filters / Sieves: 1 x 150 µm; 1 x 100 µm; 1 x 20 µm.
6. Approx. 6 Plastic beakers (500 mℓ) & 3 Plastic wash bottles.
7. At least 4 glass “Schott” bottles (1 ℓ, 2 ℓt & 5 ℓ sizes) for make-up and storage of the chemical solutions and de-ionized water.
8. Magnetic stirrer and stirring magnets.
9. 15 mℓ and 50 mℓ plastic conical test tubes.
10. 3 x Small glass beakers (100 mℓ).
11. Plastic Pasteur Pipettes & Plastic Stirring Rods.
12. Glass microscope slides (76 x 26 x 1,2 mm).
13. Square & Rectangular Cover-slips (22 x 22 mm & 22 x 40 mm).

14. A binocular compound microscope with 10x eyepieces, a 10x objective and a 40x objective.

Working out the g-force of your centrifuge

G-force (or g) = $(1{,}118 \times 10^{-5})\ r\ s^2 = 0{,}00001118 \times r \times s^2$

Where : s = revolutions per minute (i.e. the speed you spin at)

r = the radius (the distance in centimetres from the centre of the rotor to the bottom of the bucket holding the tubes, when the bucket is in the swing-out position)

Reagents

Zinc Sulphate

1. $ZnSO_4$ (heptahydrate) is made up by dissolving 500 g of the chemical in 880 mℓ de-ionised or distilled water.

2. A hydrometer must be used to adjust the specific gravity (SG) to 1.3, using more chemical if the SG is too low or more water if it is >1,3.

This high specific gravity facilitates the floating of heavier ova such as *Taenia* sp. (SG = 1.27). It is not critical if the SG of the $ZnSO_4$ solution is just over 1.3 but it should **never** be below this value!

Ammonium Bicarbonate

The AMBIC solution is essentially a saturated ammonium bicarbonate solution. Ammonium bicarbonate can be obtained from Merck Chemicals and is made up by dissolving 119 g of the chemical in 1000 mℓ of de-ionised water.

0,1% Tween80

1 mℓ of Tween80 is measured out using a pipette and placed in 1000 mℓ of de-ionized or distilled water to give a 0,1% wash solution.

Note: Tween80 is extremely viscous and it is necessary to wash **all** of it out into the water in which it is made up, by alternately sucking up water and blowing it out using the same pipette.

Appendix 1.6: Toxicity Characteristic Leaching Procedure (TCLP) extraction for sludge destined for co-disposal (USEPA Method 1311)

Summary of method

- For liquid wastes (containing <0.5% dry solid material), the waste, after filtration through a 0.6 to 0.8 µm glass fiber filter, is defined as the TCLP extract
- For wastes containing ≥ 0.5% solids, the liquid, if any, is separated from the solid phase and stored for later analyses.

Apparatus

- Agitation apparatus capable of rotating the extraction vessel in an end-over-end fashion at 30 ± 2 r.p.m.
- Extraction bottles for inorganics. These may be constructed from various materials. Borosilicate glass bottles are highly recommended. Polytetrafluoroethylene (PTFE), high density polyethylene (HDPE), polypropylene (PP), Polyvinyl chloride (PVC) and stainless steel bottles may also be used

TCLP solution 1

- Add 5.7 mℓ glacial Acetic Acid to 500 mℓ of reagent quality water (double distilled water).
- Add 64.3 mℓ of 1N NaOH.
- Dilute to a volume of 1 litre.
- When correctly prepared, the pH of this solution will be 4.93 ± 0.05.

TCLP solution 2

- Dilute 5.7 mℓ glacial acetic acid with double distilled water to a volume of 1 litre
- When correctly prepared, the pH of this solution will be 2.88 ± 0.05

Samples

- The sample must be a minimum of 100 grams.
- The sample must be able to pass through a 9.5 mm sieve, i.e. particle size of the solid must be smaller than 10 mm

TCLP extractions

Note that the TCLP test requires that a waste be pre-tested for its acid neutralization capacity. Those with low acid neutralization capacity are extracted with TCLP solution 1 (0.1 M Sodium Acetate Buffer, pH 4.93±0.05) and those with high acid neutralization capacity are extracted with TCLP solution 2 (0.1 M Acetic Acid, pH 2.88±0.05). Most sludges have a low acid neutralization capacity and will, therefore, be extracted with TCLP solution 1. After addition of lime, the acid neutralization capacity of the sludge is increased, but note that the treated sludge should be leached using the TCLP solution used for original sludge, i.e. in

most cases TCLP solution 1, so that the results are directly comparable and one can evaluate the effect of the lime treatment. This is correct even though the pre-test used in the TCLP on the lime treated sludge may indicate that TCLP solution number 2 should be used.

A. Preliminary evaluation:

This part of the extraction procedure must be performed to determine which TCLP (No. 1 or 2) solution should be used (see extraction solutions).

1. Weigh out 5.0 grams of the dry waste into a 500 mℓ beaker or Erlenmeyer flask. (In this exercise the particle size of the 5 grams should be 1 mm or less).

2. Add 96.5 mℓ of double distilled water, cover with a watch glass and stir vigorously for 5 minutes with a magnetic stirrer.

3. Measure the pH.

4. If the pH is less than 5.0, then use TCLP solution – No 1.

5. If the pH is greater than 5.0, then proceed as follows:

5.1 Add 3.5 mℓ 1N HCL and stir briefly.

5.2 Cover with a watch glass, heat to 50°C and hold at 50°C for ten minutes.

5.3 Let cool to room temperature and record the pH.

6. If the pH is less than 5.0, then use TCLP solution – No 1.

7. If the pH is less than 5.0, then use TCLP solution – No 2.

B. Extraction for analysis of contaminants:

1. Weigh out 100 gram of the dry waste, which passes through a 9.5 mm sieve, and quantitatively transfer it to the extraction bottle.

2. Add two litres (2l) of the appropriate TCLP solution (No. 1 or 2 as determined by preliminary evaluation) and close bottle tightly.

3. Rotate in agitation apparatus at 30 r.p.m. for 20 hours. Temperature of room in which extraction takes place should be maintained at 23 ± 2°C.

4. Filter through a glass fibre filter and collect filtrate. Record pH of filtrate.

5. Take aliquot samples from the filtrate for determination of metal concentrations.

6. Immediately acidify each aliquot sample with nitric acid to a pH just less than 2.

7. Analyse by AA or other sensitive and appropriate techniques for different metals.

8. If analysis cannot be performed immediately after extraction, then store the acidified aliquots at 4°C, until analysis (as soon as possible).

Reference: USEPA Test Methods SW-846 On-line
http://www.epa.gov/epaoswer/hazwaste/test/pdfs/1311.pdf

APPENDIX 2: VECTOR ATTRACTION REDUCTION OPTIONS

The following options are available to reduce the vector attraction potential. These options have been adopted from the USEPA Part 503 Rule.

Option 1: Reduction in Volatile Solids Content

Vector attraction is reduced if the fraction of volatile solids in the primary sludge is reduced by at least 38 percent during the treatment of the sludge. This percentage is the amount of volatile solids reduction that is attained by anaerobic or aerobic digestion plus any additional volatile solids reduction that occurs before the sludge leaves the treatment works, such as through processing in drying beds or lagoons, or by composting.

Digestion process efficiency can be measured by the reduction in the volatile solids content of the feed sludge to the digester and the sludge withdrawn from the digester. Anaerobic digestion of primary sludge generally results in a reduction of between 40 and 60% of the volatile solids.

O'Shaunessy's formula can be used to calculate the volatile solids (VS) reduction in a digester:

VS reduction (%) = $\{(V_i - V_o)/ V_i - (V_i \times V_o)\}x100$

Where V_i = volatile fraction in feed sludge

V_o = volatile fraction in digested sludge

Example of calculation of VS reduction

Assume volatile solids in feed sludge = 84%

Therefore volatile fraction of feed sludge = 0.84 = V_i

Assume volatile solids of digested sludge = 68%

Therefore volatile fraction of digested sludge = 0.68 = V_o

VS reduction (%) = $\{(0.84 - 0.68) / 0.84 - (0.84 \times 0.68)\} \times 100$

= 59%

Option 2: Additional Digestion of Anaerobically Digested Sludge

Frequently, primary sludge is recycled to generate fatty acids or the sludge is recycled through the biological wastewater treatment section of a treatment works or has resided for long periods of time in the wastewater collection system. During this time, the sludge undergoes substantial biological degradation. If the sludge is subsequently treated by anaerobic digestion for a period of time, it adequately reduces vector attraction. Because the sludge will have entered the digester already partially stabilized, the volatile solids reduction after treatment is frequently less than 38 percent.

Under these circumstances, the 38 percent reduction required by Option 1 may not be achievable. Option 2 allows the operator to demonstrate vector attraction reduction by testing a portion of the previously digested sludge in a **bench-scale unit** in the laboratory. Vector attraction reduction is demonstrated if, after anaerobic digestion of the sludge for an additional 40 days at a temperature between 30º and 37ºC, the volatile solids in the sludge are reduced by less than 17 percent from the beginning to the end of the bench test.

Option 3: Additional Digestion of Aerobically Digested Sludge

This option is appropriate for aerobically digested sludge that cannot meet the 38 percent volatile solids reduction required by Option 1. This includes activated sludge from extended aeration plants, where the minimum residence time of sludge leaving the wastewater treatment processes section generally exceeds 20 days. In these cases, the sludge will already have been substantially degraded biologically prior to aerobic digestion.

Under this option, aerobically digested sludge with 2 percent or less solids is considered to have achieved vector attraction reduction, if in the laboratory after 30 days of aerobic digestion in a batch test at 20ºC, volatile solids are reduced by less than 15 percent. This test is only applicable to liquid aerobically digested sludge.

Option 4: Specific Oxygen Uptake Rate (SOUR) for Aerobically Digested Sludge

Frequently, aerobically digested sludge is circulated through the aerobic biological wastewater treatment process for as long as 30 days. In these cases, the sludge entering the aerobic digester is already partially digested, which makes it difficult to demonstrate the 38 percent reduction required by Option 1.

The specific oxygen uptake rate (SOUR) is the mass of oxygen consumed per unit time per unit mass of total solids (dry-weight basis) in the sludge. Reduction in vector attraction can be demonstrated if the SOUR of the sludge that is used or disposed, determined at 20ºC, is equal to or less than 2 milligrams of oxygen per hour per gram of total sludge (dry-weight basis). This test is based on the fact that if the sludge consumes very little oxygen, its value as a food source for micro organisms is very low and therefore micro-organisms are unlikely to be attracted to it. Other temperatures can be used for this test, provided the results are corrected to a 20 ºC basis. This test is only applicable to liquid aerobic sludge withdrawn from an aerobic treatment process.

Option 5: Aerobic Processes at Greater than 40 ºC

This option applies primarily to composted sludge that also contains partially decomposed organic bulking agents. The sludge must be aerobically treated for 14 days or longer, during which time the temperature must always be over 40ºC and the average temperature must be higher than 45ºC.

This option can be applied to other aerobic processes, such as aerobic digestion, but Options 3 and 4 are likely to be easier to meet than the other aerobic processes.

Option 6: Addition of Alkaline Material

Sludge is considered to be adequately reduced in vector attraction if sufficient alkaline material is added to achieve the following:

- Raise the pH to at least 12, measured at 25 ºC, and without the addition of more alkaline material, maintain a pH of 12 for at least 2 hours.

- Maintain a pH of at least 11,5 without addition of more alkaline material for an additional 22 hours.

The conditions required under this option are designed to ensure that the sludge can be stored for at least several days at the treatment works, transported, and then used or disposed without the pH falling to the point where putrefaction occurs and vectors are attracted.

Option 7: Moisture Reduction of Sludge Containing no Un-stabilised Solids

Under this option, vector attraction is considered to be reduced if the sludge does not contain unstabilised solids generated during primary treatment and if the solids content of the sludge is at least 75% before the sludge is mixed with other materials. Thus, the reduction must be achieved by removing water, not by adding inert materials.

It is important that the sludge does not contain un-stabilised solids because the partially degraded food scraps likely to be present in such sludge would attract birds, some mammals, and possibly insects, even if the solids content of the sludge exceeds 75 percent. In other words, simply dewatering primary sludge to a 75% solid is not adequate to comply with this option. Activated sludge, humus sludge and anaerobically digested sludge can, however be dewatered to 75% solids and comply with option 7.

Option 8: Moisture Reduction of Sludge Containing Unstabilised Solids

The ability of any sludge to attract vectors is considered to be adequately reduced if the solids content of the sludge is increased to 90 percent or greater, regardless of whether this contains primary sludge or raw unstabilised sludge. The solids increase should be achieved by removal of water and not by dilution with inert solids. Drying to this extent severely limits biological activity and strips off or decomposes the volatile compounds that attract vectors.

The way dried sludge is handled, including storage before use or disposal, can again create the opportunity for vector attraction. If dried sludge is exposed to high humidity, the outer surface of the sludge will increase in moisture content and possibly attract vectors. This should be properly guarded against.

Option 9: Sludge Injection

Vector attraction reduction can be demonstrated by injecting the sludge below the ground surface. Under this option, no significant amount of sludge can be present on the land surface within 1 hour of injection, and if the sludge is Microbiological Class A or B, it must be injected within 8 hours after discharge from the pathogen-reducing process.

Note: Microbiological class A and B can be applied to soil much later than 8 hours after discharge from the pathogen-reducing process if another vector attraction reduction option such as dewatering and/or drying is applied. The time periods referred to in Option 9 are intended for liquid sludge application of Microbiological classes A and B.

Injection of sludge beneath the soil places a barrier of earth between the sludge and vectors. The soil removes water from the sludge, which reduces the mobility and odour of the sludge. Odour is usually present at the site during the injection process, but quickly dissipates once injection is complete. This option is applicable to dedicated land disposal options only.

Option 10: Incorporation of Sludge into the Soil

Under this option, sludge must be incorporated into the soil within 6 hours of application to or placement on the land. Incorporation is accomplished by ploughing or by some other means of mixing the sludge into the soil. If the sludge is Microbiological class A or B with respect to pathogens, the time between processing and application or placement must not exceed 8 hours – the same as for injection under Option 9. See the note under Option 9. This option is applicable to dedicated land disposal options only.

Note: Practical restrictions, such as the ability of the plough to function immediately after application, could cause delays in the incorporation of the sludge within the 6 hours. This could cause the development of odours and increase risk of vector attraction. In these cases the sludge producer needs to monitor the development of odours and manage the situation diligently.

Option 11: Daily cover

This option is applicable to landfill only. Most landfill operations are based on a series of trenches or cells which are prepared to receive waste. The waste is deposited in trenches or cells, spread, compacted and covered to isolate the waste from the environment. The material to be used as cover material may be soil, builder's rubble or ash.

APPENDIX 3: SAMPLING METHODS AND PROCEDURES FOR WATER AND SOIL SAMPLES

WATER SAMPLING PROCEDURE [7]

Sampling equipment needed

- Equipment to collect microbiological samples
  - Sterile sample bottles (see Table 14 and 15 for the type of sample bottle needed)
  - Sealed container or cool box which can be kept cool (preferably with ice)
- Equipment to collect chemical and physical samples
  - Correct sample bottles (see Table 14 and 15 for the different types of sample bottles required)
  - Cooler box with ice (if necessary)

Special precautions

- Microbiological water samples
  - Keep sample bottle closed and in a clean condition up to the point where it has to be filled with the water to be sampled.
  - Do not rinse bottle with any water prior to sampling.
  - When samples for chemical and microbiological analysis are to be collected from the same location, the microbiological sample should be collected first to avoid the danger of microbiological contamination of the sampling point.
  - The sampler (person taking the sample) should wear gloves (if possible) or wash his/her hands thoroughly before taking each sample. Avoid hand contact with the neck of the sampling bottle.
- Chemical water samples
  - Some plastic caps or cap liners may cause metal contamination of the water sample. Please consult with the laboratory on the correct use of bottle caps.
  - Keep sample bottle closed and in a clean condition up to the point where it has to be filled with the water to be analysed.
  - Never leave the sample bottles (empty or filled with the water sample) unprotected in the sun.

[7] For more detail on the water sampling procedure, consult the following documents:
Department of Water Affairs and Forestry. Waste Management Series. Minimum Requirements for Water Monitoring at Waste Management Facilities (Latest edition).
WRC. 2000. Quality of domestic water supplies. Volume 2: Sampling Guide. WRC no TT 117/99.

- After the sample has been collected the sample bottle should be placed directly in a cooled container (e.g. portable cooler box). Try and keep cooled container dust-free.

Surface water sampling technique

The following procedures should be followed when taking water samples in rivers and streams:

- At the sampling point remove cap of sample bottle but do not contaminate inner surface of cap and neck of sample bottle with hands.
- Take samples by holding bottle with hand near base and plunge the sample bottle, neck downward, below the water surface (wear gloves to protect your hands from contact with the water).
- Turn bottle until neck points slightly upward and mouth is directed toward the current (can also be created artificially by pushing bottle forward horizontally in a direction away from the hand).
- Fill sample bottle without rinsing and replace cap immediately.
- Before closing the sample bottle, preserve the sample (if applicable, see Table 14) and leave ample air space in the bottle (at least 2.5 cm) to facilitate mixing by shaking before examination.
- Label the sample
- Submit for analysis to a reputable analytical laboratory.

Composite Borehole Water Sampling

Composite water sampling is done by pumping water from a borehole. The recommended procedure for composite sampling is as follows:

- Activate the pump and remove (purge) at least three times the volume of water contained in the hole.
- Collect a water sample in a clean container (see Table 15).
- Filter and preserve the sample (if applicable, see Table 15) and submit for analysis to a reputable analytical laboratory.

Various types of pumps may be used. As a portable system, a submersible pump may be considered. Submersible pumps are generally available in South Africa. For sampling, a small submersible pump that yields 1 ℓ/sec would be sufficient for most sampling applications.

Where low-yielding monitoring boreholes are pumped, the borehole could temporarily run dry while being purged. In such instances, samples should be taken of the newly accumulated groundwater after recovery or partial recovery of the water level in the holes. It may be necessary to sample such boreholes a day or more after having purged the hole.

SOIL SAMPLING[8]

Sampling equipment needed

- Soil auger
- Plastic sheets
- Plastic or glass containers (bottles or bags) that can be closed tightly
- Tags and a permanent marker to label the samples

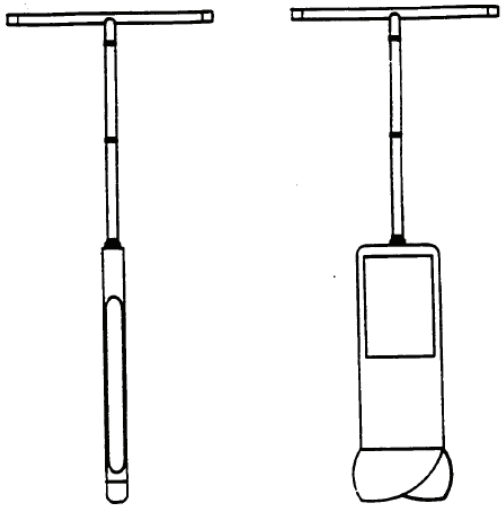


Figure 3A: Soil augers

Number of samples

For mono-fills, waste piles and lagoons at least 4 composite samples of each disposal area at each depth will be required. For DLD sites the number of samples will vary according to the size of the disposal site and different soil types present at the disposal site. At least three composite samples for each depth increment for every hectare of the DLD site are required.

Sampling procedure

The **soil auger** is used to bore a hole to a desired sampling depth, and is then withdrawn. The sample may be collected directly from the auger. The following procedure is recommended:

[8] For more information on soil sampling procedures, consult the following documents:
USEPA Environmental Response Team. 2000. Standard operating procedures: Soil sampling
USEPA 1989. Soil sampling quality assurance: User's Guide. EPA 600/8-89/046

1. Clear the area to be sampled of any surface debris (e.g. twigs, rocks, litter).

2. Begin augering and after reaching the desired depth, slowly and carefully remove the auger from the hole. Deposit the soil onto a plastic sheet spread near the hole. For soil monitoring at disposal sites these depths are 0-100 mm, 100-200 mm, 200-300 mm, 300-400 mm and 400-500 mm.

3. Place the samples into plastic or other appropriate containers, secure the caps tightly and label the sample.

4. If composite samples are to be collected, place a sample from another sampling site into the same container and mix thoroughly. When compositing is complete, place the sample into appropriate, labeled containers and secure the caps tightly.

5. Preserve the samples as recommended in Table A3 and submit to a accredited laboratory

TABLE 3A: RECOMMENDED SOIL SAMPLE CONTAINERS, PRESERVATION AND HOLDING TIMES

Contaminant	Container	Preservation	Holding Time
Acidity	Plastic/Glass	Cool, 4^{o}C	14 days
Ammonia	Plastic/Glass	Cool, 4^{o}C	28 days
Sulfate	Plastic/Glass	Cool, 4^{o}C	28 days
Nitrate	Plastic/Glass	Cool, 4^{o}C	48 hours
Organic Carbon	Plastic/Glass	Cool, 4^{o}C	28 days
Chromium (VI)	Plastic/Glass	Cool, 4^{o}C	48 hours
Mercury	Plastic/Glass	Cool, 4^{o}C	28 days
Other Metals	Plastic/Glass	Cool, 4^{o}C	6 months

Soil samples can also be collected from a **test pit or trench excavation**. The following procedure is recommended:

1. A shovel is used to remove a one to two inch layer of soil from the vertical face of the pit where sampling is to be done.

2. Samples are taken using a trowel, scoop, or coring device at the desired intervals. Be sure to scrape the vertical face at the point of sampling to remove any soil that may have fallen from above, and to expose fresh soil for sampling.

3. Place the samples into plastic or other appropriate containers, secure the caps tightly and label the sample.

4. If composite samples are to be collected, place a sample from another sampling site into the same container and mix thoroughly. When compositing is complete, place the sample into appropriate, labeled containers and secure the caps tightly.

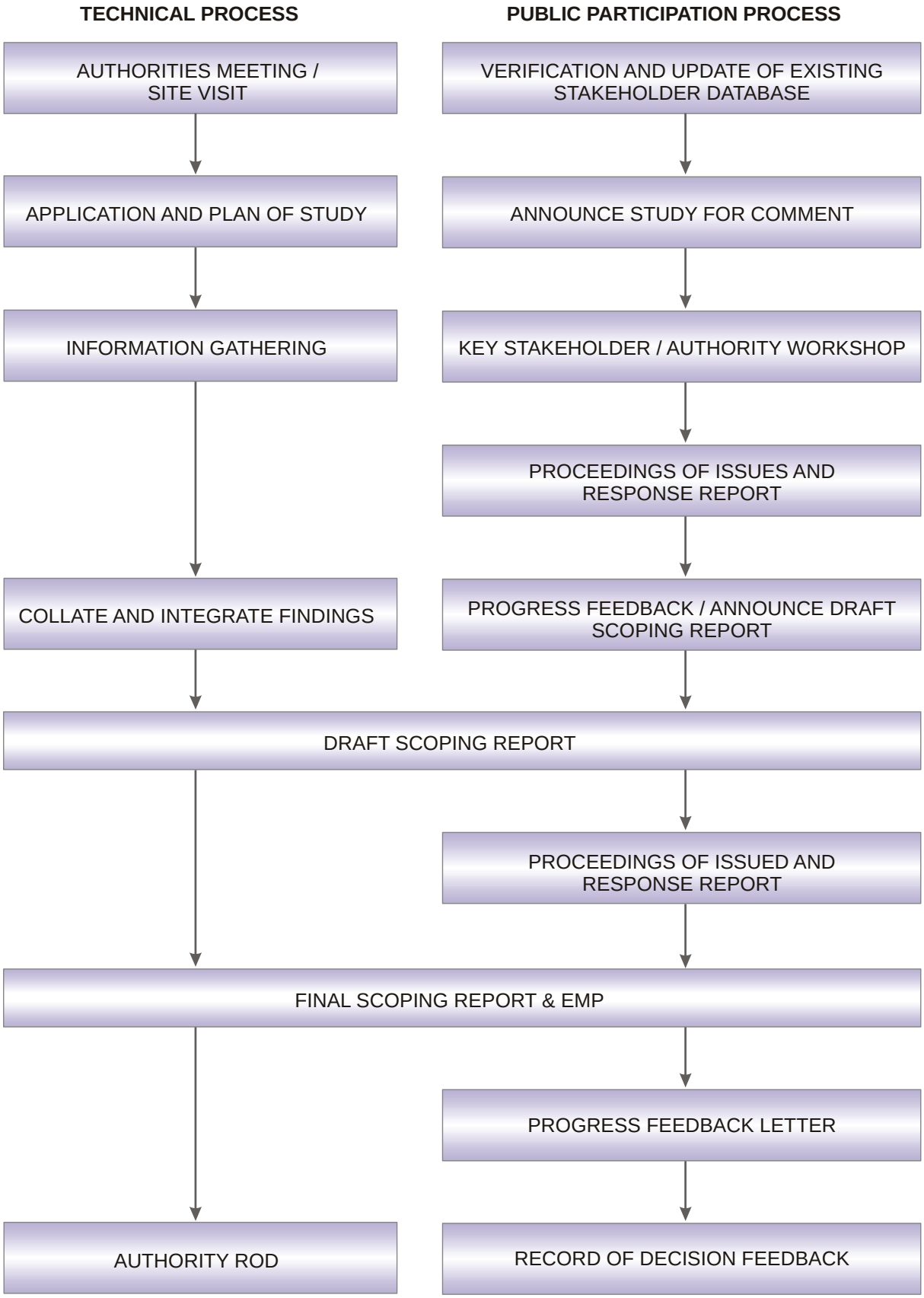
5. Preserve the samples as recommended in Table A3 and submit to an accredited laboratory

APPENDIX 4: LEGAL REQUIREMENTS

Appendix 4.1: Legislative framework governing the on-site and off-site disposal of sludge

Management Option	Relevant Legislation governing practice	Responsible Authority
On-site mono disposal	National Water Act, (Act No. 36 of 1998)	DWAF
	Environment Conservation Act, (Act No. 73 of 1989)	DEAT
	National Environmental Management Act, Act No. 107 of 1998)	DEAT
	Water Services Act, (Act 108 of 1997) (Specifically Section 12 & 13 related to Water Services Development Plans)	DWAF
	National Health Act, (Act No. 61 of 2003)	DoH
DLD sites	National Water Act, (Act No. 36 of 1998)	DWAF
	Waste Discharge Charge System, in terms of the National Water Act, 1998	DWAF
	Environment Conservation Act, (Act No. 73 of 1989)	DEAT
	National Environmental Management Act, (Act No. 107 of 1998)	DEAT
	National Health Act, (Act No. 61 of 2003)	DoH
Off-site co-disposal in landfill	National Environmental Management Act, (Act No. 107 of 1998)	DEAT
	Environment Conservation Act, (Act No. 73 of 1989	DEAT
	Minimum Requirements, 2006, Waste Management Series	DEAT
Marine disposal	National Water Act, (Act No. 36 of 1998)	DWAF
	Waste Discharge Charge System, in terms of the National Water Act, 1998	DWAF
	Operational Policy for the disposal of Land-derived water containing waste to the Marine Environment, 2004	DWAF
	South African Water Quality Guidelines for Coastal Marine Waters, 1995	DWAF
	Marine Living Resources Act, (Act No. 18 of 1998)	DEAT
	Environment Conservation Act, (Act No. 73 of 1989)	DEAT
	National Environmental Management Act, (Act No. 107 of 1998)	DEAT

Appendix 4.2: Environmental impact assessment process



DEFINITIONS AND DESCRIPTION OF KEY TERMS

Acceptable exposure (AE): The concentration of a substance that will have minimal effect on the environment or human health.

Agricultural land: Land on which a food crop, a feed crop, or a fibre crop is grown. This includes grazing land and forestry.

Agronomic rate: The sludge application rate (dry-weight basis) designed (i) to provide the amount of nitrogen needed by the food crop, feed crop, fibre crop, cover crop, or vegetation grown on the land and (ii) to minimise the amount of nitrogen in the sewage sludge that passes below the root zone of the crop or vegetation grown on the land to the groundwater.

Agricultural use: The use of sludge to produce agricultural products. It excludes the use of sludge for aquaculture and as an animal feed.

Annual pollutant loading rate: The maximum amount of a pollutant that can be applied to an area of land during a 365-day period.

Assimilative capacity: This represents the ability of the receiving environment to accept a substance without risk.

Available metal content (Soil): Specific to Volume 2. Metal fraction extracted with ammonium nitrate in soil samples.

Beneficial uses: Use of sludge with a defined benefit, such as a soil amendment.

Bioavailability: Availability of a substance for uptake by a biological system.

Biosolids: Stabilised Sludge. Organic solids derived from biological wastewater treatment processes that are in a state that they can be managed to sustainably utilise the nutrient, soil conditioning, energy, or other value.

Bund wall: A properly engineered and constructed run-off interception device around a waste disposal site or down slope of a waste disposal site.

Co-disposal (liquid with dry waste): The mixing of high moisture content or liquid waste with dry waste. This affects the water balance and is an acceptable practice on a site equipped with leachate management measures.

Co-disposal (dewatered sludge with dry waste): The mixing of dewatered sludge with dry waste in a general landfill site or hazardous landfill site without affecting the water balance of the site.

Composting: The biological decomposition of the organic constituents of sludge and other organic products under controlled conditions.

Contaminate: The addition of foreign matter to a natural system. This does not necessarily result in pollution, unless the attenuation capacity of the natural system is exceeded.

Controlled access: Where public or livestock access to sludge application areas is restricted or controlled, such as via fences or signage, for a period of time stipulated by this guideline.

Cradle-to-grave: A policy of controlling a wasteproduct from its inception to its ultimate disposal

Cumulative pollutant loading rate: The maximum amount of a pollutant that can be applied to a unit area of land.

Cut-off trench: A properly engineered and constructed trench to intercept and collect run-off.

Dedicated land disposal: Sites that receive repeated applications of sludge for the sole purpose of final disposal.

Delisting: If the estimated environmental concentration (EEC) is less than the Acceptable Exposure (AE) which is 10% of the LC_{50}, the waste can be delisted, i.e. be moved to a lower Hazard Rating or even disposed of at a General Waste landfill with a leachate collection system.

Dewatering: Dewatering processes reduce the water content of sludge to minimise the volumes for transport and improve handling characteristics. Typically, dewatered sludge can be handled as a solid rather than as liquid matter.

Disinfection: A process that destroys, inactivates or reduces pathogenic micro-organisms.

Disposal: The discharge, deposit, injection, dumping, spilling, leaking, or placing of any waste into the environment (land, surface water, ground water, and air).

Disposal site: A site used for the accumulation of waste with the purpose of disposing or treatment of such waste. See also Waste Disposal Site

Domestic sewage: Waste and wastewater from humans or household operations that is discharged to, or otherwise enters a treatment works.

Dose: In terms of monitoring exposure levels, the amount of a toxic substance taken into the body over a given period of time. See also $LD_{50.}$

Domestic waste: Waste emanating, typically, from homes and offices. Although classified as a General Waste, this waste contains organic substances and small volumes of hazardous substances.

Dose-response: How an organism's response to a toxic substance changes as its overall exposure to the substance changes. For example, a small dose of carbon monoxide may cause drowsiness; a large dose can be fatal.

Drying: A process to reduce the water content further than a dewatering process. The solids content after a drying process is typically > 75%.

Dry-weight (DW) basis: The method of measuring weight where, prior to being weighed, the material is dried at 105ºC until reaching a constant mass (i.e. essentially 100% solids content).

Dump: A land site where wastes are discarded in a disorderly or haphazard fashion without regard to protecting the environment. Uncontrolled dumping is an indiscriminate and illegal form of waste disposal. Problems associated with dumps include multiplication of disease-carrying organisms and pests, fires, air and water pollution, unsightliness, loss of habitat, and personal injury.

E. coli: A group of bacteria normally found in the intestines of humans and animals. Most types of *E. coli* are harmless, but some active strains produce harmful toxins and can cause severe illness. In sanitary bacteriology, *Escherichia coli* is considered the primary indicator of recent faecal pollution.

Ecotoxicity: Ecotoxicity is the potential to harm animals, plants, ecosystems or environmental processes.

Emission: The release or discharge of a substance into the environment. Generally refers to the release of gases or particulates into the air.

Emission Standards: Government standards that establish limits on discharges of pollutants into the environment (usually in reference to air).

Environment: Associated cultural, social, soil, biotic, atmospheric, surface and groundwater aspects associated with the disposal site that could potentially be, impacted upon by the disposal.

Environmental Impact Assessment (EIA): An investigation to determine the potential detrimental or beneficial impact on the surrounding communities, fauna, flora, water, soil and air arising from the development or presence of a waste disposal site.

Estimated Environmental Concentration (EEC): The Estimated Environmental Concentration represents the concentration of a substance in the aquatic environment when introduced under worst case scenario conditions, i.e. directly into a body of water. It is used to indicate possible risk, by comparison with the minimum concentration estimated to adversely affect aquatic organisms or to produce unacceptable concentrations in biota, water or sediment.

Faecal coliform: *Faecal coliforms* are the most commonly used bacterial indicator of faecal pollution. *Faecal coliforms* are bacteria that inhabit the digestive system of all warm-blooded animals, including humans.

Freeboard: Vertical distance from the normal water surface to the top of a confining wall.

Hazard Rating: A system for classifying and ranking Hazardous waste according to the degree of hazard they present.

Hazardous waste: Waste that may, by circumstances of use, quantity, concentration or inherent physical, chemical or infectious characteristics, cause ill health or increase mortality in humans, fauna and flora, or adversely affect the environment when improperly treated, stored, transported and disposed of.

Helminth ova: The eggs of parasitic intestinal worms.

Incineration: Incineration is both a form of treatment and a form of disposal. It is simply the controlled combustion of waste materials to a non-combustible residue or ash and exhaust gases, such as carbon dioxide and water.

Integrated Environmental Management (IEM): A code of practice ensuring that environmental considerations are fully integrated into the management of all activities in order to achieve a desirable balance between conservation and development.

Land application: The spraying or spreading of wastewater sludge onto the land surface; the injection of wastewater sludge below the land surface; or the incorporation of wastewater sludge into the soil so that the wastewater sludge can either condition the soil or fertilise crops or vegetation grown in the soil.

Land disposal: Application of sludge where beneficial use is not an objective. Disposal will normally result in application rates that exceed agronomic nutrient requirements or cause significant contaminant accumulation in the soil.

Landfill: To dispose of waste on land, whether by use of waste to fill in excavation or by creation of a landform above grade, where the term “fill” is used in the engineering sense.

LC_{50}: The median lethal dose is a statistical estimate of the amount of chemical, which will kill 50% of a given population of aquatic organisms under standard control conditions. The LC50 is expressed in mg/ℓ.

LD_{50}: The median lethal dose is a statistical estimate of the amount of chemical, which will kill 50% of a given population of animals (e.g. rats) under standard control conditions.

Leachate: An aqueous solution with a high pollution potential, arising when water is permitted to percolate through decomposing waste.

Liner: A layer of low permeability placed beneath a landfill and designed to direct leachate to a collection drain or sump, or to contain leachate. It may comprise natural materials, synthetic materials, or a combination thereof.

Maximum available threshold (MAT):	The maximum available (NH_4NO_3 extractable) metal concentration allowed for soils receiving sludge.
Maximum permissible level:	The maximum total metal concentration allowed in soils at sludge disposal sites. Soil remediation would not be necessary except if this level is exceeded.
Minimum Requirement:	A standard by means of which environmentally acceptable waste disposal practices can be distinguished from environmentally unacceptable waste disposal practices.
Monthly average:	The arithmetic mean of all measurements taken during a given month.
Most probable number (MPN):	A unit that expresses the amount of bacteria per gram of total dry solids in wastewater sludge.
Off-site:	Sludge disposal site outside the boundaries of the wastewater treatment plant (WWTP)
On-site:	Sludge disposal site within the boundaries of the wastewater treatment plant (WWTP)
Pathogenic organisms:	Disease-causing organisms. This includes, but is not limited to, certain bacteria, protozoa, viruses, and viable Helminth ova.
pH:	The logarithm of the reciprocal of the hydrogen ion concentration. The pH measures acidity/alkalinity and ranges from 0 to 14. A pH of 7 indicates the material is neutral. Moving a pH of 7 to 0, the pH indicates progressively more acid conditions. Moving from a pH of 7 to 14, the pH indicates progressively more alkaline conditions.
Pollution:	The direct or indirect alteration of the physical, chemical or biological properties of a (water) resource so as to make it less fit for any beneficial purpose for which it may reasonably be expected to be used; or harmful or potentially harmful to the welfare, health or safety of human beings; to any aquatic or non-aquatic organisms; to the resource quality; or to property.
Primary treatment:	Treatment of wastewater prior to other forms of treatment and involving settling and removal of suspended solids.
Qualified person:	A person is suitably qualified for a job as a result of one, or any combination of that person's formal qualifications, prior learning, relevant experience; or capacity to acquire, within a reasonable time, the ability to do the job.
Receptor:	Sensitive component of the ecosystem that reacts to or is influenced by environmental stressors.
Recycle:	The use, re-use, or reclamation of a material so that it re-enters the industrial process rather than becoming a waste.
Rehabilitation:	Restoring a waste site for a new industrial function, recreational use, or to a natural state.
Remediation:	The improvement of a contaminated site to prevent, minimize or mitigate damage to human health or the environment. Remediation involves the development and application of a planned approach that removes, destroys, contains or otherwise reduces the availability of contaminants to receptors of concern.
Residue:	A substance that is left over after a waste has been treated or destroyed.
Responsible person:	A person(s), who takes professional responsibility for ensuring that all or some of the facets of the handling and disposal of Hazardous Waste are properly directed, guided and executed, in a professionally justifiable manner.

Restricted agricultural use: Use of sludge in agriculture is permitted but restrictions apply (crop restrictions, access restrictions etc.).

Risk: The scientific judgement of probability of harm. This basic and important concept has two dimensions: the consequences of an event or set of circumstances and the likelihood of particular consequences being realised. Both dimensions apply to environmental risk management with it generally being taken that only adverse consequences are relevant.

Risk assessment: The evaluation of the results of risk analysis against criteria or objectives to determine acceptability or tolerability of residual risk levels, or to determine risk management priorities (or the effectiveness or cost-effectiveness of alternative risk management options and strategies).

Risk management: The systematic application of policies, procedures and practices to identify hazards, analysing the consequences and the likelihood associated with those hazards, estimating risk levels, assessing those risk levels against relevant criteria and objectives, and making decisions and acting to reduce risk levels to acceptable environmental and legal standards.

Secondary Treatment: Treatment of wastewater that typically follows primary treatment and involves biological processes and settling tanks to remove organic material.

Sludge-amended soil: Soil to which sludge has been added.

Sludge: Solid, semi-solid, or liquid residue generated during the treatment of domestic sewage in a treatment works. Wastewater sludge includes, but is not limited to, domestic septage; scum or solids removed in primary, secondary, or advanced wastewater treatment processes; and material derived from wastewater sludge in a wastewater sludge incinerator. It does not include the grit and screenings generated during preliminary treatment of domestic wastewater in a treatment works.

Soil organisms: A broad range of organisms, including microorganisms and various invertebrates living in or on the soil.

Specific oxygen uptake rate (SOUR): The mass of oxygen consumed per unit time per unit mass of total solids (dry-weight basis).

Stabilisation: The processing of sludge to reduce volatile organic matter, vector attraction, and the potential for putrefaction and offensive odours.

Stabilised sludge: Organic solids derived from biological wastewater treatment processes that are in a state that they can be managed to utilise the nutrient, soil conditioning, energy, or other value.

Sterilise: Make free from microorganisms.

Supplier: A person or organisation that produces and supplies sludge for use. This includes a water business producing and treating sludge and processors involved in further treatment.

Surface water interception mechanism: A mechanism placed between the disposal site and the surface water body to intercept possible run-off from the disposal site before it can reach the water body.

Sustainability: Being able to meet the needs of present and future generations by the responsible use of resources.

Sustainable use: The use of nutrients in sludge at or below the agronomic loading rate and/or use of the soil conditioning properties of sludge. Sustainable use involves protection of human health, the environment and soil functionality.

Total investigative level (TIL): The total metal concentration in agricultural soils where further investigation is necessary before sludge application can commence.

Total load capacity: The capacity of a landfill site to accept a certain substance or the amount of a substance, which can be safely disposed of at a certain site. The total load capacity is influenced by the concentration levels and mobility of the waste, and by the landfill practice and design.

Total maximum threshold (TMT): The maximum total metal concentration allowed in agricultural soils receiving sludge.

Total metal content: Metal fraction extracted using an *aqua regia* solution (HCl/HNO_3 solution).

Total trigger value (TTV): The total metal concentration in soils at disposal sites indicating that additional management options should be implemented to reduce the impact on the soil.

Toxic: Poisonous.

Toxicity: An intrinsic property of a substance which can cause harm or a particular adverse effect to humans, animals or plants at some dose.

Toxicity Characteristic Leaching Procedure (TCLP): A test developed by the USA Environmental Protection Agency to measure the ability of a substance to leach from the waste into the environment. It thus measures the risk posed by a substance to groundwater.

Transporters: A person, organisation, industry or enterprise engaged in or offering to engage in the transportation of waste.

Treatment: Treatment is used to remove, separate, concentrate or recover a hazardous or toxic component of a waste or to destroy or, at least, to reduce its toxicity in order to minimise its impact on the environment.

Unrestricted agricultural use: Sludge is of such good quality that it can be used in agricultural practices without any restrictions.

VAR: Vector Attraction Reduction.

Vector attraction: The characteristic of wastewater sludge that attracts rodents, flies, mosquitoes, or other organisms capable of transporting infectious agents.

Vectors: Any living organisms that are capable of transmitting pathogens from one organism to another, either: (i) mechanically by transporting the pathogen or (ii) biologically by playing a role in the lifecycle of the pathogen. Vectors include flies, mosquitoes or other insects, birds, rats and other vermon.

Waste: An undesirable or superfluous by-product, emission, or residue of any process or activity, which has been discarded, accumulated or stored for the purpose of discarding or processing. It may be gaseous, liquid or solid or any combination thereof and may originate from a residential, commercial or industrial area.

Waste disposal site: Any place at which more than 100 kg of a Hazardous Waste is stored for more than 90 days or a place at which a dedicated incinerator is located.

Waste Permit: An authorisation in terms of the Environment Conservation Act (Act No. 73 of 1989) to establish, provide or operate any disposal site (See definition of disposal site)

Wastewater Sludge: The material recovered from predominantly domestic wastewater treatment plants. (Also see Sludge)

Wastewater Treatment Plant (WWTP):	Any device or system used to treat (including recycling and reclamation) either domestic wastewater or a combination of domestic wastewater and industrial waste of a liquid nature.
Water Use Authorisation:	An entitlement to undertake a water use in terms of the National Water Act (Act No. 36 of 1998). An authorisation may be a water use license, permissible under a general authorisation, an existing lawful water use, or a Schedule I water use.
Wet weight:	Weight measured of material that has not been dried (see Dry-weight basis).