SWARTLAND MUNICIPALITY

WASTEWATER RISK ABATEMENT PLAN (W_2RAP) FOR KORINGBERG

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Abbreviations and Definitions

ADWF	Average Dry Weather Flow
AHP	Analytic Hierarchy Process
BOD	Biochemical Oxygen Demand
CMA	Catchment Management Agency
COD	Chemical Oxygen Demand
CRC	Current Replacement Cost
CRR	Cumulative Risk Ratio
CSIR	Council for Scientific and Industrial Research
DRC	Depreciated Replacement Cost
DWS	Department of Water and Sanitation
EIS	Ecological Importance and Sensitivity
ERA	Ecological Risk Assessment
ETT	Emergency Task Team
GDIP	Green Drop Improvement Plan
GDS	Green Drop System
GWSA	Green Water Services Audit
HIV	Human Immunodeficiency Virus
IHAS	Invertebrate Habitat Assessment Systems
km^2	Square Kilometre
m	Metre
Mℓ	Mega Litre
Ml/a	Mega Litre per Annum
PAT	Progress Assessment Tool
PESC	Present Ecological State and Condition
PFC	Power Factor Corrections
RPMS	Regulatory Performance Management System
SAR	Sodium Absorption Ratio
TDS	Total Dissolved Solids
TOC	Total Organic Carbon
VSD	Variable Speed Drive
WIMP	Wastewater Incident Management Protocol
WSDP	Water Services Development Plan
WSP	Water Services Provider
WWTW	Waste Water Treatment Works

Key Terms

TERM	INTERPRETATION
Annual Average Daily Flow	Represents the total flow over a year divided by 365.
Average Dry Weather Flow	It is a term that was brought to South Africa as a result of European and American practice where combined storm water and sewerage systems were used. When the storm water is very intense, it cannot be allowed into the foul water sewers, as the peak flow rates would be unmanageable in treatment works. Therefore, the storm water is kept out of the sewers. There is always some ingress of storm water into the sewers and hence the flow increases as the result of a storm.
Corrective Action	The action to be taken when the results of monitoring indicate a deviation from an operational or critical limit.
Hazard	A biological, chemical, physical or radiological agent that has the potential to cause harm
Hazardous Event	An incident or situation that can lead to the presence of a hazard.
Monitoring	Is the act of conducting a planned series of observations or measurements of operational and / or critical limits to assess whether the components of the WWTWs are operating properly.
Process Controller	The class of person that is responsible for the day-to-day operations that determine the effectiveness of the treatment system.
Risk	The likelihood of identified hazards causing harm in exposed populations in a specified time frame, including the magnitude of that harm and / or the consequences.

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CHARACTERISTICS OF SEWAGE

PHYSICAL CHARACTERISTICS

Sewage, when received in a reasonably fresh state at a WWTW, is usually greyish in colour with a slight odour. The sewage is called septic when the dissolved oxygen has been used up, the sewage becomes stale and certain organisms start utilising the sulphate as an oxygen source. It is then blackish in colour with a fairly strong offensive sulphide odour.

Solids: Sewage contains larger (screenable), settleable and colloidal solid matter:

- Screenable material; paper, rags, plastics, miscellaneous large objects, grit or sand
- Settleable organic matter; a slower sedimentation or settling rate (about 40% of the sewage strength or load)
- Colloidal state; too small to be settled out, predominantly organic and consists of fine particles.

The remaining solids are in solution or dissolved solids. A portion of these is organic and affected by the treatment process. The remainder are inorganic compounds and salts, which, apart from ammonia, generally pass through a WWTW unchanged. The treatment process removes all the solids from the sewage apart from the dissolved inorganic matter.

CHEMICAL CHARACTERISTICS

Organic compounds have complex carbon based molecules with structures and formulae. Apart from carbon, organic molecules contain hydrogen (H) and sometimes oxygen (O), nitrogen (N), sulphur (S) and / or phosphorus (P).

It is impossible to analyse for all possible compounds and combinations and thus various standard tests are used to assess the strength and characteristics of the sewage. The overall amount of oxygen required to oxidise the carbon, hydrogen, and nitrogen in the sewage is thus a measure of its strength. Some of the tests developed that measure oxygen include the following:

- Oxygen absorbed from potassium permanganate (OA)
- Permanganate Value (PV) (Similar to OA)
- Biochemical Oxygen Demand (BOD)
- Chemical Oxygen Demand (COD)
- Total Organic Carbon (TOC)

Sewage, therefore, has a strength, which is measured by its demand for oxygen to complete the oxidation reactions required to render it stable and inoffensive.

The strength, as measured by the OA, BOD or COD, does not measure the nitrogen oxidation requirements and is usually referred to as the carbonaceous strength.

The nitrogen content of sewage is measured as ammonia and total organic (Kjeldahl) nitrogen. The oxygen demand or strength in this regard is then calculated from chemical considerations.

Phosphorus is present in small quantities. It is not oxidised in the purification process but is converted to the inorganic form. Phosphorus and the small quantities of sulphur that may be present are disregarded from a strength or load point of view. Phosphorus, essential for growth of algae, is a cause of eutrophication in dams. Many new plants how have a phosphorus removal process included in the treatment system.

Knowledge of the total and inorganic phosphorus content is important and specific tests to measure these are used. A significant proportion of the phosphorus in sewage results from the use of phosphate-containing detergents. The sulphur content of sewage is sometimes measured.

BACTERIOLOGICAL CHARACTERISTICS

Sewage, as it arrives at the purification works, contains a complex biological flora. There are many millions of harmless micro-organisms, many of which aid in the subsequent purification. However, as sewage also includes man's excreta, often together with hospital wastes, abattoir wastes, and many others, it is not surprising that there are also millions of potentially dangerous pathogenic organisms.

Besides pathogens such as those causing gastric fever, dysentery, typhoid fever and tuberculosis, there are also viruses, among others those of poliomyelitis, together with eggs of certain intestinal worms, such as roundworms, hookworms and tapeworms. Many of these pathogens do not survive for long in sewage, but others, like the eggs mentioned, can remain viable for weeks or months.

Sewage is, therefore, capable of transmitting disease, and untreated sewage must, at all times, be regarded as potentially dangerous.

TREATMENT PROCESSES
MECHANICAL PROCESSES
These processes are a preliminary treatment to remove wastewater components that may cause operational or maintenance problems in the treatment operations, processes and systems. They should be present for most types of treatment systems as they not only prevent operational problems, but also greatly improve the efficiency and lifespan of a treatment system.
Screening
Large solids are removed by either hand-raked or automated mechanical screens. The first screen, at the inlet of the works, traps large objects such as tin cans and large stones, the second removes paper, rags, plastic, sanitary towels, condoms, etc. It is important that the screens do not remove organic solids such as unbroken faecal matter. Material removed from the screens is normally dried on racks, before being incinerated or buried.
Initial settling and separating
Heavy solids such as grit and sand are settled out in grit channels or a "teacup" separator. In the grit channels, a constant flow speed enables sand and grit to settle, but keeps organic matter in suspension. Settled grit is removed from channels by hand or, on larger plants, by a combination of an airlift pump and classifier that separates the sand from the water.
Primary settling
Primary settling is a mechanical process generally used in conventional treatment plants and also in pond systems. This process removes suspended organic solids from the stream. Settling takes place in square or circular tanks with either an upward or radial outward flow pattern. Wastewater enters at the centre of the tank via a vertical pipe, and as its velocity is reduced, the solid particles settle to the tank floor, forming sludge that is removed by the pressure of the water in the tank (desludging). This primary treatment to remove physical pollutants is purely mechanical, and its effluent still contains a considerable amount of organic material. In oxidation ponds similar settling occurs, though not in a formal tank but in the primary (often anaerobic) ponds. It is for this reason that primary ponds should be as deep as possible as they are not easy to desludge regularly. The primary chamber of a septic tank also serves to remove the settleable solids from the wastewater stream.
BIOLOGICAL PROCESSES
Bacteria, oxygen and nutrients in harmony
Bacteria occur naturally in the wastewater, but oxygen is usually depleted and needs to be added by bubbling air through the wastewater, or by breaking the water into fine droplets that absorb air (surface aeration). Nutrients are already present in wastewater in the form of dissolved pollutants. This biological process takes place in a single unit. Older treatment plants have one or more biological filter units, while modern plants have activated sludge reactor units. Biological filters produce humus, and activated sludge reactors produce waste-activated sludge. Both by-products consist of large numbers of dead organisms in suspensions that now need to be removed. This is done by secondary settling, the last mechanical process in wastewater treatment, which takes place in circular tanks similar to primary settling tanks. Tanks following biological filters are known as humus tanks; those following activated sludge reactors are called clarifiers. Both units produce what is known as the final effluent.
Other systems, same principles
In a facultative pond in an oxidation pond system, the nutrients are provided by the incoming wastewater while the oxygen is dissolved as wind blows over the surface of the pond, causing waves. The bacteria in a facultative pond use the nutrients and oxygen to complete their life cycle and multiply, and this process improves the quality of the water by removing the waste products. Similarly, in a reed bed treatment system, the incoming stream of wastewater provides the nutrients for the multitude of bacteria living both above and below the substrate or medium in which the reeds are planted. Both oxidation ponds and reed bed treatment systems rely heavily on naturally occurring biological processes for their functioning.

CHEMICAL PROCESSES
If the treatment process is operated well, the effluent is crystal clear and odourless. However, it still contains microscopic bacteria and viruses, normally not removed by the previous processes. As it is extremely difficult to remove these organisms mechanically, it is normal to use oxidising chemicals such as chlorine or ozone in the final process of disinfection.
Sludge handling
Three types of sludge are produced at a wastewater treatment plant. Primary sludge comes from the primary settling process and contains large quantities or organic material and pathogens. As primary sludge is 80% water, it is usually thickened either chemically, by adding a flocculent, or by gravity in a tank, thus reducing the volume of sludge and the space required to treat it. In a similar fashion, the digested solid materials in a septic tank and in the primary ponds of an oxidation pond system are reduced in volume by the weight of the liquid above the sludge and the developing layers of sludge. Sludge is then treated in a conical tank known as a digester. This anaerobic process requires a closed tank to prevent the entrance of air. Digestion is usually a two-step process in either a single combined process unit or in two separate tanks. The by-products of this digestion process are carbon dioxide and methane gas, and a thick, brown, tar-like liquid that is completely stable in terms of biological activity. Water remaining in this liquid is removed by air-drying on open drying beds or by a mechanical belt press. After drying, the sludge forms crumbly cakes that can be used for compost. The activated sludge process produces two other by-products. The first, waste activated sludge, is withdrawn from the activated sludge reactor, thickened and dried. It is a stable product that does not require digestion. When dry, it forms small, hard blocks, typically 25mm square, which can be used as compost. The second type of sludge is return activated sludge, which is generally recycled between the secondary settling tanks and the activated sludge reactor, to ensure sufficient quantities of bacteria in the reactor.

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WASTEWATER RISK ABATEMENT PLAN FOR KORINGBERG

Background

The Green Drop Process of the DWS ensures regular assessment of WWTWs to ensure that they comply with wastewater legislation and other best practices. Through the Green Drop Programme, DWS have identified core competencies that enable acceptable performance in wastewater service provision and management. It generates feedback for participating municipalities to define risk profiles and inform turnaround plans.

Effective management of the wastewater treatment systems in Swartland Municipality's Management Area requires:

- a comprehensive understanding of the system;
- knowledge of the range and magnitude of hazards that may be present;
- the ability of existing processes and infrastructure to manage actual- or potential risks; and
- an assessment of capabilities to meet targets.

The DWS also completed their Third Order Assessment of Municipal Waste Water Treatment Plants, DWS's Green Drop Report for 2013, which provides a scientific and verifiable status of municipal waste water treatment. Green drop status is awarded to those WSAs that comply with 90% criteria on key selected indicators on waste water quality management. The green drop performance of Swartland Municipality is summarised as follows in the DWS's 2013 Green Drop Report.

Table A.1: Green Drop Performance of the Municipality (DWS's 2013 Green Drop Report)	
Average Green Drop Score	**2009 – 75.00%, 2011 – 72.70%, 2013 –72.38%**

Regulatory Impression: Swartland Local Municipality's commitment to its wastewater business and ambition towards Green Drop Certification cannot be faulted. This inspectorate was welcomed by the Mayor, the Municipal Manager and Senior Technical- and Financial Managers. The Regulator is of firm opinion that with such leadership, management and true understanding of the requirements to wastewater excellence, Swartland will improve in strides going forward. The team wishes to encourage the Municipality to continue being so positive.

Swartland has managed to maintain its municipal Green Drop score at 75.3%, marking an above average performance. This is no small feat, given the stringent standard of the GWSA criteria for 2013. The team is congratulated and encouraged to use the feedback to address the remaining shortcomings.

The most significant factor that retained scores below the 80% (and even 90%) mark, has been the uncertainties of the applicable standards to calculate compliance. The municipality must make a concerted effort to resolve authorisations, especially as pertaining to irrigation- and no-discharge systems. The WSA's resolve to use General Limits as internal standard is commendable and evidence of this accomplished team upholding of good practice. However, by addressing this single aspect, a significant upwards change can be expected during the next cycle GWSA scoring. A special mention of the Process Controllers on Malmesbury WWTW for display of their practical knowledge of the systems – continue to transfer this know-how to fellow practitioners. This is indeed a scarce skill.

Swartland's approach to risk abatement has received a full score for its resolve and Tender Committee approval for the implementation of the W_2RAP. At the moment, all 9 treatment systems remain in moderate risk positions, and the Regulator encourage the municipality to move plants towards low risk space by rigorous implementation of the W_2RAP. Already, the municipality's construction of the new Malmesbury WWTW and planning of the Riebeeck valley WWTW is a proactive step to relieve the pressure on the current systems. Note the recommendation to include the WIMP (O&M) and alert levels specifications in the W_2RAP and GDIP.

Green Drop findings:

1. Regulation 17 compliance is not in place for most plants, and registration of process controllers should be fast-tracked.
2. A number of systems did not have process assessments and network inspection in place, this should be the basis to inform the W_2RAP.
3. Effluent quality fails at 9 of 9 treatment systems.
4. Four (4) of 9 treatment plants are operated above their hydraulic design capacity, and 1 plant do not have base information to complete this calculation (assume highest risk of 151%).

The green drop performance for Koringberg is summarised as follows in the DWS's 2013 Green Drop Report.

Table A.2: 2013 Green Drop Performance of the Koringberg WWTW (DWS's 2013 Green Drop Report)

Key Performance Area	Koringberg
Process Control, Maintenance and Management Skill	80
Monitoring Programme	100
Submission of Results	50
Effluent Quality Compliance	0
Risk Management	96
Local Regulation	100
Treatment Capacity	29
Asset Management	80
Bonus Scores	6.61
Penalties	0.00
Green Drop Score (2013)	**64.96%**
Green Drop Score (2011)	**66.40%**
Green Drop Score (2009)	**0.00%**
System Design Capacity (Ml/d)	0.030
Capacity Utilisation (% ADWF ito Design Capacity)	NI (151.00%)
Resource Discharged into	No discharge
Microbiological Compliance (%)	58.33%
Chemical Compliance (%)	22.92%
Physical Compliance (%)	33.33%
Overall Compliance (%)	31.25%
Wastewater Risk Rating (2012)	**41.20%**
Wastewater Risk Rating (2013)	**52.94%**

A risk- based regulatory approach is followed by the DWS that provides early warning signs of WWTWs that contain a certain measure of risk, and in directing the type of intervention required to manage and mitigate the identified risk and move to a more favourable position of compliance and ultimately, excellence. The updated Cumulative Risk Ratio (CRR) for each of the WWTWs was calculated by the DWS for their 2014 Green Drop Progress Report. The following formula is used by the DWS for the calculation of the CRR of the WWTW:

CRR = A*B + C + D, where

A = **Design Capacity** of plant, which also represents the hydraulic loading onto the receiving water body.

B = **Average Daily Flow** volume exceeding, on or below the hydraulic design capacity (as ADWF).

C = The number of **non-compliance trends** in terms of the effluent quality discharged to the receiving water body.

D = The compliance or non-compliance in terms of the **Technical Skills** staffing requirements.

The Weighting Factors (WF) used for the purpose of establishing the cumulative risk rating per WWTW are summarised in the table below.

Table A.3: DWS's Weighting Factors assigned to the four risk areas for the calculation of the CRR		
Design Capacity Rating (A)	**Design Capacity (Ml/d)**	**WF**
	> 400	7
	201 – 400	6
	101 – 200	5
	51 – 100	4
	21 – 50	3
	5 – 20	2
	< 5	1
Capacity Exceedance Rating (B)	**Capacity Exceedance (%)**	**WF**
	> 151 %	5
	101 – 150%	4
	51 – 100%	3
	11 – 50%	2
	0 – 10%	1
	< 0%	0
No of Non-Compliant Parameter Failures (C)	**WF:** 9, 8, 7, 6, 5, 4, 3, 2, 1, 0	
Technical Skills Rating (D)	**Priorities**	**WF**
	Superintendent & Process Controllers & Maintenance Team in place.	1
	Superintendent + Maintenance Team & No Process Controllers	2
	Process Controllers + Maintenance Team & No Superintendent	
	Process Controllers + Superintendent & No Maintenance Team	
	Superintendent & No Maintenance Team & No Process Controllers	3
	Process Controllers & No Maintenance Team & No Superintendent	
	Maintenance Team & No Superintendent & No Process Controllers	
	No Superintendent & No Process Controllers	4

The 2014 Green Drop Risk Profile Progress Report of the DWS is further the product of a "gap" year, whereby progress is reported in terms of the improvement or decline in the risk position of the particular WWTW, as compare to the previous year's risks profile. This tool to collect, assess and report the risk profile is called the Green Drop Progress Assessment Tool (PAT). The PAT progress assessment period was done on compliance data and actions during 1 July 2012 – 30 June 2013, which represents the year immediately following the Green Drop 2013 assessment period. The results for Koringberg were summarised as follow in DWS's 2014 Green Drop Risk Profile Progress Report.

Table A.4: DWS's 2014 Green Drop Risk Profile Progress Report results for Koringberg	
Technology Description	**Koringberg**
Technology (Liquid)	Anaerobic ponds/ Facultative ponds
Technology (Sludge)	None specified
Key Risk Areas	
ADWF Design Capacity (Ml/d)	0.03
Operational flow (% i.t.o. Design Capacity)	151% (NI)
Annual Average Effluent Quality Compliance (2012-2013)	**46.9%**
Microbiological Compliance (%)	**100.0%**
Physical Compliance (%)	**44.4%**
Chemical Compliance (%)	**35.4%**
Technical skills (Reg. 813)	Partial
2014 Wastewater Risk Rating (%CRR/CRR_{max})	**76.5%**
2013 Wastewater Risk Rating (%CRR/CRR_{max})	**52.9%**
Risk Abatement Planning	
Highest Risk Areas based on the CRR	Wastewater quality, technical skills, operational

Table A.4: DWS's 2014 Green Drop Risk Profile Progress Report results for Koringberg		
		capacity
WW Risk Abatement Status		Draft document (Unapproved by Council)
Capital & Refurbishment expenditure for Fin Year 2012-2013 (Rand)		NI
Description of Projects' Expenditure 2012-2013		NI
W_2RAP Abatement Document and Status Commentary	W_2RAP provided dated 11 October 2011. Although actions refer to the following years, the document needs to be reviewed for 2012/13. All elements of the W_2RAP guideline addressed in the W_2RAP. A collaborative, multi-stakeholder team was assembled. All 9 systems were addressed. Medium and high risks for wastewater source (2), wastewater treatment (5) and facility safety and worker protection (1) finalized as indicated. Existing control measures were identified, evaluated and additional control measures proposed where necessary – as part of the Improvement Plan. The Upgrade / Improvement plan includes short- and long-term programmes. The short-term improvements include additional control measures to improve the effluent quality, while long-term programmes relate to capital works, which include the upgrading of Malmesbury, with which the Municipality is currently busy, and the future upgrading of the Riebeek Kasteel (Incl. Riebeek Wes and Ongegund), Koringberg, Koringberg and Chatsworth plants. Implementation of the plan to be monitored to confirm improvements were made. Timeframes and responsibilities were specified. Management procedures such as incident management protocol compiled and being implemented. Supporting programmes to indirectly support the management of risks include actions such as training of personnel, quality management, communication procedures indicated.	
Regulatory impression	The Swartland Municipality maintained its status on a municipal Green Drop score of 72.38% for the 2013 audit, when compared with the 2011 score of 72.70%. The highest score was achieved for the Malmesbury system at 75.49%. During the 2013-2014 Green Drop Progress Reporting the CRR Risk Rating increased in 7 of the systems, while in 2 systems (Malmesbury and Darling) the score decreased. It appears as if the necessary maintenance team competency is available at all systems and the Municipality is urged to maintain this situation. The DWS is understandably concerned about the increase in risk rating in most of the systems and requests the Municipality to intervene urgently to improve the situation. The DWS has the following concerns about wastewater management at the Municipality: lack of flow metering data at 7 of the plants, resulting in the worse situation (151%) being reported for operational capacity at the works; lack of supervisory and process control competencies at all the works; general non-compliant effluent quality except at the Koringberg works. The Municipality should address the gaps identified in this and the 2013 Green Drop report through an updated GDIP which should be implemented with care to ensure improvement at their wastewater systems. The upgrade at the Malmesbury works is commended, as well as the projects to build activated sludge plants at Riebeek Kasteel, Riebeek Wes and Ongegund.	

According to the CRR formulae logic, the lowest CRR that can be achieved will be 1 and the highest CRR possible will be 48.

The DWS also developed a revised CRR (CRRr), which takes the Environmental Sensitivity Weighting and the Effective Management Weighting factors into account. The calculation of the CRRr is as follows:

CRRr = CRR * H * I, where

H = **Effective Management** Weighting (Green Drop Score)

I = **Environmental Sensitivity Weighting** (F: Present Ecological State and Condition + G: Ecological Importance and Sensitivity)

The CRRr is therefore CRR * H * (F + G)

The Weighting Factors (WF) used for the purpose of establishing the Effective Management Weighting and the Environmental Sensitivity Weighting per WWTW are summarised in the table below.

Table A.5: DWS's Weighting Factors assigned to the effective management weighting and the environmental sensitivity weighting areas for the calculation of the CRRr

	Category	Description	Median PESC and EIS Scores	WF
Present Ecological State and Condition – PESC (F)	A	Unmodified, natural	>4	1.00
	B	Largely natural with few modifications. A small change in natural habitats and biota may have taken place but the ecosystem functions are essentially unchanged.	> 3 & < 4	0.85
	C	Moderately modified. Loss and change of natural habitat and biota have occurred, but the basic ecosystem functions are still predominantly unchanged.	> 2 & < 3	0.70

Table A.5: DWS's Weighting Factors assigned to the effective management weighting and the environmental sensitivity weighting areas for the calculation of the CRRr				
	D	Largely modified. A large loss of natural habitat, biota and basic ecosystem functions has occurred.	= 2	0.50
	E	Seriously modified. The loss of natural habitat, biota and basic ecosystem functions is extensive.	< 2 & > 1	0.30
	F	Critically / Extremely modified. Modifications have reached a critical level and the system has been modified completely with an almost complete loss of natural habitat and biota. In the worst instances the basic ecosystem functions have been destroyed and the changes are irreversible.	< 1	0.10
Ecological Importance and Sensitivity – EIS (G)	Very High	Quaternaries / delineations that are considered to be unique on a national or even international level, based on unique biodiversity. These rivers (in terms of biota and habitat) are usually **very sensitive** to flow modifications and **have no or only a small capacity** for use.	> 3	1.00
	High	Quaternaries / delineations that are considered to be unique on a national scale due to biodiversity. These rivers (in terms of biota and habitat) may be **sensitive** to flow modifications, but in some cases, may have **a substantial capacity** for use.	> 2 & < 3	0.75
	Moderate	Quaternaries / delineations that are considered to be unique on a provincial or local scale due to biodiversity. These rivers (in terms of biota and habitat) are usually **not very sensitive** to flow modifications and often have a **substantial capacity** for use.	> 1 & < 2	0.50
	Low	Quaternaries / delineations that is not unique at any scale. These rivers are generally **not very sensitive** to flow modifications and usually have a **substantial capacity** for use.	< 1	0.25
Green Drop Certification Score in % (H)	**Category / Description**			**WF**
	90 – 100			0.25
	80 – 89			0.50
	60 – 79			0.75
	40 – 59			1.00
	20 – 39			1.25
	0 - 19			1.50

The lowest CRRr that can be achieved will be 0.1 and the highest CRRr will be 144. WSAs therefore need to address the following, in order to reduce their current CRR.

- Forward planning and upgrading / refurbishment of treatment plants to ensure adequate capacity for the flows received;
- Operate and maintain the WWTWs within design- and equipment specifications;
- Have trained, qualified and registered staff in place;
- Get mentoring / coaching contracts in place where there is a great demand for adequately skilled process controllers and supervision;
- Monitoring of flow to- and from the plants;
- Sampling and monitoring of effluent quality;
- Appropriate authorisation in accordance with the National Water Act (36 of 1998); and / or
- Where plant is overloaded, introduce innovative methods to ensure enhancement of effluent quality.

1 WASTEWATER QUALITY COMPLIANCE

1.1 Wastewater Risk Abatement Plan (W_2RAP)

The most effective means of consistently ensuring the responsible treatment and discharge or re-use of wastewater and its byproducts, is through the use of a comprehensive risk assessment and risk management approach that encompasses all steps in the wastewater value chain, from production to discharge or reuse in a particular catchment.

Wastewater can be treated to obtain various different levels of effluent quality depending on the treatment process and the management thereof. The quality of wastewater services (collection, treatment, final disposal/re-use) is a large contributor to risks associated with public health and environmental integrity of a country. It is therefore an imperative, given that a treatment plant can produce any quality of effluent, that risks associated with the collection, treatment and disposal of wastewater is managed in a consistent, responsible and sustainable manner.

Risk management involves the development of guidelines, standards and management strategies for specific elements in the value chain of wastewater services. The use of a comprehensive risk assessment and risk management approach, that includes all the various steps and aspects of wastewater treatment, can be considered and effective means of **consistently, responsibly** and **sustainably** ensuring the safety of wastewater treatment and its byproducts.

Swartland Municipality therefore has the responsibility to:

- Monitor the quality of effluent that is disposed into the various water resources;
- To ensure that the quality of the effluent comply with the standards prescribed by the DWS for a particular wastewater treatment works;
- To take preventative measures to prevent the pollution of any water or natural resource by the collection, and treatment of raw sewage or the disposal of treated effluent.

The DWS identified the operation, maintenance and management of wastewater treatment works (WWTW) as the largest contributor to risks associated with public health and environmental integrity. They have developed a wastewater risk assessment plan in 2010, together with the Water Research Commission and other specialists in the water sector, which is linked to the Water Safety Plan (WSP). The guideline is based on the principles for the development of a WSP such as the description of risks associated with wastewater management and how the risks can be abated. The document developed based on the guidelines is referred to as a Wastewater Risk Abatement Plan (W_2RAP).

The W_2RAP is an all-inclusive risk analysis tool by which risks associated with the management of collection, treatment and disposal of wastewater, are identified and rated (quantified). The identified risks can then be managed according to its potential impacts on the receiving environment / community / resource. This step is referred to as Risk Management.

Hence, the W_2RAP is a planning tool which will include various steps and the involvement of various individuals from different specialist knowledge fields within the water sector.

The W_2RAP will particularly address management and process control aspects, which was the municipality's lowest scoring areas, and areas as directed by the CRR for the individual WWTW to reduce any possible risks associated with the WWTW and to improve the overall management and control of the WWTW.

Aims of the Wastewater Risk Abatement Plan (W$_2$RAP)

The primary objectives of a Wastewater Risk Abatement Plan (W$_2$RAP) are:

- To minimize contamination of the resource to which the treated effluent is returned to
- To reduce or remove contamination through the treatment processes, and
- To prevent contamination during transport of wastewater, storage and disposal of sludge.

The intended consequences of these objectives have direct bearing on safeguarding public health and environmental integrity. The objectives are equally applicable to large wastewater treatment plants, as well as smaller wastewater treatment systems, and are achieved through:

- development of an understanding of the specific system and its capability to treat wastewater and release treated effluent that meets health-based and environmental targets;
- identification of potential sources of contamination and how they can be controlled;
- validation of control measures employed to control hazards;
- implementation of a system for monitoring the control measures within the wastewater treatment system;
- timely corrective actions to ensure that returned effluent is to standard and sludge have been disposed of safely; and
- undertake verification of effluent quality to ensure that the W$_2$RAP is being implemented correctly and is achieving the performance required to meet relevant national, regional and local waste quality standards or objectives.

For the W$_2$RAP to be relied on for controlling the hazards and hazardous events for which it was set in place, it needs to be supported by accurate and reliable technical information. This process of obtaining evidence that the W$_2$RAP is effective is known as validation. Such information could be obtained from relevant industry bodies, from partnering and benchmarking with larger authorities (to optimize resource sharing), from scientific and technical literature and from expert judgement.

Validation normally includes more extensive and intensive monitoring than routine operational monitoring, in order to determine whether system units are performing as assumed in the system assessment. This process often leads to improvements in operating performance through the identification of the most effective and robust operating modes. Additional benefits of the validation process may include identification of more suitable operational monitoring parameters for unit performance.

Verification of treated effluent quality provides an indication of the overall performance of the treatment system and the ultimate quality of the effluent being released into the receiving environment. This incorporates monitoring of final effluent quality as well as assessment of the impact on the receiving environment.

Methodology

The specific objectives to be achieved within the overall purpose of drafting the W_2RAP for the Koringberg drainage network and WWTW were as follows:

- To ensure that the W_2RAP approach fits in with the way Swartland Municipality is organized and operates, in order to ensure that the W_2RAP is accepted within the Municipality.
- Continue to work with the qualified and dedicated W_2RAP team, responsible for developing, implementing and maintaining of the W_2RAP as a core part of their day-to-day roles.
- Detailed up-to-date descriptions of the collection, treatment and disposal systems, including a flow diagram for the Koringberg WWTW.
- List of all the hazards and hazardous events that could result in the wastewater treatment being, or becoming compromised or interrupted. An assessment of the risks expressed in an interpretable and comparable manner, such that more significant risks are clearly distinguished from less significant risks.
- Identification of the existing controls that are in place and a validation of the effectiveness of these controls. Identification and prioritization of insufficiently controlled risks.
- An improvement plan to address all uncontrolled and prioritized risks. The plan will indicate who is responsible for the improvements, together with an appropriate time frame for implementation of the controls.
- Assessment of the performance of the existing control measures, with a list of the short and long term monitoring requirements and corrective actions necessary when targets are not met (Verification monitoring included).
- Clear management procedures documenting actions to be taken when the system is operating under normal conditions and when the system is operating in ‘incident’ situations (corrective actions).

The effective management of a wastewater treatment system is strongly supported by the comprehensive understanding of the existing treatment system and infrastructure, the type and magnitude of hazards and risks, the knowledge of how to manage the hazards and risks, and good communication between all role players. The methodology applied to compile the W_2RAP for the Koringberg drainage network and WWTW consisted of the following three phases:

- ***System Assessment*** – Continue to work with the W_2RAP team. A comprehensive review and description of existing infrastructure and the treatment system was performed. This enable the W_2RAP team to determine whether the wastewater treatment as a whole can deliver effluent of a quality that meets health-based and environmental targets.
- ***Risk Assessment*** - Identification of hazards and the determination of the associated risk. The impact of each of the hazards or hazardous events were characterised by assessing the severity of the likely health outcome and the probability of occurrence. A risk is the likelihood of the identified hazard/s causing harm to exposed populations in a specified timeframe including the magnitude of that harm and / or the consequences.

The following hazard assessment matrix was used to score the existing risks associated with the management of collection, treatment and disposal of wastewater in order to establish priorities.

Table 1.1.1: Hazard assessment matrix used to score existing risks			
Likelihood	**Rating**	**Consequence**	**Rating**
Almost certain (Once a day or permanent feature)	1	Catastrophic (Death expected from exposure / environmental damage)	100
Likely (Once per week)	0.8	Major (Population exposed to significant illness / environmental concerns)	70
Moderately likely (Once per month)	0.5	Moderate (Large impact on treatment processes)	20
Unlikely (Once per year)	0.2	Minor (Small impact on treatment processes)	2
Rare (1 in 5 years)	0.1	Insignificant (No impact)	1

The table below gives an overview of the risk profile based on the score calculated from the risk assessment matrix.

Table 1.1.2: Overview of the risk profile based on the score calculated from the risk assessment matrix	
Score	**Risk Profile**
0 – 9	**Low:** These are systems that operate with minor deficiencies. Usually the systems meet the required effluent standards, as stipulated in the authorisations.
10 – 49	**Medium:** These are systems with deficiencies which individually or combined pose a high risk to human health and the environment. These systems would not generally require immediate action but the deficiencies could be more easily corrected to avoid future problems.
50 – 100	**High:** These are systems with major deficiencies which individually combined pose a high risk to the environment and potential human health. Once systems are classified under this category, immediate corrective action is required to minimize or eliminate efficiencies.

Likelihood is determined by "how often" or "how likely" a hazard or a hazardous event occurs. It should take into account hazards that have occurred in the past and their likelihood of re-occurrence and must also predict the likelihood of hazards and events that have not occurred to date.

Consequence looks at the severity of the results of the hazard / hazardous event and the seriousness or intensity of the impact of the hazard.

Risk Rating = Likelihood × Consequence

		Consequence					Risk Keys	
Risk Matrix							I	Institutional
							O	Operation
							M	Maintenance
		1	2	20	70	100	SW	Safety & Worker Protection
Likelihood	0.1	0.1	0.2	2	7	10	S	Source
	0.2	0.2	0.4	4	14	20	C	Collection
	0.5	0.5	1	10	35	50	T	Treatment
	0.8	0.8	1.6	16	56	80	SD	Sludge Disposal
	1	1	2	20	70	100	D	Discharge

- ***Risk Management*** - Establishment of control measures through operational monitoring, management procedures (corrective actions, emergency protocol, etc.) documentation and communication through management levels. Supporting programs, validation and verification of control measures.

Flow diagram of the summary methodology that was followed:

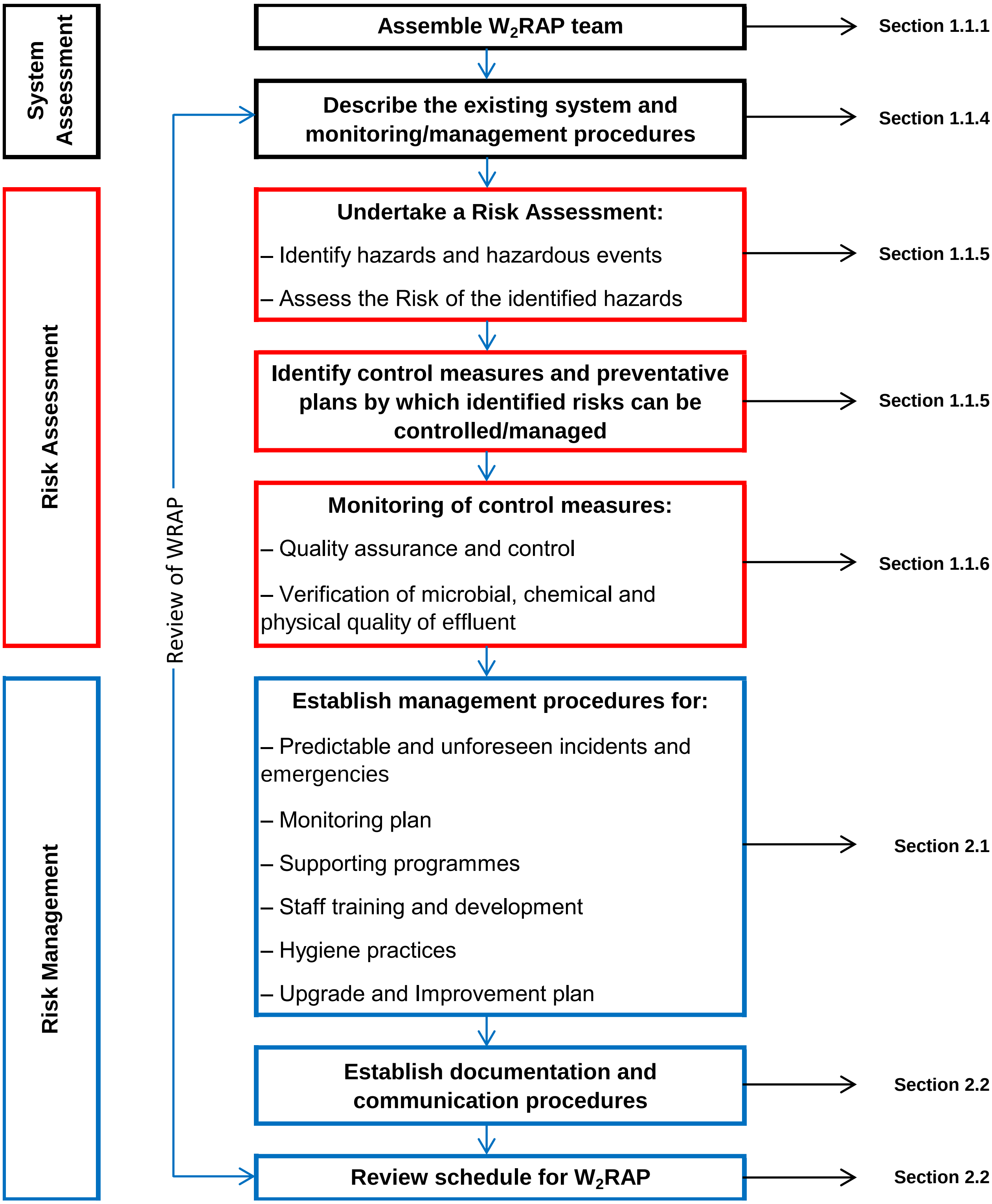

Figure 1: W_2RAP Process Flow Diagram

The detailed process, approach and methodology followed by Swartland Municipality for compiling the W_2RAP for the Koringberg drainage network and WWTW included the following:

Table 1.1.3:Detailed Approach and Methodology followed for compiling the W_2RAP

Process	Approach and Methodology
System Assessment	
Assemble the W_2RAP Team	
Continue to work with the W_2RAP Team and the External Stakeholders	• A team of individuals was identified by Swartland Municipality and from a wider group of stakeholders, with the collective responsibility for understanding the wastewater treatment system and identifying hazards that can affect the effluent quality and public health and environmental integrity throughout the wastewater collection, drainage, treatment and final effluent disposal.
Arrange and introduction session with the W_2RAP Team	• A meeting was set up with the W_2RAP Team to discuss the process that will be followed and to work through the various tasks with the Team. • An agreement was reached on the W_2RAP approach to be implemented and the methodology that will be used, particularly in assessing the risks. • The roles and responsibilities of the individuals on the W_2RAP team was defined and recorded.
Detailed descriptions of the Wastewater Treatment Systems	
Compiled detailed descriptions for each of the wastewater treatment systems	A description was given for each of the wastewater collection and treatment systems, which included the following: • Description of catchment and drainage area; • Land use in the catchment, drainage / discharge points; • Collection and reticulation (including tankers for septic tanks and small bore systems; • The treatment facility (plant history, general description, process description, process detail and specifications, revised design capacity, plans to upgrade and facilities to become redundant); • Flow figures, influent quantity and quality; • Final disposal; and re-use of final effluent; • Relevant effluent water quality standards; • Availability of trained staff; • How well existing procedures are documented; and • Detailed flow diagrams were compiled for each of the wastewater treatment systems.

Risk Assessment	
Identify hazards and hazardous events and assess the risks	
Identify all potential biological, physical and chemical hazards.	• A list of the potential biological, physical and chemical hazards for each of the steps in the validated process flow diagrams was identified.
Identify all hazards and hazardous events that could result in the wastewater treatment being, or becoming, compromised or interrupted or hazards which will result in a natural resource to become contaminated with raw sewage.	• All the hazards and hazardous events were identified and a list was compiled for each of the WWTWs.
Evaluate the risks identified at each point in the flow diagrams previously prepared.	• All potential hazardous events and associated hazards were recorded systematically, together with an estimation of the magnitude of risk in table format for each of the WWTWs (Matrix Approach)
Liaise with the W_2RAP team regarding the risk assessment	• The list of hazards and hazardous events were worked through with the W_2RAP Team in order to agree on the magnitude of the risks.
Determine and validate control measures, reassess and prioritize the risks	
Identify existing and potential control measures	• Liaised with the Municipality in order to determine the existing control measures for each of the identified hazards and hazardous events.
Validate the effectiveness of the controls	• The effectiveness of the existing control measures was validated.

Risk Management	
Define monitoring of the control measures	
Assessment of the performance of control measures at appropriate time intervals.	• Control measures were defined and monitoring of control measures was defined. Actions were documented in the Management Procedures.
Compile a list of short and long term monitoring requirements and corrective actions (Operational monitoring)	• A list of short and long term monitoring requirements and corrective actions necessary when operational targets that are not met was compiled (Operational monitoring).
Improvement / Upgrade Plan	
The short-, medium- or long term mitigation or controls for each significant uncontrolled risk were identified. The W_2RAP Team identified who is responsible for the improvements, together with an appropriate time frame for implementation of these controls.	
A list of the verification monitoring activities, linked to the operational monitoring activities, was compiled.	
Prepare Management Procedures (Incident Management Protocols)	
Compile management procedures for normal and incident / emergency conditions	• The existing procedures were evaluated and the proposed control procedures, that will be effective within the set-up of the WWTWs, were worked through. • Management procedures were compiled for areas with inadequate control, which include Response Actions; Operational monitoring; Responsibilities of the Municipality and other stakeholders; Communication protocols and strategies, Responsibilities for co-ordinating measures to be taken in an emergency; A communication plan, A programme to review and revise documentation.

1.1.1 Wastewater Risk Abatement Plan Team

The project team responsible for assembling a W_2RAP must be a multi-disciplinary team consisting of individuals from various sectors involved in the management of the water catchment, wastewater and the environment. The team must have a thorough understanding of the particular wastewater treatment systems, the catchment and receiving environment, and the risks involved with wastewater.

The success of the W_2RAP will be dependent on the success of its implementation. It is therefore essential to allocate accountability and responsibilities to the persons involved with the management with the collection, treatment and final disposal of wastewater.

Swartland Municipality applied a collaborative, multi-stakeholder approach in establishing the W_2RAP team. The W_2RAP team consists of Senior Management and Process Controllers from Swartland Municipality, DWS's representatives and WorleyParsons. The table below gives an overview of the various W_2RAP Team members.

Table 1.1.1.1: Overview of the various W_2RAP Team members	
National Government	**Provincial Government**
• DWS: Waste Water Quality Management:	• DWS: Natasha Davis
Local Government	**External Role-players**
• Swartland Municipality › Senior Management Support: Louis Zikmann (Director) › W_2RAP Team Leader: Esmari Steenkamp (Civil Engineer Trade Services) › **Wastewater Treatment Services** › Supervisor: DF Malan (Class V) › Process Controllers: › Malmesbury WWTW: H. Strydom (Class V) › Malmesbury WWTW: W Barendse (Class III) › Malmesbury WWTW: R Jenneke (Class II) › Darling WWTW: E Basson (Class III) › Riebeek Valley WWTW: W. M. Maarman (Class V) › Moorreesburg WWTW: E. P. Alexander (Class III)	• Proto Berg-Olifants CMA: • Consultant WorleyParsons: Jaco Human

The team was compiled during the first meeting that was held on the 14th of September 2016 in Malmesbury. The W_2RAP process / approach to be followed and the various tasks were worked through with the team during this meeting. The roles and responsibilities of the individuals on the team were also defined and recorded. **The Agenda, attendance register and presentation used at the meeting are included in Annexure A. The following additional information was handed out to the W_2RAP team on the 14th of September 2016 in order to support and guide the risk identification process and to assist with the potential impact of each hazard or hazardous event.**

- **Hazard assessment matrix** that will be used to score the existing risks associated with the management of collection, treatment and disposal of wastewater in order to establish priorities, as well as the **risk profile** based on the score calculated from the risk assessment matrix.

- **Condition of Sewerage Assets**: Summary of the current and depreciated replacement costs of the water and sewerage infrastructure (CRC, DRC, Remaining Useful Life and Age Distribution).

- **Recommendations from October 2014 WWTW Process Audits**.

- Five year summary of **final effluent compliance percentages** per parameter (Average, Minimum and Maximum).

- **Questionnaire for Process Controllers**, which include the design capacities of the WWTWs and the current flows, risk identification table, operational sampling currently implemented at the WWTW and control forms that are in place to ensure proper process control.

1.1.2 Authorisation for implementation of Wastewater Risk Abatement Plan

Swartland Municipality is committed to implement the updated W_2RAP. The table below indicates the commitment by the Political and Administrative officials of Swartland Municipality for the implementation of the updated W_2RAP.

Table 1.1.2.1: Commitment from Political and Administrative officials for implementation of the W2RAP

Position	Name	Signature	Date
Mayor	Tijmen van Essen		
Municipal Manager	Joggie Scholtz		
Chief Financial Officer	Mark Bolton		
Director Civil Engineering Services	Louis Zikmann		
Manager Trade Services	Esmari Steenkamp		

- We recognise the value of the W_2RAP process and all the necessary required aspects (e.g. Incident Management Protocols, Monitoring Programmes, Support Documentation, etc.) as a viable mechanism to continue to improve wastewater performance in the Swartland Municipality.

- We undertake to support and mobilise the necessary resources to implement the W_2RAP in a phased approach, giving attention to the critical and high risk areas in the short term and working towards abating the medium to lower risk areas in the longer term.

- We further commit to monitor and track progress on a regular basis and assign clear responsibilities to the person/s responsible for the implementation of the Koringberg wastewater system. The wastewater system presents valuable KPAs to ensure that the Municipality's functionality aligns and share the common strategic objectives, as outlined in Swartland Municipality's Vision and Mission Statements.

1.1.3 Implementation of the previous Wastewater Risk Abatement Plan

Improved risk-based performance on a year-to-year basis indicates the successful implementation of the W_2RAP (Improvement / Upgrade Plan) and the recommendations from the Process Audits. It can be monitored through the CRR ratings, the effluent quality compliance and the risk scores. The DWS's CRR ratings for the Koringberg WWTW are summarised in the table below:

Table 1.1.3.1: DWS's CRR ratings for the Koringberg WWTW				
2011	**2012**	**2013**	**2014**	**Trend**
55.6%	41.2%	52.9%	76.5%	Increase

The final effluent quality compliance percentages per parameter, for the last five financial years, are summarised in Table 1.1.4.3.2. The previous W_2RAP of Swartland Municipality included the following medium and high risks and risk scores and proposed control measures for addressing these risks. Swartland Municipality's current progress with regard to the implementation of the previous proposed control measures is summarised in the table below, which also includes the previous identified risks and risk scores.

Table 1.1.3.2: Progress with regard to the implementation of the previous W_2RAP Improvement / Upgrade Plan			
Existing Medium and High Risks	**Risk Ratings**	**Control Measures**	**Comments on implementation of the proposed Control Measures**
Wastewater Source, Collection and Drainage Systems			
-	-	-	-
Wastewater Treatment			
Flow and load variations that exceed the design limits	56	Investigate upgrading options. Appoint consulting engineers: Include in the following year's capital budget	Still to be budgeted for.
Sludge Management and Disposal			
-	-	-	-
Effluent Returned to Catchment, Reclamation and Re-use			
-	-	-	-
Facility Safety and Worker Protection			
-	-	-	-

Swartland Municipality's historical sewerage capital expenditure in Koringberg is summarised in the table below.

Table 1.1.3.3: Historical sewerage capital expenditure of projects implemented in Koringberg					
Project	**2012/2013 Audited**	**2013/2014 Audited**	**2014/2015 Audited**	**2015/2016 Audited**	**2016/2017 Actual Expenditure**
Sewerage Koringberg	R208 264	-	-	-	-
Equipment: Sewerage Telemetry (Mun)	-	R42 458	R45 357	R49 963	R21 563
Equipment: Sewerage (Mun)	-	R27 146	R29 000	R17 559	R18 550

1.1.4 Description of Existing Wastewater Treatment Systems

Factors for consideration during the documentation and description of the drainage systems include the following:

Table 1.1.4.1: Factors to consider during the documentation and description of the drainage systems	
Area	**Factors for consideration**
Catchment / Drainage Area	• Average Dry Weather Flow and Peak Wet Weather Flow to treatment plant • Maps and catchment layout plans • Water quality objectives of the receiving water resource • Restrictions on effluent quality limits within the catchment

Table 1.1.4.1: Factors to consider during the documentation and description of the drainage systems	
Area	**Factors for consideration**
Collection and Reticulation	• Gravity and pump systems • Age, capacity and condition of main collectors and pumping mains • Industrial / domestic sources
Treatment Facility	• Capacity and plant classification • Age, upgrade history • Technology, process units • Sludge management • Authorisation and legal requirements • Plans to upgrade – short to long term • Facilities to become redundant • Buildings, structures and landscaping
Influent quantity and quality	• Typical inflow • Typical outflow
Receiving environment and end users	• Discharge to water body • Reuse of reclamation (including irrigation)

1.1.4.1 Catchment Collection and Reticulation

Catchment: The relative importance and ranking of the 36 quaternary catchments in the former Berg River Catchment are summarised in the table below (*Prioritising quaternary catchments for invasive alien plant control within the fynbos and karoo biomes of the Western Cape Province, CSIR Report No. CSIR/NRE/ECO/EF/2009/0094/B*):

Table 1.1.4.1.1: Summary of relative importance and ranking of the quaternary catchments in the former Berg Catchment				
Quaternary Catchment	**Relative importance**	**Position of Swartland Municipality's WWTWs (Sanitation Service Levels in Towns)**	**Criteria – Weighting assigned (%)**	
G10B	0.091		State land	30.7%
G10G	0.081		Other land	10.2%
G22A	0.066		Water stressed catchments	13.9%
G22F	0.062		Highest water yielding catchments	4.9%
G10A	0.055		Maintain functioning of rivers	1.5%
G22B	0.054		Restore functioning or rivers	1.4%
G22J	0.039		Proportion of the catchment available	
G10E	0.036		for invasion	12.5%
G22K	0.034		Potential invasion by priority species	5.0%
G10C	0.029		Current invasion by priority species	2.1%
G10D	0.027		Alignment with conservation corridors	3.6%
G21A	0.027		Conservation status of rivers	3.0%
G21B	0.027		Conservation status of vegetation types	2.3%
G22H	0.025		Legal status of protected areas	0.8%
G10F	0.023	Riebeek Valley WWTW (Waterborne and conservancy / septic tanks)	Proportion of area protected	0.6%
G10M	0.021		Risk of fire induced erosion	4.5%
G10K	0.019	**Koringberg WWTW (Waterborne and conservancy / septic tanks)**	Proportion of area protected	3.0%
G30B	0.019			
G30C	0.019			
G21D	0.017	Malmesbury WWTW (Waterborne), Kalbaskraal WWTW (Waterborne and conservancy / septic tanks), Chatsworth WWTW (Waterborne and conservancy / septic tanks)		
G22D	0.017			
G22G	0.017			

Table 1.1.4.1.1: Summary of relative importance and ranking of the quaternary catchments in the former Berg Catchment			
Quaternary Catchment	**Relative importance**	**Position of Swartland Municipality's WWTWs (Sanitation Service Levels in Towns)**	**Criteria – Weighting assigned (%)**
G30D	0.017		
G30F	0.017		
G10J	0.016	Moorreesburg WWTW (Waterborne with a small number of conservancy / septic tanks)	
G10H	0.015		
G30E	0.015		
G30G	0.015		
G30H	0.014		
G10L	0.013	Darling WWTW (Waterborne with a small number of conservancy / septic tanks and tankers from Yzerfontein)	
G21F	0.013		
G22C	0.013		
G22E	0.013		
G30A	0.013		
G21E	0.010		
G21C	0.009		

The final consolidated model used for weighting criteria and sub-criteria for the fynbos, succulent and Nama karoo biomes occurring in the quaternary catchments of the Western Cape, as included in the previous table, was as follows:

- Improve the integrity of the water resource (L:.223)
  - Maintain the integrity of the river system (L:.073)
    - Rivers (L:.750)
    - Azonal ecosystems & wetlands (L:.250)
  - Highest yielding catchment (L:.205)
  - Water stressed catchments (demand) (L:.722)

- Value the catchment for biodiversity (L:.104)
  - Conservation status of rivers (L:.750)
  - Conservation status of vegetation type (L:.250)

- Potential veld utilisation (L:.037)
  - Flower harvesting (fynbos) (L:.333)
  - Other harvestable products (Karoo) (L:.333)
  - Grazing (Karoo, renosterveld & grassland) (L:.333)

- Capacity to maintain the gains (L:.424)
  - State: protected areas (L:.750)
  - Other (L:.250)

- Potential to spread (L:.173)
  - Current invasion by priority species (L:.105)
  - Proportion of the catchment available for invasion (L:.637)
  - Potential invasion by priority species (L:.258)

- Poverty relief (L:.038)

The Expert Choice software (Anon 2002) requires the weights of alternatives (quaternary catchments in this case) to be expressed as proportions that sum to one. For each of the criteria and sub-criteria used by the AHP model listed above the sum of the value for the corresponding variable for each quaternary catchment was calculated. Each quaternary catchment's value was then divided by the corresponding total to give the final weight.

Collection and Reticulation: Only the erven towards the north of Koringberg are connected to the waterborne sewer system. The other erven are serviced through conservancy / septic tanks. There are no sewer pump stations in Koringberg and all sewage from the waterborne sewer system flows under gravity to the oxidation pond system. The table below gives an overview of the sanitation indicators monitored by Swartland Municipality for Koringberg.

Table 1.1.4.1.2: Sanitation indicators monitored by Swartland Municipality for Koringberg

Service	Indicator	2013/2014	2014/2015	2015/2016	2016/2017
Sewer blockages	Repair blockages on main sewer pipelines up to connection points	9	18	30	15
Septic tanks	Empty septic tanks	307	319	287	358
Investigate sewer reticulation network	Investigate and clear blockages in network	5	6	2	3
Other	Other sewer complaints (Not specified)	-	2	-	1
Sewer spillage	Investigate and clean sewer spillages	-	-	-	-
Pipeline sewer	Installation of sewer pipelines or repair of pipelines	-	-	-	-
Sewer Connections	Installation of sewer connections	-	-	-	-
Sewer effluent	Investigate effluent distribution for irrigation purposes	-	-	-	-
Investigate sewer reticulation pump stations	Work carried out at sewer pump stations	-	-	-	-

There are no industrial consumers in Koringberg. **The existing water reticulation networks and sewer drainage networks in Koringberg are indicated on the Aerial Photo included in Annexure A.**

1.1.4.2 Wastewater Treatment Works

1.1.4.2.1 Description of the Wastewater Treatment Works

Figure 2: Aerial photo of the Koringberg WWTW

The WWTW is an oxidation pond system with unlined ponds, with an estimated treatment capacity of 0.030 Ml/d. The WWTW includes two primary oxidation ponds and three secondary ponds. There is no re-use of treated effluent. Treated effluent is returned into a local stream (Brak River).

1.1.4.2.2 General and Treatment Process Description of Wastewater Treatment Works

The position of the WWTW, the type of WWTW, the treatment processes and the type of incoming raw sewerage are summarised in the table below:

Table 1.1.4.2.2.1: Position of the WWTW, the type of WWTW and the type of incoming raw sewerage to the WWTW			
Longitude	Latitude	Type of Plant	Type of Sewerage
33º0'39.333"	18º40'46.276"	Oxidation Ponds	Residential and limited commercial

The treatment processes at the Koringberg WWTW are summarised in the table below:

Table 1.1.4.2.2.2: Treatment and unit treatment processes at the Koringberg WWTW
• Primary Ponds (Two) The dimensions of the first and second primary ponds are 30m x 30m and 12m x 30m, respectively. At an aerobic pond depth of 1.5m, this represents retention times of 45 days and 18 days respectively at design flow. At current flows of $90m^3/d$, this is reduced to 15 days and 6 days.
• Secondary Ponds (Three) The three secondary ponds each has a surface area of $180m^2$ (6m x 30m). The retention time of each pond is thus 9 days, or a total of 27 days.

Inlet at Primary Pond

Primary Pond No.1

Primary Pond No.2

Secondary Ponds

Overflow from last secondary pond

1.1.4.2.3 Treatment Process Flow Diagrams

The assessment and evaluation of a wastewater treatment system are enhanced through the development of a flow diagram. Diagrams provide an overview description of the wastewater treatment system, including characterization of the type of wastewater to be received, treatment processes, storage and effluent disposal distribution infrastructure and measures for resource and environmental protection. It is essential that the representation of the wastewater treatment system is conceptually accurate. If the flow diagram is not correct, it is possible to overlook potential hazards that may be significant. To ensure accuracy, the flow diagram should be validated by visually checking the diagram against features observed on the ground.

Data on the occurrence of pathogens and chemicals in the treated effluent, combined with information concerning the effectiveness of existing controls, enable an assessment of whether health-based and environmental targets can be achieved with the existing infrastructure.

They also assist in identifying catchment management measures, treatment processes and system operating conditions that would reasonably be expected to achieve those targets if improvements are required.

The flow diagram for the Koringberg WWTW is included in Annexure A.

1.1.4.2.4 Plans for Upgrading of the WWTW

The Municipality is not planning to upgrade the Koringberg WWTW in the nearby future and the approved 2017/2018 Capital Budget of Swartland Municipality does not include any projects for the Koringberg WWTW for the next three years.

Table 1.1.4.2.4.1: Capital projects for Koringberg included in the approved 2017/2018 Capital Budget			
Project	**2017/2018**	**2018/2019**	**2019/2020**
No projects for Koringberg	-	-	-

The table below gives an overview of the recommendations from the detail WWTW Process Audit, which was completed during October 2014.

Table 1.1.4.2.4.2: Recommendations from Koringberg WWTW Process Audit (October 2014)
Design Aspects
• It was mentioned in the previous audit report that the hydraulic loading on the ponds are three times the design capacity, thus resulting in poor COD reduction to within the standards for disposal by irrigation. For this reason additional upgrading of the ponds should be expedited.
Operational Aspects
• Due to the high TDS of the final effluent, the SAR should also be determined to ensure that the soil where the water is irrigated is not adversely affected. • The following are recommended as routine tasks for Koringberg:

Table 1.1.4.2.4.2: Recommendations from Koringberg WWTW Process Audit (October 2014)
➢ Removing of grass and vegetation that grows on the embankment to prevent it from falling into the pond and generating the formation of mosquito breeding habitats. ➢ Removal of floating scum and macrophytes to prevent fly and mosquito breeding. ➢ Removal of any accumulated solids in the ponds' inlets and outlets. ➢ Repair of any damage to the embankments caused by rodents or other animals. ➢ Repair of any damage to external fences and gates or points of access to the system. The operator responsible should register these activities in a pond maintenance record sheet. Regular servicing and maintenance of the mechanical and electrical equipment and instrumentation is of paramount importance and must be carried out in accordance with manuals supplied by the equipment suppliers. All damaged or defective equipment must be reported to the Senior Process Controller immediately and must be repaired or replaced as soon as possible. • Hand tools are required for maintaining the pond embankments, overflows and the site in general. • Embankments should be inspected regularly for erosion due to wind, wave action, surface run-off, or burrowing animals. Any necessary repairs to the embankments must be made immediately after the damage occurs. • Operators on the works must know what is expected of them in terms of performance and related tasks.
Overall Conclusions
• Koringberg is a small treatment system, but the flow is already exceeding the design capacity by about three times. Extensions and upgrading is already in planning and will provide more retention in the ponds for the biological oxidation processes.

1.1.4.2.5 Management of the Wastewater Treatment Works

Supervision and required skills levels

The current classification of the Koringberg WWTW, the current classification of the Process Controllers and Supervisors at the WWTW and the minimum required class of Process Controller per shift and Supervision requirements are summarised in the table below.

Table 1.1.4.2.5.1: Classification of the Koringberg WWTW and the required number of Process Controllers and the existing employed Process Controllers at the plant (Regulation 17)

Class	Shifts at the WWTW	Requirements according to Classification	Currently Employed (Class)
E	08:00 – 17:00	Class I Process Controller per shift	No full-time operator on site, but there is an official in attendance at the adjacent solid waste transfer station.
		Class V Process Controller for Supervision	DF Malan (Class V)

Operational and Maintenance support personnel must be available at all times, but may be in-house or outsourced (Electrician, fitter and instrumentation technician). The Supervisor for Class C – E works does not have to be at the works at all the times, but must be available at all times.

The Maintenance Team mainly performs their own repair and preventative maintenance work to the equipment and infrastructure of the Municipality, except when specialised repair work is required, in which case the work is sub-contracted to approved sub-contractors on the municipal database.

The current number of Process Controllers does not comply with the Regulation 17 requirements and the following proposed actions are recommended.

- The current number of shifts need to be increased or the necessary control measures need to be put in place in order to ensure proper process control during periods when there is no Process Controllers at the plant.
- Provide appropriate training in order for the current official to be registered as Class I Process Controller.

- Investigate as per approved organogram the appointment of the appropriate Class I Process Controllers.

Operation and Maintenance Check Sheets for Process Controllers / Operators

There are no existing control sheets in place for the Koringberg WWTW and new control, inspection, maintenance and incident sheets were therefore developed for the Koringberg WWTW as part of the W_2RAP process. It is important for Swartland Municipality to ensure that these sheets are used by the Process Controllers at the Koringberg WWTW. The newly developed sheets need to be signed-off by the Area Superintendent. The proposed control, inspection, maintenance and incident sheets are included in Table 2.2.2.1.

Management check sheet for the Manager / Supervisor

All the control, inspection, maintenance and incident sheets need to be signed-off by the Area Superintendent. The purpose of signing the control sheets is to control whether the routine operational tasks, checks and maintenance tasks are carried out by the process controllers / operators at the Koringberg WWTW.

1.1.4.3 Influent Quantity and Quality

The table below gives an overview of the estimated average, minimum and maximum incoming monthly flows at the Koringberg WWTW. The hydraulic design capacity of the Koringberg WWTW is 0.030 Ml/d.

Table 1.1.4.3.1: Average estimated monthly flows at the Koringberg WWTW

Year	Average Monthly Flow		Minimum Monthly Flow (Month)		Maximum Monthly Flow (Month)	
	Ml/d	% i.t.o. Design Capacity	Ml/d	% i.t.o. Design Capacity	Ml/d	% i.t.o. Design Capacity
2010/2011	0.089	296.7%	0.047 (Jul.)	156.7%	0.135 (Mar.)	450.0%
2011/2012	0.091	303.3%	0.046 (Sept.)	153.3%	0.151 (Mar.)	503.3%
2012/2013	0.088	293.3%	0.045 (Sept.)	150.0%	0.146 (Dec.)	486.7%
2013/2014	0.093	310.0%	0.039 (Sept.)	130.0%	0.172 (Febr.)	573.3%
2014/2015	0.113	376.7%	0.044 (Jul.)	146.7%	0.161 (Mar.)	536.7%
2015/2016	0.106	353.3%	0.061 (Aug.)	203.3%	0.185 (Jan.)	616.7%
2016/2017	0.098	326.7%	0.057 (Jul.)	190.0%	0.174 (Jan.)	580.0%

The incoming flow at the Koringberg WWTW is not metered and the average monthly flow was therefore estimated as a percentage of the billed metered consumption (70%).

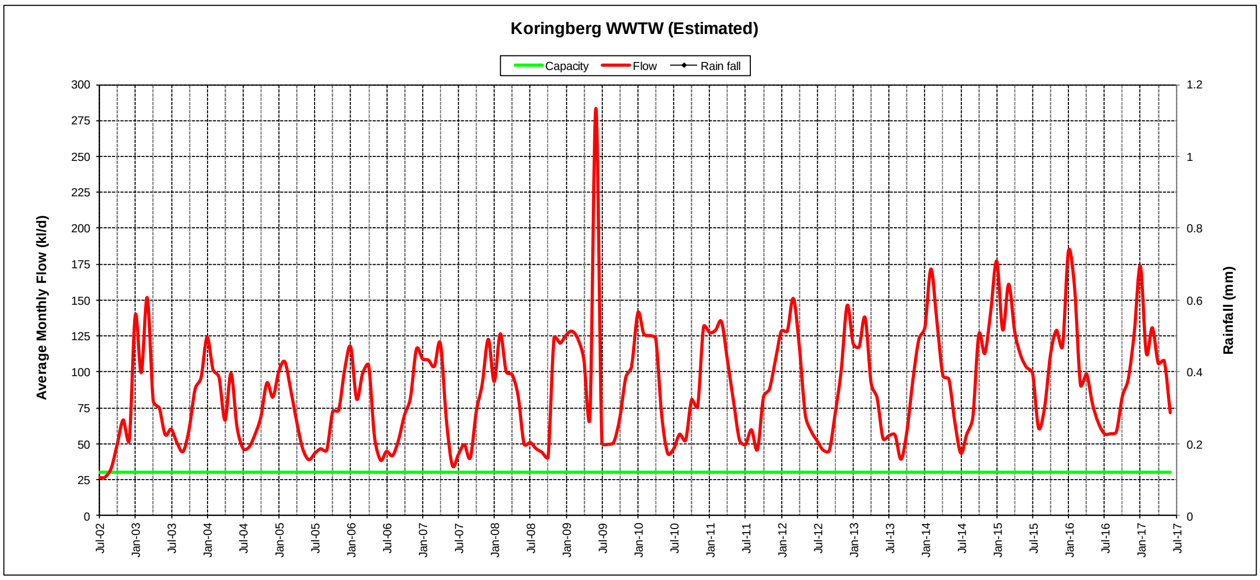

Figure 3: Estimated average monthly inflow at the Koringberg WWTW

The table and graphs below give an overview of the final effluent wastewater quality results for the Koringberg WWTW for the last four financial years, compared to the General Authorisation, General Limits.

Table 1.1.4.3.2: Final effluent wastewater quality compliance sample results						
Parameter	**General Limit**	**Year**	**Aver.**	**Min.**	**Max.**	**Compliance**
Microbiological						
Faecal Coliforms (org./100mL)	1 000 Max	2012/2013	1 451.2	0.0	2 419.0	8.3%
		2013/2014	1 920.7	5.0	2 419.0	16.7%
		2014/2015	2 204.8	534.0	2 419.0	8.3%
		2015/2016	2 217.8	4.0	2 419.0	8.3%
		2016/2017	2 199.1	0.0	2 419.0	16.7%
Chemical						
Ammonia (mg/L as N)	6.0	2012/2013	100.9	31.7	152.0	0.0%
		2013/2014	113.3	56.7	184.0	0.0%
		2014/2015	83.4	70.6	96.7	0.0%
		2015/2016	80.4	24.9	128.0	0.0%
		2016/2017	89.3	46.3	110.0	0.0%
Nitrates & Nitrites (mg/L as N)	15.0	2012/2013	5.3	0.3	15.8	91.7%
		2013/2014	2.6	0.3	14.7	100.0%
		2014/2015	0.5	0.3	0.7	100.0%
		2015/2016	0.4	0.4	0.7	100.0%
		2016/2017	0.6	0.4	2.9	100.0%
COD (mg/L)	75	2012/2013	747.8	433.0	1 029.0	0.0%
		2013/2014	521.3	110.0	1 241.0	0.0%
		2014/2015	667.8	347.0	854.0	0.0%
		2015/2016	579.3	364.0	961.0	0.0%
		2016/2017	787.6	328.0	3 192.0	0.0%
Orthophosphates (as P)	10	2012/2013	11.9	5.9	20.4	50.0%
		2013/2014	11.6	2.5	18.8	33.3%
		2014/2015	12.2	1.0	20.5	33.3%
		2015/2016	13.1	3.0	16.5	16.7%
		2016/2017	14.7	6.9	24.5	33.3%
Physical						
pH (at 25 °C)	5.5 – 9.5	2012/2013	7.5	7.0	7.9	100.0%
		2013/2014	7.2	6.8	7.7	100.0%

Table 1.1.4.3.2: Final effluent wastewater quality compliance sample results						
Parameter	**General Limit**	**Year**	**Aver.**	**Min.**	**Max.**	**Compliance**
		2014/2015	7.1	6.5	7.3	100.0%
		2015/2016	7.3	7.0	7.9	100.0%
		2016/2017	7.1	6.9	7.7	100.0%
Electrical Conductivity (at 25 °C)	150 (F+70)	2012/2013	219.9	177.0	268.0	0.0%
		2013/2014	215.3	177.0	268.0	0.0%
		2014/2015	214.8	169.0	250.0	0.0%
		2015/2016	188.5	0.2	285.0	16.7%
		2016/2017	247.3	184.0	450.0	0.0%
Total Suspended Solids (mg/L)	25	2012/2013	132.7	45.0	424.0	0.0%
		2013/2014	209.5	37.0	726.0	0.0%
		2014/2015	377.1	112.0	668.0	0.0%
		2015/2016	400.4	22.0	1 400.0	8.3%
		2016/2017	723.4	260.0	2 248.0	0.0%

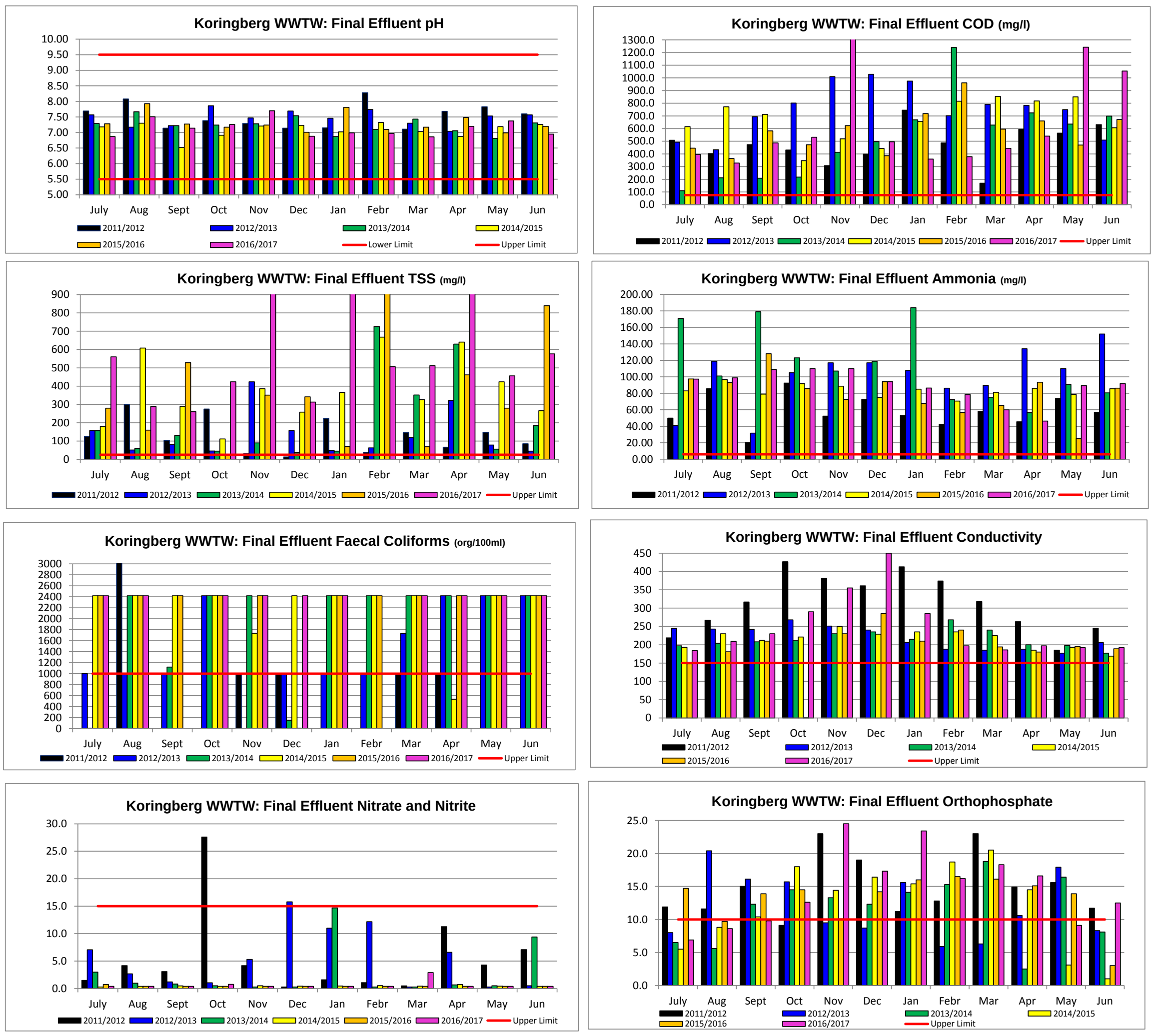

Figure 4: Final effluent wastewater quality results and compliance with the General Limits for the Koringberg WWTW

1.1.4.4 Receiving Environment and Quality

The table below gives an overview of the current re-use practices and the legal requirements with regard to the discharge of treated effluent, at each of the WWTWs.

Table 1.1.4.4.1: Current re-use practices and the legal requirements with regard to the discharge of treated effluent

Current re-use practices	Discharge into Source	Legal Requirement (Authorisation)
No re-use practices	Treated effluent returned into a local stream (Brak River)	General Authorisation 28/08/2014 (General Limits). Discharge up to 180m³/day into a small tributary of the Brak River

WWTWs normally receives a General Authorisation in terms of the Water Act of 1998 from the DWS that allows for the discharge of the final effluent from the WWTWs to be irrigated on suitable land (Full details of the land topography, vegetation, soil types and characteristics and rainfall patterns are required by the Department during the application for the General Authorisation), provided that the volume of final effluent discharge does not exceed 500 m³ per day (0.5 Ml/d). Chemical and microbiological water quality limits are provided with which the final effluent needs to comply, in terms of the General Authorisation.

The treated effluent discharged from the Koringberg WWTW is currently monitored against the General Standards for the disposal of treated effluent. The Wastewater limit values applicable to the discharge of wastewater into a water resource, as per the General Authorisation (Section 39 of the National Water Act no 36 of 1998) are summarised in the table below.

Table 1.1.4.4.2: Wastewater limit values applicable to the discharge of wastewater into a water resource.

Parameter	General Limit	Special Limit
Faecal Coliforms (cfu / per 100ml)	1 000	0
Chemical Oxygen Demand – COD (mg/l)	75 (After removal of algae)	30 (After removal of algae)
pH	5.5 – 9.5	5.5 – 7.5
Ammonia as Nitrogen (mg/l)	6	2
Nitrate / Nitrite as Nitrogen (mg/l)	15	1.5
Chlorine as Free Chlorine (mg/l)	0.25	0
Suspended Solids (mg/l)	25	10
Electrical Conductivity (mS/m)	70 mS/m above intake to a maximum of 150 mS/m	50 mS/m above background receiving water, to a maximum of 100 mS/m
Ortho-Phosphate as phosphorous (mg/l)	10	1 (median) and 2.5 (maximum)
Fluoride (mg/l)	1	1
Soap, oil or grease (mg/l)	2.5	0
Dissolved Arsenic (mg/l)	0.02	0.01
Dissolved Cadmium (mg/l)	0.005	0.001
Dissolved Chromium (VI) (mg/l)	0.05	0.02
Dissolved Copper (mg/l)	0.01	0.002
Dissolved Cyanide (mg/l)	0.02	0.01
Dissolved Iron (mg/l)	0.3	0.3
Dissolved Lead (mg/l)	0.01	0.006
Dissolved Manganese (mg/l)	0.1	0.1
Mercury and its compounds (mg/l)	0.005	0.001
Dissolved Selenium (mg/l)	0.02	0.02
Dissolved Zinc (mg/l)	0.1	0.04
Boron (mg/l)	1	0.5

The Department of Health's Guide for Permissible utilization and disposal of treated sewage effluent includes the following general remarks and precautions for the irrigation of treated sewage effluent.

- In order to obviate the irrigation system causing a nuisance in the course of time, evidence must be produced that the type of soil and the size of the surface as well as the type of plants are suitable for irrigation with the proposed quantity and quality of effluent.
- The piping used for effluent shall be markedly different from the piping used for drinking water in respect of colour, type of material and construction. This is necessary in order to obviate future accidental cross-coupling of piping.
- In order to prevent persons from unwittingly drinking effluent water or washing therewith the taps, valves and sprayers of the irrigation system shall be so designed that only authorized persons can open or bring them into operation.
- All water points where uninformed persons could possibly drink effluent water shall be provided with notices in clearly legible Afrikaans, English and appropriate Bantu languages, indicating that it is potentially dangerous to drink the water.
- Statements that an act may take place only after "proper draining and drying" of the irrigated area, mean that no drops or pools of the effluent shall be evident.
- All possible precautions should be taken to ensure that no surface and underground water is contaminated by the irrigation of water, especially where the latter does not comply with the General Standard. Excessive irrigation must therefore be avoided and the irrigation area protected against stormwater by contours and screening walls.
- Sprinkler irrigation shall only be permitted if no spray is blown over to adjoining areas where such irrigation is forbidden. In this connection the quality of the effluent, the use of the adjoining area and the distance thereof from the irrigation area shall be considered before sprinkler irrigation is permitted.

1.1.5 Risk Assessment

1.1.5.1 Hazards and Hazardous Events Identification

The success of each step in the treatment system (from production of wastewater to final disposal) is determined by possible events that could lead to an environmental health and safety risk and failure of the treatment process. A risk is the likelihood of the identified hazard / s causing harm to exposed populations in a specified timeframe including the magnitude of that harm and / or the consequences. This section of chapter 1.1.5 aims to identify the possible hazards that could result in an environmental health and safety risk and / or treatment failure. The source and type of hazards were identified and its risk and possible consequence were determined for each of the categories listed below:

- Institutional (I)
- Operation (O)
- Maintenance (M)
- Waste Water Source (S)
  - Domestic
  - Commercial Shops and Offices
  - Industrial (Factories, wineries, distilleries, abattoirs)
- Collection and Drainage (C)
  - Sewer drainage network
  - Sewer pump stations
- Facility Safety and Worker Protection (SW)

- WWTW (T)
  - General
  - Primary Treatment
  - Secondary Treatment
  - Tertiary Treatment
- Final Discharge of treated effluent (D)
- Sludge Disposal (SD)

The detail list of possible hazards for the Koringberg drainage system and WWTW that could result in an environmental health and safety risk and / or treatment failure is included in Annexure A.

1.1.5.2 Assessment of the Risks (Drainage system and WWTW)

Once the potential risks and its sources were identified, the impact of each of the hazards or hazardous events can be characterized / quantified by assessing the severity of the consequence and the probability of occurrence. Although there are numerous hazards that can compromise wastewater reticulation and treatment systems, not every hazard will require the same degree of attention. A risk is the likelihood of the identified hazard/s causing harm to exposed populations in a specified timeframe including the magnitude of that harm and / or the consequences.

The hazard assessment matrix as illustrated in Section 1.1 was used to score the existing risks in order to prioritise the risks. **The complete risk assessment and risk ratings are included in Annexure A.** The identified hazards with a residual risk score of "medium" or "high" for the Koringberg WWTW and drainage system are indicated on the graph below.

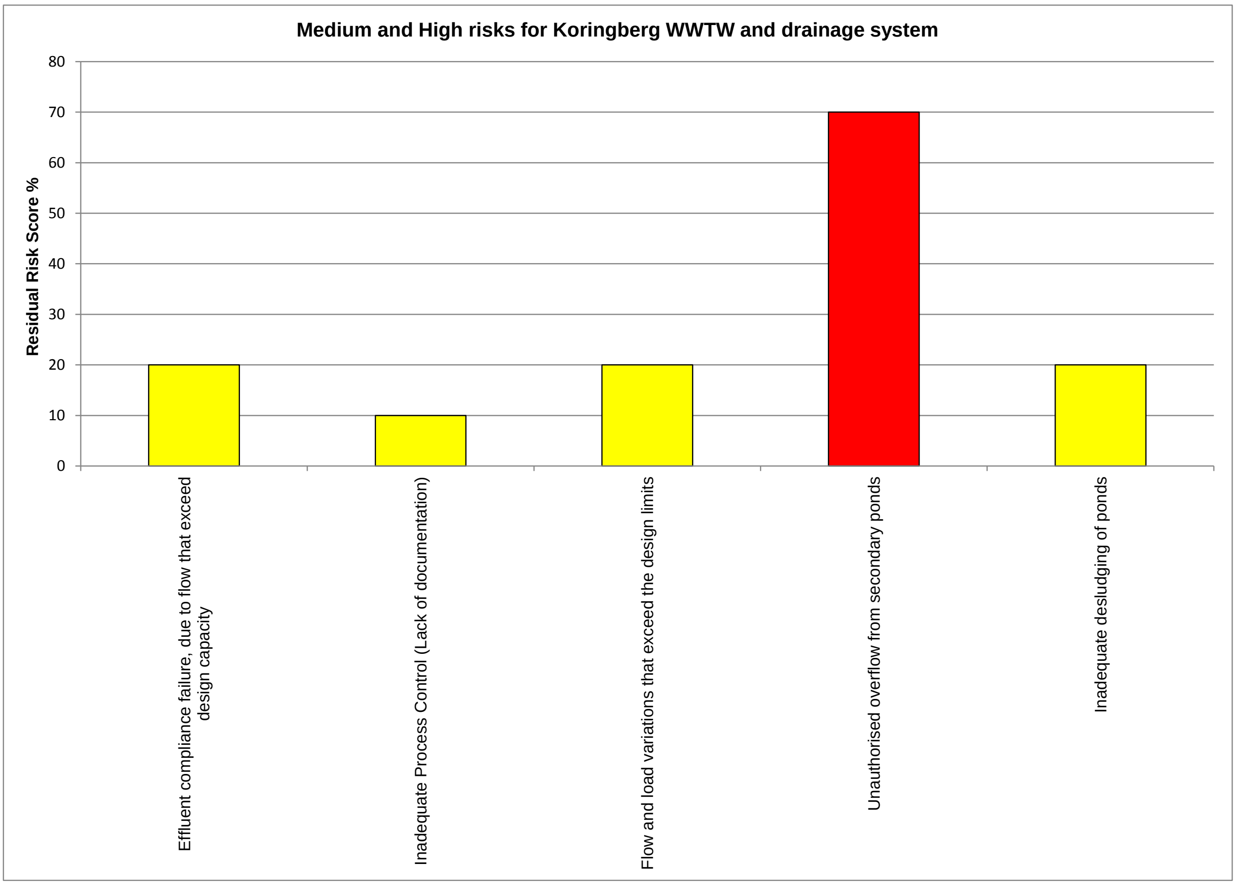

Figure 5: Medium and high risks for the Koringberg WWTW and drainage system

1.1.6 Risk Management

1.1.6.1 Control Measures for Priority Risks

The assessment and planning of control measures are to ensure that health-based and environmental targets are met and should be based on hazard identification and assessment. The level of control applied to a hazard should be proportional to the associated ranking. Assessment of control measures includes the following:

- Identifying existing control measures for each significant hazard or hazardous event from consumer (initial point of waste collection) to catchment (final point of effluent discharge);
- Evaluating whether the control measures, when considered together, are effective in controlling risk to acceptable levels; and
- If improvement is required, evaluating alternative and additional control measures that could be applied.

Risk treatment strategies / control measures also include the implementation of policies, standards, procedures, training and physical changes to the infrastructure to reduce and mitigate the risks. This involves reducing the likelihood and / or consequences of an incident occurring to an acceptable level.

If the existing controls and contingency measures are not adequate, it is necessary to develop the appropriate control measure to reduce the risk. After an (risk) event or incident, it is necessary to re-assess the risks and the control measures.

Sometimes the risk control measures may not be affordable, possible or the likelihood is rare or too costly to mitigate. Then the following risk control strategies can be considered:

- Reduce the level of risk, i.e. either the likelihood or the consequence.
- Accept the risk, no action is required.
- Transfer the risk.
- Avoid the risk.
- A combination of the above

Critical control points were also established for each of the identified hazards and after the risk assessments. The Critical control points are the points along the wastewater collection and treatment chain where monitoring and / or interventions can have a significant impact on the quality of wastewater. The purpose of the critical control points is to act as a multi-barrier protection process. This provides the ability to locate, isolate and mitigate and arrest a specific problem before it escalates to higher risk scenarios, or before it is fatal to health and environment.

The proposed control measures, the monitoring of the proposed control measures and the operational parameters and / or limits to monitor at the specific critical control points, for the priority risks (Medium to High) are included on the Risk Rating sheets in Annexure A for the Koringberg WWTW and drainage system.

1.1.6.2 Improvement and Upgrade Plan

Upgrade and improvement plans can include short-term (< 1 year) or long-term programmes (> 5 years). Short-term improvements might include, immediate improvement to effluent quality via adjustments in process control points (i.e. operate plant as extended aeration with longer sludge age). Long-term project relate to capital works projects, which could include expansion, enhancement of systems or developing system back structures (i.e. emergency diversion weir and pond).

Implementation of improvement plans may have significant budgetary implications and therefore may require detailed analysis and careful prioritization in accordance with the outcomes of the risk assessment. Implementation of plans should be monitored to confirm that improvements were made and that they are effective. Control measures often require considerable expenditure, and decisions about wastewater treatment quality improvements cannot be made in isolation from other aspects of drinking-water supply that compete for limited financial resources. Priorities will need to be established, and improvements may need to be phased in over a period of time.

Timeframes and responsibilities were identified by the W_2RAP team to ensure the successful implementation of the proposed Improvement / Upgrade Plan. **The recommended actions to be taken, responsible team member and the timeframe for the implementation of the proposed control measures, as identified through the risk assessment process, were summarized and included on the Risk Rating sheets in Annexure A for the Koringberg WWTW and drainage system.** The CRR of the Koringberg WWTW will be lowered as follows through the implementation of the proposed Improvement / Upgrade Plan.

Table 1.1.6.2.1: Future CRR for the Koringberg WWTW (After implementation of the Improvement / Upgrade Plan)

Historical CRR				Planned Wastewater Risk Rating (CRR)						
2011	**2012**	**2013**	**2014**	**Design Capacity Rating (A)**	**Capacity Exceedance Rating (B)**	**Effluent Failure Rating (C)**	**Technical Skills Rating (D)**	**Cumulative Risk Rating CRR**	**Maximum CRR that can be achieved**	**% Deviation = Actual CRR / Max CRR**
55.6%	41.2%	52.9%	76.5%	1	5	3	2	10	18	**55.6%**

1.1.6.3 Verification and Validation

Verification of treated effluent quality provides an indication of the overall performance of the treatment system and the ultimate quality of the effluent being released into the receiving environment. This incorporates monitoring of final effluent quality (chemical, physical, microbiological), as well as assessment of the impact on the receiving environment, for example:

- determination of the condition of the biological communities in-stream, using indices such as the South African Scoring System (SASS5),
- Invertebrate Habitat Assessment Systems (IHAS] toxicity testing for use with rapid biological assessment protocols, which expresses the suitability of biotopes, where 100% represents "ideal" habitat availability.
- Aquatic toxicology, particularly applied within Ecological Risk Assessment (ERA), is of most use to those who discharge wastewater or whose activities contribute to non-point source pollution.

In addition to operational monitoring of the performance of the individual components of a wastewater treatment system, it is necessary to undertake final verification for reassurance that the system as a whole is operating safely. Verification may be undertaken by;

- the regulatory / enforcement agency (inspectorate);
- the supplier;
- by an independent authority; or
- By a combination of these, depending on the administrative regime in a given country.

For South Africa, this would be the responsibility of the DWS to oversee the registration of monitoring programmes and regular submission of analysis results. Nation-wide programmes such as the RPMS (Regulatory Performance Monitoring System), the Green Drop certification and risk-based assessment and prioritization allow for data collection, assembly and verification on an on-going basis (mostly annually).

Verification provides a final check on the overall safety of the wastewater treatment process. Verification may be undertaken by the surveillance agency and/or can be a component of supplier quality control.

The microbial, chemical and physical sample results of the final treated effluent discharged at the Koringberg WWTW are included under Section 1.1.4.3.

The W_2RAP of Swartland Municipality is a live document and the risk mitigation measures were aligned with the Municipality's other systems (Asset Management Plans, Operation and Maintenance Plans and Budgets). The W_2RAP will be reviewed by the Municipality as required. The implementation of the W_2RAP and the relevant mitigation measures will assist with the reduction of the Koringberg WWTW's CRR.

2 WASTEWATER QUALITY FAILURES RESPONSE MANAGEMENT

2.1 Wastewater Incident Management Protocol

An incident is any situation where loss of control over the system occurs, or where there is any reason to suspect non-compliance or danger to the environment or a health risk. Significant deviations in the operational monitoring such as where critical limits are exceeded, is also referred to as an "incident". This section will ensure that adequate management procedures are in place for when an incident occurs.

Some incident triggers can include the following:

- Non-compliance with operational monitoring criteria;
- Inadequate performance of a sewage treatment plant discharging to source water;
- Spillage of a hazardous substance into source water;
- Sewer losses during reticulation and pumping of wastewater – not arriving at treatment plant;
- Failure of the power supply to an essential control measure;
- Extreme rainfall in a catchment;
- Detection of unacceptable levels of metals, ammonia, etc.;
- Unusual odour or appearance of returned effluent water;
- Detection of microbial indicator parameters, including unusually high faecal indicator densities and unusually high pathogen densities in returned effluent; and
- Public health indicators or a disease outbreak for which water is suspect vector.

Following any incident or emergency, an investigation should be undertaken involving all concerned staff. The investigation should consider factors such as:

- What was the cause of the problem?
- How was the problem first identified or recognised?
- What were the most essential actions required?
- What communication problems arose and how were they addressed?
- What were the immediate and longer-term consequences?
- How well did the emergency response plan function?
- Did the turnaround plan match the seriousness of the incident?
- Should documentation (e.g. SOPs) be updated or reviewed?

Appropriate documentation and reporting of the incident or emergency should also be established. The Municipality should learn as much as possible from the incident or emergency to improve preparedness and planning for future incidents. Review of the incident or emergency may indicate necessary amendments to existing protocols.

A Disaster Management Plan for the West Coast Region is in place, which confirms the arrangements for managing disaster risk and for preparing for- and responding to disasters within the West Coast Region as required by the Disaster Management Act. **The West Coast District Municipality's Disaster Management Structure and Disaster Response Flowchart are included in Annexure B.** The types of disasters that might occur within the area of the West Coast District Municipality are summarised in the table below:

Table 2.1.1: Risks included in the West Coast District Municipality's Disaster Management Plan

Risks requiring risk reduction plans	Risks requiring preparedness plans	Priority Risks
• Fire , Drought, Road Accidents, Wind, HIV / Aids, TB	• Fire, Drought, Floods, Storms, Wind • Diseases such as HIV/Aids, TB, Cholera, Diptheria, Haemorrhagic Fever, Typhus Fever, Typhoid, Dysentry, Polio, Plague, Meningitis, Measles, Rabies, Anthrax, Food poisoning • Red tide, Aircraft crash, Storm surges, Hazardous Installations, Road accidents, Hazmat incidents: Road, Rail and Sea, Air pollution, Water pollution, Land degradation, Deforestation, Desertification, Tornado	• Fire, Drought, Severe Weather (Storms, Wind, Rain), Hazardous Materials Incidents, Communicable diseases / Health

The Wastewater Incident Management Protocols that are implemented by Swartland Municipality with regard to the sewer drainage systems and the operation of the WWTWs are included in Annexure B.

The three risk categories and Alert Levels that were adopted by Swartland Municipality for their Incident Management Protocols are as follows:

Table 2.1.2: Actions and parties to be informed for various risk categories

Risk Category	Alert Level	Action	Inform
Low	I	Swartland Municipality will be able to resolve the issue internally without the need to communicate to external parties.	Process Controllers, Sewer and WWTWs Area Superintendent and Civil Engineer Trade Services
Minor	II	Swartland Municipality will communicate potential issues to vulnerable groups (e.g. clinics, DWS, etc.) if necessary	Sewer and WWTWs Area Superintendent, Civil Engineer Trade Services, Senior Manager Technical Services and vulnerable groups if necessary.
Major	III	Swartland Municipality will communicate potential issues to vulnerable groups (e.g. clinics, DWS, etc.) and ensure that the Emergency Task Team (ETT) is activated. The duties of the ETT include the management of the emergency, the coordination of activities, role allocation to stakeholders and reporting. The West Coast Disaster Management Advisory Forum will coordinate and manage the compilation of the ETT.	Same as Alert Level II, Director Civil Engineering Services, Municipal Manager, ETT and external role-players as necessary (Clinics, DWS, Department of Health, Public, etc.)

The Incident Management Protocol for plant infrastructure, networks and pump stations include the following categories:

- Incidents (Network blockages, network breakages, electricity failure, mechanical equipment failure, civil infrastructure failure, human injury / fatality)
- Incident is reported
- Assess incident
- Determine alert level

- Determine decision maker
- Respond to incident
- Remedial actions
- Record / Investigate / Review Incident

Incident Management Protocols for the final effluent compliance at the WWTW are also in place, which include the following alert levels:

- Alert Level 1: Incident occurs only once
- Alert Level 2: Incident occurs recurringly
- Alert Level 3: Incident occurs continuously

2.1.1 Supporting Programmes

Supporting programmes is actions that are taken that do not directly affect the collection of wastewater, wastewater treatment process and final discharge and quality of the effluent. It is actions that indirectly support the management of the risks. An action which has a direct impact on the management of the risks is referred to as control measures. Support programmes can aid to optimise the treatment process and improve quality control. It ensures that the operating environment, the equipment used and the people themselves does not become an additional source of potential hazards to the treatment process and public safety and health. Supporting programmes can include the following:

- Controlling access to treatment plants, pump stations, sewers, discharge points, disposal sites, etc. and implementing the appropriate security measures to prevent transfer of hazards from people;

- Developing verification protocols for the use of chemicals and materials in the wastewater treatment – for instance, to ensure the use of suppliers that participate in quality assurance programmes;

- Using designated equipment for attending to incidents such as sewer leaks, pump station failures, mains bursts (e.g. equipment should not be designated for potable water work and not for sewage work); and

- Training and educational programmes for personnel involved in activities that could influence wastewater treatment safety; training should be implemented as part of induction programmes and frequently updated.

The existing supporting programmes implemented by Swartland Municipality are as follows:

- **Supply Chain Management Procedures**

  Specific procedures are in place for purchasing of chemicals and materials for ensuring adequate quality.

- **Security Measures**

  Swartland Municipality will start focussing more strongly on strict control (Limited access) of people at the treatment works and sewer pump stations. This includes the implementation of security measures such as fences, locked gates, security guards, alarms, etc.

- **Training of Personnel**

  A Workplace Skills Plan is compiled annually by the Municipality. The specific training needs for wastewater treatment personnel are identified annually as part of the process of compiling the Workplace Skills Plan. Areas of training to aid the optimisation of the waste water treatment system are as follows

- Reticulation management;
- Maintenance and calibration of equipment;
- Safety and hygiene awareness;
- Sampling, monitoring and analysis during the treatment process;
- Interpretation and recording of results;
- Disinfection system operation and dosing calculations.

- **Quality Management**

  Good operating procedures, updated management practices are essential for the success of supporting programs. Quality management procedures currently implemented by the Municipality includes the following:

  - Periodic review and updating of operational and management practices to continuously improve the existing practices;
  - Audits of practices to ensure that it is implemented and corrective actions are applied when problems are identified.
  - Ensuring the reporting line and communication between management levels is effective.
  - Good record keeping.

- **Stakeholder engagement**

  - Swartland Municipality's current awareness raising processes should focus more strongly on the education of the communities and the general public with regard to the activities that may impact on the quality of influent, treatment processes or the quality of the final effluent. Communities are promoted to take ownership of their roles in the treatment system through the process. Some other issues that can form part of the awareness raising process includes: resource protection, risks to their health w.r.t. raw sewage and the potential for the re-use of treated effluent.
  - The quality of industrial effluent discharged into the Municipality's sewer system by industrial consumers is monitored on a monthly basis by Swartland Municipality.
  - Creating a transparent process where the public is informed by publishing effluent quality compliance percentages, Green Drop audit results and how non-compliant aspects are addressed by the Municipality. This is also used to inform the general public on the contribution that they can make to improve or aid the treatment process;
  - Actively involve the other Municipal Departments such as stormwater, land use, spatial development planning in wastewater management discussions;
  - Peer review. Engaging with other municipalities for peer review and exchange of management ideas.

2.2 Evidence of Implementation of Protocol (Documentation and Communication)

Documentation and up-dated records of information as it becomes available is an essential part of management. It enables the municipality to have control over the wastewater treatment systems, notice trends, taking effective corrective actions when non-compliance trends are noticed, etc. It also reduces the amount of work at the end of the operational year when the W_2RAP is reviewed or when Green Drop Assessments takes place.

The documentation of the Koringberg W_2RAP includes the following:

- Description and assessment of the wastewater treatment system (Section 1.1.4), including programmes to upgrade and improve existing wastewater service (Sections 1.1.4.2.4 and 1.1.6.2);
- Operational monitoring and verification of the wastewater treatment systems (Sections 1.1.4.3, 3.1 and 3.2);
- Wastewater Treatment Safety Management procedures for normal operation, incidents (specific and unforeseen) and emergency situations, including communication plans (Section 2.1); and
- Description of supporting programmes (Section 2.1.1)

2.2.1 Existing Control Sheets and SOPs

Operation and Maintenance Check Sheets for Process Controllers / Operators: No control sheets are in place for use by the Process Controllers at the Koringberg WWTW.

Management check sheet for the Manager / Supervisor: The Civil Engineer Trade Services needs to meet every Friday with the Sewer and WWTWs Area Superintendent to go through the weeks' control, inspection, maintenance and incident sheets. The control, inspection, maintenance and incident sheets need to be signed-off by the Area Superintendent to control whether the routine operational tasks, checks and maintenance tasks are carried out by the process controllers / operators for the Koringberg WWTW.

Records are essential to review the adequacy of the W_2RAP and to demonstrate the adherence of the wastewater treatment system to the W_2RAP. Five types of records are generally kept, which include the following:

- Supporting documentation for developing the W_2RAP including validation;
- Records and results generated through operational monitoring and verification;
- Outcomes of incident investigations;
- Documentation of methods and procedures used; and
- Records of employee training programmes.

Swartland Municipality's existing communication strategies include the following:

- Provision of monitoring data to the DWS on a monthly basis through the GDS.
- Procedures for rapidly advising of any significant incidents within whole collection, treatment and final discharge system. Also notifying the public health authority where applicable;
- Summary wastewater treatment information to the public – examples include WSDP, WSDP Performance and Water Services Audit Report and publication of the Municipality's Green Drop performance;

- Establishment of mechanisms and processes to receive and actively address community complaints in a timely fashion.

2.2.2 Proposed Control Sheets

It is recommended that the following control, inspection, maintenance and incident forms be implemented by the Process Controllers at the Koringberg WWTW.

Table 2.2.2.1: Proposed Control, Inspection, Maintenance and Incident Forms to be implemented at the Koringberg WWTW

Reference	Description	Frequency
Proposed Control Forms		
KB-QLY-MNT-ALL-01/01	Analysis Monitoring Analytical Results	Weekly
KB-QTY-MNT-ALL-01/01	Flow Meter Readings	Daily
SRTL-REC-MTC-ALL	Maintenance Control Form	When maintenance work is carried out
SRTL-REC-INC	Incident / Accident Report	Per Incident / Accident
Proposed Inspection Forms		
KB-CHK-INS_D-01	Daily inspection sheet for Inlet Works	Daily
KB-CHK-INS_M-01	Monthly inspection sheet for Inlet Works and Oxidation Ponds	Monthly

2.2.3 Implementation and Review Schedule for the W_2RAP

The W_2RAP team of Swartland Municipality is committed to meet regularly to review the implementation and all the aspects of the W_2RAP and to determine whether the field assessments need updates or modifications.

The Municipality is committed to implement the W_2RAP and the Improvement / Upgrade Plan. Data from the verification and validation measures will be used to evaluate the accuracy of the W_2RAP. The evaluation will give an indication whether certain aspects of the risk assessment need to be updated or modified and whether there exists any gaps in the W_2RAP.

If the analysis indicates that critical limits are not achieved at critical control points, despite the implementation of control measures and preventative action plans, then it points to:

- Risks have been identified incorrectly;
- Control measures are insufficient;
- Control measures have identified incorrectly; or
- The critical limits are inappropriate

The W_2RAP is a dynamic document and should be reviewed:

- Annually;
- After an incident as part of the debriefing;
- After any significant change in the value (production) chain;
- When a weakness in the W_2RAP has been identified; and
- Additional information is received that warrant a revised risk level for that system.

The table below gives a summary for the review process and the reasons for review:

Table 2.2.3.1: Review schedule for the W_2RAP			
Document	**Date**	**Review Period**	**Reason for Review**
W_2RAP that includes all the WWTWs	October 2011	Wastewater Quality data July 2010 – June 2011	First W_2RAP
Separate W_2RAPs per system	January 2018	Wastewater Quality data July 2011 – June 2017	First Review

3 WASTEWATER QUALITY MONITORING

3.1 Operational Monitoring

No operational samples are currently taken at the Koringberg WWTW. The proposed Analysis Monitoring control form (KB-QLY-MNT-ALL-01/01) for the Koringberg WWTW include the following recommended weekly sampling points.

Table 3.1.1: Proposed Wastewater Operational Sampling Programme for the Koringberg WWTW	
Position	**Determinand**
Raw	pH, COD, SS, NH_3-N, EC
Final Effluent	pH, COD, COD (Filtered), NH_3-N, NO_3, SS, Cl, EC, Faecal Coliforms

3.2 Compliance Monitoring

Monthly wastewater compliance samples are taken and tested by an external accredited Laboratory. The current monthly Compliance Monitoring Programme implemented at the Koringberg WWTW is summarised in the table below.

Table 3.2.1: Current Monthly Wastewater Compliance Sampling Programme at the Koringberg WWTW	
Position	**Determinand**
Final Effluent	pH, Conductivity, Chemical Oxygen Demand, Chemical Oxygen Demand (Filtered), Ammonia Nitrogen, Nitrate Nitrogen, Nitrite Nitrogen, Total Suspended Solids, Ortho Phosphate, Faecal Coliforms

The current compliance monitoring programme implemented at the Koringberg WWTW is adequate.

3.3 Historical Energy Demands and Future Projected Demands

There is currently not electricity usage at the Koringberg WWTW.

Potential energy saving opportunities for WWTWs are summarised in the table below.

Table 3.3.1: Energy saving opportunities at WWTWs	
Area / Component	**Energy saving opportunity**
Electrical Network	• Introduction power factor corrections (PFC) control systems from the substation to the WWTW. • Test all power supply cables for possible leakages.
Motor Efficiency	• Implement motor efficiency- and core replacement programmes; Upgrade old low efficient motors; Select high-efficiency motors with high power factors. • Motors may be oversized as much as 50% - replace with the correct size and efficiency. • Implementation of a variable speed drive (VSD) for mixers, lifting pumps and aeration. • Increase of pump impeller size or adjusting the size accordingly. • Oxygen demand requirements to oxidation ponds may be solved with floating solar aeration systems.
Gearbox Drivers	• Energy transfer loss from the electrical motor to the gear system may be excessive if the gearbox is oversized. • Grease maintenance has not been regularly conducted.
Pumps	• Select pumps based on existing flows with the ability to increase impeller size to handle larger flows. Use supplementary pumps to assist with peak flows.

Table 3.3.1: Energy saving opportunities at WWTWs	
Area / Component	**Energy saving opportunity**
	• Minimize the elevation change for a pump to lift liquid.
Pump Stations	• Introduce storage capacity during peak flow durations to reduce "on-peak" hour pumping capacity. • Match pump flows properly. • Alternating pumps- one pump must be turned off before another pump is started.
Generators	• Use stand-by generators regularly during "on-peak" hours to reduce treatment energy consumption during such peak scheduled times. The cost of fuel per kWh must validate the viability.
Treatment Process	• Use DO probes to control the oxygen and match the demand of the system. PS: energy required to remove the first 30% of the BOD is 5%.
Energy Monitoring	• Introduce power use monitoring systems (as a minimum monitoring measure it is recommended that electricity into the plant needs to be monitored / recorded).
Other Components	• Introduce photovoltaic (PV) solar panel or / and micro wind power generation systems for emergency lights and measuring equipment including computer systems. • Implement solar power for generating hot water to the building of the treatment facility. • Introduction to low energy light fittings for internal and external application with latter switching either through "daylight" switches or through remote sensing to reduce light usage on treatment facility.
Overall Management Best Practice	• Optimize energy consumption and identify energy savings opportunities by means of an energy audit. • The price structure of the plants electrical account will benefit in understanding the cost structure for the WWTW during assessment stages. • Shifting the power consumption from "on peak" hours.

4 RECOMMENDATIONS AND WAY FORWARD

The Municipality needs to note that some recommendations of the Koringberg W_2RAP have extensive financial implications and can be achieved over a longer period of time whilst others can be achieved over a short term period. Therefore adequate budgeting is essential for the successful implementation of the Improvement / Upgrade plan. **The recommended mitigation / improvement plan of the Koringberg W_2RAP is included in the Swartland Risk Assessment spreadsheet in Annexure A.** The following information is included in the table:

- Linkage with DWS's Green Drop Assessment Criteria (Green Drop Improvement Plan)
- Recommended mitigation / improvement plan (Proposed Control Measure)
- Monitoring of Proposed Control Measures
- Operational Parameters and / or Limits (Critical Control Points)
- Responsibility
- Deadline
- Estimated Cost
- Signature
- Progress Reporting
- Confirmed Expenditure 2012/2013 to 2016/2017
- Budget 2017/2018 to 2019/2020

ANNEXURE A: WASTEWATER QUALITY COMPLIANCE

DWS's 2013 Green Drop Report and DWS's 2014 Green Drop Progress Report

Compliance Sample Results for Koringberg WWTW

Agenda, Attendance Register and presentation used for risk meeting with W_2RAP Team

Process Flow Diagram for Koringberg WWTW

Aerial Photo of water and sewer distribution network of Koringberg

Hazards and Hazardous Events and Assessment of the Risks

ABOVE INFORMATION IS INCLUDED ON THE CD

ANNEXURE B: WASTEWATER QUALITY FAILURES RESPONSE MANAGEMENT

Proposed Control Sheets

West Coast District Municipality's Disaster Management Plan

Incident Management Protocols

ABOVE INFORMATION IS INCLUDED ON THE CD