ENVIRONMENTAL IMPACT ASSESSMENT
Final Environmental Impact Assessment Report for the Proposed Construction, Operation and Decommissioning of a Seawater Reverse Osmosis Plant and Associated Infrastructure in Tongaat, Kwazulu-Natal

FINAL EIA REPORT

CHAPTER 2: PROJECT DESCRIPTION

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2. PROJECT DESCRIPTION

This chapter provides project-related information provided by Umgeni Water and the appointed consulting engineers, Aurecon. The purpose of this chapter is to present sufficient project information to inform the EIA Process. The information presented in this chapter is based on screening and feasibility studies undertaken by Umgeni Water and Aurecon. In 2011, a Due Diligence Study (i.e. screening study) was conducted, which formed Phase 1 of the engineering investigations (Aurecon, 2012). In June 2015, a detailed feasibility study (and preliminary design) was completed, which constituted Phase 2 (Aurecon, 2015). However, it is important to note that the project description details are preliminary at this stage and it is likely that some of the details presented herein may change during the subsequent detailed design phase and upon further investigations, should this scheme progress to eventual implementation.

2.1. INTRODUCTION

As previously noted, Umgeni Water is planning to construct a SWRO plant at Lovu and Tongaat, on the South Coast and North coast of the eThekwini Municipality, respectively. The information presented within this Final EIA Report only relates to the proposed Tongaat desalination plant, with the Lovu site being dealt with as part of a separate EIA Process.

The proposed Tongaat desalination plant will consist of the following main infrastructural components, which are described in detail in Section 2.4 of this chapter:

- Sea water intake and marine pipelines;
- Sea water pump station;
- Sea water rising main pipeline;
- SWRO desalination plant;
- Brine discharge pipeline;
- Brine diffuser system;
- Potable water pipelines; and
- Power supply infrastructure.

Note that when referring to "pipeline route" in this report, we mean a 50 m corridor, i.e. 25 m each side of the proposed alignment. This applies to the seawater and brine discharge pipelines as well as to the potable water pipeline.

2.2. RESEARCH PILOT PLANT

International guidelines (WHO 2007; UNEP 2008) recommend that, prior to the design and construction of a desalination plant, a study should be conducted on the chemical and physical properties of the raw water. A thorough raw water characterisation at the proposed intake site should include an evaluation of physical, microbial and chemical characteristics, meteorological and oceanographic data, and aquatic biology. Seasonal variations should also be taken into account. The study should consider all constituents that may impact plant operation and process performance including water temperature, total dissolved solids (TDS), total suspended solids (TSS), membrane scaling compounds (calcium, silica, magnesium, barium, etc.) and total organic carbon (TOC). In line with this, the water quality at the proposed sea water intake site at Tongaat was monitored continuously for 12 months and grab samples were taken at two weekly intervals for laboratory analysis. A marine and offshore geophysical survey (including bathymetric survey) was also undertaken.

Linked to the above, Umgeni Water will also construct a pre-treatment filtration Pilot Plant at the Scottburgh Caravan Park located approximately 20 km south of the proposed development. The preliminary design was completed (in October 2014) and Umgeni Water has issued a tender (November 2014) for the final design and construction of the proposed filter Pilot Plant. The proposed filter Pilot Plant will be used to obtain further information on the suitability of various filters for pre-treatment, particularly for the removal of algae (which was present in some of the samples taken during the initial 12 month monitoring period). **It is important to note that the construction of the proposed Pilot Plant is not included within the scope of this EIA for the Tongaat Desalination Plant**. The data from the Pilot Plant will be used to inform the detailed design of the actual, proposed Tongaat SWRO plant, should this proceed to implementation.

2.3. SITE SELECTION

2.3.1. Environmental Screening Study

As noted previously, the water requirements of the KZN Coastal Metropolitan areas in the vicinity of Durban are growing rapidly. Based on this, as well as current water sources and demand, Umgeni Water has recognized the possibility of implementing desalination at a large scale as an alternative to the Mkomazi Water Project, and as a scheme which could be implemented fairly quickly, with opportunity for phasing of its implementation.

In 2010/2011 Umgeni Water undertook an Environmental Screening Study (ESS) during the pre-feasibility phase. In this ESS, eleven potential sites along the South Coast and north coast of KZN were investigated for **possible** desalination implementation. The ESS was site specific and focussed on selecting a suitable site for the implementation of the proposed desalination plants on the south and north coast of KZN (therefore pipeline routes or alternatives were not considered at this reconnaissance level assessment). For the North Coast desalination plant, a total of five sites between Durban and Ballito (north of Durban) were investigated, and these included the a site near Virginia Airport; Tongati; Umhlanga by Sibaya Casino, Mdloti and Tongaat near Desainagar as shown in Figure 2.1. Figure 2.1 also shows the five sites in relation to one another and to the existing bulk water pipelines owned by Umgeni Water and the eThekwini Municipality.

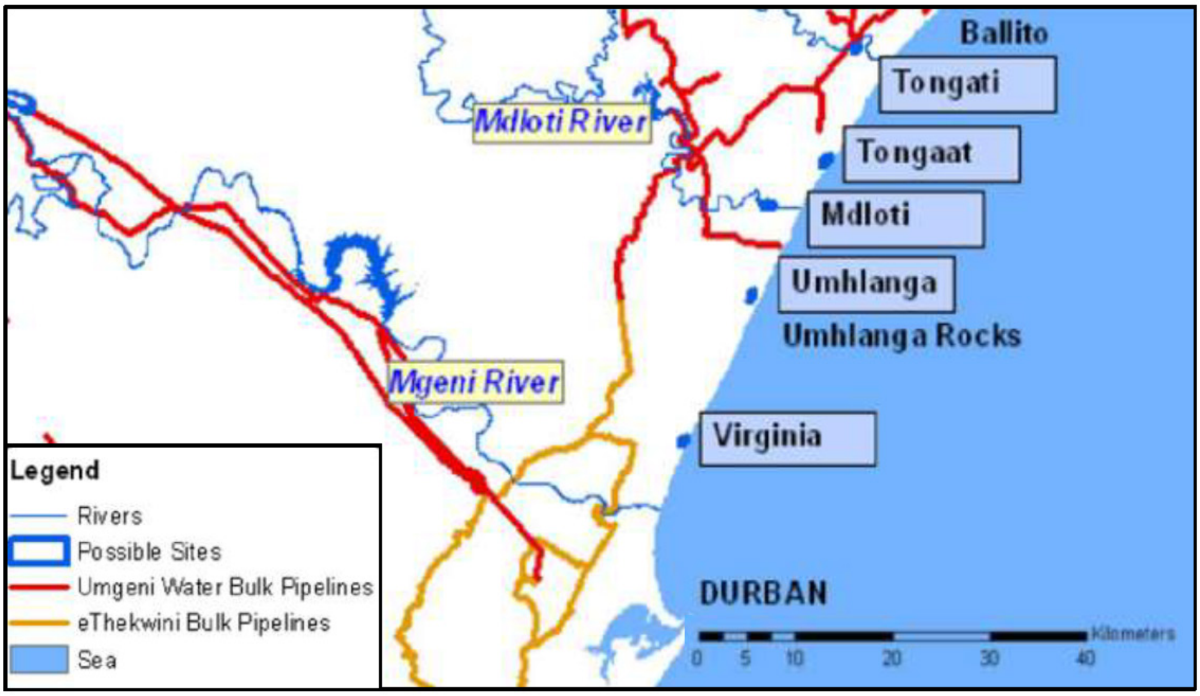

Figure 2-1: Initial screening sites on the KwaZulu-Natal North Coast that were considered for the positioning of the proposed Umgeni Water northern desalination facility

This ESS had the following objectives:

- To assess 5 initial sites on the KZN North Coast (Figure 2-1) in terms of risks to the ecological and social sensitivity of the receiving marine and terrestrial environments; therefore, minimising the risk of irreversible environmental harm and a negative project Environmental Authorisation; and
- To provide a tool for the project proponent to plan proactively for the incorporation of ecological and social considerations into the planning and design of the project prior to the commencement of the public EIA Process.

The ESS identified potential environmental impacts associated with the five site locations between Durban and Ballito (north of Durban). These initial sites were selected by Umgeni Water based on criteria such as land zoning or ownership, access to services, coastline exposure relating to seawater intake and brine discharge; elevation and other technical criteria. The screening criteria used were strongly informed by United Nations Environmental Programme (2008) Resource and Guidance Manual for EIA for Desalination; and the Department of Water Affairs and Forestry (2007) Guidelines for the Evaluation of the Possible Environmental Impacts during the Development of the Seawater Desalination Process. The criteria included:

- Planning constraints such as municipal spatial zoning and proximity to residential areas, access to infrastructure and services, costing etc.;
- Terrestrial ecology (e.g. conservation/biodiversity value of habitat on the site, Ezemvelo KZN Wildlife's Index of Environmental Irreplaceability was taken into account)
- Estuaries – no permanent infrastructure footprints or permanent disturbance below the 5m contour within the estuarine environment;

- Social impacts such as the effects of noise and visual aesthetics or impacts to the local economy such as mariculture and brine discharge. The effects of disrupting one's 'sense of place' was also considered;
- Heritage (cultural, archaeological and palaeontological) aspects;
- Marine hydrodynamics and water quality (e.g. brine dispersion and ecological effects – high energy zones and other technical criteria such as quality of feedwater; and the location of existing marine outfalls that would impact on water quality); and
- Marine ecology (e.g. organism entrainment/impingement, effects of discharge of brine and biocides in benthic communities; the Ezemvelo KZN Wildlife's proposed Marine Biodiversity Protection Areas were avoided).

The sites were also investigated in terms of the following technical criteria:

- Plant elevation above sea-level – limited to 30 m maximum.
- Plant distance from the sea – 3000 m from coastline set as the limit.
- Distance from the shore to the sea intake – at most sites, 20m depth is reached within 1000 m.
- Existing land-use – no development of desalination plants in or adjacent to extensively built-up urban areas.
- Position of Existing Bulk Water Infrastructure was one of the most important criteria considered. Conveyance capacity of existing infrastructure into the current system via bulk pipelines belonging to eThekwini Municipality or Umgeni Water was considered.
- Position of Electrical Infrastructure – the existing bulk electricity supply lines were considered, however spare capacity would need to be confirmed.
- Product Water Quality Integration – product water quality and disinfection practices in the existing distribution system were evaluated for compatibility with the desalinated water.
- Sea Surface Temperature – increased water temperature is favourable due to reduced viscosity and more effective RO membrane performance resulting.
- Site Location Issues – the flooding potential, wave height and beach erosion of the intake pump station site and the desalination plant site were evaluated in order to assess the potential natural hazards that will need to be mitigated by appropriate design measures.
- Factors of anthropogenic nature such as wastewater and storm water discharges within 2 km of the intake location were identified and evaluated for potential impact on source water quality.
- Location, direction and velocity of underwater currents in the vicinity of the potential plant intake sites were studied to determine suitable position to avoid the conveyance and recirculation of concentrate (brine) discharge into the intake system.

For the purposes of the ESS, a potential 'fatal flaw' was defined as an impact that could have a 'no-go' implication for the project based on environmental criteria. The 'no-go' situation could arise if the proposed project were to lead to:

- Exceedance of legislated environmental standards or guidelines, resulting in the necessary licences/approvals not being issued by the authorities. Typical examples are exceedance of water quality guidelines, air quality guidelines or noise guidelines;
- Direct impact on areas designated in existing conservation planning studies as being of high ecological value;
- Location within dynamic zones of natural systems;
- Direct impact on areas with high heritage value, such as known existence of paleontological and archaeological artefacts. This could include features such as fossils, shell middens (in coastal areas), historical buildings and graves;

- Direct impact on cultivated agricultural land such as irrigated fields and pastures;
- Conflict with planned land use or zoning schemes; and
- Direct conflict with the 'sense of place' and associated tourism and/or recreational usage of an area.

Table 2.1 below provides a detailed description of findings of the ESS and provides the advantages and disadvantages of each site, as well as the potential fatal flaws, based on the abovementioned criteria.

Table 2-1: Summary of the findings of the site selection ESS

Site Name	Advantages	Disadvantages	Viability
Virginia Airport	• Positioned on transformed land so minimal terrestrial environmental impact expected. • Short and unobstructed route to the coastline. • Short distance to 20 m depth contour. • Low environmental impact on marine aquatic system.	• Positioned a long way from existing infrastructure and access to this infrastructure would be through densely populated residential housing. • The Virginia Airport is no longer to be closed and hence this site is not an option.	Excluded
Umhlanga/ Ohlanga	• Positioned on agricultural land so minimal terrestrial environmental impact expected. • Short distance to 20 m depth contour. • Short and relatively unobstructed route to the coastline (coastal road).	• Positioned on the banks of a river so poor water quality and the potential for flooding must be considered. • Positioned a long way from existing infrastructure. • Positioned on the site of an up market development and hence the social environmental impacts will be high. • Potential for environmental impact on marine aquatic system although it is likely that these could be managed.	Excluded
Mdloti	• Positioned on agricultural land so minimal terrestrial environmental impact expected. • Short distance to 20 m depth contour. • Short and relatively unobstructed route to the coastline (coastal road). • Infrastructure tie in point has the potential to service a large area through the Northern Pipeline.	• Positioned on the banks of a river so poor water quality and the potential for flooding must be considered. • Positioned approximately 6 km from existing infrastructure. • Potential for environmental impact on marine aquatic system although it is likely that these could be managed.	Viable
Tongaat	• Positioned on agricultural land so minimal terrestrial environmental impact expected. • Short distance to 20 m depth contour. • Short and relatively unobstructed route to the coastline (coastal road).	• Positioned on a site with a high water table causing wetland areas and lagoons. • Positioned approximately 5 km from existing infrastructure. • Positioned alongside existing residential areas which the high	Viable

Site Name	Advantages	Disadvantages	Viability
		social environmental impacts expected.	
Tongati	• Positioned close to existing infrastructure. • Positioned on agricultural land so minimal terrestrial environmental impact expected. • Short distance to 20 m depth contour.	• Positioned on the banks of a river so poor water quality and the potential for major flooding must be considered. • Potential for environmental impact on marine aquatic system although it is likely that these could be managed. • Inlet and outlet structures would have to be routed around a hill and alongside the estuary. This would be difficult and costly. Alternatively tunnelling would have to be considered although the site is a fair distance from the coastline (2500 m). • Positioned alongside a planned up market development with the associated social environmental impacts	Not favored

The underlined text in Table 2.1 above indicates the disadvantages that are considered as potential fatal flaws.

Three of the five sites originally considered were determined to be non-viable or unfavourable for various reasons (Table 2.1). The general recommendation of the ESS determined that the following site locations would (in all likelihood) place stress on sensitive terrestrial environments and therefore would not be suitable for the location of a 7 ha desalination facility:

- Virginia Airport;
- Tongati; and
- Umhlanga by Sibaya Casino.

In addition, access to applicable services and infrastructure would be extremely expensive to construct and ultimately put increased pressure on the natural terrestrial environment e.g. extending pipelines, roads and electrical infrastructure. These sites were also deemed inappropriate for the site location owing to the sheer distance from existing infrastructure and bulk water supply and storage reservoirs. Other criteria such as the proximity to holiday homes and residential areas proved to be important in excluding the Bluff area as a potential site location.

Subsequently, the ESS recommended that for potential desalination on the KZN North Coast, the Mdloti and Tongaat sites appeared favourable. These two sites were then reviewed by Aurecon based on criteria such as land zoning or ownership, access to services, coastline exposure relating to seawater intake and brine discharge; and other technical criteria, and formed part of a Phase 1 Due Diligence Report ("KwaZulu-Natal East Coast Desalination Plants, Detailed Feasibility Study, Phase 1 - Due Diligence Report", Aurecon 2012). This report provided an overview of the proposed desalination project and associated infrastructure; and included an overview of potential social and environmental impacts based on site visits and specialist input. Shortly after initial site visits as part of the Phase 1 Detailed Feasibility Study; it became apparent that the potential estuarine impacts at the Mdloti site (presence of mangroves) warranted the further investigation of an alternative option for a northern site. Hence, the non-estuarine Tongaat site near Desainagar was considered to be the next best alternative for the northern area. Furthermore, the Tongaat site offered limited negative ecological impacts on the present habitat, as the site was found to be highly transformed. Following on from the Phase 1 Due Diligence study, a Phase 2 Feasibility Study has been undertaken with the explicit aim of informing the preliminary design of the desalination plant and associated infrastructure drawing insight from specialists in the field of marine modelling and shoreline characteristics, marine ecology, terrestrial ecology and water quality. The findings of the Phase 2 Feasibility Study have been used to inform this EIA process.

2.4. DESCRIPTION OF THE PROPOSED TONGAAT DESALINATION FACILITY

2.4.1. Overview of key infrastructural components

A brief description of the key infrastructural components associated with the proposed Tongaat desalination facility is provided in Table 2.2 below and shown in Figure 2.2.

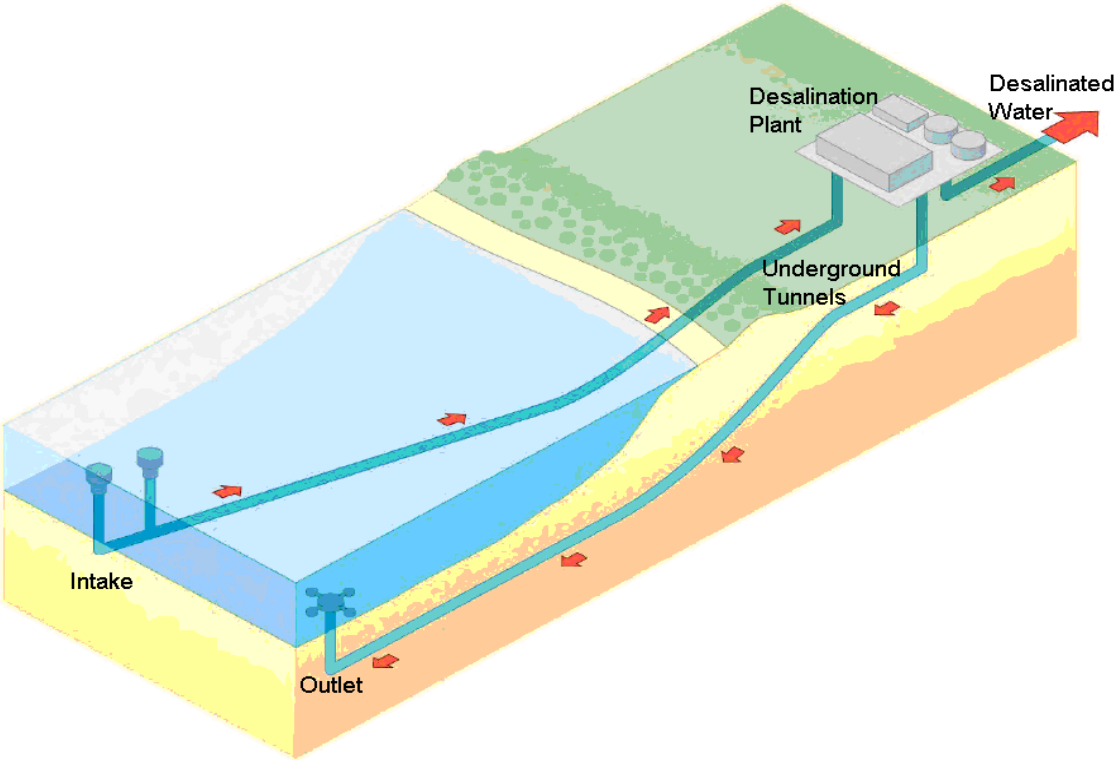

Figure 2-2: A typical layout of a SWRO plant

Table 2-2: Summary of the Proposed Key Components of the Tongaat Desalination Plant

Component of the Tongaat Desalination Plant	Brief Description
Sea Water/ Marine Intake and Pipeline	▪ Sea water will be abstracted from the marine environment via an intake structure located about 650 m from shore at a water depth of about 20 m. ▪ Water will be drawn in through coarse screens on the intake structure, at a height of between 4 m and 6 m above the seabed, in order to avoid the intake of marine sediment and floating matter. ▪ A low inflow velocity of less than 0.15 m/s will reduce the intake of small fish and other marine organisms. ▪ Pipelines will transport the intake water under gravity flow to the sea water pump station on shore. ▪ Seawater passing through the intake structure will be transported to the proposed desalination plant via a 220 m long seawater intake pipeline laid on the seabed and a 680 m tunnel which will be excavated in rock under the surf zone and under the beach, the coastal forest and the M4 highway to the pump station. ▪ Refer to Sections 2.4.3 of this chapter for additional information.
Sea Water Pump Station	▪ A sea water pump station is proposed within the footprint of the desalination plant (Figure 2.3). ▪ It is anticipated that the excavation for the invert of the pump station sump is likely to be at approximately 11 m below Mean Sea Level (MSL). This is based on the requirement that the sump at the pump station be deep enough to allow for gravitational inflow of the sea water into the sump. ▪ Refer to Section 2.4.3 of this chapter for additional information.
SRWO Desalination Plant	▪ The proposed desalination site will require an area of land approximately 70 000 m^2 in extent (7 ha). ▪ The desalination plant is proposed at an elevation of approximately 22 m above sea level, inland of the M4 highway and about 200 m from the coast. ▪ The site is situated within approximately 3 km north of the Mdloti River estuary and constitutes a non-estuarine site. ▪ Refer to Section 2.4.5 of this chapter for additional information.
Brine Discharge pipeline and Diffuser System	▪ From the pump station, the brine discharge pipeline will be tunnelled under the M4 highway, the coastal forest and the beach, to a diffuser sited at a water depth of approximately 10 to 12 m. ▪ Brine will be discharged via a number of outlet ports located in series along the length of a diffuser. ▪ These will discharge the dense brine upwards into the water column to provide good mixing with the ambient seawater. ▪ Refer to Section 2.4.6 of this chapter for additional information.
Potable Water Pipelines	▪ The integration of the proposed desalination plant requires construction of three potable water pipelines. ▪ The first potable water pipeline will lead from the desalination plant in a north-west direction to the La Mercy Reservoir. From there, a second potable water pipeline will continue north-westwards from the La Mercy Reservoir to the Hazelmere Bifurcation pipeline (Tying into the Hazelmere Bifurcation pipeline would allow for water to be delivered to both the north and to the south by reversing the flow in the bifurcation pipeline). The third pipeline will extend from the La Mercy Reservoir in a south-west direction following the direction of the N2 National Road before turning westwards and coming to an end at the Waterloo Reservoir. The potable water pipelines will be developed with a

<table>
<tr><th>Component of the Tongaat Desalination Plant</th><th>Brief Description</th></tr>
<tr><td></td><td>capacity of more than 150 Ml/day.
<table>
<tr><th>Potable Water Pipeline</th><th>Length</th></tr>
<tr><td>Tongaat Desalination Plant to La Mercy Reservoir</td><td>1.67 km</td></tr>
<tr><td>La Mercy Reservoir to Hazelmere Bifurcation Pipeline</td><td>2.66 km</td></tr>
<tr><td>La Mercy Reservoir to Waterloo Reservoir</td><td>11.40 km</td></tr>
<tr><td>TOTAL</td><td>15.73 km</td></tr>
</table>
Refer to Section 2.4.5 of this chapter for additional information.</td></tr>
<tr><td>Power Supply Infrastructure</td><td>
The proposed desalination plant is anticipated to have a total energy demand of approximately 32 MW (i.e. approximately 4 kWh/m^3 of potable water produced, while additional power will be required to pump water to the plant from the sea and to deliver potable water into the existing bulk supply infrastructure).
It is expected that the total electrical connection to the proposed plant would be approximately 40 MVA.
A transmission line (132 kV) would be required to transfer electricity to the desalination site and the pump station, and a substation would be required to reduce the voltage to 11 kV (Figure 2.3).
Refer to Section 2.4.7 of this chapter for additional information.
</td></tr>
<tr><td>Other auxiliary infrastructures</td><td>
Extension and/or upgrading of existing access roads;
Development of internal access roads;
Chemical infrastructure for conditioning of the pre and post-filtered water;
Two freshwater holding reservoirs of 37.5 Ml;
Onsite sewerage treatment facility;
Stormwater handling facility;
Concrete retention tank; and
A 3 m high security fence.
</td></tr>
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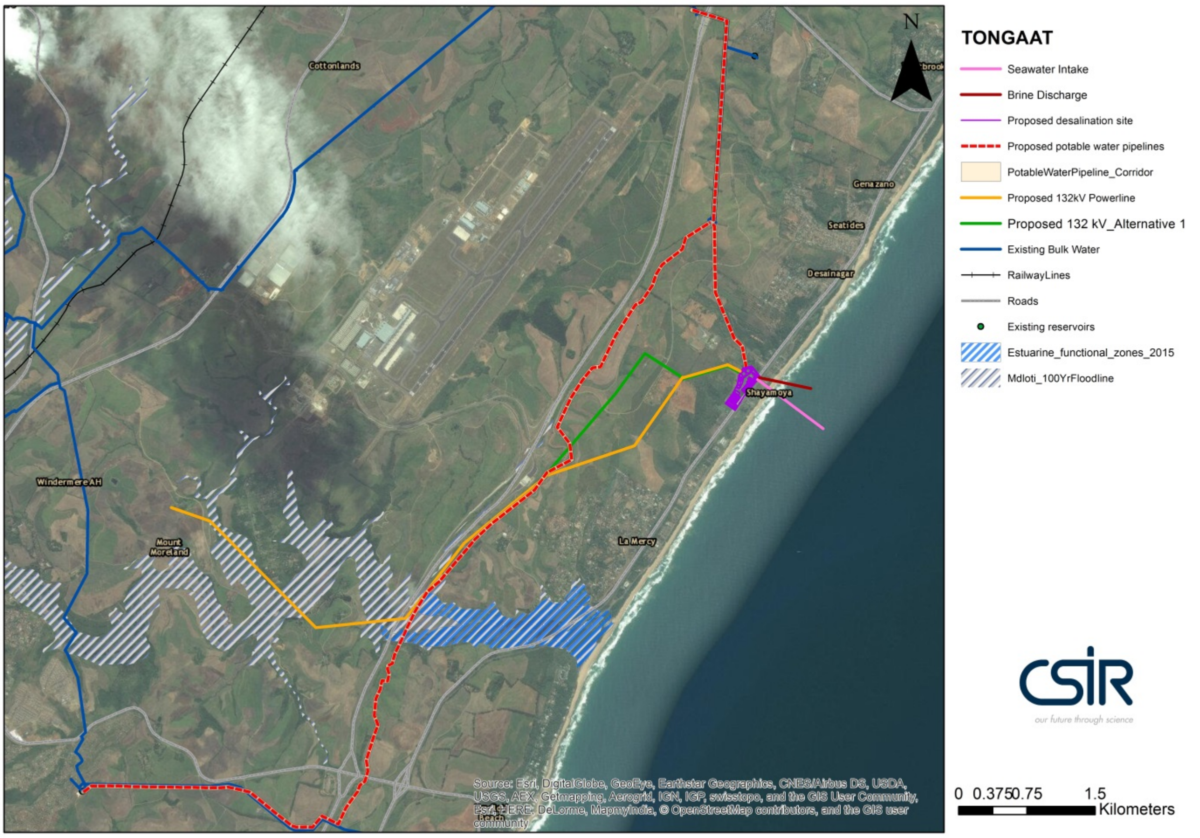
The corner/bend point coordinates for the preferred development site, as well as at the start, middle and end point of the proposed pipeline routes are included in Appendix D.



Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community, Esri, HERE, DeLorme, MapmyIndia, © OpenStreetMap contributors, and the GIS user community

Figure 2-3: View of the proposed 150 Ml/day Tongaat Sea Water Reverse Osmosis facility and associated infrastructure

2.4.2. The Sea Water Reverse Osmosis System

Membrane desalination is based on the ability of semi-permeable membranes to separate mineral salts and water by allowing the selective migration of water (but almost no salts) from one side of the membrane to the other side. Membranes are used in two desalination processes, namely: Electrodialysis (ED) and Reverse Osmosis (RO). A third desalination process, closely related to ED, namely Electrodialysis Reversal (EDR) is also gaining recognition. A fourth process, Forward Osmosis (FO) is currently under development and shows significant benefits for future desalination but is not being used on a commercial and municipal level yet.

Scientists have experimented with the concept of RO and ED for nearly a century. However, the use of membrane technology for municipal desalination only gained commercial interest over the last 30 years (Crisp, 2005). Membrane usage for commercial desalination begun in the 1960's with the introduction of the ED Process. RO made its commercial break-through a decade later, in the early 1970's. One of the significant benefits of membrane usage for desalination as opposed to distillation is the reduction in energy consumption, due to the fact that heat energy does not need to drive evaporation in these processes. Due to pressurization, the energy requirements are still, however, significant for membrane desalination.

RO is currently the most widely implemented desalination process globally. RO technology has been applied in over 90% of the municipal desalination plants built over the past two decades (Voutchkov, [in press]). RO is a membrane filtration process used to reduce the salinity of seawater. The process works by applying pressure to overcome the natural osmotic pressure of seawater. This works by forcing seawater through a semi-permeable membrane, from a region of high salinity (the seawater side) to a region of low salinity (the freshwater side). This process retains the brine (high salinity) on one side and allows freshwater (very low salinity) to be produced as potable water for drinking. High pressure pumps are required to force relatively pure water through a semi-permeable membrane. Figure 2.4 shows the typical components of an RO system.

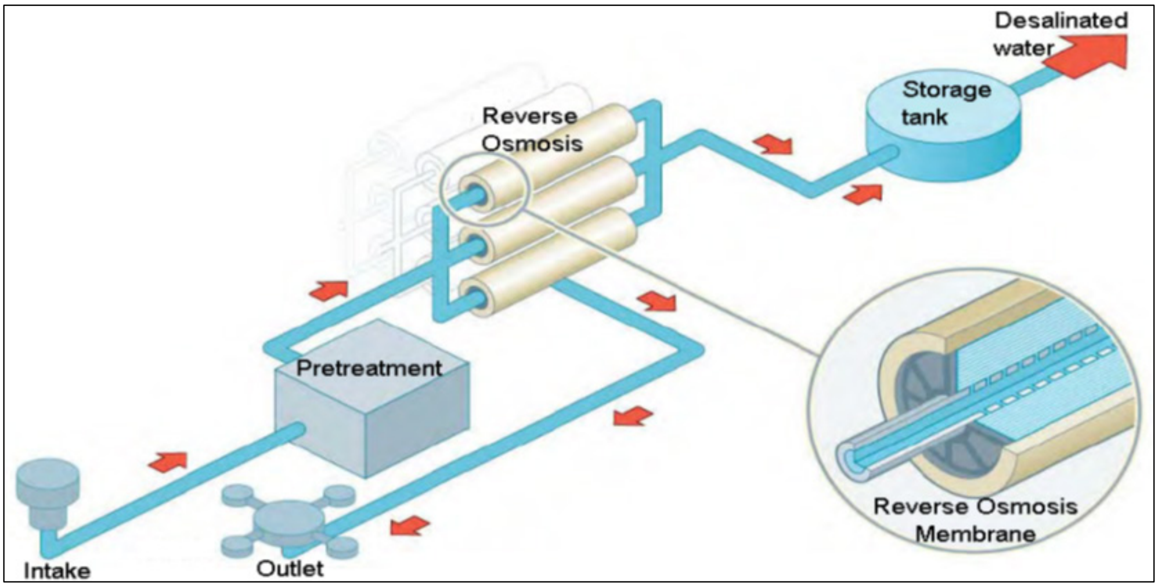


Figure 2-4: A typical SWRO desalination system

The overall output of the treatment system, from intake structure to finished water, will be a maximum of 40 - 45% desalinated water (i.e. 55-60% of the seawater abstracted will be returned to the sea as brine). Figure 2.5 shows that a maximum freshwater (permeate) recovery of approximately 45% of the intake volume will be achieved, meaning that approximately 45% of the seawater will be converted into freshwater, while the remaining 55% will constitute the brine (concentrate) which is returned to the sea.

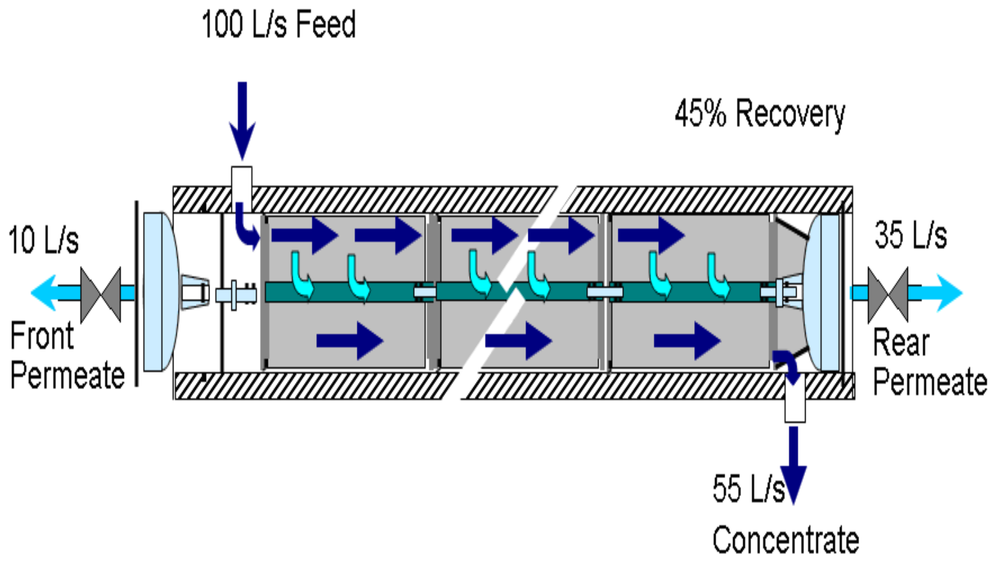


Figure 2-5: Schematic of volume of freshwater (permeate) and brine (concentrate) produced by a SWRO plant

The SWRO system would incorporate the following key features:

- RO membrane elements in vessels assembled in trains (racks) for desalination.
- RO system with installed fresh water production capacity such that it is capable of continuous operation and production of between 135 and 165 Ml/day of drinking water at any given time.
- Fully automated primary system operating cycles (start-up, steady state operation, shutdown, flushing, etc.).
- System treatment components arranged in parallel modular units (e.g. individual RO membrane trains), each capable of operating independently of the other units.

RO plants are available in various configurations (spiral wound (Figure 2.6), tubular, hollow fine fibre). The RO system would include the following components, which are briefly described in Table 2.3:

- RO feed water conditioning facilities;
- Cartridge filters;
- RO membrane trains;
- Energy recovery system;
- Membrane cleaning system; and
- Membrane flushing system.

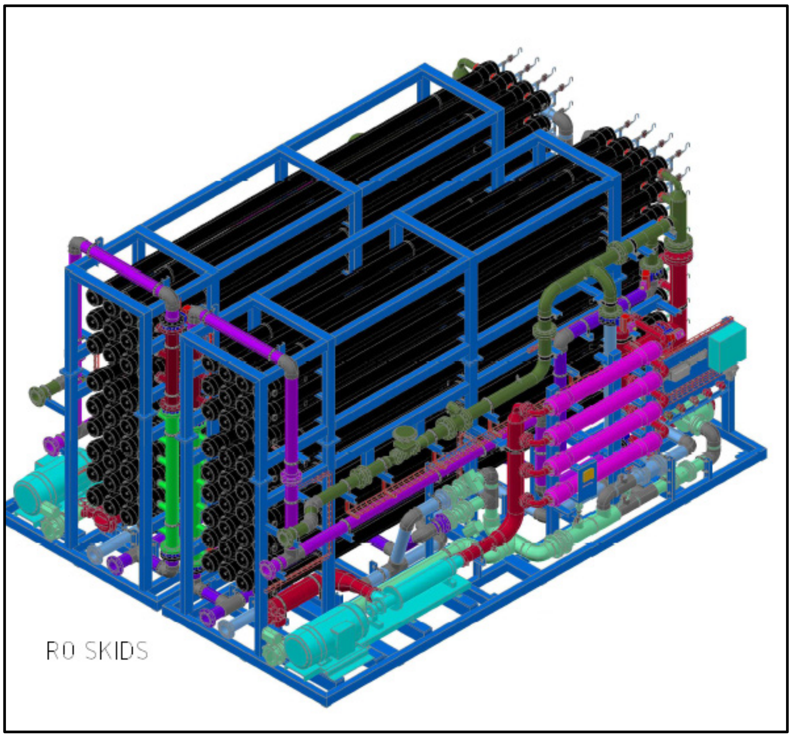


Figure 2-6: A typical SWRO spiral wound membrane system train

Table 2-3: Description of the proposed RO Membrane System Components

RO Membrane System Component	**Description**
RO Feed Water Conditioning Facilities	▪ The feed water to the SWRO system will be pH adjusted, dosed with antiscalant, and treated with Sodium bi-sulphite when required to adjust the oxidation-reduction potential.
Cartridge Filters	▪ The pre-treated sea water from the second-stage filters would be conveyed through cartridge filters as a protection device to capture any remaining particles in the water before it is directed to the RO membrane system. Figure 2.7 shows a typical cartridge filter arrangement.  Figure 2-7: A typical cartridge filter arrangement
RO Membrane Trains	<u>Source and Product Water Quality</u> ▪ The RO membrane system design would be driven by the source water quality. Table 2.4 defines the operating envelope of salinity and water temperature, based on the water quality assessment undertaken during the

RO Membrane System Component	Description
	detailed feasibility study. The proposed desalination plant would need to produce fresh water in accordance with the drinking water quality specifications.

Table 2-4: Operation Envelope of the Tongaat Desalination Plant (Water Quality)

Operating Condition	Source Water at Tongaat	
	Salinity (mg/l)	***Water Temperature (°C)***
Average	35 080	21.9
High Salinity, High Temperature	35 700	25.7
High Salinity, Low Temperature	35 700	18.4
Low Salinity, High Temperature	32 700	25.7

RO Membrane System Component	Description
	▪ A RO train is defined as a stand-alone modular unit incorporating a high pressure feed pump, pressure vessels with membrane elements installed on racks, vessel manifold piping, permeate header, concentrate header with flow control, associated instrumentation and valves. The simplest and lowest cost RO system is one which allows the target product water quality to be achieved by treatment of the source sea water only once in a single set of RO membrane elements (often referred to as a single pass).
Energy Recovery System	▪ Refer to Section 2.4.2.1 of this chapter for a description of the energy recovery system.
Membrane Cleaning System	▪ The RO system will be furnished with a permanently piped clean-in-place (CIP) system to allow in-situ cleaning of membranes in each RO train. Cleaning solutions would be prepared in a cleaning solution storage tank(s) and pumped through the vessels of the train being cleaned via dedicated solution feed and return pipe headers. Train piping manifolds would be designed to allow isolation for cleaning of individual vessels within the train in discrete blocks.
Membrane Flushing System	▪ The RO system would include a permanently piped membrane flushing system, to automatically flush vessels in the first pass trains on shutdown to remove residual concentrate.

It has been assumed that the infrastructure serving the desalination plant would be sized to meet the ultimate demand of 150 Ml/day and that the sea water pump station and the treated pump stations at the desalination plant. The reverse osmosis components would be constructed in two phases, the first to supply 75 Ml/day and the second an additional 75 Ml/day.

As noted above, a single pass SWRO system is recommended in order to minimize plant costs, whilst producing a product water quality that can be integrated into Umgeni Water's existing system. However, for planning purposes (plant footprint area) a possible full-two pass SWRO system has been allowed for. If second pass is desired, additional second pass brackish water RO trains would be required.

2.4.2.1. Energy Recovery

A major advantage of the RO technology is that no heating or phase changing is required. Pressurizing the feed water does, however, require energy but compared with distillation processes, RO has a relatively low total energy cost (Blinda, 2010). Energy, in the form of electricity, is therefore a major cost input for SWRO desalination plants, accounting for 45% - 60% of the total operating costs. It is for this reason that energy recovery systems using pressure exchangers are now incorporated into all medium to large seawater desalination facilities. Where energy recovery is installed, the energy requirement for RO is currently between 2.5 and 2.8 kWh/m^3, however, the total energy requirement is between 4.0 and 4.5 kWh/m^3 (1 m^3 = 0.001 Ml) including the costs of pumping of seawater, desalinated water and for various other processes (1 m^3 = 0.001 Ml). The recovery of energy is a critical design consideration for large seawater desalination plants because of the impact of the energy cost on the final price of water. While the average power demand is estimated to be 24.15 MW, the proposed electrical substation will be designed for a total load of 40 MVA. For a two pass system, the increase in power demand would be about 0.54 kWh/m^3.

A large portion of the energy used for the desalination of sea water is retained as residual pressure in the concentrate produced by the RO system. This energy can be recovered and reused for pumping of new saline source water by equipment specifically designed for this purpose (referred to as an Energy Recovery Device). Reuse of this energy is very beneficial and cost effective. Energy recovery equipment can be divided into two main groups based on the principle of its operation, namely Centrifugal Energy Recovery Devices, and Isobaric Energy Recovery Devices.

In Centrifugal Energy Recovery Devices the pressure contained in the concentrate is applied to an impeller which converts this energy into rotational energy. This rotational energy is then used to reduce the energy needed to run the high pressure pump.

Energy recovery systems currently available are devices each requiring dedicated piping, control and infrastructure. Therefore the desalination plant will be fitted with suitable energy recovery systems to result in a very energy efficient plant to reduce operational costs and hence the production cost of water. A typical energy recovery device such as the Energy Recover Inc. pressure exchanger is shown in Figure 2.8.

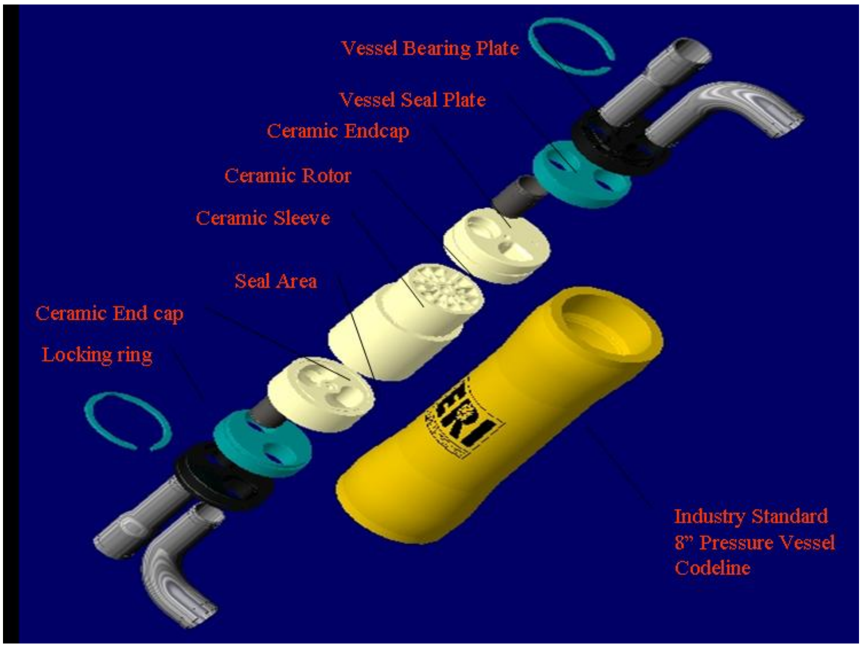


Figure 2-8: Energy Recover Inc. pressure exchanger

2.4.3. Sea water Intake

2.4.3.1. Sea water quantity and quality

Intake source sea water quantity for the proposed RO desalination plant with production capacity of 150 Ml/day will be a maximum of 428 Ml/day with an average recovery of 43 %. The source water quality will determine the nature of pre-treatment that will be required, in order to ensure optimum functioning of the RO process and the protection and longevity of the RO components.

Water quality data was collected during the period of June 2012 to June 2013 as part of the detailed feasibility report in order to determine the quality of the proposed source water. The findings of the water quality analysis indicates that over the one year sampling period, there were minor variations in physical, chemical and biological characteristics of the water column with distance offshore and with depth at Tongaat. The source water of the Tongaat site contains relatively high concentrations of pathogens and copper. These manmade pollutants most likely originate from the discharges of the wastewater treatment plants into the Tongaat River, located within the river catchment area in a 20-km radius from the Tongaat plant intake site. It should be noted however that these concentrations are well within the concentrations that can be completely removed by the seawater pre-treatment and reverse osmosis systems. Based on the feasibility investigations, from a water quality perspective, the Tongaat location is therefore viable for the construction of the proposed desalination plant.

The source water quality parameters which will require plant shutdown will depend on how conservative the final design of the SWRO system is, and in particular, what treatment technologies are ultimately selected. However, what is known at this stage is that regardless of the final treatment technology, complete shutdown will be required if the source water contains a hydrocarbon concentration exceeding 0.05 mg/L, or oil and grease exceeding 0.01 mg/L. For all other water quality parameters, exceedance of certain concentrations (depending on the treatment technology selected) will result in temporary reduction of the volume of the desalinated water produced by the plant.

2.4.3.2. Intake structure

In general, intake structures for proposed desalination plants can be divided into two main categories, namely surface (open) and subsurface (or alternative well (ground water)) intakes. During the detailed feasibility study, site specific conditions were taken into account in evaluating both types of intakes. Beach wells or subsurface drains are not appropriate for the size of this project and the geological conditions are not favourable. Furthermore, they are not feasible due to the large number of wells that would be required, the high environmental impacts and costs, and the relatively high potential for beach erosion.

Therefore, an open intake structure is proposed for the Tongaat desalination plant. The two general types of open intakes considered for the proposed project are onshore intakes and offshore intakes.

Onshore intakes typically consist of a large, deep intake canal ending in a concrete forebay structure equipped with coarse bar screens followed by fine screens and an intake pump station. At Tongaat, this type of intake would require the construction of a breakwater to provide shelter from the waves which would be very costly and would have significant environmental impact. As such, onshore intakes are not considered as a viable option for the proposed project.

Therefore, the proposed project will entail the construction of an offshore intake. The two basic types of offshore open intakes that could be implemented are Conventional Open Intakes and Wedgewire Screens. Conventional open intakes typically consist of a velocity-cap type inlet structure, one or more intake water conduits (pipelines or intake tunnel), an on-shore intake chamber, trash racks, fine screens, and a source water intake pump station.

Wedgewire Screens are passive (no mechanical moving parts) screens located off-shore and are directly connected to the suction end of the intake pump station thereby eliminating the need for additional coarse or fine screening facilities.

The proposed intake will comprise a 6 m high structure located on the sea bed about 650 m offshore at a depth of 20 m. The type of offshore intake structure and the exact distance offshore will be determined during the detailed design phase of this project. However, the detailed feasibility study recommends that the proposed intake structure should be a single, reinforced concrete caisson type structure with vertical sides. This layout will keep inflow velocities to a minimum and helps to limit the intake of sediments.

The preliminary intake design criteria for the proposed plant are:

- Minimum Inflow Rate: 284 Ml/day
- Maximum Inflow Rate: 428 Ml/day
- Average Inflow Rate: 389 Ml/day

Marine growth, variable currents and difficult costly maintenance require that the intake should be simple and robust. Therefore it is proposed that the intake should comprise bar screens bars at 150 mm spacing and sufficient area to limit the intake velocity to 0.15 m/s, which are typical for similar large intakes.

Provision will be made to dose sodium hypochlorite into the intake pipeline to reduce marine growth. Dosing will be intermittent and would only take place when the pumps are in operation so that there is no risk that the sodium hypochlorite will be released to the marine environment.

Flow meters will also record the proposed desalination plant intake flow continuously. If the intake flow would be discontinued for any reason, this would trigger automatic plant shutdown. Water quality monitoring in the forebay would trigger alarms that would notify desalination plant staff and ultimately trigger opening of the valve in the flow bypass structure that would redirect the source water to the plant discharge and initiate plant shutdown. Additional source water quality instrumentation and monitoring provisions include:

- Intake water temperature;
- Intake water salinity; and
- Intake water oil detection (hydrocarbons).

2.4.3.3. Intake Pump Station

For the specific conditions along the KZN coastline, vertical turbine pumps are planned to be installed in a dry well pump station on shore. The selection of a dry well pump station is preferable as it allows for the screens to be located at the proposed desalination plant where easy access is possible. Dry well pumps would either comprise immersible pumps or vertical turbine pumps.

It is proposed that sea water will flow by gravity from the offshore sea water intake, located on the seabed, to the sea water pump station. The sea water would be pumped via a sea water rising main from the sea water pump station to the screening works at the desalination plant.

The pump station (and shaft) and the outfall shaft will be located at the junction of the onshore and offshore pipelines (as shown in Figure 2.3). The sea water pump station will comprise an open sump in which the range of water levels or head fluctuation would typically be up to 2.9 m on a daily basis when the pumps are operating. It should be note that at Tongaat the intake and outfall shaft is located within the desalination plant site and as such the extent of the land based sea intake pipeline and brine return pipeline is very short, connecting the shaft to the adjacent desalination plant.

The geotechnical investigations found that sound dolerite rock was encountered at a depth of 6 m at the proposed site for the sea water pump station which would be sited at a depth below ground level of about 27.5 m. It is proposed that the sea water pump station should comprise an underground pump chamber, which would be accessed via a shaft that would also be used for micro tunnelling of the offshore intake tunnel.

2.4.4. Sea water and Brine Pipelines

The plant intake and outfall are projected to be located approximately 650 m and 350 m from the shore respectively. The outfall would also be located 300 m away and downstream from the desalination plant intake (Figure 2.9).

The Tongaat surfzone is rocky in nature and HDPE pipelines are not suited to a rocky seabed. These can become easily damaged through abrasion on rock, should the pipe move. Pipelines supported on a jetty have also been considered as an option. However, given that the jetty would have to be long enough to at least cross the surfzone, it would be a permanent structure with considerable negative visual impact on the environment.

A sub-surface tunnel (Micro-Tunnel Boring Machine or MTBM), with riser connection to the seabed and conventional HDPE pipelines from the riser to the appropriate intake depth, was considered as the most viable option for the Tongaat site. The tunnel will be constructed from land and cross the surfzone beneath the seabed. At a suitable location, the tunnel will connect upward to the seabed surface through a riser structure, and from there connect to the sea water intake structure via an HDPE surface laid pipe.

Typical tunnelling methods that were considered are:

- Drill and blast. This is not considered suitable for the relatively small diameter of both tunnels (2m).
- Tunnel boring machine (TBM). This can be used in varied sub-surface conditions but conventional TBMs are usually used for tunnels with diameters larger than 3m and rock cover above the tunnel must be sound and of low permeability. The TBM can usually not be recovered, and is encased in the seaward end of the tunnel. The capital cost of the TBM must therefore be included in the project cost.
- Micro-tunnel boring machine (MTBM). This combines pipe-jacking methods with a (comparatively) small, remotely operated tunnel boring machine. Tunnel diameters typically vary between 1m and 3m and can be excavated in soft or hard (rock) material and a relatively small site area (in the order to 2 000 m^2) and access shaft is required on land. The continuous tunnelling drive limit (influenced primarily by operating constraints) for an MTBM application is 2 000 m. This technology suits the constrained nature of the Tongaat site and the intended drilling lengths (680m for the intake and 520m for the outfall). MTBM and pipe-jacking is therefore considered the most suitable tunnelling method for Tongaat.

A similar approach will be used for the brine outfall which will connect from its riser to its diffuser also via an HDPE pipe. The proposed sea water and brine pipelines will be laid in parallel.

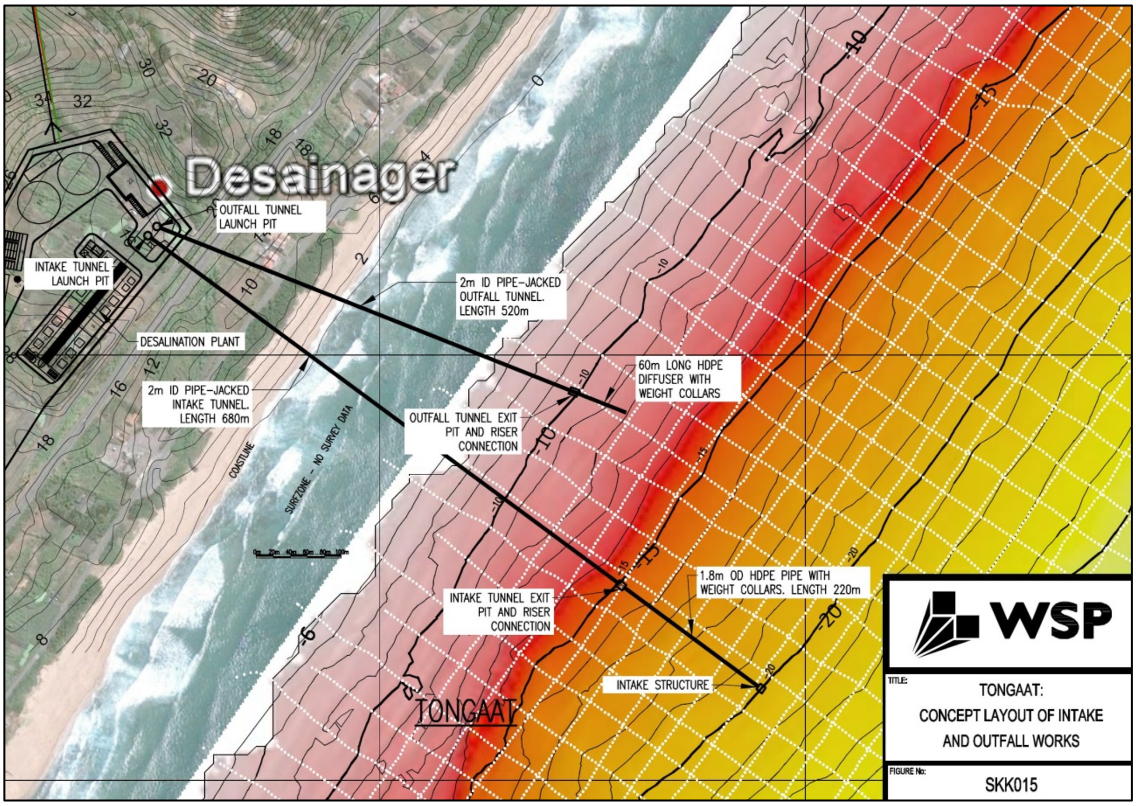


Figure 2.9: Proposed Intake and Outfall Configuration at Tongaat

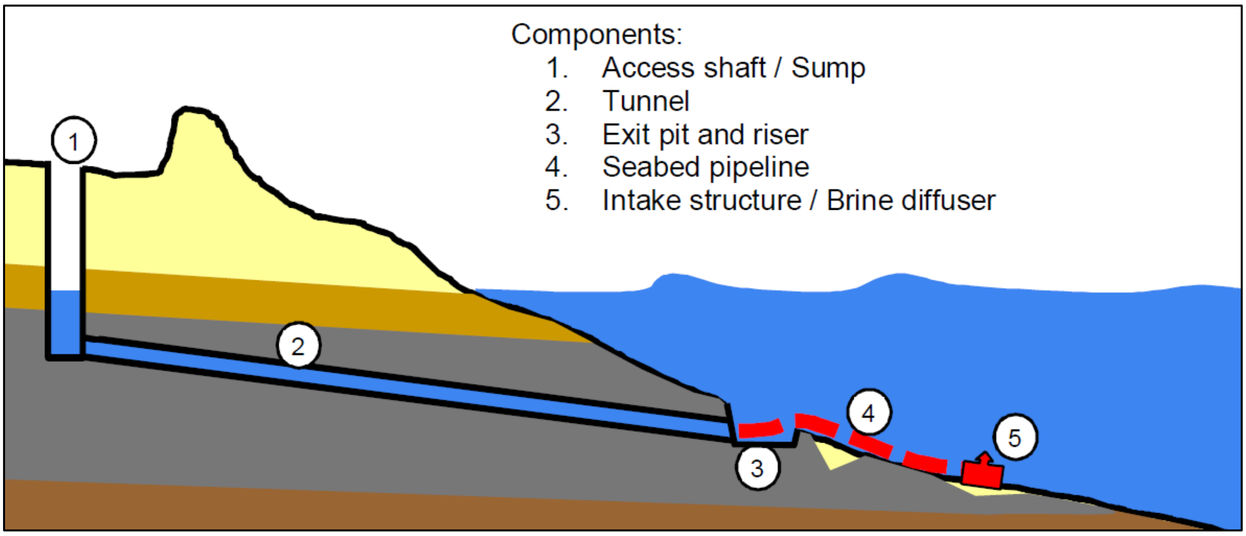


Figure 2.10: Main Components of the Micro-Tunnel Boring Machine based Infrastructure at Tongaat

Figure 2.10 above shows the recommended intake and outfall configuration for Tongaat, namely:

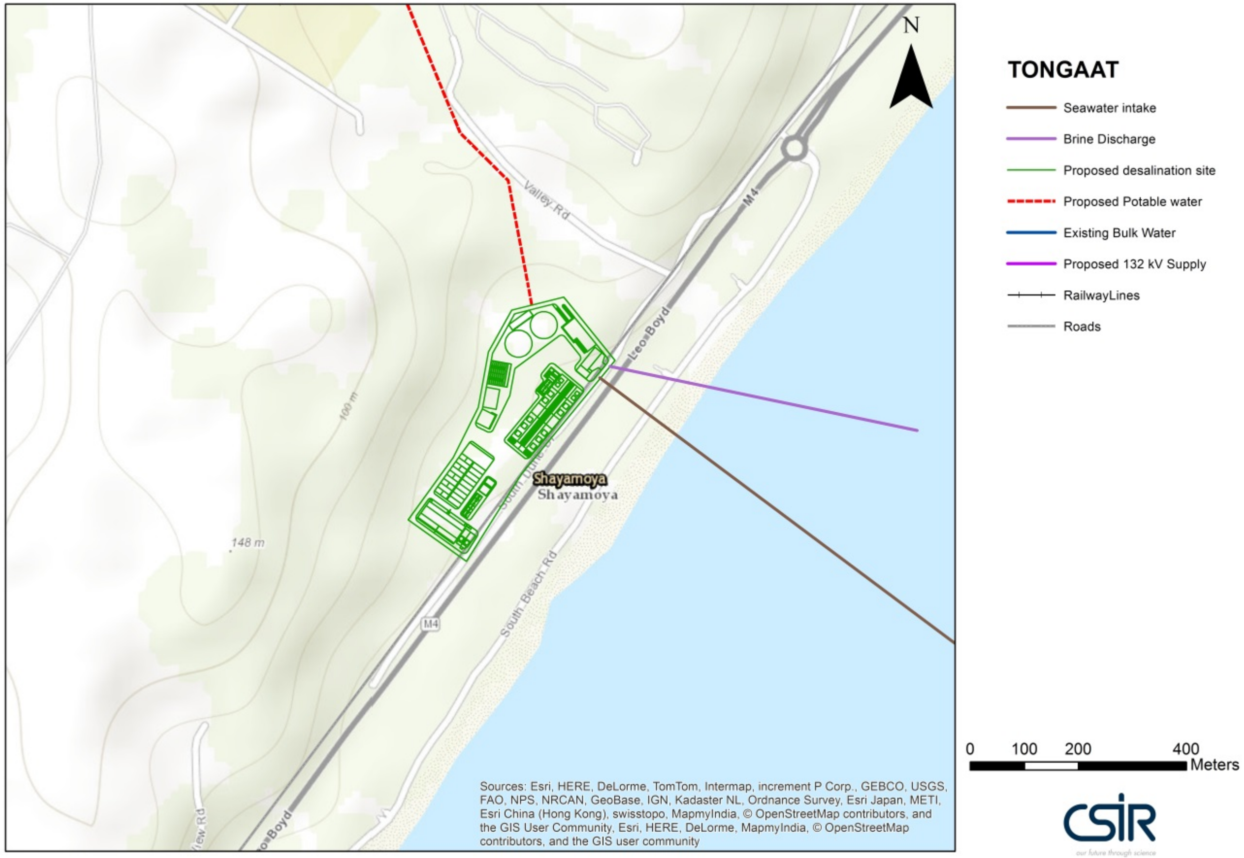
- 1 x intake tunnel launch pit at the plant site
- 1 x ø2 000 mm (ID) pipe-jacked intake tunnel (680 m long)
- 1 x 1 800 mm (OD) HDPE intake pipe on the sea bed (220 m long)
- 1 x Open Intake Structure
- 1 x outfall tunnel launch pit at the plant site
- 1 x ø2 000 mm (ID) pipe-jacked outfall tunnel (520 m long)
- 1 x ø1 600mm (OD) HDPE tapered diffuser (60m long) on the sea bed.

2.4.5. Desalination plant

2.4.5.1. Site location

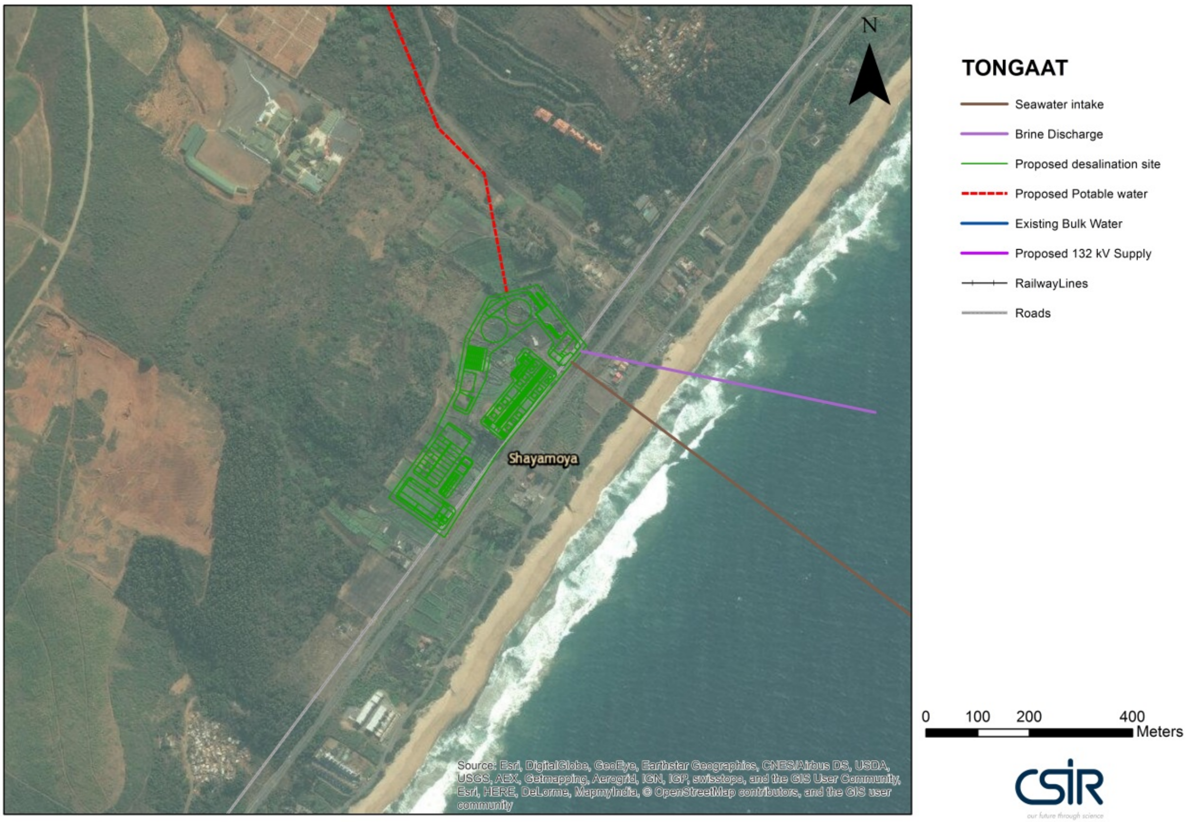
The proposed desalination site will require an area of land approximately 70 000 m^2 in extent (7 ha). The site of the proposed Tongaat SWRO plant (see Figure 2.11) is located within 200m from the ocean shore. The sea water intake would be located approximately 700m offshore and would deliver source water to the intake pump station located at the plant site.

The proposed Tongaat site is currently used for relatively small-scale vegetable production (lettuce, carrots, beetroot, etc.) and the bulk of the produce is sold to formal traders and shops in the Durban area (Pick 'n Pay, Shoprite, Spar, etc.) with lower grade produce also sold on the informal market. There is about 100 staff working on the affected land mainly from the surrounding informal settlements. Full geotechnical investigations at the proposed site have been undertaken.



Sources: Esri, HERE, DeLorme, TomTom, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), swisstopo, MapmyIndia, © OpenStreetMap contributors, and the GIS User Community, Esri, HERE, DeLorme, MapmyIndia, © OpenStreetMap contributors, and the GIS user community

Figure 2-11a: Location of the proposed Tongaat Desalination Plant



Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community, Esri, HERE, DeLorme, MapmyIndia, © OpenStreetMap contributors, and the GIS user community

Figure 2-11b: Location of the proposed Tongaat Desalination Plant

2.4.5.2. The Pre-treatment Process

In order for SWRO membrane desalination to be feasible, a pre-treatment of the sea water is necessary. The proposed pre-treatment system would include two processes aimed at removing the majority of suspended solids and at protecting the SWRO membranes from accelerated fouling by contaminants and would be based on the outcomes of the filter pilot investigation being undertaken.

A dissolved air flotation (DAF) clarifier or gravity granular media filtration (GMF) system would be implemented, followed by second stage ultrafiltration (UF), microfiltration (MF) or finer size GMF units aimed at removing smaller-size particulates (fine solids, microalgae and emulsions) and some of the organics from the sea water. Sodium hypochlorite dosing of the source sea water would also be provided at the intake to prevent the growth of marine organisms in the intake pipeline and downstream piping.

If DAF or granular media filtration is implemented for the source water pre-treatment, coagulant (ferric sulfate or ferric chloride) and flocculent feed and mixing systems would be installed upstream of the DAF and filtration units. This would improve the performance of the pre-treatment facility.

If a membrane pre-treatment system is planned, the feed water for this system would be pre-screened with a micro-screening technology. The micro-screening would be installed upstream of the membrane pre-treatment system and downstream of the DAF/membrane pre-filtration system. No micro-screening system would be needed if granular media filters are used for source sea water pre-treatment. The final phase of pre-treatment would be a cartridge filtration system, constructed irrespective of the type of filtration pre-treatment technology upstream of the cartridge filters.

2.4.5.3. Desalinated Water Management

The water produced from desalination plants is characteristically low in mineral content, hardness, alkalinity and pH. Therefore, desalinated water must be conditioned (post-treated) prior to final distribution and use. Post-treatment of fresh water produced by desalination has two key components, namely mineral addition in order to protect public health and to safeguard integrity of the water distribution system (i.e. re-mineralization); and disinfection. Drinking water will comply with the requirements specified in SANS 241-1:2015, Edition 2, SOUTH AFRICAN NATIONAL STANDARD for Drinking water, Part 1: Microbiological, physical, aesthetic and chemical determinands (Refer to Table 2.5 and 2.6 below)

- Re-mineralization

The lack of carbonate alkalinity as well as the low content of calcium and magnesium causes desalinated water to be very unstable and prone to wide variations in pH. Re-mineralizing desalinated water to match the water quality of the other water sources which are delivered to the same distribution system is therefore of critical importance for maintaining the high quality of the blended water.

Based on worldwide experience and taking into account practical (economic) considerations, the following set of post-treatment water quality criteria could be considered for desalinated water that is intended to have multiple uses:

- Alkalinity > 60 mg/l as $CaCO_3$;
- 80 < Ca2+< 120 mg/l as CaCO3;
- 3 < Calcium Carbonate Precipitation Potential CCPP) < 10 mg/l as $CaCO_3$;
- 7.5 < pH< 8.5; and
- Larson index < 5 (not obligatory).

The two key alternatives for re-mineralization of desalinated water are addition of:

- Lime and Carbon Dioxide; and
- Limestone (Calcite) Contactors.

At present, Umgeni Water uses lime in its other water treatment facilities and this could make the use of this re-mineralization chemical a preferred option. However, the construction costs of a limestone contactor system are about 50% less than for a lime and carbon dioxide system and this should be considered. In order to maintain consistency and to simplify chemical procurement it would be an option for Umgeni Water to use lime and carbon dioxide for post-treatment of the desalinated water and the cost estimates in this study are based thereon. The use of limestone (calcite) contactors is an alternative also worthy of consideration because of their potential cost and performance benefits.

Disinfection

Sea water RO desalination systems can produce water of different quality depending on the number of treatment steps of the source sea water. A full-two pass RO system will produce product water that meets these requirements. On the other hand, a single pass system will require further consideration in terms of how the product water could be integrated with treated water from other sources.

The coastal supply systems of Umgeni Water currently all use chlorine for disinfection and only the inland Waste Water Treatment Works disinfect with chloramines. This could allow for a single pass SWRO system to be considered, if the blending of the desalinated water (disinfected with chlorine) is undertaken only with water from coastal sources, where chlorination has also been used. A single pass RO system would not be suitable should the product water be blended with chloraminated water from other sources. There would be a risk of undesirably destabilizing the chloramine residual due to elevated bromide concentrations in the desalinated water, where only a single pass system is used. The feasibility study recommends that chlorine (i.e. either chlorine gas or sodium hypochlorite) should be used for disinfection of the desalinated water.

Table 2.5 Microbiological determinants (SANS 241-1: 2015)

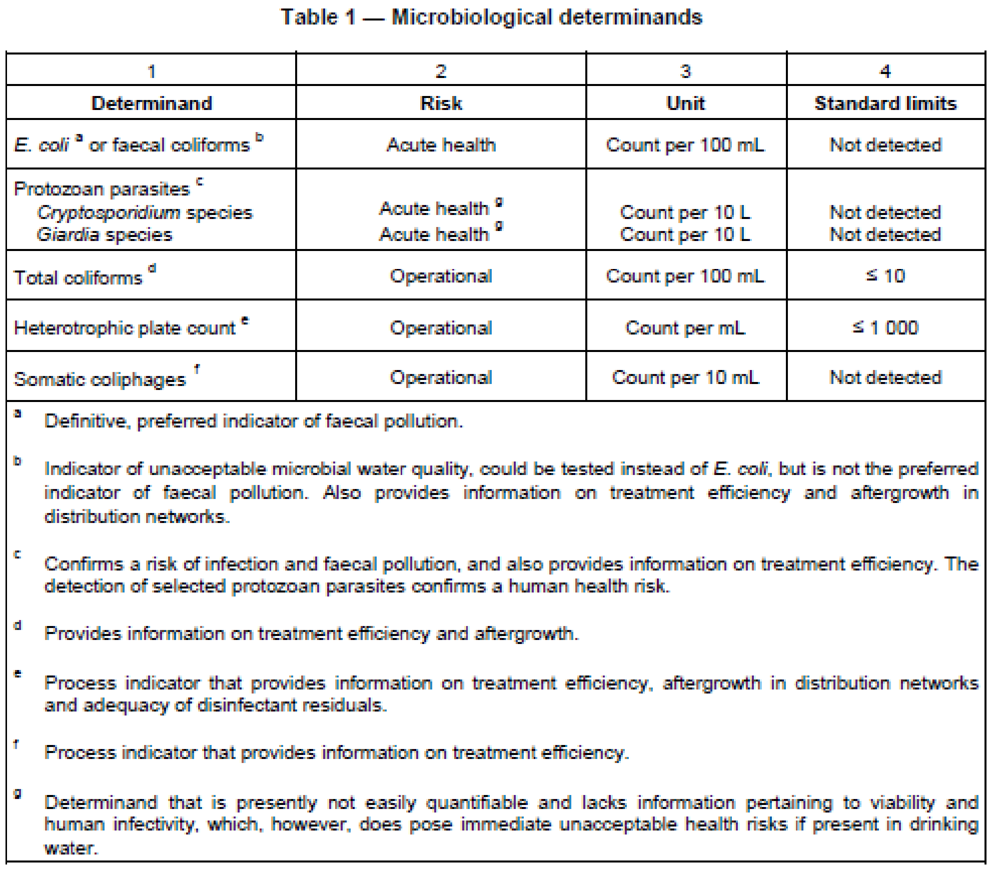


Table 1 — Microbiological determinands

1	2	3	4
Determinand	**Risk**	**Unit**	**Standard limits**
E. coli [a] or faecal coliforms [b]	Acute health	Count per 100 mL	Not detected
Protozoan parasites [c]			
Cryptosporidium species	Acute health [g]	Count per 10 L	Not detected
Giardia species	Acute health [g]	Count per 10 L	Not detected
Total coliforms [d]	Operational	Count per 100 mL	≤ 10
Heterotrophic plate count [e]	Operational	Count per mL	≤ 1 000
Somatic coliphages [f]	Operational	Count per 10 mL	Not detected

[a] Definitive, preferred indicator of faecal pollution.

[b] Indicator of unacceptable microbial water quality, could be tested instead of *E. coli*, but is not the preferred indicator of faecal pollution. Also provides information on treatment efficiency and aftergrowth in distribution networks.

[c] Confirms a risk of infection and faecal pollution, and also provides information on treatment efficiency. The detection of selected protozoan parasites confirms a human health risk.

[d] Provides information on treatment efficiency and aftergrowth.

[e] Process indicator that provides information on treatment efficiency, aftergrowth in distribution networks and adequacy of disinfectant residuals.

[f] Process indicator that provides information on treatment efficiency.

[g] Determinand that is presently not easily quantifiable and lacks information pertaining to viability and human infectivity, which, however, does pose immediate unacceptable health risks if present in drinking water.

Table 2.6 Physical, aesthetic, operational and chemical determinands (SANS 241-1: 2015)

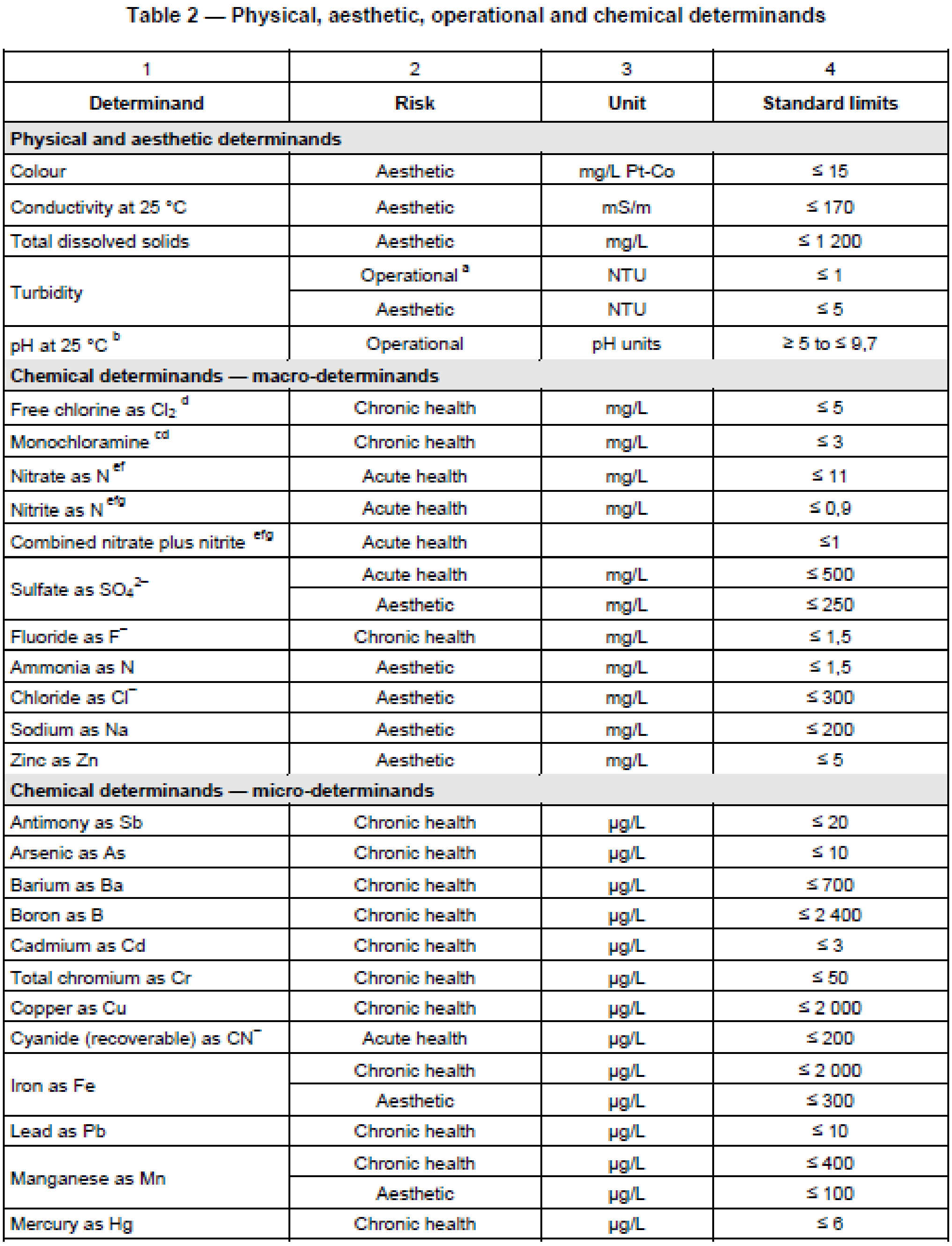
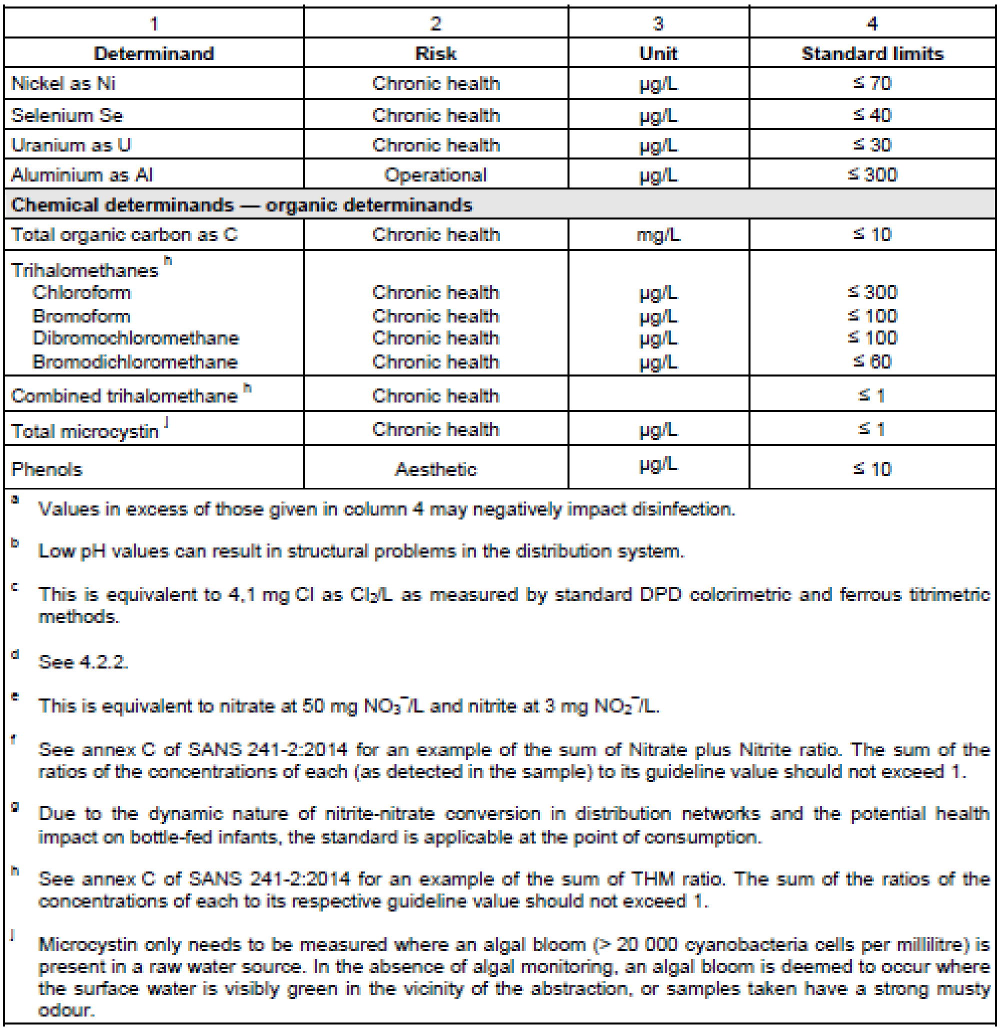


Table 2 — Physical, aesthetic, operational and chemical determinands

1	2	3	4
Determinand	**Risk**	**Unit**	**Standard limits**
Physical and aesthetic determinands			
Colour	Aesthetic	mg/L Pt-Co	≤ 15
Conductivity at 25 °C	Aesthetic	mS/m	≤ 170
Total dissolved solids	Aesthetic	mg/L	≤ 1 200
Turbidity	Operational [a]	NTU	≤ 1
	Aesthetic	NTU	≤ 5
pH at 25 °C [b]	Operational	pH units	≥ 5 to ≤ 9,7
Chemical determinands — macro-determinands			
Free chlorine as Cl_2 [d]	Chronic health	mg/L	≤ 5
Monochloramine [cd]	Chronic health	mg/L	≤ 3
Nitrate as N [ef]	Acute health	mg/L	≤ 11
Nitrite as N [efg]	Acute health	mg/L	≤ 0,9
Combined nitrate plus nitrite [efg]	Acute health		≤1
Sulfate as SO_4^{2-}	Acute health	mg/L	≤ 500
	Aesthetic	mg/L	≤ 250
Fluoride as F^-	Chronic health	mg/L	≤ 1,5
Ammonia as N	Aesthetic	mg/L	≤ 1,5
Chloride as Cl^-	Aesthetic	mg/L	≤ 300
Sodium as Na	Aesthetic	mg/L	≤ 200
Zinc as Zn	Aesthetic	mg/L	≤ 5
Chemical determinands — micro-determinands			
Antimony as Sb	Chronic health	µg/L	≤ 20
Arsenic as As	Chronic health	µg/L	≤ 10
Barium as Ba	Chronic health	µg/L	≤ 700
Boron as B	Chronic health	µg/L	≤ 2 400
Cadmium as Cd	Chronic health	µg/L	≤ 3
Total chromium as Cr	Chronic health	µg/L	≤ 50
Copper as Cu	Chronic health	µg/L	≤ 2 000
Cyanide (recoverable) as CN^-	Acute health	µg/L	≤ 200
Iron as Fe	Chronic health	µg/L	≤ 2 000
	Aesthetic	µg/L	≤ 300
Lead as Pb	Chronic health	µg/L	≤ 10
Manganese as Mn	Chronic health	µg/L	≤ 400
	Aesthetic	µg/L	≤ 100
Mercury as Hg	Chronic health	µg/L	≤ 6

Table 2 *(concluded)*



1	2	3	4
Determinand	**Risk**	**Unit**	**Standard limits**
Nickel as Ni	Chronic health	µg/L	≤ 70
Selenium Se	Chronic health	µg/L	≤ 40
Uranium as U	Chronic health	µg/L	≤ 30
Aluminium as Al	Operational	µg/L	≤ 300
Chemical determinands — organic determinands			
Total organic carbon as C	Chronic health	mg/L	≤ 10
Trihalomethanes [h] Chloroform Bromoform Dibromochloromethane Bromodichloromethane	 Chronic health Chronic health Chronic health Chronic health	 µg/L µg/L µg/L µg/L	 ≤ 300 ≤ 100 ≤ 100 ≤ 60
Combined trihalomethane [h]	Chronic health		≤ 1
Total microcystin [i]	Chronic health	µg/L	≤ 1
Phenols	Aesthetic	µg/L	≤ 10

[a] Values in excess of those given in column 4 may negatively impact disinfection.

[b] Low pH values can result in structural problems in the distribution system.

[c] This is equivalent to 4,1 mg Cl as Cl_2/L as measured by standard DPD colorimetric and ferrous titrimetric methods.

[d] See 4.2.2.

[e] This is equivalent to nitrate at 50 mg NO_3^-/L and nitrite at 3 mg NO_2^-/L.

[f] See annex C of SANS 241-2:2014 for an example of the sum of Nitrate plus Nitrite ratio. The sum of the ratios of the concentrations of each (as detected in the sample) to its guideline value should not exceed 1.

[g] Due to the dynamic nature of nitrite-nitrate conversion in distribution networks and the potential health impact on bottle-fed infants, the standard is applicable at the point of consumption.

[h] See annex C of SANS 241-2:2014 for an example of the sum of THM ratio. The sum of the ratios of the concentrations of each to its respective guideline value should not exceed 1.

[i] Microcystin only needs to be measured where an algal bloom (> 20 000 cyanobacteria cells per millilitre) is present in a raw water source. In the absence of algal monitoring, an algal bloom is deemed to occur where the surface water is visibly green in the vicinity of the abstraction, or samples taken have a strong musty odour.

2.4.5.4. Chemical Use and Storage

Bulk chemicals will be stored close to the point of use for each chemical in appropriately designed housing with easy truck access. The liquid chemical bulk storage facilities will be enclosed in a suitable chemical resistant bunded structure and protected from direct sunlight. All chemical tanks and chemical storage areas would be provided with containment provisions in accordance with the applicable codes and regulations, however, these areas would not be smaller than 110 % of the tank volume. Provision will be made for chemical bulk tank delivery, at a point close to the bulk storage tank and the fill point will be located within a contained area. In some instances splash and spray protection shields will be provided with safety showers and adequate ventilation and neutralisation facilities. Recommendations for the storage of dangerous goods and chemicals are provided in the EMPr (Part B of this Final EIA Report).

Provision will most probably made for the storage of chemicals for the ultimate size of the plant (150 Ml/day) to limit the footprint of the tanks (lesser number of tanks required) and infrastructure such as pumps that would be required.

Pilot Plant studies to determine what filter process configuration would be the optimum for the desalination plant still need to be undertaken. These details will determine the type of chemicals required and also the dosing rate requirements. Once this has been established, it will provide the volumes and types of chemicals required for on-site storage. Another factor that needs to be investigated is the percentage concentration of chemicals available in South Africa as well as the commercially delivered volumes of the different chemicals that are normally transported in South Africa to site. One wishes to have adequate storage volume on site to minimise frequent truck movement. These factors will have a major influence on the storage volume to be provided on site and will only be determined once the detailed design stage has been finalised.

The detailed feasibility study concluded that the proposed desalination plant would most likely use the following chemicals at the following possible locations:

- Intake:
    - Sodium hypochlorite (intermittent addition) – once every other day for 4 hours/day. This would be used to control bio-growth;
    - Sulphuric acid may be added every second week for 4 to 6 hours per day (following chlorination) to periodically remove shellfish growth from the intake piping.

- Pre-filtration System:
    - Ferric chloride – continuous addition upstream of the pre-filtration system to coagulate particles in the water for enhanced removal;
    - Polymer – continuous addition upstream of the pre-filtration system and downstream of the point of coagulant addition to enlarge the size of the coagulated particles for more efficient removal;
    - Sulphuric acid – continuous addition upstream of the pre-filtration system to enhance coagulation by pH adjustment as coagulation efficiency is a function of pH.

- RO System – Feed Water Conditioning:

The following chemicals would be added upstream of the RO system and downstream of the plant cartridge filters:

- Sodium bisulphite – to neutralize the oxidizing effect of chlorine (sodium hypochlorite) remaining in the pre-treated sea water after its addition at the intake;
- Antiscalant to prevent the formation of mineral scale on the RO membrane elements;
- Sodium hydroxide to increase the pH of the feed water to the SWRO to approximately 8.8 in order to enhance removal of boron from the sea water; and
- If a second pass RO system is installed then sodium hydroxide would also be added continuously to the feed water of the second pass RO system (i.e. permeate from the first pass RO system), in order to achieve additional boron removal as needed.

- RO System Cleaning:
    - Every one of the SWRO membrane trains would also need to be cleaned, once every two to four months, using a clean-in-place procedure. Membrane cleaning would involve low pH cleaning with citric acid and high pH cleaning with sodium hydroxide and commercial soap cleaning as per the recommendations of the SWRO membrane supplier.

- RO System Permeate Conditioning:
    - Lime and carbon dioxide would be added to the permeate in order to provide adequate alkalinity and hardness of the finished water.

- Chlorine and possibly aqueous ammonia solutions would be fed to the permeate downstream of the points of lime and carbon dioxide addition to disinfect the finished water.
- Sodium hydroxide would be added to the finished water as needed to maintain the target alkalinity and pH of the finished water and to control corrosion.

An estimate of chemical use and storage has been prepared for an average annual plant fresh water production flow of 150 Ml/d, a single pass RO system recovery of 45 %; and total volume of waste pre-treatment streams equal to 10 % of the total plant intake flow:

- Sulphuric Acid = 2 tanks each with a volume of 10 m^3
- Caustic Soda = 2 tanks each with a volume of 5 m^3
- Sodium Bisulphite = 1 tank with a volume of 5 m^3
- Ferric Chloride = 2 tanks each with a volume of 10 m^3
- PolyDADMAC = 1 tank with a volume of 1.5 m^3
- Sodium Hypochlorite = 2 tanks each with a volume of 5 m^3
- Ammonia = 1 tank with a volume of 5 m^3
- Antiscalant = 2 tanks each with a volume of 1 m^3
- Citric Acid = 1 tank with a volume of 5 m^3
- Hydrochloric acid = 1 tank with a volume of 2.5 m^3

It is important to note that similar chemicals will be based on the Pilot Plant filtration trials to be conducted for at least 12 months. It should also be noted that the above list and quantities might change after Pilot Plant data becomes available.

2.4.6. Marine Outfall

2.4.6.1. Brine Management

There are two broad categories of brine outfall structures which can be used, namely, rosette-style diffusers which consist of several outfall risers above the seafloor with a small number of nozzles attached to each riser and pipeline-style diffusers which consist of nozzles arranged along a pipe instead of a rosette. All large Australian SWRO projects including Victoria (550 Ml/day), Sydney (500 Ml/day), Perth (144 Ml/day) and Gold Coast (133 Ml/day) plants - in use or proposed - are set to use one of the above mentioned diffuser systems (Lattemann, 2010).

The discharge design primarily influences the mixing behaviour in the near-field region, which extends up to a few hundred meters away from the outfall location. In the near-field, a velocity discontinuity between the effluent and the ambient flow arises from initial momentum flux and buoyancy flux of the effluent. It causes turbulent mixing, which leads to entrainment of seawater and thereby decrease differences in salinity, temperature or residual chemicals between the effluent and ambient water body. With such a design, a salinity level of one psu above background levels can be achieved at the edge of the near-field mixing zone[1] (Lattemann, 2010).

A brine discharge system will convey brine from the proposed desalination plant back to the sea via a single pipeline which is projected to extend at least 800 m offshore from the pump station. Brine is negatively buoyant and will generally sink towards the seabed. The brine discharge outlet is planned

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[1] A mixing zone is the area around an effluent discharge point where the effluent is actively diluted with the water of the receiving environment.

to be located at a depth of -10 m to -12 m to MSL and 300 m away and towards the shore from the proposed plant intake to ensure that adequate dilutions are obtained and to avoid short-circuiting of higher salinity concentrations at the intake system. Potential recirculation of the brine into the intake was assessed from the model results and found to be very low, with typical salinity increases of between 0 and 0.25 ppt above ambient.

The outfall pipeline will be equipped with diffusers for accelerated dilution of the concentrate. The diffuser will consist of an approximately 60 m long HDPE pipe with multiple outlet ports/nozzles (i.e. multiport diffuser) that disperse the brine upward into the water column over a relatively large area to facilitate the dispersed release of the brine and to minimise impacts on the marine ecology. To ensure optimum dilution in the near-field, it is envisaged that the nozzles would be configured to discharge at a high velocity and at an angle of 60° above horizontal. The brine will be dispersed in ambient seawater in a moving current and at a rate which will depend on the diffuser design and the current velocity. Based on the detailed feasibility study, the discharge would be disposed at a velocity of 3 to 4m/s, which would allow almost complete dispersion of the plant concentrate into the ambient sea water within a short distance from the diffusers.

The brine effluent at design capacity is anticipated to have approximately 1.5°C temperature elevation above the average background temperature of seawater and a salinity of approximately 1.6 times the salinity of seawater (i.e. approximately 58 psu). The brine discharge will be up to about 3 000 litres/second depending on the number of the desalination plant trains that are in operation.

The "plume" of higher salinity would be distributed in an along-shore direction, as this is the prevailing current direction, as well as seaward. The modelling results indicate that salinity increases are greatest near the bottom, generally exceeding 0.6 ppt above ambient for 1% of the time only in proximity of the diffuser. A level of 1 ppt above ambient is reached only for the minimum discharge case. This is due to the fact that under the minimum discharge case, the resulting brine flow velocity through the diffuser is very low which in turn inhibits the dispersion of the plume. The plant outfall design is such that it is located sufficiently far from the intake to avoid short-circuiting (intake of elevated salinity). At a distance of 30 m from the diffuser (affected area amounts to 0.004 km^2), the 1% exceedance of salinity reduces to less than 1 ppt above ambient conditions. The maximum salinity footprints at the seabed where the salinity exceeded ambient conditions by 0.5 psu was 0.165 km^2.

The modelling results also indicated that persistent elevated salinities not exceeding 36.5 ppt (or 1 ppt above ambient) at the seabed are localised to within <50 m of the diffuser at depths between -5 m to -15 m.

Based on the detailed feasibility study, the outfall would be capable of discharging the entire volume of the source water collected by the intake system via a cross connection to the delivery system.

Figure 2-12: Brine nozzle discharge from Australian SWRO plant with the addition of a red dye (rhodamine) to indicate dispersion for the monitoring process

2.4.6.2. Waste Management

In general, the discharges from a desalination plant would include, as shown in Figure 2.13 below:

- concentrate (brine) from the SWRO membrane system;
- treated waste streams originating from the DAF clarifier (if such clarifier is used);
- spent backwash water from the pre-treatment system; and
- RO and spent (used) membrane cleaning solution, and post-flush water generated during CIP (cleaning in place)
- filter-to-waste water; and
- sludge from lime clarifiers (if lime is used for potabilisation purposes).

During the detailed feasibility study, it was established that the preferred waste stream option for full-scale project implementation is the disposal at sea of all desalination plant waste streams after their equalization and neutralization in the discharge retention tank and subsequent blending with the desalination plant concentrate (brine). This would amount to a maximum of 257 Ml/day discharged at sea and will eliminate the need for sludge and associated solid waste disposal to a landfill.

The brine may also contain an organic scale inhibitor which will be an approved chemical for potable water systems and will be bio-degradable.

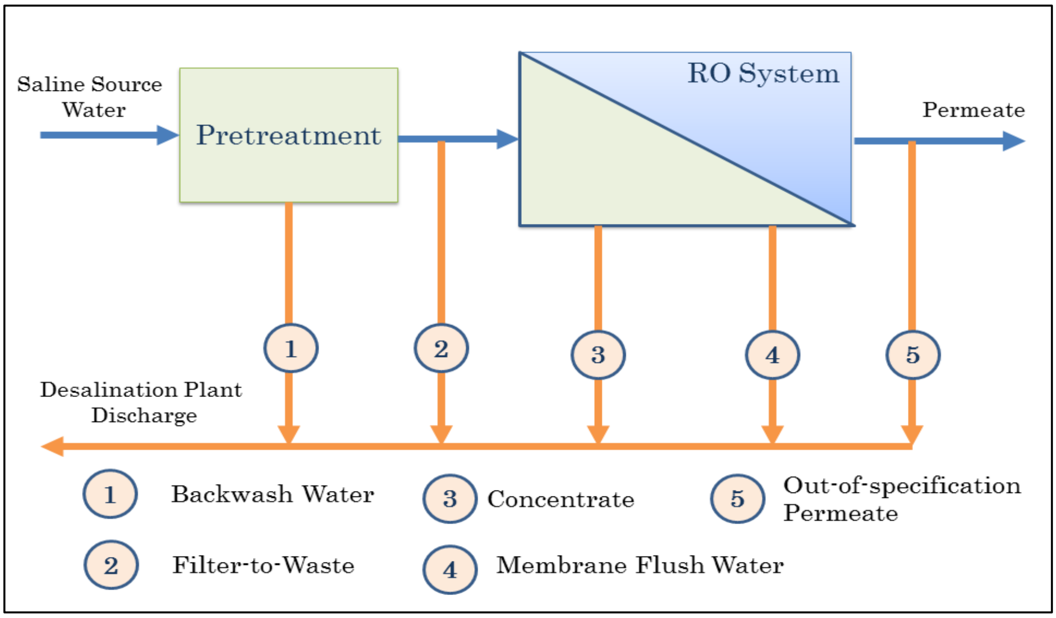


Figure 2-13: Typical Waste Streams likely to be generated at the proposed Desalination Plant

The cleaning of each RO train is expected to be undertaken three times per year and will generate approximately 380 Ml of cleaning solution and rinse water per train. The maximum expected volume of cleaning solution and rinse water for the RO unit will be approximately 11 400 Ml/year. This will depend on the quality of the raw seawater feed.

The maximum expected volume of backwash, chemically enhanced backwash, cleaning solutions and rinse water for the pre-treatment membrane filtration system is expected to average 26 Ml/day or 9 490 Ml/year on a continuous basis. More than 99% of this volume will be seawater (same quality as the abstracted seawater) and will be disposed of with the brine whilst the balance would have small amounts of chemicals in it. These volumes can be taken as maximum volumes and are based on the ultimate capacity of 150 Ml/day and will depend on the equipment supplier and exact volumes and composition.

These streams of chemicals will be mixed with the DAF sludge (if required) in a concrete retention tank fitted with mechanical mixers or recirculation pumps, and from this tank the stream will be pumped continuously to the outfall pipe where it will be blended with the brine prior to discharge to the ocean. This tank will also be equipped with feed lines for sodium hydroxide, hydrochloric acid and sodium bisulphite to adjust the water quality in the tank in order to meet the discharge requirement specifications. The sludge will consist of the naturally occurring constituents of the sea, such as clay, sand, and microscopic marine biota such as algae. Normally the DAF and lime treatment sludge is combined to produce a neutral pH sludge that can easily be disposed of through co-discharge with brine back to the marine environment.

It is likely that the use of a biocide will be required to inhibit biological growth in the pipelines and on the screens. If sodium hypochlorite is used, this needs to be neutralised with sodium metabisulphite (SMBS) before the feed water enters the RO membranes as the chlorine damages the membranes. Hence, the brine stream is not anticipated to contain any active biocide. In addition, there are recent developments in biocide technology and it may be the case that when the plant would be put into operation in about 2020, more environmentally friendly biocides might exist for use on the membranes that will not affect the marine environment to any significant extent.

Table 2.7 below provides a summary of the anticipated discharge water quality. More precise volumes will be established once the Pilot Plant has been in operation for an extended period of time.

Table 2-7: Anticipated Discharge Water Quality

Parameter	Tongaat Site	
	Design Min Value	Design Max Value
Salinity (ppm)	Within 10 % of Ambient Sea water Salinity at 300 meters from the Point of Discharge.	
Residual Chlorine	<0.1	<0.1
pH (units)	6.0	8.8
Floating Particles Above Ambient Sea water	None	None
Temperature (°C)	< 3	< 3
Above Ambient Sea water	4.0	Not Applicable
Dissolved Oxygen (DO), mg/l	8	90
Total Suspended Solids, mg/L	2	10
Turbidity, NTU	< 1.0 mg/L	< 1.0 mg/L
Nitrates, mg/l	< 1.0 mg/L	< 1.0 mg/L

It is also important to note that small amounts of solid waste would be generated periodically (once every 3 to 4 weeks) from the operation of the plant intake screens. The amount of screenings generated per month is expected to vary between 20 and 100 kg/month. These screenings would typically be disposed of at a landfill site once or twice per month. The solid waste would include plant cartridge filters and membrane elements.

During the operations, minimal amount of onsite sewerage will also be generated and is proposed to be treated on-site in a septic tank or package plant system. Sewage will be reticulated to the local sewage network and if this cannot manage the capacity then a sewage package plant will be developed on site. Umgeni Water will either contract with a refuse removal company to remove refuse from site or will use its own capacity to remove the refuse and take it to the nearest landfill site.

In terms of policy, legislation and practice of South Africa's Operational Policy for the Disposal of Land-derived Wastewater to the Marine Environment (DWAF 2004) is of relevance. Specifically, environmental quality objectives need to be set for the marine environment, based on the requirements of the site-specific marine ecosystems, as well as other designated beneficial uses (both existing and future) of the receiving environment.

To ensure that environmental quality objectives are practical and effective management tools, they need to be set in terms of measurable target values, or ranges for specific water column and sediment parameters, or in terms of the abundance and diversity of biotic components. The South African Water Quality Guidelines for Coastal Marine Waters (DWAF, 1995) provide recommended target values (as opposed to standards) for a range of substances.

2.4.6.3. Potable Water Management

Potable water will be supplied at an initial rate of 120 Ml/day from the proposed desalination plant to a 37.5 Ml above ground reservoir at the operational site. It is proposed to duplicate this reservoir in future when a capacity upgrade for the treatment plant is done. From the reservoir, a pump station and a pipeline will be constructed to transfer potable water to the existing bulk water pipeline located approximately 5 km from the proposed desalination plant site. During normal operation all water will be obtained from the sea. In the event of an emergency (e.g. fire-fighting), the water supply will be obtained from the storage reservoir on site.

The proposed Tongaat facility would initially supply water to eThekwini Municipality's Northern Aqueduct via Waterloo Reservoir from where the water would be pumped into the Northern Aqueduct. As the demand of Umgeni Water's North Coast Supply System increases and exceeds the supply from the raised Hazelmere Dam and from the Lower Thukela Bulk Water Supply Scheme, the supply to the North Coast from the desalination plant would be increased by delivering water to the Avondale Reservoir (as shown in Figure 2.14).

The proposed pipeline route is defined and assessed as a 50 m wide corridor to allow for variation in the final engineering survey and design.

Figure 2.14 shows the pipelines that are proposed to integrate the Tongaat Desalination Plant into Umgeni Water's North Coast supply system.

- Initially water would be supplied to eThekwini Municipality's Northern Aqueduct via Waterloo Reservoir from where the water would be pumped into the Northern Aqueduct. Flow in the Northern Aqueduct would be reversed to supply the demands of the areas served by this pipeline. This would relieve the demands on both the Hazelmere and Durban Heights Water Treatment Plants.
- As the demand of Umgeni Water's North Coast Supply System increases and exceeds the supply from the raised Hazelmere Dam and from the Lower Thukela Bulk Water Supply Scheme, the supply to the North Coast from the desalination plant would be increased by delivering water to the Avondale Reservoir.

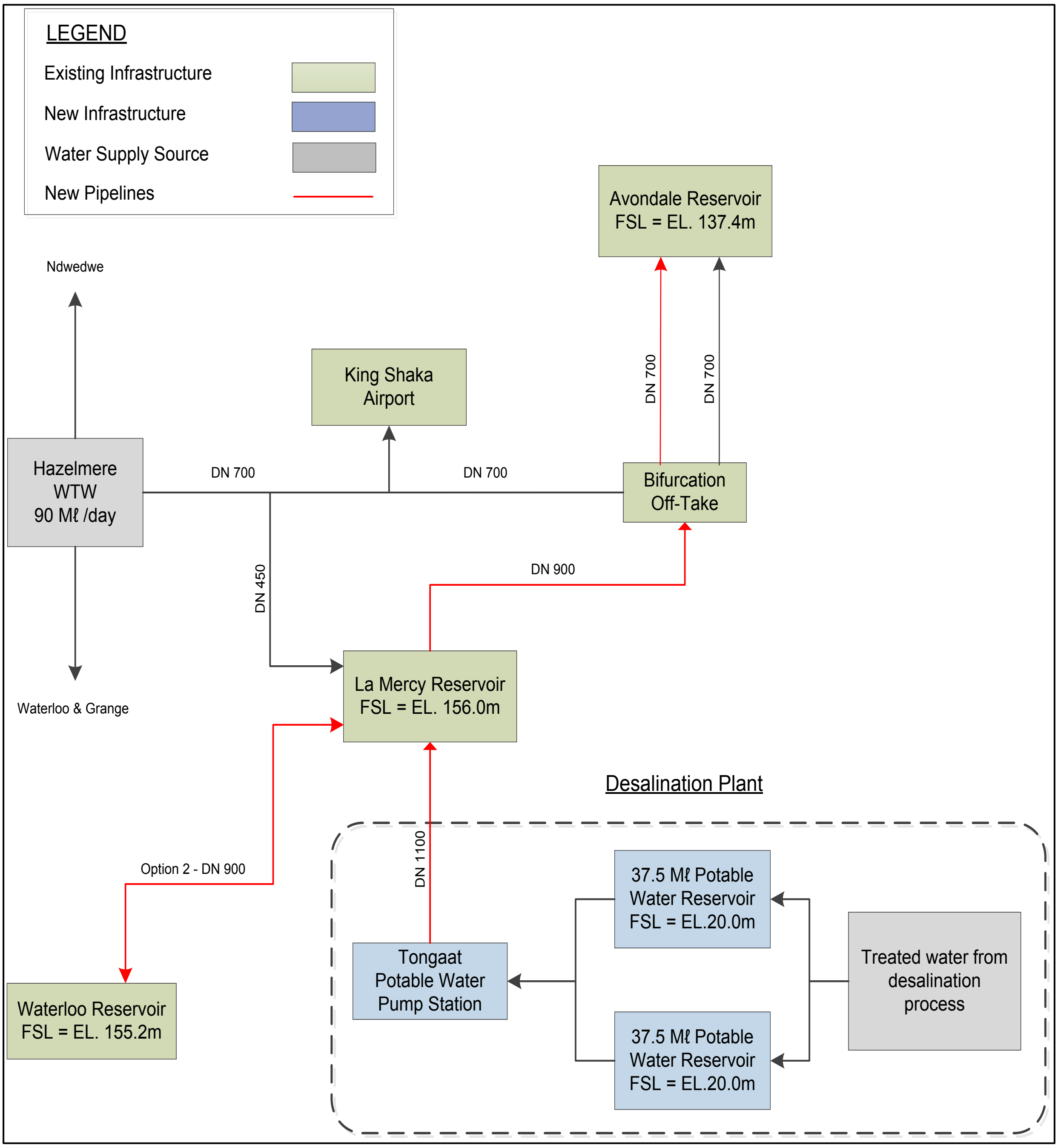


Figure 2.14: Distribution of Water from the Proposed Tongaat Desalination Plant. Note that the new pipeline from the Bifucation to the Avondale Reservoir is not part of this scope of work

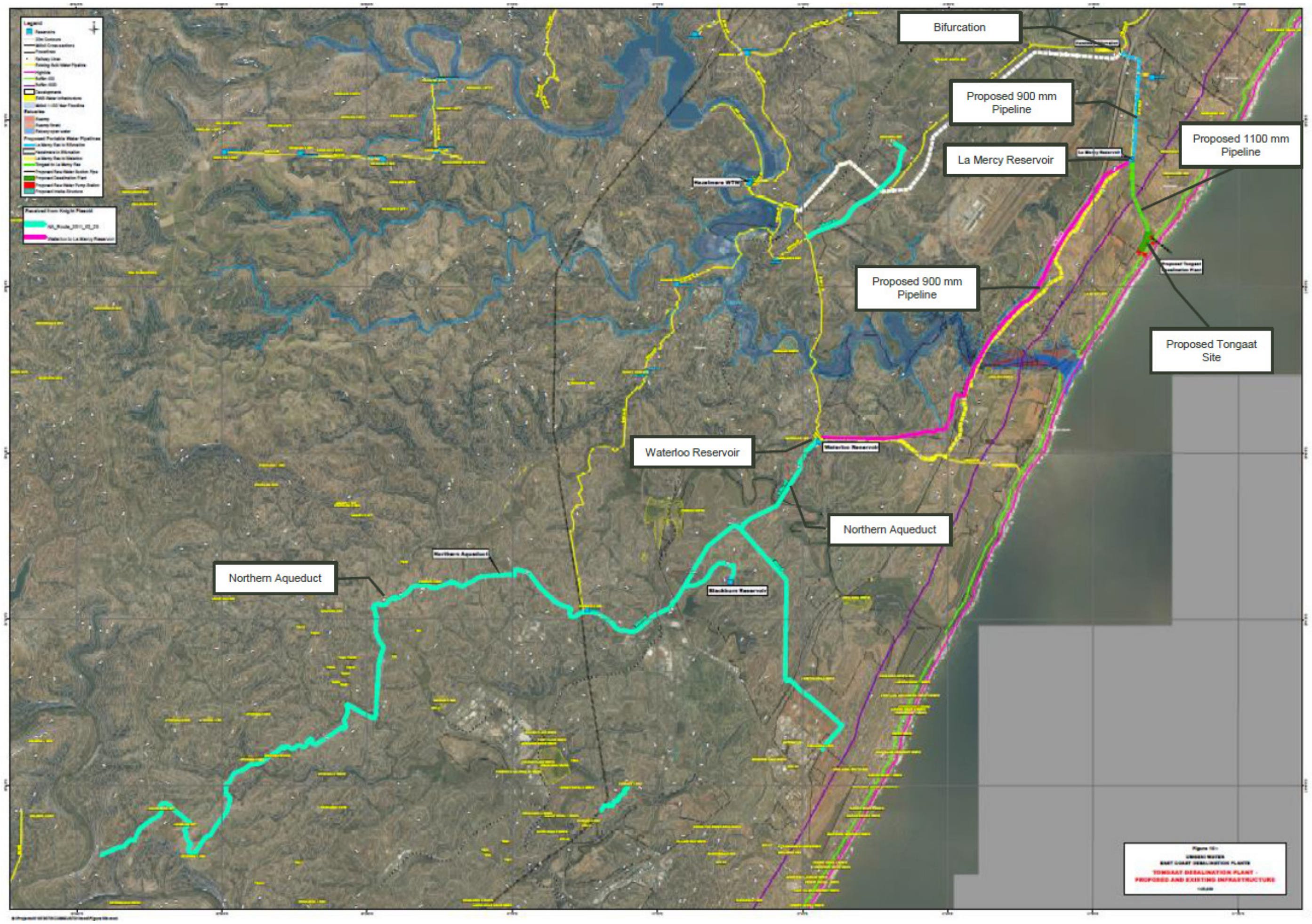


Figure 2-15: Location of Proposed Tongaat Desalination Plant and of Existing and Proposed Pipeline Infrastructure

Re-alignment of the proposed potable water pipeline

The aquatic ecology specialist study has recommended a number of shifts in the potable water pipeline routing to avoid/minimise impacts on wetlands and watercourses. Refer to the Aquatic ecology study (Chapter 8) for further details. Figure 2.16 below shows the proposed final alignment (Green) for the potable water pipeline.

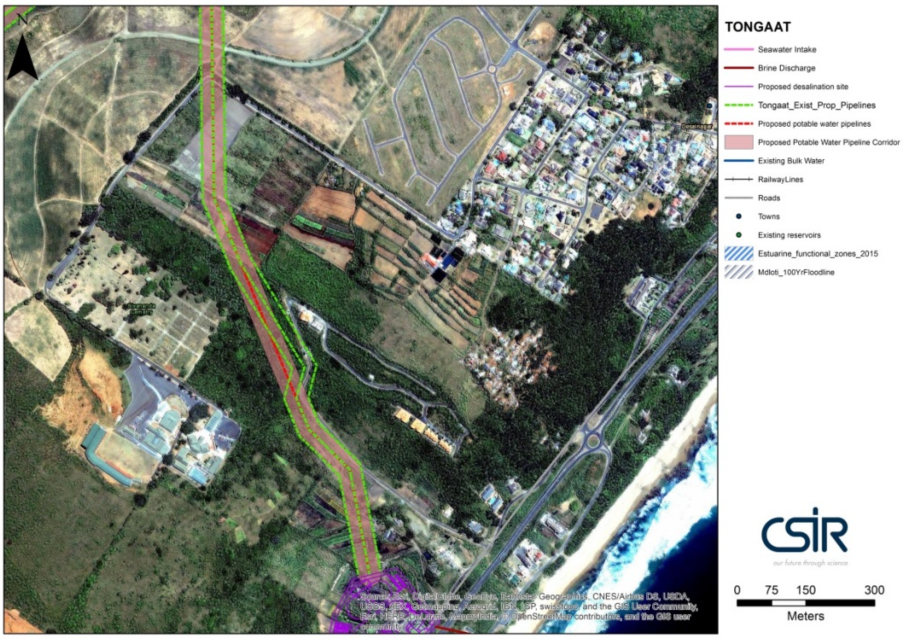


Figure 2-16: Proposed amendments to the proposed potable water pipeline (Red – Original route and Green – amended route)

2.4.7. Auxiliary Infrastructure

The Tongaat Desalination Plant is situation near to the town of Desainagar. Services such as sewage, waste removal, electricity etc. for that area are provided by eThekwini Metro. eThekwini Metro are a partner in this proposed project and hence are amenable to managing these services where possible.

2.4.7.1. Electrical infrastructure

The 150 Ml/day SWRO desalination plant is anticipated to have a total energy demand of approximately 32MW (i.e. approximately 4 kWh/m^3 of potable water produced, while additional power will be required to pump water to the plant from the sea and to deliver potable water to the bulk supply infrastructure). It is expected that the total electrical connection to the 150 Ml/day plant would be approximately 40 MVA. Power supplied to the proposed desalination plant would be via a substation with a 132 kVA transmission stepped-down to 11 kVA. As noted above, energy recovery devices are planned to be installed as part of the SWRO system.

The extent of energy required for the proposed desalination plant will be sourced from Eskom's national electricity grid. eThekwini Electricity has indicated that electricity supply for the Tongaat site would be available for the proposed project; however, written request will need to be submitted by Umgeni Water for the connection.

Connection to High Voltage Electrical Grid:

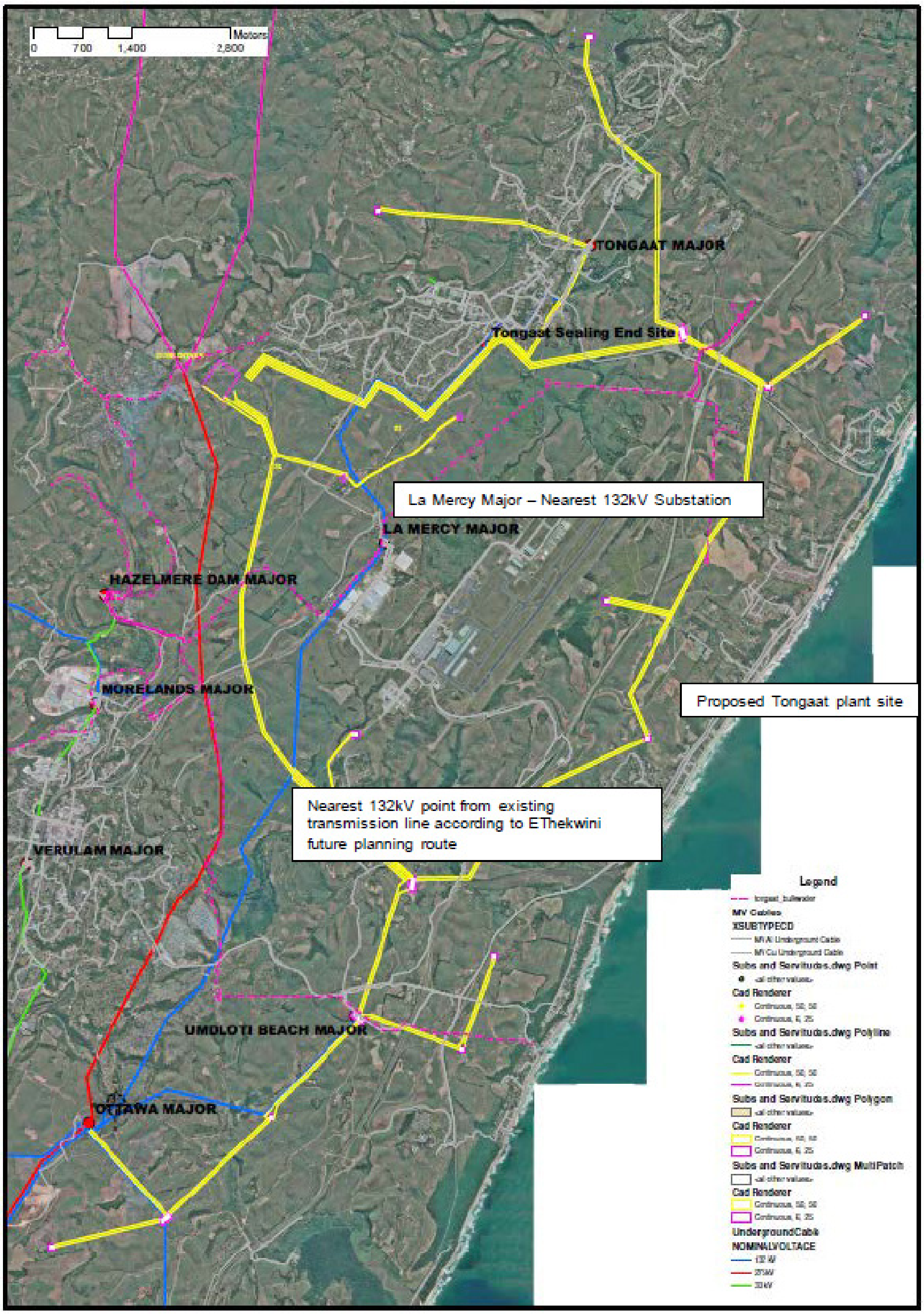
- If the supply to the proposed development is coincided with eThekwini's future development in the area (refer to Figure 2-17), then a 132kV point of supply would be available within 1km from the proposed Tongaat site. In this case, Umgeni would construct a transmission line from the latter point of supply to the proposed desalination plant (as shown in Figure 2.18).
- In the event, however, that supply to the proposed desalination plant precedes eThekwini electrical infrastructure expansion, Umgeni would construct a single-circuit 132 kV transmission line from the nearest 132 kV point of supply (i.e. which is the supply from the La Mercy Major Substation located approximately 5 km from the proposed site, on the western side of King Shaka international airport) to the proposed desalination plant site. Where possible, Umgeni intends to follow the route proposed by eThekwini as part of their electrical infrastructure expansion (as shown in Figure 2.18).

Note: The "transmission line route" is defined as a 200 m corridor (i.e. 100 m each side of the proposed alignment), with the exception of the section of transmission line along the N2 which is a 50m wide corridor given the presence of a number of drainage lines, to allow for variation in the final engineering survey and design. "Powerline" and "transmission line" are used interchangeably in this report.

- A 132 kV to 11 kV step-down substation will be constructed at the proposed plant site (i.e. to reduce the voltage to 11 kV). The substation will include transformers and associated motor control centres (MCCs), which will be located in the vicinity of the equipment they service. All MCCs would be installed in ventilated buildings.
- 30 MVA bulk supply point at 11 kV.
- A 11 kV line from the sub-station to the pump station.
- The proposed transmission line will consist of lattice towers and pile type foundations and the average spans would usually be 300 – 400 m, but can go over 600m depending on the lay of the land.

eThekwini Electricity has however indicated that a supply at the Tongaat site has some challenges to it as the La Mercy Major substation is located on the west side of the King Shaka International airport and obtaining way leaves and a servitude for the 132kV transmission line to the proposed site may be problematic.

There are currently no alternative/renewable energy generation plants in the vicinity of the proposed desalination plant site. The only successful alternative energy plants operated in the eThekwini municipal area are those generating energy from the burning of natural gas at waste sites, however these are located a significant distance from the proposed desalination plant site and can only feed into their surrounding local grid. However, it is worth noting that South Arica's energy policy clearly shows a commitment to an increased percentage of power generation from renewable energy sources, such as wind, solar photovoltaic and hydro. Over the past 4 years, as part of the REI4P programme, 92 renewable energy projects power projects approved by the Department of Energy with a generation capacity of 6327 MW; and 3725 MW commissioned by early 2016.

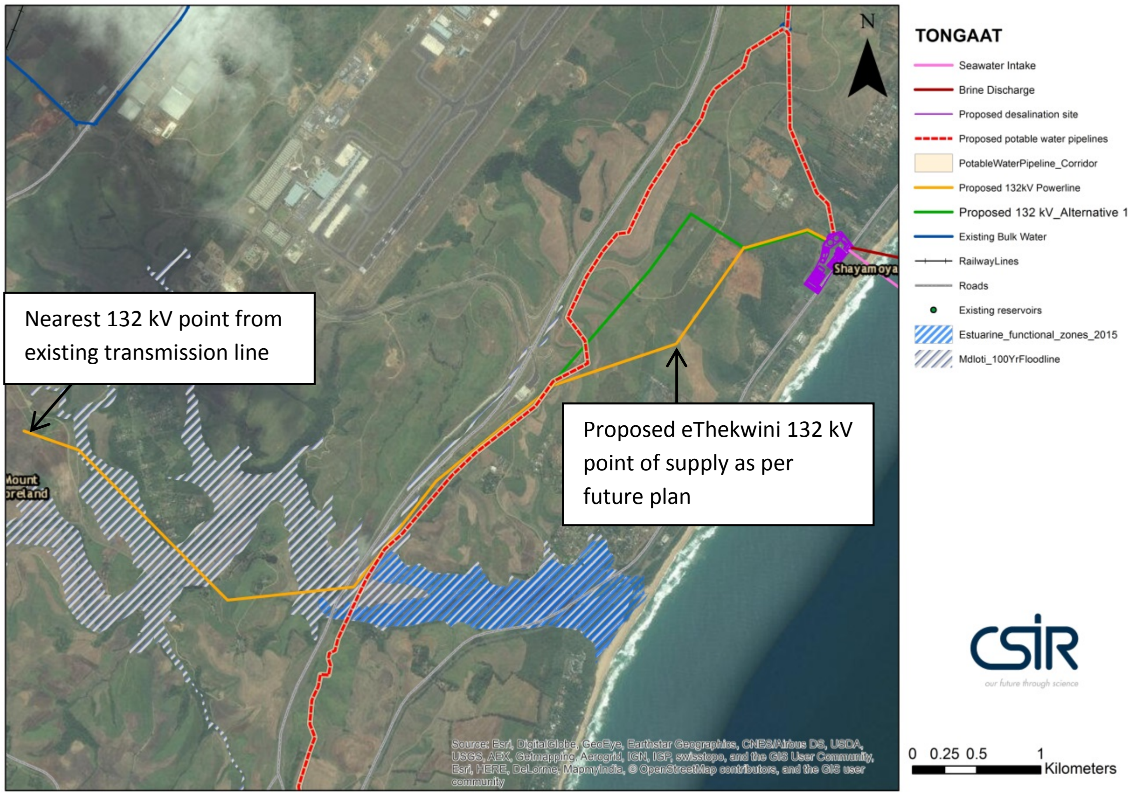


La Mercy Major – Nearest 132kV Substation

Proposed Tongaat plant site

Nearest 132kV point from existing transmission line according to EThekwini future planning route

Figure 2-17: Proposed eThekwini future electrical infrastructure expansion (yellow)



Nearest 132 kV point from existing transmission line

Proposed eThekwini 132 kV point of supply as per future plan

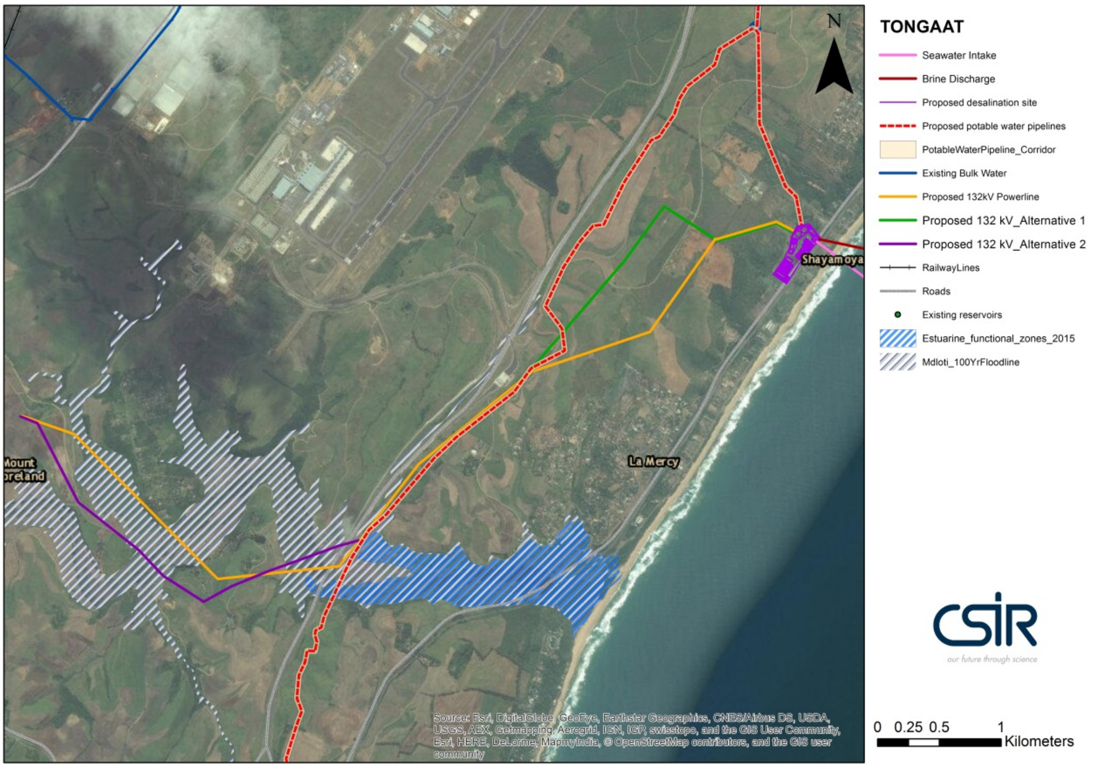
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community, Esri, HERE, DeLorme, MapmyIndia, © OpenStreetMap contributors, and the GIS user community

Figure 2-18: Proposed Bulk Electrical Infrastructure for the proposed Desalination Plant

Re-alignment of the proposed 132kV transmission line

The proposed crossing of the Mount Moreland wetland by the proposed 132 kV transmission line has been assessed by the aquatic ecology specialist study as an outright no-go proposition, and no offset mitigation would compensate for its authorization. Passage of the proposed transmission line across the wetland was therefore considered a fatally flawed impact. An alternative route (Alternative 2) has been proposed, that would avoid the important wetland areas (refer to Figure 2.19). Refer to the Aquatic ecology specialist study for further details (Chapter 8).

In addition, the power line route passes in close proximity to La Mercy residential areas. Given that there are currently no transmission lines or large substations in the coastal corridor between Ohlanga and Tongati Rivers, the proposed transmission lines is anticipated to affect many views along the route and is likely to affect future potential for scenic views of the sea in the coastal corridor. The Visual impact assessment specialist study (Chapter 10) has therefore recommended that the final route for the powerline avoids crossing over hills near La Mercy and uses topography to screen the powerline from residents of La Mercy where possible. Figure 2.19 shows an alternative route (Alternative 1) assessed as part of the proposed development to minimise impacts on La Mercy residents.



Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community, Esri, HERE, DeLorme, MapmyIndia, © OpenStreetMap contributors, and the GIS user community

Figure 2-19: Amended (purple) route for the proposed transmission lines for the proposed Desalination Plant

2.4.7.2. Proposed Plant Layout

Engineering analyses and evaluations of the surface and subsurface conditions and of plant configurations (during the detailed feasibility studies) show that the selected Tongaat site is suitable for the construction of the 150 Ml/day desalination plant. The proposed layout of the Tongaat desalination plant is shown in Figure 2.20 below.

A typical layout of a large scale desalination plant is also shown in Figure 2.21 below.

1: Raw Water Pump Station
2-3: Dissolved Air Flotation
4: Gravity Filter
5-8: RO Building
9: Limestone Contactors
10: Contactors Tower
11: Treated Water Tank
12: Treated Water Pump Station
13-14: Chemical Storage
15-16: Ultra Filtration Backwash
17-19: Retention Tanks
20: Electrical Substation
21: Transformer
22: Administration Building
23: Effluent Treatment
24: Silos

Figure 2-20: Proposed Layout of the Tongaat Desalination Plant

Figure 2-21a: Typical layout of a large SWRO desalination plant

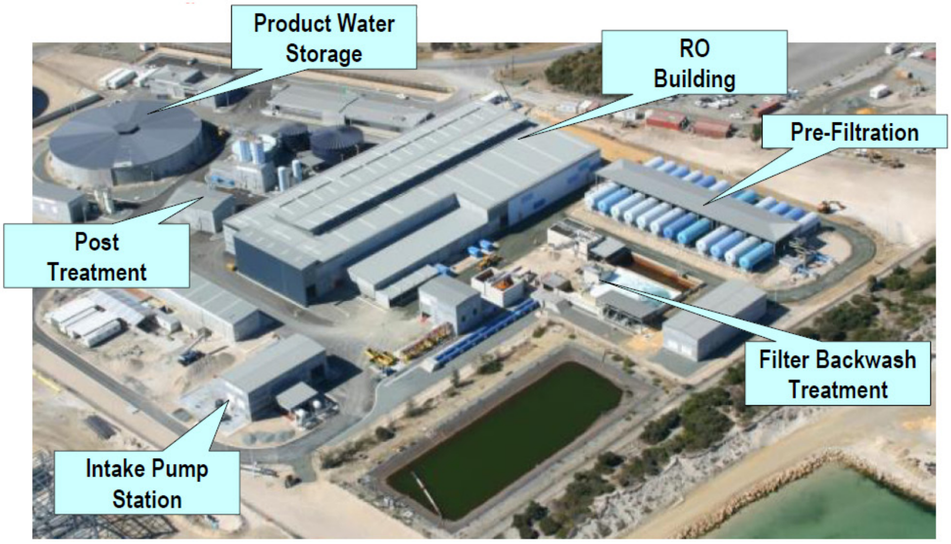


Figure 2-21b: Typical layout of a large SWRO desalination plant

The Tongaat desalination plant is planned to include the following service features and buildings during the operational phase:

- **RO System Building**: The RO system building would be designed to house all SWRO membrane trains, the energy recovery system, the electrical substation, the motor control centre, local instrumentation and controls, and service facilities (pumps, compressors, etc.). The cartridge filters would also be installed in the RO building. The building would be designed to reduce the noise generated by the RO system pumps and energy recovery devices to acceptable levels.

- **Chemical Storage Area**: As described in Section 2.4.4.4 of this chapter.

- **Electrical Substation:** As described in Section 2.4.6 of this chapter.

- **Administration Building:** A plant administration building will be constructed at the proposed desalination plant. The building will include all proposed administrative, control, laboratory and maintenance functions associated with the operation of the desalination plant. The key treatment facilities would have local control panels located near them at the desalination plant site as well as restroom facilities for the operators. This site will also accommodate all chemical storage and feed systems.

- **General Service Areas:** All roads and parking areas would be paved. The road geometry would allow ready access for the large trucks expected to make bulk deliveries to the plant. Landscaping and an associated irrigation system would be provided around the RO building.

- **Ancillary and Support Facilities:** The following systems are included in the ancillary and support facilities:
  - Service air;
  - Instrument air;
  - Fire protection;
  - Chemical treatment systems;
  - Potable water;
  - Service water; and
  - Membrane flush.

It is important to note that in terms of fire protection measures, water treatment plant equipment, concrete floors and metal building frame and walls would not constitute a fire hazard. However, a fire protection sprinkler system would be provided in accordance with the requirements of all applicable building codes.

In terms of the RO membranes, to ensure that they are flushed after each shutdown, a low TDS membrane flush system would be installed. Equipment will include flush pumps, a flush tank, and hard piping to each train.

Potable water would be provided to the restrooms, locker room and break room of the proposed desalination plant for all operational staff. This water will be supplied from the produced water tanks. Because of the small anticipated use of service water, potable water would also be used for general use. It is anticipated that a cross connection would be made to the RO product water for emergency backup.

In terms of road access, existing roads will be used to gain access to the general area of the proposed site; however a small access road and internal roads are required to be constructed. A new access link road will be required from the existing South Dune road onto the desalination plant. The need to upgrade the existing roads is currently being investigated, however it is anticipated that the South Dune road will need to be widened on approximately 1 km, from the circle to the proposed desalination plant site. This will mostly be for pipes, valves, topsoil, road layer materials (possibly) and other pre-fabricated items such as concrete cladding etc. After construction, the disturbed area outside the site will be reinstated with indigenous vegetation using the topsoil from the area. It is also understood that a ring road will be constructed along the border of the proposed desalination site (approximately 1 290m). The access road, ring road and internal roads (as well as a hard stand area within the middle of the plant extending approximately 18 470 m^2) will require a surfaced pavement. An approximate estimation of the access roads and pavement surface areas are shown in Figures 2.22 and 2.23 below.

Figure 2-22: Proposed Access Road for the Tongaat Desalination Plant

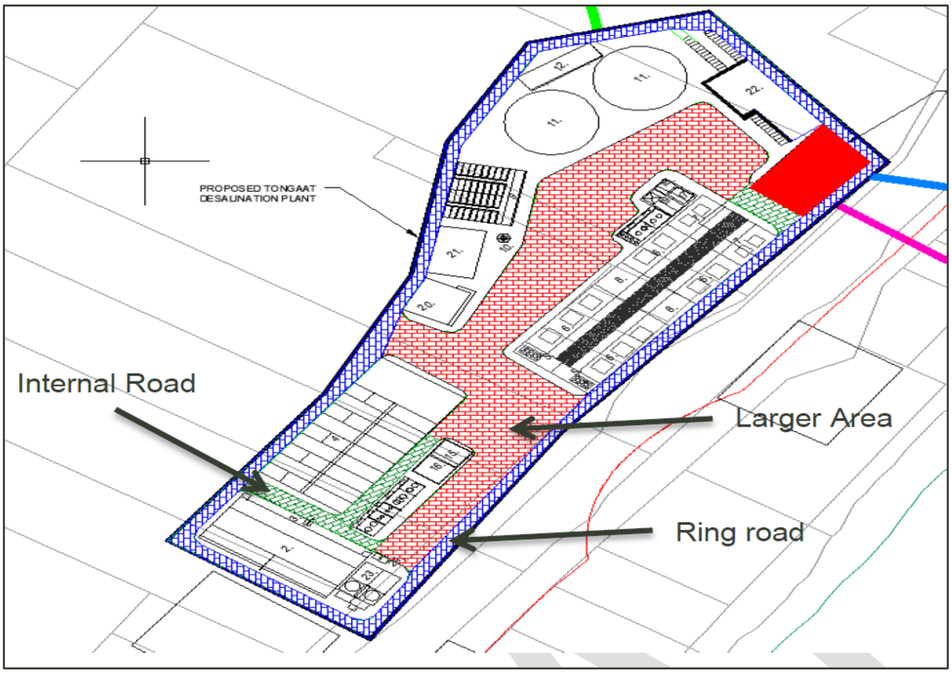


Figure 2-23: Proposed Internal Roads for the Tongaat Desalination Plant

2.5.PROJECT ACTIVITIES

2.5.1. Construction

The construction will be confined to the 7 ha site (i.e. footprint area of the desalination plant), the pipeline route, the electrical power supply infrastructure and the access roads.

For the proposed desalination plant site, where required, a level platform would be created by means of a balanced cut to fill, in order to minimise any imported or wasted material. Any excavated material which cannot be used for fill will be disposed of off-site in an environmentally manner. No infilling of watercourses will be necessary at the desalination plant site at Tongaat.

In general, the details with regards to rivers and wetlands crossing would be finalised during detail design due to the construction considerations that needs to be taken into account such as:

- Final geotechnical results
- Vertical drilling plan of contractor with respect to applicable pipe diameter, bending radius and length of drill
- Final horizontal alignment
- Scour levels of the river being crossed

For the purposes of the study the following would apply for any river, wetlands and estuary crossings:

1. Where possible, pipelines will be laid using trenching.
2. Trenchless technologies such as pipe jacking and horizontal drilling would be utilised for river crossings and areas below 5.0 m MSL, which are normally associated with the area of an estuary.
3. Any length less than 80 – 100 m could be done using pipe jacking, although the pipe diameter would dictate the final method (jacking or drilling). Drilling is to be used for lengths exceeding 100 m. It is foreseen that all trenchless construction for this project would be done using horizontal drilling.
4. The depths of the installed pipeline would depend on either the depth and quality of the rock or the scour depth of the river, whichever is the shallowest level. This level would then dictate the level the pipeline crosses below the adjacent estuary, which would be deep. The drilling depths can range from 10 to 30 m below ground level.

Drilling is a non-intrusive method, no diversion or flow or coffer dam required, no major dewatering (if any, it would be managed at the exit pit). The working areas at the entry pit and exit pit would be approximately 0.5 ha (or less) depending on the amount of waste management required. A concern associated with drilling is the possibility of frac-outs, which are generally defined as an inadvertent return of drilling fluids to the surface or into the adjacent soil or rock. Frac-outs generally occur in very coarse-grained sands containing material in the size range of pebbles to cobbles. Given the anticipated geology at the proposed depth along the proposed route (i.e. mostly consolidated materials/bedrock and weathered sandstone or shale bedrock at a relatively shallow depth), it is very unlikely that this type of material could be encountered in the course of the drilling operations. The drilling liquid used will be biodegradable (starch based) and all slurry removed from the drilling will be contained and settled. The solid fractions can either be spread on agricultural land or removed to landfill. The liquid fraction will be monitored for any hydrocarbons, and if detected, the water will be distilled to separate the clean water from that which may be contaminated, and the clean water reused. Any residual hydrocarbons will be removed and disposed to an appropriate facility.

It might however contain very minute quantities of trace metals. Bentonite is an inert clay material and is considered essentially non-toxic to aquatic organisms, although it can have adverse physical effects on organisms that might become coated with the clay. Drilling mud losses could cause temporary and localised increases in turbidity and suspended solids concentrations in surface water and also promote siltation within underlying shallow alluvial aquifers. Although the occurrence of frac-outs associated with drilling is possible, the potential related impact on surface and groundwater quality, and knock-on effects on aquatic fauna and flora, are not anticipated to be significant.

As previously stated, the tunnelled section will be undertaken by means of a micro tunnel boring machine (MTBM). This method combines pipe-jacking methods with a (comparatively) small, remotely operated tunnel boring machine. A relatively small site area (in the order to 2000m^2) and access shaft is required on land. The MTBM is advanced into the soil by the pressure exerted on it by the jacking pipes. Tunnelling would not affect groundwater as the excavated material (spoil) is removed in slurry form via a pipeline inside the tunnel. The spoil slurry is separated at the surface into the excavated material (stone chips or sand), and the drilling mud is then re-cycled back to the tunnelling machine. The earth and groundwater pressure at the cutting face is balanced by the pressure of the drilling mud at the cutting face of the machine. The tunnel is water-tight during and after construction, thus there is no groundwater inflow that would need to be pumped out and disposed of as in segmentally lined tunnels. The spoil material that is removed (sand, ground up stone chips) are separated into skips at the surface and can be used further for aggregates. Any unsuitable material that cannot be reused will be disposed of off-site to an approved landfill facility.

During the construction and commissioning period, water will be required for the preliminary earthworks (e.g. soil improvement activities, dust control), the construction of the various components of the desalination plant (e.g. concrete mixing), system hydrostatic testing, fire-fighting water and for domestic purposes (potable water). Potable water requirement during the construction period is estimated to be about 0.5 Ml /day for the proposed construction period of 30 months. This will however be determined by how much of the construction will be pre-fabricated and during which season the construction will take place. Water during the construction period will be sourced externally. No abstraction from river and groundwater is anticipated.

Construction activities are anticipated to last for approximately 30 months, including approximately 2 months pre-construction site establishment, 18 months construction and about 9 months after construction for commissioning and testing. Construction will only occur during the day, except in case of emergencies. The construction itself will last for about. The total number of construction workers is still to be assessed according to the typical South African standard of construction. The average workforce during the estimated 30 months construction phase is approximately 300 workers (at peak times). The workforce would be sourced locally where possible, however, it is likely that some of the semi-skilled workforce would come from outside the immediate vicinity. Sourcing of labour will be done according to the expanded public works programme (EPWP) Umgeni applies, which includes requirements for promoting use of local labour and broad-based black economic empowerment. Operation of the desalination plant would require approximately 30 employees working over two shifts of 8 hours per day.

2.5.2. Operation and Maintenance

The plant will be designed, and the process equipment selected, for continuous operation 24 hours per day, for 350 days per year with approximately 15 days per year allowed for maintenance. The plant will operate 24 hours per day and as there will be a number of trains that will need to be cleaned in rotation. The anticipated life-span of the desalination plant is a minimum of 20-25 years, with provisions to expand and renew equipment as and when required. Limited storage will be provided at the desalination plant site, the main storage being at the Waterloo and La Mercy Reservoirs.

A pipe ‘pigging’ system for cleaning of the seawater supply lines (intake only) may be installed. This involves the use of a ‘pig’ (bullet-shaped device with bristles), which is introduced into the seawater intake pipeline to remove marine growth.

In addition, the RO membranes need to be cleaned at regular intervals. Depending on the quality of the feed water, this is typically undertaken at intervals of three to six months. The chemicals used are mainly weak acids, bases and detergents. Additional chemicals are often added to improve the cleaning process, such as completing agents or non-oxidising biocides for membrane disinfection. It is proposed that the used cleaning solutions (i.e. water and chemicals used for cleaning membranes) will be neutralised before combining with the other residual streams from the DAF (when in use and if applicable) and ultra-filtration systems, and treated in the sludge handling facilities.

Domestic wastewater (sewage and grey water) generated (from potable use) will be collected and treated on-site in a septic tank system. In this instance, it is assumed that grey water will include capture of wastewater generated from on-site vehicle washing, floor washing, etc. Appropriate wastewater collection systems will be provided for these purposes. It is anticipated that any chemical/oil waste generated will be collected and disposed of at an appropriate off-site facility.

2.5.2.1. Monitoring and Control Systems

Monitoring of water quality throughout the plant will be conducted during the operational phase using both on-line instrumentation and grab sampling with laboratory analysis. Generally speaking, the provision will be made for sampling of every process stream before and after every process change. On-line analytical instruments will be installed in strategic locations to monitor the process and to monitor environmental parameters. On-line instruments will typically be mounted on wet racks within a building. A common sampling point may service several analytical instruments, monitoring the required water parameters for the particular process stream.

A manual sampling valve will be located adjacent to every sampling point to enable verification of the continuous on-line sampling and analysis by manual sampling and laboratory analysis.

The quality of sea water into and discharge of effluent from the desalination plant will be continuously monitored by on-line instrumentation including:

- pH;
- Conductivity;
- Turbidity;
- Oxidation reduction potential (as a surrogate for oxidising biocides); and
- Temperature.

If the set parameters at the potable water side are not met, a valve will shut and the water will be directed to the sea until the problem has been rectified. The desalination plant control system will provide a high level of automation. Start-up of the desalination plant will be manually initiated by the plant operators from the desalination plant control system. After operator initiation, the plant start-up sequences, normal operation and plant shut-down sequences will be managed automatically by the control system.

Monitoring and control will be predominantly carried out from the central control room, located in the plant administration building, with a second control room located at a remote location at the facility. A capability will also be provided to connect laptop HMI units at various points around the site to facilitate commissioning and maintenance activities over the life of the plant. In addition to the plant SCADA system the on line process data will be recorded to a database that will be dedicated to maintenance history, maintenance costs and asset register updates.

Uninterruptible power supply (UPS) units will be installed to maintain continuous power to the HMIs, and Programmable Logic Controllers (PLCs) around the site. UPS power will also back up the interface router, switches and other nominated important equipment to ensure minimum communication capability is maintained even if the main power supply has failed.

2.5.3. Decommissioning

Although decommissioning must be considered as a possibility, the probability of the plant being decommissioned is near zero. The intention would be to manage the plant indefinitely and to upgrade components of the plant as and when required. Once commissioned the plant would form an integral part of the supply system for the South Coast and as such will be needed for future supply to the area. Seawater desalination technologies will improve with time and it is possible that components of the scheme may be replaced (mostly internal process components) as these technologies improve. However, it is extremely unlikely that the plant will be decommissioned in totality.

If the plant were decommissioned then the following would apply. During decommissioning, water use will include potable water (drinking water), and fire-fighting water. Wastewater discharge will include domestic wastewater (sewage) and stormwater runoff (if contaminated, the stormwater should be regarded as a wastewater). All requirements of the EMPr and EIA regarding the rehabilitation and restoration of terrestrial and/or marine ecosystems will need to be undertaken. Underground and underwater pipelines would be capped and left in situ. Buildings would be demolished or converted to alternative agricultural or industrial buildings. Internal equipment would be relocated for use at other plants, sold or disposed of to landfill.

2.6. APPROACH TO THE ASSESSMENT OF ALTERNATIVES

As per the Western Cape Department of Environmental Affairs & Development Planning EIA Guideline Information Document Series: Guideline on Alternatives (DEA&DP, August 2010), the EIA Regulations require that alternatives to a proposed activity be considered. Alternatives are different means of meeting the general purpose and need of a proposed activity. This may include the assessment of site alternatives, activity alternatives, process or technology alternatives, temporal alternatives and/or the no-go alternative.

The EIA Regulations indicate that alternatives that are considered in an assessment process be *reasonable* and *feasible*. I&APs must also be provided with an opportunity of providing inputs into the process of formulating alternatives. The assessment of alternatives should, as a minimum, include the following:

- The consideration of the no-go alternative as a baseline scenario;
- A comparison of the reasonable and feasible alternatives; and
- Providing a methodology for the elimination of an alternative.

2.6.1. No-go alternative

The no-go alternative assumes that the project as proposed does not go ahead. This alternative provides the baseline against which other alternatives are compared and will be considered throughout the report. The implications of the "no project" alternative are that:

- The land-use on the project site remains as Agriculture;
- There is no development at the proposed location;
- There is no change in the landscape and visual character;
- Alternative and possibly more expensive water supply schemes will be developed. Much of the easily available water resources are now almost totally developed – the Mgeni Catchment in KZN is a typical example of this and now has four large dams;
- Water will become more expensive and possibly more scarce in the region and water reduction strategies will have to be enforced e.g. the watering of gardens will be prohibited;
- Industrial development in the region will be stunted under the growing concern for water; and
- Private and public sector industries will implement their own smaller-scale desalination facilities, leading to many RO plants with multiple intake and outfall (brine discharge) infrastructure components in the region.

The main implication of the no go alternative is the lack of adequate water supply to the region. Umgeni Water has a mandate to provide adequate safe potable water and not implementing this project could impact on that duty. Further, as conventional water resources near their full potential and with climate change likely to increase the risks associated with water supply (such as increased variability in rainfall and associated water supply), the region will face serious challenges in terms of sustaining the economic growth envisaged for the region. According to Umgeni Water (2015), parts of the Umgeni Water operational area are currently in a state of drought. The affected areas are the north of the eThekwini Municipality, parts of the iLembe District and the Middle South Coast. The Department of Water and Sanitation's Reconciliation Strategy Study for the Kwazulu-Natal Metropolitan Coastal Areas (2015-Ongoing) indicates that even with further augmentation of the Mgeni System (including the implementation of Spring Grove Dam and the planned Mooi-Mgeni Transfer Scheme Phase 2) by an additional 137 Ml/day (50 million m3/a), the supply of water in future will still not exceed the required 99% assurance of supply.

In order to assess the "No-Go" alternative it must be assumed that the projected inadequate assurance of water supply that informed the project planning will persist and water supplies would remain under increasing pressure in terms of ensuring potable water to residents and sustaining economic growth in the region.

2.6.2. Location Alternatives

As highlighted in Section 2.3 of this chapter, an ESS was used to assess 5 potential site locations between Durban and Ballito (north of Durban) in terms of ecological and social sensitivity to the receiving marine and terrestrial environments, as well as project technical requirements. These included a site near Virginia Airport; Tongati; Umhlanga by Sibaya Casino, Mdloti and Tongaat near Desainagar. Based on the findings of the multi-criteria analysis and the updated assessment of marine protection zones by the Natal Parks Board, the site at Tongaat was selected. The proposed site, depicted in Figure 2.2, is addressed in this EIA.

2.6.3. Layout Alternatives

2.6.3.1. Pump station

Four potential sites for the sea water pump station were considered during the feasibility study (Aurecon, 2015) (Figure 2.24). Of the four potential sites, Option 1 is the only one which falls within the overall footprint impact area of the desalination, and it coincides with the launch pit for the tunnels to sea. Consequently its impact in terms of overall impacted area would be the least, whilst also being located at a relatively low elevation, and without direct impact on existing structures. It is also located on already disturbed land (where scale agriculture takes place). Options 2 and 4 would require significant disturbance to the properties located between South Dune Road and South Beach Road, and parts of both sites would encroach within 100m of the high water mark. Not only would Option 3 increase the impact area of the desalination plant, but it is at a higher elevation which would impact on the power required for pumping and would also require more extensive earthworks due to the steep nature of the sloping land at that location.

Figure 2-24: Proposed location for the pump station at the Tongaat Desalination Plant

2.6.3.2. Potable Water Pipeline

The route for the treated water pipeline from the desalination plant to the existing La Mercy reservoir must pass through a young forest containing many exotic trees and the final route will be selected to minimise the impact on any important indigenous trees.

The route of the pipeline from the La Mercy reservoir site to the pipeline bifurcation in the north will follow the existing pipeline servitude.

A number of alternative pipeline routes from the La Mercy reservoir to Waterloo Reservoir were considered and the route selected close to the N2 and along existing roads was considered to have the lowest impact and is the route that has been assessed in this EIA.

2.6.3.3. Powerline route

eThekwini indicated that they are currently planning several new substations in the northern side of eThekwini Municipality area due to the rapid growth there as indicated in yellow in Figure 2.17. This implementation may delay providing a supply point at Tongaat. If an application is made prior to eThekwini future networks being build, the developer (i.e. Umgeni) will have to construct the 132kV transmission line in accordance with eThekwini standard and pegged by an eThekwini approved surveyor as it would have to form part of their future network and be constructed in a servitude secured and registered by them.

If however, the supply to the proposed desalination plant is coincided with eThekwini's future development, then a 132kV supply point would be available within approximately 1km from the proposed desalination plant site.

The nearest 132kV point of supply is indicated as La Mercy major Substation on the western side of King Shaka international airport and the current nearest point from where a new 132kV transmission line can be constructed from is ±5 km from the proposed desalination plant site. The transmission line route proposed by Umgeni and depicted in Figure 2.3 (orange route) complies with eThekwini future network planning. However, following findings from the visual and the aquatic ecology specialist studies, two alternatives for the powerline route have also been assessed as part of this EIA. Alternative 1 (Figure 2.19 - green route) minimizes visual impacts on La Mercy residents and Alternative 2 (Figure 2.19 - Purple route) avoids Lake Victoria wetland habitat and its high sensitive fauna.

2.6.4. Technical and Design Alternatives

The technology proposed for the construction and operation of the desalination plant will be guided by industry standards and global best practice. The applicable technology alternatives for this project relate to the infrastructure being installed and constructed. As noted above, a detailed feasibility study was undertaken by the applicant (Aurecon, 2015). The study assessed the various technology and design options for the proposed project and recommended (technically, economically and environmentally) feasible options to be considered during the detailed design phase (refer to Sections 2.4.2 to 2.4.4). The following technical and design alternatives have been discussed in this chapter based on the detailed feasibility study:

- Sea abstraction (surface intake) or beach well abstraction (subsurface intake);
- Surface intake screen types;
- A variation of pipeline technologies (trenched, versus tunnelling, including mirco tunnelling);
- Rosette or pipeline diffuser alternatives;
- A number or alternatives are possible for the best concentrate management e.g. the combination of waste streams; and
- Operational sludge strategy, e.g. co-discharge with return brine.