Transnet Projects
Ore Line Port Dust Mitigation

Reverse Osmosis Plant Site and Infrastructure Alternatives

Engineering Considerations

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Table of Contents

List of Figures

List of Tables

1. Introduction

Water is required for dust suppression at the Saldanha Iron Ore Terminal. The water supply to the Terminal falls under the West Coast District Municipality (WCDM) of the Western Cape. This is a water scarce area and municipal water allocations are limited and controlled. An alternative water source is required to supply the future dust mitigation requirements at the Terminal and to reduce the reliance on the municipal supply as much as possible.

Studies show that water supply by seawater desalination using reverse osmosis is the most reliable and viable way to supply alternate water. All other considered alternative options are either too unreliable, too costly, unusable or limited in capacity.

It is estimated that water demand will increase to 134 ML per month if phase 2 of the port expansion is authorised and executed. An alternative water supply is urgently required to meet the water demand for dust mitigation. However, it is the immediate need for water for dust suppression for current operations which is the main driver for this project.

The purpose of this document is to consider possible Reverse Osmosis (RO) site and infrastructure alternatives within and around the Iron Ore Terminal at Saldanha Bay from a high level engineering and feasibility context.

Three possible RO site locations within the port site are in the process of being assessed from an environmental impact perspective. Consideration is also given to a possible RO site located outside the Iron Ore Terminal as well as discussion around the practicality of locating the discharge point outside of Saldanha Bay.

The RO Plant locations in the port being assessed by the Environmental Assessment process are chosen to minimise the environmental impact of the RO system. From an engineering point of view (but also environmental and social perspective) it would be preferable to minimise the pipe lengths for the potable water, brine discharge and sea water intake to reduce the energy required for pumping. The position of the reservoir which stores the generated potable water should be close to the existing water reticulation system, which is at the existing storage reservoir.

It is important to emphasise that the costing exercise conducted in this document is conceptual and only intends to portray a high level picture of the possible costs involved in locating the RO installations in their respective positions. **The costs stated in this document are an estimate of the costs of installing the infrastructure for the RO plant in the various configurations for the purpose of comparing the various options.** In addition it is noted that certain of the RO infrastructure routing may change when the detailed engineering design is undertaken. The costing in this study only considers the differences between the various site options, thus the items that are common are not included i.e. The RO building, Parking areas, Two buffer tanks, brine sump etc. Items such as design allowance, contingency, escalation, engineering, procurement and contract management costs etc. are not considered in this costing. The costing is based on the infrastructure for an RO plant with 3 modules i.e. 3 x 1200m^3 of potable water per day.

For this high level analysis only one pipe trench is dug from the RO installation to the storage reservoir and it is assumed that this trench contains the potable water pipe and the requisite communications cabling interconnecting the RO installation and the storage reservoir.

The costs include for pipe jacking, trenching, pipe and cable bedding and cover up. A 160mm diameter PVC pipe is included together with medium voltage cable and communications cable.

2. Possible RO site locations

Three RO site locations are presently being assessed from an environmental impact perspective, each has several variations depending on the intake and discharge options chosen. See Table 1 below.

Table 1: RO Plant Site and Infrastructure Options

Option 1a	Site 1	Beach Wells for Intake and Direct Discharge (Big Bay)
Option 1b	Site 1	with Direct Intake and Direct Discharge (Big Bay)
Option 1c	Site 1	with Beach Well Intake and Beach well Discharge (Big Bay)
Option 2a	Site 2	with Beach Well Intake and Direct Discharge into Small Bay
Option 2b	Site 2	with Direct Intake and Direct Discharge into Small Bay
Option 3a	Site 3	with Direct Intake (Small Bay) and Direct Discharge (Small Bay)
Option 3b	Site 3	with Direct Intake (Small Bay) and Direct Discharge (Big Bay)
Option 3c	Site 3	with Intake Wells (Stockpiles) and Discharge at Caisson 3
Option 3d	Site 3	with Intake Wells (Multi Purpose Terminal) and Discharge at Caisson 3

Intakewells vs. Direct pipeline intake

In each of the three site locations there are alternative intake and discharge infrastructure options. The advantages and disadvantages of the intake infrastructure from an engineering perspective are discussed below:-

- Better quality intake water is achieved using intake wells because the water is pre filtered through the ground.
- No chlorine dosing is used to stop marine growth clogging the pipes if intake wells are used.
- During stormy weather the quality of water is not affected by the turbulence of the sea if intake wells are used.
- Less risk of damage to intake structures during big storms if intake wells are used.
- Less risk of marine growth clogging the intake pipes and buffer tank if intake wells are used.
- Construction of discharge and intake structures will have an impact on the marine environment for a direct intake.
- Up to ten intake wells may be required which will increase construction costs, however the costs of a structure for an intake pipe will also be high.

For the reasons stated above, intake wells are preferred over direct intake pipes.

Discharge wells vs. Direct pipeline discharge

Discharge wells may not be viable due to the low permeability of the ground which limits the volume of brine that can be discharged in the wells, thus direct discharge is a more viable option for brine discharge.

3. Evaluation of alternative RO plant locations and infrastructure

3.1 Criteria used for Comparison

The following general criteria were used in comparing location alternatives:

- Intake water quality & pre-treatment requirements;
- Infrastructure required – each location alternative must be practically achievable;
- Impact on Operations – The port will remain operational during construction and so the ease of integration of each location alternative with current operations and infrastructure must be considered with the aim to minimise stoppages;
- Planning impacts – each location alternative should align with current proposed expansions and Port Framework Plans. (Although it must be emphasised that these are only plans which are reviewed on a regular basis and reflect thinking / demands at the same time of conception only).

Environmental and social considerations have not been considered in this report as this is the subject of the Basic Assessment process currently underway.

Each site and infrastructure alternative has been compared throughout this report in tabular format to facilitate understanding. The comparison is of a qualitative nature only. A table comparing the estimated costs of the infrastructure for the various options is provided in the conclusion.

3.2 Site 1: East of Reclamation Dam

Located east and adjacent to the reclamation dam. The RO Plant building would be located just north east of the reclamation dam close to the beach.

3.2.1 Option 1a - Site 1 Beach Wells for Intake and Direct Discharge

Figure 1: Possible RO Location – Site 1a

Table 2: Estimated Costs Option 1a - Site 1 Beach Wells for Intake and Direct Discharge

Service	No/ length	Total Cost		Note
Electrical supply HV	861	R	861,000	Cable (trenching included in pipe trench)
Pipes, cables and Trenches to reservoir	890	R	318,620	
Pipes, cables and Trenches to Intake	490	R	175,420	
Pipes, cables and Trenches to Discharge	635	R	227,330	
Intake Pump Cables (7.5kW submersibles)	2,750	R	429,000	
Intake Beachwells	10	R	1,000,000	
Discharge Pipe Structure	1	R	950,000	
Roads	900	R	1,140,300	
Total		**R**	**5,101,670**	

Table 3: Assessment against Criteria

Consideration	Assessment	Notes
Raw water intake quality	good	Intake wells pre filter sea water
Pre-treatment requirements	good	No chlorine dosing required
Infrastructure needed - Roads	poor	High maintenance on access road to RO plant building due to wind blown sand from mobile sand dune.
Infrastructure needed - Pipes	Fair	Shorter pipe lengths than site option 3. No pipe jacking required beneath roads.
Impact on existing operations during construction and operations	good	Away from existing operations therefore minimal disruption to current operations during construction and during the iron ore handling operations.
Discharge infrastructure and feasibility	Fair	Existing rock revetment utilised for attaching discharge pipe.
Masterplan 2005 considerations (10 year and beyond 2020)	Fair	Potential long term planning is not consistent with proposed development of the liquid bulk facilities.
Integration with Phase 2 expansion	good	RO plant building and intake/discharge infrastructure most likely not affected by Phase 2 expansion. The extent of reclamation is to the south of the existing reclamation dam.

3.2.2 *Option 1b - Site 1 with Direct Intake and Direct Discharge*

Figure 2: Possible RO Location – Site 1b

Table 4: Estimated Costs Option 1b - Site 1 with Direct Intake and Direct Discharge

Service	No/length	Total Cost	Note
Electrical supply HV	861	R 861,000	Cable (trenching included in pipe trench)
Pipes, cables and Trenches to reservoir	890	R 318,620	
Pipes, cables and Trenches to Intake	370	R 132,460	
Pipes, cables and Trenches to Discharge	635	R 227,330	
Intake Pump Station	1	R 500,000	
Intake Pipe Structure	1	R 1,200,000	
Discharge Pipe Structure	1	R 950,000	
Roads	900	R 1,140,300	
Total		**R 5,329,710**	

Table 5: Assessment against Criteria

Consideration	Assessment	Notes
Raw water intake quality	poor	Intake waters not pre filtered, Intake structure required (risk of mussel growth on intake pipe).
Pre-treatment requirements	poor	Chlorine dosing required.
Infrastructure needed - Roads	poor	High maintenance on access road to RO plant building due to wind blown sand from mobile sand dune.
Infrastructure needed - Pipes	fair	Shorter pipe lengths than site option 3. Shorter discharge pipes than option 1c. No pipe jacking required beneath roads.
Impact on existing operations during construction and operations	good	Away from existing operations therefore minimal disruption to current operations during construction and during the iron ore handling operations.
Discharge infrastructure and feasibility	fair	Existing rock revetment utilised for attaching discharge pipe.
Masterplan 2005 considerations (10 year and beyond 2020)	fair	Potential long term planning is not consistent with proposed development of the liquid bulk facilities.
Integration with Phase 2 expansion	good	RO plant building and intake/discharge infrastructure most likely not affected by Phase 2 expansion. The extent of reclamation is to the south of the existing reclamation dam.

3.2.3 *Option 1c - Site 1 with Beach Well Intake and Beach well Discharge*

Figure 3: Possible RO Location – Site 1c

Table 6: Estimated Costs Option 1c - Site 1 with Beach Well Intake and Beach well Discharge

Service	No/length	Total Cost		Note
Electrical supply HV	861	R	861,000	Cable (trenching included in pipe trench)
Pipes, cables and Trenches to reservoir	890	R	318,620	
Pipes, cables and Trenches to Intake	490	R	175,420	
Pipes, cables and Trenches to Discharge	750	R	268,500	
Intake Pump Cables (7.5kW)	2,750	R	429,000	
Intake Beachwells	10	R	1,000,000	
Discharge Beachwells	3	R	300,000	
Roads	900	R	1,140,300	
Total		**R**	**4,492,840**	

Table 7: Assessment against Criteria

Consideration	Assessment	Notes
Raw water intake quality	good	Intake wells pre filter sea water
Pre-treatment requirements	good	No chlorine dosing required.
Infrastructure needed - Roads	poor	High maintenance on access road to RO plant building due to wind blown sand from mobile sand dune.
Infrastructure needed - Pipes	fair	Shorter pipe lengths than site option 3. Shorter discharge pipes than option 1b. No pipe jacking required beneath roads.
Impact on existing operations during construction and operations	good	Away from existing operations therefore minimal disruption to current operations during construction and during the iron ore handling operations.
Discharge infrastructure and feasibility	poor	Beach wells could minimise discharge impact. Low permeability of ground could affect ability to discharge effluent. (subject to study)
Masterplan 2005 considerations (10 year and beyond 2020)	fair	Potential long term planning is not consistent with proposed development of the liquid bulk facilities.
Integration with Phase 2 expansion	good	RO plant building and intake/discharge infrastructure most likely not affected by Phase 2 expansion. The extent of reclamation is to the south of the existing reclamation dam.

3.3 Site 2 : West of Tippler1

Located north and north west of the Iron Ore Handling Facility. The RO Plant building would be established in an area currently containing stockpiles of gravel and construction rubble.

3.3.1 Option 2a - Site 2 with Beachwell Intake and Direct Discharge into Small Bay

Figure 4: Possible RO Location – Position 2a

Table 8: Estimated Costs Option 2a - Site 2 with Beachwell Intake and Direct Discharge into Small Bay

Service	No/length	Total Cost		Note
Electrical supply HV	650	R	650,000	Cable (trenching included in pipe trench)
Pipes, cables and Trenches to reservoir	990	R	354,420	
Pipes, cables and Trenches to Intake	270	R	96,660	
Pipes, cables and Trenches to Discharge	342	R	122,436	
Intake Beachwells	10	R	1,000,000	
Intake Pump Cables (7.5kW submersibles)	2,750	R	429,000	
Discharge Pipe Structure	1	R	950,000	
Roads	30	R	38,010	
Pipe Jacking under roads	24	R	1,437,600	
Total		**R**	**5,078,126**	

Table 9: Assessment against Criteria

Consideration	Assessment	Notes
Raw water intake quality	good	Intake wells pre filter sea water
Pre-treatment requirements	good	No chlorine dosing required.
Infrastructure needed - Roads	good	Short service road linking RO plant building to existing roads.
Infrastructure needed - Pipes	good	Shorter pipe lengths than site option 1 and option 3. Pipe jacking required beneath roads.
Impact on existing operations during construction and operations	fair	Pipes and cables need to be installed across roads while they are in use, creating temporary construction impact close to existing terminal operations.
Discharge infrastructure and feasibility	poor	New discharge pipe structure required out into Small Bay. Currents in Small bay may impact on effluent dispersion (this will influence the discharge design).
Masterplan 2005 considerations (10 year and beyond 2020)	fair	Consistent with medium term plans however potential long-term inconsistency with proposed development of Container Terminal.
Integration with Phase 2 expansion	good	RO plant building and intake/discharge infrastructure not affected by Phase 2 expansion.

3.3.2 Option 2b - Site 2 with Direct Intake and Direct Discharge into Small Bay

Figure 5: Possible RO Location – Position 2b

Table 10: Estimated Costs Option 2b - Site 2 with Direct Intake and Direct Discharge into Small Bay

Service	No/length	Total Cost	Note
Electrical supply HV	650	R 650,000	Cable (trenching included in pipe trench)
Pipes, cables and Trenches to reservoir	990	R 354,420	
Pipes, cables and Trenches to Intake	200	R 71,600	
Pipes, cables and Trenches to Discharge	342	R 122,436	
Intake Pump Station	1	R 500,000	
Intake Pipe Structure	1	R 1,200,000	
Discharge Pipe Structure	1	R 950,000	
Roads	30	R 38,010	
Pipe Jacking under roads	24	R 1,437,600	
Total		**R 5,324,066**	

Table 11: Assessment against Criteria

Consideration	Assessment	Notes
Raw water intake quality	poor	Intake waters not pre filtered, Intake structure required (risk of mussel growth on intake pipe).
Pre-treatment requirements	poor	Chlorine dosing required.
Infrastructure needed - Roads	good	Short service road linking RO plant building to existing roads.
Infrastructure needed - Pipes	good	Shorter pipe lengths than site option 1 and option 3. Pipe jacking required beneath roads.
Impact on existing operations during construction and operations	fair	Pipes and cables need to be installed across roads while they are in use, creating temporary construction impact close to existing terminal operations.
Discharge infrastructure and feasibility	poor	New discharge pipe structure required out into Small Bay. Currents in Small bay may impact on effluent dispersion (this will influence the discharge design).
Masterplan 2005 considerations (10 year and beyond 2020)	fair	Consistent with medium term plans however potential long-term inconsistency with proposed development of Container Terminal.
Integration with Phase 2 expansion	good	RO plant building and intake/discharge infrastructure not affected by Phase 2 expansion.

3.4 Site 3 : South of Multi Purpose Terminal

The next possible RO location – Site 3 is located on the southern section of the Quay of the Iron Ore Handling Facility. The RO Plant building would be positioned on a gravel area adjacent to the Multipurpose Terminal. Four possible piping trench routes were considered for this position and are indicated in the Figures below. There is concern, due to the relatively long trench lengths from the RO installation to the storage reservoir, that buried obstacles such as existing electrical and water reticulation systems may elevate the costs of the trenching.

3.4.1 Option 3a - Site 3 with Direct Intake (Small Bay) and Direct Discharge (Small Bay)

Figure 6: Possible RO Location – Position 3a

Table 12: Estimated Costs Option 3a - Site 3 with Direct Intake (Small Bay) and Direct Discharge (Small Bay)

Service	No/length	Total Cost	Note
Electrical supply HV	800	R 800,000	Cable (trenching included in pipe trench)
Pipes, cables and Trenches to reservoir	2,800	R 1,002,400	
Pipes, cables and Trenches to Intake	140	R 50,120	
Pipes, cables and Trenches to	380	R 136,040	

Service	No/length	Total Cost	Note
Discharge			
Intake Pump Station	1	R 500,000	
Intake Pipe Structure	1	R 1,200,000	
Discharge Pipe Structure	1	R 950,000	
Roads	30	R 38,010	
Pipe Jacking under roads	24	R 1,437,600	
Total		**R 6,114,170**	

Table 13: Assessment against Criteria

Consideration	Assessment	Notes
Raw water intake quality	poor	Intake waters not pre filtered, Intake structure required (risk of mussel growth on intake pipe).
Pre-treatment requirements	poor	Chlorine dosing required.
Infrastructure needed - Roads	good	Short service road linking RO plant building to existing roads .
Infrastructure needed - Pipes	poor	Longer pipe lengths than site option 1 and option 2 to reach existing reservoir and water reticulation system.
Impact on existing operations during construction and operations	fair	Pipes and cables need to be installed across roads while they are in use, creating temporary construction impact close to existing terminal operations. Located close to the multi-purpose terminal users although minimal disruption is foreseen to their operations during the construction period.
Discharge infrastructure and feasibility	poor	New discharge pipe structure required out into Small Bay. Currents in Small bay may impact on effluent dispersion (this will influence the discharge design).
Masterplan 2005 considerations (10 year and beyond 2020)	poor	Location of building and intake/discharge infrastructure poses potential medium and long-term inconsistency with proposed extension of the multi-purpose terminal in the southerly direction.
Integration with Phase 2 expansion	good	RO plant building and intake/discharge infrastructure not affected by Phase 2 expansion.

3.4.2 *Option 3b - Site 3 with Direct Intake (Small Bay) and Direct Discharge (Big Bay)*

Figure 7: Possible RO Location – Position 3b

Table 14: Estimated Costs Option 3b - Site 3 with Direct Intake (Small Bay) and Direct Discharge (Big Bay)

Service	No/length	Total Cost		Note
Electrical supply HV	800	R	800,000	Cable (trenching included in pipe trench)
Pipes, cables and Trenches to reservoir	2,800	R	1,002,400	
Pipes, cables and Trenches to Intake	140	R	50,120	
Pipes, cables and Trenches to Discharge	440	R	157,520	
Intake Pump Station	1	R	500,000	
Intake Pipe Structure	1	R	1,200,000	
Discharge Pipe Structure	1	R	950,000	
Roads	30	R	38,010	
Pipe Jacking under roads	24	R	1,437,600	
Total		**R**	**6,135,650**	

Table 15: Assessment against Criteria

Consideration	Assessment	Notes
Raw water intake quality	poor	Intake not pre filtered, Intake structure required (risk of mussel growth on intake pipe).
Pre-treatment requirements	poor	Chlorine dosing required.
Infrastructure needed - Roads	good	Short service road linking RO plant building to existing roads .
Infrastructure needed - Pipes	poor	Longer pipe lengths than site option 1 and option 2 to reach existing reservoir and water reticulation system.
Impact on existing operations during construction and operations	fair	Pipes and cables need to be installed across roads while they are in use, creating temporary construction impact close to existing terminal operations. Located close to the multi-purpose terminal users although minimal disruption is foreseen to their operations during the construction period.
Discharge infrastructure and feasibility	fair	New discharge pipe structure required into Big Bay. Water circulation in Big bay more suited to dispersion of effluent (affecting discharge design).
Masterplan 2005 considerations (10 year and beyond 2020)	poor	Location of building and intake infrastructure poses potential medium and long-term inconsistency with proposed extension of the multi-purpose terminal in the southerly direction.
Integration with Phase 2 expansion	fair	RO plant intake structures not affected by Phase 2 development. Discharge infrastructure could be affected by dredging and quay construction activities.

3.4.3 Option 3c - Site 3 with Intake Wells (Stockpiles) and Discharge at Caisson 3

Figure 8: Possible RO Location – Position 3c

Table 16: Estimated Costs Option 3c - Site 3 with Intake Wells (Stockpiles) and Discharge at Caisson 3

Service	No/length	Total Cost	Note
Electrical supply HV	800	R 800,000	Cable (trenching included in pipe trench)
Pipes, cables and Trenches to reservoir	1,875	R 671,250	
Pipes, cables and Trenches to Intake	1,060	R 379,480	
Pipes, cables and Trenches to Discharge	5,735	R 2,053,130	
Intake Beachwells	10	R 1,000,000	
Intake Pump Cables (7.5kW submersibles)	2,750	R 429,000	
Discharge Pipe Structure	1	R 250,000	Using existing Caisson structure
Roads	30	R 38,010	
Pipe Jacking under roads	24	R 1,437,600	
Total		**R 7,058,470**	

Table 17: Assessment against Criteria

Consideration	Assessment	Notes
Raw water intake quality	good	Intake wells pre filter sea water
Pre-treatment requirements	good	No chlorine dosing required.
Infrastructure needed - Roads	good	Short service road linking RO plant building to existing roads .
Infrastructure needed - Pipes	poor	Longer pipe lengths than site option 1 and option 2 to reach existing reservoir and water reticulation system.
Impact on existing operations during construction and operations	fair	Pipes and cables need to be installed across roads while they are in use, creating temporary construction impact close to existing terminal operations. Intake wells located close to the eastern access road behind the stockpiles which is likely to affect serviceability during construction period.
Discharge infrastructure and feasibility	good	Use of existing caisson structure minimises cost. Water circulation in Big bay more suited to dispersion of effluent (affecting discharge design).
Masterplan 2005 considerations (10 year and beyond 2020)	poor	Location of building poses potential medium and long-term inconsistency with proposed extension of the multi-purpose terminal in the southerly direction.
Integration with Phase 2 expansion	fair	RO plant intake structures most likely not affected by Phase 2 development. Discharge infrastructure could be affected by dredging and quay construction activities.

3.4.4 *Option 3d - Site 3 with Intake Wells (Multi Purpose Terminal) and Discharge at Caisson 3*

Figure 9: Possible RO Location – Position 3d

Table 18: Estimated Costs Option 3d - Site 3 with Intake Wells (Multi Purpose Terminal) and Discharge at Caisson 3

Service	No/length	Total Cost		Note
Electrical supply HV	800	R	800,000	Cable (trenching included in pipe trench)
Pipes, cables and Trenches to reservoir	2,800	R	1,002,400	
Pipes, cables and Trenches to Intake	350	R	125,300	
Pipes, cables and Trenches to Discharge	1,060	R	379,480	
Intake Beachwells	10	R	1,000,000	
Intake Pump Cables (7.5kW submersibles)	2,750	R	429,000	
Discharge Pipe Structure	1	R	250,000	Using existing Caisson structure
Roads	30	R	38,010	
Pipe Jacking under roads	24	R	1,437,600	
Total		**R**	**5,461,790**	

Table 19: Assessment against Criteria

Consideration	Assessment	Notes
Raw water intake quality	good	Intake wells pre filter sea water
Pre-treatment requirements	good	No chlorine dosing required
Infrastructure needed - Roads	good	Short service road linking RO plant building to existing roads .
Infrastructure needed - Pipes	Poor	Longer pipe lengths than site option 1 and option 2 to reach existing reservoir and water reticulation system.
Impact on existing operations during construction and operations	fair	Pipes and cables need to be installed across roads while they are in use, creating temporary construction impact close to existing terminal operations.. Intake wells located close to western access road adjacent to multi-purpose terminal. It is not envisaged that the serviceability of this road would be affected during construction of intake wells.
Discharge infrastructure and feasibility	good	Use of existing caisson structure minimises cost. Water circulation in Big bay more suited to dispersion of effluent (affecting discharge design).
Masterplan 2005 considerations (10 year and beyond 2020)	poor	Location of building poses potential medium and long-term inconsistency with proposed extension of the multi-purpose terminal in the southerly direction.
Integration with Phase 2 expansion	fair	RO plant intake structures most likely not affected by Phase 2 development. Discharge infrastructure could be affected by dredging and quay construction activities.

4. RO Discharge to Outside Saldanha Bay via overland pipe

An off site location for the RO was considered, however there are many risks involved with locating the RO installation outside of the port where it is more difficult to control and maintain. A better solution would be to keep the RO Plant installation inside the port as close as possible to the water reservoir and for the discharge pipes to be installed to an external location. The two discharge locations considered were Jacobs Bay (as indicated in Figure 10) because it is the closest point outside of the bay with access via existing roads and Municipal servitudes and Velddrif (as indicated in Figure 11) as this is where the Cerebos and Velddrif Salt Works are situated. **A costing in table 22 compares the costs of the infrastructure but excludes costs such as Land servitudes, infrastructure disturbances, Engineering, Procurement and Construction Management costs etc.**

The two discharge options are appraised against the additional implementation, operational and maintenance requirements and project risks when compared to that of discharge options within Saldanha Bay.

4.1 Discharge pipe to Jacobs Bay (18km)

The RO Plant would be situated inside the port and the sea water intake would be from intake wells. The discharge site was chosen at Jacobs Bay to avoid disruption to residential infrastructure and to discharge the brine into the surf zone. The pipe material would be PVC and it would be buried in a trench approximately one meter deep along the proposed pipe route which follows the local roads in the area (see figure 10). A municipal servitude may be available for laying the pipeline, this would be subject to an agreement being reached between Transnet and Saldanha Bay Municipality. Up to three pump stations to boost the brine discharge over the long pipe distance would be needed. Electrical supply for the pump stations is assumed to be available from the nearby residential development (this assumption would need further investigation as it may be problematic to secure power from a residential supply. For example, there may not be sufficient capacity to supply a pump station or there may not be a 400 volt supply near to the pump station). Pipe jacking would be necessary in order for the pipeline to cross roads where traffic disruption would be problematic.

The installation of the brine discharge outlet pipe at Jacobs Bay would either be done by digging a trench on the beach, installing the pipe and covering it or by pipe jacking, as follows. A launching well would be constructed on the beach to establish a pipe jacking culvert, the pipe would be jacked into place under the beach and exit in the surf line. Depending on the sea conditions, the brine discharge pipe could be terminated at up to 300 meters from the beach in order to optimise the dispersion of the brine. Brine diffusers can also be installed along the pipe line in order to disperse the brine over a larger area.

The estimated cost of building a discharge pipe to Jacobs Bay is R13.3m.

Table 20: Discharge pipe to Jacobs Bay - Considerations

Category	Appraisal	Explanation
Additional Infrastructure Required	Higher Cost	This option requires significantly more infrastructure to be installed and will cost at least R13.3m more than the current preferred option.

Impact on Operations	Higher Cost	Significant increase in energy cost to pump brine due to additional distance to discharge location.
Impact on Maintenance	Higher Cost	Maintenance of remote pump stations and long pipelines would increase maintenance costs and difficulty.
Impact on Project Schedule	Additional Time to Secure Servitudes & Longer Construction Period	Time required to secure servitudes, including negotiating the use of municipal servitudes could lead to a considerable delay in the project completion.
Discharge outside Saldanha Bay	Low Risk	The brine will be discharged into the surf zone, outside Saldanha Bay, away from any Marine Protected Areas.
Project Risk (Time, Cost, Construction & Other)	High Risk	Risk of obtaining servitudes for the pipes is a risk in terms of both time and cost.
	Medium Risk	Accidental damage that may be caused to other existing municipal infrastructure while installing the pipes is a risk.
	Low Risk	Pipe leaks may be a risk to the ground water in the area.

4.2 Discharge Pipe to Velddrif (38 km)

The RO Plant would be situated inside the port and the intake would be from intake wells. The pipe route used follows the local roads in the area to avoid disruption to residential infrastructure as far as possible and to discharge the brine at the Velddrif Salt Works. The pipe material would be PVC and it would be buried in a trench approximately one meter deep. The pipe route proposed follows the local roads in the area (see figure 11). A municipal servitude may be available for laying the pipeline, this would be subject to an agreement being reached between Transnet and Saldanha Bay Municipality. Up to six pump stations to boost the brine discharge over the long pipe distance would be needed. Electrical supply for the pump stations is assumed to be available from the nearby residential development (this assumption would need further investigation as it may be problematic to secure power from a residential supply. For example, there may not be sufficient capacity to supply a pump station or there may not be a 400 volt supply near to the pump station). Pipe jacking would be necessary in order for the pipeline to cross roads where traffic disruption would be problematic.

An agreement would need to be reached with one of the local the Salt Works in order to discharge the brine to their works. During discussions with Cerebos Salt Works, they have indicated that they have an excess capacity at the works for brine production and their bottle neck is in the salt refinery thus they would not be interested in purchasing the brine from the RO unless they were to upgrade their production. Their daily production is about 140 tons per day of raw salt, which is much lower than the potential 280 tons of salt that the RO Plant could deliver. The economic value of the brine is relatively low because of the concentration of the brine (6.3%) is fairly low (crystallisation of salt starts at 25%).

The estimated cost of building a discharge pipe to Velddrif is R23.2m.

Table 21: Discharge Pipe to Velddrif - Considerations

Category	Appraisal	Explanation
Additional Infrastructure Required	Higher Cost	This option requires significantly more infrastructure to be installed and will cost at least R23.2m more than the current preferred option.
Impact on Operations	Higher Cost	Significant increase in energy cost to pump brine due to additional distance to discharge location.
Impact on Maintenance	Higher Cost	Maintenance of remote pump stations and long pipelines would increase maintenance costs and difficulty.
Impact on Project Schedule	Additional Time to Secure Servitudes & Longer Construction Period	Time required to secure servitudes, including negotiating the use of municipal servitudes could lead to a considerable delay in the project completion.
Discharge outside Saldanha Bay	Low Risk	If the brine is used by the Saltworks then discharge outside of the Bay would not be an issue.
Project Risk (Time, Cost, Construction & Other)	High Risk	Risk of obtaining servitudes for the pipes is a risk in terms of both time and cost.
	Medium Risk	Accidental damage that may be caused to other existing municipal infrastructure while installing the pipes is a risk.
	Low Risk	Pipe leaks may be a risk to the ground water in the area.

4.3 Conclusion

Brine discharge to either Jacobs Bay or Velddrif is very costly from a capital cost and an operational cost point of view due to the distances involved. The requirement to acquire servitudes outside of Transnet National Port Authority land could have long lead times and also be very costly. The potential timeframes for development of this option is not conducive with the immediate need for additional water supplies for use in dust suppression measures for current operations.

It is important that the additional costs and significant additional project related risks associated with the discharging of brine outside of Saldanha Bay be considered and balanced in conjunction with the outcomes of the marine and other specialist studies which assigns impact ratings to the potential environmental impacts associated with discharging brine within Saldanha Bay.

From the perspective of proposing a financially viable and low risk project, the considerations given above demonstrate that progressing further with these options is not justified.

Figure 10: RO Plant Brine Discharge to Jacobs Bay - Proposed pipeline route

Figure 11: RO Plant Brine Discharge to Velddrif - Proposed pipeline route

Table 22: Approximate costs per item for Possible RO Discharge location situated off site

Costs to Jacobs Bay

Item	Approx. Length meters	Requirements description	Approximate Costs		Potential Risks
RO Discharge piping	730	Pipe length only - excluded pipe foundation	R	146,000	Cost for pipe fixing - define by design
Electrical supply	600	Assume supply from nearby residential supply	R	600,000	3 phase industrial supply may be problematic
Pump Station		Civil works, pump house building, pumps	R	900,000	Noise pollution
Pipe	18000	Piping, communications, trenching & pipe jacking	R	11,607,939	Risks with extensive pipe jacking
		Approximate Total	**R**	**13,253,939**	**Land servitudes, infrastructure disturbances, etc. all excluded.**

Costs to Veldrift

Item	Approx. Length	Requirements description	Approximate Costs		Potential Risks
Piping	38km	Piping (250mm ID)	R	17,100,000	Includes only pipe costs
Trenching	38km	Trenching (Min 2m below ground)	R	4,560,000	Includes only trenching costs (no jacking)
Electrical supply		Assume supply from nearby residential supply	R	600,000	3 phase industrial supply may be problematic
Pump Station		Civil works, pump house building, pumps	R	900,000	Noise pollution
		Approximate Total	**R**	**23,160,000**	**Land servitudes, boost pump stations, infrastructure disturbances, etc. all excluded.**

Note: The costs in this table are additional to the costs of the installation of the current preferred option.

Note: Noise pollution from pump stations is a risk when in close proximity to residential houses.

Note: Risks associated with pipe jacking include hitting underground services or other obstacles resulting in additional costs and delays

5. RO Discharge to Beyond the Breakwater via pipe under the bay

5.1 Discharge Pipe laid on Sea floor to beyond the breakwater

This option would involve a 1.6 km long pipe installed on the seabed from the end of the reclaimed quay to the breakwater at Hoetjiespunt. The discharge pipe would be routed over the breakwater and then it would need to be extended to discharge the brine into the open sea. This pipe would need to be up to 600 meters long in order to discharge the brine in deep water. The area around Marcus Island is a Marine Protected Area under the Marine Living Resources Act 18 of 1998 and the pipe infrastructure should to be kept away from this area. Any structures in this area would have to withstand extremely rough seas and the construction of the discharge pipe would thus consist of a reinforced concrete structure along the sea floor to protect the pipeline.

In theory there should not be ships anchoring in this area, however Geotechnical Surveys done on the sea floor of the bay show evidence of anchor drag marks in the area that we would be laying the pipeline (directly between the jetty and the breakwater). If the pipe was damaged then the RO Plant would need to be shut down while repairs are done. This outage of the plant may lead to water shortages in the port for dust mitigation. The likelihood of this risk occurring is considered low however should the risk occur the consequence would be considered severe to the operation of the RO plant.

The pipe material would be high density polyethylene. It would be installed by floating the assembled pipe out to sea and then using controlled submergence. The pipe is flooded with sea water and the air in the pipe is released to decrease the buoyancy allowing the pipe to be lowered into position on the seabed. It would then be anchored to the sea floor using concrete collars. The installation and securing of the pipe would require extensive work by divers.

A pipeline laid on the sea floor is influenced by hydrodynamic forces caused by currents. These hydrodynamic forces cause erosion and accretion of the seabed and can lead to scours developing under the pipe and its supports. This can result in a large free span of the pipeline which can lead to failure of the pipe.

This discharge option is appraised in Table 23 against the additional implementation, operational and maintenance requirements and project risks when compared to that of discharge options immediately within Saldanha Bay (Chapter 3).

Table 23: Discharge Pipe laid on Sea floor to beyond the breakwater - Considerations

Category	Appraisal	Explanation
Additional Infrastructure Required	Higher Cost	This option requires more infrastructure than the current preferred option, including 2.2 km of pipe and additional marine structures.
Impact on Operations	Higher Cost	Increase in energy cost to pump brine due to additional distance to discharge location.
Impact on Maintenance	Higher Cost	Maintenance of pipelines under the bay would increase maintenance costs and difficulty due to any work on the pipe being carried out by divers in the shipping lanes.
Impact on Project Schedule	Longer Construction Period	There may be a time delay to lay these pipes due to the specialised construction methods.
Discharge outside Saldanha Bay	Low Risk	The brine will be discharged into deep water.
Project Risk (Time, Cost, Construction & Other)	High Risk	The pipe may be damaged by ship's anchors or by rough seas.
	Low Risk	Pipe leaks would be difficult to detect under the bay.
	Medium Risk	Maintenance dredging activities in the shipping channel may result in damage to the pipe.
	Medium Risk	Scouring can lead to a large free span of the pipe leading to pipe failure.
	Medium Risk	During construction there would need to be divers deployed in the shipping lane.

5.2 Discharge pipe buried in the sea bed

As per the option in 5.1 above, but in order to avoid the brine discharge pipe being damaged by anchors in the bay, the pipe would need to be buried along the floor of the bay. The pipe would need to be buried at least 5 meters deep to avoid being caught by the anchors of the ships mooring in the bay. From the quay to the breakwater, the pipe would be approximately 1.6 km long and would require approximately 20 000 cubic meters of dredging in order to bury the pipe. This dredging would be in the shipping lanes and could cause major disruption to operations. To avoid this disruption the dredging activities would be scheduled to avoid incoming and outgoing iron ore vessels and oil tankers. This would also reduce the risk of collision between vessels.

The largest single cost for dredging would be the mobilisation and demobilization costs for a backhoe dredger which would cost approximately R40m. A backhoe dredger operates from a barge and has a long backhoe arm that can reach the sea floor. It operates by scooping material up onto another floating barge which then removes the material for temporary storage (on land). Once the trench has been dug, the pipe would be installed by floating the pipe into position and using the controlled submergence to lower it into the trench. The trench would then be back filled using the material that was temporarily stored. If rock outcrops are encountered then blasting may be required in order to remove them. Geotechnical surveys of the sea bed done before construction starts may eliminate the need for blasting.

This discharge option is appraised in Table 24 against the additional implementation, operational and maintenance requirements and project risks when compared to that of discharge options immediately within Saldanha Bay (Chapter 3).

Table 24: Discharge pipe buried in the sea bed - Considerations

Category	Appraisal	Explanation
Additional Infrastructure Required	Higher Cost	This option requires significantly more infrastructure to be installed and will cost in excess of R40m more than the current preferred option.
Impact on Operations	Higher Cost	Increase in energy cost to pump brine due to additional distance to discharge location.
Impact on Maintenance	Higher Cost	Maintenance of pipelines under the bay would increase maintenance costs and difficulty.
Impact on Project Schedule	Longer Construction Period	There may be a time delay to dredge and lay these pipes due to the time taken to mobilize a suitable dredger.
Discharge outside Saldanha Bay	Low Risk	The brine will be discharged into deep water.
Project Risk (Time, Cost, Construction & Other)	Medium Risk	Blasting in the shipping lane may be required if the dredger hits rock outcrops.
	Medium Risk	The pipe may be damaged by rough seas beyond the breakwater.
	Low Risk	Pipe leaks would be difficult to detect under the bay.
	Medium Risk	The dredger would need to operate in the shipping lanes during construction.

5.3 Directional drilling of pipeline

Directional drilling has been investigated to install a pipe from the end of the quay to outside the bay underneath the shipping lanes. The directional drilling would need to be through rock strata that have sufficient strength to keep the hole open during drilling and pipe installation. A full geotechnical study would be needed in order to determine the geology of the bay floor before any drilling can begin.

Drilling is first done with a pilot hole of small diameter. The direction of the drilling is controlled in order to ensure that the pipe follows the correct route and exits the ground at the correct position. The hole is then reamed to the required diameter. A pullback pipe is then inserted and the new pipeline is installed by pulling it back through the drill hole from the drill exit hole. The entire pipe (1.6km long) is assembled and carefully supported in order to guide it into the drilled hole. In order to do this, a jack up platform would be installed at the end of the iron ore jetty. The jack up platform must be braced in order to withstand the forces required for drilling and pulling the pipe back through the hole. The drilling rig and ancillary equipment is installed on the jack up platform. Once drilling and pipe pullback is complete the equipment is removed and the pipe intake and outlet structures for the pipeline are installed.

The length of the pipe to the breakwater would be 1.6 km. The pipe would weigh approximately 80 tons and this job is beyond the capability of drilling rigs currently in South Africa. A large enough drilling rig would need to be imported in order to do this job.

Horizontal directional drilling is feasible but is expensive and is a high risk operation.

A budget price of R30 Million (only for the drilling) has been put forward.

This discharge option is appraised in Table 25 against the additional implementation, operational and maintenance requirements and project risks when compared to that of discharge options immediately within Saldanha Bay (Chapter 3).

Table 25: Directional drilling of pipeline - Considerations

Category	Appraisal	Explanation
Additional Infrastructure Required	Higher Cost	This option requires significantly more infrastructure to be installed and will cost in excess of R30m more than the current preferred option.
Impact on Operations	Higher Cost	Increase in energy cost to pump brine due to additional distance to discharge location.
Impact on Maintenance	Higher Cost	Maintenance of drilled pipelines under the bay would increase maintenance costs and difficulty.
Impact on Project Schedule	Additional Time to Secure Specialised Equipment & Longer Construction Period	Time required to secure a drilling rig from overseas could lead to substantial delays in completion of the project.
Discharge outside Saldanha Bay	Low Risk	The brine will be discharged into deep water.
Project Risk (Time, Cost, Construction & Other)	Medium Risk	There would be a risk of flooding and collapse of the hole during directional drilling.
	Medium Risk	The pipe may be damaged by rough seas beyond the breakwater.
	Low Risk	Pipe leaks would be difficult to detect under the bay.

5.4 Conclusion

All three of the above options would include a pipeline installed from the breakwater out into deeper water. This construction would be difficult in the rough seas and the costs would be significant.

Option 5.1 would not be feasible due to the risk of the pipe being damaged by anchors of ships in the bay. The likelihood of this risk occurring is considered low however should the risk occur the consequence would be considered severe to the operation of the RO plant. Option 5.2 and 5.3 are technically feasible but are both very expensive when compared to the preferred solution. They have significant additional project related risks and would increase the cost per unit volume of water produced which would make the RO Plant financially unviable.

It is important that the additional costs and significant additional project related risks associated with the discharging of brine outside of Saldanha Bay be considered and balanced in conjunction with the outcomes of the marine and other specialist studies which assigns impact ratings to the potential environmental impacts associated with discharging brine within Saldanha Bay.

From the perspective of proposing a financially viable and low risk project, the considerations described above demonstrate that progressing further with these options is not justified.

Figure 12: RO Plant Brine discharge beyond on the breakwater – Potential route for pipeline

6. Alternative Potable Water Reservoir Positions

Figure 13: Possible Reservoir Locations

Three potential locations for siting the potable water reservoir (s) have been identified and are illustrated in figure 13. The costing in section 3 is based on the reservoir being situated adjacent to the existing reservoir, the alternative reservoir site 3 would require additional infrastructure (pipes and cables).

6.1 Site 1 - Adjacent to existing Reservoir

This site has the advantage of being close to the existing reservoir making the control of the water supply to the various dust mitigation areas easier.

This site will have a low visual impact (due to the screening by the dunes) and requires significantly less piping than alternate site 3.

The disadvantage of this site is that space is limited due to existing services in the area and the sand dune behind the existing reservoir. Mitigation measures would be needed to minimize the impact on the dune, during construction and operation. The detailed design of the reservoir will be done to ensure that any impact on the sand dune will be minimised if not completely eliminated.

6.2 Site 2 – South of Conveyor CV217

This site is relatively close to the existing reservoir making the control of the water supply to the various dust mitigation areas easier.

This site will have a low visual impact (as it is inside the stockyard area) and requires significantly less piping than alternate site 3.

This site is not limited by the proximity of the sand dunes as site 1 is.

6.3 Site 3 - West of Borrow Pit

The advantage of this site is that there are no sand dunes in the area that could be disturbed.

The disadvantages of this site are:

- This option is far from the existing infrastructure making control more difficult.
- This site will require significantly longer length of pipes to be installed.
- There may be a higher visual impact at this position as there is less natural screening from the surrounding landscape.

7. Conclusion

There is relatively little space to situate a RO installation in and around the Iron Ore Terminal. From an infrastructure perspective Site 1c is the most cost effective option, followed by Site 2a, with Site 3 generally being the most expensive option.

The risks to install RO infrastructure external to the Port are prohibitively high and the lengthy timeframes to acquire additional land could require obtaining additional scarce water supplies from the Municipality to meet the immediate water demand for the dust suppression measures. The options have significant additional project related risks and would increase the cost per unit volume of RO water produced which would make the RO Plant financially unviable. For these reasons, these options will not be investigated further.

The table below summarises the infrastructure costs of each RO Plant option located within the Port in order of least expensive to most expensive. This is for comparative purposes only.

Table 26: Summary of estimated infrastructure costs

Option 1c - Site 1 with Beach Well Intake and Beach well Discharge	R 4,492,840
Option 2a - Site 2 with Beach Well Intake and Direct Discharge into Small Bay	R 5,078,126
Option 1a - Site 1 Beach Wells for Intake and Direct Discharge	R 5,101,670
Option 2b - Site 2 with Direct Intake and Direct Discharge into Small Bay	R 5,324,066
Option 1b - Site 1 with Direct Intake and Direct Discharge	R 5,329,710
Option 3d - Site 3 with Intake Wells (Multi Purpose Terminal) and Discharge at Caisson 3	R 5,461,790
Option 3a - Site 3 with Direct Intake (Small Bay) and Direct Discharge (Small Bay)	R 6,114,170
Option 3b - Site 3 with Direct Intake (Small Bay) and Direct Discharge (Big Bay)	R 6,135,650
Option 3c - Site 3 with Intake Wells (Stockpiles) and Discharge at Caisson 3	R 7,058,470

The preferred location for the water reservoir is site 1 adjacent to the existing reservoir which is close to the existing water infrastructure and will simplify the additional water reticulation system needed.