VOLWATERBAAI SEAWATER DESALINATION PLANT

CHEMICALS AND DISCHARGES SUMMARY

(APPENDIX TO PRELIMINARY DESIGN REPORT)

FRONTIER RARE EARTHS LIMITED

Royal HaskoningDHV
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REPORT DETAILS

Title	:	VOLWATERBAAI SEAWATER DESALINATION PLANT **CHEMICALS AND DISCHARGES SUMMARY** (APPENDIX TO PRELIMINARY DESIGN REPORT)
Author/s	:	Keith Turner
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Approved by: _____ **Japie van Eeden (Project Principal)**		Date
Report checked by: _____ **(Jack McGhie)** **Project Manager** _____ **(Keith Turner)** **Civil / Water Engineer**		Date

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ABBREVIATIONS and ACRONYMNS

CIP	Cleaning in Process
DAF	Dissolved air flotation (a solids separation process)
DEA: O&C	Department of Environmental Affairs: Oceans and Coasts
DMF	Dual media filter
EIA	Environmental Impact Assessment
MSDS	Materials Safety Data Sheet
RHDHV	Royal HaskoningDHV
RO	Reverse Osmosis
ROD	Record of Decision
SWRO	Seawater Reverse Osmosis
VWB	Volwaterbaai

DEFINITIONS

Sanitiser	Substance that simultaneously cleans and disinfects
Disinfectant	Substance applied to non-living objects to destroy microorganisms
Biocide	Substance that is used to destroy all forms of life, not just microorganisms (biocide and sanitiser are sometimes used interchangeably)

1 INTRODUCTION

1.1 Background

This report forms part of the Preliminary Design Report for the Volwaterbaai Desalination Plant (the plant). The proposed plant is a key element in the water supply scheme for the Zandkopsdrift mine. The proposed plant makes use of the seawater reverse osmosis (SWRO) process, to treat seawater abstracted from the Atlantic Ocean.

All SWRO plants use a certain number of chemicals and additives, of which a certain amount is discharged back to the sea. The purpose of this report is to describe and quantify the chemicals to be used in, and the effluents to be discharged from, the proposed plant.

1.2 Brief Description of the Works

The plant will, on average:

- use 13 700 m^3 of seawater
- produce 5 500 m3 of treated water
- discharge 8 200 m^3 of brine back to the sea

The main elements of the SWRO process are:

- Marine intake works (comprising a sea intake, a seawater pumpstation and pipeline)
- Pre-treatment (screening, suspended solids removal, and filtration)
- Reverse osmosis (mainly dissolved solids removal)
- Post-treatment (remineralisation of permeate)
- Disinfection and storage of product water
- Marine outfall works (comprising the discharge pipelines, and diffuser system)

The overall SWRO desalination process is shown schematically in Figure 1-1 below.

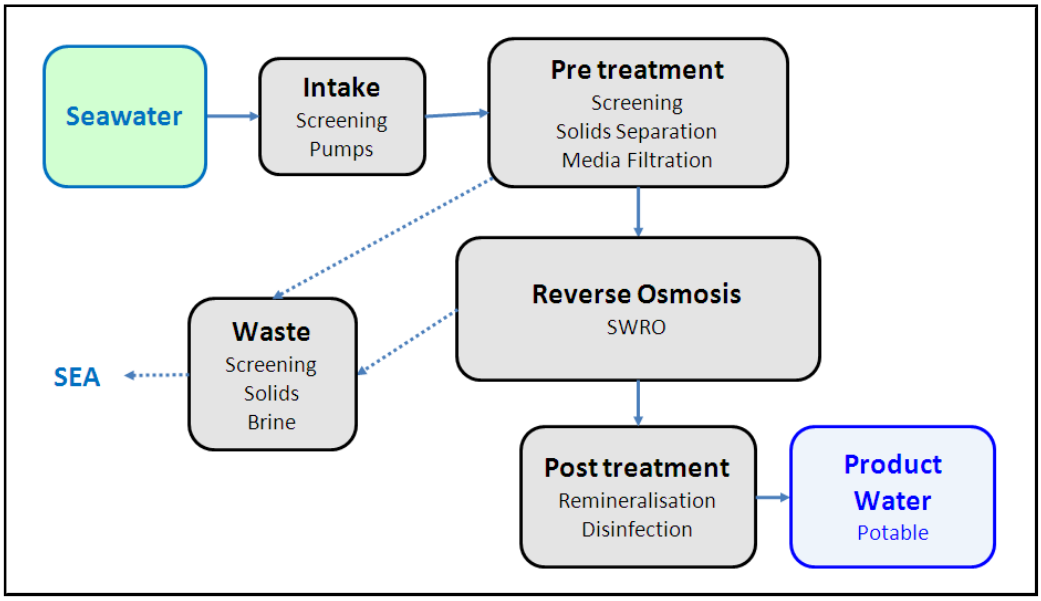

Figure 1-1: Process Overview

The plant and the process are described in detail in the main report.

2 CHEMICALS USED IN THE PROCESS

The main purpose of most of the chemicals used in the SWRO process, is to protect and prevent fouling of the RO membranes. Chemicals are also used for cleaning the plant and for preserving the RO membranes when the plant is not in operation.
Remineralisation and disinfection chemicals are added to the product water to obtain the desired characteristics for the intended water use.

2.1 Chemicals in Normal Operation

The following chemicals are proposed for use in the plant while it is in normal operation:
(* denotes alternative or additional chemicals that may, or may not, be required)

In the feedwater and pre-treatment stream:

- Chlorine, dosed at the seawater intake on a shock basis as a biocide
- Ferric Chloride, dosed in seawater feedline before DAF & DMF for flocculation
- Anionic Polymer*, dosed in seawater feedline before DAF for flocculation
- Sulphuric acid*, dosed in seawater feedline before DAF to aid flocculation

In the pretreated water:

- Sodium Metabisulfite, dosed in filtrate before RO membranes as reducing agent for the reduction of chlorine
- Phosphonate, dosed in filtrate before RO membranes as scale inhibitor (antiscalant)

In the RO permeate:

- Soda Ash, dosed in the product water for pH correction
- Carbon-dioxide, dosed prior limestone columns in order to lower the pH for dissolution of calcium carbonate ($CaCO_3$)
- Calcium carbonate, dissolved into permeate for stabilisation

In the final product water:

- Chlorine, dosed continuously to the product water stream for disinfection

The chemicals that are used in the process are supplied in different forms (eg solid, powder, liquid, gas) and are either ready to use, or require make-up and dilution on site.

Further details, dosing rates and final concentrations of the chemicals mentioned above, are given in Table 2-1 below.

Table 2-1: Chemicals Summary Details

Chemical	Description / Function	Main Ingredient	Dosing Rate	Dosing Regime	Estimated Concentration (in Waste Tank)
Sanitiser (Non-oxidizing)	Liquid used for macro- and micro-biological control	DBNPA (2,2-dibromo-3-nitrilopropion-amide)	2 mg/l	Flash dosing for 10 mins every 4 hrs	0.84 mg/l
OR					
Sanitiser (oxidizing)	Gas, or liquid, introduced into motive water stream, used for macro- and micro- biological control (seawater intake)	Chlorine (Cl_2 gas) or Sodium hypochlorite (NaClO solution)	1 mg/l	Flash dosing for 10 mins every 4 hrs	0.42 mg/l
Coagulant	Liquid used for Removal of organic matter	Ferric chloride	6 mg/l	Continuous	3.33 mg/l (as Fe)
OR					
Coagulant / Floc aid	Liquid used for removal of organic matter	Anionic polymer	1 mg/l	Continuous	1.67 mg/l
Dechlorin-ation Agent	Liquid, used for, dechlorination and for membrane preservation	Sodium Metabisulphite (SMBS)	2 mg/l	Continuous	3.14 mg/l
Antiscalant	Liquid that controls scale on membranes	Phosphonate	3 mg/l	Continuous	4.7 mg/l
Sanitiser (oxidizing)	Gas, or liquid, introduced into motive water stream, used for macro- and micro- biological control (product water)	Chlorine (Cl_2 gas) or Sodium hypochlorite (NaClO solution)	0.5 mg/l	Continuous	No discharge

Figure 3-1, in the following section, shows schematically where these chemicals are introduced and discharged in the overall process.

2.2 Chemicals in Cleaning and Maintenance Operation

The following chemicals are proposed for use in the plant while cleaning and maintenance is being carried out.
(* denotes alternative or additional chemicals that may, or may not, be required)

CIP (cleaning in place) chemicals:

- H4203 Peroxyacetic acid, a sanitising CIP solution (Hydrex 4203)
- H4502, high pH CIP solution containing Sodium Hydroxide (Hydrex 4502)
- H4503, acid, low pH CIP solution (Hydrex 4503)
- Ammonium Hydroxide, a high pH CIP solution*
- Hydrochloric Acid, a low pH CIP solution*

Memebrane Preservation

- Sodium Metabisulfite (SMBS), used for preserving the RO membranes when they are not in operation

Table 2-2 below summarises the details and concentrations of these chemicals.

Table 2-2: Summary of Cleaning and Preserving Chemicals

Chemical	Description / Function	Main Ingredient	Concen-tration (in CIP Tank)	Cleaning Regime	Concen-tration (in Waste Tank)
Peroxyacetic acid (Hydrex 4203)	Liquid, used for biofouling removal from membranes	Hydrogen peroxide & paracetic acid	1500 mg/l	Batched as required	1.55 mg/l
Low pH CIP solution (Hydrex 4503)	Liquid, used for biofouling removal from membranes		4000 mg/l	Batched as required	4.13 mg/l
High pH CIP solution (Hydrex 4502)	Liquid, used for biofouling removal from membranes	Solution containing Sodium hydroxide	4000 mg/l	Batched as required	4.13 mg/l
Preservative	Liquid, used for membrane preservation, and for dechlorination	Sodium Metabisulphite (SMBS)	5000 mg/l	Batched as required	1.87 mg/l

Figure 3-1, in the following section, shows schematically where these chemicals are introduced and discharged in the overall process.

2.3 Chemical Storage and Safety

All chemicals will be stored and handled in bunded areas and any spillage will therefore be contained and handled in these areas. Spillages will not be directed to the waste sump, unless they have been neutralised and diluted to the same concentrations that are permitted for discharge.

The relevant Materials Safety Data Sheets (MSDS) for the chemicals listed above are provided in Annexure A.

Figure 2-1: CIP Tank with RO vessels

3 DISCHARGES

As stated in the introduction, an average of 8 200 m3/day (60%) of the seawater is returned to the sea as brine from the plant. The brine has high salinity, and a slightly increased temperature (compared to the incoming feedwater), and will be combined with other waste products of the process to make up the total discharge stream.

3.1 Discharges in Normal Operation

The plant will discharge the following waste products while it is in normal operation:

3.1.1 Brine

The brine is the portion of the feedwater that does not pass through the membranes in the high pressure RO vessels, and is basically concentrated seawater. The estimated composition of the primary brine stream (before being combined with any other discharges) is as follows:

Table 3-1: Composition of Brine

Name	Concentrate (mg/l)		Name	Concentrate (mg/l)
NH_4	0.00		NO_3	15
K	838		Cl	34 800
Na	19 598		F	2
Mg	2 271		SO_4	5 345
Ca	742		SiO_2	4
Sr	13		Boron	8
Ba	0.00		CO_2	4
CO_3	12		TDS	63 949
HCO_3	265			

3.1.2 Screenings

Drum filter waste will make up a low percentage of the total waste volume and will consist mainly of suspended solids, and organic matter like kelp, seaweed, algae etc. The feedwater will pass through 40mm screens at the sea intake, and therefore it is not expected that there will be large-sized organic matter entering the system.

3.1.3 Pre-treatment (DAF and DMF) waste

DAF overflow will make up a low percentage of the total waste volume and will consist mainly of suspended solids, organic matter, algae etc. Ferric-chloride & anionic polymer will used in the flocculation process.

DMF Backwash waste will make out a low percentage of the total waste volume and will consist mainly of suspended solids, organic matter, algae etc. that is not removed in the DAF process.

3.1.4 CIP Waste and Preservative Disposal

The CIP and preservation solutions will be collected after use, in a separate CIP waste tank, the pH checked, and then drip–fed into the waste system for disposal, over a set period. A 12 hour dilution period was assumed for the purposes of this report.

If the plant is not operational, and brine is not being discharged, then the contents of the CIP waste tank will be removed by tanker, and disposed of at the mine's wastewater treatment works.

The waste components, including brine, pre-treatment effluent, filter backwash, and the spent cleaning solutions are summarised in Table 3-2 below.

Table 3-2: Summary of Discharges

Type	Description	Origin	Estimated Concentration
Brine (continuous)	High salinity water containing concentrated constituents of seawater feed	RO units	63 949 mg/l TDS
Screenings (continous)	Seawater containing suspended solids, organic matter, algae etc	Drum filters	Varies
Pre-treatment (continous)	Seawater containing suspended solids, organics and trace coagulant generated during pre-treatment (eg DAF or other solids separating process)	DAF effluent	8 mg/l SS (suspended solids)
Filter Backwash (intermittent)	Filtered seawater containing suspended solids, organics and trace coagulant generated during backwashing and rinsing of pre-filtration system	Filters	7 mg/l SS (suspended solids)
Spent CIP solution (quarterly)	Used cleaning solution resulting from membrane cleaning containing low concentrations of chemicals used for cleaning.	Membrane CIP	9.8 mg/l (sum of CIP)
Spent SMBS solution (on shutdown)	Used preservation solution from membrane preservation.	Membrane vessels	1.87 mg/l (sum of CIP)

Figure 3-1 below, shows schematically, the origin and composition of these discharges in the overall process.

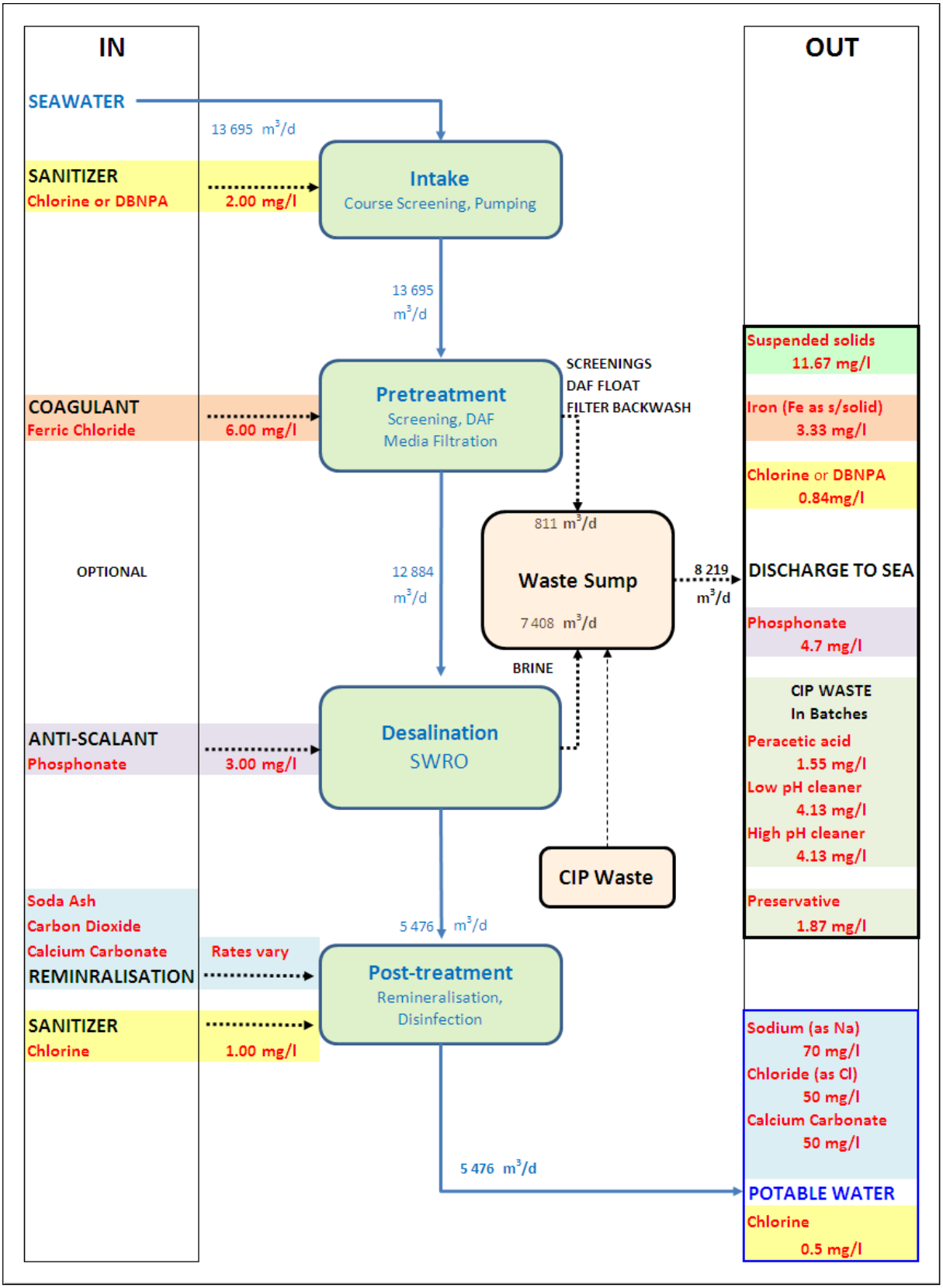

Figure 3-1: Chemicals and Discharges Flow Diagram

Note: A larger version of this figure is provided in Annexure B

3.2 Waste Discharge Alternatives

As discussed above, during normal operation of the plant, it is proposed that the waste products of the screening, and pre-treatment processes (DAF and DMF), and the spent CIP solutions, be mixed continuously and discharged with the brine.

The alternatives for the discharge of certain of the pre-treatment waste and CIP waste will be investigated, for example:

- Screenings and organic matter:
  - Dewater in a drying bed and sell or donate to local collectors of kelp and seaweed
  - Dewater and use with vegetation waste and composting toilet waste to make fertiliser for site landscaping
  - Dewater in a drying bed and dispose to landfill waste site (at plant site, or at the mine)

- DAF sludge and DMF backwash water:
  - Dewater in a drying bed and use for composting
  - Dewater in a drying bed and dispose to landfill waste site
  - removal by tanker and disposal at the mine's wastewater treatment works

- CIP and Preservative solution:
  - removal by tanker and disposal at the mine's wastewater treatment works

End of Appendix: Chemicals and Discharges – Annexures attached

ANNEXURES

A. MATERIALS SAFETY DATA SHEETS

A.1 MSDS 3930 - Polyelectrolyte.pdf
A.2 MSDS 4104 - Antiscalant RO feed.pdf
A.3 MSDS 4203 - CIP Chemical.pdf
A.4 MSDS 4502 - CIP Chemical.pdf
A.5 MSDS 4503 - CIP Chemical.pdf
A.6 MSDS Ammonium Hydroxide - CIP chemical.doc
A.7 MSDS Carbon-dioxide - re-min.pdf
A.8 MSDS Chlorine - Feed shock & product disinfection.pdf
A.9 MSDS Ferric Chloride - DAF & DMF Feed.docx
A.10 MSDS Hydrochloric Acid - CIP Chemical.doc
A.11 MSDS SMBS - RO feed.doc
A.12 MSDS Soda Ash Light - re-min.pdf
A.13 MSDS Sulphuric Acid - DMF Feed.doc

B. CHEMICALS AND DISCHARGES FLOW DIAGRAM (A3 SIZE)

ANNEXURE B: CHEMICALS AND DISCHARGES FLOW DIAGRAM