14. CONCLUSIONS / RECOMMENDATIONS

The feasibility study that was conducted into water recycling opportunities within the Port Pirie Region found that it is feasible to recycle water from two main sources, the Port Pirie wastewater treatment plant (WWTP) and the Nyrstar process effluent treatment system (PETS) using reverse osmosis. This has the potential to recover 70% of these wastewater streams, which in combination totals 1,349 ML/yr.

The recycled water stream, which will be of sufficient quality to be used as process water in the Nyrstar smelter and for irrigation systems in Port Pirie, represents 64% of the region's mains water drawn from the Morgan-Whyalla pipeline. The total amount of recycled water represents 84% of Nyrstar's mains water usage.

The recovery and purification of both recycled water streams can be achieved with a cost investment of $ 10.4 M, with a cost sensitivity of ± 30%. The technology selected is based on Reverse Osmosis, with micro filtration being required for pre-treatment. The power requirements for the project have been calculated to be 0.7 MW.

We believe that the project should qualify for financial support from the Federal Government as it satisfies the following criteria:

- "Delivers substantial and lasting volumes of water, with water saved to be delivered for environmental purposes;
- Helps secure regional economies and supports local communities facing reduced water supply; and
- Delivers value for money".

Appendix A – RO Feedwater Quality

Table A - RO Feedwater Quality, mg/L

WORLEYPARSONS PETS PLANT / NYRSTAR PORT PIRIE SMELTER	1 PETS O/FLOW 13/2/08	2 PETS O/FLOW 14/2/08	3 PETS O/FLOW 17/2/08	4 PETS O/FLOW 18/2/08	5 PETS O/FLOW 19/2/08	Average	Port Pirie WWTP (Mean)	Average
	08-FE10251	08-FE10252	08-FE10253	08-FE10254	08-FE10255			
FLOW						95	125	220
Ammonia (NH4)							7.0	7.0
Potassium	470	510	440	490	510	484		484
Sodium	6100	4100	4400	7000	7400	5800	6955	6456
Magnesium	450	300	360	530	560	440	839	667
Calcium	890	830	850	840	720	826	284	518
Strontium	4.6	1.8	3.3	9.5	9	5.6		5.6
Barium	0.033	0.026	0.033	0.065	0.063	0.044		0.0
Carbonate	<LoD	0.4	0.3	2.4	1.6	1.1		1.1
Bicarbonate	<LoD	29.6	21.7	37.5	40.3	32		32.3
Nitrate (NO3)	4.0	3.9	2.6	6.6	5.8	4.6		4.6
Chloride	8500	5200	6300	10000	11000	8200		8200.0
Fluoride								
Sulphate (S)	1500	1400	1400	1300	1200	1360		1360.0
Reactive Silica (as SiO2)	0.19	0.71	0.71	0.39	0.91	0.6		0.6
Boron				1.7		1.7		1.7
pH	6.9	8.1	8.1	8.8	8.6	8.1	8.3	8.2
Aluminium	0.11	0.14	0.075	0.16	0.022			
Copper	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01			
Hardness mg equivalent CaCO3/L	4100	3300	3600	4300	4100			
Iron	< 0.05	< 0.05	0.07	< 0.05	< 0.05			
Phosphate ortho (P)	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05			
Phosphate total (P)	0.12	0.12	0.07	0.18	0.09			
Total Dissolved Solids	20000	15000	16000	22000	23000	19200	21492	20502
Turbidity(NTU)	< 1	7.3	< 1	2.5	< 1		16	

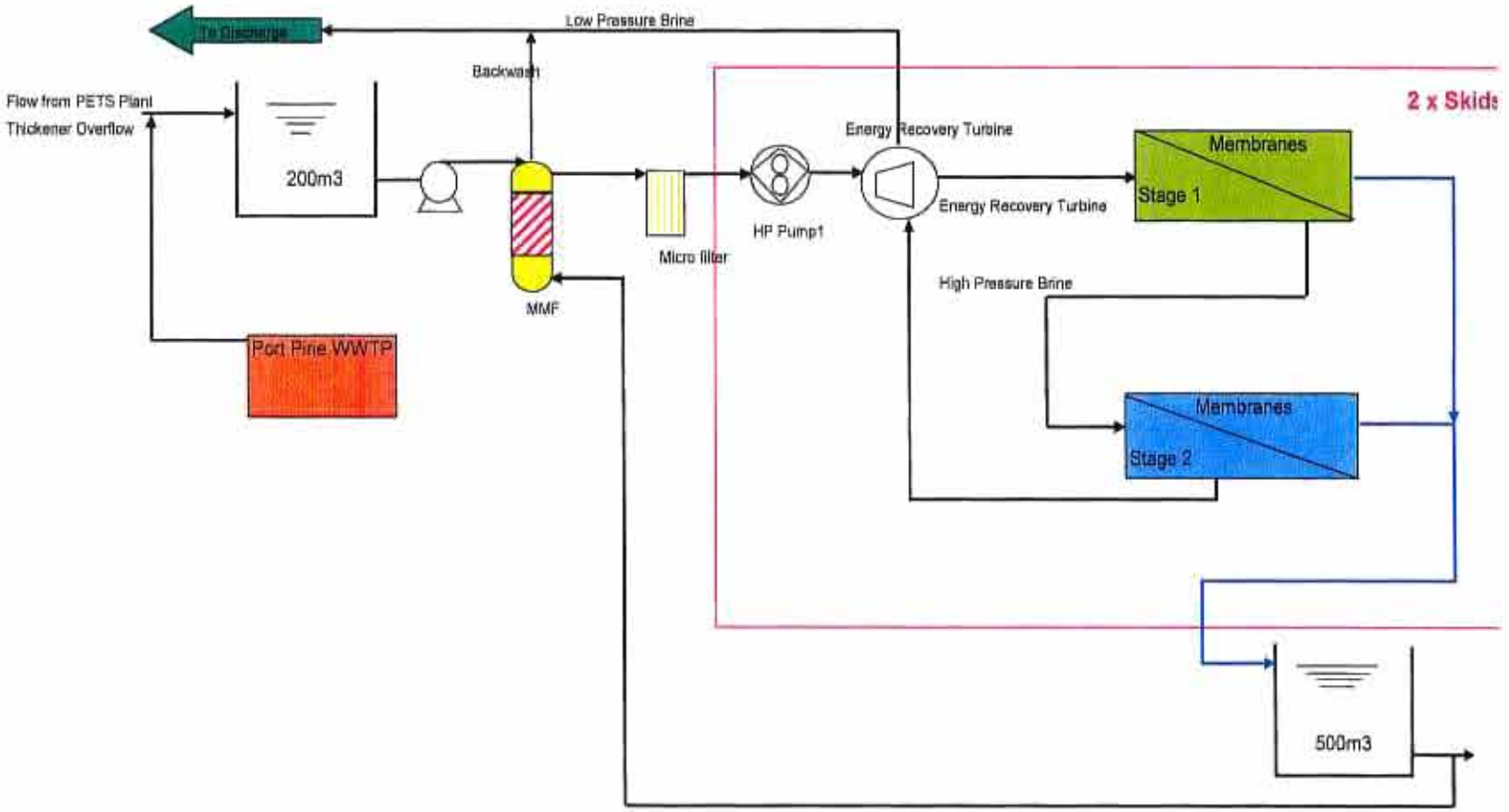
Appendix B – RO Product Water Quality

NYRSTAR PORT PIRIE SMELTER
FEASIBILITY STUDY

Table B - RO Water Quality

Chemical Parameter	Concentration in Permeate, mg/l
Total Dissolved Solids (TDS), mg/l	170
pH	6.5
Sodium, mg/l as Na	58
Magnesium, mg/l as Mg	2
Calcium, mg/l as Ca	1
Strontium, mg/l as Sr	0.01
Barium, mg/l as Ba	0
Carbonate, mg/l as CO_3	0
Bicarbonate, mg/l as HCO_3	0.5
Nitrate, mg/l as NO_3	1
Chloride, mg/l as Cl	99
Fluoride, mg/l as F	0
Sulphate, mg/l as SO_4	1
Silica, mg/l as SiO_2	0.01
Boron, mg/l as B	0.5
Carbon Dioxide, mg/l as CO_2	0.2
Ammonium, mg/l as NH_4	0.3
Potassium, mg/l as K	5

Appendix C - RO Plant process Flow Diagram (PFD)

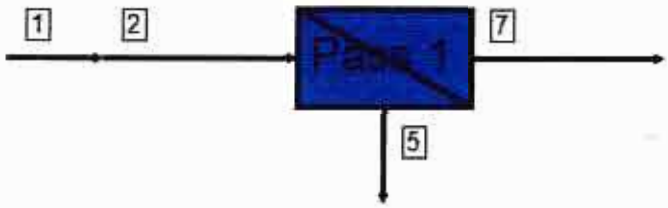

To Discharge
Low Pressure Brine
Backwash
Flow from PETS Plant
Thickener Overflow
200m3
MMF
Micro filter
HP Pump1
Energy Recovery Turbine
Energy Recovery Turbine
Membranes
Stage 1
High Pressure Brine
Membranes
Stage 2
2 x Skids
Port Pirie WWTP
500m3

Appendix D – RO Preliminary Design Data

Project: Nyrstar PETS WTP 4
Prepared By: B Shackleton
WorleyParsons

ROSA v6.1.5 ConfigDB U238786_55
Case: 1
3/12/2008

System Design Overview



Raw Water TDS	17747.27 mg/l	% System Recovery (7/1)	70.01 %
Water Classification	Seawater (Well/MF) SDI < 3	Fouling Factor (Pass 1)	0.85
Feed Temperature	20.0 C		

Pass #	**Pass 1**	
Stage #	**1**	**2**
Element Type	SW30XLE-400i	SW30XLE-400i
Pressure Vessels per Stage	24	12
Elements per Pressure Vessel	7	7
Total Number of Elements	168	84
Pass Average Flux	16.45 lmh	
Stage Average Flux	18.20 lmh	12.94 lmh
Permeate Back Pressure	20.00 bar	0.00 bar
Booster Pressure	0.00 bar	0.00 bar
Chemical Dose	-	
Energy Consumption	3.05 kWh/m³	

Project: Nyrstar PETS WTP 4
Prepared By: B Shackleton
WorleyParsons

ROSA v6.1.5 ConfigDB U238786_55
Case: 1
3/12/2008

Pass 1			
Stream #	**Flow (m^3/h)**	**Pressure (bar)**	**TDS (mg/l)**
1	220.00	0.00	17747.27
3	220.00	61.58	21792.22
5	65.98	57.89	72262.55
7	154.02	-	170.70
7/1	**% Recovery**	70.01	

Project Information:
Waste water recycling system.

Design Warnings:
-None-

Solubility Warnings:
Langelier Saturation Index > 0
Stiff & Davis Stability Index > 0
BaSO4 (% Saturation) > 100%
Antiscalants may be required. Consult your antiscalant manufacturer for dosing and maximum allowable system recovery.

Reverse Osmosis System Analysis for FILMTEC™ Membranes
Project: Nyrstar PETS WTP 4
B Shackleton, WorleyParsons

ROSA v6.1.5 ConfigDB U238786_55
Case: 1
3/12/2008

Project Information: Waste water recycling system.

System Details

Feed Flow to Stage 1	220.00 m³/h	Pass 1 Permeate Flow	154.02 m³/h	Osmotic Pressure:	
Raw Water Flow to System	220.00 m³/h	Pass 1 Recovery	70.01 %	Feed	15.06 bar
Feed Pressure	61.58 bar	Feed Temperature	20.0 C	Concentrate	52.06 bar
Fouling Factor	0.85	Feed TDS	21792.22 mg/l	Average	33.56 bar
Chem. Dose	None	Number of Elements	252	Average NDP	30.63 bar
Total Active Area	9364.32 M²	Average Pass 1 Flux	16.45 lmh	Power	470.45 kW
Water Classification: Seawater (Well/MF) SDI < 3				Specific Energy	3.05 kWh/m³

Stage	Element	#PV	#Ele	Feed Flow (m³/h)	Feed Press (bar)	Recirc Flow (m³/h)	Conc Flow (m³/h)	Conc Press (bar)	Perm Flow (m³/h)	Avg Flux (lmh)	Perm Press (bar)	Boost Press (bar)	Perm TDS (mg/l)
1	SW30XLE-400i	24	7	220.00	61.23	0.00	106.37	59.81	113.63	18.20	20.00	0.00	123.57
2	SW30XLE-400i	12	7	106.37	59.46	0.00	65.98	57.89	40.39	12.94	0.00	0.00	303.29

Pass Streams (mg/l as Ion)							
Name	Feed	Adjusted Feed	Concentrate		Permeate		
			Stage 1	Stage 2	Stage 1	Stage 2	Total
NH4	7.00	7.00	14.20	22.54	0.26	0.58	0.34
K	484.00	484.00	997.23	1602.27	3.55	8.85	4.94
Na	6456.00	6456.00	13307.82	21391.05	41.86	103.20	57.95
Mg	667.00	667.00	1378.33	2220.43	1.11	2.69	1.52
Ca	518.00	518.00	1070.44	1724.45	0.84	2.07	1.17
Sr	5.60	5.60	11.57	18.64	0.01	0.02	0.01
Ba	0.04	0.04	0.09	0.15	0.00	0.00	0.00
CO3	2.67	2.67	7.21	12.27	0.00	0.00	0.00
HCO3	32.00	32.00	63.75	101.18	0.38	0.78	0.49
NO3	4.60	4.60	8.74	13.14	0.72	1.56	0.94
Cl	8200.00	12244.95	25248.73	40596.40	71.83	177.06	99.43
F	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SO4	1360.00	1360.00	2811.93	4532.05	0.82	1.98	1.12
SiO2	0.60	0.60	1.23	1.98	0.01	0.02	0.01
Boron	1.70	1.70	3.12	4.55	0.38	0.78	0.48
CO2	0.14	0.13	0.37	0.69	0.14	0.39	0.20
TDS	17747.27	21792.22	44939.12	72262.55	123.57	303.29	170.70
pH	8.20	8.20	7.97	8.00	6.65	6.48	6.57

Reverse Osmosis System Analysis for FILMTEC™ Membranes
Project: Nyrstar PETS WTP 4
B Shackleton, WorleyParsons

ROSA v6.1.5 ConfigDB U238786_55
Case: 1
3/12/2008

Design Warnings

-None-

Solubility Warnings

Langelier Saturation Index > 0
Stiff & Davis Stability Index > 0
BaSO4 (% Saturation) > 100%
Antiscalants may be required. Consult your antiscalant manufacturer for dosing and maximum allowable system recovery.

Stage Details

Stage 1 Element	Recovery	Perm Flow (m³/h)	Perm TDS (mg/l)	Feed Flow (m³/h)	Feed TDS (mg/l)	Feed Press (bar)
1	0.11	1.04	59.70	9.17	21792.22	61.23
2	0.11	0.92	75.12	8.13	24564.07	60.92
3	0.11	0.79	96.32	7.21	27681.96	60.66
4	0.10	0.67	125.81	6.42	31093.95	60.44
5	0.10	0.55	167.27	5.75	34693.20	60.25
6	0.08	0.43	226.04	5.20	38320.75	60.08
7	0.07	0.34	309.17	4.77	41790.63	59.94
Stage 2 Element	Recovery	Perm Flow (m³/h)	Perm TDS (mg/l)	Feed Flow (m³/h)	Feed TDS (mg/l)	Feed Press (bar)
1	0.10	0.87	141.66	8.86	44939.12	59.46
2	0.09	0.71	186.54	8.00	49795.75	59.16
3	0.08	0.57	249.21	7.29	54628.94	58.89
4	0.07	0.44	336.90	6.72	59209.44	58.66
5	0.05	0.34	458.56	6.28	63340.41	58.44
6	0.04	0.25	625.76	5.94	66904.05	58.25
7	0.03	0.19	850.73	5.69	69865.55	58.07

Scaling Calculations

	Raw Water	Adjusted Feed	Concentrate
pH	8.20	8.20	8.00
Langelier Saturation Index	0.62	0.62	1.41
Stiff & Davis Stability Index	-0.10	-0.10	0.22
Ionic Strength (Molal)	0.38	0.44	1.53
TDS (mg/l)	17747.27	21792.22	72262.55
HCO3	32.00	32.00	101.18
CO2	0.14	0.14	0.69
CO3	2.67	2.67	12.27
CaSO4 (% Saturation)	21.39	21.39	80.79
BaSO4 (% Saturation)	130.78	130.78	474.72
SrSO4 (% Saturation)	8.90	8.90	40.27
CaF2 (% Saturation)	0.00	0.00	0.00
SiO2 (% Saturation)	0.42	0.42	1.58
Mg(OH)2 (% Saturation)	0.57	0.57	0.76

To balance: 4044.95 mg/l Cl added to feed.

Appendix E – Summary - RO Plant Cost Estimate

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Nyrstar Water Reduction Feasibility Study

+/- 30%

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CAPITAL COST FS - Nyrstar Water Reduction Feasibility Study +/- 30%

ESTIMATE BASIS

The Nyrstar Water Reduction Pre-Feasibility Study is a +/- 30% cost estimate. The base date for this estimate is March 2008.

The estimate is based upon equipment lists and MTO's supplied by engineering.

The total cost of the estimate is shown below and expressed in Australian Dollars

Description	AUD $
Direct Cost - Adelaide	$4,022,656
Direct Cost – Perth (RO Plant)	$3,835,986
Indirect Cost	$842,593
Contingency	$1,704,867
Total	**$10,406,102**

SCOPE

There are two parts to the estimate; the RO Plant and the pipeline associated with the RO plant. The Adelaide estimate encompasses all work associated with laying the pipeline, construction of the RO plant shed, control room and civil works associated with the construction of the RO plant as specified in MTO's. The RO Plant estimate was completed in our Perth office.

This document supplies supporting information for the work completed out of Adelaide.

The estimate is based upon equipment lists and MTO's supplied by engineering.

EARTHWORKS

Quantities of trenching, local backfill, borrowed fill, sand, bitumen have been estimated from layout drawings. Backfill is assumed to be locally available at $30 AUD per cubic meter.

CONCRETE

Quantities of concrete have been estimated and all in rate has been developed to include, rebar formwork, embeds, concrete for different type of concrete structures, including:

Equipment Foundation
Slab on Grade

BUILDINGS

Buildings have been measured in square metres and costed as per square metre rate based upon historical norms

MECHANICAL

Mechanical equipment has been sized and entered into an equipment list. Pricing for mechanical equipment has come from in house norms.

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CAPITAL COST FS - Nyrstar Water Reduction Feasibility Study +/- 30%

PIPING

Piping quantities have been generated from point to point measurement via an overhead layout.
Budget quotations have been sought for piping and some fittings. Other fittings have been factored.

ELECTRICAL

All electrical equipment including electrical bulks including Cable, Cable Tray etc has been included in this study.

INSTRUMENTION

All Instrumentation has been included in this study

DESIGN GROWTH

Design growth is an allowance for the "known unknowns". In an estimate, this is not an allowance for a change in scope.

The percentage of allowance for design growth is as follows:

	%Growth
Earthworks	10%
Concrete	10%
Steel	10%
Buildings	10%
Equipment	10%
Piping	10%
Electrical	10%
Instrumentation	10%

PRICING

Equipment pricing has been sought from recent projects and escalated to the base date of the estimate.

Prices have been sought from local contractors. An allowance has been added to the piping price to allow for fittings beyond that given in MTO's.

LABOUR RATE

A labour rate has been developed from historical data, based on similar projects within the region.

The wage rates have been used to calculate an average crew rate for each of the standard commodity codes.

Added to these are the contractor's field indirect expenses (field distributables) which include temporary facilities, indirect labour, tools, consumables, construction equipment costs, overhead and profit as follows:

	Crew Rates AU$	Contractor Distribs %	All-Incl. Rate AU$
Site Development	62	180	174
Earthworks	62	180	174
Concrete	64	120	141
Architect	63	100	128
Mechanical	65	150	163
Piping	65	130	145

INDIRECT COST

The following allowances for indirect costs have been made;

SPARE

Spare parts are excluded from the estimate

INITIAL FILLS

Initial fills are excluded from the estimate

VENDOR REPRESENTATIVES

Vendor Representatives have been factored at 0.5% of the total direct costs

COMMISSIONING

Commissioning has been factored at 2% of the total direct cost

FREIGHT

Freight has been factored at 3% for the cost of all bulk materials and plant equipment

EPCM COSTS

EPCM has been factored at 17.5% of all total direct costs for work out of Adelaide, and 8% of direct cost for work out of Perth.

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CAPITAL COST FS - Nyrstar Water Reduction Feasibility Study +/- 30%

CONTINGENCY

WorleyParsons recommend a contingency of 15% be applied to the RO, pipeline.

WorleyParsons recommend a contingency of 30% be applied to the RO Plant itself.

ALLOWANCE

1. A 50K allowance has been made for a gantry crane to be located in the RO shed and used for maintenance.
2. A 30K allowance has been made for traffic management
3. A 10K allowance has been made for signage

QUALIFICATIONS

4. No allowance for cable tray for piping in pipe rack. It is assumed the piperack supports will be at 3m intervals.
5. No allowance has been made for structural steel, it is assumed that there is room within the piperack for the proposed piping.
6. No. allowance has been made for thrust blocks located in trenches
7. In absence of soil testing, it has been assumed that no rock or the like will be encountered during excavation.
8. No allowance has been made for NDT testing
9. No allowance has been made for site fencing or temporary fencing

ESTIMATE EXCLUSIONS

The following items are excluded from the estimate.

The costs of soil and geo-technical investigations.

10. Cost of start up and commissioning and initial operating expenses subsequent to owner's acceptance of each system.
11. First fills

OWNERS COSTS

The following items are excluded from the estimate and are to be included in the owners cost:

- The cost associated with environmental studies and permits
- Communications including radio and information technology (IT)
- Land acquisition and right of way (if required)
- The cost of financing and interest charges during construction.
- The cost of this or any other study prior to notice to proceed
- Owner's project team including any operations personnel
- Owner's pre production and development costs.

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CAPITAL COST FS - Nyrstar Water Reduction Feasibility Study +/- 30%

- Process rights, royalties, license fees, technology fees and the like
- Project financing and interest charges
- Training of plant operating personnel
- Project insurances
- Operations costs including operator training
- Process Test work
- In-process inventory including charges and stocks of operating supplies and consumables
- Working capital
- Escalation beyond March 2008.
- Fluctuations in currency
- Contingency
- All costs outside of this Study Scope.

Appendix F – Intake and Distribution Pipe Layout

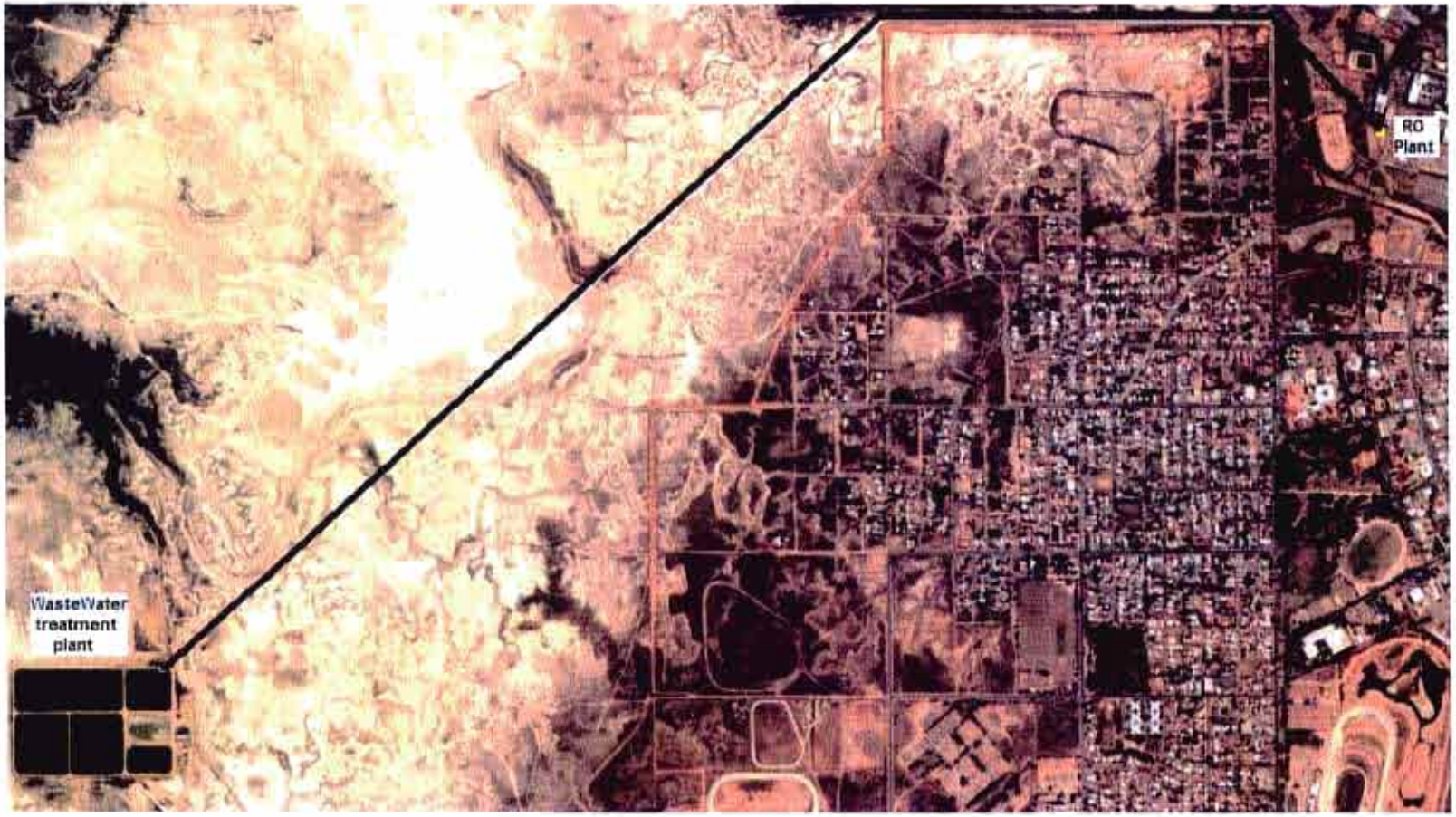

Figure F-1: Proposed pipeline route from Wastewater Treatment Plant to RO plant

Figure F-2: Proposed pipeline route between PETS and RO plant

Figure F-3: Proposed pipeline route from the RO plant to Demineralisation plant

Figure F-4: Proposed pipeline route from the RO plant to the Port Pirie Township

Appendix G – Electrical Power Requirements

Table G-1 Electrical Power Requirements

Reverse Osmosis Plant	
Disinfection System	
Sodium Hypochlorite Dosing Pump	0.10 KW, 240V ac
Sodium Metabisulphite Dosing Pump	0.10 KW, 240V ac
Filtration	
Backwash Pump	10 KW, 415V ac
Air Blower	5.0 KW, 415V ac
RO Unit	
High Pressure Pump	470 KW*, 415V ac
CIP System	
CIP PUMP	8.0 KW*, 415V ac
CIP Mixer	0.5 KW, 240V ac
CIP Heater	10 KW*, 415V ac
Drum Pump	2 KW*, 415V ac
Chemical Dosing System	
pH Adjustment System	
Sulphuric Acid Dosing Pump	0.1 KW, 240V ac
In-Line Mixer	0.5 KW, 240V ac
Sodium Hydroxide Dosing Pump	0.1 KW, 240V ac
Sodium Hydroxide Tank Heater^	10 KW*, 415V ac
Coagulation System	
Coagulant Dosing Pump	0.02KW, 240V ac
Flocculant Dosing Pump	0.02KW, 240V ac
Biocide System	
Biocide Dosing Pump	0.02 KW, 240V ac
Chlorination Dosing Pump	0.02 KW, 240V ac
PETS Plant	

PETS Effluent Transfer Pump to RO Plant	15 KW*, 415V ac
RO Reject Transfer Pump to PETS Discharge	15 KW*, 415V ac
WWTP Plant	
WWTP Effluent Transfer Pump to RO Plant	132 KW*, 415V ac
RO Water Distribution	
RO water Pump to Memorial Park	5.5 KW, 415V ac
RO water Pump from memorial Park to Rail Yard	3 KW, 415V ac
RO water Pump to Demineralisation Plant	7.5 KW*, 415V ac
Total Electrical Power Required	**695 KW (0.70 MW)**

* The power demand from these units is continuous and is estimated to be equal to 98% of the total power demand.

^ Supply of diluted caustic instead of 50% blend can replace the need for heat trace element on the caustic storage tank. However, high dosing rate is required and consequently more delivery cost.

Cost estimate for pipeline from Memorial Park to Golf Course

	Cost / m	Quantity	Cost
Pipeline			**$ 67,693**
90mm PE80 pipe	$ 19.3	2700 m	$ 52,200
Bends	$ 221.3	70 each	$ 15,493
Earthworks			**$ 369,581**
Saw cutting	$ 11.6	2700 m	$ 31,257
Bitumen	$ 79.4	2700 m	$ 214,488
Trench	$ 10.4	2700 m	$ 28,123
Sand	$ 11.9	2700 m	$ 32,027
Refill dirt	$ 4.9	2700 m	$ 13,358
Basecourse	$ 4.9	2700 m	$ 13,297
Subbase	$ 2.6	2700 m	$ 7,031
Traffic Management allowance (3 weeks)			$ 30,000
		Total Cost	**$ 437,274**