MINERAL RESOURCES TASMANIA

Tasmania

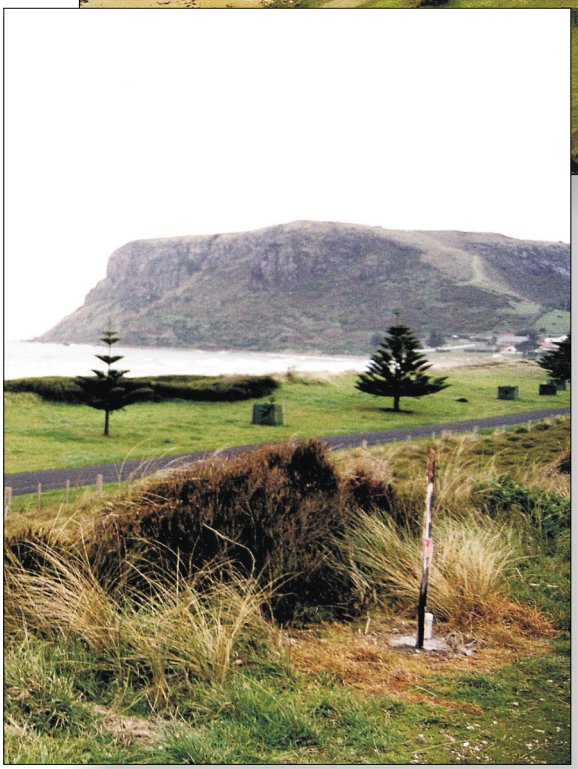
DEPARTMENT *of* INFRASTRUCTURE, ENERGY *and* RESOURCES

NHT Funded Project
NLP 13188

Natural Heritage Trust

Helping Communities Helping Australia

The effects of waste disposal on groundwater quality in Tasmania



Stanley sewage lagoons

Tasmanian Geological Survey Record 2002/08

Mineral Resources Tasmania
Tasmanian Geological Survey
Record 2002/08

Groundwater quality investigations at the Stanley sewage lagoons

A. R. Ezzy

Abstract

Groundwater was investigated in the area of the Stanley sewage lagoons to determine if the lagoons were affecting groundwater quality. Nitrite and nitrate were detected at low concentrations in close proximity to the lagoons. The lagoons are located close to a landfill, which also has the potential to affect groundwater quality in the area of the lagoons.

INTRODUCTION

Mineral Resources Tasmania (MRT) initiated a project to investigate the effects of waste disposal on groundwater quality in Tasmania. The project was funded by MRT and the Natural Heritage Trust (NHT) and included a number of sites for detailed study. The sewage lagoons at Stanley were one of these sites.

The objectives of the investigations at the Stanley sewage lagoons were to:

- Determine the geological nature of the host materials;
- Identify the depth of the water table;
- Examine the quality of the groundwater; and
- Determine the permeability of the host materials.

SITE DESCRIPTION

The Stanley sewage lagoons are clay lined and are located approximately 250 metres north of Stanley (354 800 mE, 5 486 800 mN) (fig. 1). The Department of Primary Industries, Water and Environment (DPIWE) currently license the facility.

During early years of operation, the northern maturation lagoon (lagoon number 3) was lined with additional bentonite. Information was not available on the thickness of the liners and the designed hydraulic permeability. Each lagoon has a one metre cement wave wall constructed at surface level to prevent wave erosion damage. All three lagoons are located in geological materials consisting primarily of sand. Plate 1 shows the local setting of the sewage lagoons.

An old landfill site is located between the sewage lagoons and Godfreys Beach. The landfill waste stream was mainly sourced from the township of Stanley between approximately 1983 and 1992.

Geology

The Tasmania Department of Mines 1:50 000 scale Smithton geological map (Lennox *et al.*, 1982) indicates that the geology of the Stanley area consists of Quaternary beach and dune sand (fig. 2). These deposits are suggested to have stabilised since the early Holocene.

Figure 1
Location of the Stanley sewage lagoons.

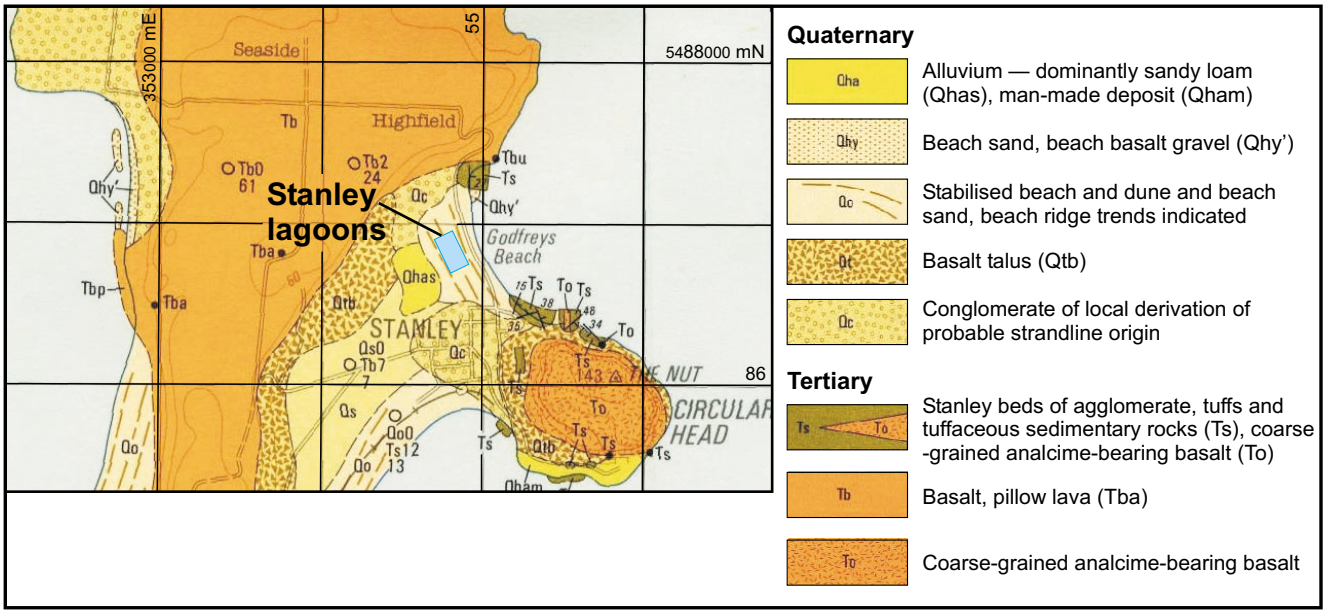


Figure 2

Extract from Smithton geological map (Lennox et al., 1982) of the local area and related geology.

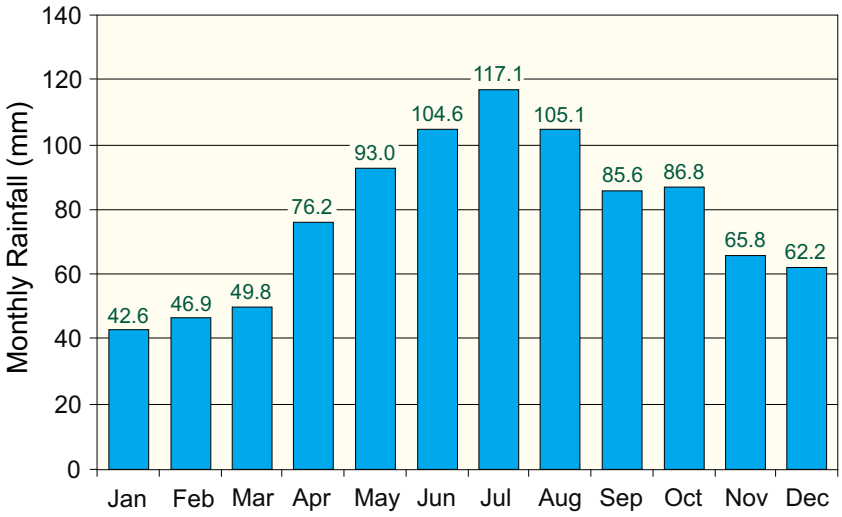


Figure 3

Average monthly rainfall for Australian Bureau of Meteorology rainfall station 091094, Stanley (Post Office).

Plate 1

The local setting of the Stanley sewage lagoons depicting Godfreys Beach and the Tertiary basalt Stanley Nut.

Geological mapping during the current study indicated that the site is dominated by surface Quaternary sand deposits within 50 metres of the lagoons in all directions.

Hydrology

The lagoons are located approximately 30 m west of Godfreys Beach and approximately 35 m east of marsh land which feeds a drainage line that discharges onto the northern end of Godfreys Beach. Australian Bureau of Meteorology rainfall station 091094 at Stanley (Post office) is the closest rainfall station to the site. The rainfall chart of average monthly recorded rainfall (fig. 3) shows that the average annual rainfall for the station is 935.7 mm.

INVESTIGATION METHODS

Borehole drilling and installation

Four 120 mm diameter monitoring bores were auger drilled on 7 September 2000 for this project (fig. 4), with 50 mm casing being installed in each hole. All bores were logged in accordance with AS 1726-1993; engineering logs are presented in Appendix 1. Disturbed samples were collected at appropriate intervals and are stored in the MRT core shed.

Groundwater was encountered at depths of between 1.5 and 4.5 m across the site. SSL2000/4 was drilled as a background bore, although no inflow or water table was intercepted. Flow during drilling indicated that the groundwater in boreholes SSL2000/1, SSL2000/2

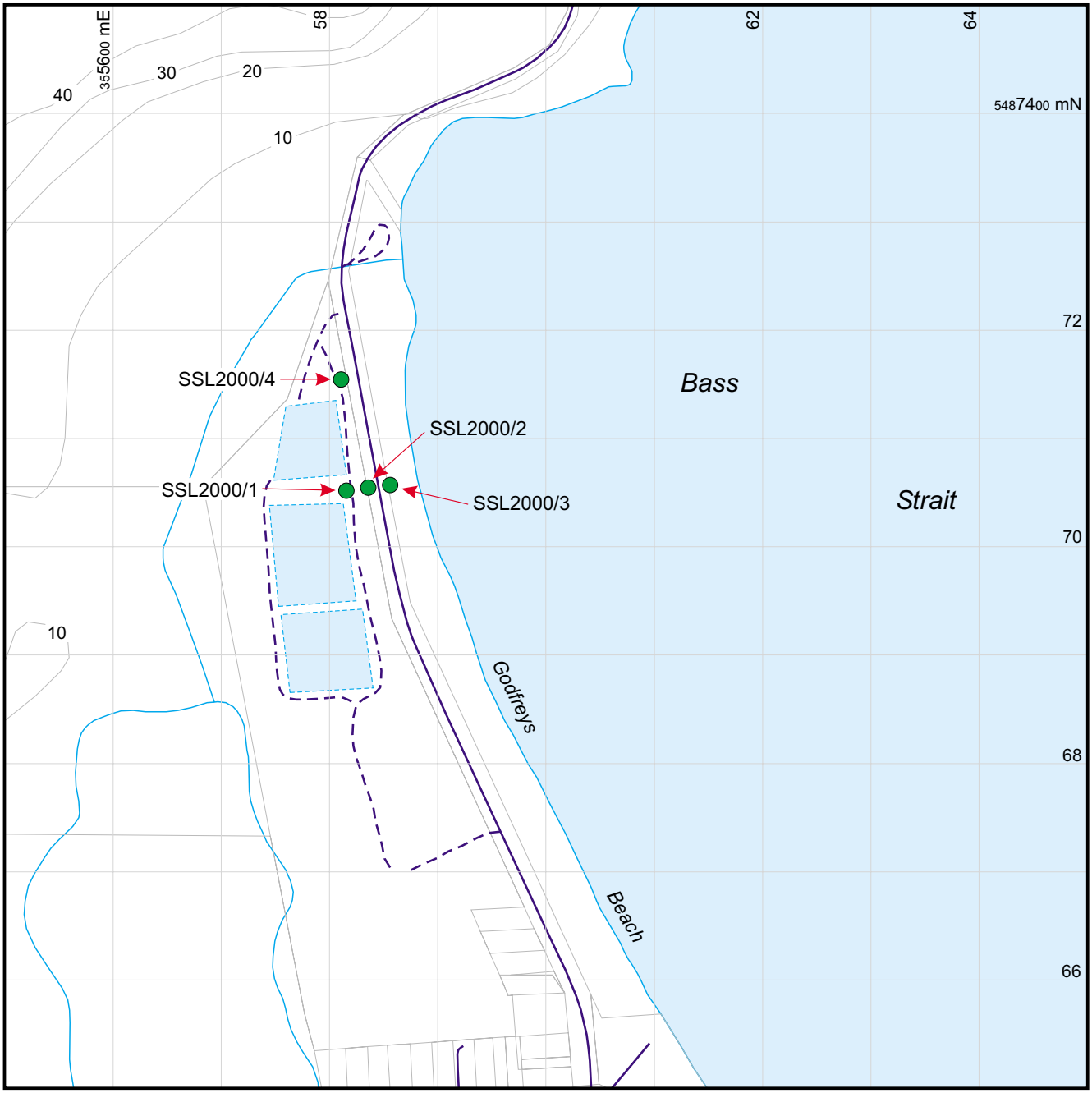


Figure 4

Locations of environmental monitoring bores installed at the Stanley sewage lagoons.

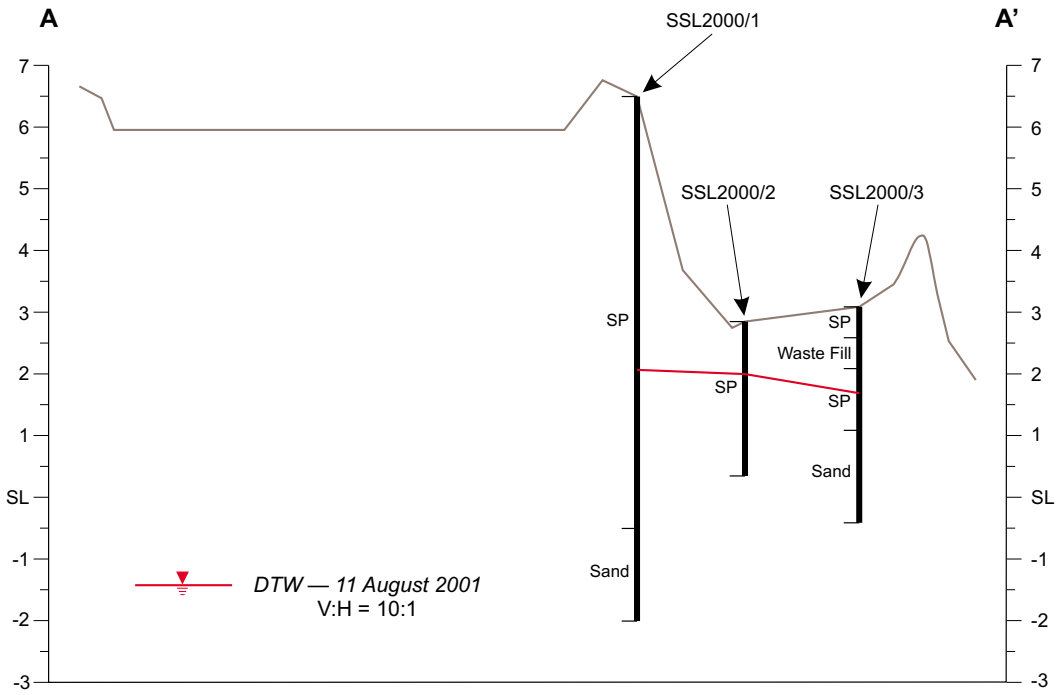


Figure 5

Cross-section and related standing water levels on 11 August 2001 for bores SSL2000/1, 2 and 3.

and SSL2000/3 was unconfined. Recorded yields of bores ranged between 0.048 to 0.72 l/s. Figure 5 shows a cross-section and related standing water levels on 11 August 2001 for bores SSL2000/1, SSL2000/2 and SSL2000/3.

Both the unsaturated and saturated zones consist of heterogenous layers of fine to coarse-grained sand. Well rounded basalt pebbles were intersected at the base of bores SSL2000/1 and SSL2000/3. Horizons of shell fragments were intersected in all boreholes. This suggests that past environments of deposition at the site included a beach coastal setting.

In situ permeability testing

Slug extraction tests were carried out on bores SSL2000/2 and SSL2000/3 on 14 August 2001 (Appendix 2). The slug extraction tests were completed (5 to 20 litres) and levels monitored for five minutes (time for 95% plus recovery). Test data were analysed in the software package *AquiferWin32* (Version 2.17, Environmental Simulations Inc.). The Bouwer and Rice (1976 Unconfined Aquifer) solution was used to calculate the hydraulic conductivities shown in Figure 6 (a) and (b) for SSL2000/2 and SSL2000/3 respectively. This method was selected as the most appropriate available within the software package.

HYDROLOGICAL MODEL

Figure 7 illustrates an interpretation of the piezometric surface based on surveyed heights and groundwater depths in the boreholes. Based on this linear interpretation, local groundwater flow is to the east of the lagoons towards Godfreys Beach. Recharge to the western marsh could also occur from the higher surrounding terrain to the south and mainly north.

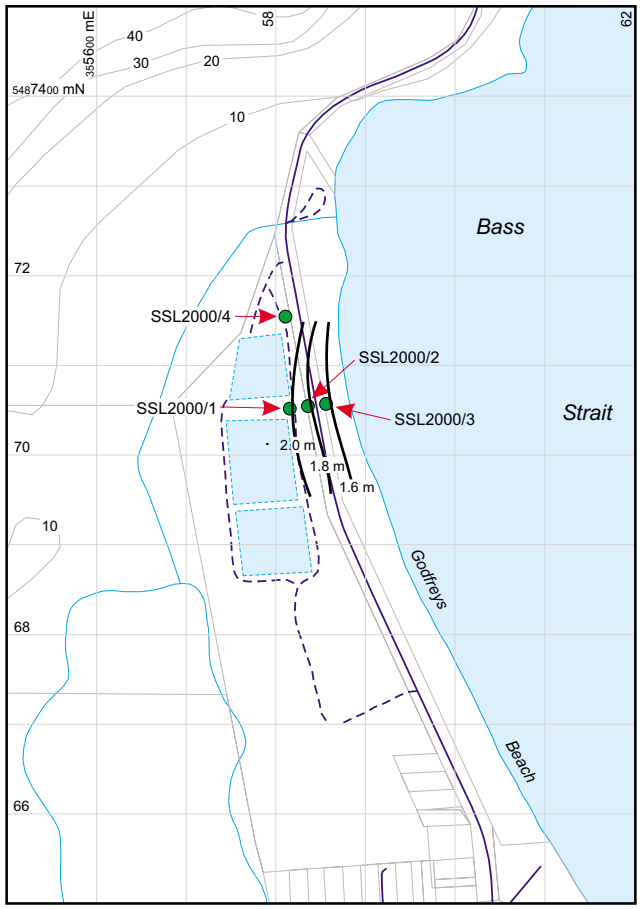
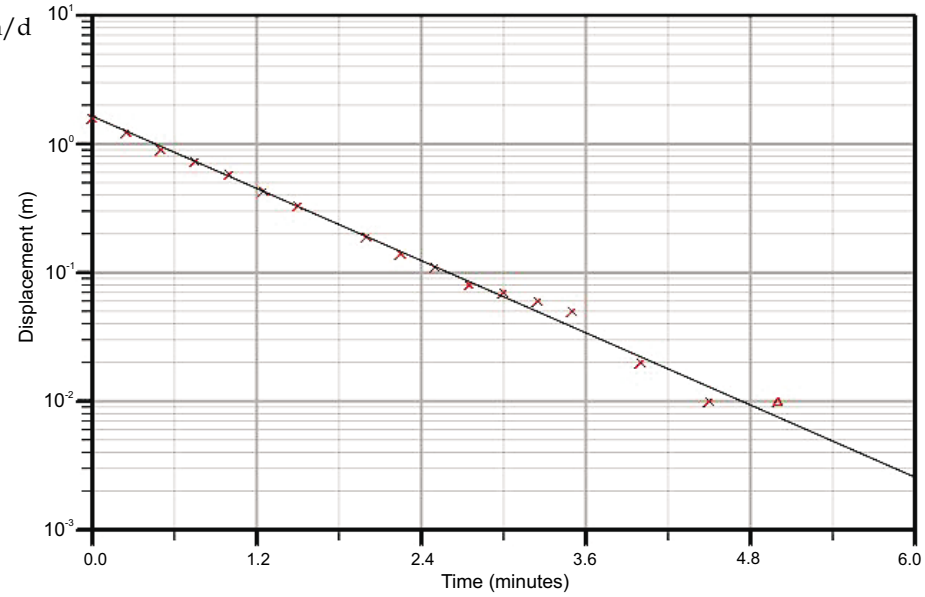


Figure 7

Interpretation of the piezometric surface based on surveyed heights and groundwater depths of the boreholes.

(a) SSL2000/2, (K = 1.80 m/d = 2.08 x 10^{-5} m/sec)



(b) SSL2000/3 (K = 2.53 m/d = 2.93 x 10^{-5} m/sec)

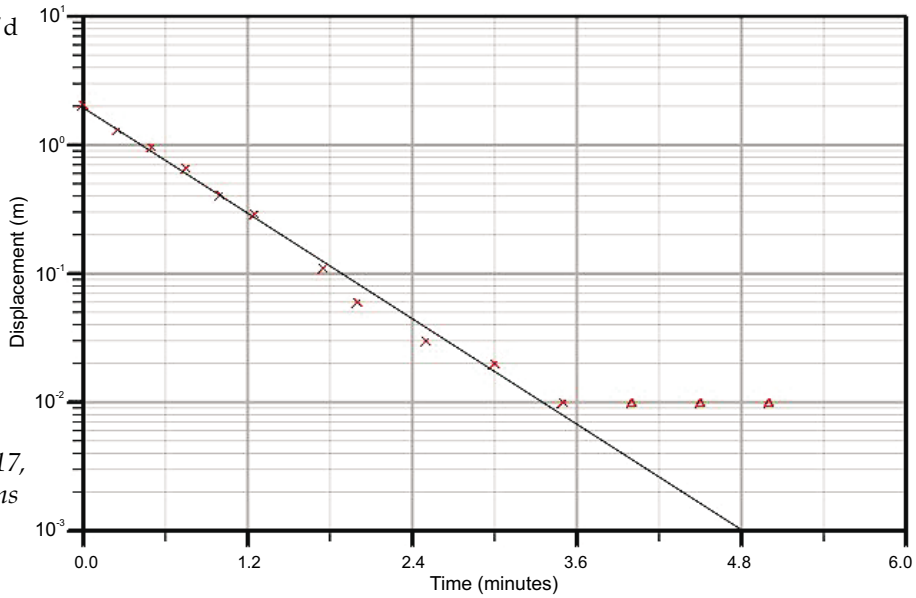


Figure 6

Hydraulic conductivity values calculated in AquiferWin32 (Version 2.17, Environmental Simulations Inc.), Bouwer and Rice (1976, Unconfined Aquifer) solution

GROUNDWATER CHEMISTRY

All bores were sampled on 2 November 2000 in accordance with Australian/New Zealand Standard AS/NZS 5667.11:1998. Bore SSL2000/4 contained no water and therefore was not sampled. Laboratory testing of samples of groundwater extracted from the bore holes was carried out by Analytical Services Tasmania, in accordance with relevant Australian and international standards. The laboratory report from Analytical Services Tasmania is presented in Appendix 3. Values for pH varied by only 0.1 pH unit, from 7.4 to 7.5. Conductivity values ranged between 1290 and 1480 µS/cm. Analytical results are presented on site maps in Appendix 4. Figure 8 is an anion Ternary plot for the results of the groundwater samples. Tables 1 and 2 compare analytical results against international standards where a guideline/ emission value is stated by the relevant standard.

Groundwater appears to be of poorer quality within the Quaternary sand aquifer in close proximity to the lagoons and within the landfill waste fill. Nitrate +

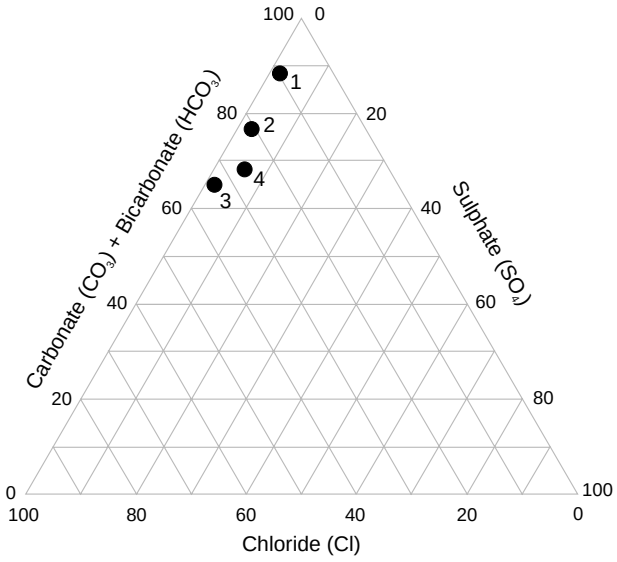


Figure 8

Anion Ternary plot for groundwater bores at the Stanley sewage lagoons. 1 – SSL2000/1; 2 – SSL2000/2; 3 – SSL000/3; 4 – average of all MRT records for groundwater in Quaternary coastal sand.

Table 1

Comparison of analytical results against water quality standards (guideline value listed when stated by a relevant standard)

Parameter	*SSL 2000/1*	*SSL 2000/2*	*SSL 2000/3*	*Emission limit*
pH	7.5	7.5	7.4	N/A
Conductivity (µS/cm)	1480	1290	1460	N/A: note average sea water value 36 000
TDS (mg/L)	924	804	866	N/A
Alkalinity CO_3 (mg/L)	3	2	1	N/A
Alkalinity HCO_3 (mg/L)	1590	701	541	N/A
Chloride (mg/L)	99	110	160	250* (mg/L)
Fluoride (mg/L)	0.11	0.15	0.12	1.5* (mg/L)
Sulphate (mg/L)	28	19	12	250* (mg/L)
Ammonia (mg/-NL)	0.156	0.293	0.206	0.5* (mg/L) nitrogen (as ammonia)
Nitrate + Nitrite (mg/-NL)	9.220	0.099	0.279	10.0* (mg/L) nitrogen (as nitrate or nitrite)
Nitrite	0.303	0.012	0.028	10.0* (mg/L) nitrogen (as nitrate or nitrite)
Ortho-P (mg/-PL)	0.007	0.008	0.012	2.0* as phosphorus

* *Environment Protection (Water Pollution) Regulations 1974*, emission into inland water.
** Australian Water Quality Guidelines for Fresh and Marine Waters 1992.
N/A— no emission limit available.

Table 2

Comparison of analytical results against the Australian and New Zealand Guidelines for Fresh and Marine Water Quality 2000

	STANLEY SEWERAGE LAGOONS			**ANZECC 2000**		
Bore hole number	SSL2000/1	SSL2000/2	SSL2000/3	IRRIGATION		LIVESTOCK DRINKING
Analyte				STV (Short-term)	LTV (Long-term)	
Standing Water Level (m)	4.73	1.02	1.53			
pH (pH Units)	7.5	7.5	7.4	**6.0–8.5		
Conductivity (µS/cm)	1480	1290	1460	(1) (Refer Tables 4.2.3 & 4.2.4)		
TDS (mg/L)	924	804	866			(2) 2000–10 000 (Refer Table 4.3.1)
Chloride (mg/L)	99	110	160	(3) MT (Refer Table 4.2.6) MR (Refer Table 4.2.7)		
Fluoride (mg/L)	0.11	0.15	0.12	4	1	
Potassium (mg/L)	2.59	3.8	2.34			
Sodium (mg/L)	48.4	33	84.2	(3) MT (Refer Table 4.2.8)		
PO_4-P (mg/L)	0.007	0.008	0.012			
SO_4 (mg/L)	28	19	12			
NH_3-N (mg/L)	0.156	0.293	0.206			
(NO_2 + NO_3)-N (mg/L)	9.22	0.099	0.279			
NO_2-N (mg/L)	0.303	0.012	0.028			

Shaded areas indicate values above relevant guideline levels

Notes: ** set to limit potential for corrosion and fouling of pumping, irrigation and stock watering systems

(1) Suitability depends on salt tolerance of crop & calculation of ECse, the average root zone salinity. ECse depends on soil type & average root zone leaching fraction.

(2) Depending on animal type, within this salinity range may be reluctance to drink or may be some scouring but stock should adapt without loss of production.

(3) MR = Medium risk of increasing crop cadmium concentrations

STV — Short term trigger value for contaminant in irrigation water (<20 years) use

LTV — Long term trigger value for contaminant in irrigation water (100 years) use

nitrite concentrations were highest in the borehole closest to the lagoons (SSL2000/1). Chloride concentration increased in the area of the old landfill, although chloride values could be significantly affected by sea spray. Relatively high bicarbonate concentrations in all three bores are most likely the result of shell fragments within the unconsolidated sediments.

CONTAMINATION ASSESSMENT

Groundwater flow is interpreted as a tidally-controlled system between marshland to the west and Godfreys Beach, passing beneath the area of the lagoons. The cross section (fig. 5) supports this interpretation.

Tidal effects most likely strongly influence this hydraulic system. Plates 2 and 3 show spring seepages on Godfreys Beach during low tide on 11 August 2001; these are interpreted as discharge points of the local hydrogeological system. This suggests that tidal movements affect groundwater flow.

The cross section (fig. 5) combined with the annual rainfall pattern (fig. 3) indicate that the water table is highly likely to interact with the lagoon liners on a seasonal basis. This may also occur in very high tidal events.

Based on the groundwater quality data, no direct evidence exists to suggest that leakage from the Stanley sewage lagoons is causing major groundwater contamination.

Increased hydraulic conductivities would be expected in areas of the waste fill, which implies any future migration of contaminates may be even more rapid within these materials.

The local area is interpreted as being underlain by Tertiary basalt. As the two southern lagoons are approximately 1.5 metres deep, any future leakage from the lagoons recharging the fractured basalt aquifer may affect groundwater quality within this aquifer, although the aquifer may be ultra saline as a result of seawater migration inland.

PRINCIPAL CONCLUSIONS

No evidence currently exists for major leakage or groundwater degradation occurring at the Stanley sewage lagoons. Continued monitoring of groundwater quality may aid in the on-going quality control assessment of the lagoon liners. The lagoons are in close proximity to seawater plus an unlined and uncapped landfill site, and any beneficial use of the groundwater in the local area may possibly be compromised in the short to long term.

FURTHER WORK

Future monitoring of microbiological water quality parameters may help to identify any potential degradation of groundwater quality in the local area. Monitoring of groundwater levels across tidal events would help to identify any related changes in groundwater levels.

An electromagnetic survey (EM31/EM34, TEM) is recommended to identify zones of high and low ground conductivity. The survey could help to define the extent of variations in groundwater chemistry and potentially any preferred pathways of flow. The interface of seawater with any future identified contamination migration (either from the landfill or the lagoons) could also be more closely examined using geophysics. An additional benefit would be to identify the extent of the landfill footprint within the coastal fore dune.

Any additional drilling should include a borehole sited in similar sand well away from any pollution source in the local area (i.e. to replace the original background bore BSL2000/4). A deeper hard-rock bore could also be drilled to investigate groundwater quality within the underlying bedrock, although this is not seen as a current priority. All future work should acknowledge the potential impacts of the historical landfill within the hydrogeological system.

REFERENCES

LENNOX, P. G.; CORBETT, K. D.; BAILLIE, P. W.; CORBETT, E. B.; BROWN, A. V. 1982. *Geological Atlas 1:50 000 Series. Sheet 21 (7916S). Smithton*. Department of Mines Tasmania.

[30 May 2002]

Plate 2
Spring soakage northeast of the sewage lagoons on Godfreys Beach at low tide, 11 August 2001.

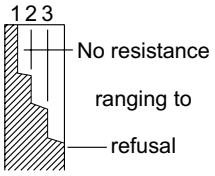
Plate 3
Spring soakage east of the sewage lagoons on Godfreys Beach at low tide, 11 August 2001.

Appendix 1

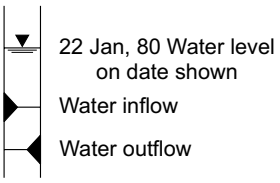
Engineering logs of boreholes

EXPLANATION SHEET FOR ENGINEERING LOGS
Borehole and excavation log

Penetration



Water



Notes — samples and tests

U50	Undisturbed sample 50 mm diameter
D	Disturbed sample
N	Standard penetrometer blow count for 300 mm
N*	SPT + Sample

Material classification

Based on Unified Soil Classification System.

In Graphic Log materials are represented by clear contrasting symbols consistent for each project.

Moisture content

D	Dry, looks and feels dry
M	Moist, no free water on hand when remoulding
W	Wet, free water on hand when remoulding
LL	Liquid limit
PL	Plastic limit
PI	Plasticity index

e.g. M>PL — Moist, moisture content greater than the plastic limit

Consistency

: hand penetrometer

VS	Very soft	<25 (kPa)
S	Soft	25 – 50
F	Firm	50 – 100
St	Stiff	100 – 200
VSt	Very stiff	200 – 400
H	Hard	>400
Fb	Friable	

Notes: X on log is test result
— is range of results

Density index

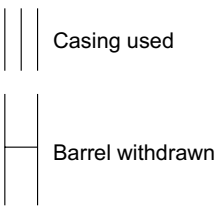
		%
VL	Very loose	0 – 15
L	Loose	15 – 35
MD	Medium dense	35 – 65
D	Dense	65 – 85
VD	Very dense	85 – 100

Fracture description

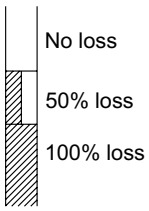
RP	Rough planar
RL	Rough irregular
SP	Smooth planar
SL	Smooth irregular

Cored borehole log

Case - lift



Fluid loss



Lugeons

Lugeon units (uL) are a measure of rock mass permeability. For a 46 to 74 mm diameter borehole 1 Lugeon is defined as a rate of loss of 1 litre per metre per minute. 1 Lugeon is roughly equivalent to a permeability of 1 x 10^{-4} mm / sec.

Graphic log

No core

Rock substances represented by clear, contrasting symbols consistent for each project.

Weathering

Fr	Fresh
SW	Slightly weathered
HW	Highly weathered
EW	Extremely weathered

Strength

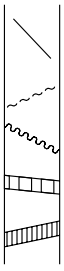
point load strength index $I_{s\,(50)}$ (MPa)

EL	Extremely low	< 0.03
VL	Very low	0.03 – 0.1
L	Low	0.1 – 0.3
M	Medium	0.3 – 1
H	High	1 – 3
VH	Very high	3 – 10
EH	Extremely high	>10

Notes: X on log is test result.

Significant defects

Significant defects shown graphically



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ENGINEERING LOG - BOREHOLE

Borehole no. **SSL2000/1**
Sheet 1 of 2

Project	Stanley sewage lagoons			Location	Green Hills Road, Stanley
Co-ordinates	55 355816 mE 5487052 mN	Drill type	Auger	Hole commenced	7 September 2000
		Drill method	Rotary	Hole completed	7 September 2000
R.L.		Drill fluid	Nil	Drilled by	Mr Shane Heawood
Inclination	Vertical			Logged by	Mr Andrew Ezzy
Bearing				Checked by	Mr Adrian Waite

penetration 1 2 3	support	water	notes samples, tests	metres R.L. / depth	graphic log	classification symbol	material: soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency density index	structure, geology
		Cement	D Sample ID 1			SP	SAND - medium, brown, 20% angular cobbles	D	S L	Fill - Reworked Quaternary sand and roadbase
		Bentonite	D Sample ID 2	0.5		SP	SAND - medium, brown	D	S L	Fill - Reworked Quaternary sand
			D Sample ID 3	1.0						
	No Screen		D Sample ID 4	1.5		SP	SAND - medium, light brown and grey	D	S L	Quaternary sand
			D Sample ID 5	2.0						
		7 mm Gravel	D Sample ID 6	2.5						
			D Sample ID 7	3.0						
			D Sample ID 8	3.5						
	2 metre slotted screen		D Sample ID 9	4.0						
		▼	S.W.L. 07/09/00	4.5						
			D Sample ID 10							

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ENGINEERING LOG - BOREHOLE

Borehole no. SSL2000/1
Sheet 2 of 2

Project Stanley sewage lagoons — Location Green Hills Road, Stanley

Co-ordinates 55 355816 mE
5487052 mN

R.L.
Inclination Vertical
Bearing

Drill type Auger
Drill method Rotary
Drill fluid Nil

Hole commenced 7 September 2000
Hole completed 7 September 2000
Drilled by Mr Shane Heawood
Logged by Mr Andrew Ezzy
Checked by Mr Adrian Waite

penetration 1 2 3	support	water	notes: samples, tests	metres: R.L. / depth	graphic log	classification symbol	material: soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency density index	structure, geology
	Screen	7 mm Gravel	D Sample ID 11			SP	SAND - medium, light red and yellow	D	S L	Quaternary dune sand
			D Sample ID 12	5.5						
	No Screen		D Sample ID 13			SP	SAND - fine to medium, green-grey	D	S L	Quaternary dune sand
				6.0						
			D Sample ID 14			SP	SAND - fine to medium, green-grey	M	S L	Quaternary dune sand
			D Sample ID 15	6.5						
	Back fill	Back fill		7.0			SAND - medium, green, clayey, shell fragments and basalt well rounded pebbles up to 100 mm in diameter	W	S L	Quaternary beach deposit
			D Sample ID 16	7.5						
				8.0			SAND - fine to medium, green, clayey, basalt well rounded pebbles	W	S	Quaternary beach deposit
			D Sample ID 17							
			Sample ID numbers refer to samples stored in MRT core shed	8.5			Drilling stopped due to auger refusal at 8.5 m. Green-grey water pumped for 60 minutes at 24 L/m. At end of pumping pH 7.7 and conductivity 1220 µS/cm. End of hole.			

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ENGINEERING LOG - BOREHOLE

Borehole no. **SSL2000/2**
Sheet 1 of 1

Project	Stanley sewage lagoons	Location	Green Hills Road, Stanley
Co-ordinates	55 355836 mE 5487054 mN	Drill type	Auger
		Drill method	Rotary
		Drill fluid	Nil
R.L.		Hole commenced	7 September 2000
Inclination	Vertical	Hole completed	7 September 2000
Bearing		Drilled by	Mr Shane Heawood
		Logged by	Mr Andrew Ezzy
		Checked by	Mr Adrian Waite

penetration 1 2 3	support	water	notes samples, tests	metres R.L.	metres depth	graphic log	classification symbol	material: soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency density index	structure, geology
	No Screen	Cement	D Sample ID 1				SP	SAND - medium, light red and yellow, angular quartzite cobbles	M	S L	Fill - Reworked Quaternary sand
		Bentonite	D Sample ID 2		0.5						
	1.5 metre slotted screen	7 mm Gravel	D Sample ID 3		1.0		SP	SAND - medium, light red and yellow, angular quartzite cobbles	W	S L	Fill - Reworked Quaternary sand
			D Sample ID 4		1.5		SP	SAND - medium, dark green-grey, shell fragments	W	S L	Quaternary beach deposit
			D Sample ID 5		2.0						
			Sample ID numbers refer to samples stored in MRT core shed		2.5			End of hole at 2.5 m Pumped for 45 minutes at 1.6 L/m. At end of pumping pH 7.7 and conductivity 1180 µS/cm. End of hole.			

MINERAL RESOURCES TASMANIA

ENGINEERING LOG - BOREHOLE

Borehole no. **SSL2000/3**
Sheet 1 of 1

Project Stanley sewage lagoons — Location Green Hills Road, Stanley

Co-ordinates 55 355856 mE
5487057 mN

R.L.
Inclination Vertical
Bearing

Drill type Auger
Drill method Rotary
Drill fluid Nil

Hole commenced 7 September 2000
Hole completed 7 September 2000
Drilled by Mr Shane Heawood
Logged by Mr Andrew Ezzy
Checked by Mr Adrian Waite

penetration 1 2 3	support	water	notes samples, tests	metres R.L. / depth	graphic log	classification symbol	material: soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency density index	structure, geology
	No Screen	Cement	D Sample ID 1			SP	SAND - medium, grey and brown, angular quartzite fragments	M	S L	Fill - Reworked Quaternary sand
		Bentonite	D Sample ID 2	0.5			WASTE fill - plastic, wood, steel chain, glass, sand, medium, black	M		Fill - Domestic refuse
	2.0 metre slotted screen	7 mm Gravel	D Sample ID 3	1.0		SP	SAND - medium, light red and yellow	M	S L	Quaternary dune deposit
			D Sample ID 4	1.5		SP	SAND - fine to medium, light green-grey, shell fragments	W	S L	Quaternary beach deposit
	B.I.F.	B.I.F.	D Sample ID 5	2.0			SAND - medium, dark green-grey, well rounded basalt pebbles	W	S L	Quaternary beach deposit
			Sample ID numbers refer to samples stored in MRT core shed	3.5			End of hole at 3.5 m Pumped for 70 minutes at 3.6 L/m. At end of pumping pH 7.9 and conductivity 1250 µS/cm. End of hole.			

MINERAL RESOURCES TASMANIA

ENGINEERING LOG - BOREHOLE

Borehole no. **SSL2000/4**
Sheet 1 of 1

Project Stanley sewage lagoons — Location Green Hills Road, Stanley

Co-ordinates 55 355811 mE
5487154 mN

R.L.
Inclination Vertical
Bearing

Drill type Auger
Drill method Rotary
Drill fluid Nil

Hole commenced 7 September 2000
Hole completed 7 September 2000
Drilled by Mr Shane Heawood
Logged by Mr Andrew Ezzy
Checked by Mr Adrian Waite

penetration 1 2 3	support	water	notes samples, tests	metres R.L. / depth	graphic log	classification symbol	material: soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency density index	structure, geology
	No Screen	Cement	D Sample ID 1	0.0		SM	SAND - fine, black	M	S L	Soil
		Bentonite	D Sample ID 2	0.5		SP	SAND - medium, black-brown, shell fragments and quartzite cobbles	M	S L	Fill - Reworked Quaternary material with imported rock
		7 mm Gravel	D Sample ID 3	1.0		SP	SAND - medium, light grey	M	S L	Fill - Reworked Quaternary sand
			D Sample ID 3	1.5						
			D Sample ID 3	2.0						
	1.5 metre slotted screen		D Sample ID 4	2.5		SP	SAND - medium, red-brown and light grey	M	S L	Fill - Reworked Quaternary sand
			D Sample ID 5	3.0		SP	SAND - medium, dark red	M	S L	Fill - Reworked Quaternary sand
			D Sample ID 6	3.5		SP	SAND - medium, light red and yellow	M	S L	Quaternary dune sand
			Sample ID numbers refer to samples stored in MRT core shed	4.0			Drilling stopped due to refusal on suspected basalt bedrock at 4.0 m Not pumped as hand bailing implied poor inflow. End of hole.			

Appendix 2

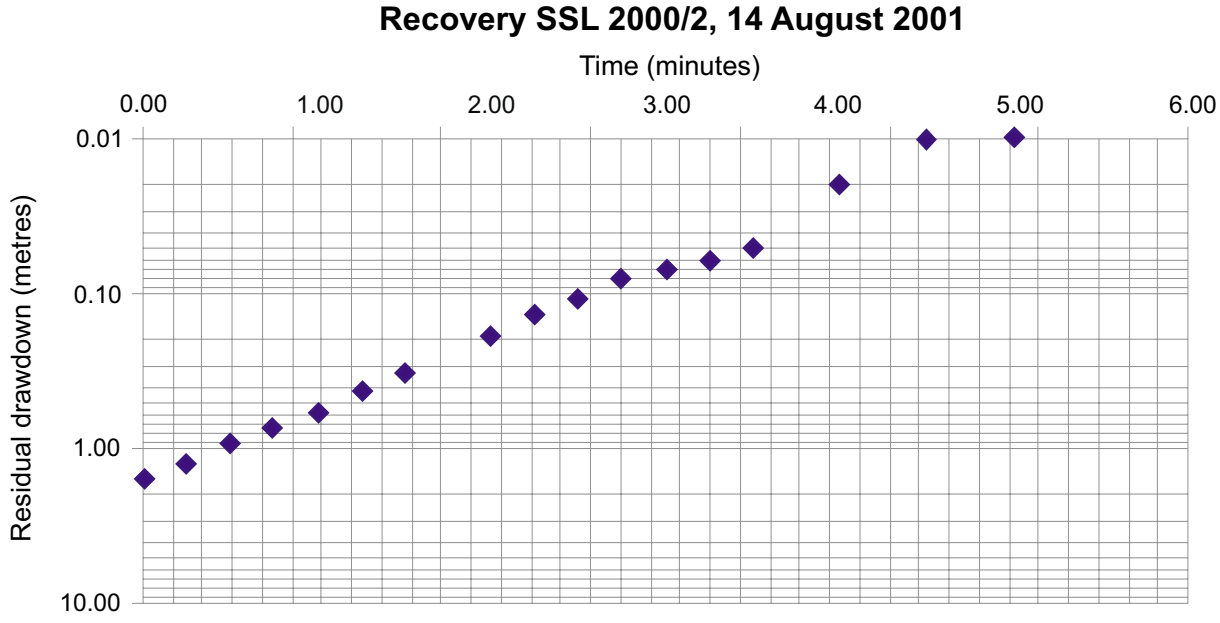
Raw data collected for slug extraction tests

Stanley lagoons recovery pump test — Slug extraction recovery data

Date: 14/08/2001
Bore: SSL 2000/2
TD: 2.50 m
Flow: 4.0 l/m
SWL: 0.92 m

Recovery data

Time	*Residual drawdown*	*Measurement*
0.00	1.58	2.50
0.25	1.23	2.15
0.50	0.90	1.82
0.75	0.73	1.65
1.00	0.58	1.50
1.25	0.43	1.35
1.50	0.33	1.25
2.00	0.19	1.11
2.25	0.14	1.06
2.50	0.11	1.03
2.75	0.08	1.00
3.00	0.07	0.99
3.25	0.06	0.98
3.50	0.05	0.97
4.00	0.02	0.94
4.50	0.01	0.93
5.00	0.01	0.93

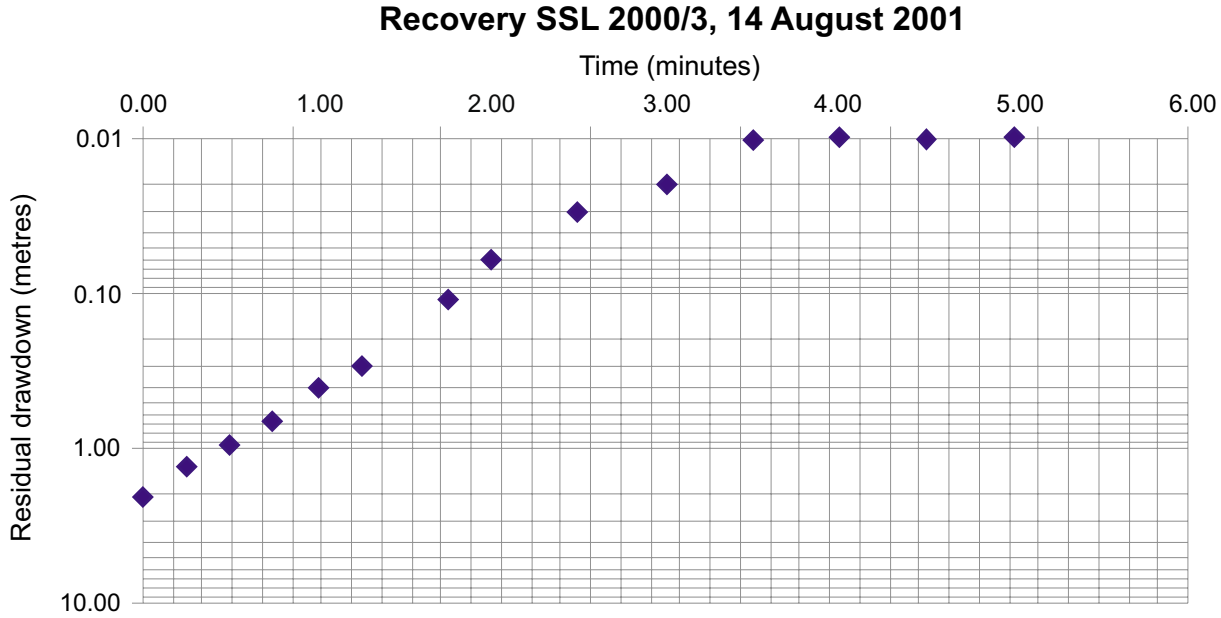


Stanley lagoons recovery pump test — Slug extraction recovery data

Date: 14/08/2001
Bore: SSL 2000/3
TD: 3.50 m
Flow: 1.0 l/m
SWL: 1.44 m

Recovery data

Time	*Residual drawdown*	*Measurement*
0.00	2.06	3.50
0.25	1.31	2.75
0.50	0.96	2.40
0.75	0.66	2.10
1.00	0.41	1.85
1.25	0.29	1.73
1.75	0.11	1.55
2.00	0.06	1.50
2.50	0.03	1.47
3.00	0.02	1.46
3.50	0.01	1.45
4.00	0.01	1.45
4.50	0.01	1.45
5.00	0.01	1.45



Appendix 3

Analytical Services Tasmania — Laboratory reports

Tasmania

ANALYTICAL SERVICES TASMANIA
Sandy Bay Laboratory
c|- Chemistry Department University of Tasmania
Sandy Bay Tasmania 7005
Telephone: (03) 6226 7175 Fax: (03) 6226 7825
Email: ast.sandybay@dpiwe.tas.gov.au

NATA Accreditation Number: 5589

Laboratory Report

Report No:	13771	***Please quote this number when making enquiries about this report***
Submitted By:	Andrew Ezzy	
Client:	Mineral Resources Tasmania	
Site Description:	Stanley Sewage Lagoons	
Received:	03-Nov-00	**Client Order No:**
Report Date:	01-Dec-00	
Report To:	Andrew Ezzy	
Address:	Gordons Hill Rd Rosny TAS 7018	

Test Method(s) :

1001-Water:	pH in Water by APHA Method 4500-H
1002-Water:	Conductivity by APHA Method 2510
1004-Water:	Solids, Total Dissolved by APHA Method 2540C
1101-Water:	Alkalinity by APHA Method 2320/4500-CO2
1103-Water:	Anions by Ion Chromatography APHA Method 4110C
1201-Water:	Nutrients by APHA Method 4500

Mike Johnson
Manager

Tasmania

ANALYTICAL SERVICES TASMANIA
Sandy Bay Laboratory
c|- Chemistry Department University of Tasmania
Sandy Bay Tasmania 7005

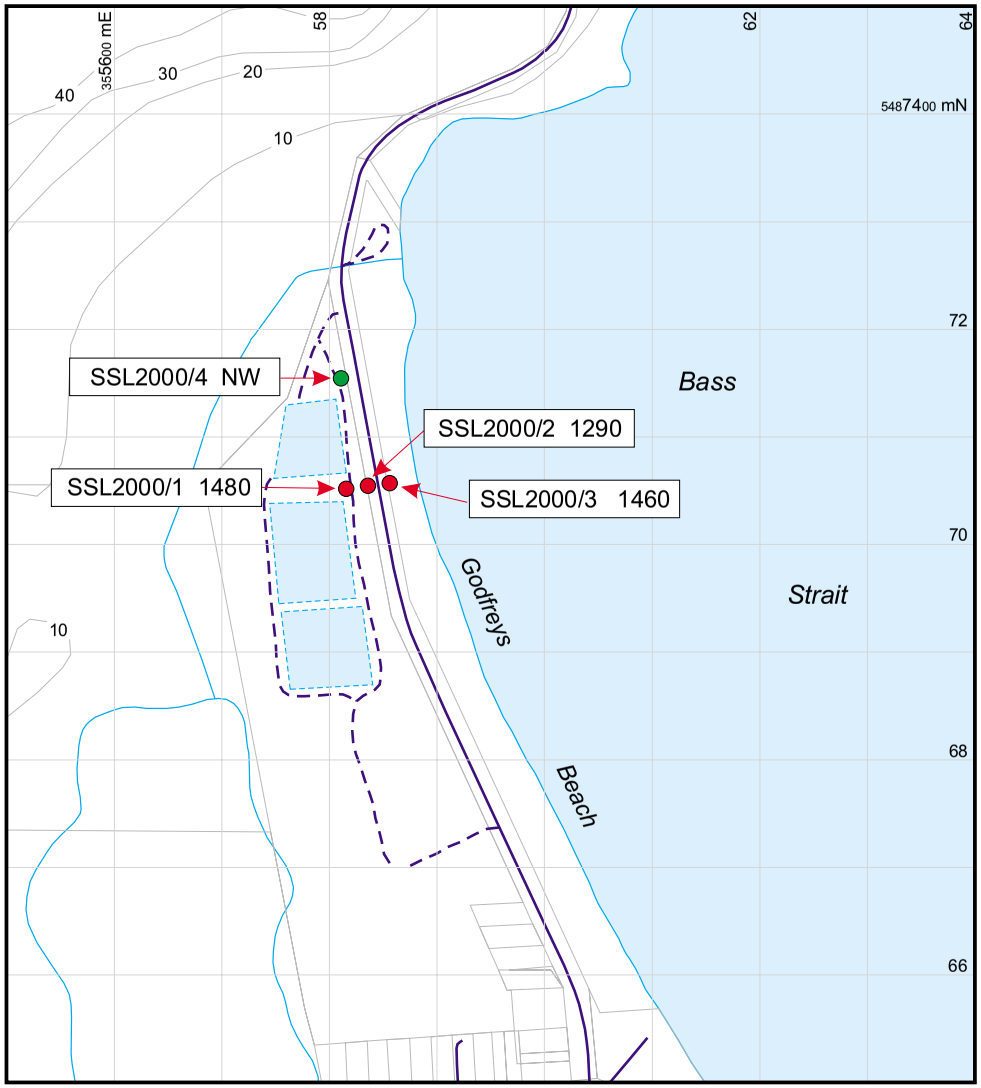
NATA Accreditation Number: 5589

Report No: 13771 **Report Date:** 01-Dec-00

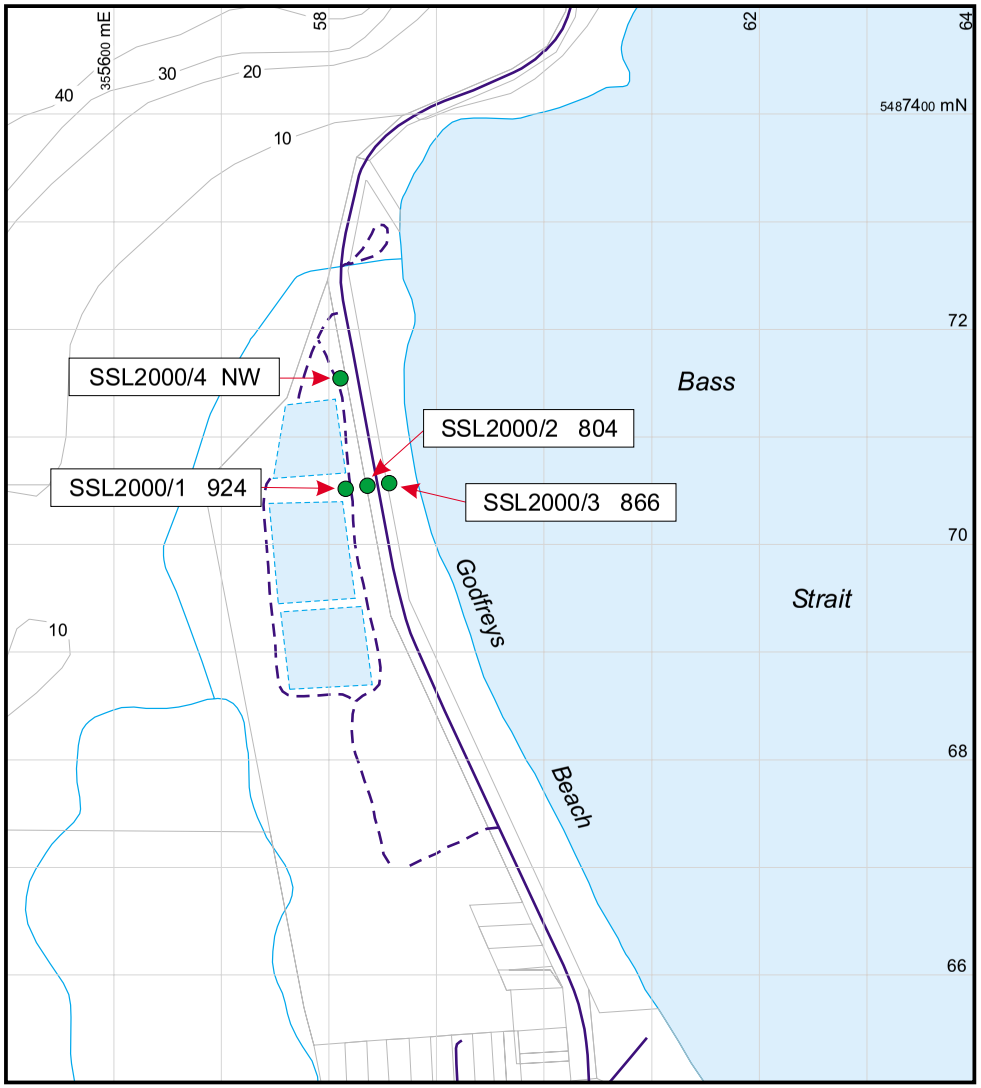
Method	Analyte	Lab.No.: / Sample Id.: / Units / Sampled On :	13078 SSL 2000/1 02/11/00	13079 SSL 2000/2 02/11/00	13080 SSL 2000/3 02/11/00
1001-Water	pH		7.5	7.5	7.4
1002-Water	Conductivity	µS/cm	1480	1290	1460
1004-Water	TDS	mg/L	924	804	866
1101-Water	Alkalinity CO3	mg/L CaCO3	3	2	1
	Alkalinity HCO3	mg/L CaCO3	1590	701	541
1103-Water	Chloride	mg/L	99	110	160
	Fluoride	mg/L	0.11	0.15	0.12
	Sulphate	mg/L	28	19	12
1201-Water	Ammonia	µg-N/L	156	293	206
	Nitrate+Nitrite	µg-N/L	9220	99	279
	Nitrite	µg-N/L	303	12	28
	Ortho-P	µg-P/L	7	8	12

Appendix 4
Analytical results on site maps

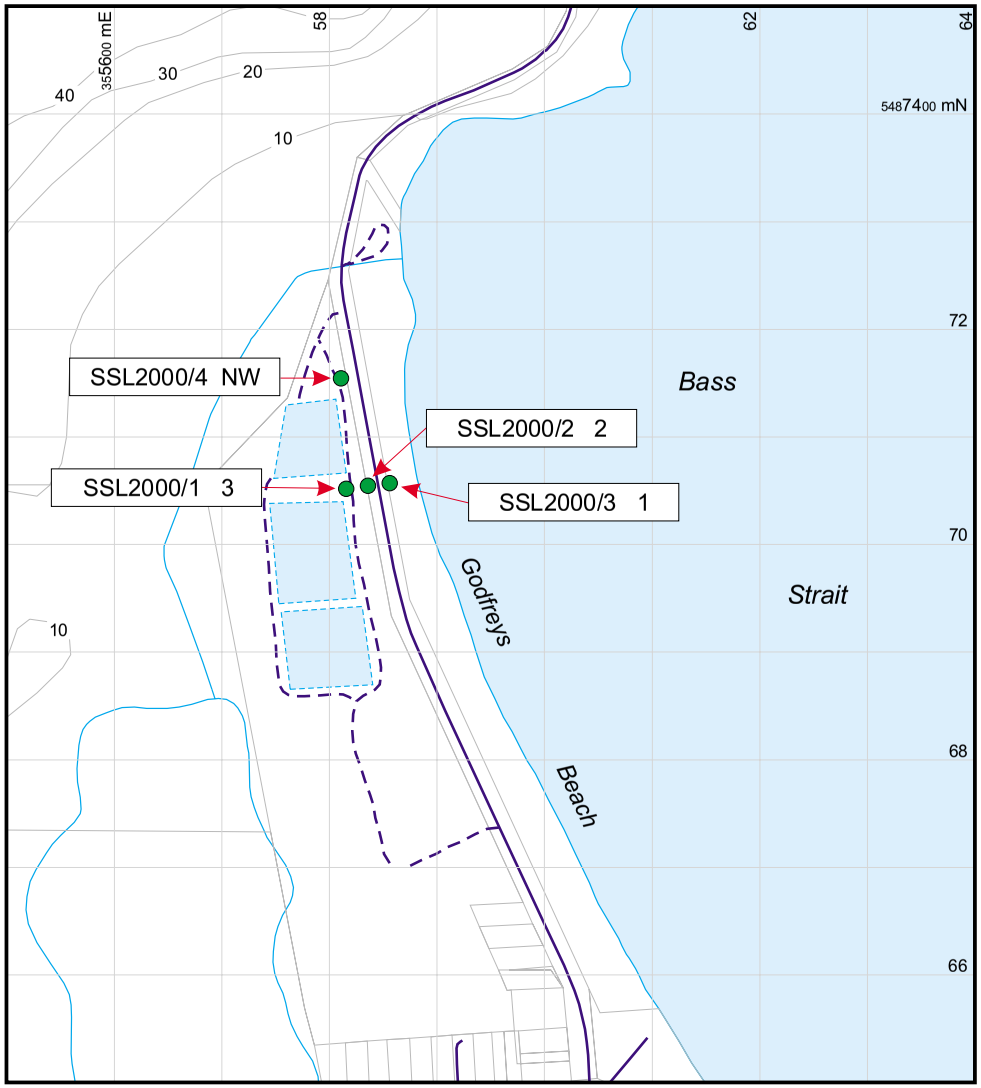
Stanley Sewage Lagoons
November 2000
Conductivity (μS/cm)



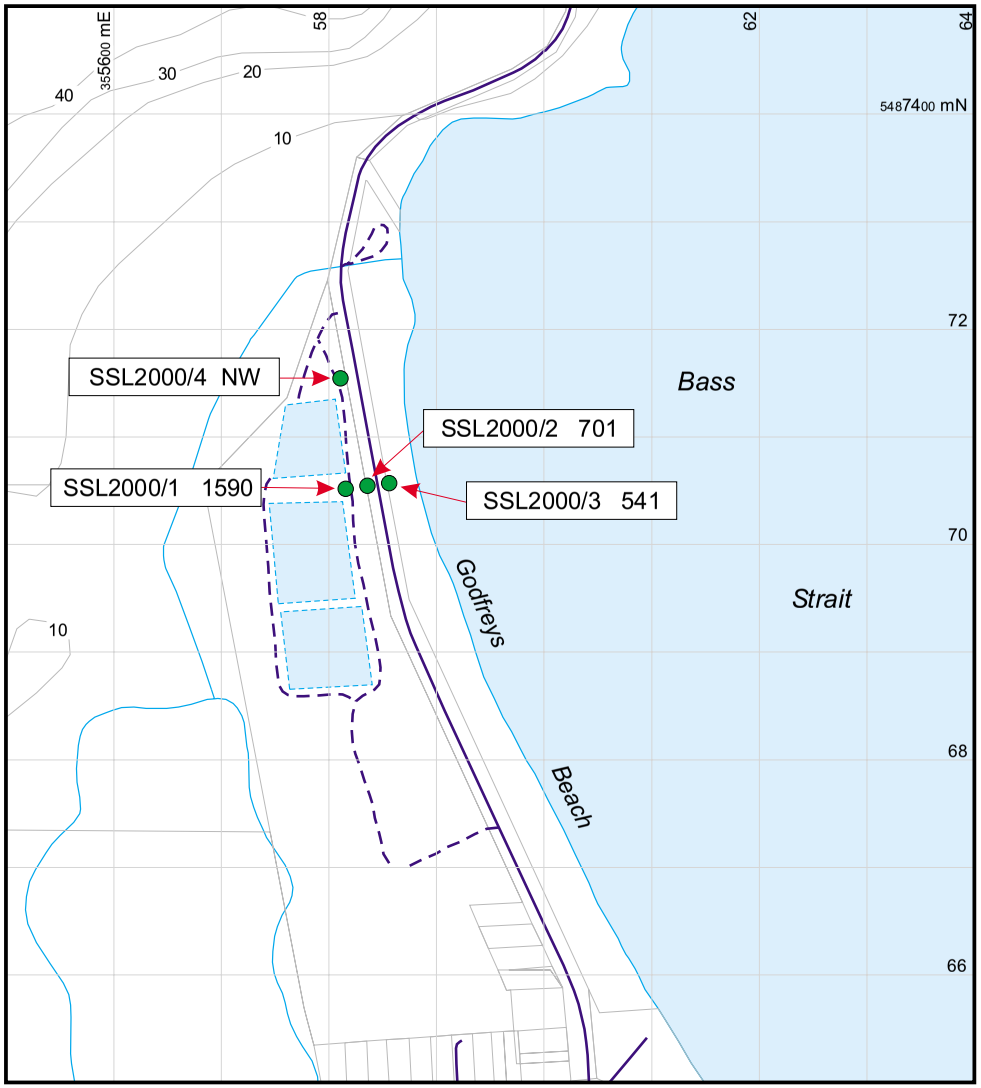
Stanley Sewage Lagoons
November 2000
TDS (mg/L)



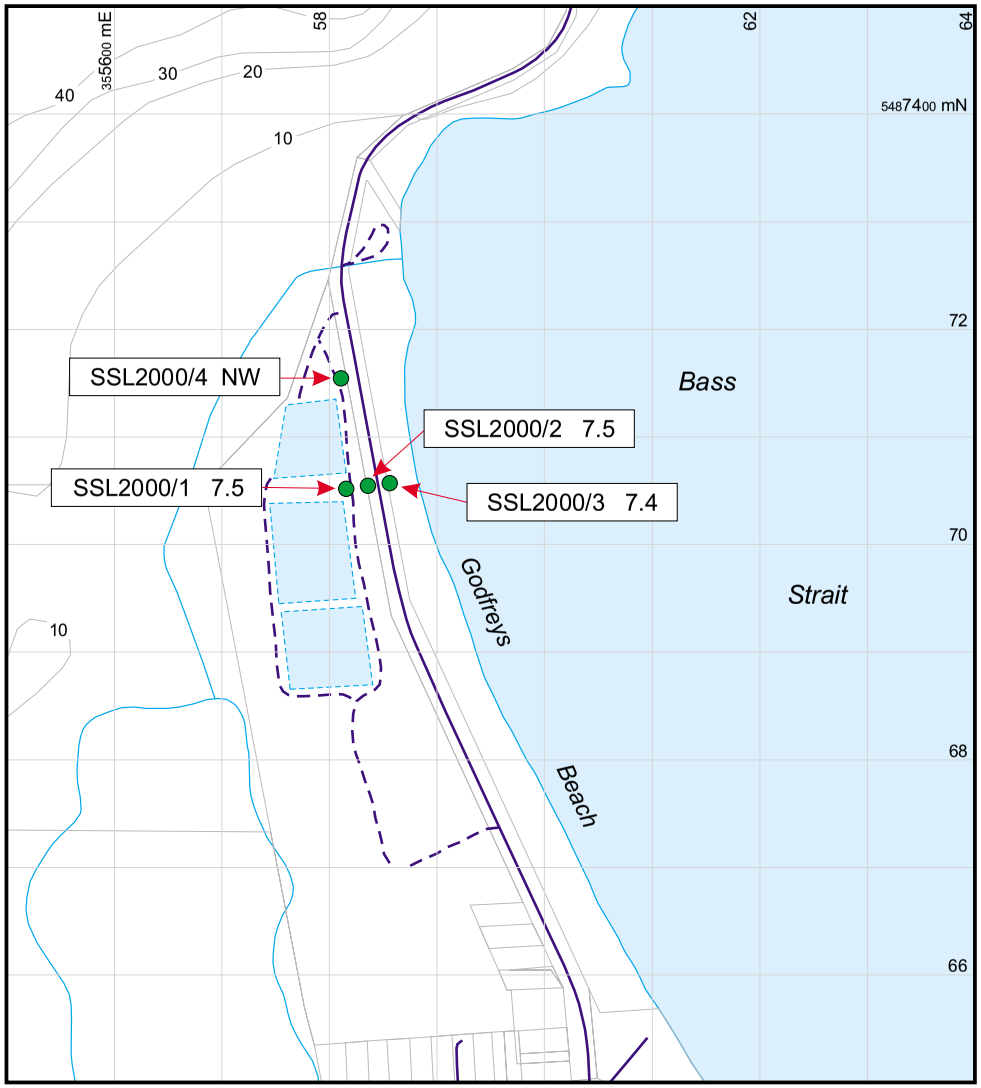
Stanley Sewage Lagoons
November 2000
Alkalinity CO_3 (mg/L $CaCO_3$)



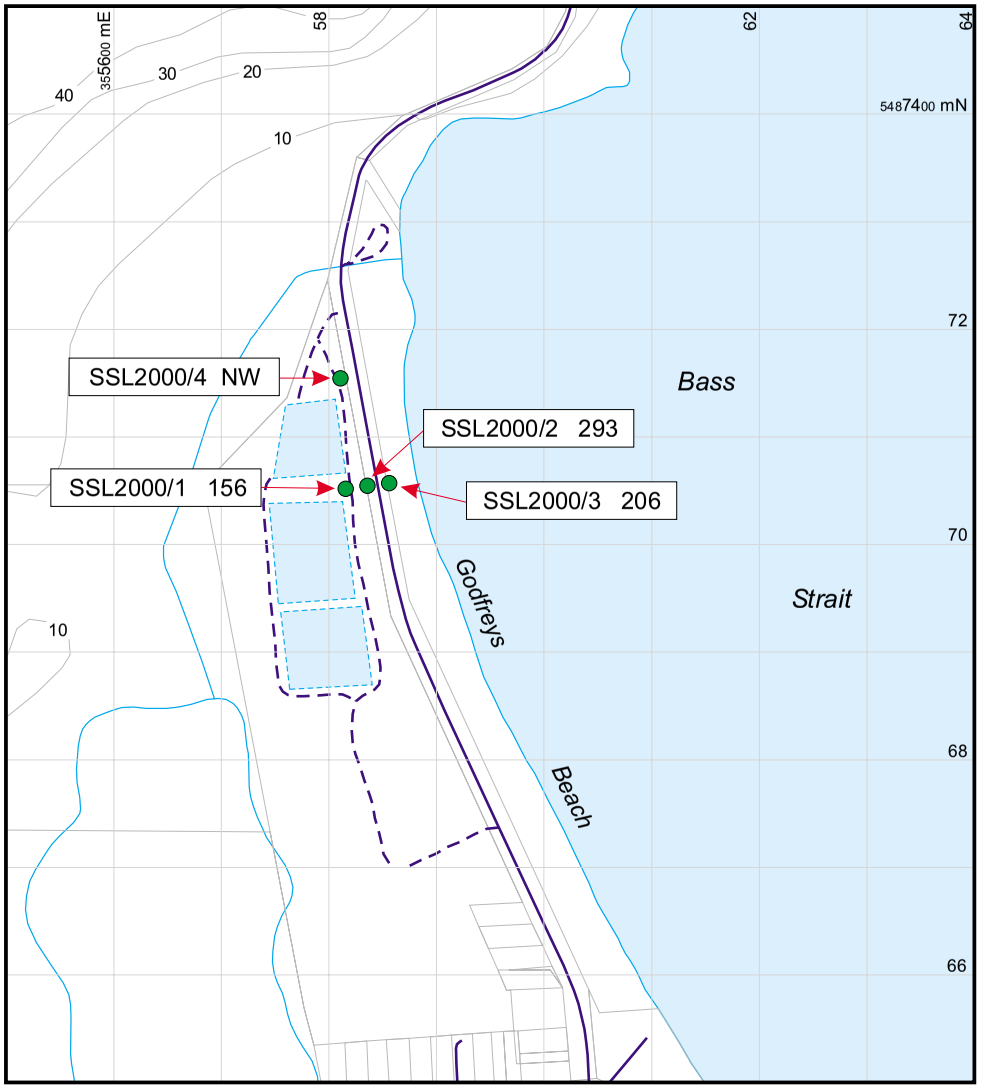
Stanley Sewage Lagoons
November 2000
Alkalinity HCO_3 (mg/L $CaCO_3$)



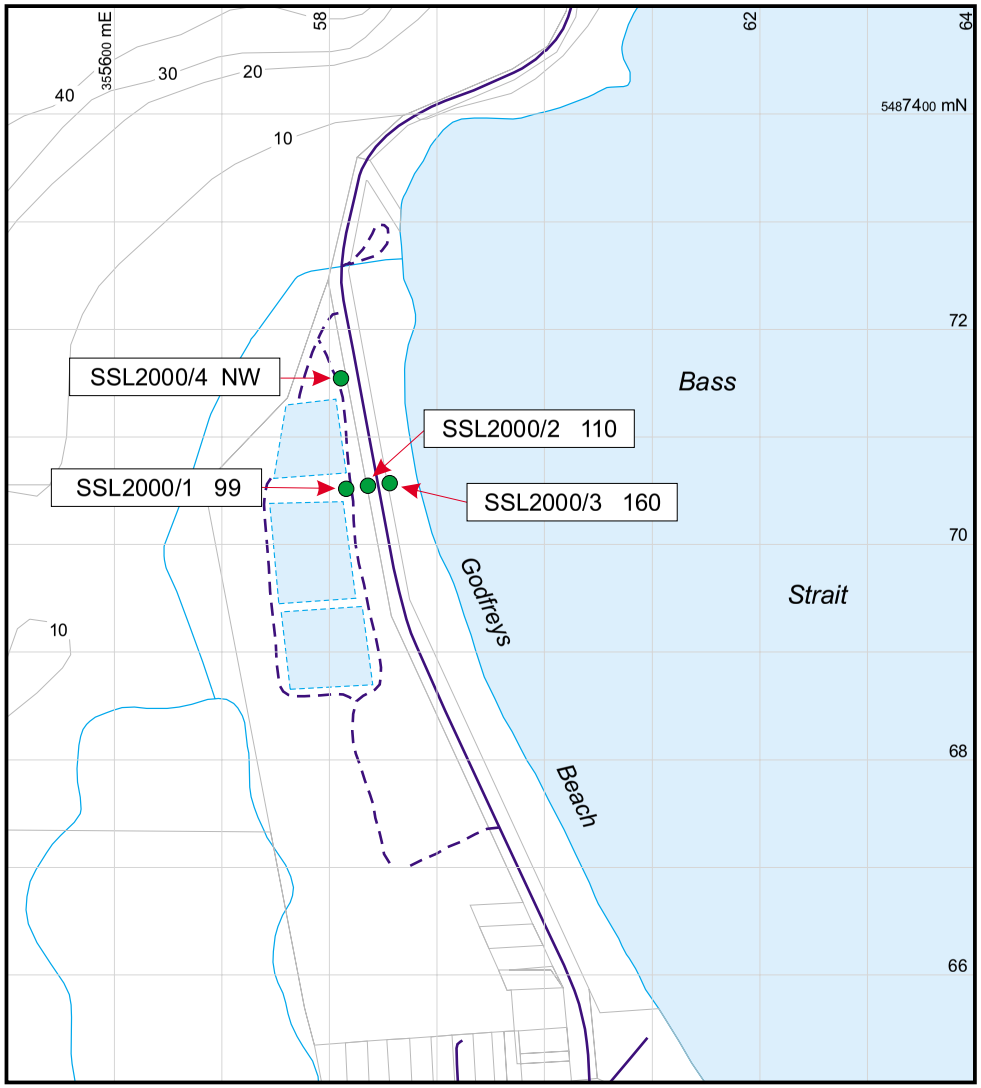
Stanley Sewage Lagoons
November 2000
pH



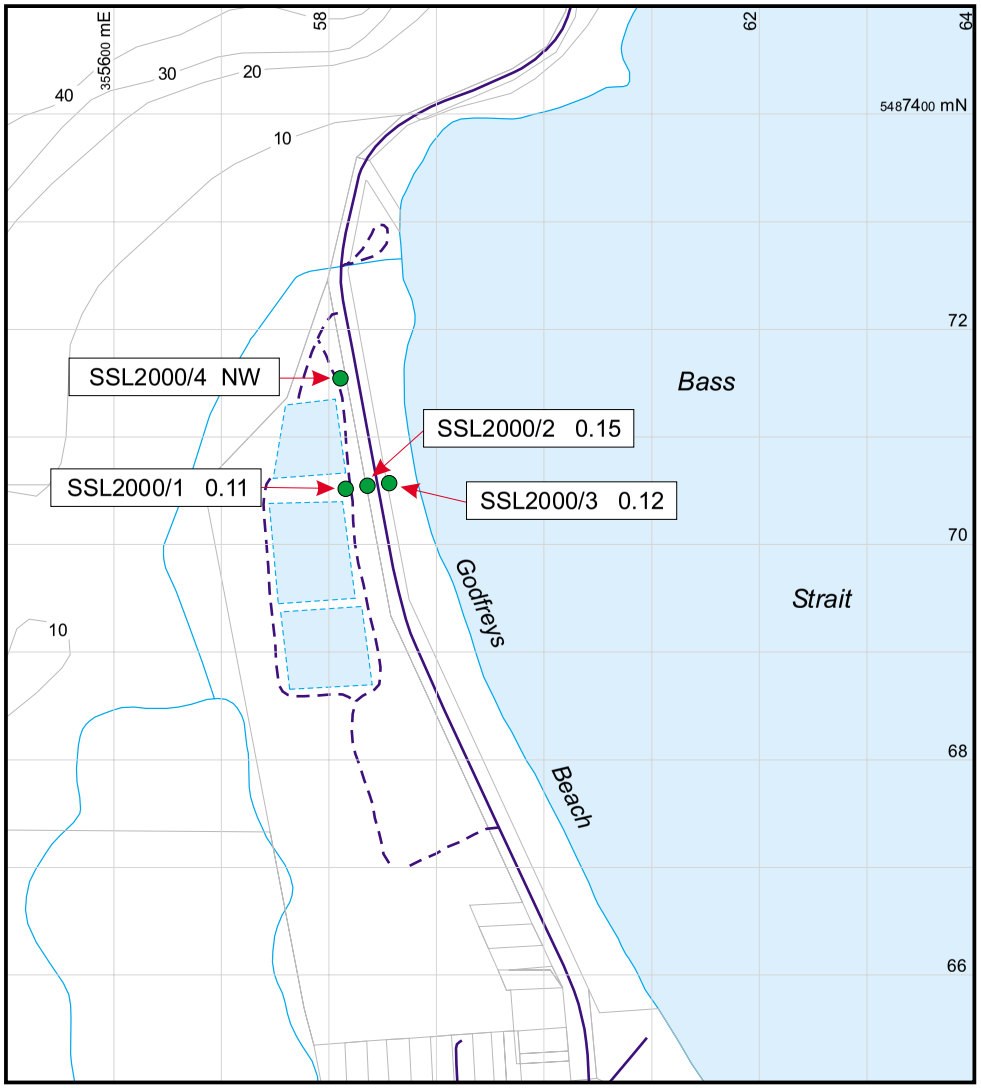
Stanley Sewage Lagoons
November 2000
Ammonia (μg-N/L)



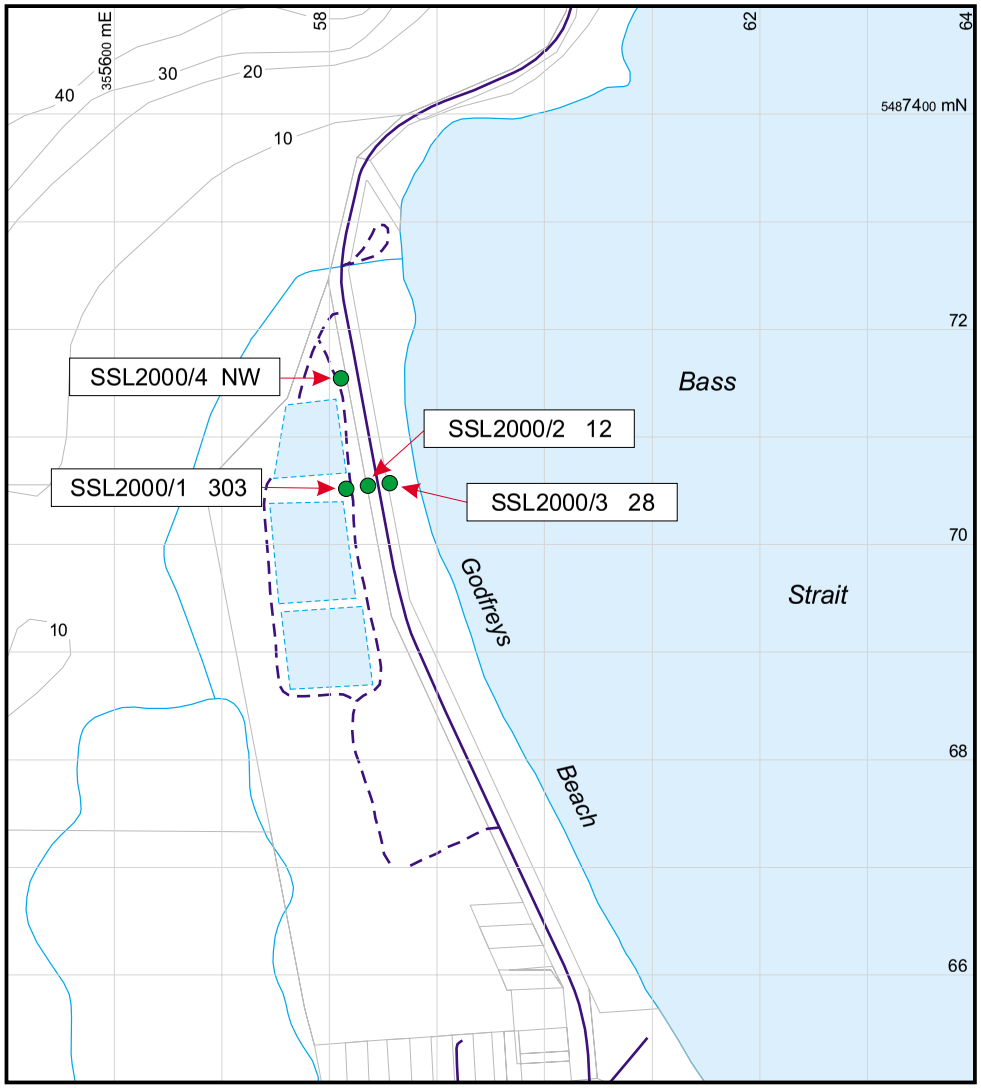
Stanley Sewage Lagoons
November 2000
Chloride (mg/L)



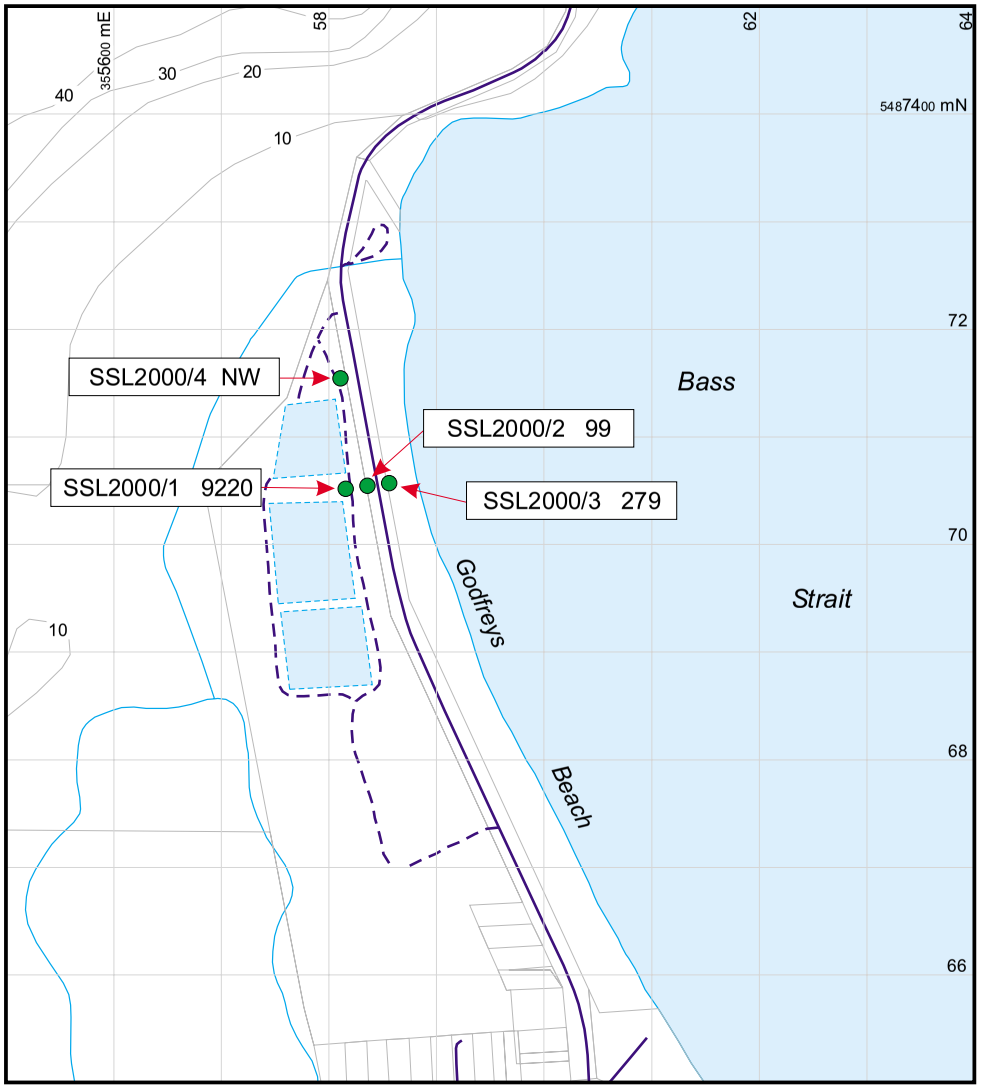
Stanley Sewage Lagoons
November 2000
Fluoride (mg/L)



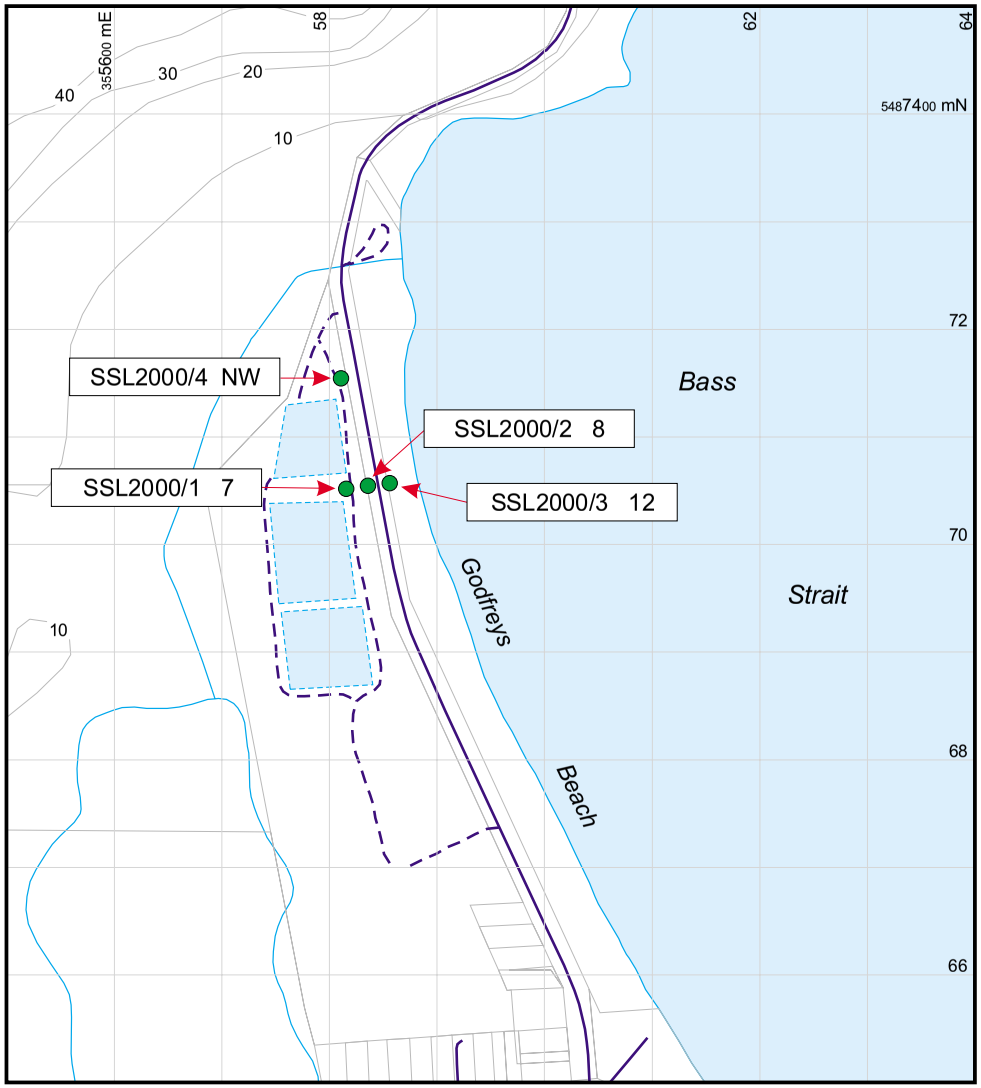
Stanley Sewage Lagoons
November 2000
Nitrite (µg-N/L)



Stanley Sewage Lagoons
November 2000
Nitrate + Nitrite (µg-N/L)



Stanley Sewage Lagoons
November 2000
Ortho-P (μg-P/L)



Stanley Sewage Lagoons
November 2000
Sulphate (mg/L)