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

Bridport sewage lagoons

Tasmanian Geological Survey Record 2002/01

Mineral Resources Tasmania
Tasmanian Geological Survey
Record 2002/01

Groundwater quality investigations at the Bridport sewage lagoons

A. R. Ezzy

Abstract

Groundwater was investigated in the area of the Bridport sewage lagoons to determine if the lagoons were affecting groundwater quality. Water table depth and groundwater quality indicates a hydraulic connection between the lagoons and the groundwater system. Groundwater quality down gradient is degraded compared to that up gradient of the lagoons. Further work is required to quantify the extent and nature of groundwater degradation.

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 Bridport were one of these sites.

The objectives of the investigations at the Bridport 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;
- Determine the permeability of the host materials; and
- Identify if a potential hydraulic connection exists between the lagoons and the local groundwater system.

SITE DESCRIPTION

The Bridport sewage lagoons are located approximately 750 metres northwest of Bridport in northeast Tasmania (531 800 mE, 5 462 500 mN) (fig. 1). The construction of the lagoons, which have been in operation since 1975, was approved by the (then) Department of the Environment and the facility is currently licensed by the Department of Primary Industries, Water and Environment (DPIWE). Engineering consultants Gutteridge Haskins and Davey undertook the initial engineering specification and construction of the lagoons.

During construction the two lagoons were lined with a cationic emulsion and a wire reinforcement framework. Each lagoon has a one metre cement wave wall constructed at surface level to prevent wave erosion damage. Both lagoons are located in sand.

Geology

The Tasmania Department of Mines 1:60 000 scale geological map of the area (*Geology of the Scottsdale sedimentary basin*, Moore, 1990) indicates that the

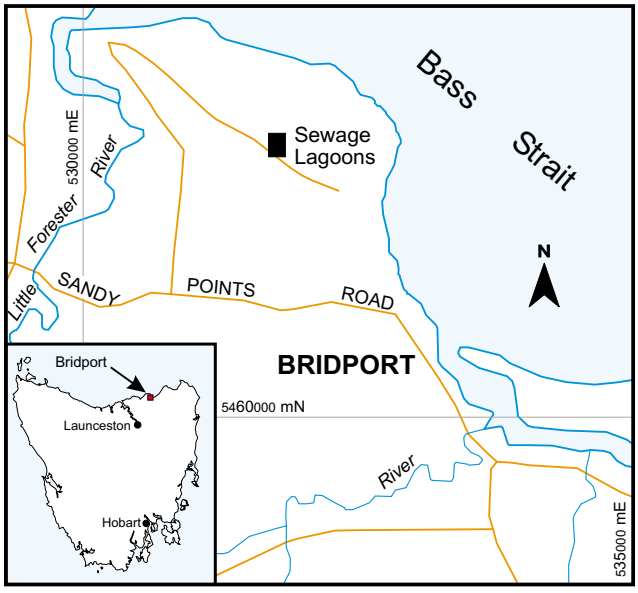


Figure 1
Location of sewage lagoons, Bridport

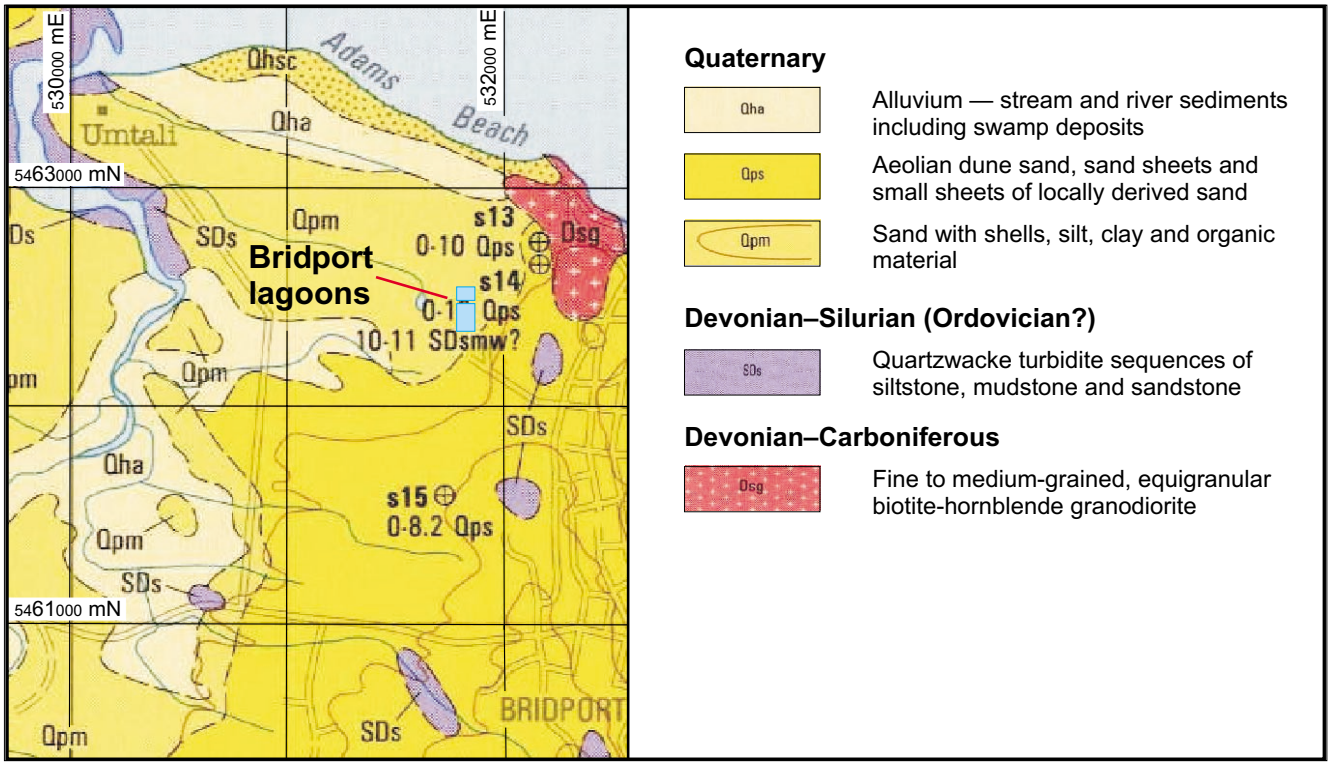


Figure 2

Geology of the Bridport area (from Moore, 1990).

geology of the area comprises Quaternary coastal plain sediments consisting of sand containing silt, shells and organic material (fig. 2).

Geological mapping during the current study indicated that Quaternary sand deposits occur within 100 metres of the lagoons in all directions. One outcrop of dark grey coarse-grained sandstone was located sixteen metres south of the lagoons (Plate 1). This supports mapping by Moore (1990) which implied that Devonian–Silurian sediments (Mathinna Beds) underlie the Quaternary deposits at shallow depth (most likely between 5-10 metres).

Hydrology

The lagoons are located within 100 metres of a drainage line to the west that has been excavated to handle storm loading which discharges into the estuarine section of the Little Forester River. Australian Bureau of Meteorology rainfall station 091116 at Scottsdale (Kraft Foods) is the closest rainfall station to the site. The rainfall chart (fig. 3) shows that the average annual rainfall for the station is 983.6 mm. There is a marked seasonality, with highest rainfall in autumn/winter (April to August).

DATA OBSERVATIONS

Investigation and sampling

Six 120 mm diameter monitoring bores were auger drilled on 19 September 2000 for this project (fig. 4). Fifty millimetre PVC casing and slotted screens with bentonite seals were installed in each hole. All bores

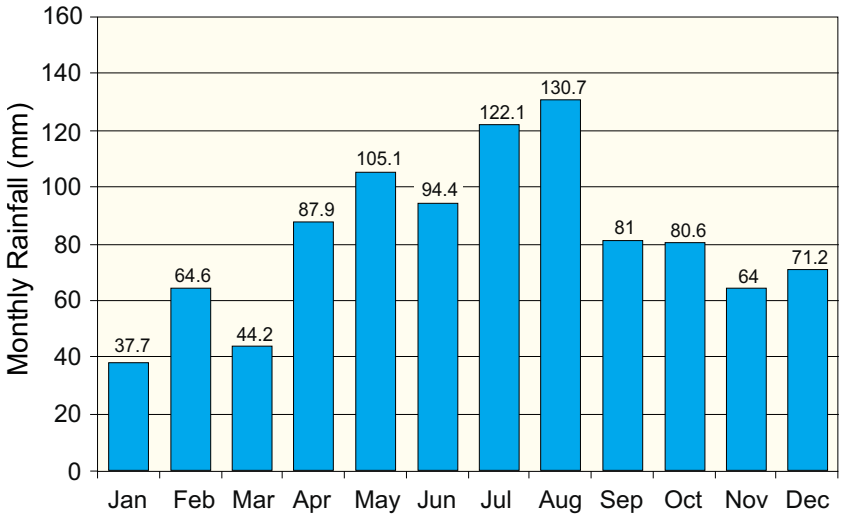


Figure 3

Average monthly rainfall for Australian Bureau of Meteorology rainfall station 091116, Scottsdale (Kraft Foods).

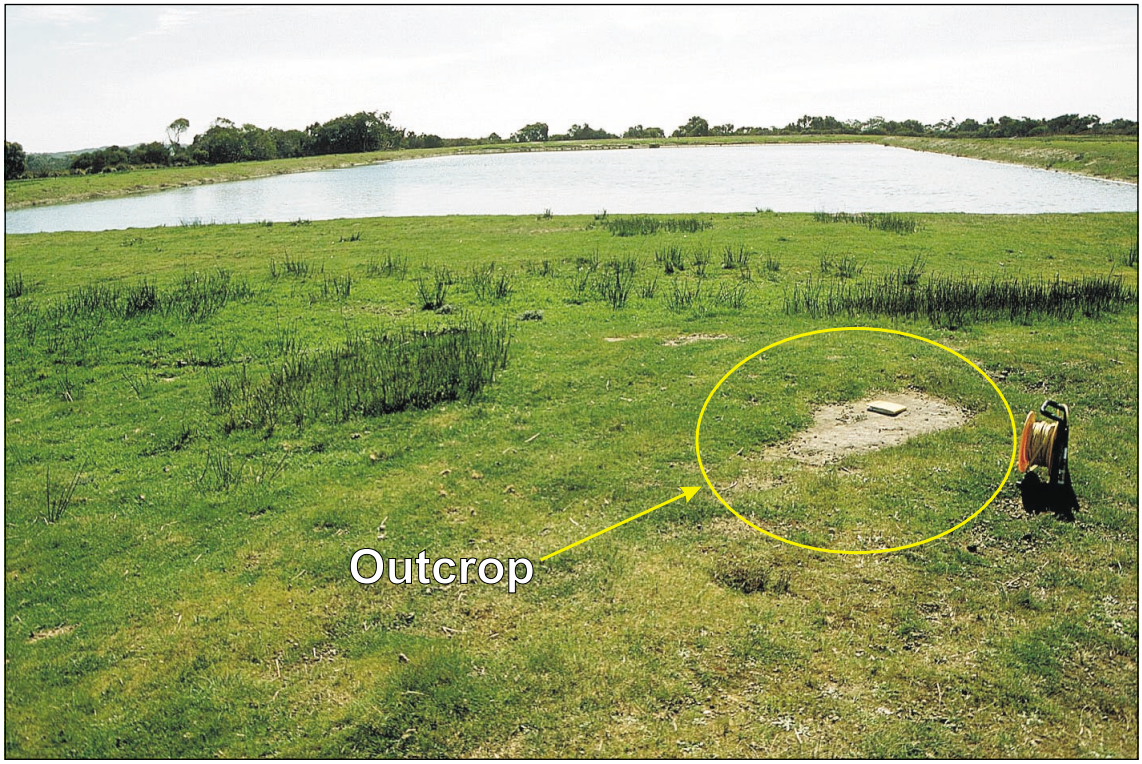


Plate 1

Outcrop of dark grey coarse-grained sandstone located 16 m south of the southern lagoon.

Plate 2

Shallow standing water level (0.38 m below ground level) observed in the test pit excavated by the Dorset Council 26 m north of BSL2000/6.

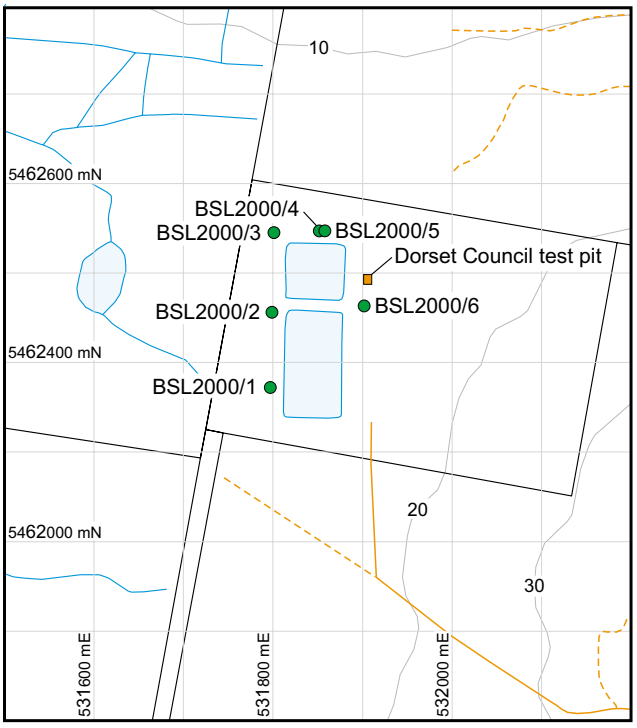


Figure 4

Locations of monitoring bores installed at the Bridport sewage lagoons, and test pit excavated by Dorset Council.

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 if required for further analysis.

Groundwater was encountered between 1.2 and 3.0 m depth across the site. A perched water table was intercepted in hole BSL2000/4 at 1.2 m and hole BSL2000/5 was installed specifically to monitor this perched water table. Flow during drilling indicated that the groundwater in all boreholes was unconfined. A shallow standing water level (0.38 m below ground level) was observed in the test pit excavated and left open by the Dorset Council 26 m north of BSL2000/6 (Plate 2). Recorded yields from the bores ranged between 0.005 to 0.015 l/s. Figure 5 shows a cross-section and related standing water level on 20 August 2001.

Both the unsaturated and saturated zones consist of heterogenous layers of fine to coarse-grained sand. Rounded pebbles were intersected in several horizons during the drilling of bores BSL2000/3, 4 and 5.

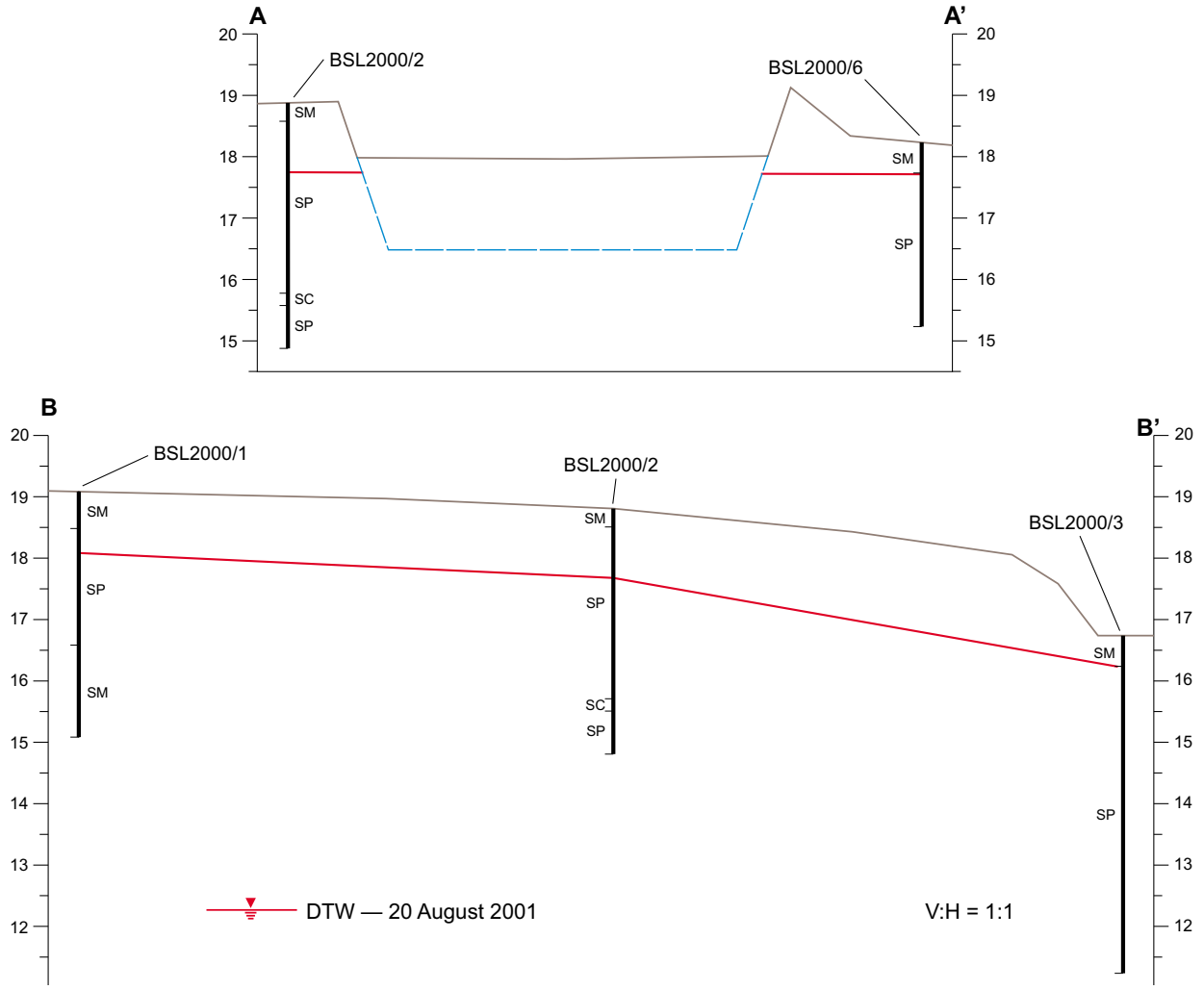


Figure 5. *Cross-section and related standing water level on 20 August 2001 for: (a) bores BSL 2000/2 and 6 [A–A'] and (b) bores BSL 2000/1, 2 and 3 [B–B'].*

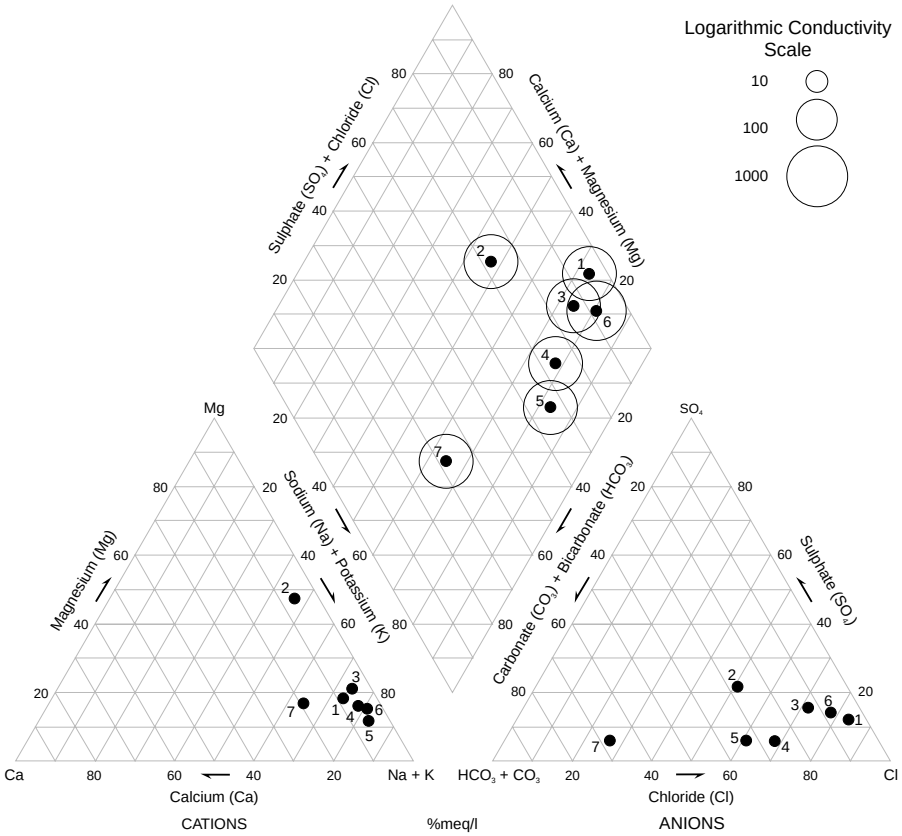


Figure 6

Piper plots for groundwater bores at the Bridport sewage lagoons. 1 - BSL2000/1; 2 – BSL2000/2; 3 – BSL2000/3; 4 – BSL2000/4; 5 – BSL2000/5; 6 – BSL2000/6; 7 — average of all MRT groundwater records for Quaternary coastal sands.

Table 1

Comparison of analytical results against water quality standards (guideline value listed when stated by a relevant standard). Bold values exceed emission limits

Parameter	*BSL 2000/1*	*BSL 2000/2*	*BSL 2000/3*	*BSL 2000/4*	*BSL 2000/5*	*BSL 2000/6*	*Emission limit*
pH	5.0	5.8	5.3	5.7	6.3	5.9	N/A
Conductivity (µS/cm)	371	354	615	588	777	1130	N/A: note average seawater value 36 000
Alkalinity CO_3 (mg/L)	<1	<1	<1	<1	<1	<1	N/A
Alkalinity HCO_3 (mg/L)	7	41	34	78	133	48	N/A
Bromide (mg/L)	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	N/A
Chloride (mg/L)	78	44	110	120	140	**270**	250* (mg/L)
Fluoride (mg/L)	<0.02	0.09	0.03	0.03	0.13	0.06	1.5* (mg/L)
Sulphate (mg/L)	15	25	32	13	18	64	250* (mg/L)
Ammonia (mg/L)	**1.73**	**1.11**	**1.68**	**4.92**	0.067	0.052	0.5* (mg/L) nitrogen (as ammonia)
Nitrate + Nitrite (mg/L)	0.171	0.164	0.178	0.328	0.092	0.109	10.0* (mg/L) nitrogen (as nitrate or nitrite)
Nitrite (mg/L)	0.035	0.062	0.036	0.168	0.084	0.034	10.0* (mg/L) nitrogen (as nitrate or nitrite)
Ortho-P (mg/L)	0.014	0.021	0.016	0.100	0.031	0.022	2.0* as phosphorus
Calcium (mg/L)	4.46	3.71	3.94	1.72	0.57	0.48	N/A
Potassium (mg/L)	2.599	3.80	2.34	0.70	0.48	0.24	N/A
Magnesium (mg/L)	6.70	18.9	13.1	3.47	0.95	1.56	N/A
Sodium (mg/L)	48.4	33.0	84.2	30.5	11.9	14.7	N/A

* *Environment Protection (Water Pollution) Regulations 1974*, emissions 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

Analyte	Bridport sewage lagoons						ANZECC 2000		
	BSL 2000/1	BSL 2000/2	BSL 2000/3	BSL 2000/4	BSL 2000/5	BSL 2000/6	IRRIGATION STV (Short-term)	IRRIGATION LTV (Long-term)	LIVESTOCK DRINKING
Standing Water Level	1.16	1.44	1.88	1.44	1.01	1.0			
pH	5.0	5.8	5.3	5.7	6.3	5.9	**6.0–8.5		
Conductivity (µS/cm)	371	354	615	588	777	1130	(1)(Refer Tables 4.2.3 & 4.2.4)		
Manganese (µg/L)	6700	18900	13100	3470	950	1560	10,000	200	NST
Chloride (mg/L)	78	44	110	120	140	270	(2)MT (Refer Table 4.2.6) MR (Refer Table 4.2.7)		
Fluoride (mg/L)	<0.02	0.09	0.03	0.03	0.13	0.06	4	1	
Potassium (mg/L)	2.59	3.8	2.34	0.7	0.48	0.24			
Sodium (mg/L)	48.4	33	84.2	30.5	11.9	14.7	(2)MT (Refer Table 4.2.8)		
PO_4-P (mg/L)	0.014	0.021	0.016	0.1	0.031	0.022			
SO_4 (mg/L)	0.015	0.025	0.032	0.013	0.018	0.064			
NH_3-N (mg/L)	1.730	1.110	1.680	4.920	0.067	0.052			
(NO_2+NO_3)-N (mg/L)	0.171	0.164	0.178	0.328	0.092	0.109			
NO_2-N (mg/L)	0.035	0.062	0.036	0.168	0.084	0.034			

Shaded boxes indicate where values are above relevant guideline levels (also shaded).

This table is derived from: *ANZECC 2000: Guidelines for fresh and marine water quality — Vol. 1 Ch. 4 Primary Industries and Vol. 3 Ch. 9 Primary Industries — Rationale and Background Information.*

Notes:

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

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

(2) ES = suits extremely sensitive crops
S = suits crops sensitive to foliar injury through foliar absorption
MS = suits moderately sensitive crops, may affect sensitive crops
MT = suits moderately tolerant crops
MA = may affect crops sensitive to foliar injury through foliar absorption
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
NST — not sufficiently toxic

Analytical data

All bores were sampled on 29 November 2000 in accordance with Australian/New Zealand Standard AS/NZS 5667.11:1998. Laboratory testing of samples of groundwater extracted from the boreholes was carried out by Analytical Services Tasmania, in accordance with relevant Australian and international standards. The laboratory report from Analytical Services Tasmania is included as Appendix 2. Values for pH ranged between 5.0 and 6.3 while conductivity values ranged between 371 and 1130 µS/cm. Analytical results are presented on site maps in Appendix 3.

Figure 6 is a Piper plot of the results of the groundwater samples, while Tables 1 and 2 compare the analytical results against international standards where a guideline/emission value is stated by the relevant standard.

INTERPRETATION

In situ permeability testing

Slug extraction tests were carried out on 16 August 2001 on bores BSL2000/1 and BSL2000/6 to gain an understanding of the permeability of the host materials. Data collected during the slug extraction tests is presented in Appendix 4.

Slug extraction tests (30 to 40 litres) were completed and levels monitored for ten 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 calculated the hydraulic conductivities depicted in Figure 7 (a) and (b) for holes BSL2000/1 and BSL2000/6 respectively. This method was selected as the most appropriate available within the software package. The hydraulic conductivity values (0.69 and 0.50 m/d) imply a muddy/silty sandy aquifer, which may suggest that fines were washed out of the returns during drilling and therefore are not identified on the engineering logs.

Hydrogeology

Figure 8 is an interpretation of the piezometric surface based on surveyed heights and groundwater depths of the boreholes. Based on this interpretation, groundwater flow is to the northwest of the lagoons. The cross-section slopes also support this interpretation.

Borehole BSL2000/6 appears to be the most appropriate hole to use as a background comparison although elevated chloride and manganese concentrations indicate that the hole may not be suitable as a background hole in the medium to long term.

Groundwater chemistry varies up and down-gradient near the lagoons. Groundwater from holes down gradient of the lagoons (BSL2000/1, BSL2000/2, BSL2000/3 and BSL2000/4) had elevated chemical results for selective water quality parameters compared to water from hole BSL2000/6 up gradient. These included ammonia (one order of magnitude higher down gradient), sodium, calcium, potassium, and magnesium. The reverse effect existed for sulphate and chloride, possibly due to dilution effects relating to the lagoons. BSL2000/5 (screened in a perched water table, most likely related to recharge by rainfall through the soil profile) had elevated values for ortho-phosphate and alkalinity ($CaCO_3$).

The water chemistry of BSL2000/2 on the Piper plot (fig. 6) varies significantly compared to the other five bores. This may imply a preferred groundwater pathway (possibly related to coarse sand) from the lagoons towards the surface water system to the west. Nitrogen and ammonia values indicate leakage to the northwest and particularly to the north.

The groundwater in the local area of the lagoons is of moderate to poor quality. The ANZECC guidelines state that water of this quality is only specifically useful for sensitive crops. Further monitoring of microbiological water quality parameters may further limit the potential usefulness of the groundwater.

There appears to be a direct hydraulic connection between the groundwater system and the infrastructure of both lagoons (i.e. the lagoons are located in the groundwater table). A groundwater mounding effect may be associated with the lagoons and influenced by the bedrock topography. The combination of *in situ* permeability tests (hydraulic conductivity values of 0.69 and 0.50 m/d) and the cross sections (fig. 5) demonstrate that the Quaternary sand aquifer could exert a slight hydraulic head on the lagoon liners. More observations are needed.

PRINCIPAL CONCLUSIONS

With respect to current data collection points, groundwater quality down-gradient appears to be notably degraded compared to that up-gradient of the lagoons. The integrity of the lagoon liners requires further investigation. On-going interaction between the solid and liquid wastes within the lagoons and the groundwater system will most likely continue to degrade groundwater quality north and west of the lagoons.

FURTHER WORK

Future monitoring of microbiological water quality parameters may help to confirm the extent of the degradation of groundwater quality related to the sewage lagoon infrastructure. An electromagnetic (EM31/EM34, TEM) survey is recommended to identify zones of high and low ground conductivity. The survey may help to define the extent of variations in groundwater chemistry within the areas up and down-gradient of the lagoon footprints. Differentiation of the contamination plume using geophysical techniques should consider the implications of elevated chloride and manganese concentrations identified in BSL2000/6. Additional drilling should include a borehole sited in similar sand well away from any pollution source in the local area.

REFERENCES

MOORE, W. R. 1990. *North East Tasmania Groundwater Resource Project 1:60 000 Series. Map 1. Geology of the Scottsdale Sedimentary Basin*. Department of Mines Tasmania.

[30 May 2002]

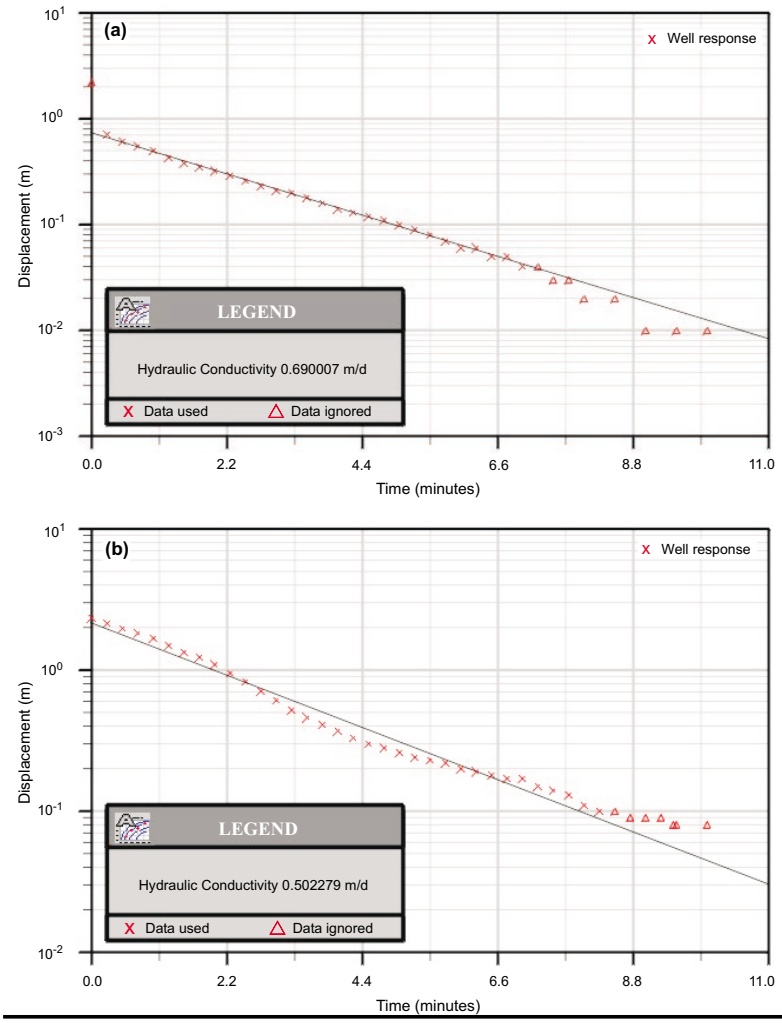


Figure 7

Hydraulic conductivity values for: (a) BSL2000/1 (K = 0.69 m/d = 7.98 × 10^{-6} m/sec) (b) BSL2000/6 (K = 0.50 m/d = 5.81 × 10^{-6} m/sec), calculated in AquiferWin32 (Version 2.17, Environmental Simulations Inc.), Bouwer and Rice (1976, Unconfined Aquifer) solution.

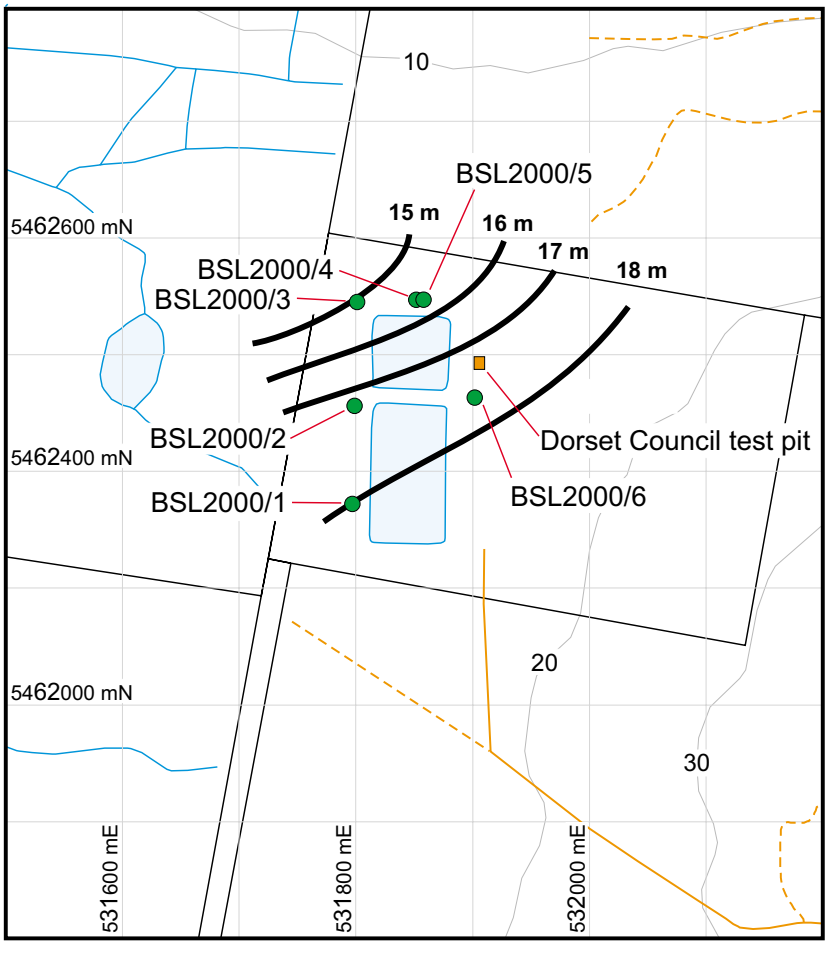


Figure 8

Interpretation of the piezometric surface (shown as RL heights) based on surveyed heights and groundwater depths of the boreholes.

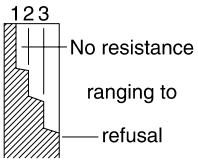
Appendix 1

Engineering logs

EXPLANATION SHEET FOR ENGINEERING LOGS

Borehole and excavation log

Penetration



Water

22 Jan, 80 Water level on date shown

Water inflow

Water outflow

Notes - samples and tests

U50	Undisturbed sample 50mm diameter
D	Disturbed sample
N	Standard penetrometer blow count for 300mm
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 feel 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

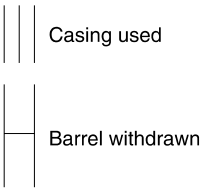
		%
VL	Very loose	0 - 15
L	Loose	15 - 35
MD	Medium dense	35 - 65
D	Dense	65 - 85
VD	Very dense	85 - 100

Fracture description

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

Cored borehole log

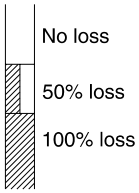
Case - lift



Casing used

Barrel withdrawn

Fluid loss



No loss

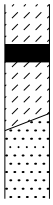
50% loss

100% loss

Lugeons

Lugeon units (uL) are a measure of rock mass permeability. For a 46 to 74mm 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 $1X10^{-4}$ 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

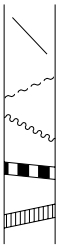
point load strength index $I_{s\,(50)}$ (MPa)

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



Joint

Sheared zone

Crushed seam

Infill seam

Extremely weathered seam

Implies protective OH&S equipment required for drilling personal

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MINERAL RESOURCES TASMANIA

ENGINEERING LOG - BOREHOLE

Borehole no. **BSL2000/1**
Sheet 1 of 1

Project: Bridport sewage lagoons — Location: Charles Street, Bridport

Co-ordinates: 55 531797 mE, 5462372 mN
R.L.
Inclination: Vertical
Bearing

Drill type: Auger
Drill method: Rotary
Drill fluid: Nil

Hole commenced: 19 September 2000
Hole completed: 19 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
		Bentonite	D Sample ID 1	0.5		SM	SAND - black	D	S L	Quaternary sand soil
	No Screen - Class 6 PVC pipe	7mm Gravel	D Sample ID 2	1.0		SP	SAND - medium, light grey	M	S L	Quaternary sand
			D Sample ID 3	1.5		SP	SAND - coarse, grey and dark brown	M	VL	Quaternary sand
			D Sample ID 4	2.0		SP	SAND - coarse, dark brown	M	VL	Quaternary sand
	1.4 m Pro slotted screen		D Sample ID 5	2.5		SP	SAND - coarse, dark brown	M	VL	Quaternary sand
			D Sample ID 6	3.0		SM	SAND - fine, light red-brown, strong H_2S odour	W	VL	Quaternary sand
	Back in fill	Back in fill		3.5						
				4.0			End of hole at 4.0 m Pumped for 30 minutes At end of pumping, flow 0.9 L/m, pH 7.4 and conductivity 450 µS/cm. Strong H_2S odour from water samples			

Sample ID numbers refer to samples stored in MRT core shed

MINERAL RESOURCES TASMANIA

ENGINEERING LOG - BOREHOLE

Borehole no. **BSL2000/2**
Sheet 1 of 1

Project Bridport sewage lagoons — Location Charles Street, Bridport

Co-ordinates 55 531799 mE
5462456 mN
R.L.
Inclination Vertical
Bearing

Drill type Auger
Drill method Rotary
Drill fluid Nil

Hole commenced 19 September 2000
Hole completed 19 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	Bentonite	D Sample ID 1 & 2			SM	SAND - dark brown	M	S L	Quaternary sand
				0.5		SP	SAND -medium, dark grey	M	S L	Quaternary sand
			D Sample ID 3			SP	SAND - coarse, brown-grey	M	VS L	Quaternary sand
				1.0						
				1.5						
		7mm Gravel	D Sample ID 4			SP	SAND - medium, brown	M	S L	Quaternary sand
	2.0 metre slotted Screen		D Sample ID 5	2.0		SP	SAND - medium, grey-light brown	W	S L	Quaternary sand
				2.5						
			D Sample ID 6							
				3.0						
	No Screen	Back in fill	D Sample ID 7			SC	SAND - light grey, clayey	M	St	Quaternary sand
						SP	SAND - medium, light brown	W	VL VS	Quaternary sand
	Back in fill			3.5						
				4.0			End of hole at 4.0m Pumped for 15 minutes At end of pumping, flow 0.3 L/m, pH 7.4 and conductivity 330 µS/cm. Detergent appearance of all pumped water during development of hole.			

Sample ID numbers refer to samples stored in MRT core shed

MINERAL RESOURCES TASMANIA

ENGINEERING LOG - BOREHOLE

Borehole no. **BSL2000/3**
Sheet 1 of 2

Project	Bridport sewage lagoons			Location	Charles Street, Bridport
Co-ordinates	55 531801 mE 5462545 mN	Drill type	Auger	Hole commenced	19 September 2000
		Drill method	Rotary	Hole completed	19 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
		Bentonite	D Sample ID 1			SM	SAND - black	M	L	Quaternary sandy soil
			D Sample ID 2	0.5		SP	SAND - medium, 10% black and 90% dark grey	M	L	Quaternary sand
			D Sample ID 3	1.0		SP	SAND - medium, dark grey, 5% quartzite light yellow rounded pebbles	M	L S	Quaternary sand
	No Screen	7mm Gravel	D Sample ID 4	1.5		SP	SAND - medium, dark red-brown, 2% quartzite rounded pebbles	M	L	Quaternary sand
			D Sample ID 5	2.0						
			D Sample ID 6	2.5		SP	SAND - coarse, dark brown, 2% quartzite pebbles	M	L	Quaternary sand
			D Sample ID 7	3.0		SP	SAND - coarse, dark brown, 2% quartzite pebbles	W	L S	Quaternary sand
	2.0 metre slotted Screen		D Sample ID 8	3.5		SP	SAND - coarse, dark grey, 5% quartzite pebbles	W	VL	Quaternary sand
			D Sample ID 8	4.0						
		Back in fill	D Sample ID 8	4.5						

MINERAL RESOURCES TASMANIA

ENGINEERING LOG - BOREHOLE

Borehole no. **BSL2000/3**
Sheet 2 of 2

Project Bridport sewage lagoons — Location Charles Street, Bridport

Co-ordinates 55 531801 mE
5462545 mN

R.L.
Inclination Vertical
Bearing

Drill type Auger
Drill method Rotary
Drill fluid Nil

Hole commenced 19 September 2000
Hole completed 19 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
	Back in fill	Back in fill	D Sample ID 8				(As sheet 1)			
				5.5			End of hole at 5.5 m Hand bailed for 10 minutes. At end of bailing, pH 7.5 and conductivity 790 µS/cm.			

Sample ID numbers refer to samples stored in MRT core shed

MINERAL RESOURCES TASMANIA

ENGINEERING LOG - BOREHOLE

Borehole no. **BSL2000/4**
Sheet 1 of 2

Project Bridport sewage lagoons — Location Charles Street, Bridport

Co-ordinates 55 531852 mE
5462547 mN

R.L.
Inclination Vertical
Bearing

Drill type Auger
Drill method Rotary
Drill fluid Nil

Hole commenced 19 September 2000
Hole completed 19 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
		Bentonite	D Sample ID 1			SM	SAND - black	M	L S	Quaternary sand, soil
	No Screen		D Sample ID 2	0.5		SP	SAND - coarse, light grey, 5% white quartzite pebbles	M	L	Quaternary coastal plain sediments
		7mm Gravel	D Sample ID 3	1.0		SP	SAND -medium, brownish grey, 5% white rounded quartzite pebbles	W	L	Quaternary coastal plain sediments
			D Sample ID 4	1.5						
	2.0 metre slotted Screen		D Sample ID 5	2.0		SP	SAND - coarse, light yellow-brown and grey, quartzite pebbles	M	L	Quaternary coastal plain sediments
			D Sample ID 6	2.5		SP	SAND - medium, dark grey, white rounded pebbles	W	VL	Quaternary coastal plain sediments
	Back in fill	Back in fill		3.0		SP	SAND - coarse, light grey, clayey, 5% white rounded small pebbles	W	VL	Quaternary coastal plain sediments
				3.5						
				4.0						
				4.5						

MINERAL RESOURCES TASMANIA

ENGINEERING LOG - BOREHOLE

Borehole no. **BSL2000/4**
Sheet 2 of 2

Project: Bridport sewage lagoons — Location: Charles Street, Bridport

Co-ordinates: 55 531801 mE, 5462545 mN
R.L.
Inclination: Vertical
Bearing

Drill type: Auger
Drill method: Rotary
Drill fluid: Nil

Hole commenced: 19 September 2000
Hole completed: 19 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.	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
	Back in fill	Back in fill						(As sheet 1)			
					5.5			End of hole at 5.5 m			
			Sample ID numbers refer to samples stored in MRT core shed								

MINERAL RESOURCES TASMANIA

ENGINEERING LOG - BOREHOLE

Borehole no. **BSL2000/5**
Sheet 1 of 1

Project: Bridport sewage lagoons — Location: Charles Street, Bridport

Co-ordinates: 55 531858 mE, 5462547 mN
R.L.
Inclination: Vertical
Bearing

Drill type: Auger
Drill method: Rotary
Drill fluid: Nil

Hole commenced: 19 September 2000
Hole completed: 19 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	Bentonite	Samples as BSL2000/4			SM	SAND - black	M	L S	Quaternary sand soil
				0.5		SP	SAND - coarse, brown-grey, 5% white quartzite pebbles	M	L	Quaternary coastal plain sediments
	1 metre slotted screen	7mm Gravel		1.0		SP	SAND - medium, brown-grey, 5% white rounded quartzite pebbles	W	L	Quaternary coastal plain sediments
				1.5						
						SP	SAND - coarse, light brown-grey, quartzite pebbles	M	L	Quaternary coastal plain sediments
				2.0			End of hole at 2.0 m			

MINERAL RESOURCES TASMANIA

ENGINEERING LOG - BOREHOLE

Borehole no. **BSL2000/6**
Sheet 1 of 1

Project: Bridport sewage lagoons
Location: Charles Street, Bridport

Co-ordinates: 55 531902 mE, 54625463 mN
R.L.
Inclination: Vertical
Bearing

Drill type: Auger
Drill method: Rotary
Drill fluid: Nil

Hole commenced: 19 September 2000
Hole completed: 19 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	Bentonite	D Sample ID 1			SM	SAND - black	M	L S	Quaternary sandy soil
			D Sample ID 2	0.5		SP	SAND - coarse, brown- grey	M	L	Quaternary sand
	2 metre slotted screen	7mm Gravel	D Sample ID 3	1.0		SP	SAND - coarse, light yellow	W	VL	Quaternary sand
			D Sample ID 4	1.5		SP	SAND - coarse, light grey, clayey	W	VL	Quaternary sand
			D Sample ID 5	2.0						
			D Sample ID 6	2.5						
			Sample ID numbers refer to samples stored in MRT core shed	3.0			End of hole at 3.0 m			

Appendix 2

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:	13954	***Please quote this number when making enquiries about this report***
Submitted By:	Andrew Ezzy	
Client:	Mineral Resources Tasmania	
Site Description:	Bridport	
Received:	01-Dec-00	**Client Order No:**
Report Date:	02-Jan-01	
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
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
1302-Water:	Major Cations in Water by APHA Method 3030/3120

Greg Hince
Senior Chemist

Tasmania

ANALYTICAL SERVICES TASMANIA

Sandy Bay Laboratory

c|- Chemistry Department University of Tasmania

Sandy Bay Tasmania 7005

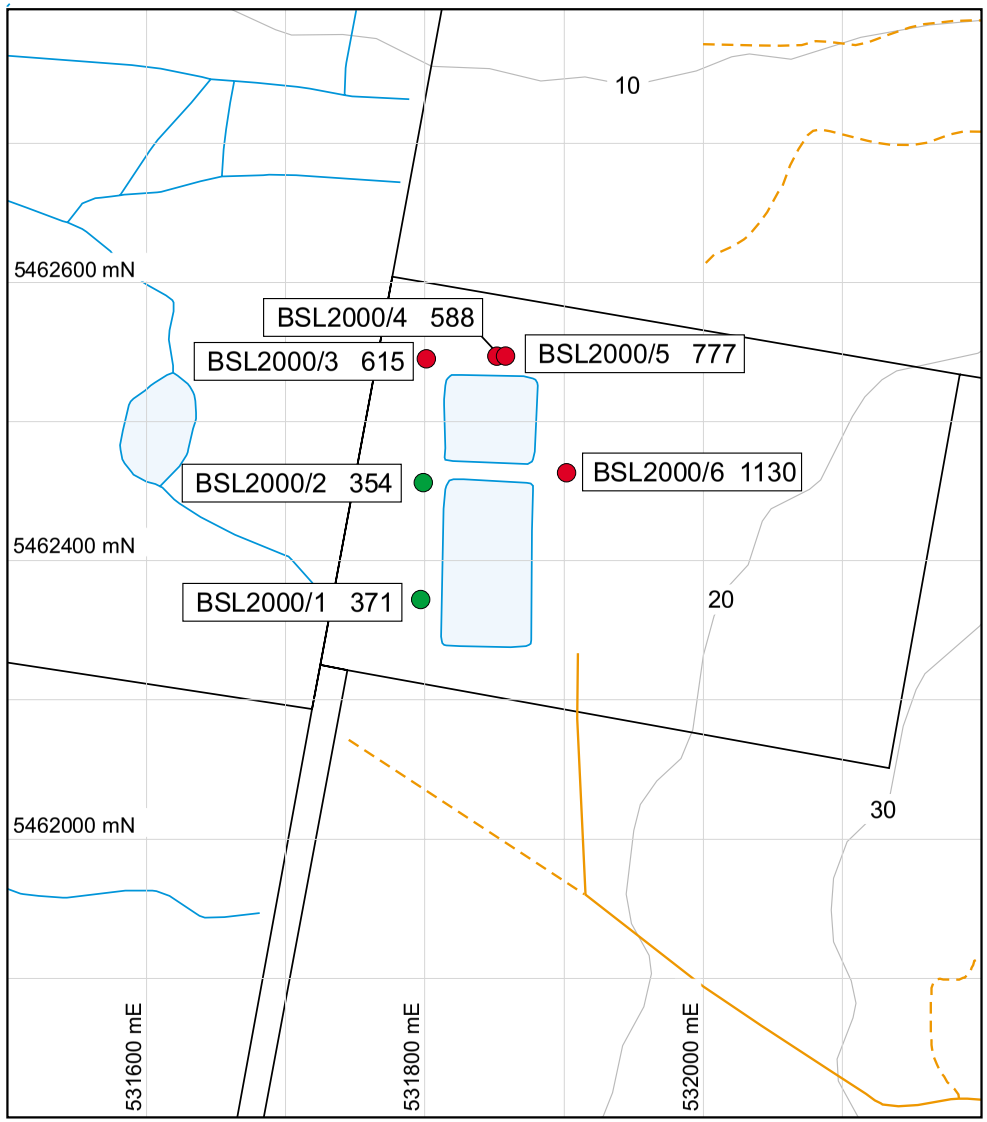
NATA Accreditation Number: 5589

Report No: 13954 **Report Date:** 02-Jan-01

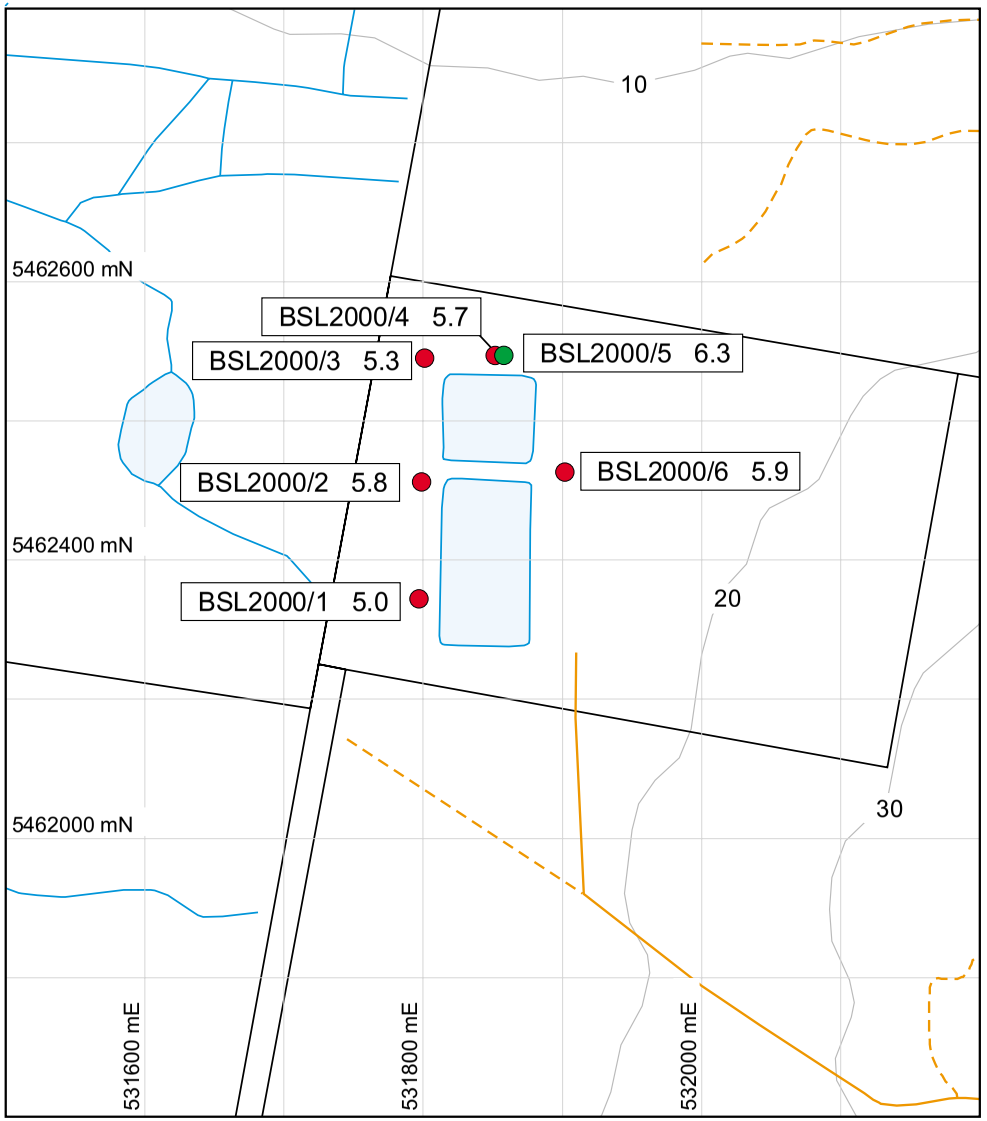
		Lab.No.:	14229	14230	14231	14232	14233	14234
		Sample Id.:	BSL2000/1	BSL2000/2	BSL2000/3	BSL2000/4	BSL2000/5	BSL2000/6
Method	Analyte	Units / Sampled On :	29/11/00 10:40	29/11/00 10:20	29/11/00 10:00	29/11/00 09:10	29/11/00 09:25	29/11/00 08:50
1001-Water	pH		5.0	5.8	5.3	5.7	6.3	5.9
1002-Water	Conductivity	µS/cm	371	354	615	588	777	1130
1101-Water	Alkalinity CO3	mg/L CaCO3	<1	<1	<1	<1	<1	<1
	Alkalinity HCO3	mg/L CaCO3	7	41	34	78	133	48
1103-Water	Bromide	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
	Chloride	mg/L	78	44	110	120	140	270
	Fluoride	mg/L	<0.02	0.09	0.03	0.03	0.13	0.06
	Sulphate	mg/L	15	25	32	13	18	64
1201-Water	Ammonia	µg-N/L	1730	1110	1680	4920	67	52
	Nitrate+Nitrite	µg-N/L	171	164	178	328	92	109
	Nitrite	µg-N/L	35	62	36	168	84	34
	Ortho-P	µg-P/L	14	21	16	100	31	22
1302-Water	Ca (Dissolved)	mg/L	4.46	3.71	3.94	1.72	0.57	0.48
	K (Dissolved)	mg/L	2.59	3.80	2.34	0.70	0.48	0.24
	Mg (Dissolved)	mg/L	6.70	18.9	13.1	3.47	0.95	1.56
	Na (Dissolved)	mg/L	48.4	33.0	84.2	30.5	11.9	14.7

Appendix 3
Analytical results on site map

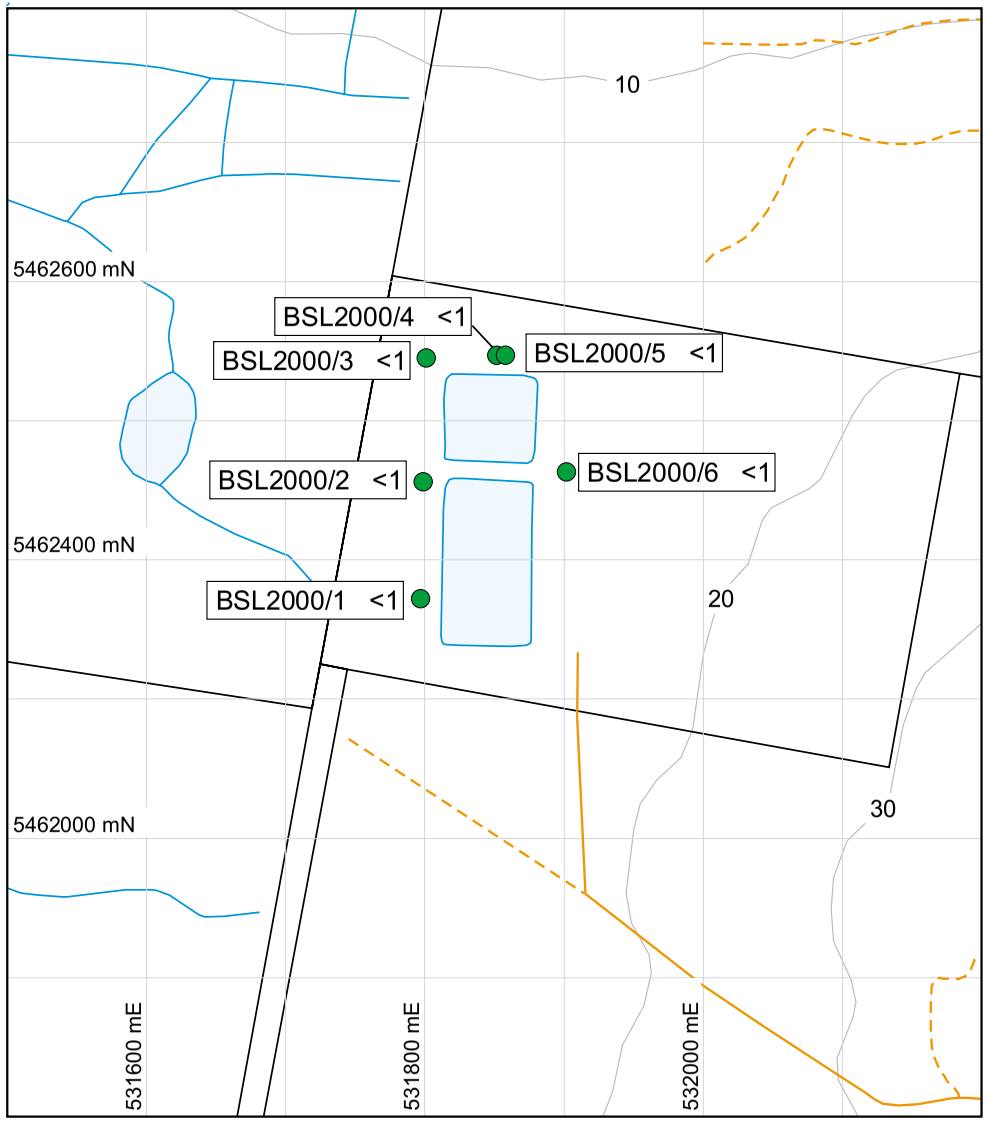
Bridport sewage lagoons
November 2000
Conductivity (µS/cm)



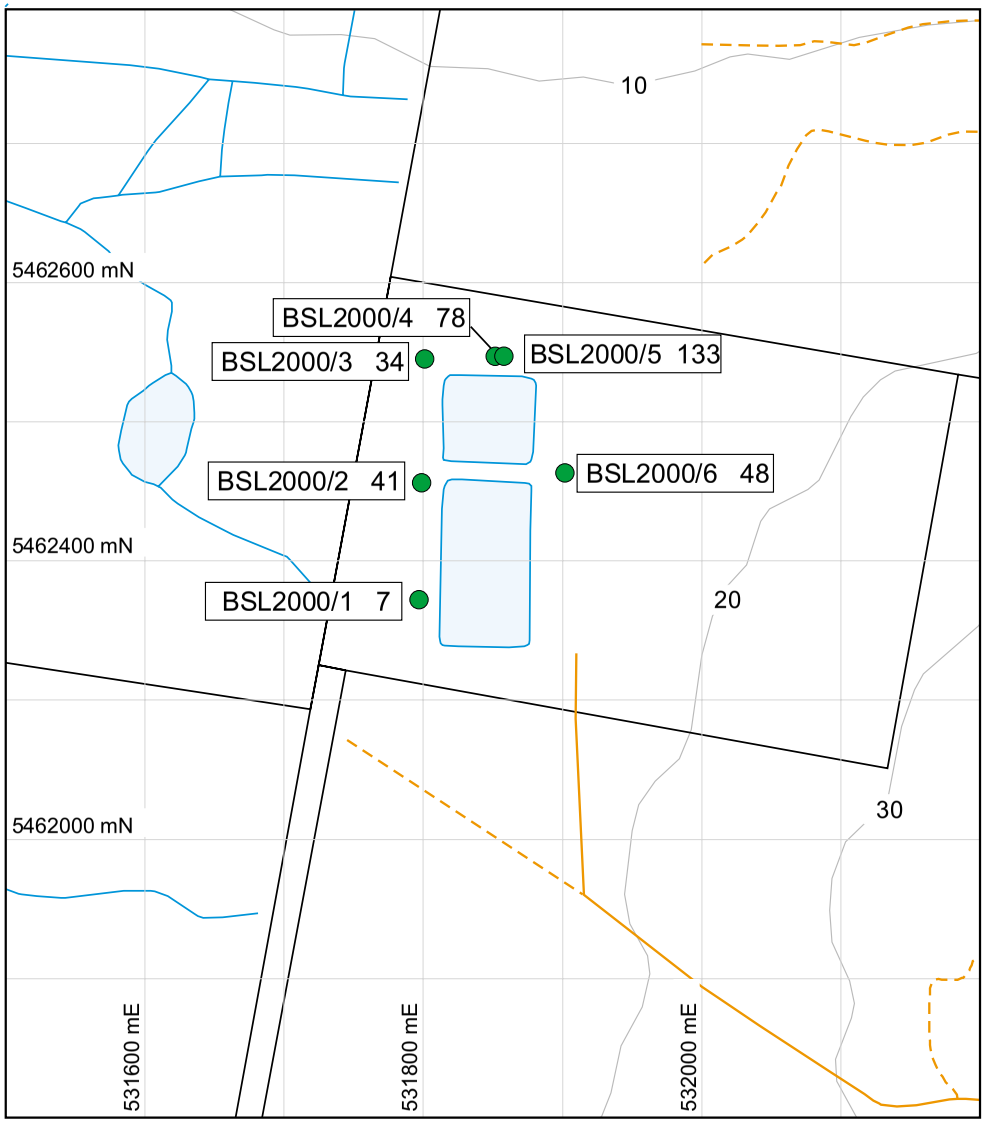
Bridport sewage lagoons
November 2000
pH



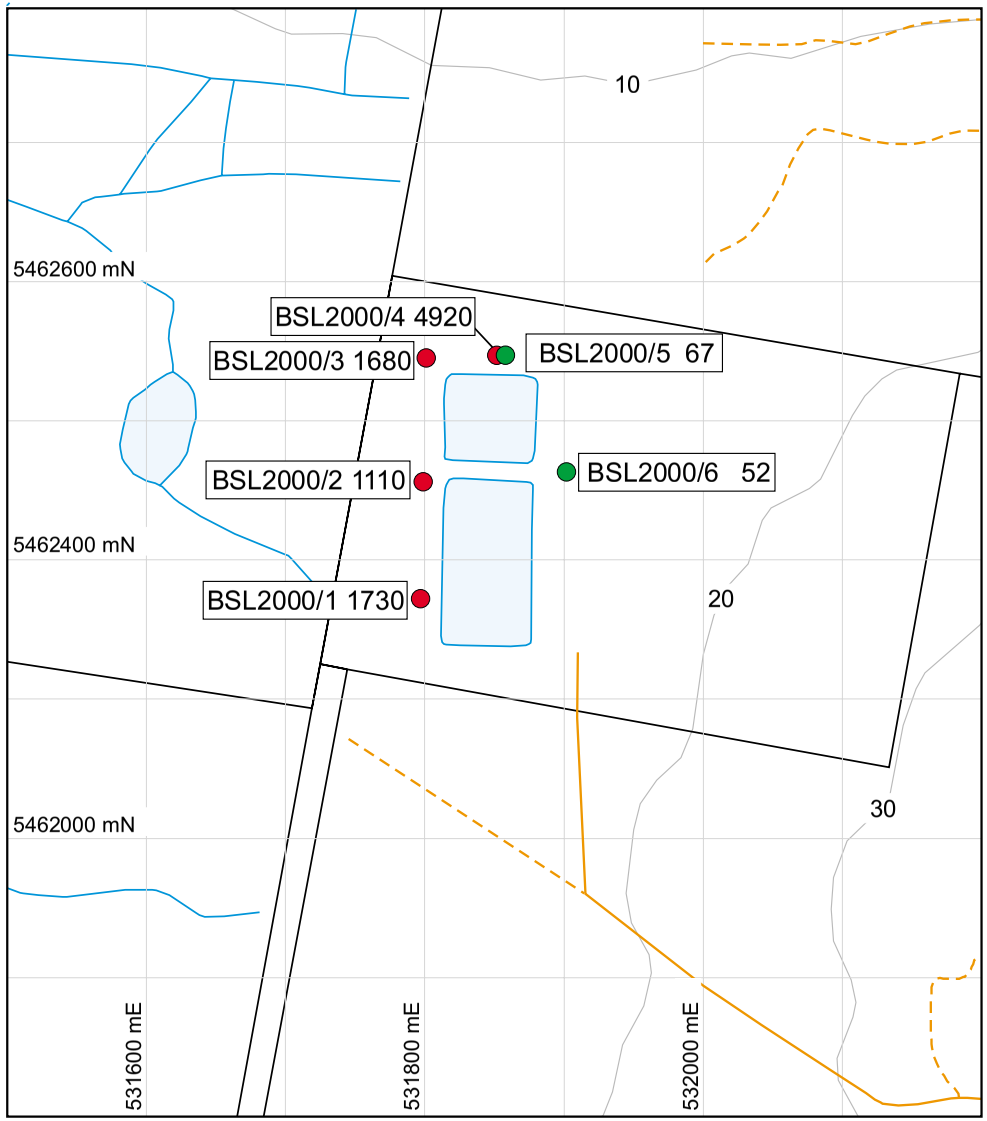
Bridport sewage lagoons
November 2000
Alkalinity CO_3 (mg/L $CaCO_3$)



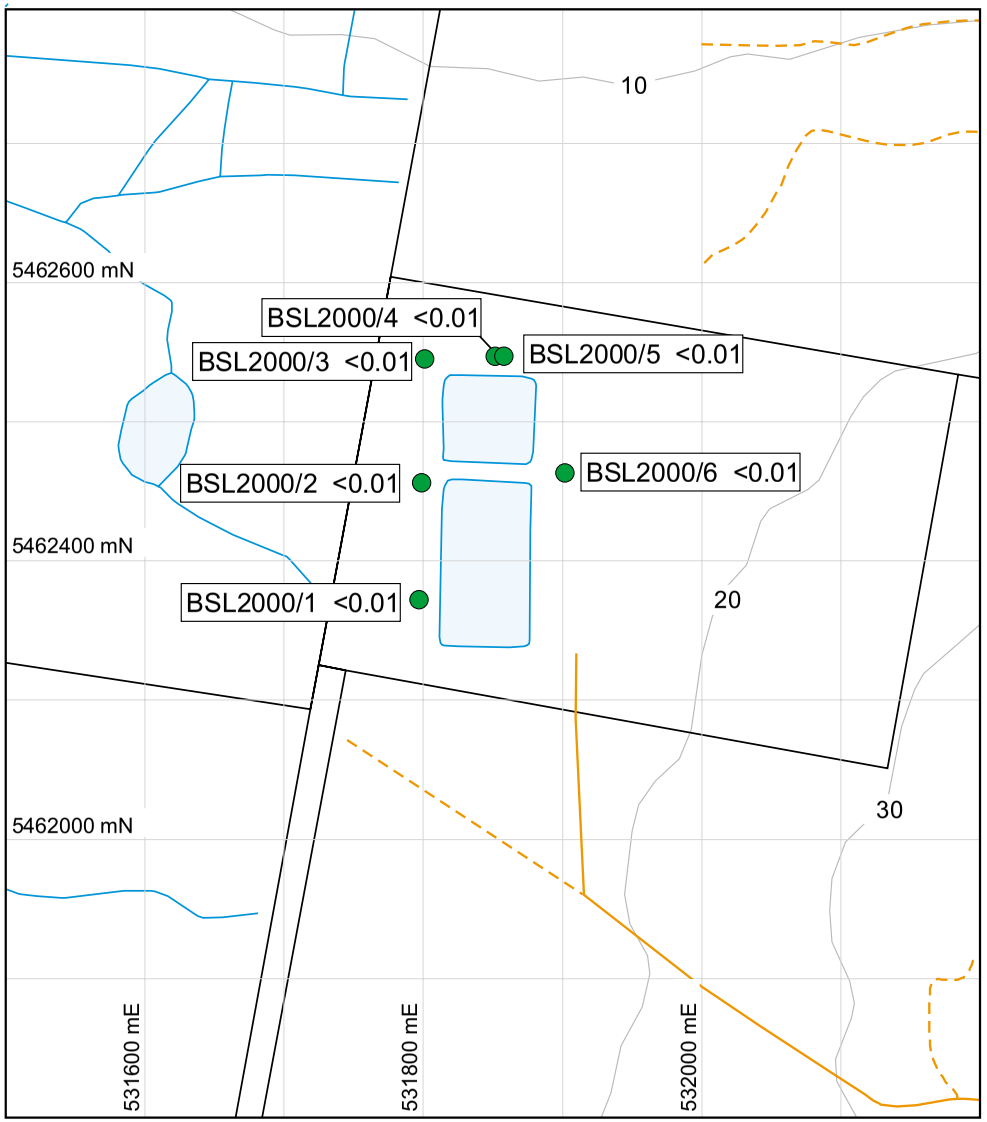
Bridport sewage lagoons
November 2000
Alkalinity HCO_3 (mg/L $CaCO_3$)



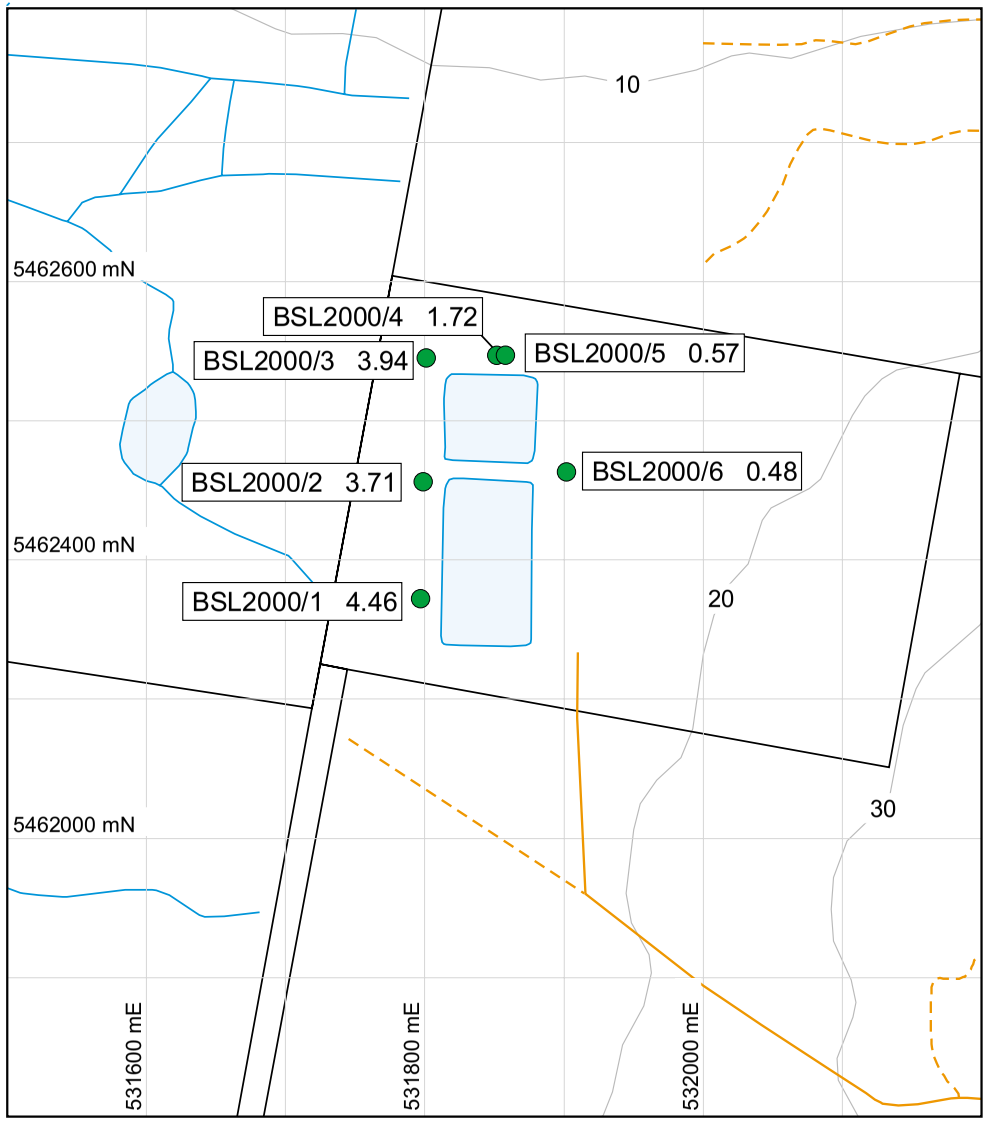
Bridport sewage lagoons
November 2000
Ammonia (μg-N/L)



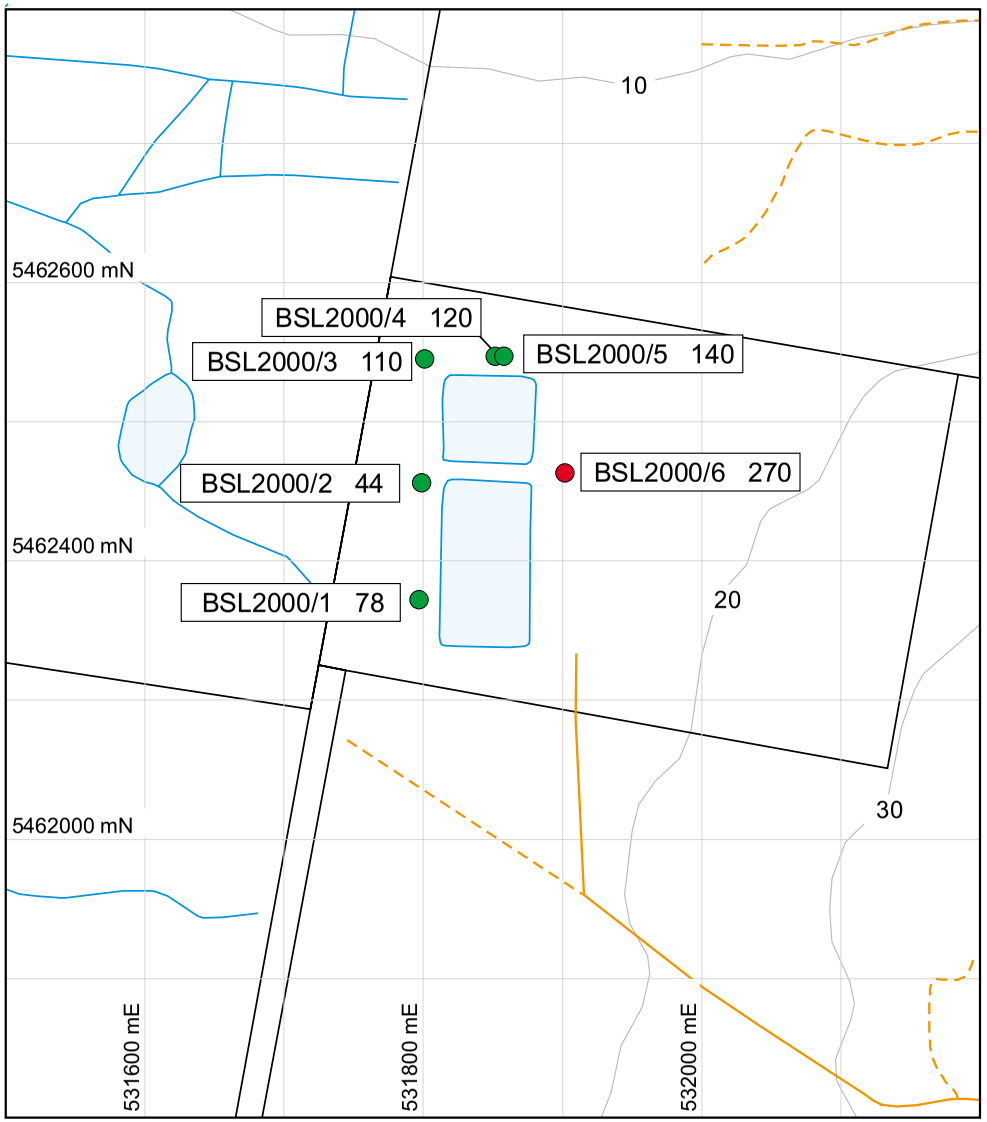
Bridport sewage lagoons
November 2000
Bromide (mg/L)



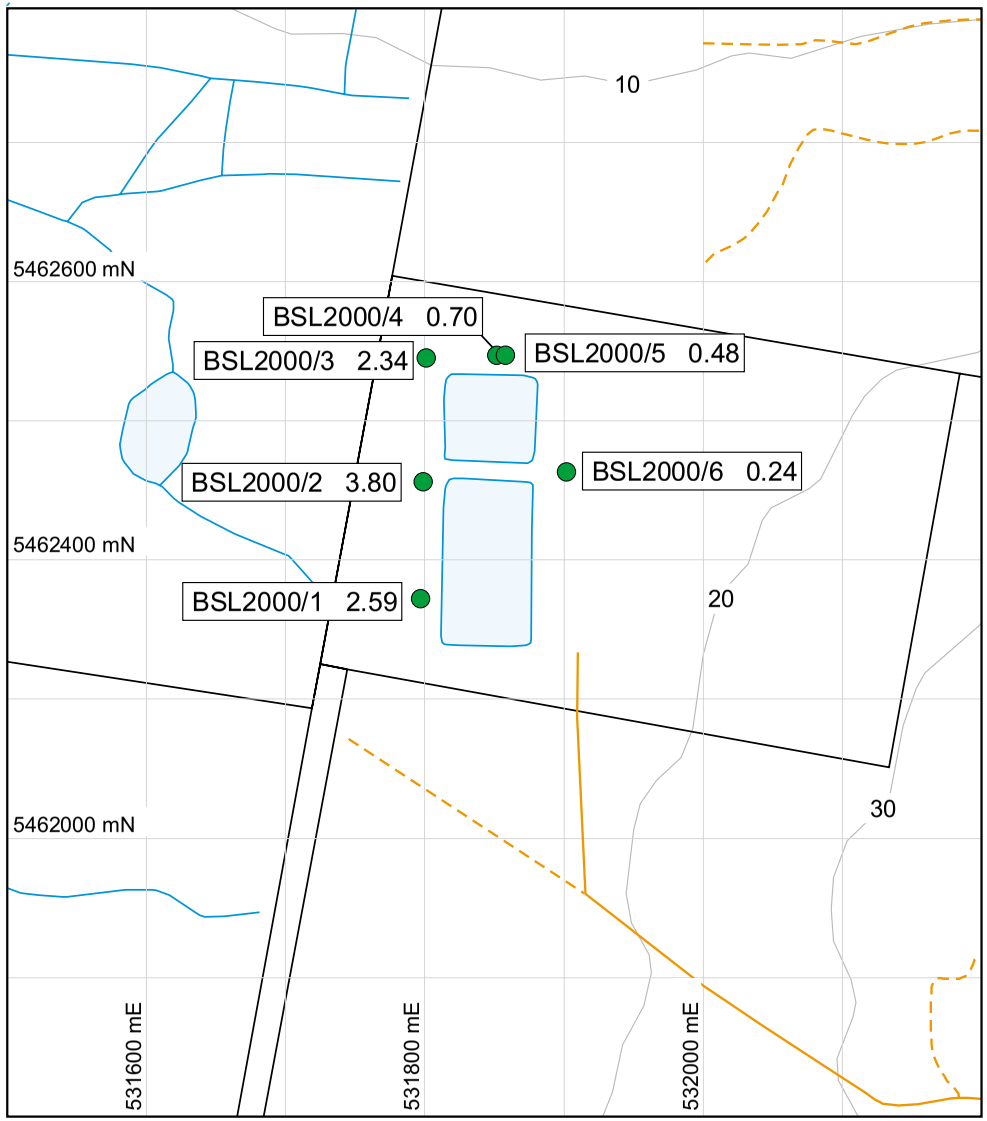
Bridport sewage lagoons
November 2000
Ca (mg/L)



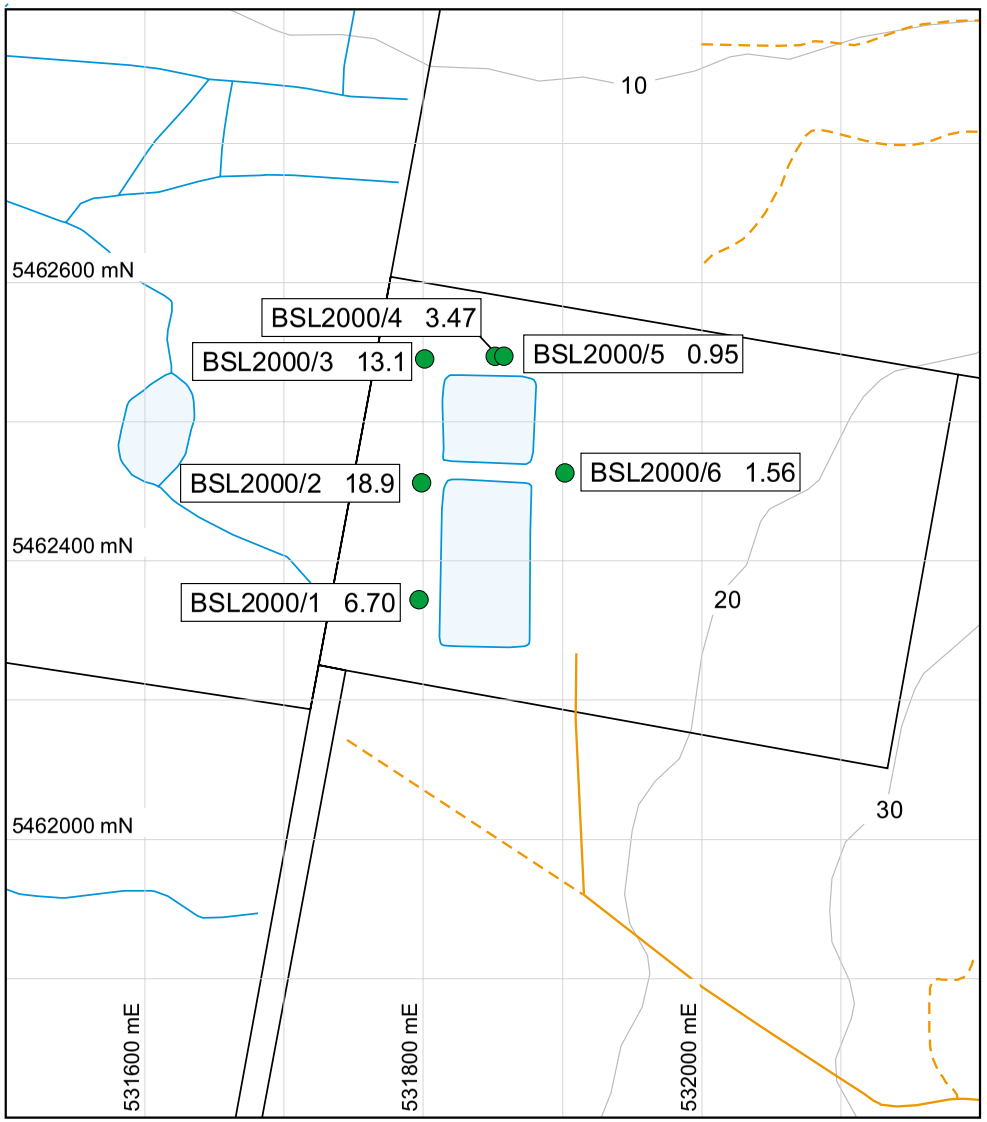
Bridport sewage lagoons
November 2000
Chloride (mg/L)



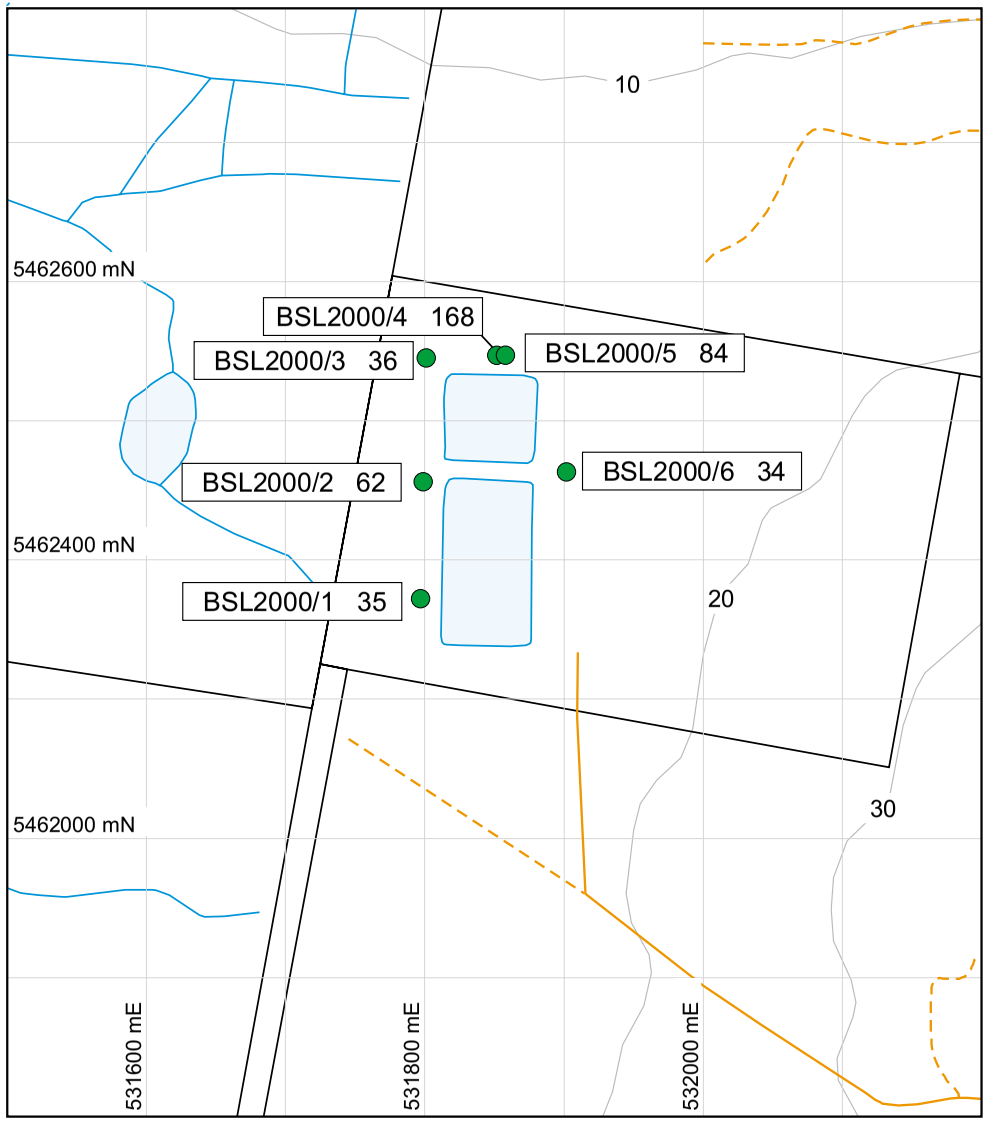
Bridport sewage lagoons
November 2000
K (mg/L)



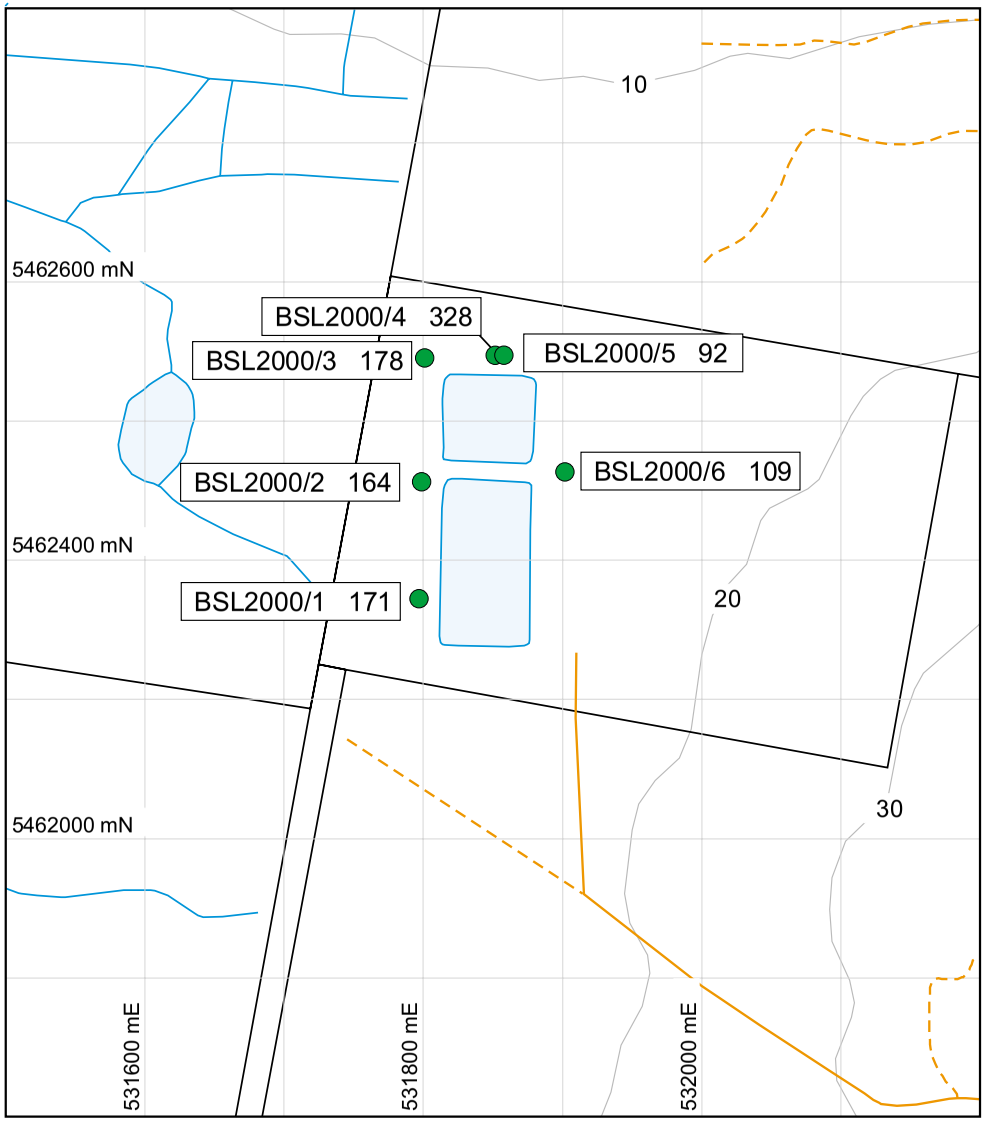
Bridport sewage lagoons
November 2000
Mg (mg/L)



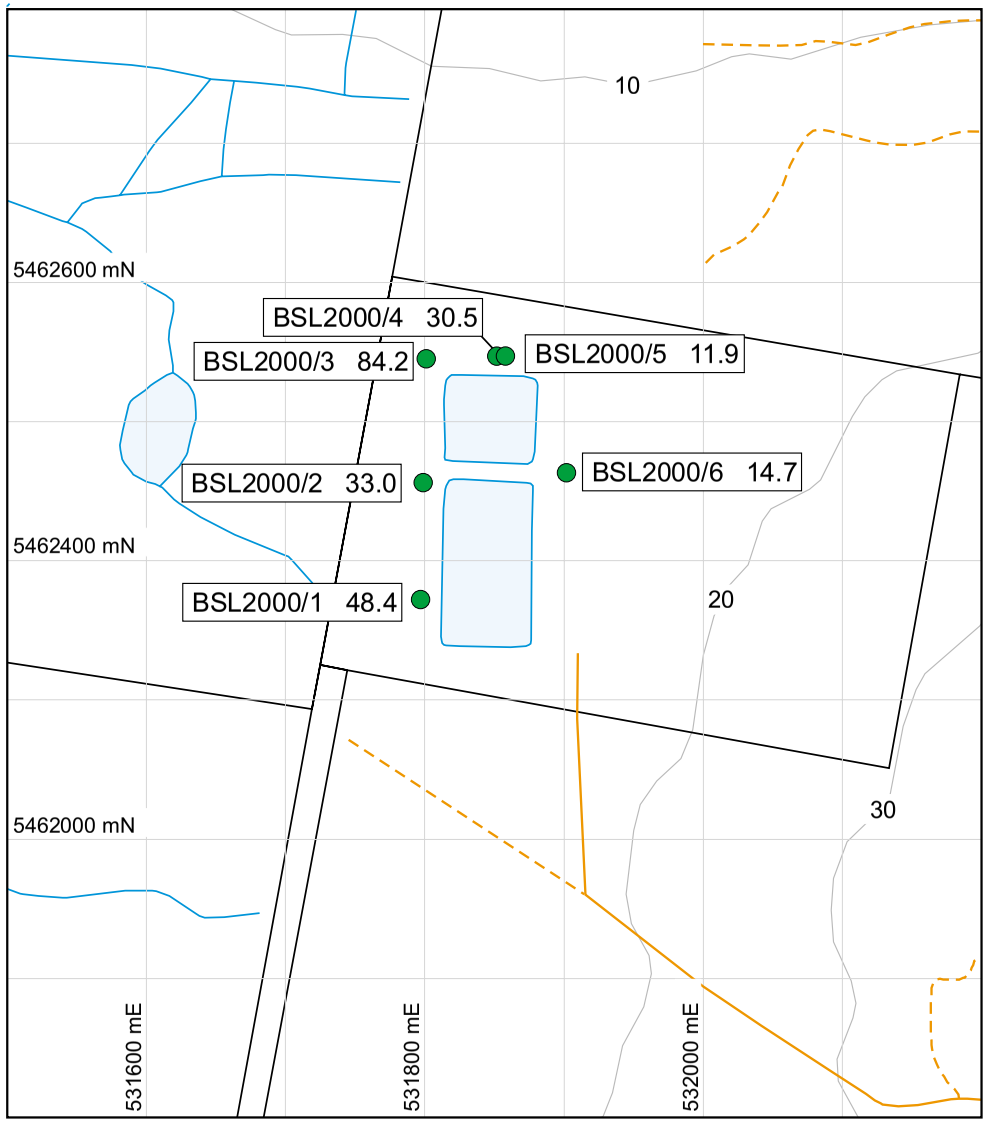
Bridport sewage lagoons
November 2000
Nitrite (µg-N/L)



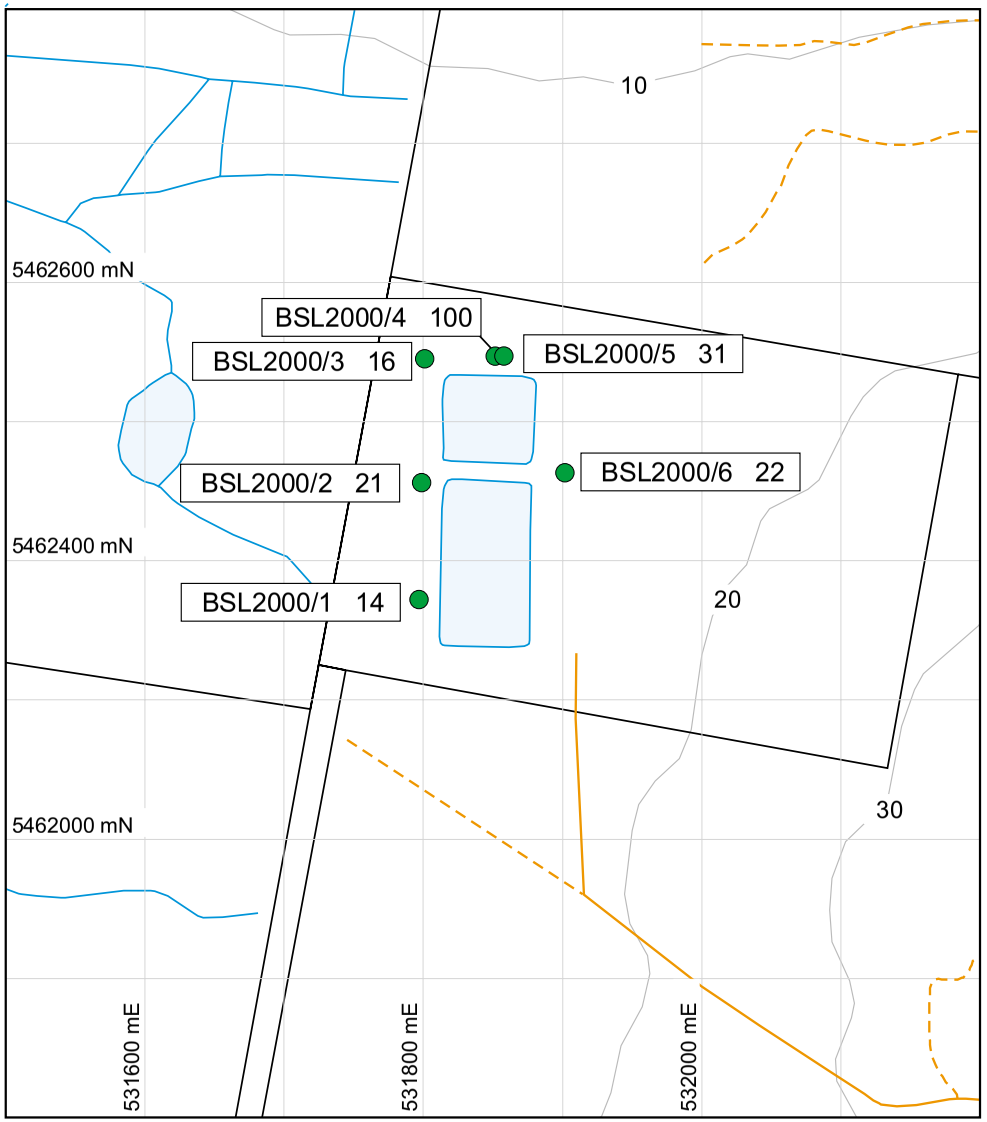
Bridport sewage lagoons
November 2000
Nitrite + Nitrate (µg-N/L)



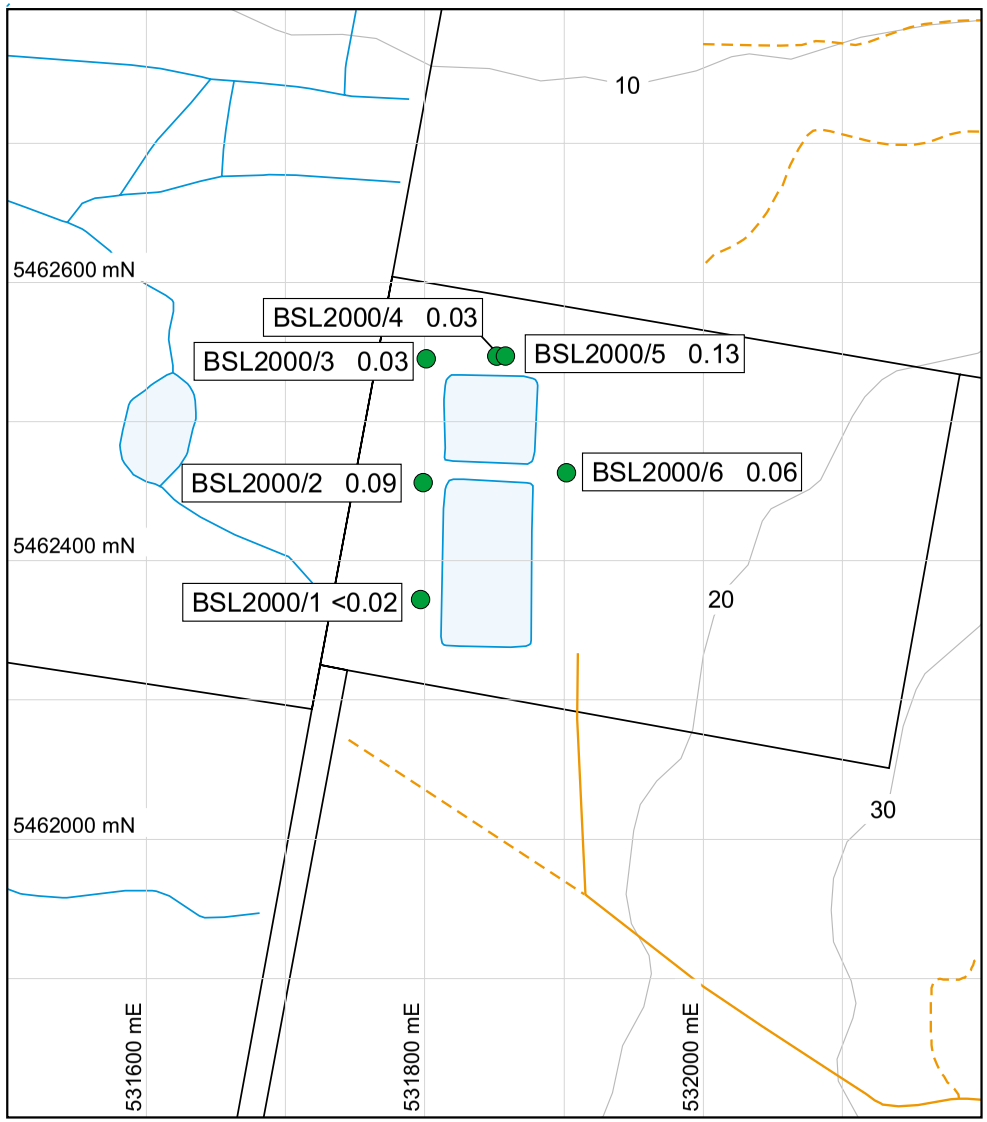
Bridport sewage lagoons
November 2000
Na (mg/L)



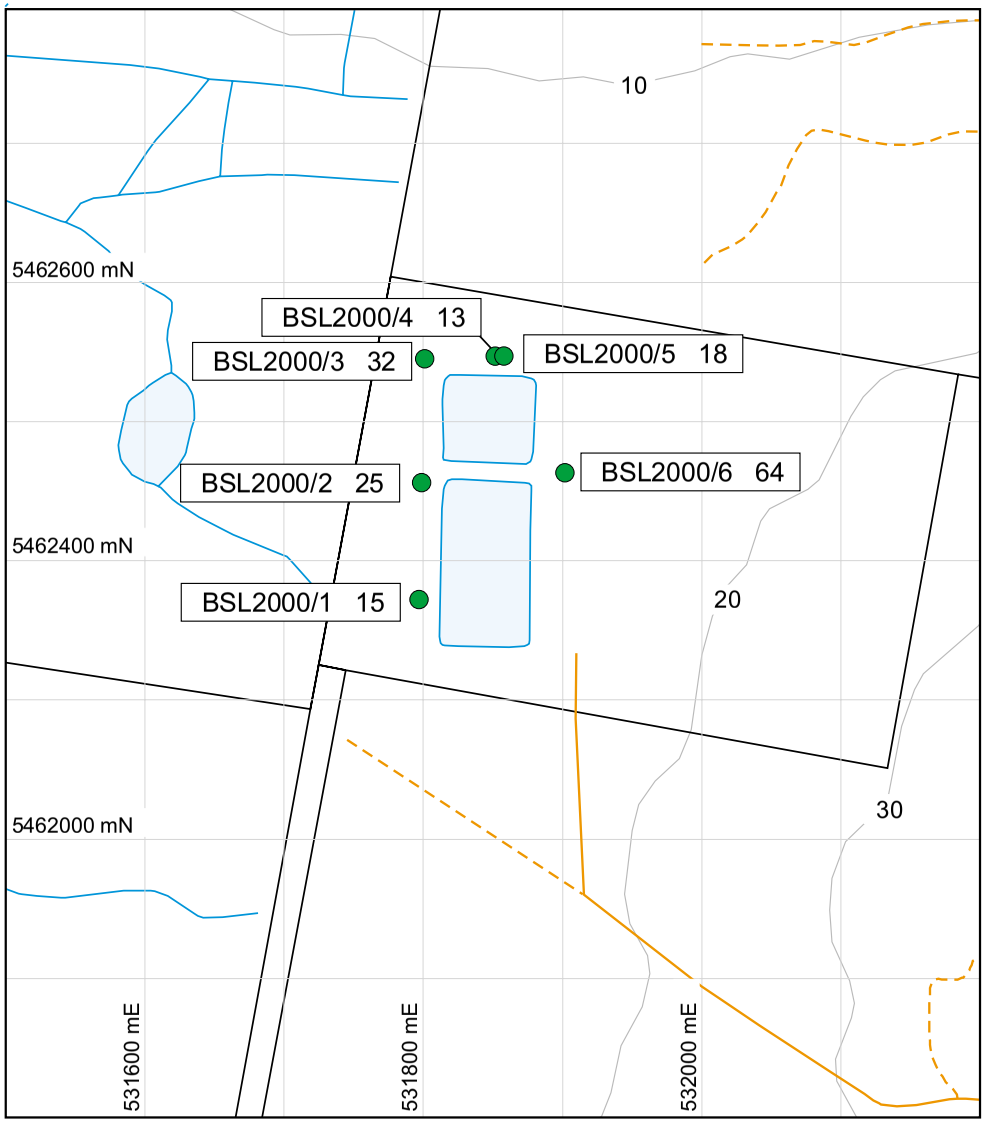
Bridport sewage lagoons
November 2000
Ortho-P (μg-P/L)



Bridport sewage lagoons
November 2000
Fluoride (mg/L)



Bridport sewage lagoons
November 2000
Sulphate (mg/L)



Appendix 4

Raw data collected for slug extraction tests — Bridport Lagoons

Date: 16/08/2001 Flow: 3 L/m
Bore: BSL 2000/1 SWL: 1.07 m
TD: 4.00 m

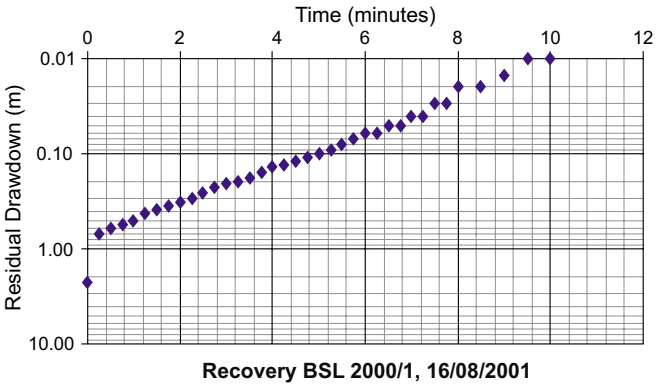
Recovery data

Time (min)	*Residual drawdown (m)*	*Measurement (m)*
0.00	2.21	3.28
0.25	0.71	1.78
0.50	0.61	1.68
0.75	0.55	1.62
1.00	0.50	1.57
1.25	0.43	1.50
1.50	0.38	1.45
1.75	0.35	1.42
2.00	0.32	1.39
2.25	0.29	1.36
2.50	0.26	1.33
2.75	0.23	1.30
3.00	0.21	1.28
3.25	0.20	1.27
3.50	0.18	1.25
3.75	0.16	1.23
4.00	0.14	1.21
4.25	0.13	1.20
4.50	0.12	1.19
4.75	0.11	1.18
5.00	0.10	1.17
5.25	0.09	1.16
5.50	0.08	1.15
5.75	0.07	1.14
6.00	0.06	1.13
6.25	0.06	1.13
6.50	0.05	1.12
6.75	0.05	1.12
7.00	0.04	1.11
7.25	0.04	1.11
7.50	0.03	1.10
7.75	0.03	1.10
8.00	0.02	1.09
8.50	0.02	1.09
9.00	0.01	1.085
9.50	0.01	1.08
10.00	0.01	1.08

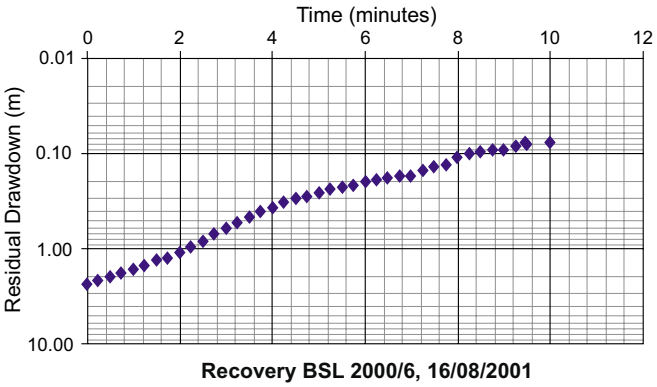
Date: 16/08/2001 Flow: 4.0 L/m
Bore: BSL 2000/6 SWL: 0.66 m
TD: 3.00 m

Recovery data

Time (min)	*Residual drawdown (m)*	*Measurement (m)*
0.00	2.34	3.00
0.25	2.14	2.80
0.50	1.97	2.63
0.75	1.82	2.48
1.00	1.68	2.34
1.25	1.49	2.15
1.50	1.34	2.00
1.75	1.23	1.89
2.00	1.09	1.75
2.25	0.95	1.61
2.50	0.83	1.49
2.75	0.71	1.37
3.00	0.61	1.27
3.25	0.52	1.18
3.50	0.46	1.12
3.75	0.41	1.07
4.00	0.37	1.03
4.25	0.33	0.99
4.50	0.30	0.96
4.75	0.28	0.94
5.00	0.26	0.92
5.25	0.24	0.90
5.50	0.23	0.89
5.75	0.22	0.88
6.00	0.20	0.86
6.25	0.19	0.85
6.50	0.18	0.84
6.75	0.17	0.83
7.00	0.17	0.83
7.25	0.15	0.81
7.50	0.14	0.80
7.75	0.13	0.79
8.00	0.11	0.77
8.25	0.10	0.76
8.50	0.10	0.755
8.75	0.09	0.75
9.00	0.09	0.75
9.25	0.09	0.745
9.50	0.08	0.74
9.45	0.08	0.735
10.00	0.08	0.735



Recovery BSL 2000/1, 16/08/2001



Recovery BSL 2000/6, 16/08/2001