

**Table 3.1:** Monitoring Well Construction Details - Buckland Park

Well ID	Easting GCS GDA94	Northing GCS GDA94	TOC Elevn (mAHD)	Stickup (mAGL)	Well Depth (mBGL)	EOH (mTOC)	EOH (mAHD)	Screen Interval (mBGL)	Drill Date
MWREM01	272962	6164330	12.343	0.57	9.73	10.30	2.043	5.1 - 9.6	14/01/2008
MWREM02	273617	6162946	8.267	0.60	4.81	5.41	2.857	1.7 - 4.7	14/01/2008
MWREM03	270211	6162703	7.895	0.57	9.34	9.91	-2.015	5.5 - 10.0	14/01/2008
MWREM04	270644	6161346	4.356	0.60	3.05	3.65	0.706	0.6 - 3.6	14/01/2008
MWREM05	272258	6162471	6.651	0.50	7.17	7.67	-1.019	3.6 - 8.1	14/01/2008
MWREM06	270674	6160220	3.811	0.60	3.08	3.68	0.131	0.5 - 3.5	15/01/2008
MWREM07	270772	6159069	3.050	0.60	3.38	3.98	-0.930	0.5 - 3.5	15/01/2008
MWREM08	271896	6159019	3.669	0.60	3.65	4.25	-0.581	0.5 - 3.5	15/01/2008
MWREM09	271475	6159993	5.368	0.60	5.17	5.77	-0.402	2.1 - 5.1	15/01/2008
MWREM11	271717	6161581	6.646	0.50	6.75	7.25	-0.604	2.5 - 7.0	15/01/2008
MWREM12	272248	6160113	4.173	0.60	4.13	4.73	-0.557	1.0 - 4.0	15/01/2008

**Notes:**

- m metres
- AHD Australian Height Datum
- TOC Top Of Casing
- BGL Below Ground Level
- AGL Above Ground Level
- DTW Depth To Water
- SWL Standing Water Level
- Stickup Height of PVC casing above ground level

**Table 4.1:** Groundwater Levels (RSWL in m AHD) from All Available Monitoring Wells - Buckland Park

Name	Easting	Northing	Aq Mon	8/01/2008	15/01/2008	07/02/2008	20/02/2008	21/02/2008	2/07/2008	2/10/2008
MWREM01	272962.04	6164329.65	Q1/Qperch	-	-	6.400	6.367	-	6.493	6.606
MWREM02	273616.50	6162946.34	Q1/Qperch	-	-	6.283	6.244	-	6.113	6.180
MWREM03	270211.12	6162703.14	Q1/Qperch	-	-	1.659	1.622	-	1.505	1.821
MWREM04	270643.66	6161345.55	Q1/Qperch	-	-	2.666	2.702	-	2.219	2.129
MWREM05	272258.05	6162471.03	Q1/Qperch	-	-	2.814	2.770	-	2.604	2.635
MWREM06	270674.04	6160219.68	Q1/Qperch	-	-	2.271	-	2.256	2.266	2.272
MWREM07	270772.35	6159068.64	Q1/Qperch	-	-	1.570	-	1.553	1.568	1.544
MWREM08	271896.10	6159018.99	Q1/Qperch	-	-	1.380	-	1.352	1.461	1.436
MWREM09	271475.23	6159992.59	Q1/Qperch	-	-	1.749	1.719	-	1.630	1.622
MWREM11	271717.33	6161580.60	Q1/Qperch	-	-	2.382	2.339	-	2.146	2.219
MWREM12	272247.51	6160112.90	Q1/Qperch	-	-	1.731	-	1.675	1.763	1.903
6628-19991	274471.12	6163121.97	Q1/Qperch	-	8.010	-	-	-	7.406	7.864
6628-19992	274471.15	6163120.97	Qperch	-	7.990	-	-	-	7.383	7.844
6628-19993	273706.17	6164205.97	Q1	-	7.948	-	-	-	7.705	8.064
6628-19997	274952.16	6162183.95	Q1	-	7.250	-	-	-	7.212	7.214
6628-19998	274952.19	6162182.96	Qperch	-	7.133	-	-	-	7.085	7.021
6628-19999	273244.18	6161093.03	Q1	-	4.290	-	-	-	4.078	4.363
6628-20000	273242.16	6161092.98	Qperch	-	4.172	-	-	-	4.108	4.354
6628-20001	276278.16	6161889.00	Q1	-	9.476	-	-	-	8.944	9.103
6628-20002	276278.09	6161888.00	Qperch	-	9.670	-	-	-	dry	dry
6628-20003	274227.16	6160494.02	Qperch	-	6.440	-	-	-	5.953	6.328
6628-20004	274227.18	6160493.02	Qperch	-	7.145	-	-	-	8.080	7.700
6628-20005	273498.11	6161840.04	Q1	-	4.958	-	-	-	4.480	4.962
6628-20006	273498.18	6161841.04	Qperch	-	4.987	-	-	-	4.517	5.007
6628-02219	271126.72	6162899.29	Q(Q2)	2.265	-	-	2.150	-	2.008	1.988
GW1	271586.30	6161297.52	Q1/Qperch	-	-	-	-	-	2.029	2.124
GW2	271217.53	6160551.98	Q1/Qperch	-	-	-	-	-	2.064	2.155
GW3	272130.21	6160989.47	Q1/Qperch	-	-	-	-	-	2.060	2.331
GW4	272456.30	6159939.93	Q1/Qperch	-	-	-	-	-	1.566	1.733
GW5	274506.35	6162058.28	Q1/Qperch	-	-	-	-	-	6.379	6.488
GW6	272990.09	6162155.28	Q1/Qperch	-	-	-	-	-	3.305	3.577
GW7	274886.32	6162165.12	Q1/Qperch	-	-	-	-	-	7.107	7.093
GW8	273910.10	6162577.28	Q1/Qperch	-	-	-	-	-	5.712	5.718
GW9	273366.85	6162087.29	Q1/Qperch	-	-	-	-	-	3.916	4.224
GW10	274406.31	6163053.24	Q1/Qperch	-	-	-	-	-	7.207	7.526
GW11	272595.47	6159330.14	Q1/Qperch	-	-	-	-	-	2.082	2.189
GW12	272356.67	6164135.57	Q1/Qperch	-	-	-	-	-	4.369	5.152
GW13	272511.72	6161723.66	Q1/Qperch	-	-	-	-	-	2.806	2.979
GW14	272380.18	6160474.51	Q1/Qperch	-	-	-	-	-	2.308	2.447
GW15	273186.77	6159854.23	O1/Oberch	-	-	-	-	-	3.694	4.056



**Table 4.2:** Depth to Groundwater (m BGL) for New Monitoring Wells Installed by REM

<b>Name</b>	<b>Easting</b>	<b>Northing</b>	<b>Aquifer Monitored</b>	<b>7/02/2008</b>	<b>2/07/2008</b>
MWREM01	272962.04	6164329.65	Q1/Qperch	5.373	5.280
MWREM02	273616.50	6162946.34	Q1/Qperch	1.384	1.554
MWREM03	270211.12	6162703.14	Q1/Qperch	5.666	5.820
MWREM04	270643.66	6161345.55	Q1/Qperch	1.090	1.537
MWREM05	272258.05	6162471.03	Q1/Qperch	3.337	3.547
MWREM06	270674.04	6160219.68	Q1/Qperch	0.940	0.945
MWREM07	270772.35	6159068.64	Q1/Qperch	0.880	0.882
MWREM08	271896.10	6159018.99	Q1/Qperch	1.689	1.608
MWREM09	271475.23	6159992.59	Q1/Qperch	3.019	3.138
MWREM11	271717.33	6161580.60	Q1/Qperch	3.764	4.000
MWREM12	272247.51	6160112.90	Q1/Qperch	1.842	1.810

**Table 4.3:** Hydraulic Conductivity Values from Aquifer Testing - Buckland Park

Name	Easting	Northing	EOH (mTOC)	Hydraulic Conductivity (m/day)	Solution	Testing Date
MWREM01	272962	6164330	10.30	0.01	Bouwer Rice	20/02/2008
MWREM02	273617	6162946	5.41	0.33	Bouwer Rice	20/02/2008
MWREM03	270211	6162703	9.91	0.07	Bouwer Rice	20/02/2008
MWREM04	270644	6161346	3.65	1.12	Bouwer Rice	20/02/2008
MWREM05	272258	6162471	7.67	0.19	Bouwer Rice	20/02/2008
MWREM06	270674	6160220	3.68	0.59	Bouwer Rice	21/02/2008
MWREM07	270772	6159069	3.98	0.12	Bouwer Rice	21/02/2008
MWREM08	271896	6159019	4.25	0.18	Bouwer Rice	21/02/2008
MWREM09	271475	6159993	5.77	0.06	Bouwer Rice	20/02/2008
MWREM11	271717	6161581	7.25	0.59	Bouwer Rice	20/02/2008
MWREM12	272248	6160113	4.73	0.19	Bouwer Rice	21/02/2008
PTA058	271127	6162899	7.64	0.14	Bouwer Rice	20/02/2008

<b>Geo. Mean</b>	0.17
<b>Maximum</b>	1.12
<b>Minimum</b>	0.01

**Table 4.4: Summary Groundwater Analytical Results - February 2008**

Buckland Park Proposed Residential Township Area

Job Number: GM01

Chemical	ALS LOR	Laboratory LOR	Units	SA EPA EPP (Water Quality) (MUS) 2003 USE	SA EPA EPP (Water Quality) (MUS) 2003 RIGORION	SA EPA EPP (Water Quality) (MUS) 2003 LIVESFOCK	SA EPA (2003) - Aquatic Ecosystem (Marine)	SA EPA (2003) - Aquatic Ecosystem (Fresh)	ANZECC (2000) - Marine Water Quality	Date/Intervention Levels (DL)	Buckland Park											
											MO/RE/M01	MO/RE/M02	MO/RE/M03	MO/RE/M04	MO/RE/M05	MO/RE/M06	MO/RE/M07	MO/RE/M08	MO/RE/M09	MO/RE/M10	MO/RE/M11	MO/RE/M12
Location	Station	Date Sampled	Report No.	Depth	Primary	Inter	Inter	Inter	Inter	Inter	Inter	Inter	Inter	Inter	Inter	Inter	Inter	Inter	Inter	Inter	Inter	Inter
<b>Trace Metals (mg/L)</b>																						
As	0.01	0.001	0.001	0.007	0.1	0.01	0.05	0.05	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Barium	0.001	0.005	0.005	0.7	0.1	0.02	0.05	0.05	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Bismuth	0.001	0.001	0.001	0.001	0.01	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Cadmium	0.001	0.001	0.001	0.001	0.05	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Cobalt	0.001	0.001	0.001	0.001	0.01	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Copper	0.001	0.001	0.001	0.001	0.2	0.01	0.01	0.01	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Lead	0.001	0.001	0.001	0.001	0.2	0.005	0.005	0.005	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Manganese	0.001	0.001	0.001	0.001	0.2	0.015	0.015	0.015	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Nickel	0.001	0.001	0.001	0.001	0.2	0.01	0.01	0.01	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Vanadium	0.001	0.001	0.001	0.001	0.1	0.01	0.01	0.01	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Mercury	0.001	0.001	0.001	0.001	0.002	0.002	0.002	0.002	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
<b>PH</b>																						
PH	7.0	8.0	8.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0
<b>Chlorides (mg/L)</b>																						
Chloride	100	200	200	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
<b>Chromium (mg/L)</b>																						
Chromium	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
<b>Hydrocarbons (mg/L)</b>																						
Hydrocarbons	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
<b>Organochlorine Pesticides (mg/L)</b>																						
Organochlorine Pesticides	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
<b>Organophosphate Pesticides (mg/L)</b>																						
Organophosphate Pesticides	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
<b>Other (mg/L)</b>																						
Other	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

Units: mg/L - Limit of Reporting  
 LOR - Limit of Reporting  
 \*Where the reported LOR is greater than the specified Laboratory LOR it is because the LOR has been increased, due to matrix interference  
 \*\*Value for ANZECC (2000) Aquatic Ecosystems - 95% protection of species used  
 \*\*\*Chromium VI guideline

**Table 4.5: Summary of Groundwater Field Parameters - Buckland Park**

Monitoring Well	MWREM01 7/02/2008	MWREM02 7/02/2008	MWREM03 7/02/2008	MWREM04 7/02/2008	MWREM05 7/02/2008	MWREM06 7/02/2008	MWREM07 7/02/2008	MWREM08 7/02/2008	MWREM09 7/02/2008	MWREM11 7/02/2008	MWREM12 7/02/2008
pH	-	-	7.33	7.27	-	6.82	6.83	7.28	7.97	7.70	7.29
Redox (mV)	-	-	64	104	-	84	5	156	152	63	177
Temperature (oC)	-	-	19.4	19.9	-	23.2	21.6	20.4	19.9	18.7	20.0
EC (mS/cm)	-	-	10.86	34.90	-	93.90	106.30	40.90	5.02	12.82	32.20
TDS* (mg/L)	-	-	8,145	26,175	-	70,425	79,725	30,675	3,765	9,615	24,150

Monitoring Well	MWREM01 13/02/2008	MWREM02 13/02/2008	MWREM03 13/02/2008	MWREM04 13/02/2008	MWREM05 13/02/2008	MWREM06 13/02/2008	MWREM07 13/02/2008	MWREM08 13/02/2008	MWREM09 13/02/2008	MWREM11 13/02/2008	MWREM12 13/02/2008
pH	7.12	7.81	-	7.40	7.50	6.66	-	7.21	-	7.75	-
Redox (mV)	77	18	-	104	62	43	-	64	-	-1	-
Temperature (oC)	19.3	21.4	-	21.5	18.9	22.7	-	21.4	-	19.8	-
EC (mS/cm)	11.34	8.87	-	36.10	24.60	106.60	-	41.90	-	12.28	-
TDS* (mg/L)	8,505	6,653	-	27,075	18,450	79,950	-	31,425	-	9,210	-

\*TDS calculated as 750 x EC as described in Hem (1985)

**Table 5.1:** Stormwater Retention Modelling Parameters

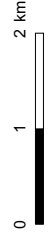
<b>Parameter</b>	<b>Symbol</b>	<b>Value</b>
Pond Area	A	150 000 m <sup>2</sup>
Pond Radius	r	218 m
Saturated Thickness	Hs	17.8 m
Unsaturated Thickness	Hm	20 m
Specific Yield	Sy	0.01
Hydraulic conductivity	K	3 m/day

**Table 5.2: Stormwater Retention Scenarios and Results**

<b>Scenario</b>	<b>Retention Time (days)</b>	<b>Lined / Unlined</b>	<b>Recharge (mm/d)</b>	<b>Mound Height (m)</b>	<b>Mound Radius (m)</b>
Ornamental Pond	365	Lined	0.5	0.62	4000
	365	Unlined	15	13.62	4000
Winter Retention	90	Lined	0.5	0.47	2000
	90	Unlined	15	10.87	2000
Month-long Retention	30	Lined	0.5	0.35	1500
	30	Unlined	15	8.54	1500
Single Event	10	Lined	0.5	0.23	1000
	10	Unlined	15	6.09	1000



- Legend**
- Site
  - Locality
  - ~ River
  - ▭ Cheetham's Salt Pan
  - ▭ Ocean



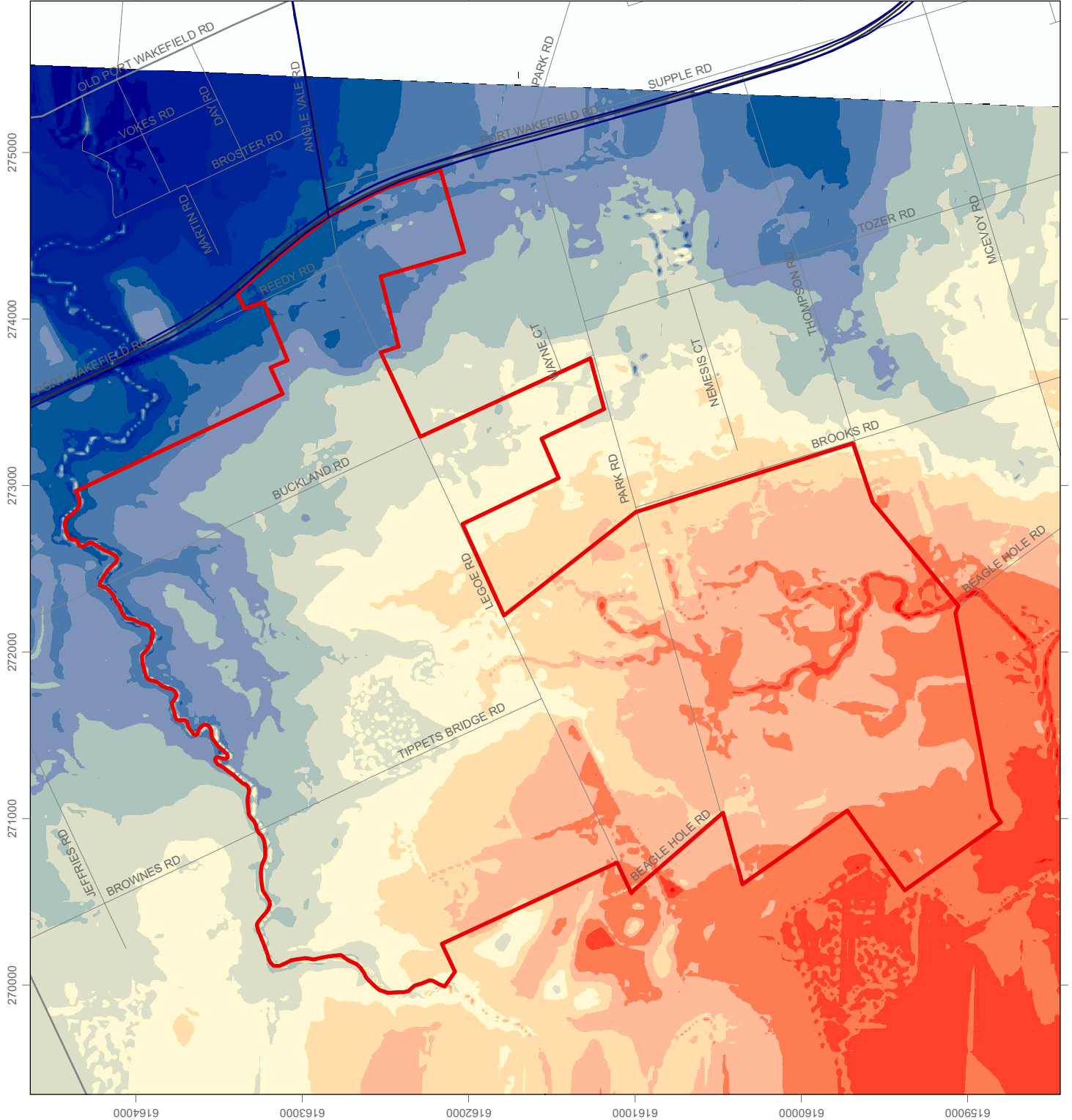
Buckland Park

## Buckland Park Site Location

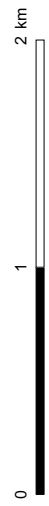
Figure 1.1







 Site



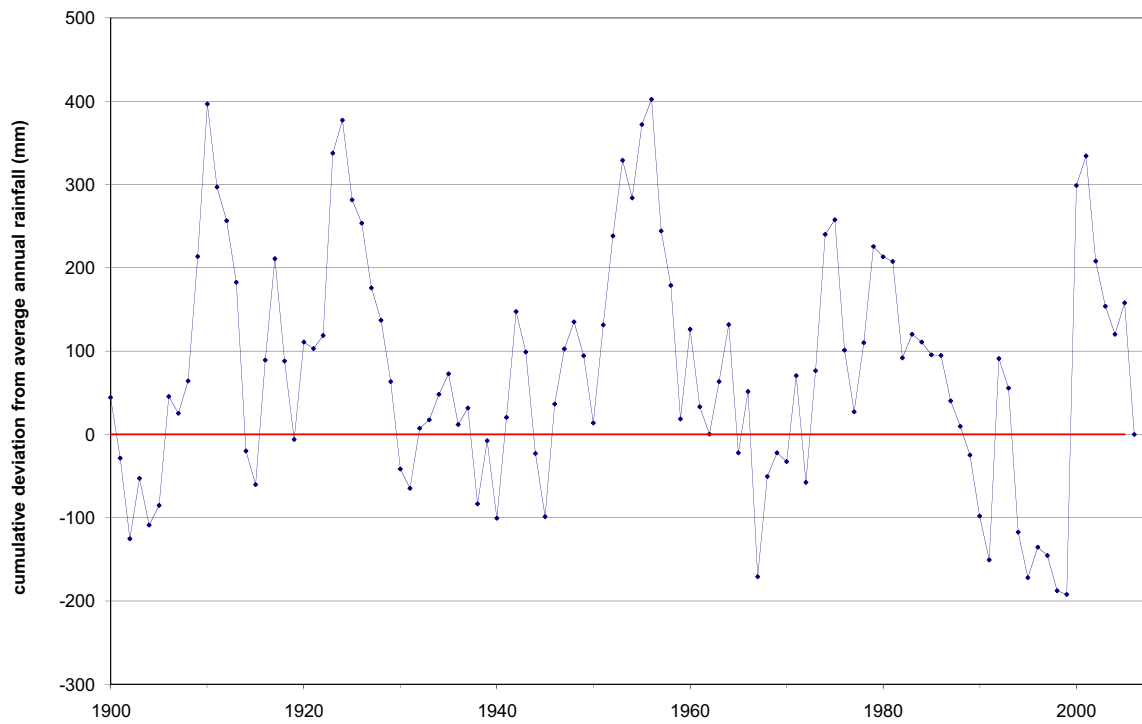
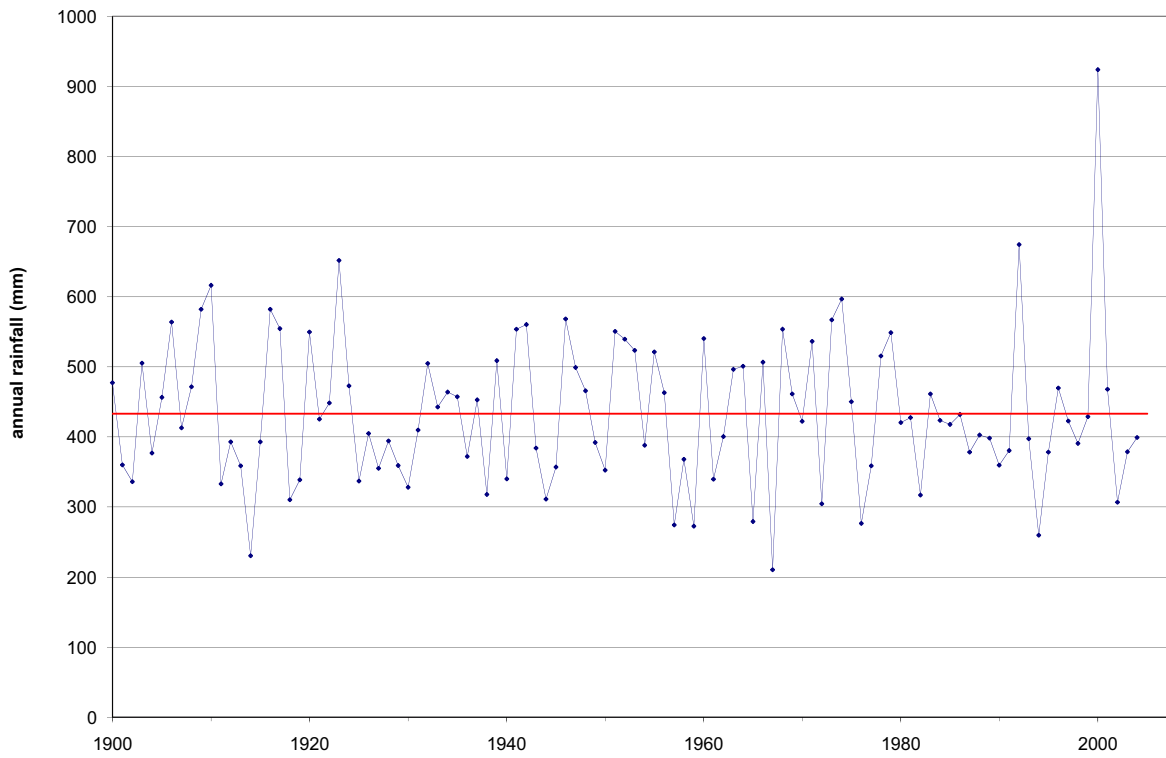
Buckland Park

# Ground Surface Elevation (mAH)



Figure 2.1





Annual rainfall and cumulative deviation from average annual rainfall at Sheedy Rd, Virginia (Stn 23030)

FIGURE

2.2

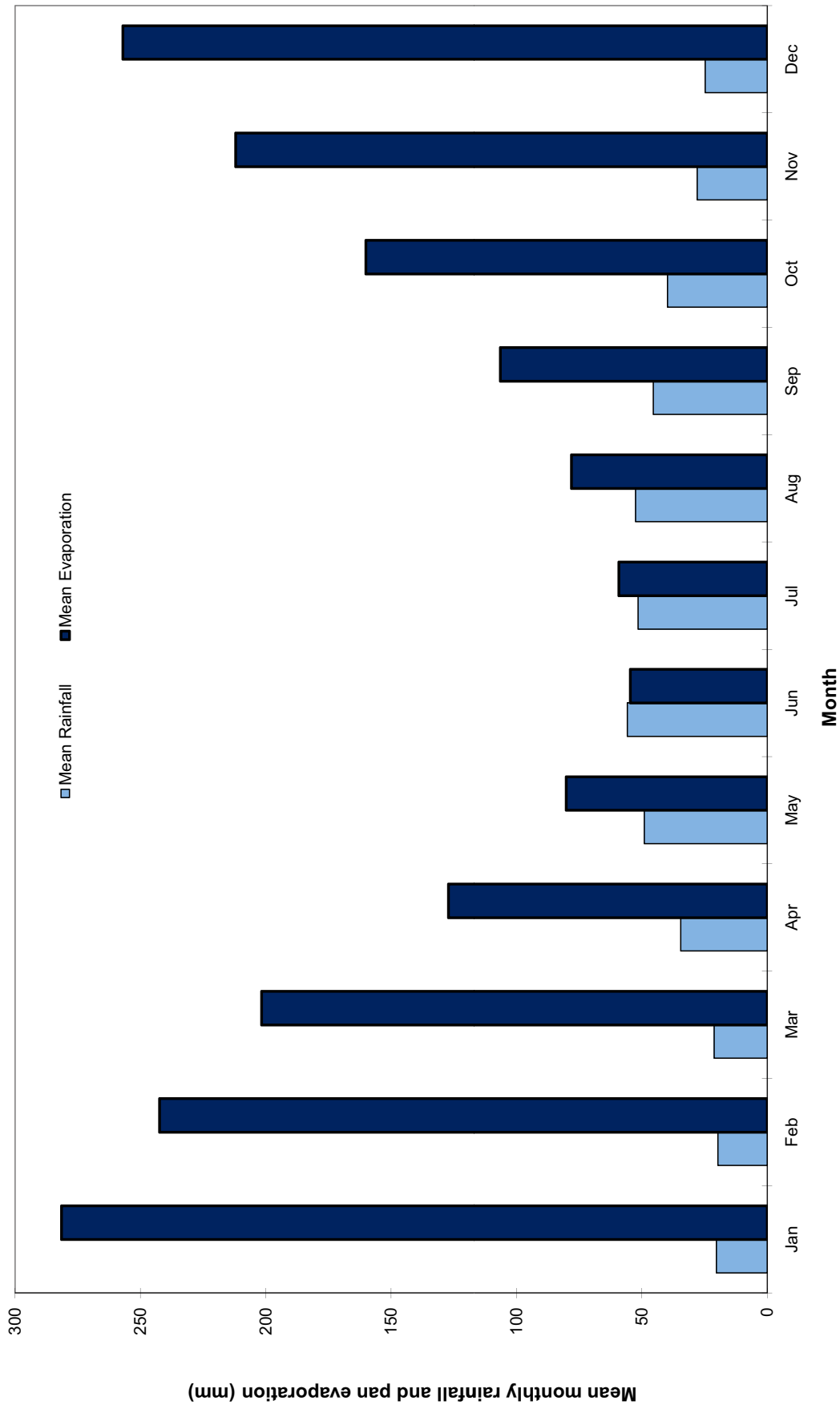


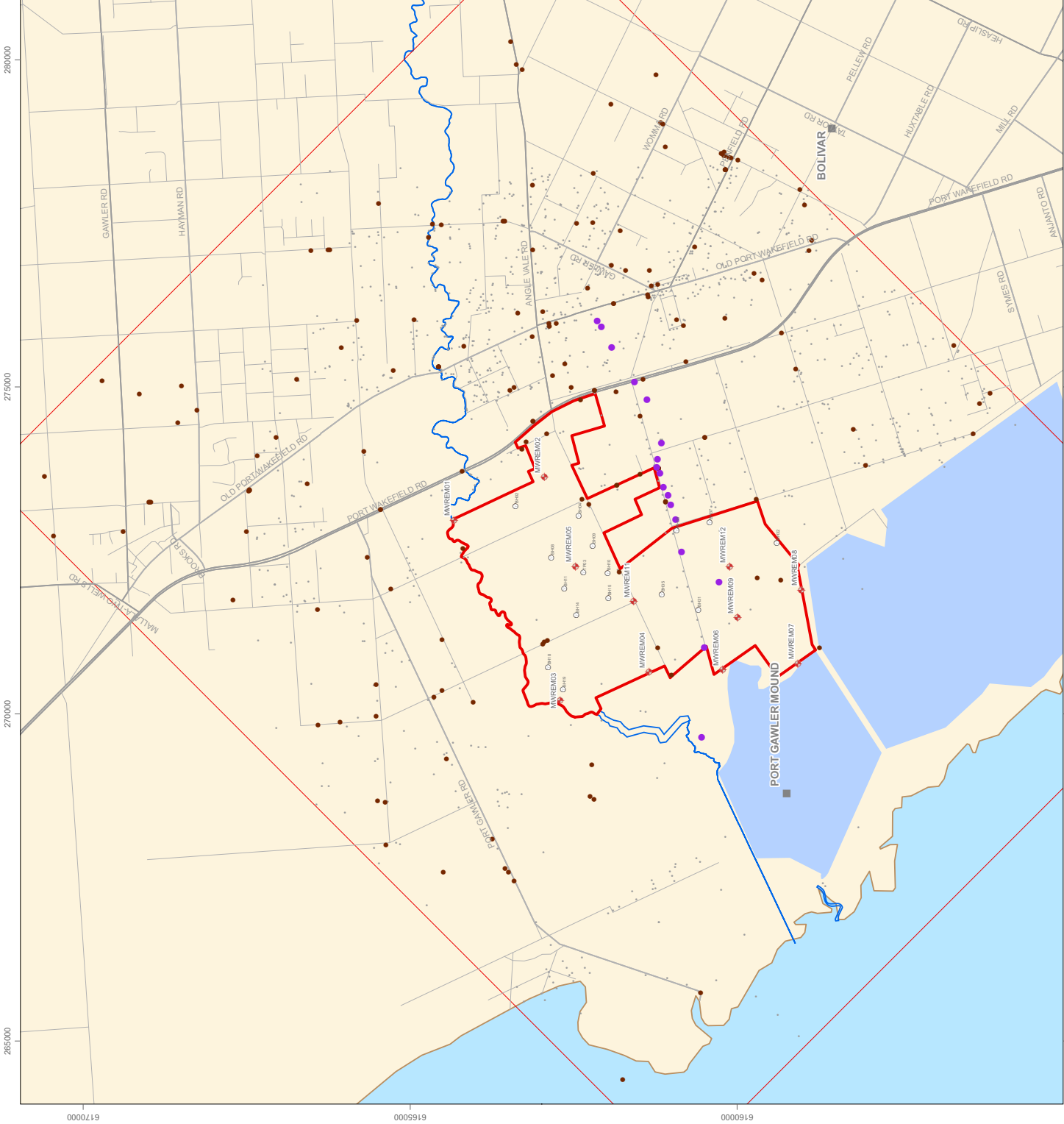
FIGURE  
**2.3**

Monthly trends in rainfall and pan evaporation, at Sheedy Rd, Virginia (Stn 23030)



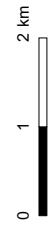
April-08

Project: GM-01



**Legend**

- Monitoring Well (REM)
- Lithological Log (cross-section)
- Soil Bore/Test Pit (Golder Associates)
- Lithological Log
- All DES Drillholes
- Site
- Model Extent
- Gawler River
- Salt Lake



Buckland Park  
**Available Lithological Information**

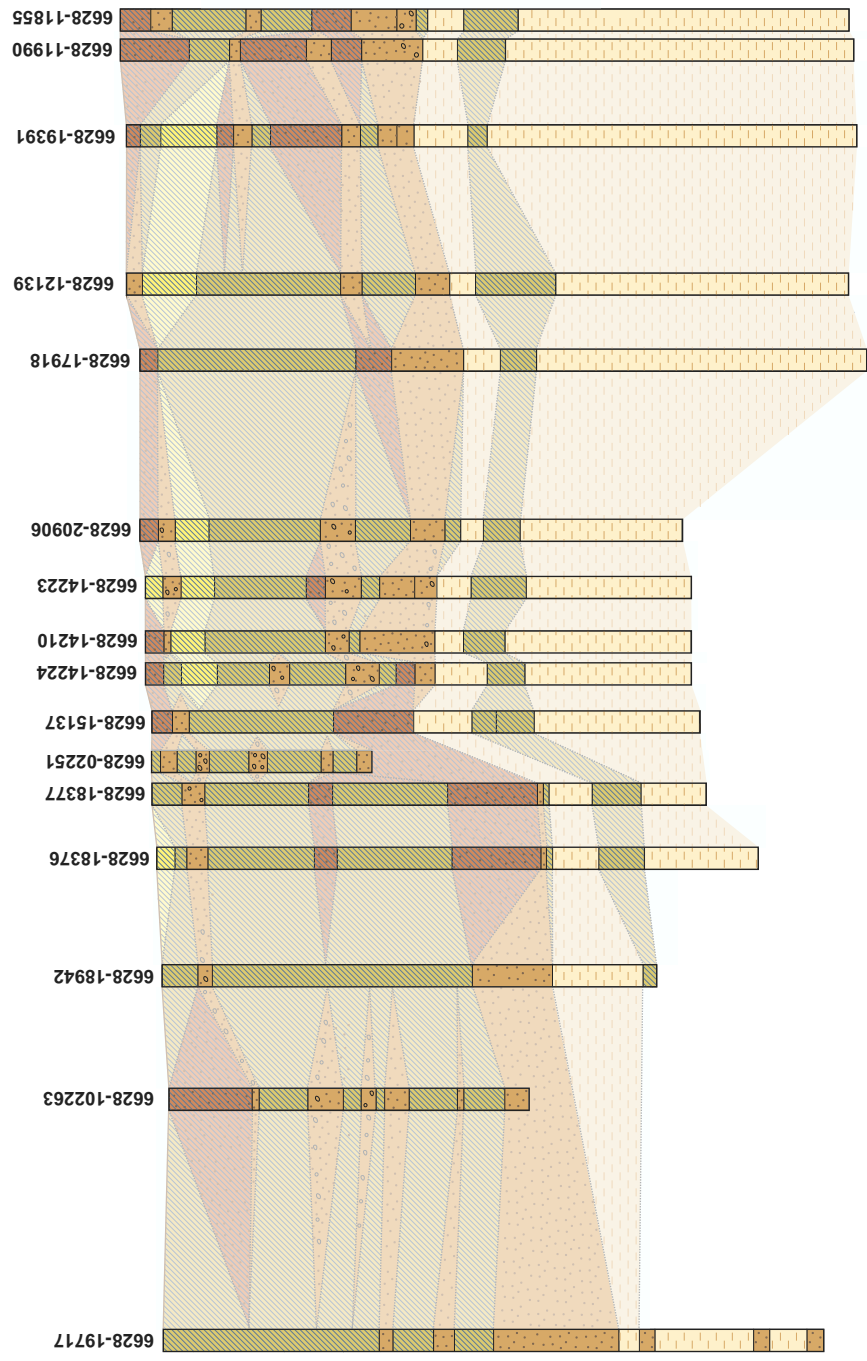


Figure  
**2.4**

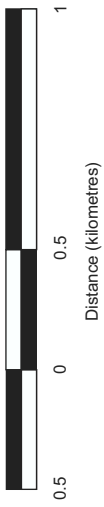
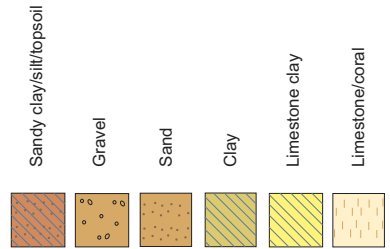
WEST

View North into Development Areas

EAST



0 20 40 60 80 100  
Depth (m)



REM Environmental Services Corporation (2010) Buckland Park/Maskeas west cross section

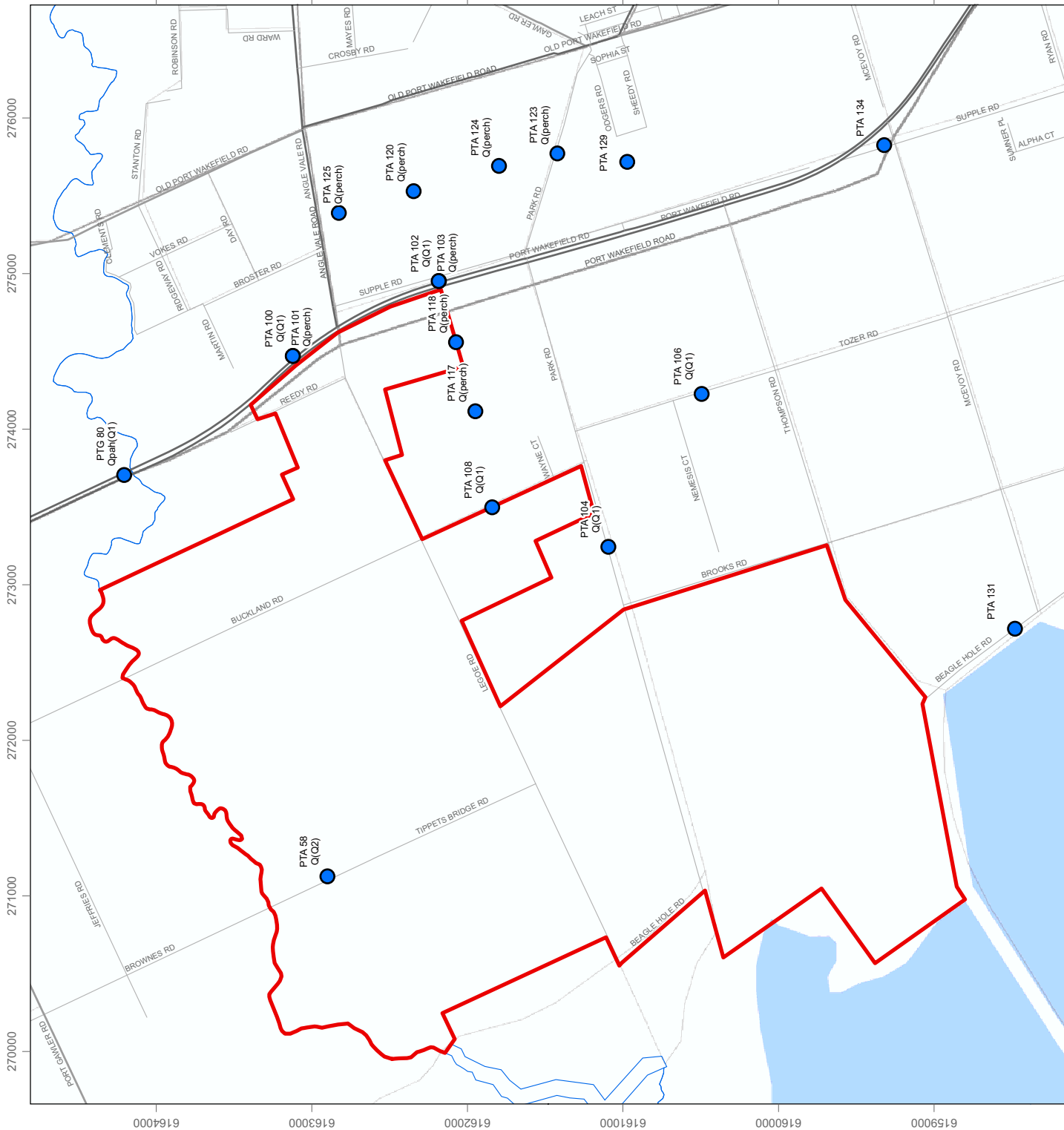
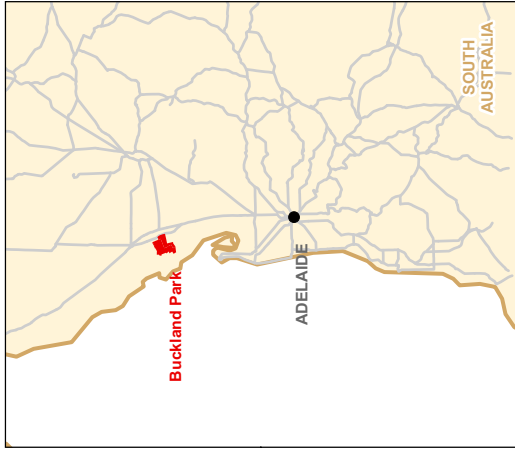


### BUCKLAND PARK East-West Cross Section

Figure

# 2.5

April 2008



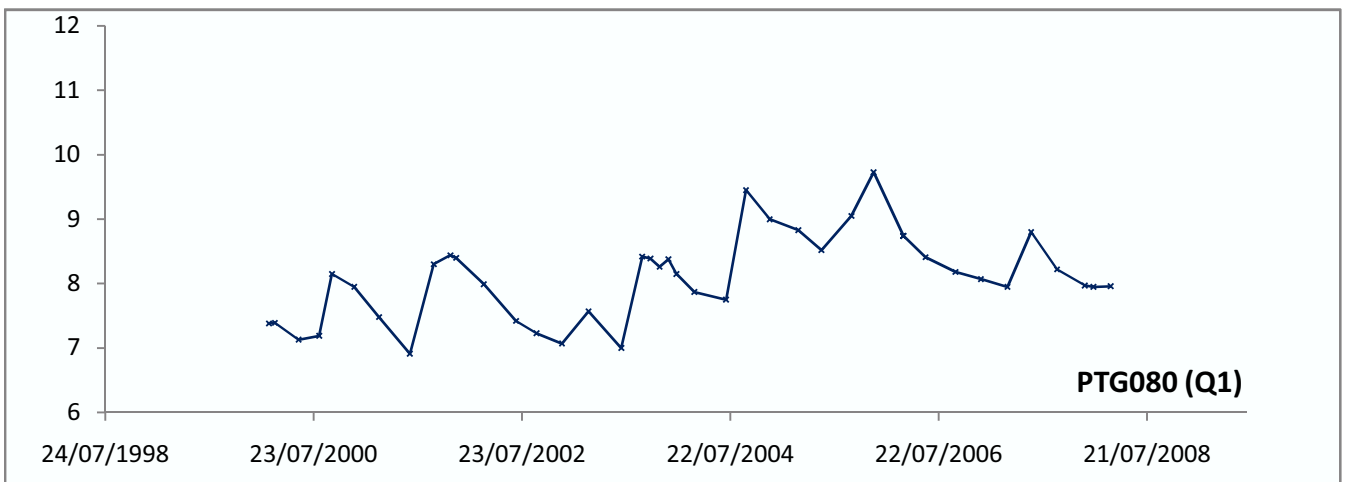
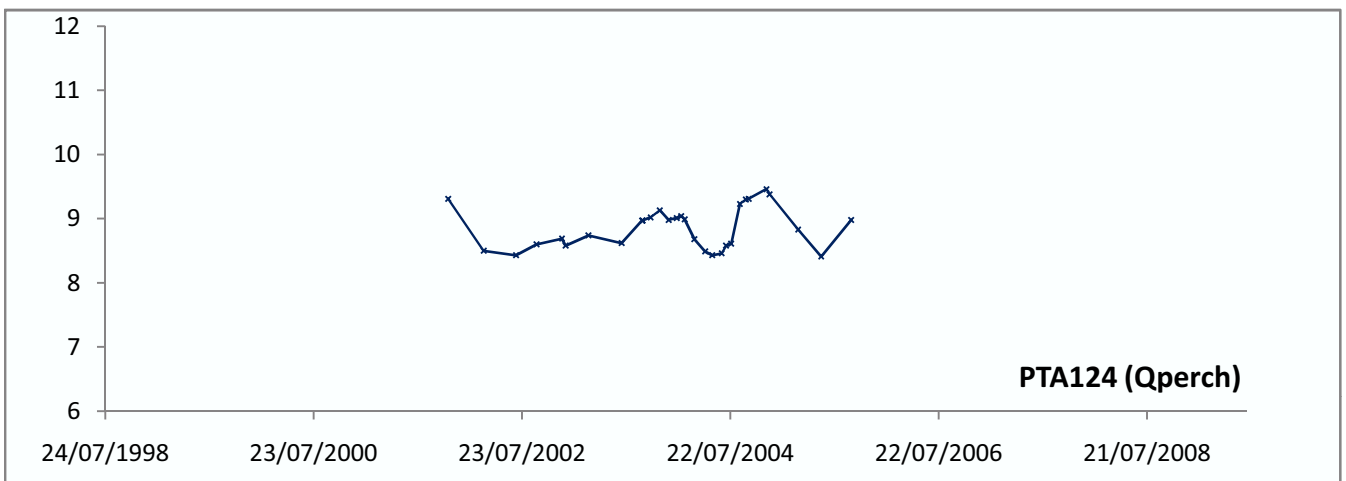
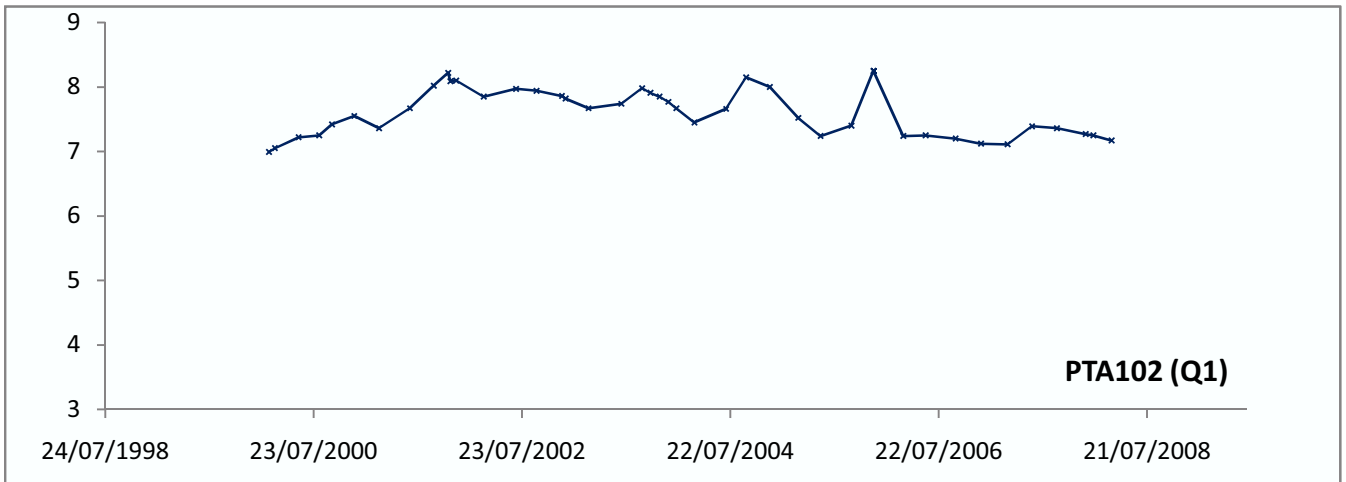
**Legend**

- Well with Time Series Data
- Site
- Gawler River
- Salt Lake



**Buckland Park  
Available Wells with  
Historical Data  
Figure  
2.6**





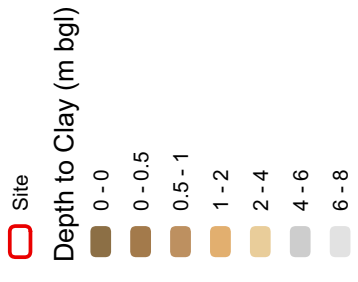
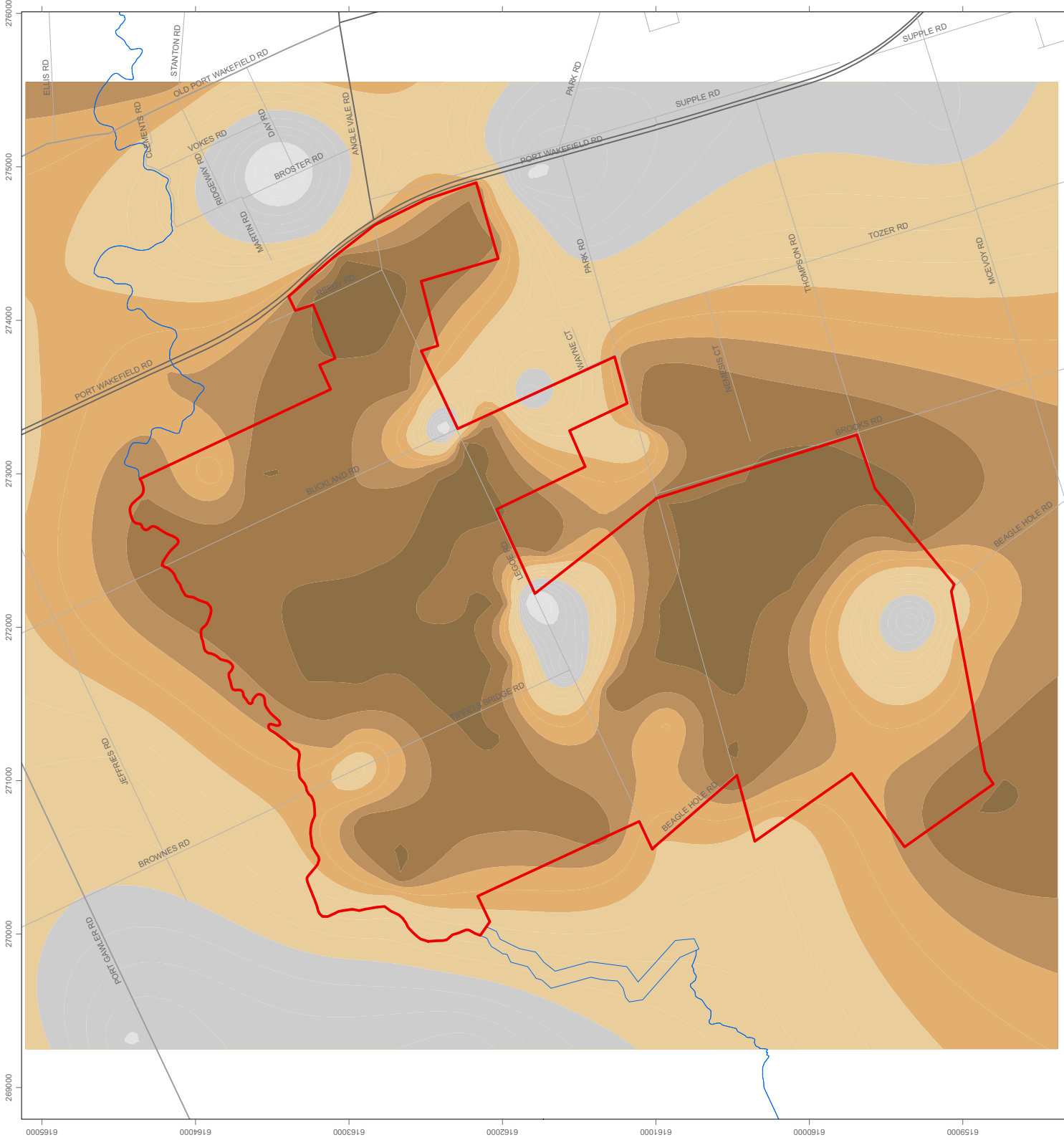
Buckland Park  
**Example of available historical time-series water level data (m AHD)**

Figure

**2.7**

July 2008

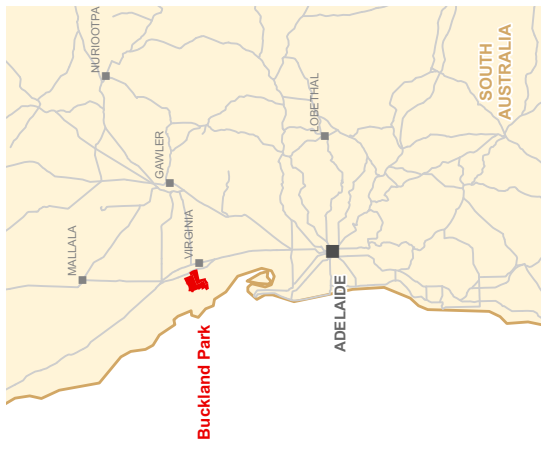
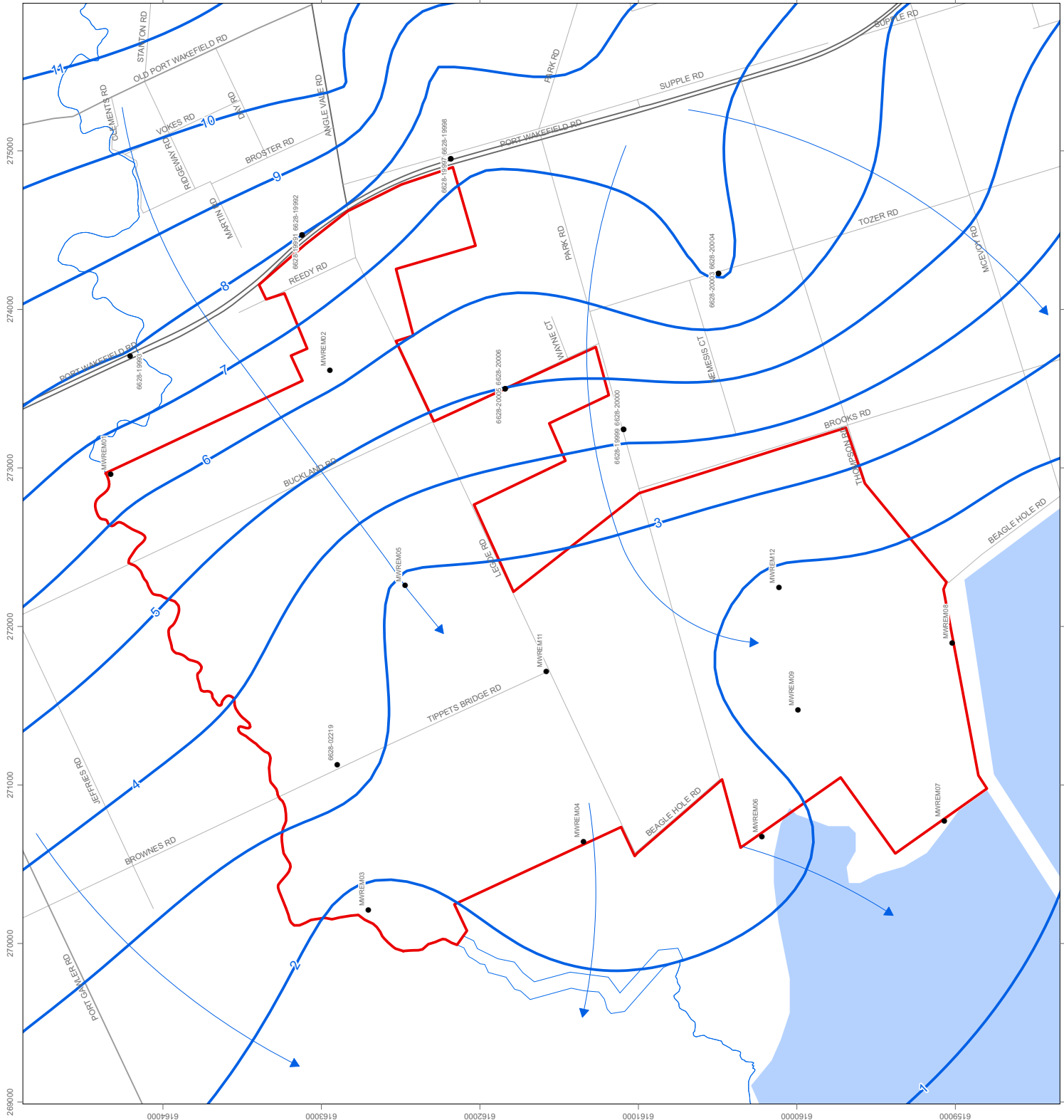









Buckland Park

**Depth to Clay**  
Figure  
**4.1**





**Legend**

-  Groundwater Elevation Contour (mAHd)
-  Groundwater Flow Direction
-  Groundwater Elevation Data Point
-  Site
-  Gawler River
-  Salt Lake

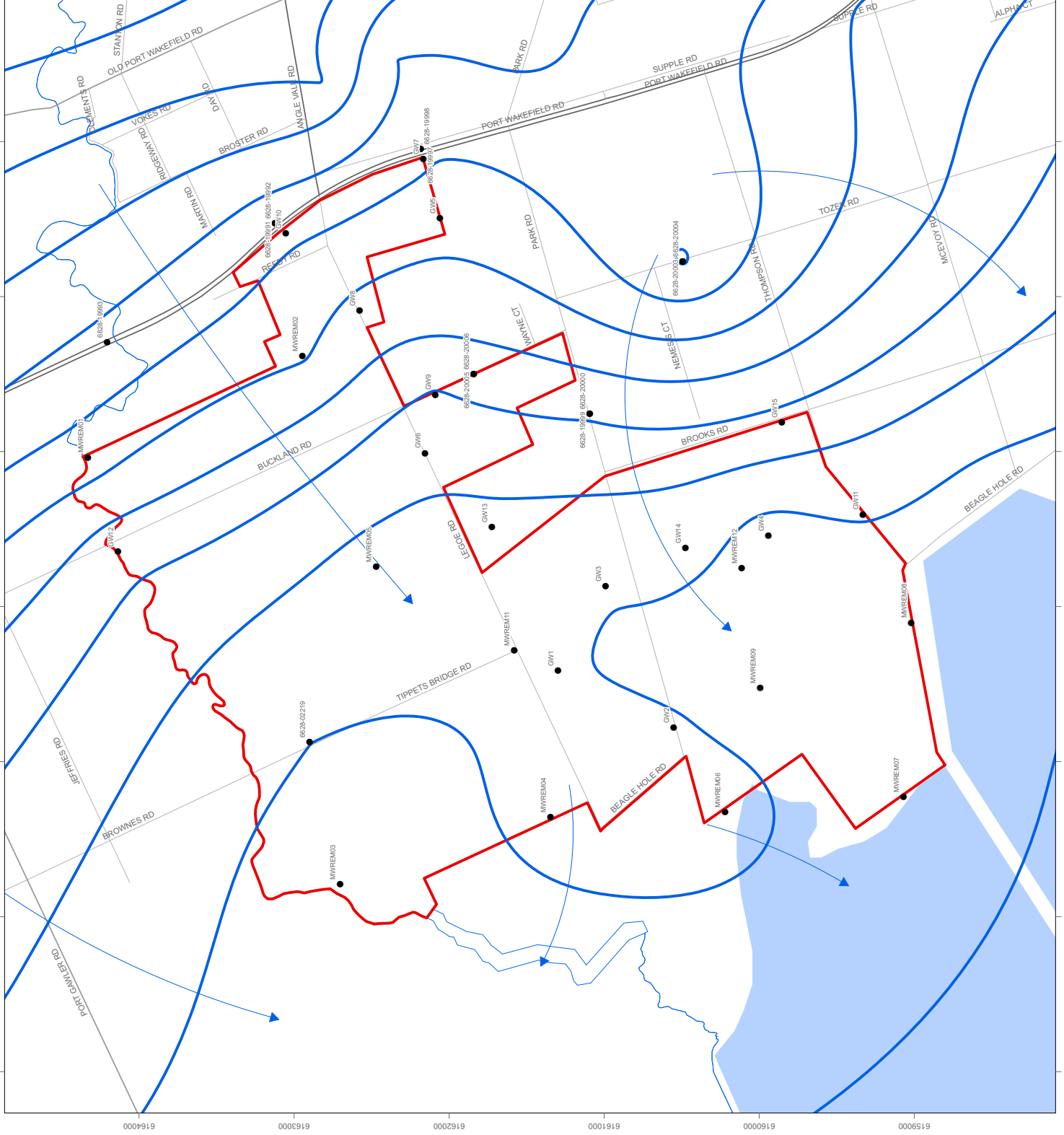


Buckland Park  
**Groundwater Elevation (mAHd),  
 Shallow Quaternary - Feb-2008**








Figure  
**4.2**





**Legend**

-  Groundwater Elevation Contour (mAHd) July08
-  Groundwater Flow Direction
-  Groundwater Elevation Data Point
-  Site
-  Gawler River
-  Salt Lake

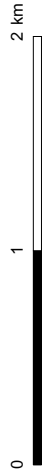
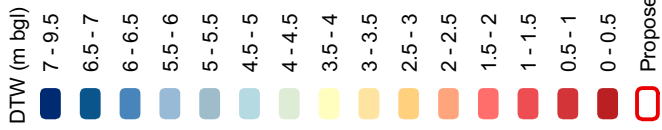
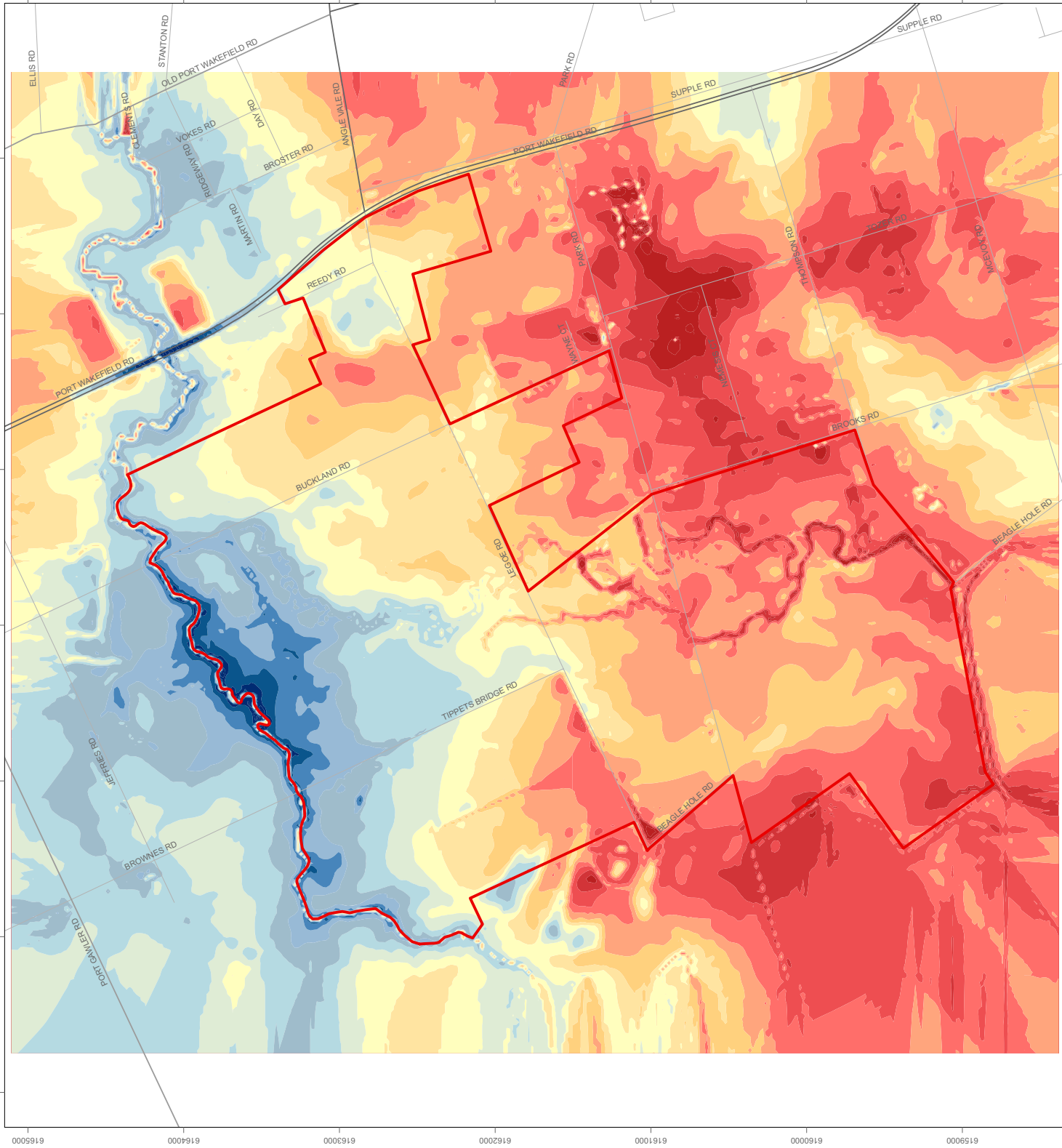


**Buckland Park  
Groundwater Elevation (mAHd),  
Shallow Quaternary - July-2008**



Figure 4.3

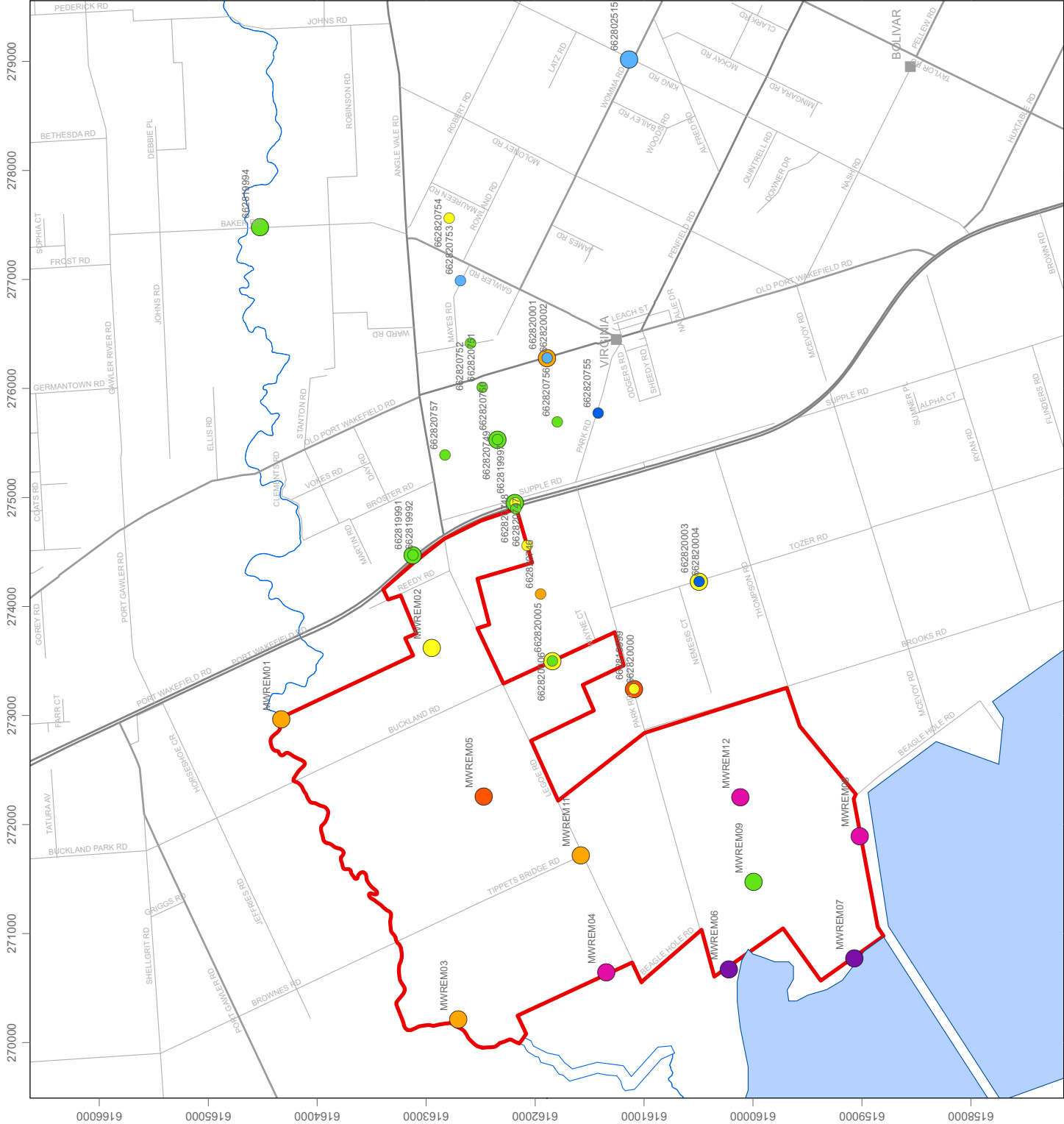




Buckland Park  
**Depth to Groundwater (DTW)**  
**July 2008**



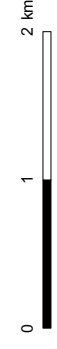
Figure  
**4.5**



**Q1 / Qperch TDS (mg/L)**

- 0 - 1,000
- 1,001 - 2,500
- 2,501 - 5,000
- 5,001 - 7,500
- 7,501 - 10,000
- 10,001 - 20,000
- 20,001 - 40,000
- 40,001 - 80,000

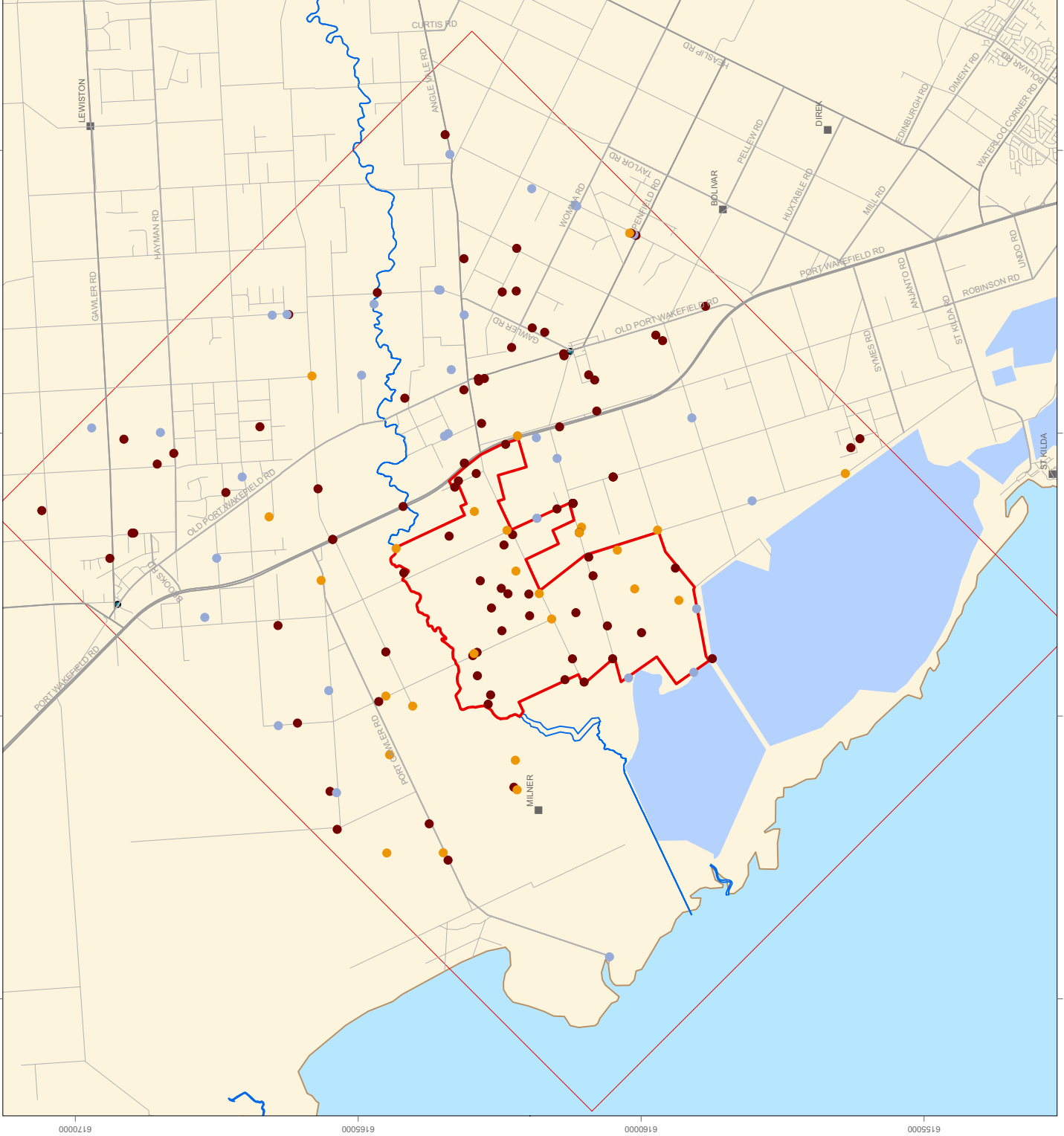
- Gawler River
- Salt Lake
- Site



**Buckland Park  
Groundwater Salinity in  
the Quaternary Aquifer**



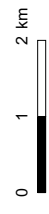
Figure 4.6



**Legend**  
**Dominant Soil Type 0 - 5 m**

- clay
- silt
- sand

- Model Extent
- Gawler River
- Salt Lake
- Site
- Buckland Park Lake

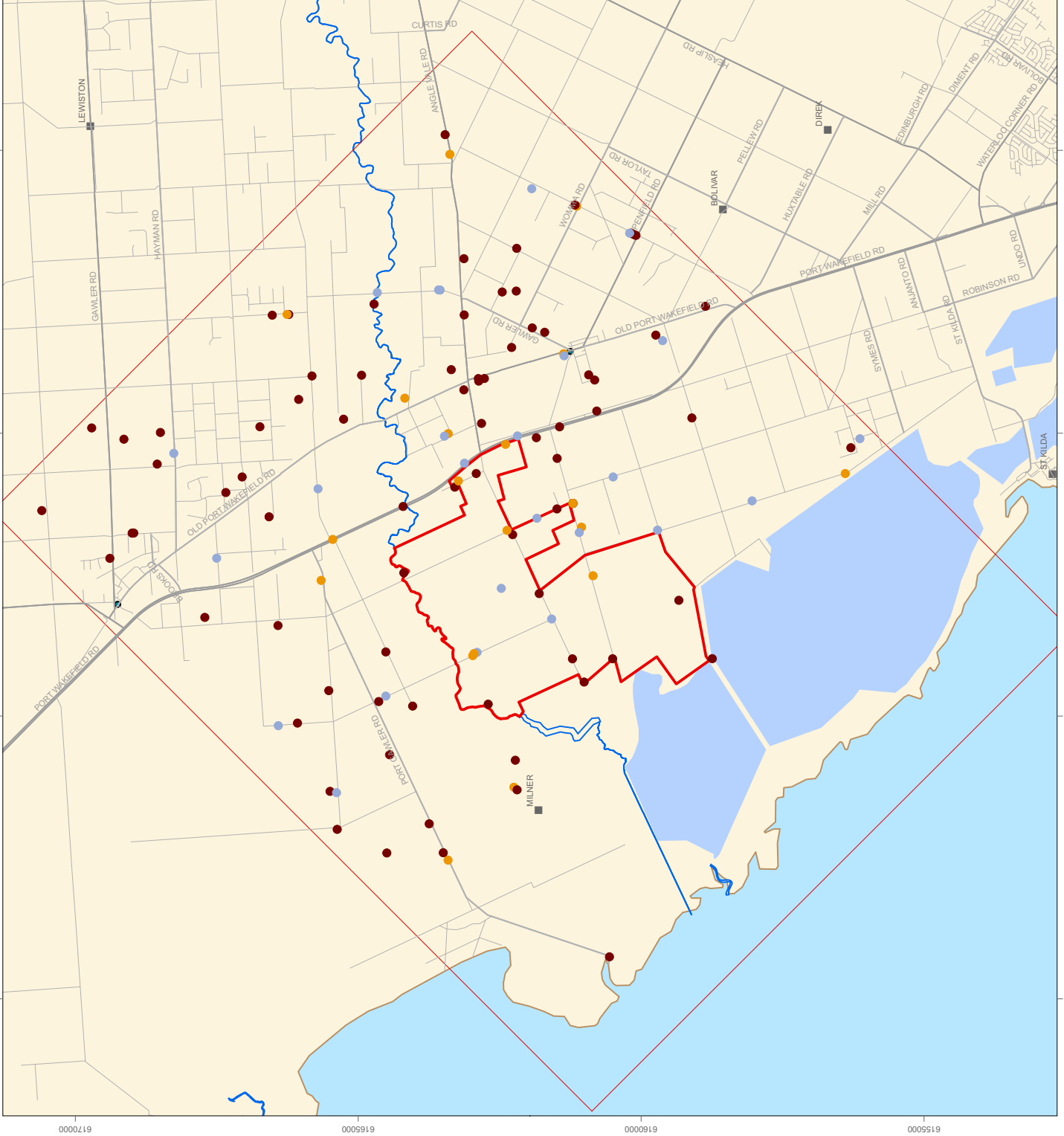


Buckland Park  
**Interpreted Dominant Soil Type  
 0-5 m bgl (Layer 1)**



Figure  
**5.1**

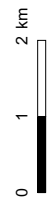




**Legend**  
**Dominant Soil Type 5 - 10 m**

- clay
- silt
- sand

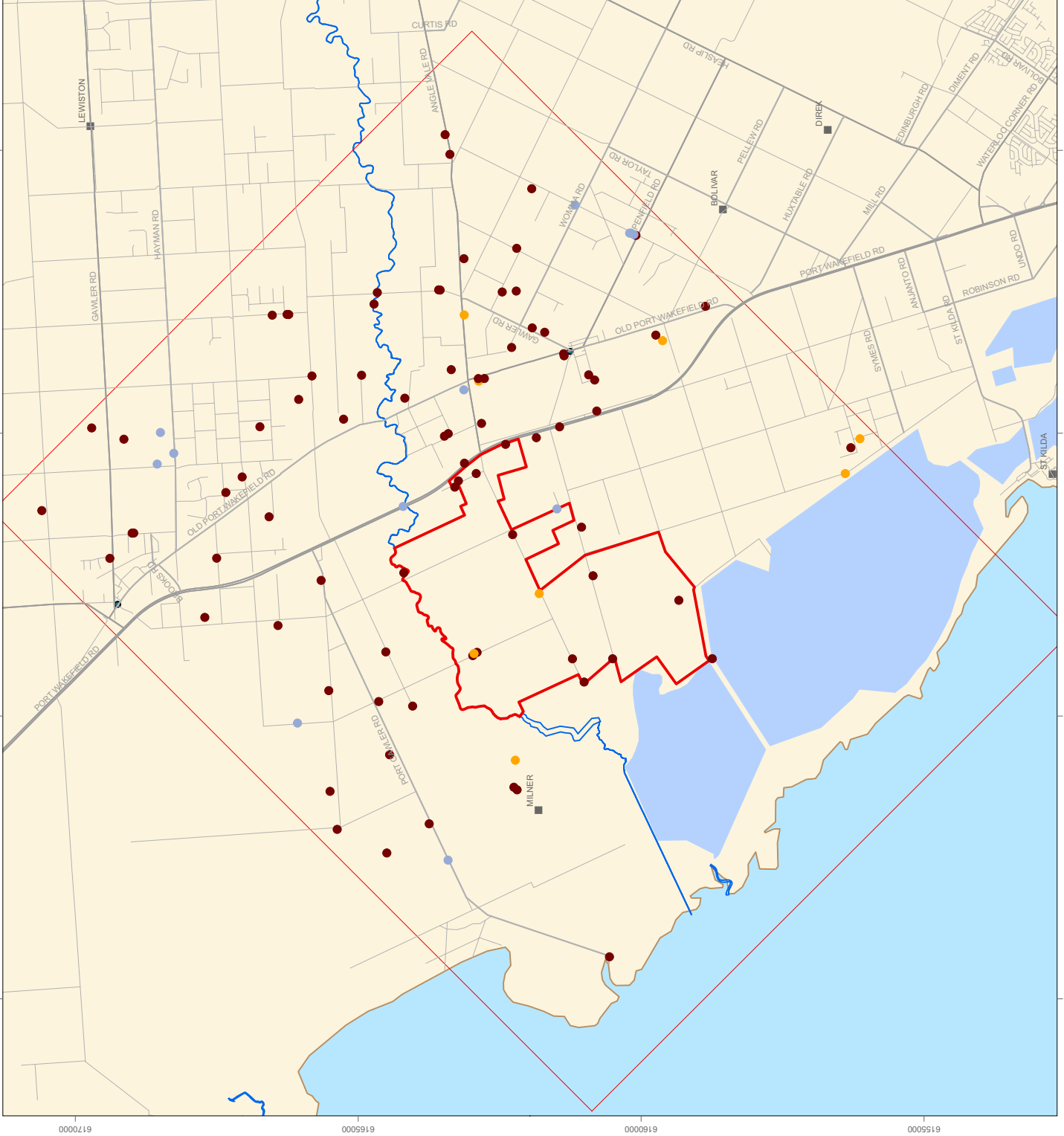
- Model Extent
- Gawler River
- Salt Lake
- Site
- Buckland Park Lake



Buckland Park  
**Interpreted Dominant Soil Type  
 5-10 m bgl (Layer 2)**

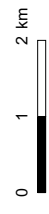


Figure  
**5.2**



**Legend**  
**Dominant Soil Type 10 - 20 m**

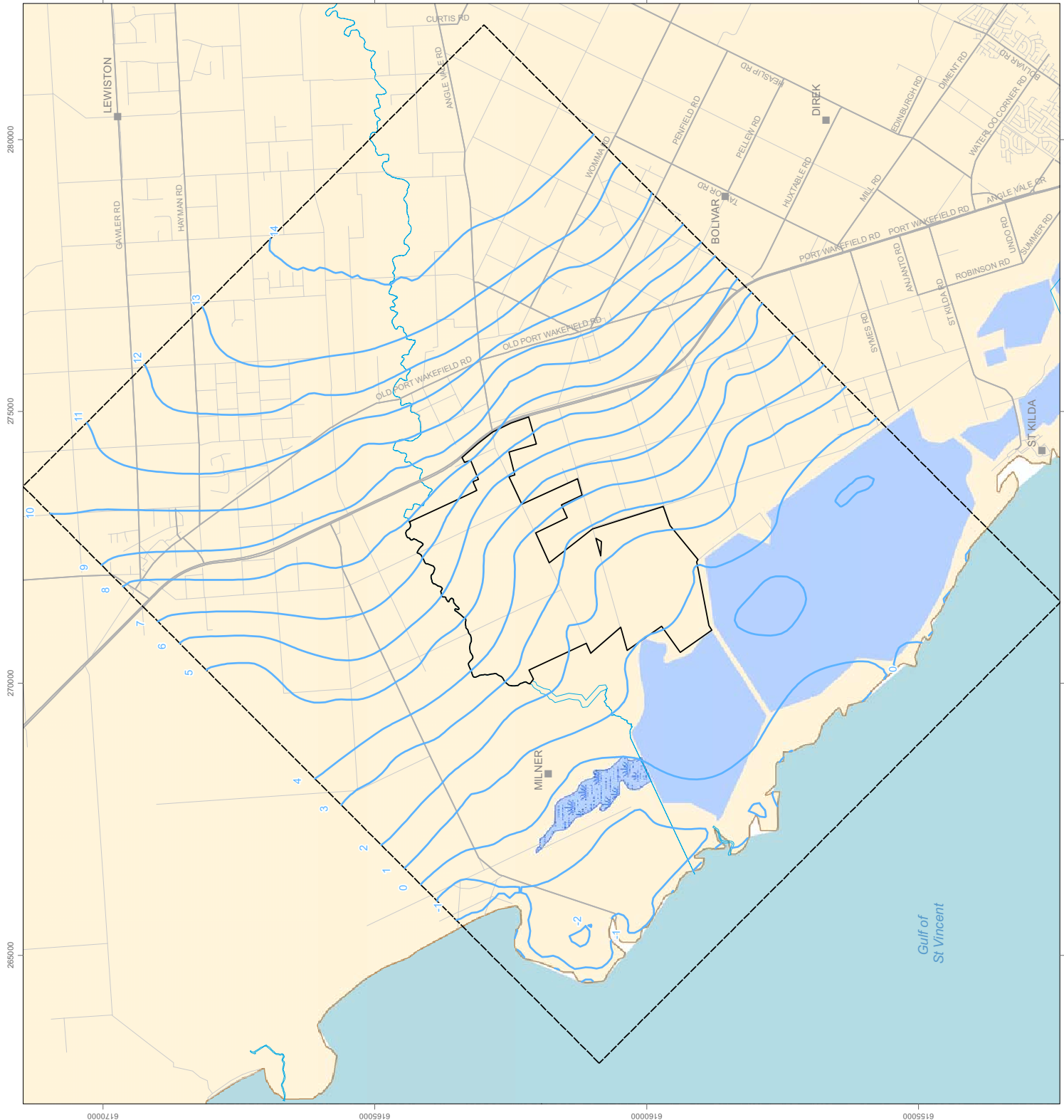
- clay
- silt
- sand
- Model Extent
- Gawler River
- Salt Lake
- Site
- Buckland Park Lake









Buckland Park  
**Interpreted Dominant Soil Type  
 10-20 m bgl (Layer 3)**

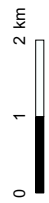


Figure  
**5.3**



**Legend**

-  Modelled Elevation Contour
-  Development Extent
-  Model Extent
-  Gawler River
-  Buckland Lake
-  Salt Lake

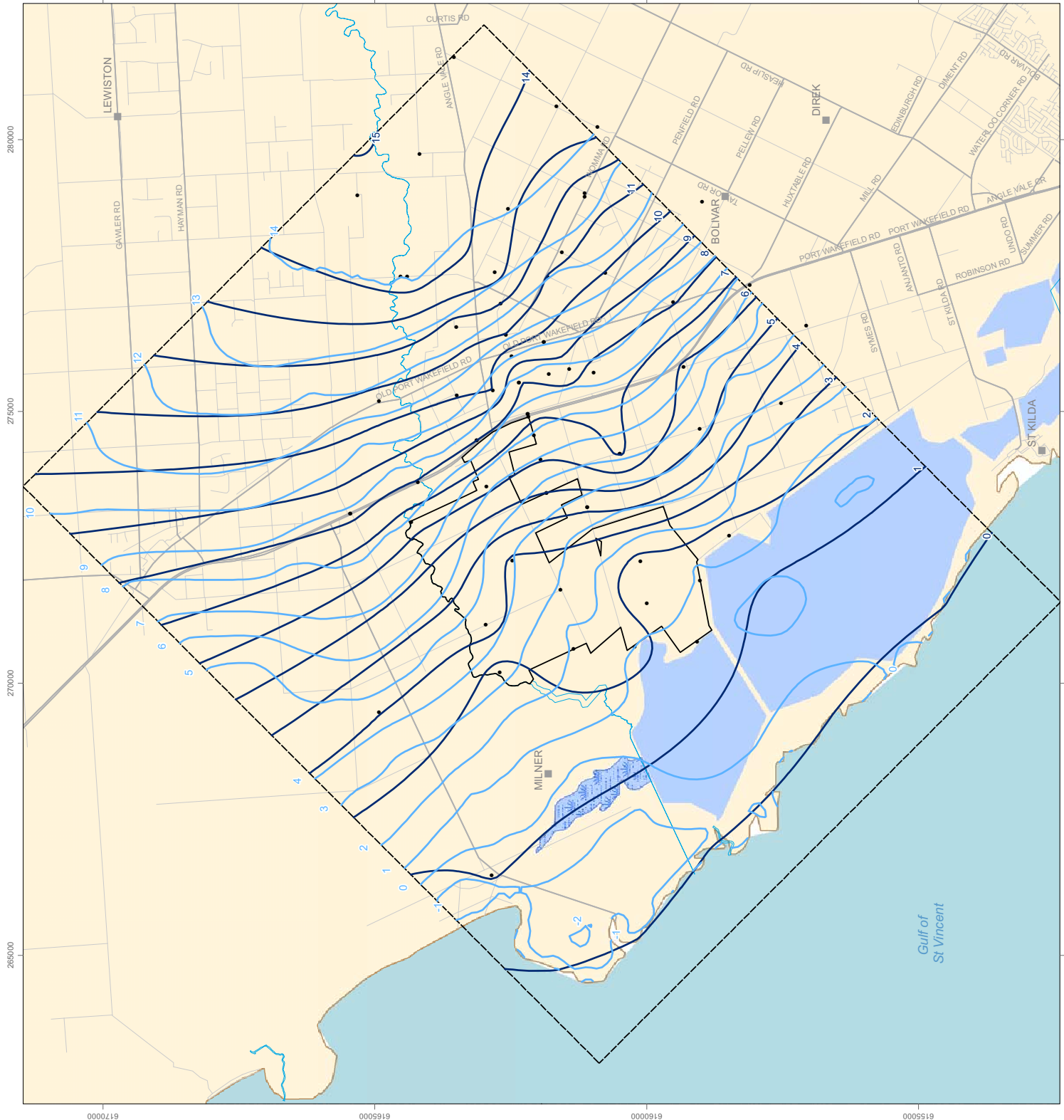


Buckland Park

**Modelled Groundwater  
Elevation (m AHD)**

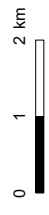
Figure **5.4**





**Legend**

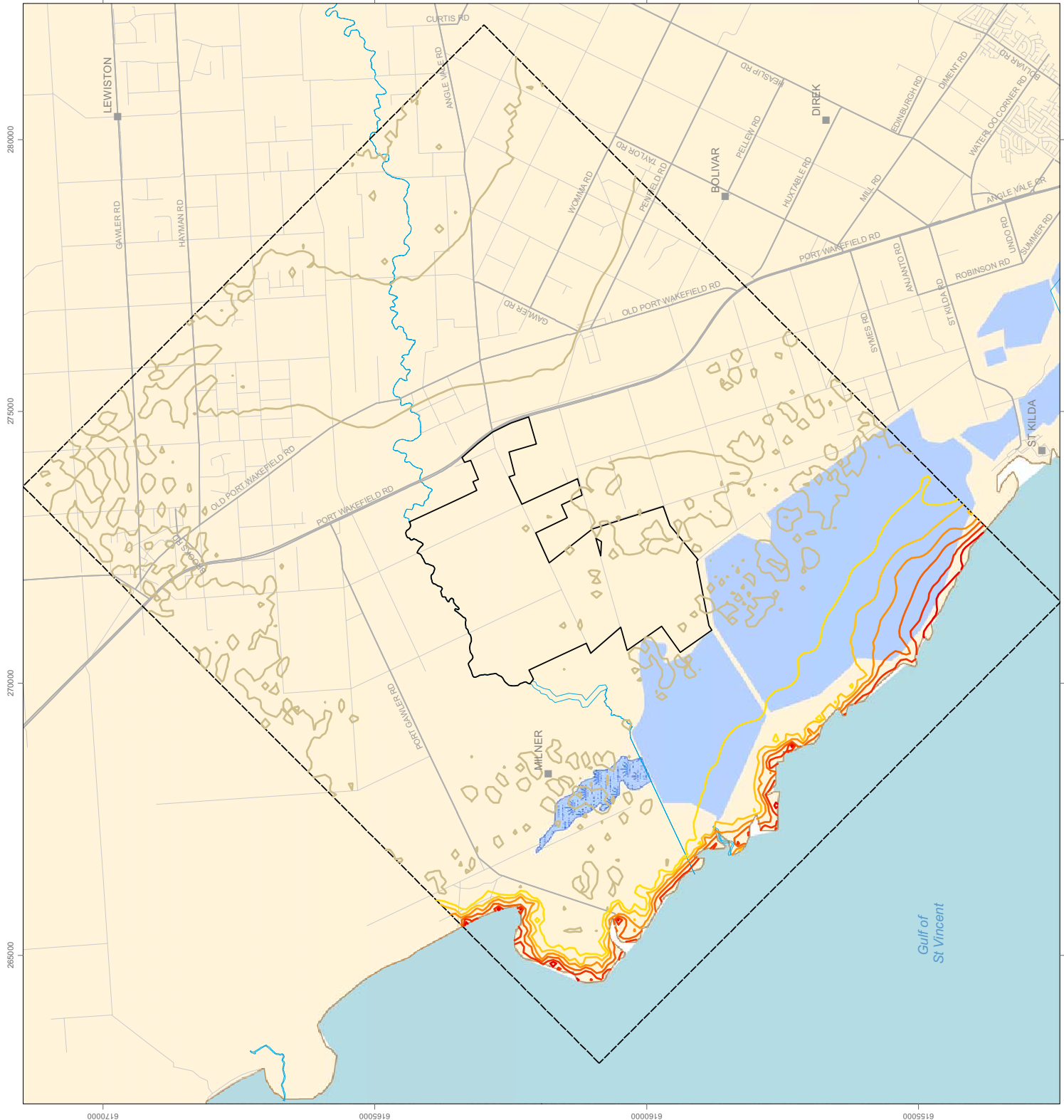
- Modelled Elevation Contour
- Observed Elevation Contour
- Observed Level Data Point
- Development Extent
- Model Extent
- Gawler River
- Buckland Lake
- Salt Lake



Buckland Park

**Modelled and Observed  
Groundwater Elevation (m AHD)**

Figure 5.5

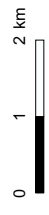


**Legend**

**Change\* in Groundwater Level (m AHD)**

- 0.2
  - 0.15
  - 0.1
  - 0.05
  - 0
  - 0.05
  - 0.1
  - 0.15
  - 0.2
  - 0.25
  - 0.3
- Development Extent
  - Model Extent
  - Gawler River
  - Buckland Lake
  - Salt Lake

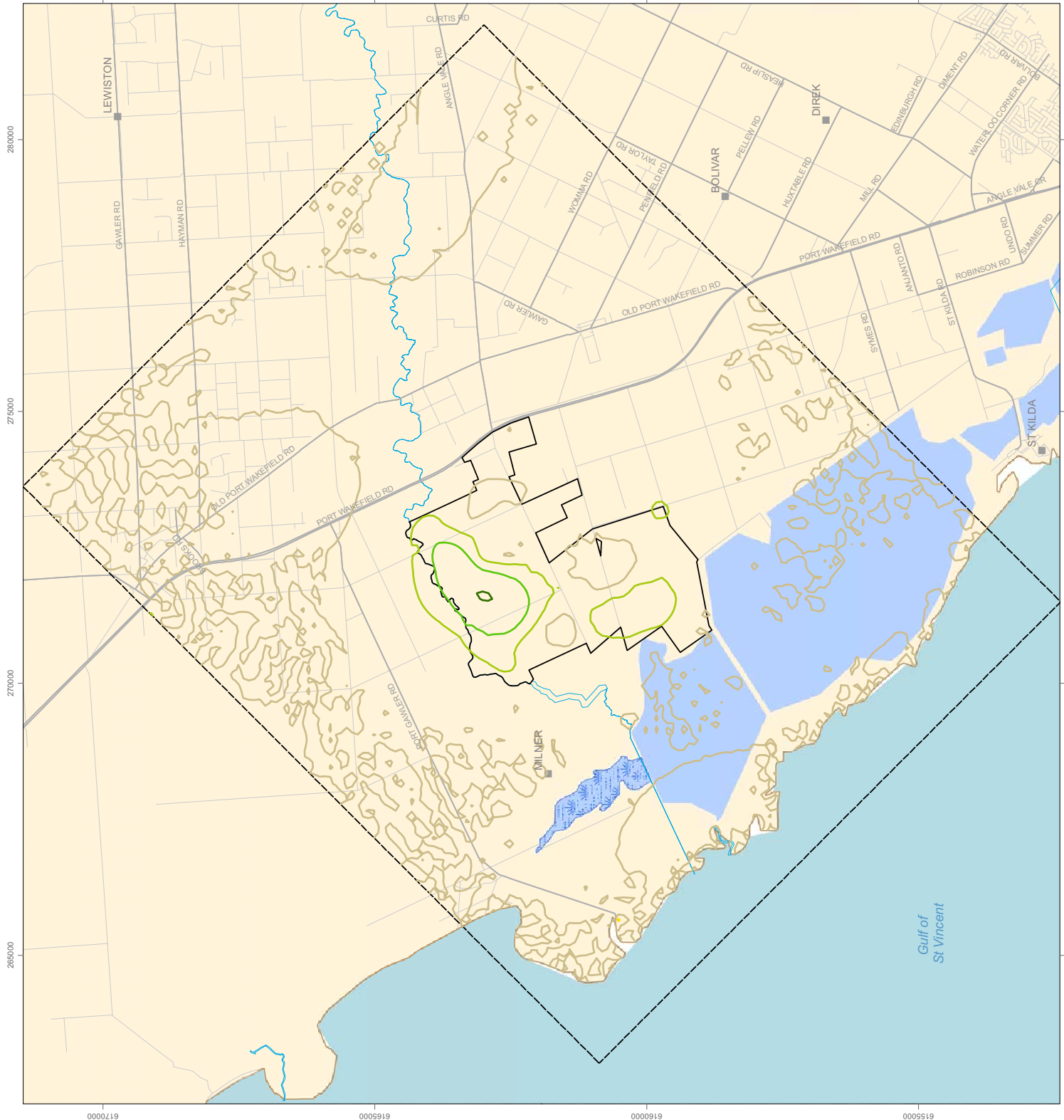
\*resulting from no change in recharge and evapotranspiration within the development footprint and a 0.3m increase in sea level.



**Modelled Change in Groundwater Elevation - without Development with Climate Change (moderate)**

Buckland Park

Figure 5.6

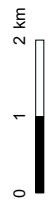


**Legend**

**Change\* in Groundwater Level (m AHD)**

- 0.2
  - 0.15
  - 0.1
  - 0.05
  - 0
  - 0.05
  - 0.1
  - 0.15
  - 0.2
  - 0.25
  - 0.3
- Development Extent
  - Model Extent
  - Gawler River
  - Buckland Lake
  - Salt Lake

\*resulting from a 50% reduction in recharge and a 30% reduction in evapotranspiration within the development footprint and no change in sea level.

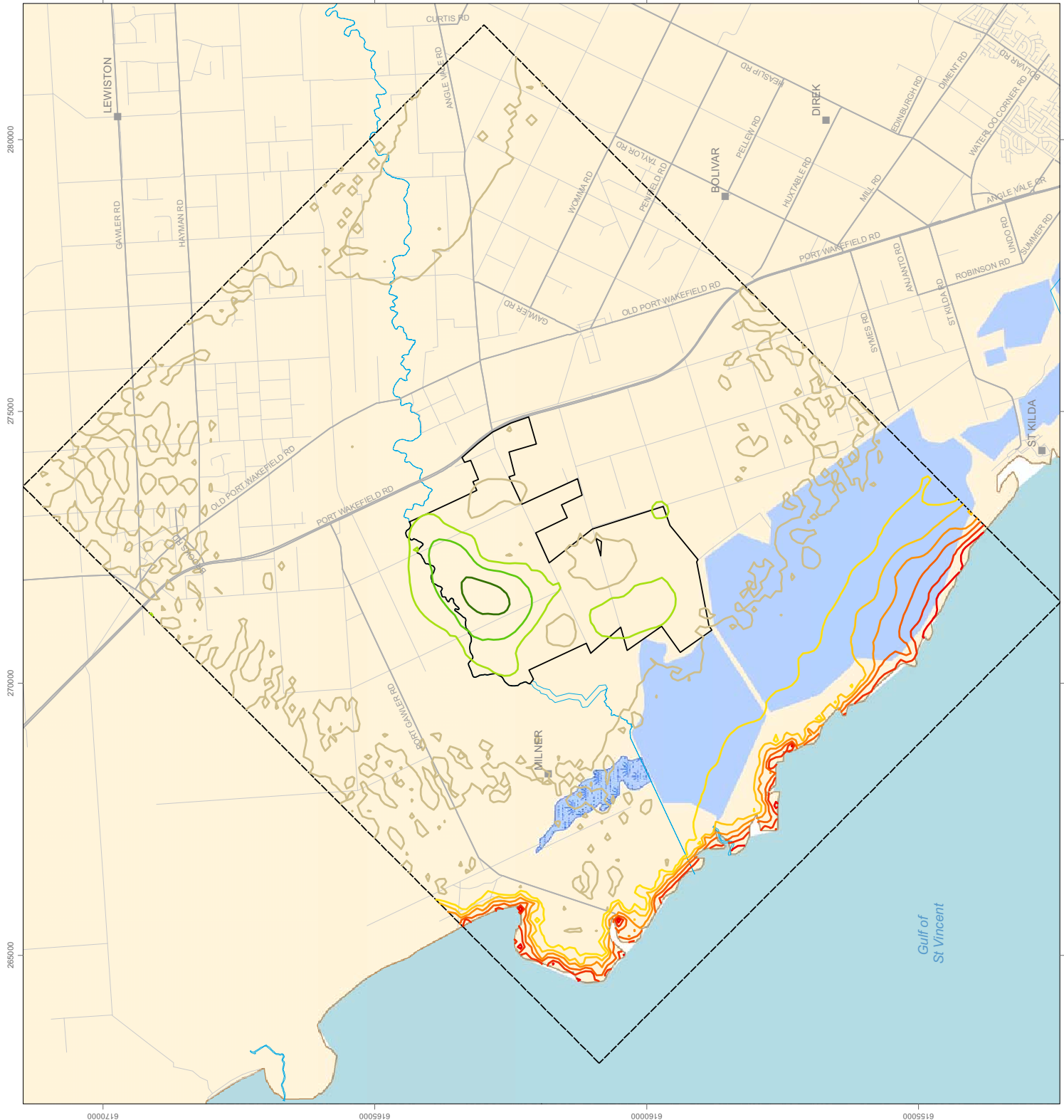


Buckland Park

**Modelled Change in Groundwater Elevation - with Development but without Climate Change**

Figure 5.7



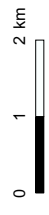


**Legend**

**Change\* in Groundwater Level (m AHD)**

- 0.2
  - 0.15
  - 0.1
  - 0.05
  - 0
  - 0.05
  - 0.1
  - 0.15
  - 0.2
  - 0.25
  - 0.3
- Development Extent
  - Model Extent
  - Gawler River
  - Buckland Lake
  - Salt Lake

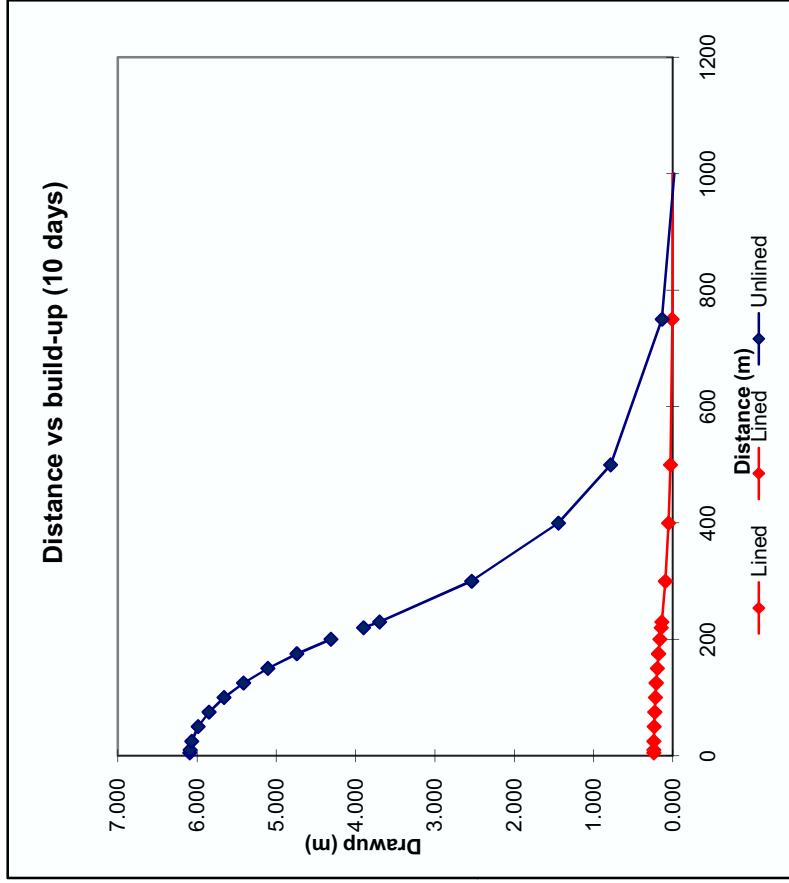
\*resulting from a 50% reduction in recharge and 30% reduction in evapotranspiration within the development footprint and a 0.3m increase in sea level.



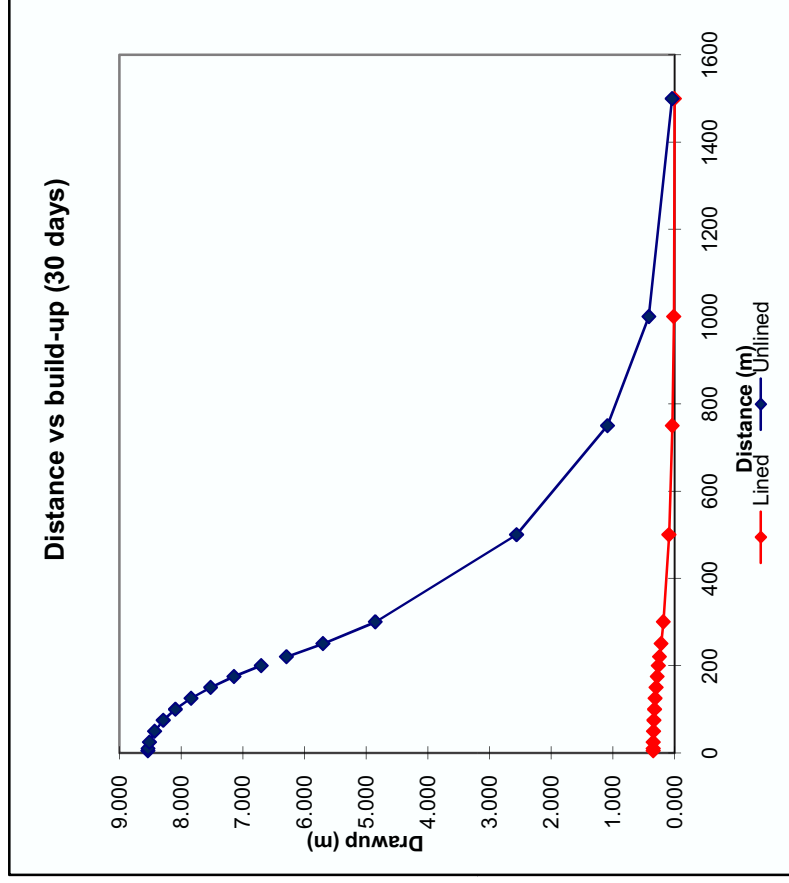
**Buckland Park  
Modelled Change in Groundwater  
Elevation - with Development  
and Climate Change (moderate)**

Figure **5.8**

Figure 5.9: Stormwater retention modelling results Single Event and Month-long scenarios

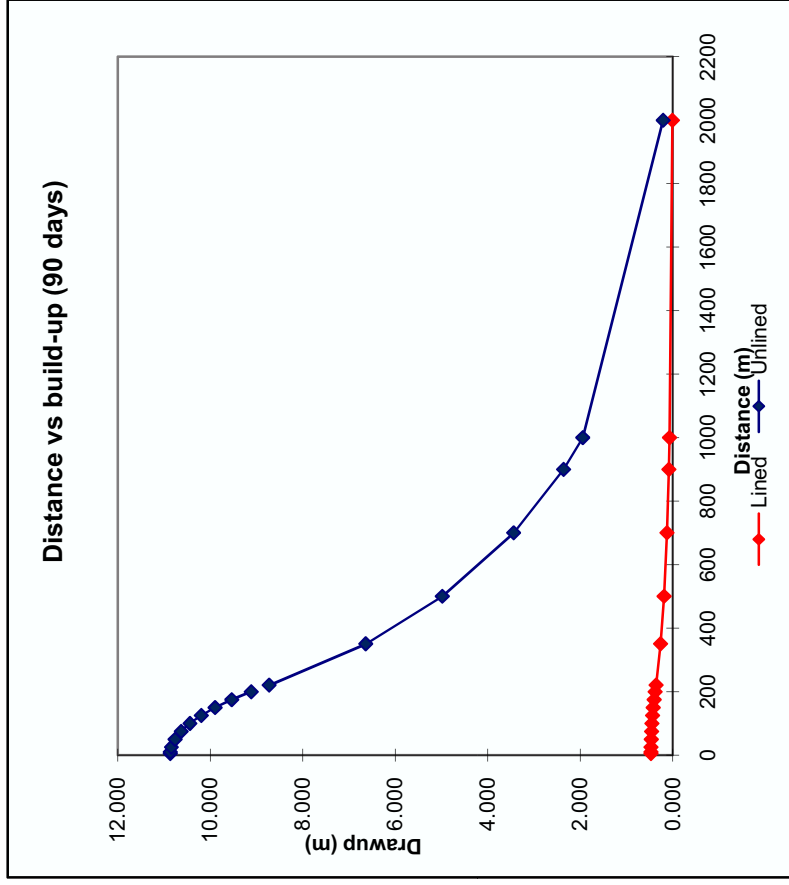


Single Event (10 days detention)

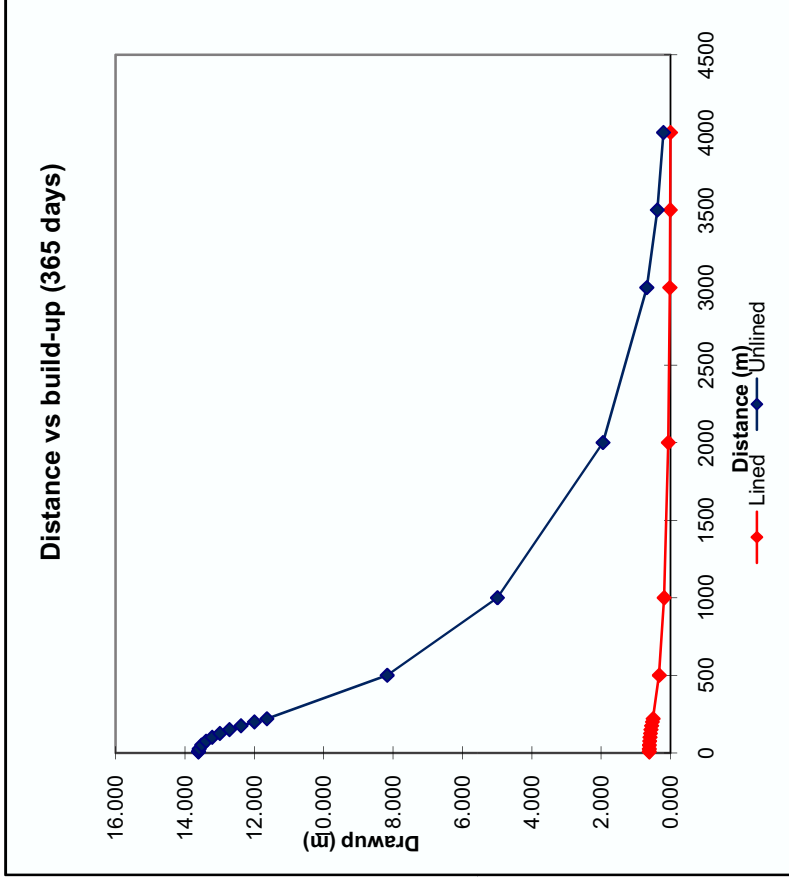


Month-long (30 days detention)

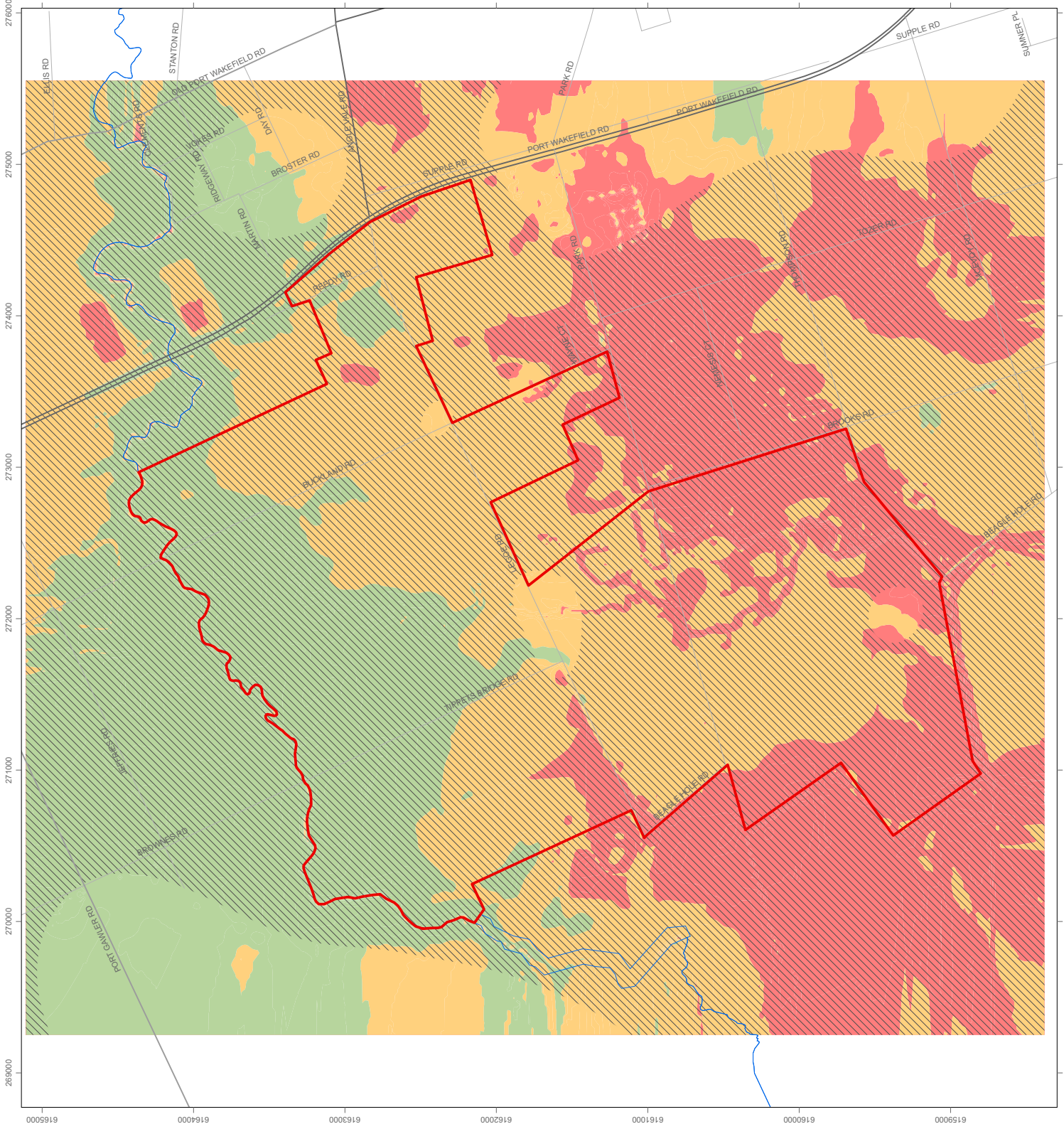
Figure 5.10: Stormwater retention modelling results Winter and Ornamental Pond scenarios



Winter (90 days detention)



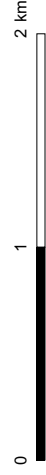
Ornamental Pond (365 days detention)



**Interpreted Salinity Hazard**

- Low:** Groundwater > 4m bgl and clay layer absent in upper 4m of soil profile
- Moderate:** Groundwater > 4m bgl and clay layer present in upper 4m of soil profile
- High(a):** Groundwater 2 - 4m bgl and clay layer absent in upper 4m of soil profile
- High(b):** Groundwater 2 - 4m bgl and clay layer present in upper 4m of soil profile
- Very High:** Groundwater < 2m bgl and clay layer absent in upper 4m of soil profile
- Very High:** Groundwater < 2m bgl and clay layer present in upper 4m of soil profile

**Site**



Buckland Park

**Interpreted Salinity Hazard**

(Based on July 2008 groundwater levels)

Figure

**6.1**





resource and environmental management

# Buckland Park EIS

## GROUNDWATER INVESTIGATIONS

- Final Report
- 17 December 2008

SINCLAIR KNIGHT MERZ

**SKM**





# Buckland Park EIS

## GROUNDWATER INVESTIGATIONS

- Final Report
- 17 December 2008

---

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## Document history and status

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## Executive Summary

The Buckland Park Site is 32 km north of Adelaide. Potential groundwater issues associated with the proposal have been identified in the Environmental Impact Statement guidelines by the Development Assessment Commission. Resource and Environmental Management (REM), now merged with Sinclair Knight Merz Pty. Ltd., was engaged to investigate various groundwater issues. This report primarily addresses the issues associated with shallow groundwater at the site. The content of this report is based on desktop work, field investigations and groundwater flow modelling using all available information.

This report specifically addresses the following objectives:

- Description of the existing hydrogeological conditions affecting the site and its locality by undertaking a desk top study and detailed field survey.
- Description of the high unconfined water table(s) that exists in this area, including the predicted movement over the short and long term and the risk this represents to infrastructure, including housing stock.
- Identification of measures that could be applied to manage these risks (“...the high unconfined groundwater water table(s) that exists in this area”) in the short and long term.
- Description of measures to protect the Gawler River and coastal environments during operations.
- Description of the short and long term effects of constructing waterways for detention purposes on land and/or groundwater quality and movement, especially salinity.
- Description of any special engineering requirements for infrastructure due to the expected high water table in this area including the cost of developing and maintaining infrastructure for saline and acid sulphate soils, seasonal variations in height and groundwater rise due to sea level rise.
- Quantitative assessment of on-site groundwater hazards.

The Buckland Park site covers approximately 1,308 hectares adjacent to the Gawler River 32 km north of Adelaide. The land is characterised as low lying and low coastal relief plain. Two natural watercourses drain the area: the Gawler River and Thompson Creek. The climate is a mild Mediterranean climate with hot dry summers and cool, wet winters. Average annual evaporation exceeds average annual rainfall by almost four times. During wet periods the Gawler River may flood and overflow is channelled along Thompson Creek. Cheethams salt lakes are located between the Buckland Park site and the coast.

The Buckland Park site is underlain by a series of shallow aquifers that are hydraulically connected. These are composed of intercalated sands, silts and clays. Groundwater levels are typically shallow particularly where clay layers cause local perching. Salinity levels vary widely across the site but increase dramatically to hypersaline levels in the vicinity of the salt lakes.

A series of 11 new monitoring wells were drilled to obtain site specific information within the Buckland Park site. All wells were sampled for groundwater levels, salinity, hydraulic conductivity and hydro-geochemistry. Results from these surveys were used to improve the conceptualisation of groundwater



processes within and around the Buckland Park site which was used in the establishment of a numerical model.

The lithological information indicates near surface geology is highly variable both across the study area and with depth and contains a high proportion of clay and clayey sediments at depths of less than 4m below ground level. These clays act as an impediment to downward movement of water and may result in the development of perched watertables. Depth to groundwater is generally shallow and varies from around 8 m in the northeast of the site to less than 2 m in the south west. Problems associated with waterlogging and salinity are most likely to occur in areas where the depth to groundwater is less than 2 m below ground level. Groundwater flow is predominantly from the northeast to the southwest.

A steady-state numerical model was developed to model the interaction of groundwater within the Buckland Park site and adjoining regions. This model conceptualises the aquifer system as three layers underlain by an impervious aquitard at 20m. The lithological data was interpreted as forming layers from 0-5 m, 5-10 m and 10-20 m with varying proportions of sand, silt and clay and differing hydrogeological properties. Groundwater levels were set from interpreted groundwater contours along the eastern and western boundaries, recharge was determined as a proportion of rainfall and discharge via evapotranspiration was set from assumed values. This model was calibrated against the recently measured groundwater levels from the field survey and a model calibration error (mean relative error) of 6.8% was achieved.

Modifications were then made to the model in order to conduct predictive scenario modelling. These included a reduction of 50% to the recharge and 30% to the maximum evapotranspiration rate beneath the development footprint (due to the large area of paving), the inclusion of new proposed drainage and the option of examining a 0.3 m rise in sea-level as a result of climate change.

These results indicate:

- There will be minimal falls in groundwater levels as a result of the Buckland Park proposal; and
- The impacts on groundwater from a climate change-induced rise in sea level will be restricted to the coastal zone and largely confined to the area beneath the salt lakes.

Additional spreadsheet modelling was conducted to determine the impact of stormwater retention on groundwater levels. Results from the stormwater retention modelling indicate unless the channels and ponds are lined, a groundwater mound may form in an area surrounding the pond, thus increasing the risk from rising groundwater and shallow watertables in adjacent areas. The mound will effectively reduce the salinity of shallow groundwater within the mound perimeter as a result of the leakage of low salinity stormwater.

The impacts of engineering works were considered and a range of groundwater mitigation options examined. Of these most require pumping to a detention basin for disposal via evaporation. It is considered unlikely an active groundwater disposal scheme would be developed. Temporary storage of high salinity groundwater may be required for deep trenching works, and under these circumstances a carefully located lined retention pond is recommended.



The shallow and often saline watertable presents a potential threat in the Buckland Park site if irrigation practices in residential areas are poor, resulting in excess infiltration. The watertable is shallow and salinity impacts are evident in areas of the site, particularly in the lower southwest sectors. In the context of residential development, the relative risk of urban salinity is provided by the combination of groundwater depth in the regional watertable aquifer and the occurrence of subsurface clay in the upper 4 m of the soil profile. The approach adopted here categorised five levels of urban salinity risk on a scale grading from low to very high and the level of management response varies accordingly.

Risk levels are lowest along the Gawler River where the watertable is deepest and risk levels are highest on the low lying portions of the site, particularly in the south and west. The extensive presence of clay material in the upper 4 m of the soil profile increases the salinity risk across the site due to the potential for perched watertables to develop. This is particularly pertinent to areas where clay is in the subsurface and is overlain by a more permeable material such as sand or silt that could act as an aquifer.

Where there is potential for perched groundwater to develop the installation of a subsurface drainage system should be considered. Management strategies must be concerned with maintaining groundwater at a safe depth below ground level and efficient water use practices to minimise groundwater recharge.

Proper design and verification of all proposed salinity management strategies is essential to successful urban development in areas at risk of urban salinity. The cost of a proper hydrogeological assessment prior to development would certainly be lower than that of the ongoing impact and remediation of salinisation.



# 1 Introduction

The Walker Corporation Pty Ltd engaged Resource & Environmental Management Pty Ltd (REM), now merged with Sinclair Knight Merz Pty Ltd (SKM), to investigate various groundwater issues as part of the preparation of an Environmental Impact Statement (EIS) for the proposed Buckland Park Country Township (Buckland Park). The development is situated 32 km north of Adelaide, adjacent to the Gawler River, west of Port Wakefield Road (Figure 1.1).

The potential groundwater issues associated with the Buckland Park proposal have been identified in the EIS guidelines prepared by the Development Assessment Commission. These issues, as provided to REM, can be arranged into the broad categories of shallow groundwater issues, contamination issues and Aquifer Storage and Recovery (ASR) potential.

This report primarily addresses the issues associated with shallow groundwater at the site. The content of this report is based on desktop work, field investigations and groundwater flow modelling using all available information. Analytical results from initial groundwater sampling are also reported, but issues relating to potential groundwater contamination have not been fully addressed in this report. The potential for an ASR operation at the site has been assessed and reported by REM in a separate document (REM, 2008).

## 1.1 Objectives

This report specifically addresses the following objectives:

- Description of the existing hydrogeological conditions affecting the site and its locality by undertaking a desk top study and detailed field survey.
- Description of the high unconfined water table(s) that exists in this area, including the predicted movement over the short and long term and the risk this represents to infrastructure, including housing stock.
- Identification of measures that could be applied to manage these risks (“...the high unconfined groundwater water table(s) that exists in this area”) in the short and long term.
- Description of measures to protect the Gawler River and coastal environments during operations.
- Description of the short and long term effects of constructing waterways for detention purposes on land and/or groundwater quality and movement, especially salinity.
- Description of any special engineering requirements for infrastructure due to the expected high water table in this area including the cost of developing and maintaining infrastructure for saline and acid sulphate soils, seasonal variations in height and groundwater rise due to sea level rise.
- Quantitative assessment of on-site groundwater hazards.



## 1.2 Scope of Work

The objectives of this report have been achieved through an assessment of existing information combined with new data collected from field investigations. The scope of work includes:

- Review of existing hydrogeological information;
- Installation of 11 new monitoring wells into the shallow watertable aquifer across the site;
- Hydraulic conductivity testing of all 11 new wells and 1 existing well to provide aquifer parameter data for inclusion in the groundwater flow modelling;
- Sampling of all 11 new wells for nutrients, major cations and anions and a broad contaminant screen;
- Mapping of groundwater depth, elevation and salinity across the development area using new data combined with data contained within existing databases (e.g. SA Geodata and Obswell). Groundwater depth was calculated as groundwater elevation subtracted from the available ground surface information.
- Description of the hydrogeology of the development area, including features and stresses that affect the level, salinity and movement of groundwater using new and existing information. Relevant features include those that currently exist such as drains and rivers and the proposed features such as new waterways.
- Assessment of seasonal and longer term trends in groundwater levels, to the extent possible using available time-series data, in order to assist in understanding potential threats to the proposed development.
- Inclusion of soil information obtained by Golder Associates during the geotechnical field program in the assessment of soil characteristics across the site;
- Estimation of changes to groundwater levels under the development scenario, taking into account changes to stormwater management and the increase in the paved area.
- Assessment of a range of potential activities associated with the proposed development to predict the impact of changes in land use on the shallow watertable aquifer and determine the impact of these changes on the watertable aquifer. Potential management measures will be assessed to rectify possible adverse impacts that may be identified.
- Assessment of groundwater elevation changes under the new development over time including an assessment of the impact of stormwater retention facilities.
- Assessment of a range of scenarios relating to groundwater levels (steady state conditions) associated with the development, including landscape options, impacts of wetlands and any need for sub-surface drainage.



- Provision of concepts for management responses in relation to the potential impacts of changes to shallow groundwater conditions on housing infrastructure, the Gawler River and coastal environment;



## 2 Data Review

### 2.1 Site Description

The site is situated to the west of Port Wakefield Road about 32 km north of Adelaide (Figure 1.1). The site covers around 1,308 hectares immediately south of the Gawler River.

Current land use in the area includes agricultural land (grazing and horticulture) with smaller portions of residential development and the Cheetham Salt evaporation ponds immediately to the west and south of the site.

The landscape is characterised as low lying and low relief coastal plain, as illustrated by the ground surface topography presented in Figure 2.1. Two natural watercourses (Gawler River and Thompson Creek) provide the majority of natural drainage. Prior to alteration, the drainage systems of the Gawler River (being the larger of the two watercourses) would have ended in a raised coastal delta formation within the mangroves and tidal flats which remain along the coast on the western boundary of the study area.

An overview of the physical characteristics of the land across the study area has been provided by Rural Solutions (2007). The higher land on the margin of north sector east, which sits at around 10-12 m AHD, is the tail end of a very gently inclined plain with sand to sandy loam topsoils over clayey subsoils. The system is underlain by alluvial sediments deposited by the Gawler River as it meandered across the plain. The sediments are mantled by aeolian carbonates. As the land drops below 10 m towards north sector west, saline groundwater tables begin to influence soil profiles and productivity potential. As the land further drops away to the low lying coastal flats and associated saline water courses the soils become poorly drained and the watertable is shallow and saline. In these areas the presence of land salinisation is recognisable either as saline subsoils or as surface seepage and the presence of salt tolerant vegetation.

### 2.2 Climate

The Adelaide coastal plain is characterised by a Mediterranean climate, with hot, dry summers and relatively cool, wet winters.

Local climate data has been sourced from the Bureau of Meteorology for the weather station on Sheedy Rd in Virginia, located approximately 2 km east of the Buckland Park site. This station was in operation during the period from 1889 through to 2005 and although it has now been closed, the data represent a long term climate record, spanning more than 100 years, that is situated very close to the present site. Annual rainfall totals and cumulative deviation from average annual rainfall are presented for the period of record in Figure 2.2 and mean monthly rainfall has been compared with mean monthly pan evaporation in Figure 2.3.

The average annual rainfall of 442 mm occurs mostly in the winter months with average monthly rainfall between June and August around 53 mm, in contrast to the months December to February with mean monthly rainfall around 22 mm.





The average annual pan evaporation of 1860 mm exceeds average annual rainfall by more than four times. On average during the winter months evaporation is approximately equal to rainfall, while during summer evaporation exceeds rainfall by around 12 times.

The record of cumulative deviation from the average annual rainfall (Figure 2.1) shows there have been a number of wetter and drier cycles over the last 100 years, with the most recent wet periods occurring in 2000 and then back in the mid 70's and again in the mid 50's. These wet periods correspond to years of above average rainfall.

### **2.3 Hydrology**

The surface water hydrology of the Buckland Park area is largely controlled by the Gawler River situated immediately north of the site. The Gawler River extends across the northern and western boundary of the site. The ephemeral water course of the Gawler River can have large flows and flooding during the winter wet season but is largely dry, with only stagnant pools, during the drier summer months. The river channel has been incised below ground level by three to four metres. When flood flows break from the channel, flood waters will spill away from the channel towards lower lying areas. These flows generally do not re-enter the Gawler River channel.

Extending through the North Sector East and South Sector, Thompson Creek is a shallow intermittent ephemeral watercourse that channels surface flows during the wet season and periods of flooding when the Gawler River overflows. It is likely this watercourse also acts as a shallow groundwater drain when the shallow watertable is elevated above the creek bed as a result of direct recharge during the wet season.

The two salt lakes present immediately to the southwest of the site are currently operated by Cheetham Salt. A representative of Cheetham Salt, Mr. Kevin Taylor (*pers. comm.*, 22/2/2008), could not provide exact operational details for the lakes, but indicated the northern of the two lakes is held at a level of about 2.85 m AHD and the southern lake is held at about 3.25 m AHD. Mr Taylor also indicated the network of surface drains surrounding the lakes are intended to provide some management of the ingress of salt water onto the surrounding land. Survey data relating to the levels or inverts of the drains was not available, but Mr. Taylor did indicate to the north the drains discharge via pumping into the Gawler River channel. Flow gradients in the area are very low and Mr. Taylor suggested not a lot of flow occurs in the drains and the primary out flux was probably by evaporation.

### **2.4 Soils and Geology**

In "Natural History of the Adelaide Region" (Royal Society of SA, 1976) Northcote describes the dominant soils of the study area as permeable, alkaline, red brown soils/calcareous red pedal clays with a moderate to high bearing capacity and deficiencies in nitrogen, phosphorous and zinc.

Reference to the Geologic Survey of South Australia – Adelaide 1:250,000 map sheet (DME, 1969) indicates the near surface stratigraphy of the study area comprises the Quaternary sediments of the Pooraka Formation, across the majority of the site, and the St Kilda and Glanville Formations towards the coast. The Pooraka Formation is described as mottled clay and silt inter-bedded with sand, gravel and thin sandstone layers. The St Kilda formation is characterised by estuarine muds, sands, peats and shelly beds and often contains lenses of highly permeable sand layers.



The Late Quaternary sediments on the Northern Adelaide Plains overlie the older sediments of the Hindmarsh Clay, which is described as a layered sequence of mottled red-brown sandy clay and sand and gravel lenses. In a hydrogeological context these units can together be collectively described as clays containing lenses and discontinuous layers of silts, sands and gravels.

Interpretation of available lithological logs and drillers logs from the state Drillhole Enquiry System (DES) (locations shown on Figure 2.4) indicates the near surface sediments comprise discontinuous beds and lenses of clay, silt and sand. In a similar fashion to the site specific data, presented below, there is a high degree of variability in the logged sediments both laterally across the area, and vertically through the profile. However, it also became evident interpretation of the data is confounded by a lack of detail in the near surface interval in many of the logs. A geological cross-section, based on the logs from DES (Figure 2.5) illustrates the variability from west to east across the site (location shown on Figure 2.4), but also seems to indicate a relatively consistent clay layer sitting at a depth of around 20 metres across the site.

## **2.5 Shallow Aquifer Sequence**

The uppermost groundwater aquifers across the study area occur in the sand and gravel lenses of the Pooraka, St Kilda and Hindmarsh Clay Formations. While it appears these thin shallow aquifers are often discontinuous it has also been suggested (REM, 2002) the top Quaternary aquifer (Q1) is hydraulically connected with aquifers within the marine sediments of the St Kilda Formation forming a somewhat continuous aquifer system (and pathway) across the study area.

According to Martin and Hodgkin (2005), a shallow Quaternary aquifer is present in the area between Virginia and Gawler River. Wells to monitor this perched aquifer have been drilled to depths of between 2.5 and 9.5 m, but most commonly wells are completed at 4-6 m depth (Rural Solutions, 2007). According to AGT (2004), pumping test results for two sites close to Buckland Park showed this perched aquifer can be hydraulically connected to the underlying Q1 aquifer, while the Q1 aquifer and underlying Q2 aquifer had almost no hydraulic connection. Three Quaternary aquifers (Q1 to Q3) are generally recognised in the Northern Adelaide Plains region with thicknesses ranging from about 3 to 15 m. They can be quite discontinuous with lateral extents of less than 2,000 m. Overall, the thickness of the Hindmarsh Clay diminishes northwards and can be as little as 20 to 30 m near the northern limit of the Northern Adelaide Plains Prescribed Wells Area (PWA). Clay generally underlies the Q3 aquifer and forms a confining bed, although there are localised occurrences where the Q3 aquifer is in hydraulic continuity with the underlying aquifer.

A report produced by Rural Solutions SA (Rural Solutions, 2007) covering the nearby Virginia area provides information on aquifer delineation within the Quaternary sequence. According to that report, the unconfined Q1 aquifer, uppermost in a series of sandy layers in the Hindmarsh Clay, comprises thin layers of silt and sand at depths of around 5 to 10 m, although wells have been drilled to depths of up to 17 m to delineate the Q1 aquifer. To delineate the Q2 aquifer wells have been drilled to depths of between 13 and 28 m.

## **2.6 Groundwater Levels and Trends**

Available existing data on groundwater levels in the watertable aquifer were obtained from the DWLBC database. These data, also assessed by REM (2002) showed water levels are typically quite shallow, at



between around 1 to 6 m below ground level (bgl). Shallow groundwater occurs particularly in low lying areas and where clay layers cause perching. There was generally a decreasing trend in groundwater levels from the higher land to the north east towards the coast in the southwest. The available historical data was rather sparse, but some time series information was found. The locations of the few wells with time series data are shown in Figure 2.6. The data from these wells has been plotted up and an example is presented in Figure 2.7. Plots of the data from all the wells are attached in Appendix A. This information shows what appears to be a seasonal fluctuation in water levels, indicating diffuse rainfall recharge of the shallow aquifer. However, with rainfall amounts being quite variable in this region the seasonal fluctuations are somewhat less than regular. Seasonal watertable fluctuations appear to be in the order of around 1 to 2 m, obviously depending on the amount of seasonal rainfall.

## **2.7 Groundwater Salinity**

The shallow groundwater is generally quite saline, but according to existing information assessed by REM (2002), salinity can range widely from almost potable (1,280 mg/L) to around that of sea water (30,000 mg/L). Typically fresh groundwater occurs where localised recharge has occurred from a surface water source such as river losses or excess irrigation water. Groundwater in much of the area is quite shallow and, particularly in low lying areas, evaporative processes are active in concentrating salts in the shallow watertable aquifer.

## **2.8 Data Gaps and Project Approach**

The availability of hydrogeological information within the Buckland Park study area was limited prior to the field investigation programs undertaken as part of this project. The nearby Virginia area has been much more intensively investigated in the past due to the high level of activity there, but to the west of the Port Wakefield Road there has been much less activity and available stratigraphic and hydrogeological information is scattered and sparse.

The geological layering in the project area, particularly in the Quaternary sediments, appears to be highly variable. Soil type varies widely both spatially and with depth through the profile and as a result it does not appear to be possible to construct an obvious 'layer cake' of the profile clearly represents the sequence of aquifers and aquitards beneath the area.

A field investigation program has been undertaken to support the analysis and provide additional information with which to understand the subsurface conditions. Lithological information and groundwater level and groundwater quality information were obtained from the drilling and installation of 11 groundwater monitoring wells by REM. Additional soil information was obtained from site investigations undertaken by Golder Associates and Connell Wagner as part of the EIS-related investigations, and groundwater level data were obtained from the 15 wells installed by Connell-Wagner.

While some historical groundwater level monitoring data was found for a few wells on or near some parts of the study area, the distribution and extent of the available time series information was not sufficient to support the development of a transient state groundwater flow model for the site. Rather it was considered more useful within the project framework to focus on the development of a steady state groundwater flow model and achieve model calibration using available existing information combined with newly generated



groundwater level information. This model can still be used to assess relative potential changes to groundwater conditions at the site from a range of scenarios associated with the development.

A qualitative analysis of the likely transient behaviour of the groundwater system has been included in this assessment from interpretation of the few available water level hydrographs.



## 3 Groundwater Investigation Program

### 3.1 Approach

To provide the additional data necessary to develop an understanding of the shallow subsurface conditions present at the Buckland Park site and to allow testing of shallow groundwater for the presence of contamination, additional groundwater monitoring wells were required. Eleven new groundwater monitoring wells were installed to depths ranging from 10 m in the northeast of the site to around 3.5 m in the southwest, to screen the shallow watertable aquifer. The locations of these new wells, as shown on Figure 2.4) were chosen to complement existing monitoring wells in the area and to provide an even distribution across the site.

This section describes the methodology for well installation, sampling and aquifer testing and the laboratory analysis and reference criteria for the analytical data.

### 3.2 Monitoring Well Installation

Solid flight augers were utilised for the drilling of all groundwater monitoring wells. Due to the sandy nature of the water table aquifer in some areas three of the wells were installed with spear-point end caps and filter sock covering the screened interval. All drilling equipment was thoroughly cleaned before the commencement of drilling and between sites to minimise the potential for cross-contamination between locations.

Well construction details for all new groundwater monitoring wells installed by REM are presented in Table 3.1. Each new groundwater monitoring well was constructed using DN 50 mm Class 18 uPVC with screen intervals varying from 3 m to 4.5 m. The annular space between the well screen and the borehole wall was backfilled with clean, washed, well graded, predominantly silica sand (filter material) of a size compatible with the screened geological unit so no significant loss of filter material from the well annulus occurred during development. A bentonite seal and cement grout was placed above the filter material extending up to the ground level. The wells were then completed at the surface with a lockable cap and lockable standpipe set into a concrete pad.

Well materials were supplied by the drilling contractor. All materials were new and undamaged. All equipment and materials (except for new materials such as sand and cement grouts) were decontaminated and stored in a fashion that provided adequate protection from contamination or damage prior to use.

Drilling and installation of all groundwater monitoring wells was supervised by a qualified REM hydrogeologist. The lithological logs and well construction details for the newly installed wells are provided as Appendix B along with the well construction permits in Appendix C.

All new monitoring wells installed by REM were surveyed to the Australian Height Datum (AHD) by Connell Wagner as part of their involvement in the project. Groundwater level data were reduced relative to AHD and used to produce groundwater elevation contours and assess flow directions.

In addition to the wells installed by REM, 15 more groundwater monitoring wells were installed by Connell Wagner on 16-18 April 2008 and the resulting soil and water level information collected from these wells has also been included in this assessment.



### **3.3 Groundwater Sampling**

Groundwater monitoring wells MWREM03, MWREM04, MWREM06, MWREM07, MWREM08, MWREM09, MWREM11 and MWREM12 were sampled on the 7 February 2008. However, some samples were lost en-route to the analytical laboratory so re-sampling of some wells occurred as part of the second day of sampling activities. The remaining three groundwater monitoring wells, MWREM01, MWREM02, MWREM05, were sampled on 13 February 2008 along with re-sampling of MWREM04, MWREM06, MWREM08 and MWREM11 for selected analytes. Groundwater levels at each location were recorded prior to disturbance using an electronic water level probe.

All monitoring wells were purged of at least three bore volumes, or purged dry using dedicated disposable bailers prior to sampling. The purging process ensures the groundwater sample collected is representative of groundwater in the aquifer at that location. Field chemical parameters were recorded after each bore volume was removed to ensure stable geochemical conditions existed prior to the collection of the groundwater sample. The pH, redox, electrical conductivity and temperature meters were calibrated prior to the commencement of purging.

Groundwater purge sheets are presented in Appendix D.

Groundwater samples were placed in laboratory cleaned bottles containing appropriate preservatives, and then placed into a chilled esky for transport to the Australian Laboratory Services, a National Association of Testing Authorities (NATA) registered laboratory. Duplicate groundwater samples were also collected and sent to Labmark Environmental Laboratories, another NATA registered laboratory. Groundwater samples analysed for metals were filtered in the field using dedicated 0.45 micron filter for each sample and were placed into pre-acidified containers.

### **3.4 Aquifer Hydraulic Testing**

To provide information on aquifer hydraulic conductivity within the study area, slug recovery tests were carried out by REM on the eleven newly installed monitoring wells and one existing well at the site. Rising head slug tests were undertaken by instantaneously removing a slug of water from the tested well using an inline submersible pump and dedicated WATERA tubing for each well. Water level recovery in the well was recorded, using an In-Situ Inc. miniTROLL down-hole pressure transducer, to within 5% of the pre-pumping standing water level. Data were recorded electronically on a laptop computer, at 0.5 or 1 second intervals, as pressure in pounds per square inch above the transducer. The raw data were later transformed into depth to water in the well using a two-step process. A calculation was applied to give the height of water column in the well, using the approximate groundwater salinity, and then the data were adjusted using the known (measured) depth to water at the completion of the test as a reference point.

Analysis of the rising head slug test data was undertaken using the Bouwer-Rice method (Bouwer and Rice, 1976) to determine horizontal hydraulic conductivity of the aquifer in the vicinity of each well. This approach is suited to partially penetrating wells in which the water level falls below the top of the screened interval. In addition to the water level drawdown data, input parameters included well casing diameter of 50 mm ID, drill-hole diameter of 125 mm and the total depth and screened interval of the wells.



The aquifer testing analysis sheets, used to calculate hydraulic conductivity from the test results, are provided as Appendix E.

### **3.5 Analytical Laboratory Program and Criteria**

Groundwater samples were analysed for nutrients, major cations and anions and a broad contaminant screen including 13 metals, total petroleum hydrocarbons (TPH), benzene, toluene, ethylbenzene and xylene (BTEX), polycyclic aromatic hydrocarbons (PAH's), organochlorine pesticides (OCP's) and phenoxyacetic acid herbicides.

Groundwater at the site ranges in salinity from almost potable through to more saline than seawater and potential receivers of this groundwater include the Gawler River and the marine environment. In this context, the groundwater analytical results from the site have been compared to the following guidelines:

- SA EPA (2003) Environment Protection Policy - for Potable, Irrigation and Livestock uses
- SA EPA (2003) Aquatic Ecosystems - both Fresh and Marine waters
- ANZECC (2000) – Marine Water Quality; and
- MHSPE, 2000 Dutch Intervention Criteria (adopted where no alternative guideline was available).





## 4 Site Investigation Results

### 4.1 Site Soils and Geology

Drilling logs were produced by REM from the installation of 11 groundwater monitoring wells to depths ranging from about 10 metres near the Gawler River to about 3.5 metres in the lower lying areas in South Sector West. In addition, logs were obtained from Golder Associates, covering depths of 3 to 6 metres, and from Connell Wagner, covering depths of 6 to 9 metres. Existing information from the Department of Water Land and Biodiversity Conservation (DWLBC) online Drillhole Enquiry System (DES) was also incorporated in this assessment.

This lithological information indicates a near surface geology that is highly variable both across the study area and with depth through the profile. Sediment composition included sand, silt and clay in varying proportions, but in general an abundance of clay and clayey sediments were identified across the site. Sand and silt appeared to be present in lenses and pockets that were not spatially continuous across the site. In the majority of holes an appreciable thickness of clay was present at or near the surface. In order to illustrate the spatial distribution of clay across the site, and the relative levels at which it occurs, a map of depth to clay (Figure 4.1) was produced from all available lithological logs. This interpretation shows that clay is likely to be present in the upper 4 m of the soil profile across nearly the entire site, and there are large areas where clay is at the ground surface. The few areas where clay is deeper than 4 m are isolated and mostly associated with only one or two data points.

The data shows that subsurface clays occur extensively throughout the study area at depths of less than 4 m bgl. These clays will act as an impediment to downward movement of water and, in the case where they are overlain by more permeable sediments like sand or silt, there is potential for development of shallow perched watertables to develop.

For practical purposes, the soil profile relevant to the watertable aquifer system is assumed to extend to around 20 m bgl. This assumption is based on the more regional interpretation of lithological information presented in cross section in Figure 2.5. Below this depth the extensive occurrence of clay across the region is assumed to act as an aquitard separating the surface system from the deeper confined aquifers.

It should be noted that drill holes completed in this study were targeting either the groundwater table (REM and Connell-Wagner holes) or the shallow soil composition (Golder Associates), so the resulting lithological information covers only a portion of the profile associated with the upper Quaternary sedimentation and shallow aquifers. In particular, holes in North Sector East extend to near 10 metres, while those in South Sector West extend to only 3.5 metres.

### 4.2 Site Hydrogeology

#### 4.2.1 Groundwater Levels and Flow Direction

Groundwater level gauging of new and existing monitoring wells has been undertaken by REM, using an electronic dip meter, on five separate occasions as part of this investigation (Table 4.1). Initial water level gauging of available existing wells took place during REM's initial site visit on 8 January 2008 and during new monitoring well installation works on 15 January 2008. Gauging of all newly installed REM wells took place on 7 February 2008, followed by repeat gauging of all new REM wells and one existing



well during groundwater sampling activities on 20-21 February 2008. Following installation of the additional wells by Connell Wagner, further rounds of water level gauging was undertaken by REM on 2 July 2008 and 2 October 2008, including all new and available existing wells.

The results of groundwater level gauging from 7 February 2008 showed the elevation of the watertable beneath the site ranging from a low of 1.38 m AHD in MWREM08, situated in the southernmost and lowest point of the site, to a high of 6.40 m AHD in MWREM01, situated in the northernmost and highest point of the site. As with most areas, the watertable elevation and groundwater flow direction across the study area generally mimics the shape of the land surface dropping down towards the coast. Groundwater elevations vary from around 8 m AHD immediately northeast of the site to 0 m AHD at sea level not far to the southeast and east of the site.

Groundwater elevation contours interpreted from the 7 February 2008 data (Figure 4.2) the 2 July 2008 data (Figure 4.3) and the 2 October 2008 show that groundwater flow occurs in a general westerly and south westerly direction towards the coast. Comparison of the sets of data show some minor changes in watertable elevation, but all of the main features of the groundwater flow pattern across the study area are essentially the same. This provides an improved level of confidence in the data. Two areas of groundwater mounding were quite well defined by the data. The first area is situated in the vicinity of wells MWREM04, MWREM06 and GW2. The cause of more elevated groundwater levels in this area is not clear, but it may be associated with historic or current irrigation practices in that area. The second area is situated in the vicinity of well 6628-20004, which is completed at a depth of 3 m bgl. Groundwater mounding at that location is more obviously caused by roof runoff and possibly excess irrigation from adjacent glass house horticulture. This well is nested with an 8 m deep well, which recorded a water level of 1 - 2 m lower than the shallower well. This indicates that a perched watertable has developed in sediments on top of a shallow low permeability clay layer in this area. At this site REM personnel observed that downpipes channelled runoff from the glass house roofs to an area right next to the nested shallow wells. It seems likely that this localised source of recharge has affected the shallow groundwater levels in this area. While this water level data point has been included in the interpretation of groundwater elevation contours across the study area, it might have unduly influenced the interpretation of water levels in the surrounding area, causing groundwater mounding to appear more extensive than is actually the case.

The hydraulic gradient across the site varies between about 1 to 2 metres per kilometre (0.001 to 0.002) and is controlled by factors including hydraulic conductivity of aquifer materials, recharge, surface drainage and topography. The hydraulic gradient is somewhat steeper across the eastern part of the site and this could be due to factors including steeper surface topography, variable hydraulic parameters and/or higher recharge from irrigation activities.

Local variations to the shallow groundwater flow not picked up in this monitoring data might occur close to hydrological features including rivers and drains and near the salt lakes where groundwater mounds exist. Due to the elevated pool levels in the salt lakes immediately to the southwest of the site, it is likely that over time water from the salt lakes has seeped through the beds and caused mounding of shallow groundwater in that vicinity. However, during construction of the salt lakes a system of groundwater drains surrounding the lakes was also installed, in an attempt to manage the effects of groundwater



mounding on the surrounding land. These drains are supposed to collect seepage water and channel it into the natural drainage that discharges to the sea. In reality it would appear that flow gradients are so slight in that low lying area that most water discharge occurs as evaporative out-flux from the open drains and from shallow groundwater tables.

A reduction in the groundwater flow gradient towards the coast is evident in the interpreted watertable elevation contours, but specific hydraulic effects of the elevated pool levels in the salt lakes are not apparent in the available data.

#### **4.2.2 Depth to Groundwater**

The results of groundwater level gauging undertaken by REM reveal that the groundwater table is quite shallow, at less than 4 m, across the majority of the site. Depth to groundwater, measured on 7 February 2008 in the 11 new wells installed by REM (Table 4.2), ranged from 0.88 m bgl in MWREM07, situated in the low lying south sector west, to 5.67 m bgl in MWREM03 situated on the higher ground adjacent to the Gawler River along the northern boundary of the site. A subsequent round of water level gauging on 2 July 2008 (Table 4.2) showed minimal change at MWREM07 and a fall in the watertable at MWREM03 to 5.82 m bgl.

Mapping of depth to groundwater across the study area, covering all points in between the measured points obtained from groundwater gauging activities, was achieved by subtracting an interpolation of groundwater elevation from the ground surface elevation. This method minimises the error in the interpretation of groundwater depth because it accounts for the variability in the ground surface in addition to spatial trends identified in gauging data. However, it must be stressed that while the groundwater data is valid for the current situation, future changes to groundwater levels may occur that would require periodic updates to the data set.

Interpreted groundwater depth across the study area is presented in Figure 4.5, for the 2 July 2008 water level gauging event. This information shows a broad gradient in depth to groundwater, with deepest levels along the Gawler River to the north, and also highlights the fairly extensive occurrence of shallow groundwater (less than 4 m depth) across much the site, particularly along the south, east and west perimeter. The watertable could be less than 4 m bgl across much of the central sector, south sector and south sector west of the site. The occurrence of shallow groundwater is strongly controlled by the surface topography, with these areas occurring in the lower lying places and natural or artificial depressions in the landscape. The land along the Gawler River, in the north sector east and north sector west, is the only portion of the site where groundwater is likely to be deeper than about 4 m bgl. A spur of higher ground extending down the southwest of the site increases the depth to groundwater in that area slightly.

Problems associated with water logging and salinity are most likely to occur in areas where the depth to groundwater is less than 2 m bgl. This hazard is independent of whether the shallow groundwater is in the regional watertable aquifer or in a more localised perched aquifer sitting on top of a low permeability clay layer. The latter occurrence is typically of most concern when the top of said clay layer occurs within the top 4 m of the soil profile.



### 4.2.3 Hydraulic Aquifer Characteristics

Aquifer testing was undertaken on 20 - 21 February 2008 to provide aquifer property data for input to the numerical groundwater flow model. Water level recovery tests were conducted on the eleven newly installed wells MWREM01 thru MWREM09 and MWREM11 and MWREM12 plus one existing well with the state database Observation Number PTA058.

Hydraulic conductivity values are presented in Table 4.3. Values range from 0.01 to 1.12 m/day. Lower values are reported along the Gawler River where values of 0.01 and 0.07 m/day were recorded for bores MWREM01 and MWREM07 respectively. These are the lowest values on site with the other value of similar magnitude (0.06 m/day) occurring at MWREM09. Slightly more elevated values occur along the southern boundary (0.12 m/day at MWREM07, 0.18 m/day at MWREM08 and 0.19 m/day at MWREM12. Remaining wells have still slightly higher values of hydraulic conductivity but all of the wells tested display low hydraulic conductivities.

The information provided by the slug recovery testing on the shallow wells installed by REM provides perhaps an overly conservative indication of the permeability of near surface sediments across the study area. It is recognised that the wells were installed mainly to enable monitoring of groundwater levels and, as such, they do not fully penetrate the watertable aquifer. In many cases the well screen penetrates only partially into sandy sediments that were encountered. Therefore it is quite likely that the resulting permeability values obtained from these wells are an underestimation of the actual values of this parameter for the watertable aquifer system. Based on experience it is possible that actual aquifer permeability values could range from around 0.01 m/d for clayey sediments up to around 10 m/d for coarser sandy sediments.

## 4.3 Groundwater Analytical Results

Groundwater analytical results are presented in Table 4.4 and laboratory analytical reports are contained in Appendix F.

### 4.3.1 Field Parameters

Field parameters (Table 4.5) measured during the groundwater sampling program, which was undertaken on 7 February and 13 February 2008, indicate the following hydro-geochemical conditions exist in groundwater sampled from wells across the Buckland Park site:

- pH values range from 6.66 at MWREM06 to 7.97 at MWREM09. Groundwater was generally neutral to slightly alkaline. Groundwater sampled from MWREM06 and MWREM07, at the low lying southwest end of the site, was slightly acidic.
- Electrical conductivity of sampled groundwater ranged from 5.02 mS/cm at MWREM09 to 106.6 mS/cm at MWREM06.
- Temperature of sampled groundwater ranged from 18.7 °C at MWREM11 to 23.2°C at MWREM06.

### 4.3.2 Groundwater Salinity

The salinity of sampled groundwater from the Buckland Park site has been estimated, as total dissolved solids (TDS), from field measurements of groundwater electrical conductivity (EC). This approach has



been adopted in favour of using the sum of cations and anions from the analytical laboratory data because the charge balance error was in excess of acceptable limits.

The simple linear relationship reported in Hem (1985) was used to convert field measured EC in mS/cm into TDS in mg/L, by applying a multiplication factor of 750. In natural waters this multiplication factor commonly ranges between 550 and 750, with the higher values generally being associated with water high in sulphate concentration. Perusal of the analytical data for sampled groundwater from Buckland Park shows high sulphate concentrations for many of the samples, thus the higher multiplication factor was used.

The salinity of groundwater samples collected from the new wells installed by REM (Table 4.5) ranged from a relatively fresh 3,765 mg/L at MWREM09 to a hyper-saline 79,725 mg/L at MWREM07 and 79,950 mg/L at MWREM06. Both of these hyper-saline wells are situated adjacent to the salt lakes in the low lying southwest corner of the site.

When combined with available data from existing nearby wells this information provides a good indication of the spatial variability of the salinity of shallow groundwater across the study area. As shown in Figure 4.6, groundwater salinity is broadly more saline in the west and fresher to the east. Some notable features of the groundwater salinity data include the following points:

- The salinity of groundwater in MWREM09, located centrally in the south sector west, was measured at 3,765 mg/L, which is much fresher than that of surrounding nearby wells. This is an area that is suspected to have been subject to historic irrigation, and it is postulated that the lower salinity correlates to a lens of fresh water remaining from the historic irrigation.
- The salinity of groundwater in MWREM05, measured at 18,450 mg/L, was significantly higher than that of other nearby wells. Field observations made by REM staff and interpretation of the site aerial photo suggest that this well is adjacent to clay pans and a natural depression where water tends to pond. It is likely that groundwater in this area is subject to a higher rate of evaporative discharge and subsequent concentration of salts in groundwater.
- At sites where data from nested monitoring wells is available, the groundwater in the shallower well is usually much fresher than that in the deeper well. This suggests that perched groundwater does occur in some areas of the site and it is likely that this water originates from drainage of excess irrigation water. Thus it follows that perched groundwater would typically be expected in areas where such irrigation practices are in effect.

### **4.3.3 Analytical Laboratory Data**

#### **4.3.3.1 Major Ions**

Major ion chemistry data showed that the sampled groundwater at Buckland Park was generally very saline (average TDS of 28,930 mg/L), and the ionic composition of the groundwater samples was dominated by sodium and chloride, as is usual for most natural waters, but a significant proportion of sulphate was also present in most samples.

Sulphate concentrations exceeded the SA EPA (2003) guideline value for Livestock use of 1000 mg/L in samples from seven of the eleven wells across the site. The highest levels of sulphate occurred in wells



MWREM06 (6,990 mg/L), MWREM07 (9,820 mg/L) and MWREM08 (3,390 mg/L) all of which are situated in the hyper-saline area adjacent to the salt lakes. Other samples with sulphate levels of 1000 to 3000 mg/L were from MWREM03, MWREM04, MWREM05, MWREM08 and MWREM12.

Sulphate concentrations exceeded the SA EPA (2003) guideline value for Potable use of 500 mg/L in samples from ten of the eleven wells across the site. In addition to the wells listed above for exceeding the Livestock value, samples from wells MWREM01, MWREM02 and MWREM11 exceeded the Potable guideline value, with sulphate concentrations from 731 to 981 mg/L.

The ionic balance errors for MW3, MW9, MW12 and MW6 were reported to be greater than the 5% target amount due to analytes not quantified in the reported analysis. This is a limitation to the confidence that can be placed in the major ionic composition of these samples, but does not affect the validity of other samples or analytes. Re-sampling and analysis of major ion chemistry and TDS would enable a more accurate determination of the cation and anion composition of these samples.

#### 4.3.3.2 Fluoride

Fluoride concentrations were reported for field duplicate samples analysed by Labmark. Fluoride concentrations exceeded the SA EPA (2003) guideline value for Livestock use of 2 mg/L in MWREM07 (3.2 mg/L). Fluoride concentrations also exceeded SA EPA (2003) guideline values for Irrigation use of 1 mg/L in MWREM11 (1.3 mg/L).

#### 4.3.3.3 Nutrients

Groundwater analytical results for nutrients identified the following:

- Ammonia concentration exceeding the SA EPA (2003) Aquatic Ecosystem (Fresh) guideline value of 0.5 mg/L was reported in groundwater sampled from MWREM06 (0.61 mg/L). In addition, ammonia concentration exceeding the SA EPA (2003) Aquatic Ecosystem (Marine) guideline value of 0.2 mg/L was reported in groundwater sampled from MWREM06 (0.61 mg/L) and MWREM07 (0.43 mg/L).
- Nitrate concentration exceeding the SA EPA EPP (2003) Water Quality (Potable Use) guideline value of 10 mg/L was reported in groundwater sampled from MWREM02 (23.4 mg/L).
- Total nitrogen concentrations exceeding the SA EPA (2003) Aquatic Ecosystem (Marine) guideline value of 5 mg/L were reported in groundwater sampled from MWREM02 (26.4 mg/L), MWREM04 (7.4 mg/L), MWREM08 (5.6 mg/L) and MWREM11 (5.0 mg/L)
- Total phosphorous concentrations exceeding the SA EPA (2003) Aquatic Ecosystem (Marine) guideline value of 0.5 mg/L were reported in groundwater sampled from MWREM01 (0.57mg/L), MWREM04 (0.97 mg/L), MWREM07 (0.5 mg/L) and MWREM08 (1.39 mg/L).

#### 4.3.3.4 Metals

Groundwater analytical results for heavy metals identified the following:

- Chromium concentrations exceeding the SA EPA (2003) Aquatic Ecosystem (Marine) Chromium VI guideline value of 0.0044 mg/L were reported in groundwater sampled





from MWREM05 (0.005 mg/L), MWREM07 (0.014 mg/L) and MWREM09 (0.005 mg/L).

- Copper concentrations exceeding the SA EPA (2003) Aquatic Ecosystem (Marine) Copper guideline value of 0.01 mg/L were reported in groundwater sampled from MWREM06 (0.016 mg/L), MWREM07 (0.04 mg/L) and MWREM08 (0.011 mg/L)
- Lead concentrations exceeding the SA EPA (2003) Potable Water use guideline value of 0.01 mg/L were reported in groundwater sampled from MWREM06 (0.014 mg/L) and MWREM07 (0.123 mg/L).
- Manganese concentrations exceeded the SA EPA (2003) Irrigation use guideline value of 2 mg/L were reported in groundwater sampled from MWREM01 (8.55 mg/L).
- Nickel concentrations exceeding the SA EPA (2003) Aquatic Ecosystem (Marine) guideline value of 0.015 mg/L were reported in groundwater sampled from MWREM01 (0.016 mg/L), MWREM06 (0.015 mg/L) and MWREM08 (0.015 mg/L).
- Zinc concentrations exceeding the SA EPA (2003) Aquatic Ecosystem (Marine) guideline value of 0.05 were reported in groundwater sampled from MWREM06 (0.302 mg/L) and MWREM07 (0.071 mg/L).

Three of the eleven samples analysed for chromium showed levels elevated above the SA EPA criteria for chromium VI in marine aquatic ecosystems. However, in the absence of specific industrial activities that generate chromium VI, chromium in the environment occurs as the relatively benign chromium III species. It is likely that the small amount of chromium detected in some of the samples from the Buckland Park site is the latter chromium III species.

#### **4.3.3.5 TPH and BTEX**

The SA EPA does not nominate a limit for TPH under Potable, Irrigation, Livestock or Aquatic Ecosystem guidelines. Dutch Intervention Levels state a limit of 600 µg/L for Total C10-C36. All samples analysed from the Buckland Park site were returned at levels below this standard.

Groundwater sampled from all but two bores reported levels of BTEX below detection limits. Those samples that did report BTEX components at detectable levels were well below SA EPA (2003) standards for Potable Water, Aquatic Ecosystems (Marine) or Aquatic Ecosystems (Fresh).

#### **4.3.3.6 PAH's**

The PAH criteria value specified by the SA EPA is known to be the limit for benzo-a-pyrene. No other values are specified. The laboratory standard detection limits of reporting for PAH's are higher than this SA EPA guideline value and higher than some of the ANZECC (2000) and Dutch Intervention Levels values but all samples analysed from the Buckland Park site came back at below the laboratory standard detection limit of reporting.

#### **4.3.3.7 OCP's**

Similarly, all samples analysed for organochlorine pesticides came back at below the laboratory standard detection limits of reporting, although for some individual analytes this limit was above the available guideline value.





#### **4.3.3.8 Phenoxyacetic Acid Herbicides**

The SA EPA does not nominate a limit for PAH under Potable, Irrigation, Livestock or Aquatic Ecosystem guidelines. Dutch Intervention Levels state a limit of 50 µg/L for MCPA. All samples analysed from the Buckland Park site were returned at levels below this standard.

#### **4.3.4 Analytical Data Quality**

The quality of analytical data produced for this project has been assessed with reference to the following issues:

- sampling technique;
- preservation and storage of samples upon collection and during transport to the laboratory;
- sample holding times;
- analytical procedures;
- laboratory limits of reporting;
- field duplicate agreement;
- laboratory quality assurance/quality control (QA/QC) procedures; and
- the occurrence of apparently unusual or anomalous results.

Laboratory QA/QC procedures and results are detailed in the certified laboratory results contained in Appendix F. A summary of the data quality assessment and a summary of the field duplicate sample relative percentage differences are included as Appendix G.

All samples were collected, stored and transported to the laboratory in accordance with standard REM protocols which are consistent with the requirements of Schedule B(2) of the NEPM (NEPC,1999). Laboratory analysis was undertaken within specified holding times and in accordance with National Association of Testing Authorities (NATA) accepted analytical procedures and the requirements of Schedule B(3) of the NEPM (NEPC,1999).

Laboratory quality control information indicates an acceptable degree of QA/QC information was collected and reported and the data provides confidence in the accuracy and precision of reported results.

Relative Percentage Differences (RPD's) were elevated for a range of analytes in some samples. The discrepancy is not considered significant in the interpretation of the results as the results were either close to the limit of reporting where precision is somewhat comprised or the absolute differences between reported concentration results were quite small. The remaining elevated RPD% of field duplicates were within acceptable limits giving confidence to the values reported by the primary laboratory.

Overall, the accuracy and precision of analytical data is considered suitable to form a basis for interpretation of results for the purposes of this assessment.



The Limit of Reporting (LOR) for some analytes in some samples was increased due to matrix interference as a result of high sample salinity. Increased LORs occurred for Ammonia, Metals and Phenoxy Acid Herbicides.

Three intra-laboratory duplicates (MW2, MW7 and MW11) and two inter-laboratory duplicates (MW7 and MW11) were undertaken as part of the sampling activities. For MW11 the primary and intra-lab duplicate samples were lost en-route to the lab for all analytes except TPH and BTEX. Two intra-lab duplicates and one inter-lab duplicate have therefore been reported, with the exception of TPH and BTEX for which all duplicates undertaken have been reported.

Elevated RPD's were identified between the primary (ALS) and the intra-laboratory duplicate (ALS) and the inter-laboratory duplicate (Labmark) for the following analytes:

- Nitrate between the primary and intra-lab duplicate samples for MW7. However, the detected concentrations are close to the LOR and are well below the relevant guideline values for nitrate.
- Total phosphorous between the primary and the intra-lab duplicate samples for MW2, however, the detected concentrations are close to the LOR so the actual exceedance is considered marginal. Total phosphorous between the primary and inter-lab duplicate samples for MW7, however, the exceedance is considered relatively small and neither value exceeded any of the relevant guideline values.
- Reactive phosphorous between the primary and the intra-lab duplicate samples for MW7, however, the exceedance is marginal and the reported values are close to the LOR and well below the relevant guideline values.
- Lead between the primary and intra- and inter-laboratory duplicates for W7. The intra- and inter-laboratory samples are more similar to, and considerably lower than the primary sample, thus placing the validity of the primary sample into question. It is likely that the actual lead concentration is lower than the value reported for the primary sample.
- Zinc between the primary and inter-lab duplicate samples for MW7. Also zinc between the primary and intra-lab duplicate samples for MW2.
- Toluene between the primary and intra-lab duplicate samples for MW2. However, the reported values are near or below the LOR and well below the relevant guideline value.

#### **4.4 On-going Investigations: Nutrient and Contaminant Impacts**

Further works are currently being undertaken to determine sources of potential nutrient and contaminant impact to groundwater within the site. Further works are also being undertaken to assess nutrient and contaminant levels in groundwater from the existing groundwater monitoring wells. The results and findings of these works will be reviewed by SKM's Victorian EPA Environmental Auditor (Contaminated Land), Mr Don McCarthy who will also prepare the necessary technical responses to the Development Assessment Commission in relation to the questions previously posed with respect to contaminant and nutrient loads and any risk(s) to the receiving marine environment.



## 5 Numerical Groundwater Flow Model

### 5.1 Overview

A numerical groundwater flow model was constructed based on available existing information and new information generated from site specific field investigations as part of this project. The model was calibrated in steady-state to measured groundwater levels across the site and surrounding nearby area.

The numerical model was designed to examine the effect of changes to the shallow watertable as a result of Buckland Park construction and activities.

### 5.2 Conceptual Hydrological Model

The conceptual model for the site hydrogeology is based upon interpretation of available geological and hydrogeological information including bore logs and groundwater level data. New information provided by the installation of groundwater monitoring wells and aquifer testing data has formed an important part of the conceptual model development.

#### 5.2.1 Aquifer Structure

The shallow groundwater system exists in Quaternary aged sediments associated with alluvial outwash deposits. Sediments comprise discontinuous beds and lenses of clay, silt and sand, with clay being the dominant soil type across most of the study area. The shallow groundwater system is assumed to be hydraulically continuous laterally, although with varying degrees of permeability. The modelled sequence is assumed to have a nominal thickness of 20 m, with the extensive occurrence of underlying clayey material acting as an aquitard.

Groundwater occurs variably in sand lenses between more clayey sediments and this may occur at multiple levels in the vertical dimension at any given location. However, these lenses of more permeable sediments are not continuous across the study area. In the context of this modelling exercise, it was not realistic to attempt to fully define the soil lithology in three dimensions. Rather, the 20 m thick profile was nominally divided into the three layers of 0 – 5 m, 5 – 10 m and 10 – 20 m bgl. The available lithological logs for the study area were then simplified by assigning a dominant soil type to each of these three intervals, as shown in Figures 5.1, Figure 5.2 and Figure 5.3. A spatial interpretation of the dominant soil types for each layer was then used to define the soil hydraulic properties in the groundwater flow model.

#### 5.2.2 Groundwater Flow

The general groundwater flow pattern across the study area generally mimics the shape of the land surface dropping down towards the coast. Groundwater flows from the higher land in the southeast and east toward the coast to the southwest and west. Groundwater flow is controlled primarily by the permeability of the aquifer and recharge and discharge processes. Local variations in the flow pattern can occur in areas where additional recharge occurs from irrigation practices, water holding in unlined dams, or river flooding events. The flow gradients are steeper to the east where the topographic gradient is also steeper. The flow gradient is minimal on the low lying land near the coast. This condition is probably influenced to some extent by the presence of the salt lakes adjacent to the southwest of the site, which are held at a level above that of the surrounding groundwater.



### 5.2.3 Recharge Processes

The primary source of recharge to the watertable aquifer in the study area is infiltration of rainfall during periods when rainfall is in excess of evapotranspiration in the winter period. This concept is supported by historical water level gauging data from nearby existing wells which show seasonal fluctuations in groundwater levels consistent with an aquifer that is fed by diffuse rainfall recharge. In a temperate to semi arid climate, like that of Buckland Park, groundwater recharge is typically in the order of 2 – 5 % of annual rainfall. With an average annual total of 442 mm, the estimated annual recharge could be expected to be around 9 – 22 mm/yr. Although the amount of actual recharge would also be affected by soil type, with more clayey soils slowing the infiltration rate of water and reducing the amount of effective recharge. This may well be the case at Buckland Park, where clay occurs extensively in the soil profile.

Additional recharge could be derived from high flows and overbank flooding of the Gawler River. Available information on the river flow regime indicates that this occurrence is somewhat irregular, but such events would provide a significant volume of water for recharge to the shallow aquifer.

Recharge derived from infiltration of excess irrigation waters or leakage from unlined irrigation water holding dams could also occur in localised areas. The extent or significance of this source is not clear, but some areas of local groundwater mounding are evident in the groundwater level data collected from the site.

Where the shallow groundwater flow system is laterally extensive, groundwater inflows can occur from up-gradient and off site. Given that lateral groundwater flow is predicted to occur from northeast to southwest there is likely to be zones of lateral inflow within the aquifer along the eastern and northern boundaries of the site.

### 5.2.4 Discharge Processes

Groundwater discharge from the watertable aquifer can occur by mechanisms including evaporation directly from the watertable, transpiration by plants, lateral outflow along the flow gradient, baseflow to rivers and drains and extraction by pumping.

Evaporation of groundwater occurs where the capillary fringe zone<sup>1</sup> of the watertable intersects the ground surface. The height of the capillary fringe zone, also known as the evaporation extinction depth, above the watertable varies with soil type, with clayey soils having a higher extinction depth than sandy soils. For this modelling exercise a uniform evaporation extinction depth of 2.3 m has been adopted across the study area. The climate of the study area is one in which potential evaporation exceeds rainfall for most of the year and the average annual potential pan evaporation of 1860 mm exceeds the average annual rainfall by more than four times. Given that a considerable portion of the site is at low elevations and

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<sup>1</sup> The capillary fringe is the zone immediately above the watertable into which water may be drawn upward as a consequence of surface tension forces between the water and the soil particles, known as 'capillary action'. When the capillary zone intersects the soil surface water can move to the soil surface via the effects of surface evaporation and dissolved salts, which are not removed by evaporation, may become concentrated at the soil surface.



groundwater levels are very shallow, there is likely to be significant discharge as a consequence of evaporation.

Transpiration of shallow groundwater by vegetation is an important mechanism of groundwater discharge, particularly where deep rooted plants such as native vegetation, orchards or lucerne are present. Recent aerial photography of the site combined with on-site observations indicates that:

- Olive groves are situated adjacent to the northern section of the western boundary of the site;
- Old growth gum trees are scattered across the northern portion of the site, with highest density along the Gawler River; and
- Irrigated agriculture (market gardening) is present in the central portion of the site and along the eastern boundary.

The concepts of evaporation and transpiration are often simplified and considered together as evapotranspiration. A single value is assigned to represent the effective rate of discharge due to these two mechanisms. Evapotranspiration was set at 500 mm/yr for this modelling exercise.

Where the shallow groundwater flow system is laterally extensive, groundwater outflows can occur down gradient and off site. Given that lateral groundwater flow is predicted to occur from northeast to southwest there is likely to be zones of lateral outflow within the aquifer along the western and southern boundaries of the site.

Baseflow of groundwater into the Gawler River, Thompson Creek and the various drainage channels on and around the site is likely to be an appreciable component of groundwater discharge from the site during times when the watertable is elevated above the bed elevations of these features. Field observations made by REM staff indicate that this condition occurs variably across the site and is most common in the low lying areas where groundwater is naturally very shallow.

Extraction by pumping is assumed to be a negligible component of groundwater discharge because the watertable aquifer typically does not provide sufficient water volume or quality to warrant such usage.

### **5.2.5 River-Aquifer Interaction**

The Gawler River is the main hydrological feature affecting groundwater conditions in the study area. The river is ephemeral and only flows following large sustained rainfall events through winter. During these times the river would act as a 'losing stream' meaning that water from the river would recharge into the shallow aquifers, the water levels of which are typically below the river bed. It is possible that there could be a period following sustained wet winter conditions that the river could become a 'gaining stream' for a short period as groundwater discharges from elevated levels in the shallow aquifer in the process of restoring the usual equilibrium.

### **5.2.6 Influence of Salt Lakes and Drains**

The two salt lakes located to the southwest of the site are managed features and are operated with pool levels above that of the surrounding groundwater levels. It is understood that the northern of the two lakes



is held at a level of about 2.85 m AHD and the southern lake is held at about 3.25 m AHD. A network of surface drains surrounding the lakes is intended to provide some management of the ingress of this high salinity water onto the surrounding land. Field observations by REM staff indicate that these drains are probably effective in intercepting some of the discharge caused by mounding beneath the salt lakes, but the flow gradient in the drains is so low that it is unlikely that much of this water moves away from the area. Sampling of monitoring wells installed on the site adjacent to the salt lakes showed that groundwater is hyper saline in that area, and indicates that significant evaporative concentration of salt in the water is occurring in the area. That is water is being discharged by evaporation but salt is left behind causing an increase in the concentration in the remaining water.

Field observations also indicate that the Thompson Creek bed has been deepened and enlarged in places to act as more of a groundwater drain for the surrounding low lying land. This was observed on the south sector west and south sector of the site.

### **5.3 Numerical Model Development**

The MODFLOW software package developed by the United States Geological Survey (MacDonald and Harbough, 1988) was used to simulate steady state, saturated groundwater flow conditions, and Visual MODFLOW software (Waterloo Hydrogeologic Inc., 2001) was used to pre- and post-process the MODFLOW data files.

MODFLOW is a finite difference code that is generally accepted as the industry standard for groundwater flow modelling, and it has a number of sub-routines that enhance its applicability to situations where drainage and groundwater - surface water interactions are important.

Model set up figures detailing the model grid configuration and profile, boundary conditions, recharge zones, evapotranspiration zones and hydraulic conductivity values and model calibration are contained in Appendix H.

#### **5.3.1 Geometry**

The model covers an area of approximately 12 km wide and 15 km long that is centred on the area proposed for development at Buckland Park. The model is oriented in a northeast – southwest alignment to match the regional groundwater flow path towards the coast.

The nominal grid dimensions across the model domain are approximately 290 x 280 m. Grid cells have been refined down to approximately 29 x 28 m square within the site area proposed for development at Buckland Park.

The shape of the land surface was interpolated onto the model grid from the available elevation contours using the Surfer™ program. The three layered aquifer system, conceptualised for this modelling exercise, was defined firstly by importing the elevation data for the top of the Glanville Formation as the base of Layer 1. This is the marine sedimentation underlying the St Kilda Formation to the southwest of the site. For the remainder of the area, Layer 1 and Layer 2 of the model were defined with a uniform thickness of 5 m, following the shape of the land surface. The base of Layer 3 was defined by subtracting 20 m from the surface elevation data, giving it a nominal thickness of 10 m.



### 5.3.2 Aquifer Properties

Hydraulic conductivity values were assigned for each dominant soil type based on experience and the results of the aquifer testing conducted on the 11 new wells installed by REM into the shallow aquifer. Variable hydraulic conductivity was captured in three zones based on interpretation of available lithological information representing, in a simplified way, the varying hydraulic properties of clay, silt and sand. Initial conductivity values were increased during the process of achieving a steady state model calibration in order to balance with the expected recharge rate. The three conductivity zones of the model are 0.75, 1 and 3 m/d (See Appendix H Figures H3, H4 and H5).

Although not specifically used in the steady state model, appropriate aquifer storage values were assigned to each of the three zones.

### 5.3.3 Boundary Conditions

Constant Head boundaries were assigned to all layers at the up gradient and down gradient edges of the model. At the down gradient end a constant head boundary of 0 m AHD was assigned to represent sea level, while at the up gradient edge a constant head boundary of variable elevation was defined by the shape and elevation of the interpreted groundwater level contour. The constant head elevation graded from 14 m AHD in the south to 10 m AHD in the north.

The MODFLOW Rivers Package boundary condition was used to represent the salt lakes to the southwest of the site. Bed elevation was defined at 2 m AHD from interpretation of available ground surface elevation data and a pool level of 0.5 m above the lake bed was assigned. These details differ somewhat from the information that was provided by the salt lake operator Cheetham Salt, but in the context of this modelling exercise it was necessary to have the levels fit in with the rest of the model data. Bed conductance for the salt lake was set at the low value of 0.001 to represent a low permeability clay liner for the lakes.

The MODFLOW Drains Package boundary condition was used to simulate the Gawler River, Thompson Creek and the drains surrounding the salt lakes. Bed elevations were defined from interpretation of the ground surface elevation data using linear gradients between the known end points. Bed conductance for the drain features was set at 1 to represent a permeable bed that can easily transmit water.

Recharge was applied to the model domain at a uniform rate of 6 mm/yr to simulate rainfall recharge, and evapotranspiration was applied at a maximum rate of 500 mm/yr to simulate the combined effect of evaporation from the groundwater table and transpiration from vegetation. A uniform extinction depth of 2.3 m below ground level was used. These rates are consistent with the average annual rainfall and pan evaporation data published by the Bureau of Meteorology.

### 5.3.4 Model Assumptions

The following key assumptions have been made in undertaking this steady state modelling exercise:

- The watertable aquifer system occurs in the upper 20 m of the sediment profile and is effectively isolated from the deeper aquifers by an extensive clay aquitard;
- The water level at the up-gradient boundary of the model domain is constant;





- The formations in the modelled profile provide a continuous flow path for groundwater across the model domain, although formation permeability and hence the rate of flow does vary;
- Simplification of variability in the soil profile into the three modelled layers provides reasonable average of soil permeability and effectively represents the hydraulic groundwater flow.
- The Gawler River and Thompson Creek act primarily as groundwater drains;

### 5.3.5 Model Calibration

The groundwater flow model calibration was undertaken by making reasonable iterative adjustments to model parameters to achieve a close match between predicted and observed groundwater levels. The steady state model was calibrated to a data set of 48 water level measurements from individual wells on and around the site. The data comprised a primary set of wells, including the new wells installed by REM and a selection of existing wells that were gauged on 7 February 2008, combined with a secondary set of wells that had been gauged in March 2007 to provide a broader coverage of data for interpretation. These points were imported into the model as observation wells and modelled results were compared to this data as predicted versus observed values. A model calibration error (mean relative error) of 6.8 % was achieved (See Appendix H Figure H9).

## 5.4 Model Results

### 5.4.1 Predictive Scenarios

#### 5.4.1.1 Scenario Overview

Four predictive scenarios were developed to model the future impact of the Buckland Park proposal. These scenarios take into account the steady-state nature of the model. Modelling time varying inputs is beyond the capacity of the model and a separate spreadsheet model was developed to account for the build-up of groundwater beneath stormwater retention ponds. Results from the numerical modelling are reported as the difference in groundwater head between scenarios.

A number of assumptions are made in order to model the hydrological features at the site.

- The new drainage network for the proposal can be represented using the MODFLOW Drains package. This is consistent with the development of the calibration model. With the relatively dry climate at the site, periods of flooding are likely to be infrequent and short. The impact of flood events on groundwater levels is likely to be temporary.
- Recharge beneath the developed area will be reduced due to the presence of paved areas. These paved areas will form a patchwork across the site and in order to simulate this a reduction in recharge is applied across the whole site in order to average out the effect. A visual estimate of the proposal masterplan indicates that approximately 50% of the land surface under development will be paved. This is assumed to have the effect of reducing recharge in this zone by 50%.
- Evapotranspiration beneath the development will be reduced due to the presence of paved areas. The paved areas will form a patchwork of zones with no evapotranspiration across the site and a uniform reduction in the maximum evapotranspiration rate has been applied to



account for this. However, residential gardens are likely to comprise more deep-rooting vegetation. This will lead to an increase in evapotranspiration on the vegetated areas. The assumed net effect of the development on evapotranspiration is an overall reduction of the maximum evapotranspiration rate of 30%. A complicating issue is that although the maximum evapotranspiration rate has been reduced this only applies where the depth to water table is less than the extinction depth.

- Stormwater retention will occur in a detention basin at the downstream end of the new drainage network. This is predicted to contain water at a depth of approximately 1m for several days after rainfall events and the detention time will vary depending on weather conditions. The steady-state model is not capable of modelling these fluctuating conditions and the impact of the detention pond will be modelled separately using a spreadsheet model.
- The predicted 0.3 m rise in sea level is modelled by raising the groundwater level in the constant head boundaries representing the current coastline. Data relating to the predicted average sea level coastline from geomorphic modelling was not available and it is assumed that the numerical groundwater model will respond in a realistic manner as a result of raising the constant head boundaries.

#### **5.4.1.2 Baseline Scenario: No Development, Current Climate**

The baseline scenario models the conditions prior to development and provides the basis with which to compare the other scenarios. This is represented by the model as calibrated and has the following boundary conditions:

- 6 mm/yr of uniform recharge across the model;
- Gawler River, Thompson Creek and existing groundwater drains represented using the MODFLOW Drains package;
- The Cheetham Salt Pans represented using the MODFLOW Rivers package with a constant pool of surface water of 0.5 m and a low permeability bed;
- Sea level set at 0 m AHD elevation and modelled at the coastline's present location based on interpretation of aerial photographs; and
- Upgradient (regional) groundwater levels controlled by constant head boundaries.

#### **5.4.1.3 Scenario A: No Development with Climate Change**

In order to assess the relative impact of the individual components it is necessary to determine the incremental difference to groundwater levels as a result of a sea level rise due to a change in climate. On the basis of the International Panel on Climate Change projections, the Coast Protection Board recommends a mid-range sea level rise of 0.3 m by the year 2050 be adopted for coastal planning and design (Coast Protection Board 2004). It is noted that, while the effects of a sea level rise have been modelled, the Buckland Park site lies outside the jurisdiction of the Coast Development Board and regulatory controls do not apply to the development.

Scenario A maintains the same boundary conditions as the baseline scenario with the addition of:



- Constant Head Cells at the current coastline set at 0.3 m AHD.

#### 5.4.1.4 Scenario B: Development with Current Climate

The Buckland Park proposal will introduce a set of new conditions at the site. These will include the construction of roads and housing and the installation of drainage and stormwater detention ponds. These have been represented in the model by:

- Reducing recharge beneath the development footprint by 50% to 3 mm/yr;
- Reducing maximum evapotranspiration beneath the development footprint by 30%;
- The new drainage network modelled using the MODFLOW Drains package; and
- Stormwater retention modelled separately using a spreadsheet model to determine radial extent of impact.

#### 5.4.1.5 Scenario C: Development with Climate Change

The total impact on site of the Buckland Park development and the results of a sea level rise due to climate change (in 2050) are modelled in scenario D. This is achieved by combining the boundary condition changes for scenario B and scenario C. These include:

- Reducing recharge beneath the development footprint by 50% (3 mm/yr);
- Reducing maximum evapotranspiration beneath the development footprint by 30%;
- The new drainage network modelled using the MODFLOW Drains package;
- Stormwater retention modelled separately using a spreadsheet model to determine radial extent of impact; and
- Constant Head Cells at the current coastline set at 0.3 m AHD.

### 5.4.2 Modelled Groundwater Levels

#### 5.4.2.1 Baseline Scenario

The results of the baseline scenario (the calibration model) are presented in Figure 5.4. The modelled contours grade from east to west across the model and are in reasonable agreement with measured groundwater levels (Figure 5.5)

#### 5.4.2.2 Scenario A: No Development with Climate Change

The groundwater response to this scenario is shown in Figure 5.6. This figure represents the difference between the baseline scenario and scenario A as a result of no change in recharge or evapotranspiration and a 0.3 m rise in sea level.

The results indicate that impacts to groundwater from sea level rise associated with climate change are limited to the coastal zone. Raised groundwater levels are largely restricted to the zone west of the salt lakes which, given the projected rise in sea level, is likely to be either inundated or within the littoral zone. Outside of this area there are minor rises in groundwater beneath the salt lakes.



#### **5.4.2.3 Scenario B: Development with Current Climate**

The groundwater response to scenario B is shown in Figure 5.7. This figure represents the difference between the baseline scenario and scenario B resulting from a 50% reduction in recharge and a 30% reduction in evapotranspiration beneath the development footprint and no change in sea level.

The impacts on groundwater levels arising from the development are largely contained to within the Buckland Park site boundary. There is minimal impact on areas outside of the development. Groundwater levels beneath the development footprint are either reduced (increasing the depth to water table) or neutral in comparison to the baseline scenario. The area displaying the greatest falls is located in the north sector of the site south of the Gawler River.

#### **5.4.2.4 Scenario C: Development with Climate Change**

The groundwater response to scenario C is shown in Figure 5.8. This figure represents the difference between the baseline scenario and scenario C resulting from a 50% reduction in recharge and a 30% reduction in evapotranspiration beneath the development footprint and a 0.3 m rise in sea level.

The impacts on groundwater levels under this scenario are two-fold and occur in spatially discrete zones of the model. The impacts of sea level rise as a result of climate change are again restricted to the zone west of the salt lakes with some raised groundwater levels beneath the salt lakes. There is a clear spatial separation between the impacts of sea level rise and the impacts occurring from the development. The developmental impacts on groundwater level result in a decline in groundwater levels beneath the development site. The greatest decline in groundwater levels is observed in the northern sector of the site south of the Gawler River.

#### **5.4.2.5 Discussion of Numerical Modelling Results**

The results from each of the scenarios indicate that there are limited impacts arising from either the development or sea level rise associated with climate change. In particular the effects of a 0.3 m sea level rise do not impact on the proposal site and are largely restricted to the coastal zone and salt lakes. A further 0.7 m rise in sea level to 1 m AHD is likely to result in increased groundwater levels moving further inland but probably no further than the salt pans. This additional hydraulic buffer may result in a decrease in the zone of groundwater level depression beneath the development site.

The model estimates that the model creates a decline in groundwater levels centred largely on an area south of the Gawler River. The decline in groundwater levels is attributed to the assumption of a decrease in recharge beneath the development site as a result of paved areas. Where paving exists surface water cannot recharge the groundwater and hence the overall volume of recharge is reduced. Reducing recharge leads to a minor fall in groundwater levels. This is partly offset by the decrease in evapotranspiration that occurs when an area is paved. This modelling is conducted on the assumption that parks and suburban gardens will, to some extent, create additional evapotranspirational losses due to the different water use between the current vegetation (largely grassland) and suburban vegetation (with an increased number of deep rooted trees and other species). The net effect of this is an assumed 30% reduction in the maximum evapotranspiration rate. If suburban gardens are over-watered there is the potential for recharge from suburban gardens to increase and this may change the results. However, current water restrictions are likely to continue into the future and excess recharge due to overwatering is not viewed as a problem.



The occurrence of the groundwater declines in close proximity to the Gawler River may result in decreased flows within the river as there is an increase in the potential for the stream to lose water due to the increased difference in head between the river and the groundwater. The degree of change beneath the development is minor and therefore, while the potential exists for reduced winter flows in the Gawler River, it is unlikely that the groundwater level decline will impact significantly. Surface water/groundwater interactions have not been explicitly modelled within this study.

### 5.4.3 Modelled Stormwater Retention

Stormwater retention was specifically excluded from the numerical modelling. This was due to the fact that stormwater basin filling and emptying cycles depend on the variable nature of rainfall and runoff within the natural system. This variability cannot be effectively modelled within the steady-state model. Instead the impact of stormwater retention within the detention basin is modelled using a spreadsheet model. This is based on the Hantush formula for determining the groundwater level in a bore from the well-function.

A number of assumptions are made:

- The formula assumes a point source of recharge; and
- A circular pond of a set radius.

A summary of stormwater retention scenarios is presented in Table 5.1.

#### 5.4.3.1 Stormwater Retention Scenarios

The details of operation of stormwater retention at the Buckland Park site have not been determined as yet. Rainfall/runoff modelling has not been conducted nor an operation plan formed as the engineering works are in the design phase. A range of scenarios were examined to model the impact of retaining water within the detention pond. These largely relate to the use of a pond liner to prevent leakage from the base of the pond and to the residence time of water within the pond.

- **Ornamental Pond**

The design of the stormwater system is to collect and dispose of surface water runoff. The Buckland Park design plans indicate a series of ponds and wetlands. This scenario is designed to account for the presence of an ornamental pond rather than a disposal basin. Water is maintained in the pond to a depth of 1m all year and options are examined for a lined or unlined pond which affects the amount of recharge to the water table through the base of the pond.

- **Winter Retention**

This scenario is designed to model the situation if there are significant rainfall events over winter. Surface water will be maintained in the detention pond and may be periodically refilled by further rainfall events lengthening the retention time of water in the pond. The three months of winter (90 days) are modelled with options for a lined or unlined pond which affects the amount of recharge to the water table through the base of the pond.



- **Month Long Retention**

An intermediate scenario is modelled that represents increased rainfall that occurs sporadically throughout winter leading to a retention time in the basin of one month (30 days) with options for a lined or unlined pond which affects the amount of recharge to the water table through the base of the pond.

- **Single Event**

The designed detention time for a single event is 10 days. This has been modelled with both a lined and unlined pond which affects the amount of recharge to the water table through the base of the pond.

#### **5.4.3.2 Stormwater Retention Modelling Parameters**

Parameters used in the modelling of stormwater retention are shown in Table 5.1. The design plans indicate that there are up to three ponds grouped together. The model assumes a circular pond with a point source of recharge located at the centre.

- The area of the ponds provided is 15 ha, which equates to a pond radius of 218m;
- The model is 20 m thick;
- Observed groundwater levels adjacent to the proposed detention ponds indicate a depth to groundwater of 2.2 m;
- An hydraulic conductivity value of 3 m/day is used as indicated in the numerical model; and
- An assumed specific yield of 0.01 is consistent with the geology.

#### **5.4.3.3 Detention Pond Recharge Estimation**

One of the critical inputs into the model is the estimate of recharge for leakage from the detention pond to the watertable. Leaky lined dams are estimated as having more than 2 mm/day of leakage through the dam walls (Coles 2003). A conservative estimate of pond leakage is applied here for the lined scenarios of 0.5 mm/day. For unlined ponds the rate of leakage or recharge is less well constrained and depends on the properties of the soil from which they have been constructed. It is assumed here that the detention pond will be constructed from soils derived from the top 5 m of the geological profile and therefore have an equivalent hydraulic conductivity to the top layer of the model (3 m/day). Darcy's Law was applied to determine the flux across the base of the pond and assumed:

- $k=3$  m/day
- $i=0.005$
- $A=150\,000$  m<sup>2</sup>

Darcy's Law gives:  $Q = kiA = 2250$  m<sup>3</sup>/day  
 $= 821250$  m<sup>3</sup>/yr

This is equivalent to a recharge rate of :



$$\begin{aligned} R_r &= Q/A = 821\,250/150\,000 \\ &= 5.475 \text{ m/yr} \\ &= 0.015 \text{ m/d} \end{aligned}$$

This value has been used to simulate the recharge through the base of an unlined detention pond.

#### 5.4.3.4 Stormwater Retention Modelling Results

The results of the spreadsheet modelling of stormwater retention are presented in Figures 5.9 and 5.10 and Table 5.2.

Results indicate that for a lined pond there is little impact on groundwater levels in the surrounding aquifer but for an unlined pond there is significant groundwater mound build-up beneath the pond.

For a lined pond the highest degree of mound development beneath the pond is 0.62 m (Figure 5.10) for a permanent ornamental pond. The majority of this impact (>0.2 m) occurs within 1000 m of the centre of the pond.

For an unlined pond even at the shortest detention time there is mound build-up beneath the pond. The unsaturated thickness of the aquifer in this region is 2.2 m and mound build-up is in excess of this under all scenarios. The spreadsheet model does not account for groundwater levels breaching the surface and returning to the surface water system, as such the spreadsheet model predicts unrealistically elevated mound build-up levels that must be interpreted as the watertable rising to ground level. Once the watertable has risen to above the base of the pond, the pond would cease to lose water to the groundwater system and would collect groundwater. The spreadsheet model also assumes a continuous supply of water to feed the recharge rate. Therefore it is concluded that even at the lowest retention time designed for the pond, it will become a gaining system.

The radius of impact for the different scenarios increases with detention time. If a 1m rise in groundwater level is considered a significant impact then for an unlined pond the radius of *significant* impact (>1m rise) occurs at approximately:

- 450m (10 days);
- 750m (30 days);
- 1600m (90 days); and
- 3000m (365 days).

It must be stressed that these calculations provide indicative estimates of impacts only. The results will be highly sensitive to assumptions regarding aquifer properties such as the specific yield, which can vary over short distances. The results indicate that further investigation of the impacts may be required once the detail design of the ponds has been undertaken.

The potential impact of unlined ponds is likely to be over-estimated given that a skin of silty material will most likely exist at the base of the pond which will act as a barrier to leakage. Leakage will also be buffered by evaporation which will reduce the rate of mound buildup.





#### **5.4.4 Stormwater Detention Impacts on Groundwater Salinity**

The stormwater retention modelling demonstrates that in an unlined detention pond there would be build-up of groundwater beneath and surrounding the pond. This will form a fresh water lens that sits on top of the regional saline groundwater. A degree of mixing will occur at the edges of the mound. It is inferred from the modelling that wherever surface water pools in the landscape (such as in the channels or detention ponds ) and groundwater levels lie below the base of the channel/pond there is the potential for the channel/pond to lose water to the groundwater system and for a mound to develop. This mound will have the effect of diluting salinity in areas around these drainage features. This is minimised where a lining is used on the channel or pond.

#### **5.5 Conclusions**

The results from the numerical model demonstrate that there will be negligible impacts from sea level rise due to climate change and that impacts arising from sea level rise will occur off-site. The impacts from the development will be to reduce groundwater levels beneath the development site by a minor amount due to a decrease in recharge and evapotranspiration losses. A reduction in groundwater levels of 0.2m or less can be considered to be insignificant and unlikely to be discernable from climate driven groundwater level fluctuations.

In terms of stormwater retention at the downstream end of the drainage system, where shallow watertables are encountered, it is probable that if the detention pond is unlined it will recharge the groundwater system until groundwater levels rise to a level equal with the surface water levels. If surface water levels are subsequently lowered, groundwater will then drain back into the detention ponds. An unlined pond results in rises in groundwater in the region surrounding the pond and would have an increased level of risk associated with it. The spreadsheet modelling indicates that a lined pond would have a lower level of risk associated with it raising groundwater levels by a minor amount in a localised area.

It must be stressed that these calculations provide indicative estimates of impacts only. The results will be highly sensitive to assumptions regarding aquifer properties such as the specific yield, which can vary over short distances. The results indicate that further investigation of the impacts may be required once the detail design of the ponds has been undertaken. Additional data will be needed to determine aquifer properties near the proposed ponds.



## 6 Potential Impacts of Development

### 6.1 Engineering Impacts

There are a range of engineering issues relating to impacts of specific activities on the groundwater conditions at the site during development operations. A discussion of these is provided in this section.

Without specific operational information it is difficult to assess in detail the likely impact on groundwater during operations. However it is possible to make some general statements relating to the impacts from works on the site.

#### 6.1.1 Groundwater Protection Measures During Operations

Groundwater flow is from northeast to southwest across the study site. Changes to this groundwater flow regime may impact on the coastal environments and Gawler River. The likely cause of disruption to groundwater flow is considered to be from groundwater extraction for the purposes of deep trenching operations. This would entail extraction of groundwater in the trenching zone, lowering the watertable to enable trenching to occur coupled with water retention ponds. The impact of a falling watertable in the study area will greatly depend on the location of the fall.

Retention of groundwater in ponds is a likely adjunct to groundwater extraction as the groundwater extracted is likely to be of high salinity and hence inappropriate for discharge to either the Gawler River or the coast under the Natural Resources Management Act 2004. This will require construction of retention ponds. There will be a degree of seepage through the base of the ponds that is dependent on their construction. Contingent on the location of the ponds high salinity seepage to the watertable may occur through build-up of a groundwater mound beneath the pond over the longer term and the development of a groundwater gradient from this mound causing groundwater flow and discharge to the river or coast. The resulting high salinity discharge to a receiving environment may impact negatively on these environments. Impacts of this type may be diminished by the use of pond linings and careful selection of pond sites in relation to the riverine and coastal environments.

#### 6.1.2 Effects of Waterway Construction

The construction of wetlands and parks is a high-profile part of the Buckland Park development. This will involve the construction of waterways and retention ponds which will have an impact on groundwater. A new drainage system is proposed in order to mitigate flooding problems associated with extreme flows down the Gawler River. The worst case flood scenario is predicted to flow along Thompson Creek south of Park Road (Connell Wagner 2007). Floodways are proposed to be constructed in this area and also along the western boundary of the Buckland Park Site.

Issues relating to these locations are similar to the construction of temporary retention ponds. However rather than highly saline seepage these areas are likely to experience low salinity seepage as per the stormwater retention spreadsheet monitoring. Any form of seepage will result in the development of a groundwater mound beneath permanent bodies of water. However, in the case of low salinity water this may be seen as beneficial. Due to density differences low salinity water will float on top of high salinity water and form a groundwater lens. This fresh water lens may provide sufficient underground fresh water to support ecosystems that would not survive under the current high salinity groundwater regime. In effect



the ponds and wetlands may create a fresh water buffer surrounding them that supports trees and shrubs. Alongside this effect will be a concurrent rise in the water table in these areas. This will have the effect of forcing water away from the groundwater mound developed beneath the wetlands where it will appear as high salinity discharge to these water bodies. In addition the presence of the wetlands will contribute to rising water tables. In this area, with a shallow water table, any rise is considered likely to exacerbate already occurring dryland salinity problems as the water table enters the evapotranspiration zone and salts become concentrated in the soil profile near the land surface.

### **6.1.3 Engineering Requirements for Infrastructure**

Detailed design of engineering infrastructure is outside the scope of this initial stage of works. Without further information regarding the location of proposed development and infrastructure it is not possible to develop specific requirements for engineering solutions. However, it is possible to comment on some options available.

Small scale salt groundwater lowering schemes can be used to mitigate groundwater mounding. These schemes could involve using spear points to collect water and distributes the collected high salinity water to a disposal basin. A similar scheme might potentially be used along proposed waterways. This may not be required if deep rooted perennial vegetation can be established in the fresh water lens developed along the waterways to mitigate the impact of lateral movement of saline groundwater on vegetation health.

Groundwater drainage is another option to be considered. The installation of a drainage network through the area would prevent the watertable from rising above the level of the drains. This would require the development of a disposal basin for drainage.

A further method to be considered would be to construct a groundwater disposal scheme to actively induce a cone of depression beneath the site lowering water tables regionally and adjusting the groundwater flow regime. Such a system would be susceptible to seawater intrusion and baseflow losses from the Gawler River.

In all cases there is a need to dispose of high salinity water to a disposal basin. The location of a retention pond to concentrate high salinity water in the vicinity of the engineering works would be required.

Although there is the potential to negotiate the use of Cheetham Salt evaporation ponds as a disposal site it is considered unlikely that an active groundwater disposal scheme will be required. If a groundwater disposal scheme were to be developed this would require a separate application and environmental management plan to be developed.

## **6.2 Salinity Impacts**

### **6.2.1 Introduction**

The modelling undertaken to assess changes to shallow groundwater levels assumes that recharge across the whole of the development footprint will reduce due to the presence of large paved areas and higher water use from gardens and parks.



However there is a potential for other impacts to occur if poor irrigation practices in residential and recreational areas were poor. Under this scenario excess irrigation water would percolate to the watertable causing a rise in levels or percolate downward to low permeability clay and form a perched layer of water. In either of these cases there is a risk of waterlogging and/or salinity problems.

This part of the analysis identifies where salinity impacts may occur under this scenario.

Salinity occurring in an urban environment is commonly referred to as ‘urban salinity’ and occurs throughout Australia in areas where dryland or irrigation induced salinity is prevalent. Potential impacts from urban salinity include:

- Declining tree health and tree death;
- Loss of vegetation and replacement with more salt tolerant species eg. sea barley grass, samphire plants, salt bush etc.
- Poor plant growth including the development of bare patches in lawn areas, including playing fields;
- Rising damp in houses and deterioration in concrete paths and paved areas;
- Fretting of bricks and mortar and a deterioration in house foundations; and
- Corrosion of underground services and deterioration of road infrastructure;

### 6.2.2 Urban Salinity Risk Classification

In the context of residential development, the relative risk of urban salinity is provided by the combination of groundwater depth in the regional watertable aquifer and the occurrence of subsurface clay in the upper 4 m of the soil profile. The approach adopted here categorised five levels of urban salinity risk on a scale grading from low to very high and the level of management response varies accordingly. The logic behind the five risk levels is summarised as:

**Low:** Groundwater is below the threshold level of 4 m bgl and a clay layer does not occur shallower than the 4 m bgl threshold for perched groundwater potential. The resulting risk of urban salinisation is low and this would be the land most suitable for development from an urban salinity perspective.

**Moderate:** Groundwater is below the threshold level of 4 m bgl and a clay layer is present in the upper 4 m of the soil profile. While regional groundwater is not a concern in these areas, there is potential for perched groundwater to develop on top of the clay layer, which presents a considerable hazard to urban development. These areas have been assigned a moderate risk level because the hazard is relatively easy to manage with the installation of a suitable drainage system. Shallow regional groundwater on the other hand is much more difficult to manage and is therefore assigned a high or very high level of risk.

**High(a):** Groundwater is 2 - 4 m bgl and the clay does not occur shallower than the 4 m bgl threshold for perched groundwater potential. In these areas groundwater is within the zone of concern for urban development and although not currently causing salinisation, poor water management could rapidly cause the onset of saline conditions.



**High(b):** Groundwater is 2 - 4 m bgl and there is potential for perched groundwater to develop on top of a clay layer in the upper 4 m of the soil profile. In addition to the hazard of perched groundwater, regional groundwater is within the zone of concern for urban development and although not currently causing salinisation, poor water management could rapidly cause the onset of saline conditions.

**Very High:** Groundwater is less than 2 m bgl. In these areas shallow saline groundwater is an immediate threat to urban development and some land may have already become salinised. The presence of salt tolerant plant species would automatically classify the affected land with a very high level of risk. Any development in such areas must be subject to the most rigorous management approach which acknowledges the liabilities.

### 6.2.3 Urban Salinity Risk at Buckland Park

The application of this urban salinity risk classification system to the Buckland Park site is presented spatially in Figure 6.1, showing the interpreted distribution of risk classes across the site. This interpretation was produced from the depth to groundwater information for the 2 July 2008 gauging event overlain with the depth to clay information derived from the lithological data obtained from new and existing drill holes.

The interpreted salinity risk across the Buckland Park site is essentially defined by the depth to groundwater information. That is, risk levels are lowest along the Gawler River where the watertable is deepest and risk levels are highest on the low lying portions of the site, particularly in the south and west. The extensive presence of clay material in the upper 4 m of the soil profile increases the salinity risk across the site due to the potential for perched watertables to develop. This is particularly pertinent to areas where clay is in the subsurface and is overlain by a more permeable material such as sand or silt that could act as an aquifer.

Where clay is at or very near the ground surface, as delineated in Figure 4.1, the potential for perched groundwater to develop and pose a threat might not be as significant because there is not enough overlying material to hold any perched groundwater. The output of the salinity risk assessment should be considered with this in mind.

### 6.2.4 Management of Urban Salinity Risk

While most of the area proposed for development was assessed to be at moderate or higher risk of urban salinity, it is likely that development could still proceed in most areas, providing that adequate salinity management measures are adopted. An overview of selected urban salinity risk management options is provided in Appendix I.

In all cases the promotion of good water management practices such as efficient lawn and garden watering and appropriate disposal of stormwater and grey water should be encouraged. This would include stormwater management systems that ensure ponding and subsequent groundwater recharge do not occur in areas susceptible to perched or shallow groundwater. In the higher risk areas and particularly where shallow regional groundwater is a threat, efficient water use should be a key feature of the development.

If development is to proceed in very high risk areas, where shallow regional groundwater is a threat, detailed assessments and implementation of appropriate management and engineering solutions will be



required. Where there is potential for perched groundwater to develop the installation of a subsurface drainage system is may be a requirement of urban development.

Management strategies must be concerned with maintaining groundwater at a safe depth below ground level and efficient water use practices to minimise groundwater recharge. For example, imported clean fill may be used to elevate the ground surface above the groundwater capillary fringe zone. However, the potential for disruption to groundwater flow up gradient of the development must be thoroughly investigated and addressed with suitable drainage prior to implementation.

### **6.3 Climate Change**

#### **6.3.1 Climate Predictions**

Recent research work by DWLBC (Bardsley 2006) on climate change suggest that there has been a warming trend for the Adelaide region throughout the latter part of the Twentieth Century, and projected climate change studies suggest that this trend is likely to continue. The trend regarding rainfall volume, intensity and pattern for the region is far less clear, although projections suggest a drying trend in the future.

Climate change predictions of increased evaporation and altered temporal rainfall are likely to result in a reduction in baseflow to creeks and streams across the Adelaide region which has significant implications for wetland habitats and groundwater recharge.

In addition coastal management will need to respond to the impacts of climate change with a rise in sea level of between 0.09-0.88 m (Bardsley 2006). The Coast Protection Board of SA (1992) uses a projected rise of 1 m by 2100 to inform planning considerations to account for the impact of rare events associated with high tides, local flooding, wave action and storm surges. The Board is recommending that a mid-range sea level rise of 0.3m by the year 2050 be adopted for most coastal planning and design

While acknowledging that there remains significant uncertainty surrounding the probable consequences of climate change there are likely to be impacts on the Buckland Park site.

#### **6.3.2 Sea Level Rise**

The results of the numerical modelling demonstrate that the impacts of sea-level rise on Buckland Park will have some ramifications.

- Sea level rise will push the shoreline and associated processes further inland.
- As the shoreline encroaches, groundwater levels will rise as a result of the increased hydraulic pressure.
- Groundwater salinity is likely to increase along the newly established shoreline and groundwater mixing will result in increased salinity further inland.
- The higher salinity water may create density stratification as perched fresh water is raised hydraulically by underlying saline water.



- The rising watertable may have the capacity to intersect the land surface or enter the evapotranspiration zone resulting in increased dryland salinity and potential waterlogging impacts throughout the Buckland Park site.

The limit of these effects can be predicted by interpreting the change in groundwater level contours in Figure 5.6. The limit of groundwater level rises due to a 0.3 m sea level rise as a result of climate change occurs within the zone currently occupied by the salt lakes. This is outside the area occupied by the Buckland Park development, however, the zone of influence of shoreline processes and the groundwater mixing zone may encroach to the western margin of the Buckland Park site.

Engineered sea defences and drainage solutions may provide a suitable defence against these impacts. Possible techniques that reduce the impact of storm events or limit the impact of coastal inundation include sea walls, levee banks, tidal barriers, pumps and ponds.

While it may not prove necessary to use these features it is recommended that allowance is made for construction of these or similar solutions within the planning phase.





## 7 Conclusions and Recommendations

### 7.1 Conclusions

- Subsurface clays occur extensively throughout the study area at depths of less than 4 m bgl. These clays will act as an impediment to downward movement of water and, in the case where they are overlain by more permeable sediments like sand or silt, there is potential for development of shallow perched watertables to develop.
- Groundwater depth across the study area is often less than 4 m depth. In addition, problems associated with water logging and salinity are most likely to occur in areas where the depth to groundwater is less than 2 m bgl.
- The results from the numerical model demonstrate that there will be negligible impacts from sea level rise due to climate change and that impacts arising from sea level rise will occur off-site.
- The impacts from the development will be to reduce groundwater levels beneath the development site by a minor amount due to a decrease in recharge and evapotranspiration losses. A reduction in groundwater levels of 0.2m or less can be considered to be insignificant and unlikely to be discernable from climate driven groundwater level fluctuations.
- Stormwater retention in unlined ponds and channels may cause localised groundwater mounding. The development of a groundwater mound increases the level of risk from rising watertables and waterlogging. Lined ponds and channels would have a far lower level of associated risk, raising groundwater levels by a minor amount in a localised area. It must be stressed that these calculations provide indicative estimates of impacts only. The results will be highly sensitive to assumptions regarding aquifer properties such as the specific yield, which can vary over short distances.
- Interpreted salinity risk associated with poor irrigation practices in the urban environment are lowest along the Gawler River where the water table is deepest and highest in low lying areas to the south and west. Most areas of the proposed development were assessed to be at moderate or higher risk of urban salinity.



## 7.2 Recommendations

- Engineering works that impact on groundwater during operations and drainage works in the longer term should utilise carefully selected lined retention pond sites, subject to a more detailed assessment of the impacts of stormwater retention.
- Development in areas identified at a moderate or higher urban salinity risk should be subject to specific water management requirements. Some engineering controls may be required where the salinity risk is high.
- Further investigation of the potential impacts of stormwater retention ponds may be required once the detail design of the ponds has been undertaken. Additional data will be needed to determine aquifer properties near the proposed ponds.
- Management strategies must be concerned with maintaining groundwater at a safe depth below ground level and efficient water use practices to minimise groundwater recharge.



## 8 Statement of Limitations

This report has been prepared in accordance with the program outlined in the proposal prepared for Walker Corporation Pty Ltd dated 13 November 2007. The services performed by REM have been conducted in a manner consistent with the level of quality and skills generally exercised by members of its profession and consulting practice. No warranty or guarantee of site conditions is intended.

This report is solely for the use of Walker Corporation Pty Ltd and may not contain sufficient information for purposes of other parties or for other uses. Any reliance on this report by third parties shall be at such parties' sole risk. This report shall only be presented in full and may not be used to support any other objectives than those set out in the report, except where written approval with comments are provided by REM.

The information in this report is considered to be accurate with respect to information provided and conditions encountered at the site at the time of investigation and considering the inherent limitations associated with extrapolating information from a sample data set. Subsurface conditions can vary across a particular site and no practical degree of sampling can ever eliminate the possibility that conditions may be present at a site that have not been represented through sampling. Actual conditions in areas not sampled may differ from predictions.

REM has used the methodology and sources of information outlined within this report and has made no independent verification of this information beyond the agreed scope of works. REM assumes no responsibility for any inaccuracies or omissions. No indications were found during our investigations that the information provided to REM was false.

Since subsurface conditions (including contamination concentrations) can change within a limited period of time and space, this inherent limitation to the representation of site conditions provided by this report should always be taken into consideration particularly if the report is used after a delay in time. No responsibility for any changes in site conditions beyond the time of this investigation is assumed by REM.



## 9 References

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## **Tables**

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## Figures



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## **Appendix A**

Historical time-series water level data from available wells

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## **Appendix B**

Drilling Logs for wells installed by REM

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## **Appendix C**

Well permits for wells installed by REM

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## **Appendix D**

Bore purging and groundwater sampling data sheets

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## **Appendix E**

Aquifer testing analysis sheets

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## **Appendix F**

Laboratory analytical reports

## **Appendix G**

### Analytical data quality assessment



## **Appendix H**

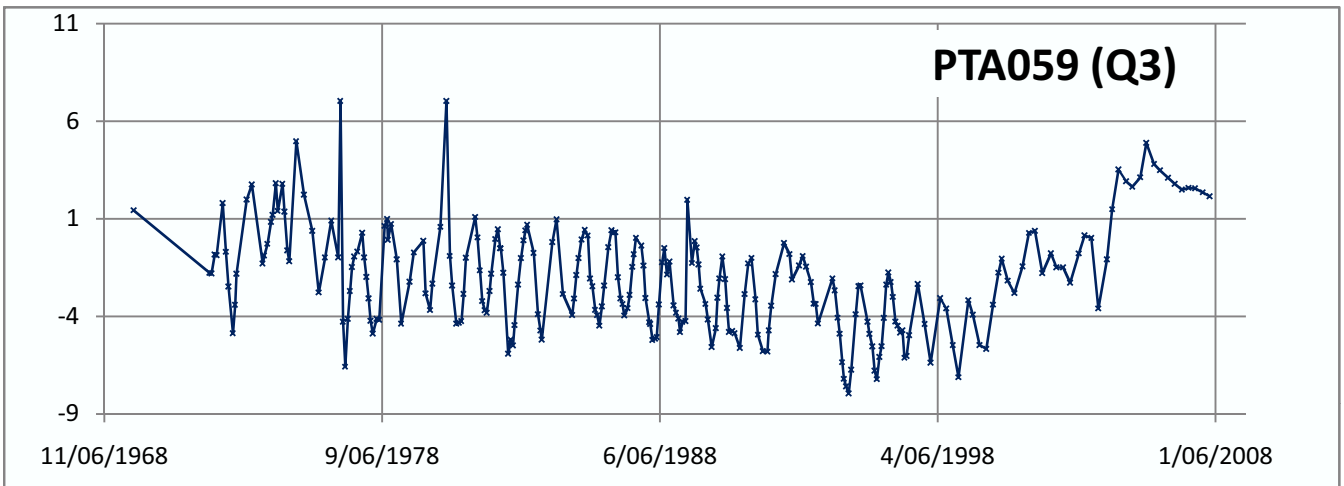
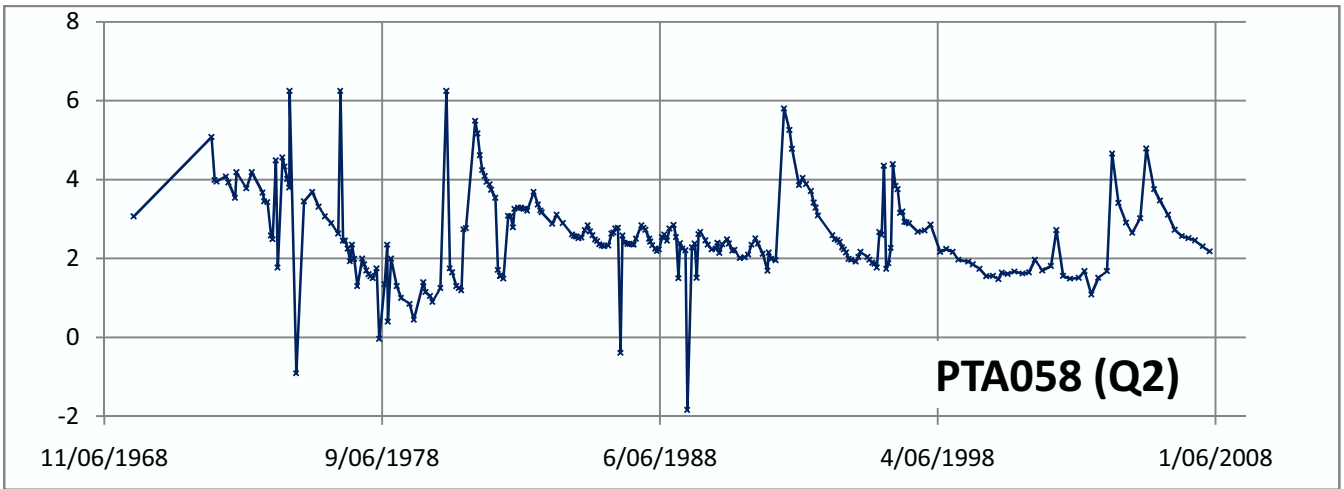
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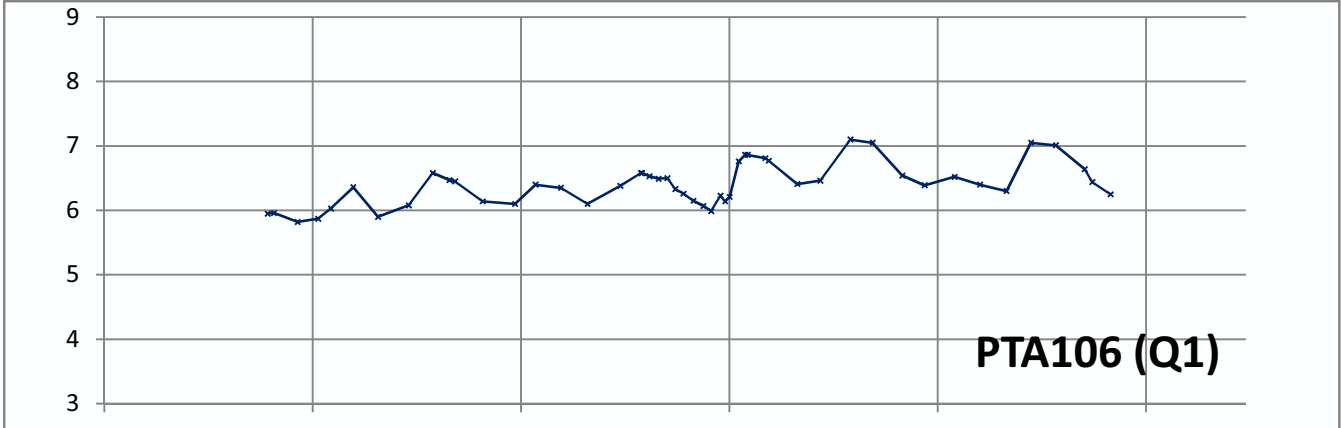
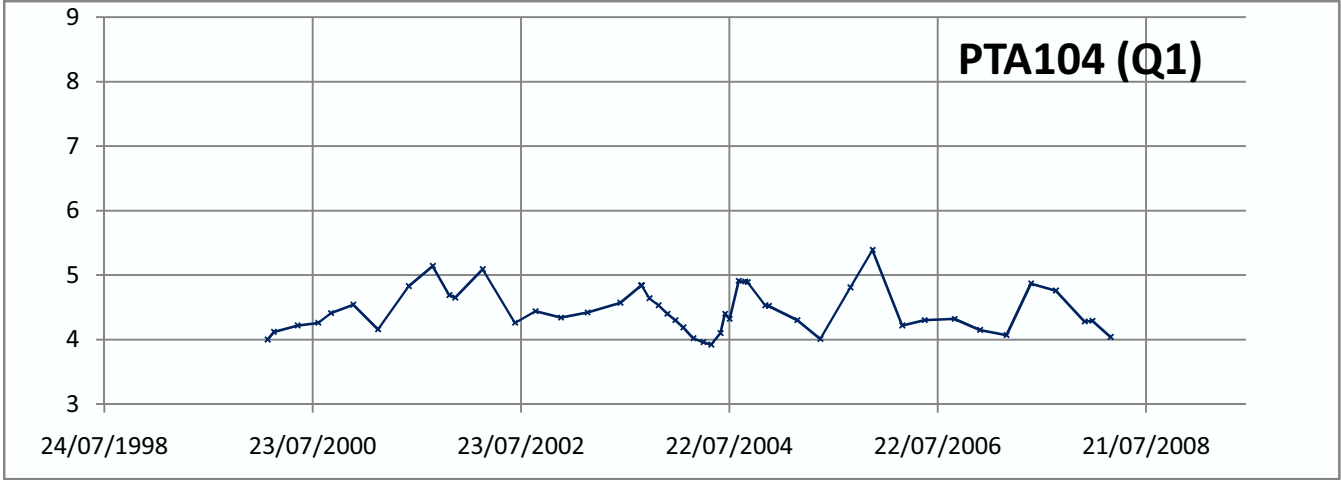
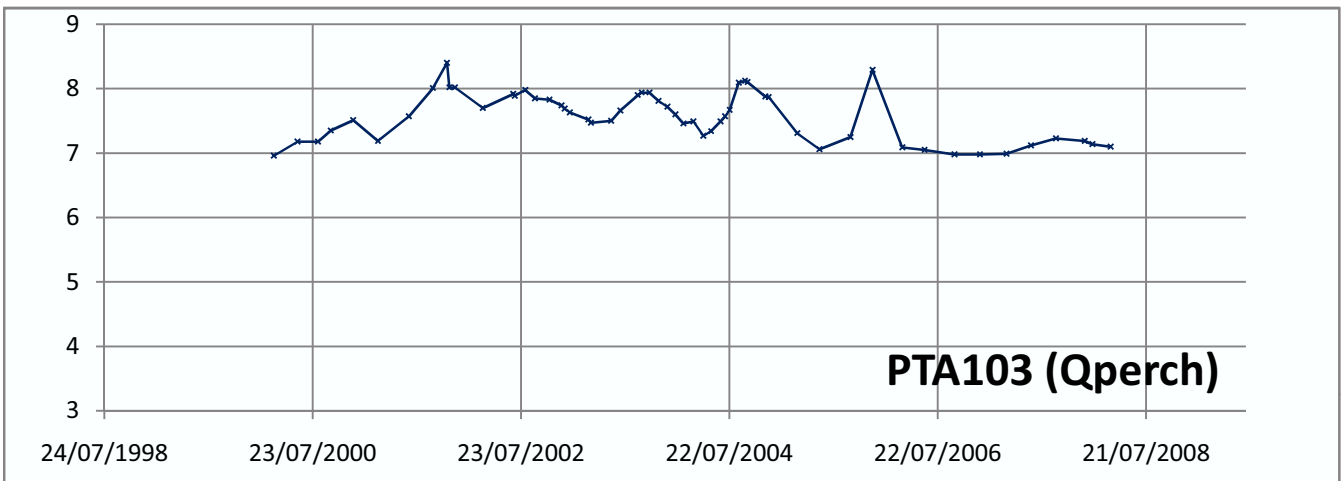
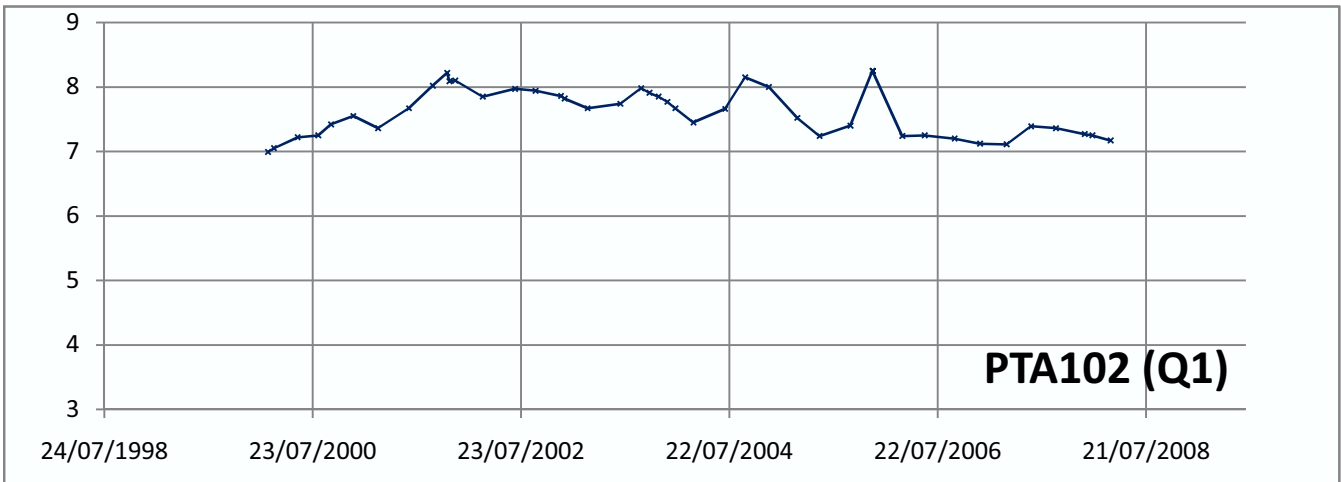
## **Appendix I**

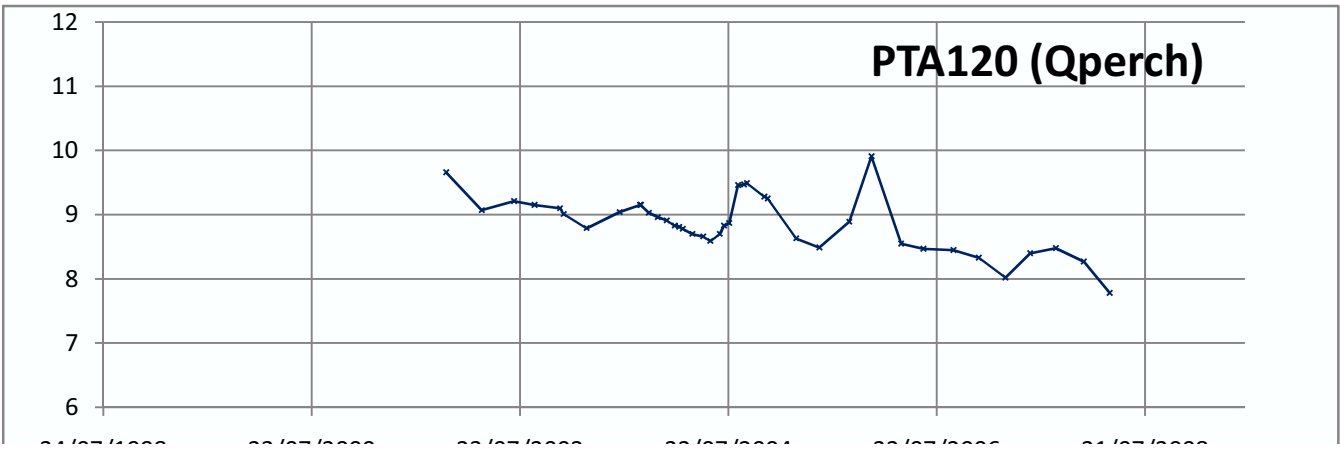
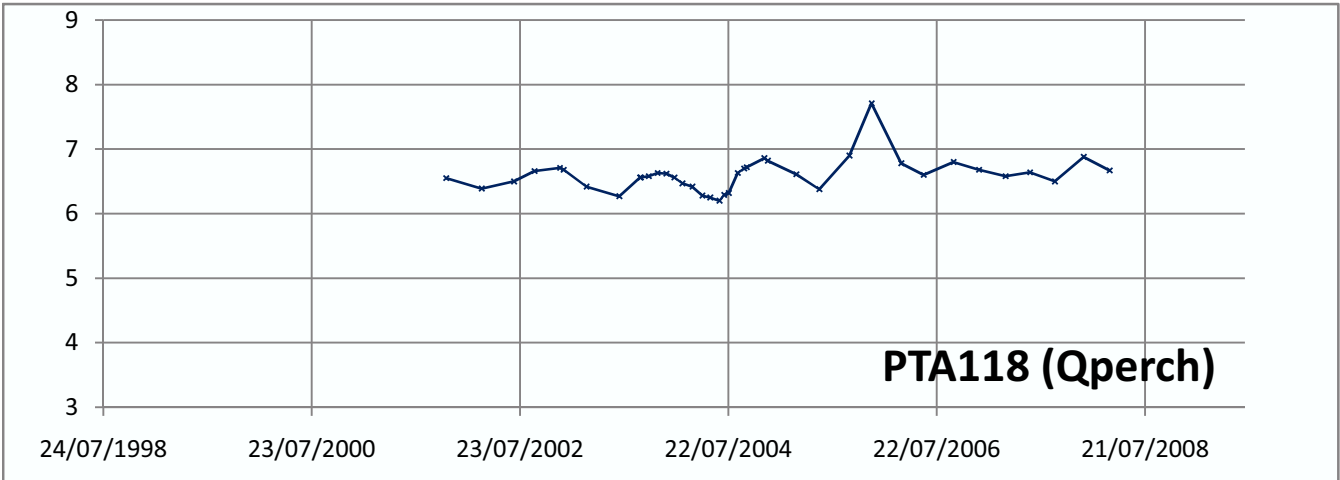
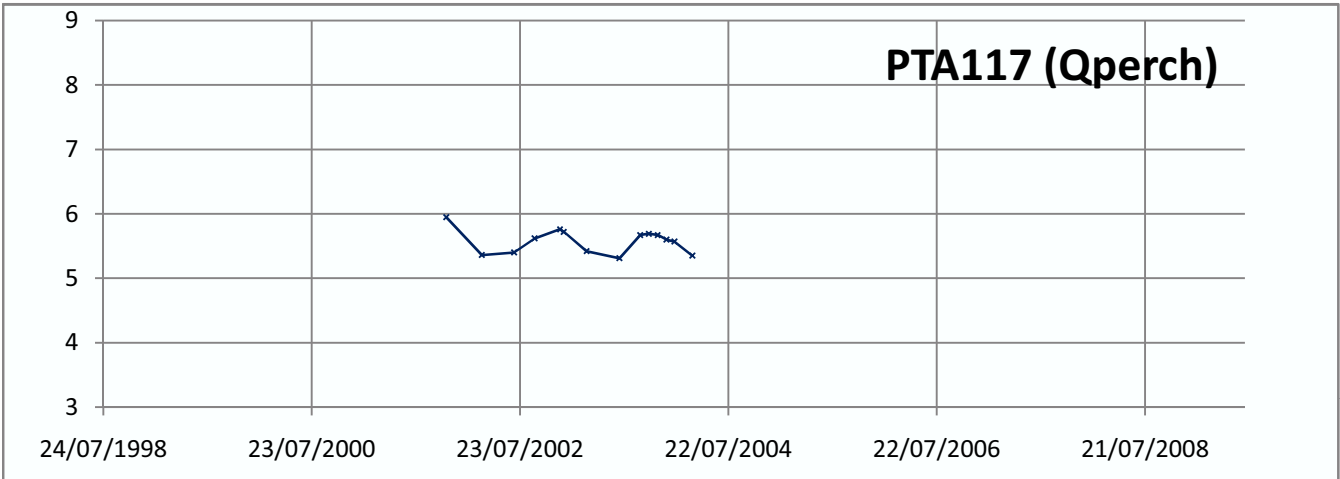
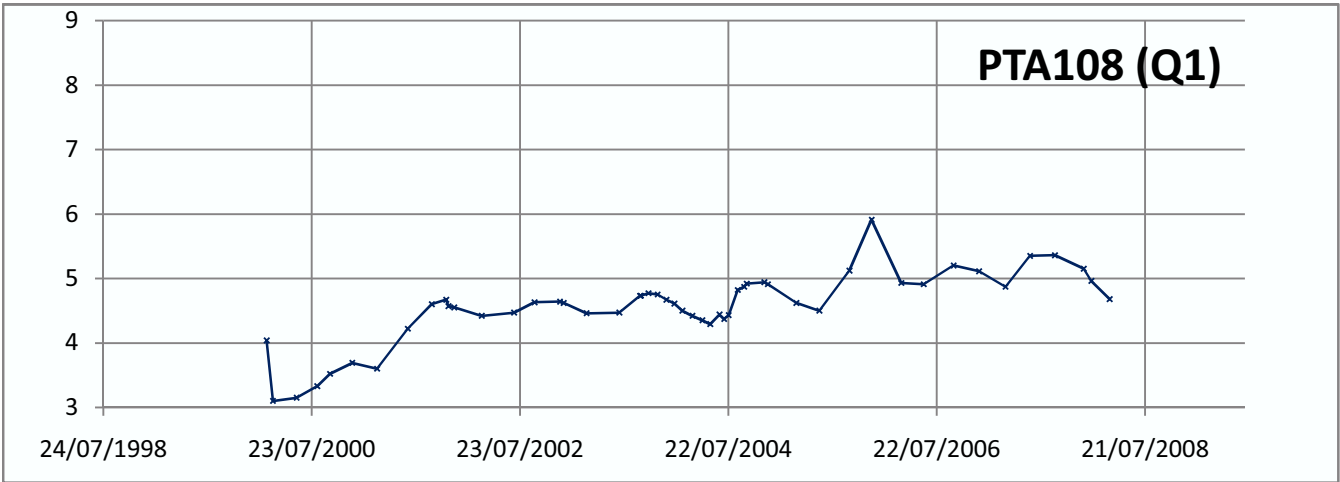
Overview of selected urban salinity risk management options

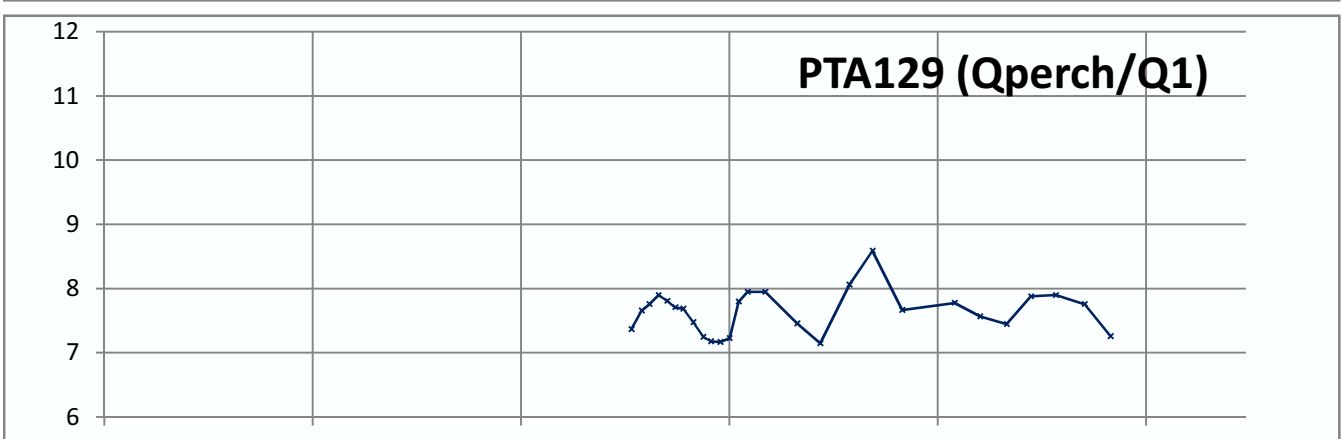
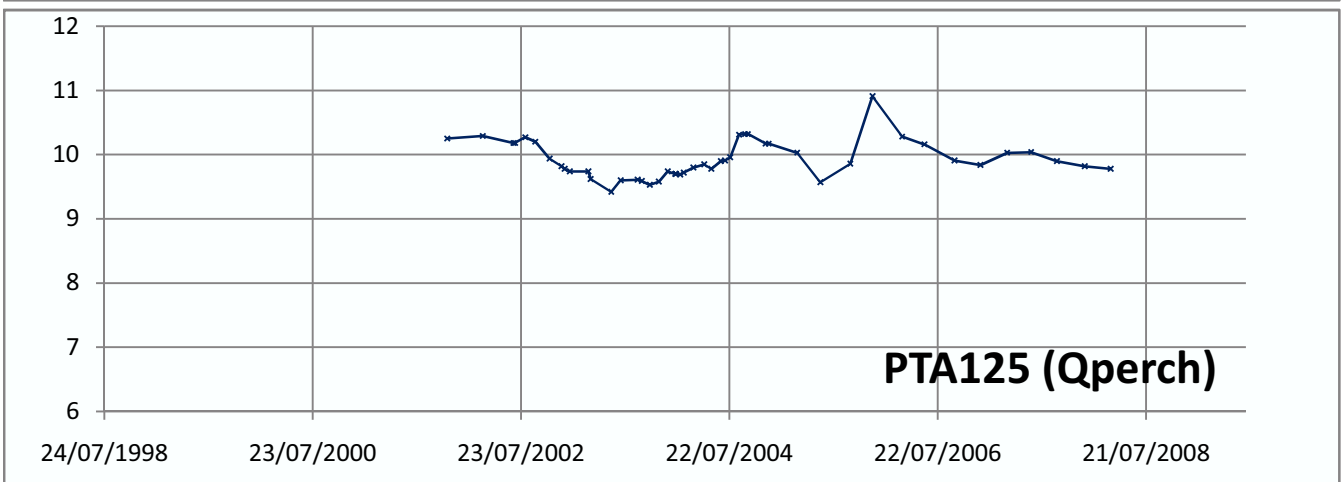
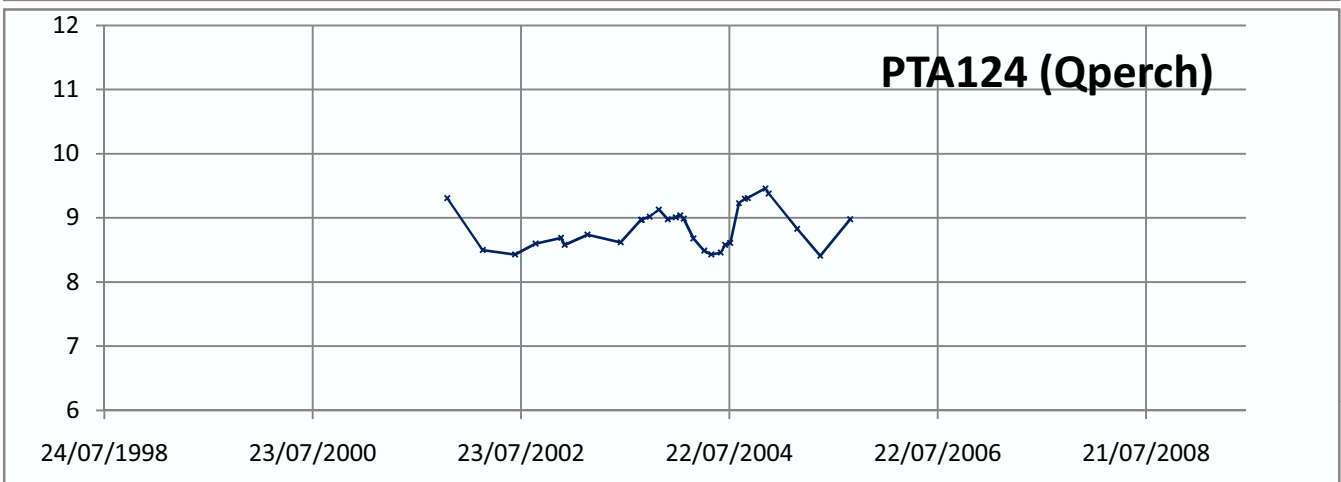
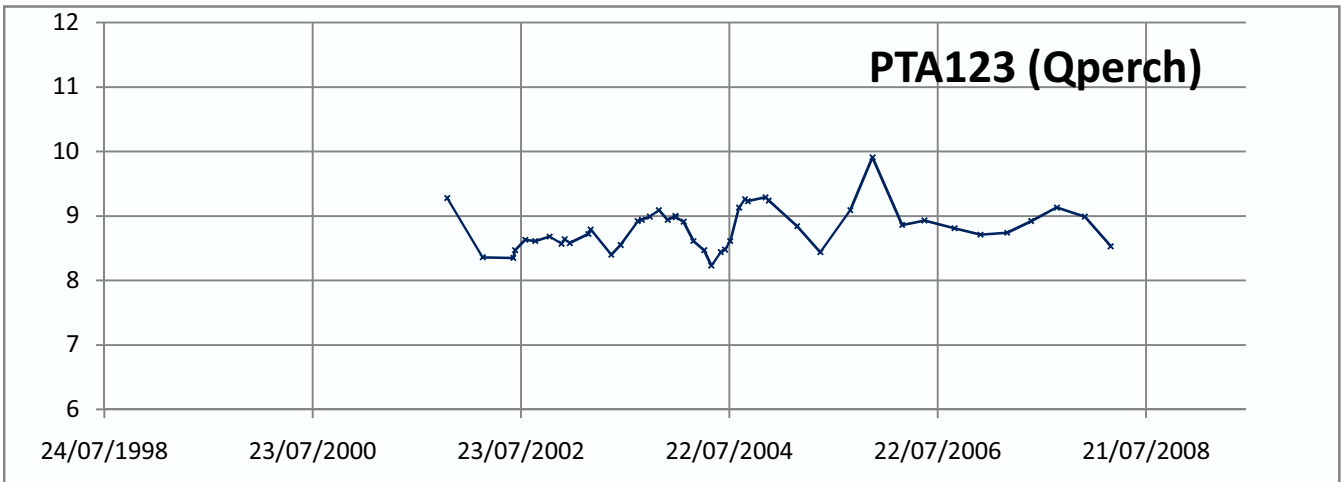
## **Appendix J**

Buckland Park development proposal overview

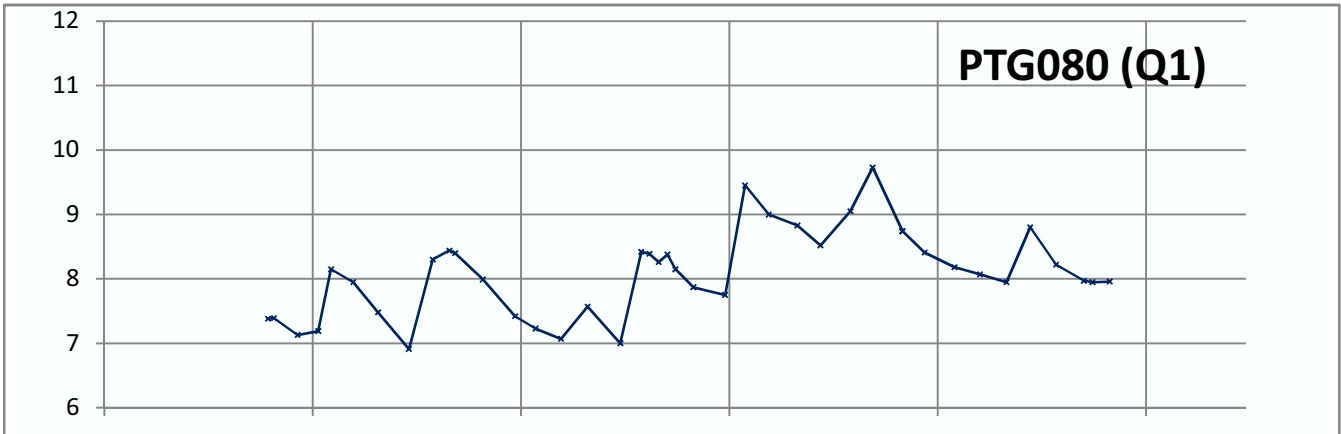
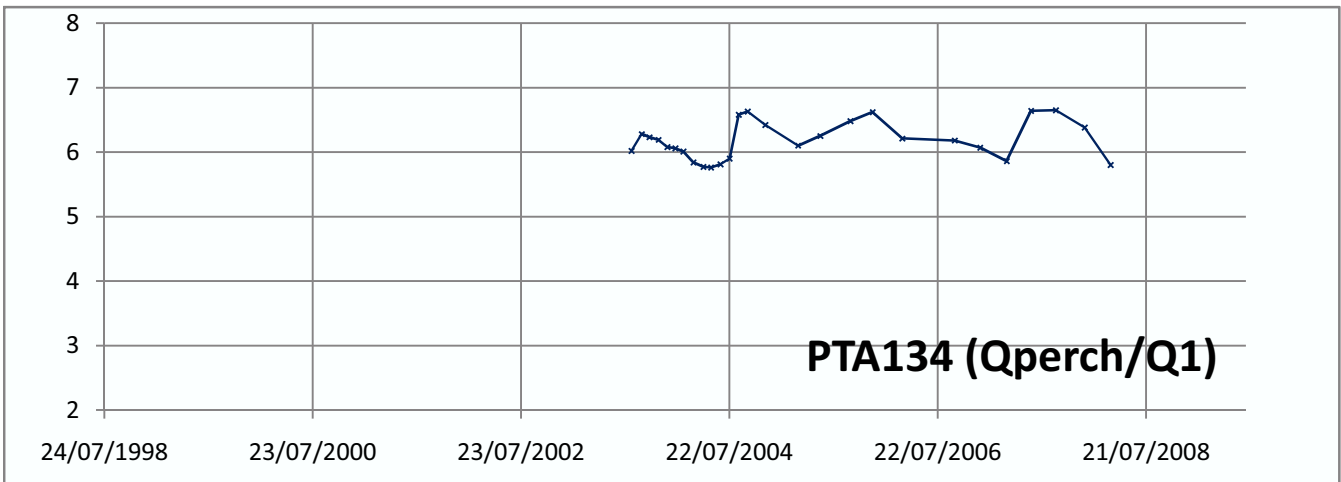
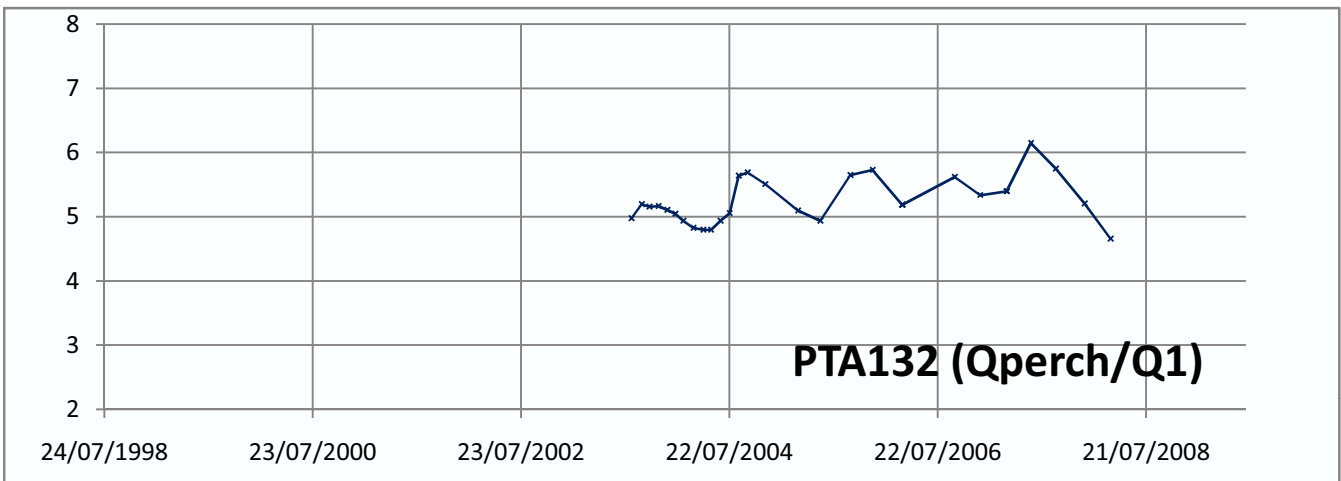
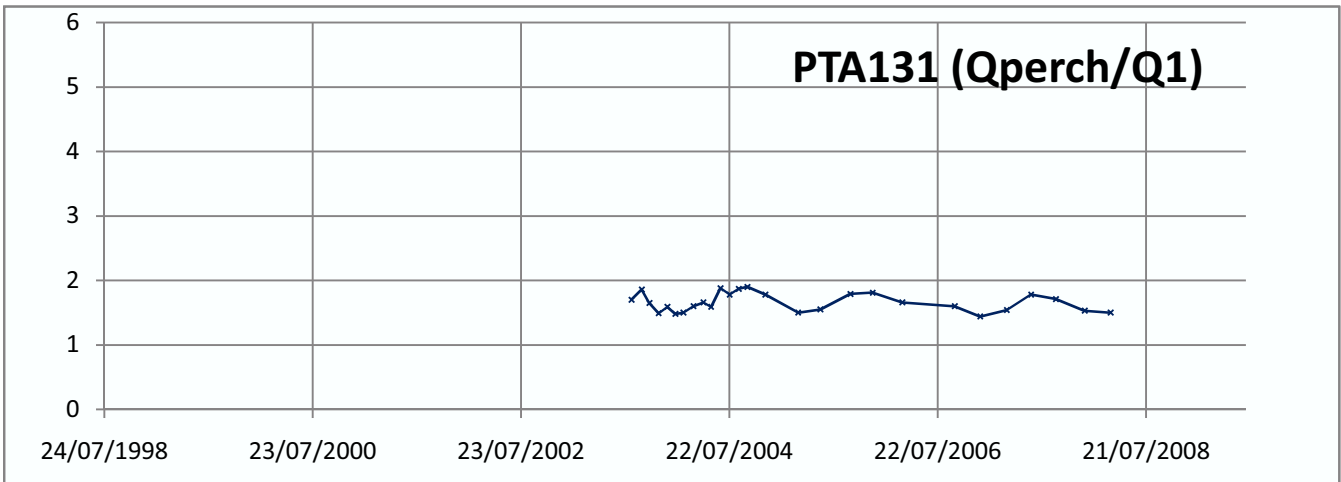














# FIELD BOREHOLE / WELL LOG

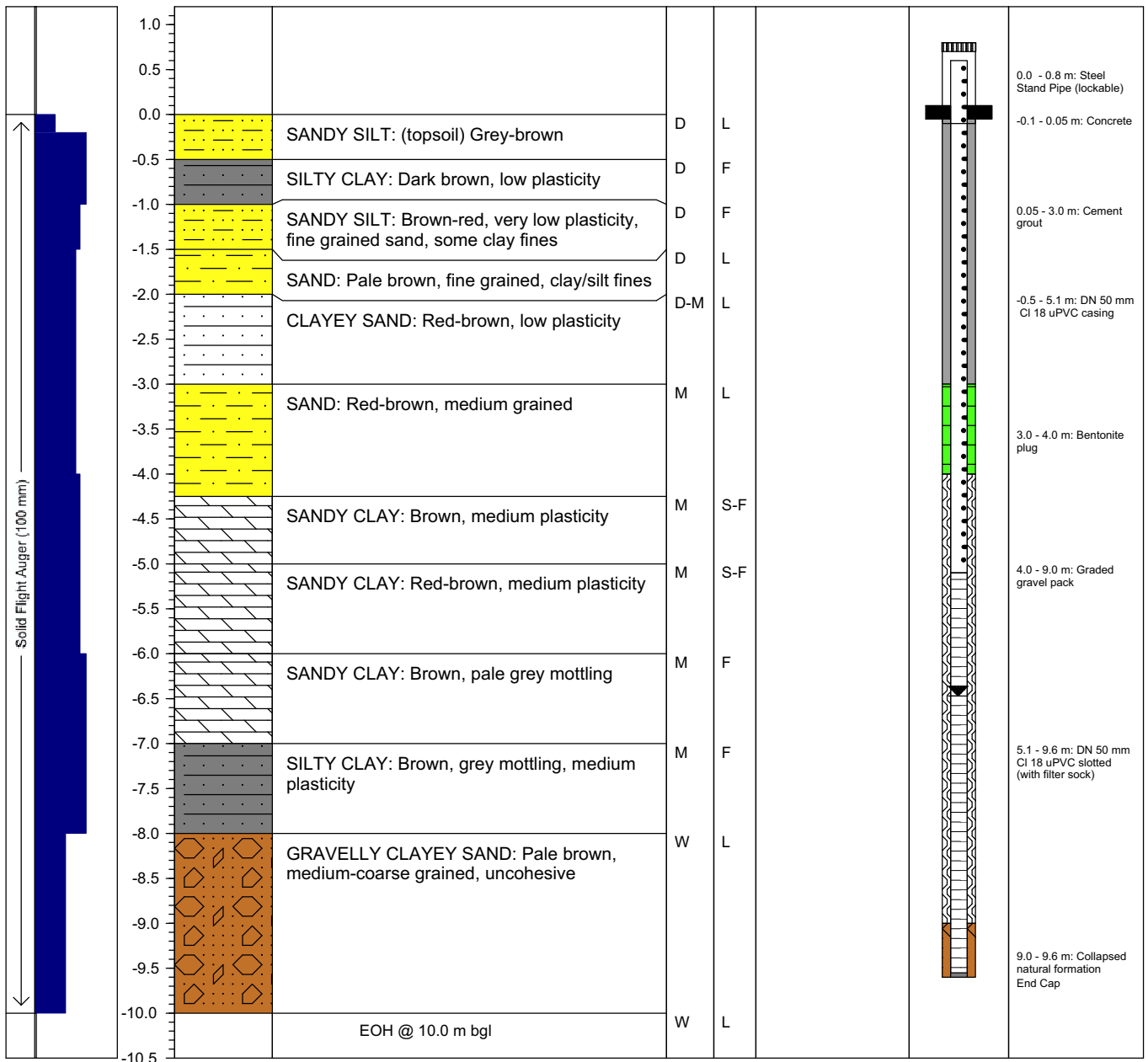
**BOREHOLE / WELL NUMBER**

MWREM01

PROJECT NUMBER: **GM-01-02**  
 PROJECT NAME: **Buckland Park Groundwater Assessment**  
 LOCATION: **Buckland Park**  
 DRILLING CO: **WB Drilling Pty Ltd**  
 DRILLING METHOD: **Solid Flight Auger**  
 BOREHOLE DIAMETER: **100mm**  
 DATE STARTED: **14/01/08**      DATE COMPLETED: **14/01/08**

WELL PERMIT NUMBER: **N/A**  
 TOTAL DEPTH (m bgl): **10.0**  
 REFERENCE POINT (m AHD): **12.343**  
 STATIC WATER LEVEL  
 Date: **14/01/08**      Depth (m bgl): **6.47**  
 PROJECTION: **GDA 1994 MGA Zone 54**  
 EASTING: **272962**      NORTHING: **6164330**

DRILLING INFO.		MATERIAL PROPERTIES				FIELD RECORDS / CONSTRUCTION INFO.		
METHOD (no resistance) PENETRATION (refusal)	DEPTH (m)	GRAPHIC LOG	MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY REL. DENSITY	COMMENTS	WELL INSTALLATION	WELL DESCRIPTION



**MOISTURE**

W = Wet  
 M = Moist  
 D = Dry

**STRENGTH**

Fine Grain      Coarse Grain  
 S = Soft              L = Loose  
 F = Firm              D = Dense  
 H = Hard              VD = Very Dense

LOGGED: David Poulsen

CHECKED: \_\_\_\_\_

DATE: 14/01/08

DATE: \_\_\_\_\_



# FIELD BOREHOLE / WELL LOG

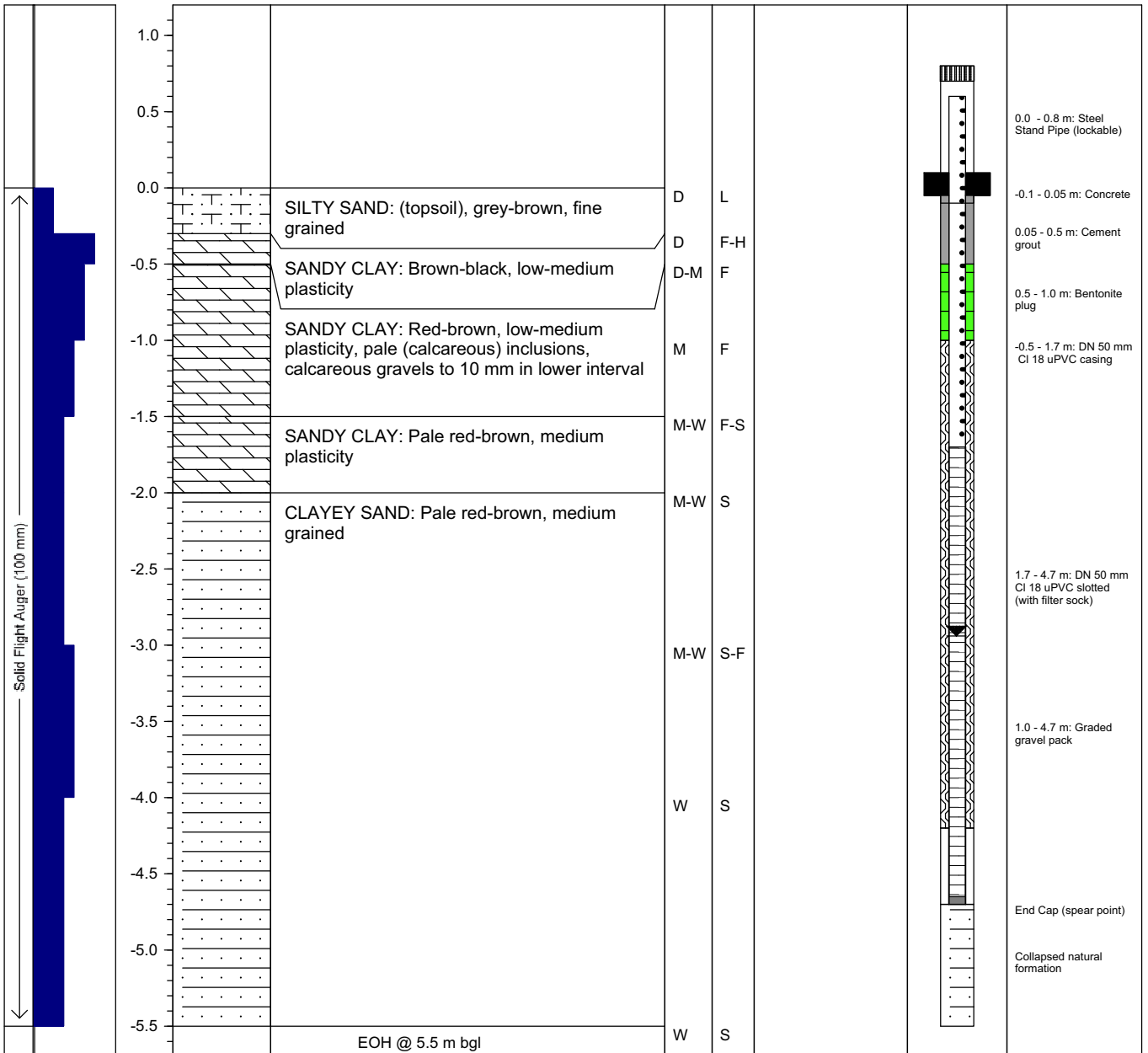
**BOREHOLE / WELL NUMBER**

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 LOCATION: **Buckland Park**  
 DRILLING CO: **WB Drilling Pty Ltd**  
 DRILLING METHOD: **Solid Flight Auger**  
 BOREHOLE DIAMETER: **100mm**  
 DATE STARTED: **14/01/08**      DATE COMPLETED: **14/01/08**

WELL PERMIT NUMBER: **N/A**  
 TOTAL DEPTH (m bgl): **5.5 (4.7)**  
 REFERENCE POINT (m AHD): **8.267**  
 STATIC WATER LEVEL  
 Date: **14/01/08**    Depth (m bgl): **2.94**  
 PROJECTION: **GDA 1994 MGA Zone 54**  
 EASTING: **273617**      NORTHING: **6162946**

DRILLING INFO.		MATERIAL PROPERTIES				FIELD RECORDS / CONSTRUCTION INFO.		
METHOD (no resistance) PENETRATION (refusal)	DEPTH (m)	GRAPHIC LOG	MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY REL. DENSITY	COMMENTS	WELL INSTALLATION	WELL DESCRIPTION



**MOISTURE**

W = Wet  
 M = Moist  
 D = Dry

**STRENGTH**

Fine Grain      Coarse Grain  
 S = Soft            L = Loose  
 F = Firm            D = Dense  
 H = Hard            VD = Very Dense

LOGGED: David Poulsen

CHECKED: \_\_\_\_\_

DATE: 14/01/08

DATE: \_\_\_\_\_



# FIELD BOREHOLE / WELL LOG

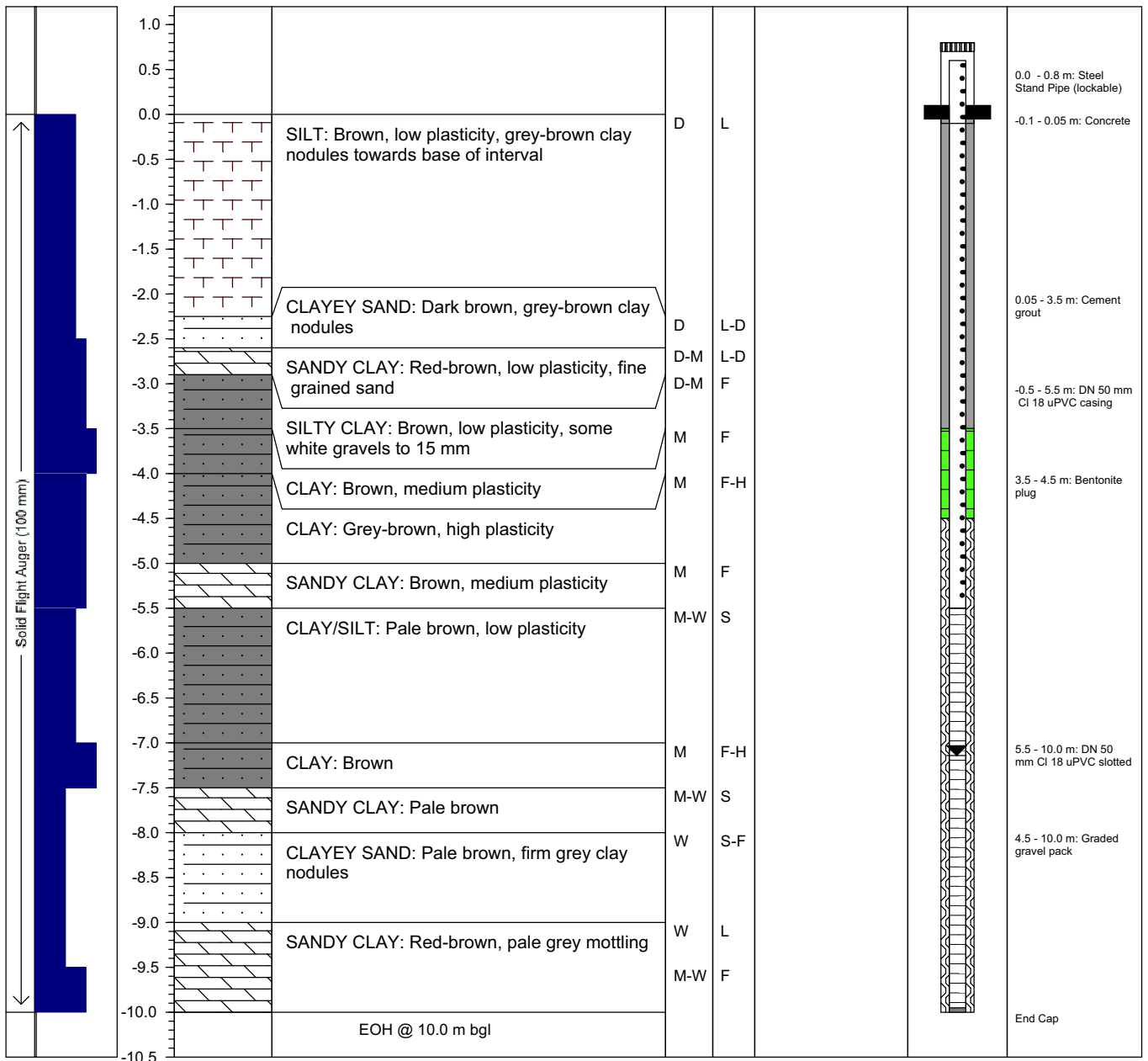
**BOREHOLE / WELL NUMBER**

MWREM03

PROJECT NUMBER: **GM-01-02**  
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 LOCATION: **Buckland Park**  
 DRILLING CO: **WB Drilling Pty Ltd**  
 DRILLING METHOD: **Solid Flight Auger**  
 BOREHOLE DIAMETER: **100mm**  
 DATE STARTED: **14/01/08**      DATE COMPLETED: **14/01/08**

WELL PERMIT NUMBER: **N/A**  
 TOTAL DEPTH (m bgl): **10.0**  
 REFERENCE POINT (m AHD): **7.895**  
 STATIC WATER LEVEL  
 Date: **14/01/08**      Depth (m bgl): **7.14**  
 PROJECTION: **GDA 1994 MGA Zone 54**  
 EASTING: **270211**      NORTHING: **6162703**

DRILLING INFO.		MATERIAL PROPERTIES				FIELD RECORDS / CONSTRUCTION INFO.		
METHOD (no resistance) PENETRATION (refusal)	DEPTH (m)	GRAPHIC LOG	MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY REL. DENSITY	COMMENTS	WELL INSTALLATION	WELL DESCRIPTION



**MOISTURE**  
 W = Wet  
 M = Moist  
 D = Dry

**STRENGTH**  
 Fine Grain      Coarse Grain  
 S = Soft              L = Loose  
 F = Firm              D = Dense  
 H = Hard              VD = Very Dense

LOGGED: David Poulsen  
 CHECKED: \_\_\_\_\_

DATE: 14/01/08  
 DATE: \_\_\_\_\_



# FIELD BOREHOLE / WELL LOG

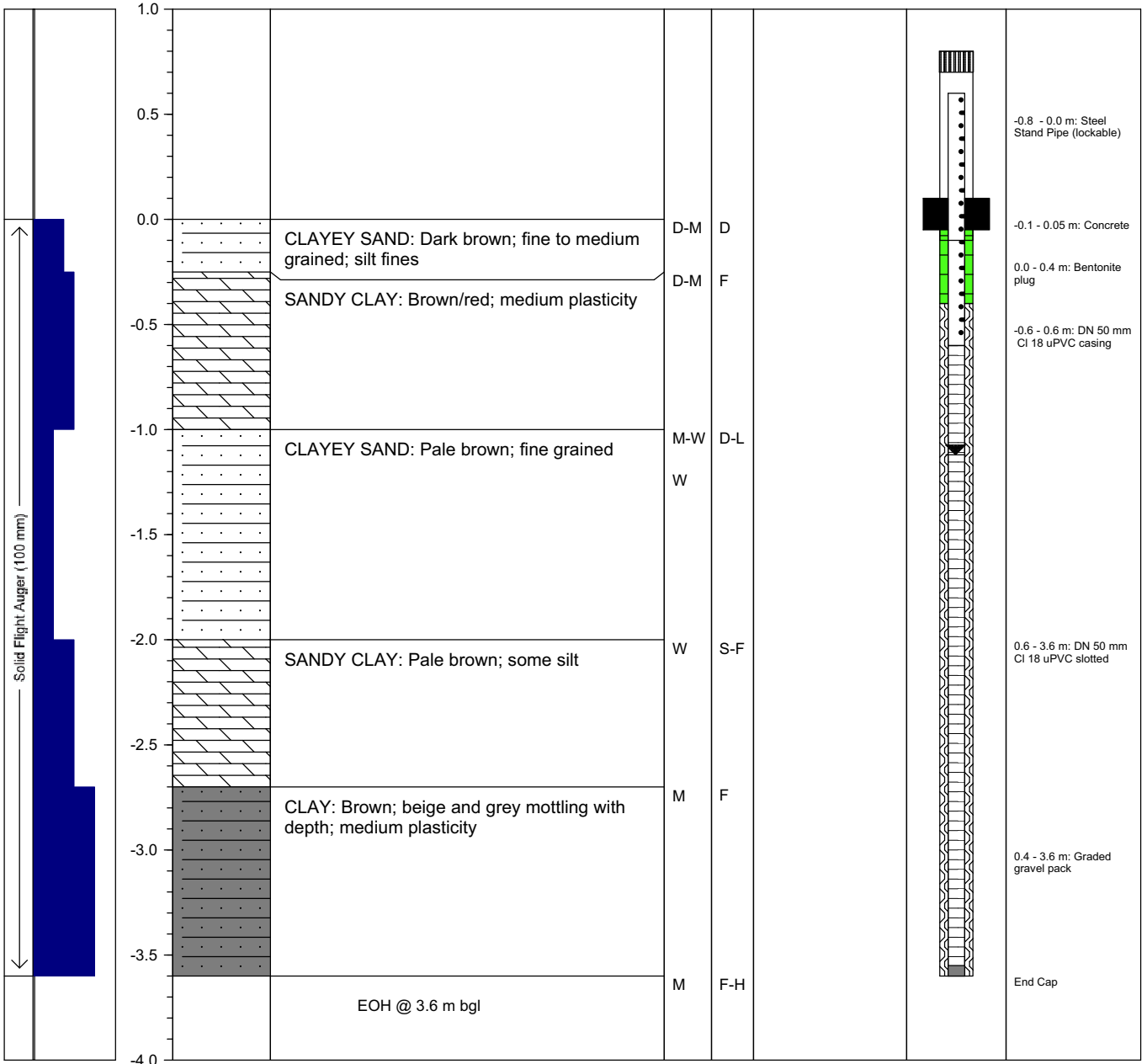
**BOREHOLE / WELL NUMBER**

MWREM04

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 LOCATION: **Buckland Park**  
 DRILLING CO: **WB Drilling Pty Ltd**  
 DRILLING METHOD: **Solid Flight Auger**  
 BOREHOLE DIAMETER: **100mm**  
 DATE STARTED: **14/01/08**      DATE COMPLETED: **14/01/08**

WELL PERMIT NUMBER: **N/A**  
 TOTAL DEPTH (m bgl): **3.6**  
 REFERENCE POINT (m AHD): **4.356**  
 STATIC WATER LEVEL  
 Date: **15/01/08**    Depth (m bgl): **1.12**  
 PROJECTION: **GDA 1994 MGA Zone 54**  
 EASTING: **270644**      NORTHING: **6161346**

DRILLING INFO.		MATERIAL PROPERTIES			FIELD RECORDS / CONSTRUCTION INFO.			
METHOD (no resistance) PENETRATION (refusal)	DEPTH (m)	GRAPHIC LOG	MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY REL. DENSITY	COMMENTS	WELL INSTALLATION	WELL DESCRIPTION



**MOISTURE**

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 D = Dry

**STRENGTH**

Fine Grain      Coarse Grain  
 S = Soft            L = Loose  
 F = Firm            D = Dense  
 H = Hard            VD = Very Dense

LOGGED: David Poulsen

CHECKED: \_\_\_\_\_

DATE: 14/01/08

DATE: \_\_\_\_\_



# FIELD BOREHOLE / WELL LOG

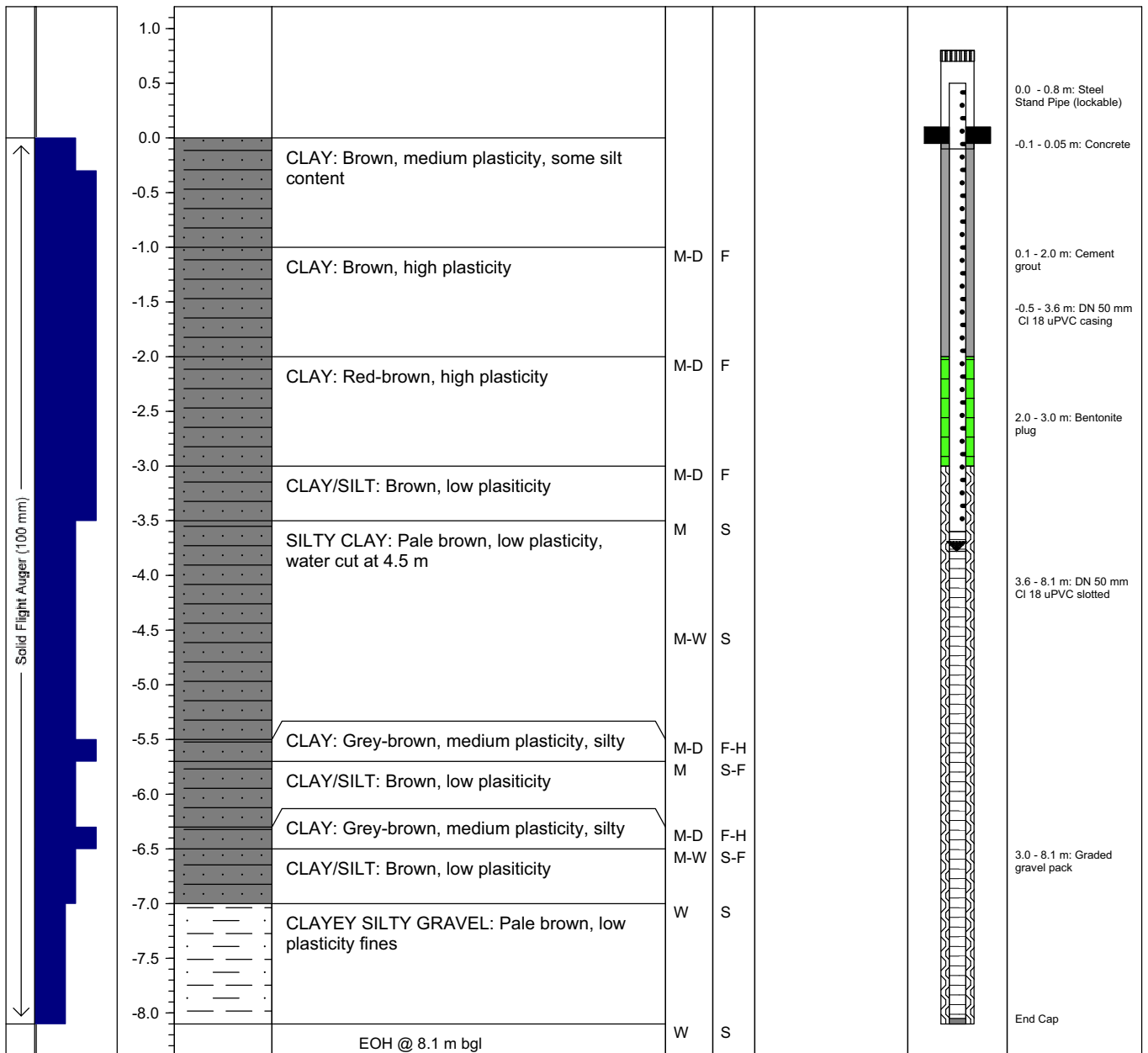
**BOREHOLE / WELL NUMBER**

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 LOCATION: **Buckland Park**  
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 DRILLING METHOD: **Solid Flight Auger**  
 BOREHOLE DIAMETER: **100mm**  
 DATE STARTED: **14/01/08**      DATE COMPLETED: **14/01/08**

WELL PERMIT NUMBER: **N/A**  
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 REFERENCE POINT (m AHD): **6.651**  
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 Date: **14/01/08**      Depth (m bgl): **3.78**  
 PROJECTION: **GDA 1994 MGA Zone 54**  
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DRILLING INFO.		MATERIAL PROPERTIES				FIELD RECORDS / CONSTRUCTION INFO.		
METHOD (no resistance) PENETRATION (refusal)	DEPTH (m)	GRAPHIC LOG	MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY REL. DENSITY	COMMENTS	WELL INSTALLATION	WELL DESCRIPTION



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 D = Dry

**STRENGTH**

Fine Grain      Coarse Grain  
 S = Soft            L = Loose  
 F = Firm            D = Dense  
 H = Hard            VD = Very Dense

LOGGED: David Poulsen

CHECKED: \_\_\_\_\_

DATE: 14/01/08

DATE: \_\_\_\_\_



# FIELD BOREHOLE / WELL LOG

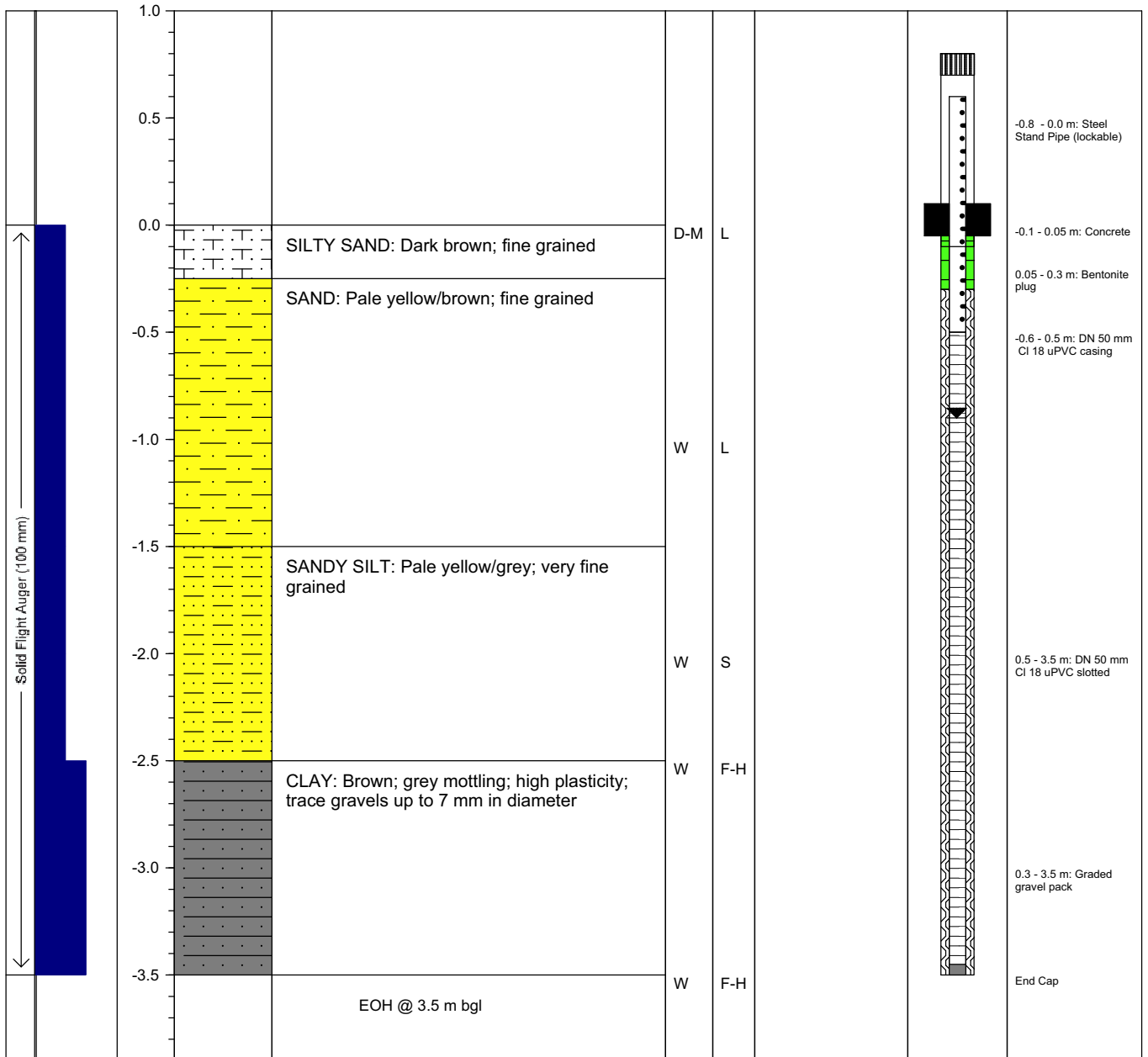
**BOREHOLE / WELL NUMBER**

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 LOCATION: **Buckland Park**  
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 DRILLING METHOD: **Solid Flight Auger**  
 BOREHOLE DIAMETER: **100mm**  
 DATE STARTED: **15/01/08**      DATE COMPLETED: **15/01/08**

WELL PERMIT NUMBER: **N/A**  
 TOTAL DEPTH (m bgl): **3.5**  
 REFERENCE POINT (m AHD): **3.811**  
 STATIC WATER LEVEL  
 Date: **15/01/08**    Depth (m bgl): **0.90**  
 PROJECTION: **GDA 1994 MGA Zone 54**  
 EASTING: **270674**      NORTHING: **6160220**

DRILLING INFO.		MATERIAL PROPERTIES				FIELD RECORDS / CONSTRUCTION INFO.		
METHOD (no resistance) PENETRATION (refusal)	DEPTH (m)	GRAPHIC LOG	MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY REL. DENSITY	COMMENTS	WELL INSTALLATION	WELL DESCRIPTION



**MOISTURE**

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 M = Moist  
 D = Dry

**STRENGTH**

Fine Grain      Coarse Grain  
 S = Soft            L = Loose  
 F = Firm            D = Dense  
 H = Hard            VD = Very Dense

LOGGED: David Poulsen

CHECKED: \_\_\_\_\_

DATE: 15/01/08

DATE: \_\_\_\_\_



# FIELD BOREHOLE / WELL LOG

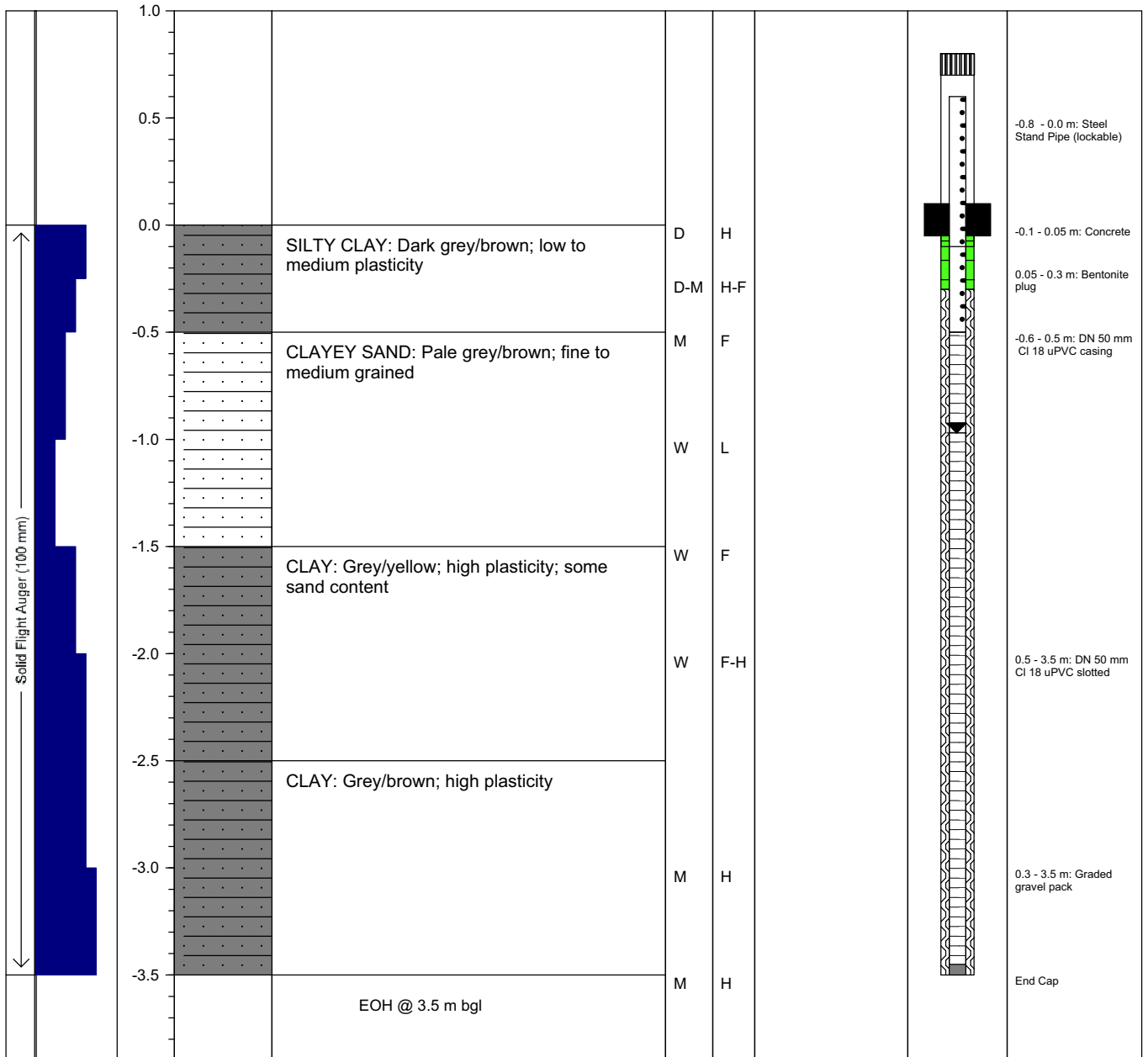
**BOREHOLE / WELL NUMBER**

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 DRILLING METHOD: **Solid Flight Auger**  
 BOREHOLE DIAMETER: **100mm**  
 DATE STARTED: **15/01/08**      DATE COMPLETED: **15/01/08**

WELL PERMIT NUMBER: **N/A**  
 TOTAL DEPTH (m bgl): **3.5**  
 REFERENCE POINT (m AHD): **3.050**  
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 Date: **15/01/08**      Depth (m bgl): **0.97**  
 PROJECTION: **GDA 1994 MGA Zone 54**  
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DRILLING INFO.		MATERIAL PROPERTIES				FIELD RECORDS / CONSTRUCTION INFO.		
METHOD (no resistance) PENETRATION (refusal)	DEPTH (m)	GRAPHIC LOG	MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY REL. DENSITY	COMMENTS	WELL INSTALLATION	WELL DESCRIPTION



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 S = Soft              L = Loose  
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LOGGED: David Poulsen

CHECKED: \_\_\_\_\_

DATE: 15/01/08

DATE: \_\_\_\_\_





# FIELD BOREHOLE / WELL LOG

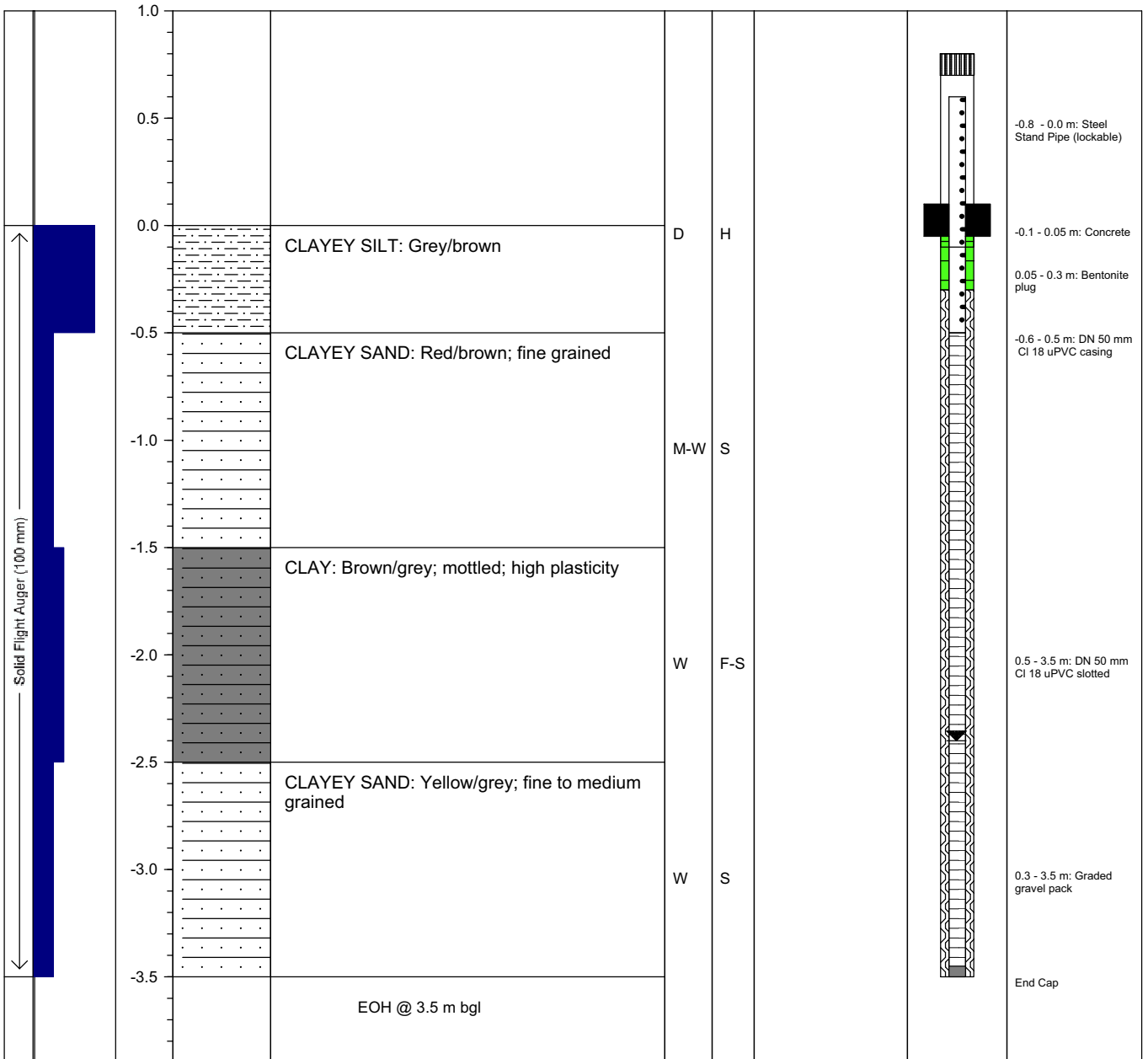
**BOREHOLE / WELL NUMBER**

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 LOCATION: **Buckland Park**  
 DRILLING CO: **WB Drilling Pty Ltd**  
 DRILLING METHOD: **Solid Flight Auger**  
 BOREHOLE DIAMETER: **100mm**  
 DATE STARTED: **15/01/08**      DATE COMPLETED: **15/01/08**

WELL PERMIT NUMBER: **N/A**  
 TOTAL DEPTH (m bgl): **3.5**  
 REFERENCE POINT (m AHD): **3.669**  
 STATIC WATER LEVEL  
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 PROJECTION: **GDA 1994 MGA Zone 54**  
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DRILLING INFO.		MATERIAL PROPERTIES			FIELD RECORDS / CONSTRUCTION INFO.			
METHOD (no resistance) PENETRATION (refusal)	DEPTH (m)	GRAPHIC LOG	MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY REL. DENSITY	COMMENTS	WELL INSTALLATION	WELL DESCRIPTION



**MOISTURE**

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 M = Moist  
 D = Dry

**STRENGTH**

Fine Grain      Coarse Grain  
 S = Soft            L = Loose  
 F = Firm            D = Dense  
 H = Hard            VD = Very Dense

LOGGED: David Poulsen

CHECKED: \_\_\_\_\_

DATE: 15/01/08

DATE: \_\_\_\_\_



# FIELD BOREHOLE / WELL LOG

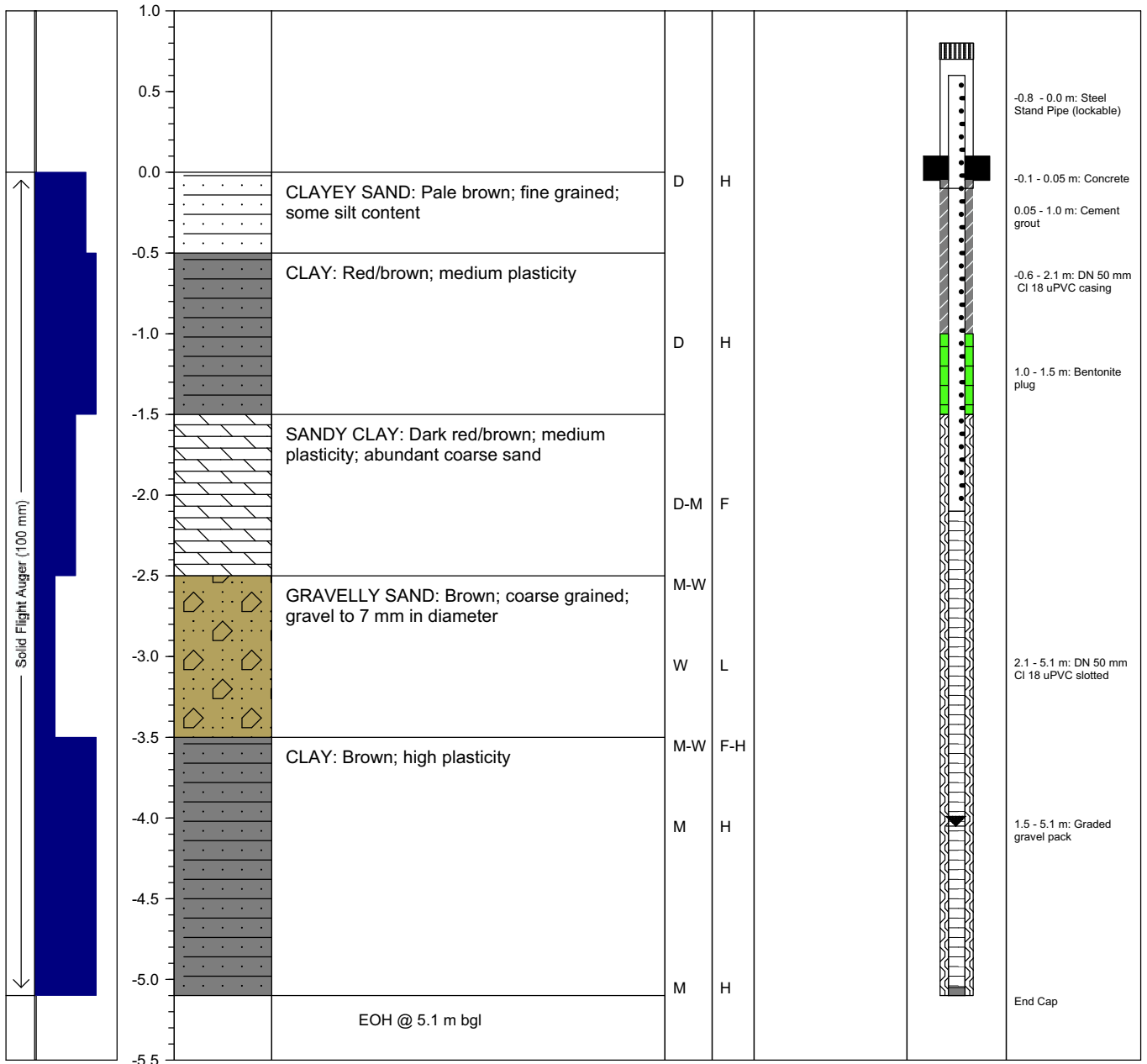
**BOREHOLE / WELL NUMBER**

MWREM09

PROJECT NUMBER: **GM-01-02**  
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 LOCATION: **Buckland Park**  
 DRILLING CO: **WB Drilling Pty Ltd**  
 DRILLING METHOD: **Solid Flight Auger**  
 BOREHOLE DIAMETER: **100mm**  
 DATE STARTED: **15/01/08**      DATE COMPLETED: **15/01/08**

WELL PERMIT NUMBER: **N/A**  
 TOTAL DEPTH (m bgl): **5.1**  
 REFERENCE POINT (m AHD): **5.368**  
 STATIC WATER LEVEL  
 Date: **15/01/08**    Depth (m bgl): **4.05**  
 PROJECTION: **GDA 1994 MGA Zone 54**  
 EASTING: **271475**      NORTHING: **6159993**

DRILLING INFO.		MATERIAL PROPERTIES				FIELD RECORDS / CONSTRUCTION INFO.		
METHOD (no resistance) PENETRATION (refusal)	DEPTH (m)	GRAPHIC LOG	MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY REL. DENSITY	COMMENTS	WELL INSTALLATION	WELL DESCRIPTION



**MOISTURE**

W = Wet  
 M = Moist  
 D = Dry

**STRENGTH**

Fine Grain      Coarse Grain  
 S = Soft            L = Loose  
 F = Firm            D = Dense  
 H = Hard            VD = Very Dense

LOGGED: David Poulsen

CHECKED: \_\_\_\_\_

DATE: 15/01/08

DATE: \_\_\_\_\_



# FIELD BOREHOLE / WELL LOG

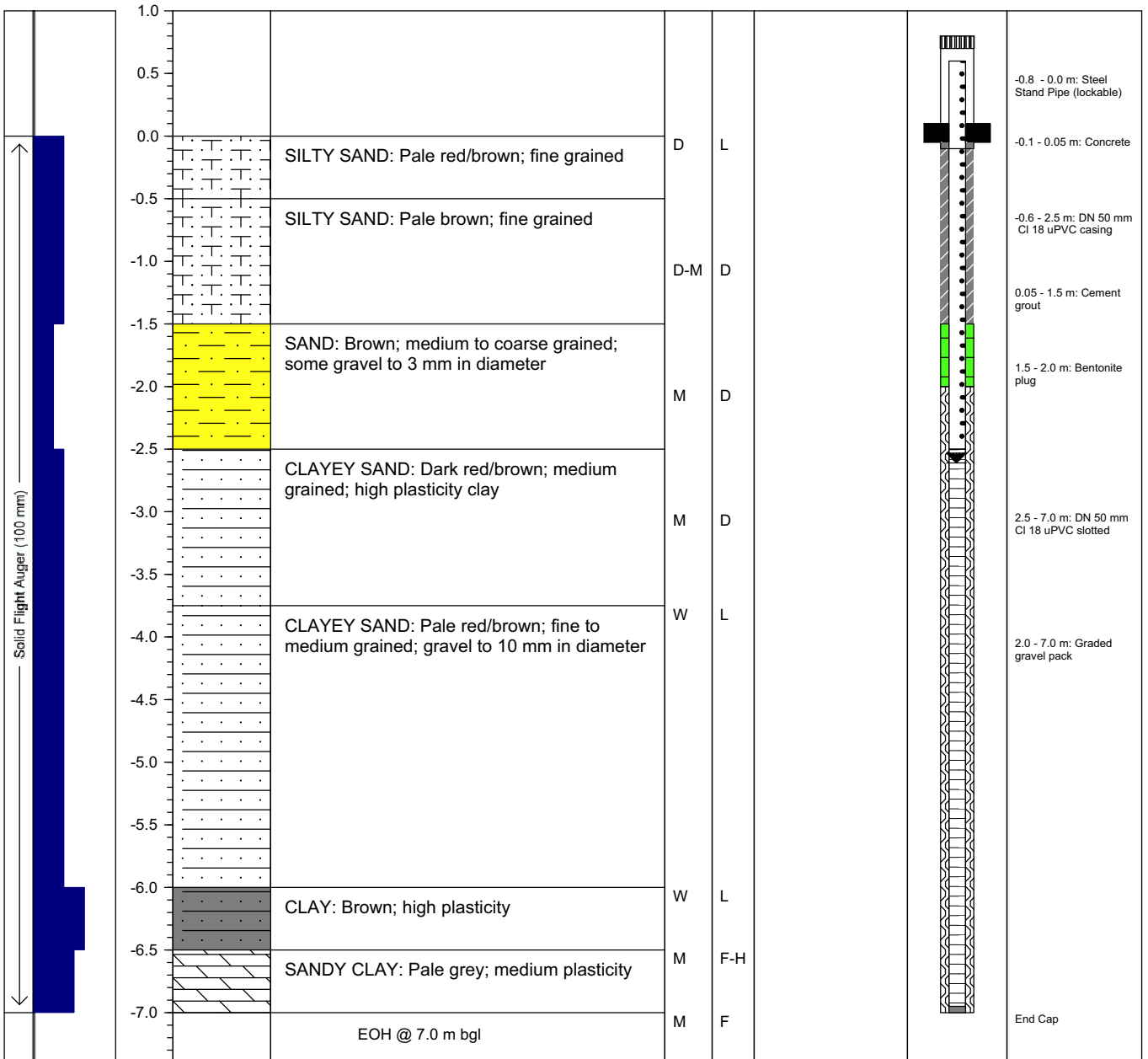
**BOREHOLE / WELL NUMBER**

MWREM11

PROJECT NUMBER: **GM-01-02**  
 PROJECT NAME: **Buckland Park Groundwater Assessment**  
 LOCATION: **Buckland Park**  
 DRILLING CO: **WB Drilling Pty Ltd**  
 DRILLING METHOD: **Solid Flight Auger**  
 BOREHOLE DIAMETER: **100mm**  
 DATE STARTED: **15/01/08**      DATE COMPLETED: **15/01/08**

WELL PERMIT NUMBER: **N/A**  
 TOTAL DEPTH (m bgl): **7.0**  
 REFERENCE POINT (m AHD): **6.646**  
 STATIC WATER LEVEL  
 Date: **15/01/08**      Depth (m bgl): **2.61**  
 PROJECTION: **GDA 1994 MGA Zone 54**  
 EASTING: **271717**      NORTHING: **6161581**

DRILLING INFO.		MATERIAL PROPERTIES				FIELD RECORDS / CONSTRUCTION INFO.		
METHOD (no resistance) PENETRATION (refusal)	DEPTH (m)	GRAPHIC LOG	MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY REL. DENSITY	COMMENTS	WELL INSTALLATION	WELL DESCRIPTION



**MOISTURE**

W = Wet  
 M = Moist  
 D = Dry

**STRENGTH**

Fine Grain      Coarse Grain  
 S = Soft              L = Loose  
 F = Firm              D = Dense  
 H = Hard              VD = Very Dense

LOGGED: David Poulsen

CHECKED: \_\_\_\_\_

DATE: 15/01/08

DATE: \_\_\_\_\_



# FIELD BOREHOLE / WELL LOG

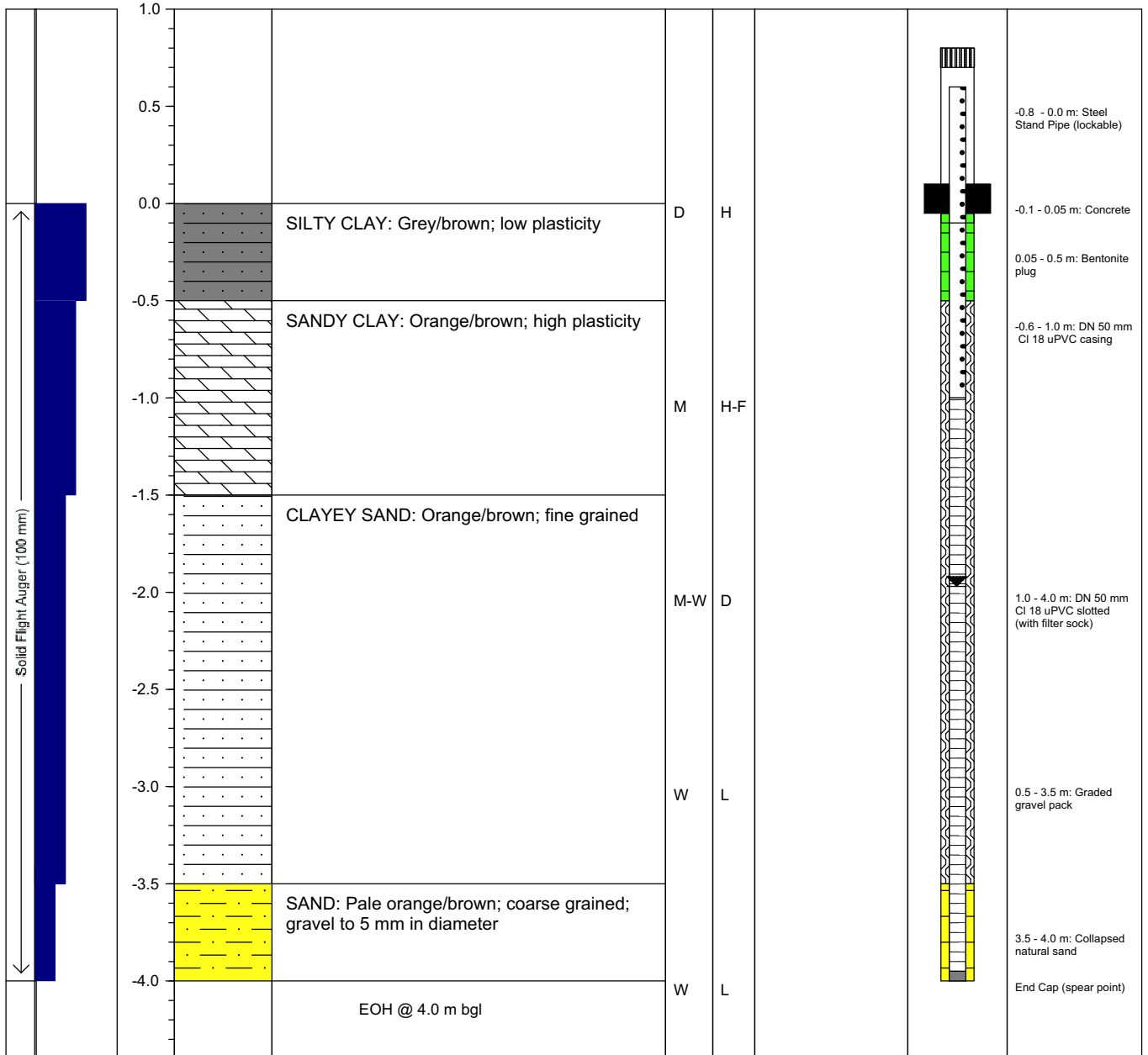
**BOREHOLE / WELL NUMBER**

MWREM12

PROJECT NUMBER: **GM-01-02**  
 PROJECT NAME: **Buckland Park Groundwater Assessment**  
 LOCATION: **Buckland Park**  
 DRILLING CO: **WB Drilling Pty Ltd**  
 DRILLING METHOD: **Solid Flight Auger**  
 BOREHOLE DIAMETER: **100mm**  
 DATE STARTED: **15/01/08**      DATE COMPLETED: **15/01/08**

WELL PERMIT NUMBER: **N/A**  
 TOTAL DEPTH (m bgl): **4.0**  
 REFERENCE POINT (m AHD): **4.173**  
 STATIC WATER LEVEL  
 Date: **15/01/08**      Depth (m bgl): **1.97**  
 PROJECTION: **GDA 1994 MGA Zone 54**  
 EASTING: **272248**      NORTHING: **6160113**

DRILLING INFO.		MATERIAL PROPERTIES			FIELD RECORDS / CONSTRUCTION INFO.			
METHOD (no resistance) PENETRATION (refusal)	DEPTH (m)	GRAPHIC LOG	MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY REL. DENSITY	COMMENTS	WELL INSTALLATION	WELL DESCRIPTION



**MOISTURE**

W = Wet  
 M = Moist  
 D = Dry

**STRENGTH**

Fine Grain      Coarse Grain  
 S = Soft              L = Loose  
 F = Firm              D = Dense  
 H = Hard              VD = Very Dense

LOGGED: David Poulsen

CHECKED: \_\_\_\_\_

DATE: 15/01/08

DATE: \_\_\_\_\_

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## **Appendix C**

Well permits for wells installed by REM

GOVERNMENT OF SOUTH AUSTRALIA  
**DEPARTMENT OF WATER, LAND AND BIODIVERSITY CONSERVATION**

RESOURCE ALLOCATION DIVISION  
GPO Box 2834 Adelaide SA 5001  
Ph: 8463 6913 Fax: 8463 6840

**PERMIT to undertake a WATER AFFECTING ACTIVITY**  
pursuant to section 135 of the *Natural Resources Management Act 2004*  
**WELL PERMIT**

Subject to full compliance with all the procedures, specifications and limitations contained or referred to, in the conditions set out below,

<b>Permit No:</b>	141391
<b>Expiry Date:</b>	20/12/2008

**Permission is hereby granted to:** RESOURCE AND ENVIRONMENTAL  
MANAGEMENT  
ACN 098 108 877  
UNIT 9, 15 FULLARTON ROAD  
KENT TOWN SA 5067

**To undertake the following water affecting activity:**

**Activity:** Well Construction and Backfill  
**Well Use:** Investigation

**CONDITIONS:**

1. The activity authorised by this permit must only be undertaken on the land described below:  
CT 5916/59  
Allotment 1 in Deposited Plan 63928  
Hundred of Port Adelaide
2. All work is to be carried out in accordance with the enclosed general specifications.
3. The well is not to penetrate beyond a maximum depth of 10 metres.
4. If the well is considered unsatisfactory, it may be abandoned and a replacement well may then be constructed provided that the abandoned well is backfilled prior to the drill rig leaving the site.
5. Water samples are required from all wells drilled in respect of this permit.
6. Strata samples are not required.
7. The licensed well driller must forward with his report a plan obtained from the permit holder, who must mark thereon the location of all wells drilled in respect of this permit.
8. All wells must be drilled vertical unless written permission is obtained from the Minister.
9. Additional land parcels that this activity is authorised to be undertaken on are as

shown on the map marked as appendix A.

**NOTES:**

1. Under section 202(1)(b)(ii) of the Natural Resources Management Act 2004, you have a right of appeal to the Environment, Resources and Development Court against the imposition of any condition on this permit. The appeal must be instituted within six weeks of the date of permit issue. The appeal must also be served upon this department within that time.
2. This permit is not transferable.
3. This well construction permit is not an authorisation for a person to enter private property and prior authority must be obtained from the land owner in all circumstances.
4. The issue of this permit does not negate the requirement to comply with the provisions of other Acts that may impact on the activity undertaken pursuant to this permit.

**TAKE NOTE that the permit holder, or a person acting on behalf of the permit holder, who contravenes or fails to comply with a condition of this permit is guilty of an offence, and such acts or omissions may result in the variation, suspension or revocation of the permit.**



Robert Freeman  
A/ COORDINATOR WATER LICENSING  
Delegate of Minister for Environment and Conservation

Date: 20/12/2007

DEPARTMENT OF WATER, LAND AND BIODIVERSITY CONSERVATION

RESOURCE ALLOCATION DIVISION  
GPO Box 2834 Adelaide SA 5001  
Ph: 8463 6913 Fax: 8463 6840

**PERMIT to undertake a WATER AFFECTING ACTIVITY**

pursuant to section 135 of the *Natural Resources Management Act 2004*

**WELL PERMIT**

Subject to full compliance with all the procedures, specifications and limitations contained or referred to, in the conditions set out below,

<b>Permit No:</b>	141392
<b>Expiry Date:</b>	20/12/2008

**Permission is hereby granted to:** RESOURCE AND ENVIRONMENTAL  
MANAGEMENT  
ACN 098 108 877  
UNIT 9, 15 FULLARTON ROAD  
KENT TOWN SA 5067

**To undertake the following water affecting activity:**

**Activity:** Well Construction and Backfill  
**Well Use:** Investigation

**CONDITIONS:**

1. The activity authorised by this permit must only be undertaken on the land described below:  
  
CT 5916/59  
Allotment 1 in Deposited Plan 63928  
Hundred of Port Adelaide
2. All work is to be carried out in accordance with the enclosed general specifications.
3. The well is not to penetrate beyond a maximum depth of 10 metres.
4. If the well is considered unsatisfactory, it may be abandoned and a replacement well may then be constructed provided that the abandoned well is backfilled prior to the drill rig leaving the site.
5. Water samples are required from all wells drilled in respect of this permit.
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Subject to full compliance with all the procedures, specifications and limitations contained or referred to, in the conditions set out below,

<b>Permit No:</b>	141393
<b>Expiry Date:</b>	20/12/2008

**Permission is hereby granted to:** RESOURCE AND ENVIRONMENTAL  
MANAGEMENT  
ACN 098 108 877  
UNIT 9, 15 FULLARTON ROAD  
KENT TOWN SA 5067

**To undertake the following water affecting activity:**

**Activity:** Well Construction and Backfill  
**Well Use:** Investigation

**CONDITIONS:**

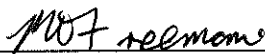
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<b>Permit No:</b>	141394
<b>Expiry Date:</b>	20/12/2008

**Permission is hereby granted to:** RESOURCE AND ENVIRONMENTAL  
MANAGEMENT  
ACN 098 108 877  
UNIT 9, 15 FULLARTON ROAD  
KENT TOWN SA 5067

**To undertake the following water affecting activity:**

**Activity:** Well Construction and Backfill  
**Well Use:** Investigation

**CONDITIONS:**

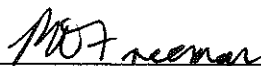
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<b>Expiry Date:</b>	20/12/2008

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MANAGEMENT  
ACN 098 108 877  
UNIT 9, 15 FULLARTON ROAD  
KENT TOWN SA 5067

**To undertake the following water affecting activity:**

**Activity:** Well Construction and Backfill  
**Well Use:** Investigation

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<b>Permit No:</b>	141396
<b>Expiry Date:</b>	20/12/2008

**Permission is hereby granted to:**

RESOURCE AND ENVIRONMENTAL  
MANAGEMENT  
ACN 098 108 877  
UNIT 9, 15 FULLARTON ROAD  
KENT TOWN SA 5067

**To undertake the following water affecting activity:**

**Activity:** Well Construction and Backfill  
**Well Use:** Investigation

**CONDITIONS:**

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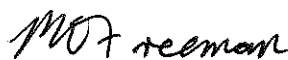


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<b>Permit No:</b>	141397
<b>Expiry Date:</b>	20/12/2008

**Permission is hereby granted to:** RESOURCE AND ENVIRONMENTAL  
MANAGEMENT  
ACN 098 108 877  
UNIT 9, 15 FULLARTON ROAD  
KENT TOWN SA 5067

**To undertake the following water affecting activity:**

**Activity:** Well Construction and Backfill  
**Well Use:** Investigation

**CONDITIONS:**

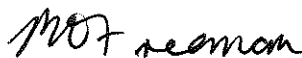
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Date: 20/12/2007

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Subject to full compliance with all the procedures, specifications and limitations contained or referred to, in the conditions set out below,

<b>Permit No:</b>	141398
<b>Expiry Date:</b>	20/12/2008

**Permission is hereby granted to:** RESOURCE AND ENVIRONMENTAL  
MANAGEMENT  
ACN 098 108 877  
UNIT 9, 15 FULLARTON ROAD  
KENT TOWN SA 5067

**To undertake the following water affecting activity:**

**Activity:** Well Construction and Backfill  
**Well Use:** Investigation

**CONDITIONS:**

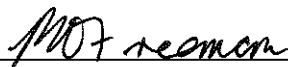
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Delegate of Minister for Environment and Conservation

Date: 20/12/2007

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RESOURCE ALLOCATION DIVISION

GPO Box 2834 Adelaide SA 5001

Ph: 8463 6913 Fax: 8463 6840

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**WELL PERMIT**

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<b>Permit No:</b>	141399
<b>Expiry Date:</b>	20/12/2008

**Permission is hereby granted to:** RESOURCE AND ENVIRONMENTAL  
MANAGEMENT  
ACN 098 108 877  
UNIT 9, 15 FULLARTON ROAD  
KENT TOWN SA 5067

**To undertake the following water affecting activity:**

**Activity:** Well Construction and Backfill  
**Well Use:** Investigation

**CONDITIONS:**

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CT 5916/59  
Allotment 1 in Deposited Plan 63928  
Hundred of Port Adelaide
2. All work is to be carried out in accordance with the enclosed general specifications.
3. The well is not to penetrate beyond a maximum depth of 10 metres.
4. If the well is considered unsatisfactory, it may be abandoned and a replacement well may then be constructed provided that the abandoned well is backfilled prior to the drill rig leaving the site.
5. Water samples are required from all wells drilled in respect of this permit.
6. Strata samples are not required.
7. The licensed well driller must forward with his report a plan obtained from the permit holder, who must mark thereon the location of all wells drilled in respect of this permit.
8. All wells must be drilled vertical unless written permission is obtained from the Minister.
9. Additional land parcels that this activity is authorised to be undertaken on are as

shown on the map marked as appendix A.

**NOTES:**

1. Under section 202(1)(b)(ii) of the Natural Resources Management Act 2004, you have a right of appeal to the Environment, Resources and Development Court against the imposition of any condition on this permit. The appeal must be instituted within six weeks of the date of permit issue. The appeal must also be served upon this department within that time.
2. This permit is not transferable.
3. This well construction permit is not an authorisation for a person to enter private property and prior authority must be obtained from the land owner in all circumstances.
4. The issue of this permit does not negate the requirement to comply with the provisions of other Acts that may impact on the activity undertaken pursuant to this permit.

**TAKE NOTE that the permit holder, or a person acting on behalf of the permit holder, who contravenes or fails to comply with a condition of this permit is guilty of an offence, and such acts or omissions may result in the variation, suspension or revocation of the permit.**



Robert Freeman  
A/ COORDINATOR WATER LICENSING  
Delegate of Minister for Environment and Conservation

Date: 20/12/2007

DEPARTMENT OF WATER, LAND AND BIODIVERSITY CONSERVATION

RESOURCE ALLOCATION DIVISION

GPO Box 2834 Adelaide SA 5001

Ph: 8463 6913 Fax: 8463 6840

**PERMIT to undertake a WATER AFFECTING ACTIVITY**

pursuant to section 135 of the *Natural Resources Management Act 2004*

**WELL PERMIT**

Subject to full compliance with all the procedures, specifications and limitations contained or referred to, in the conditions set out below,

<b>Permit No:</b>	141400
<b>Expiry Date:</b>	20/12/2008

**Permission is hereby granted to:** RESOURCE AND ENVIRONMENTAL  
MANAGEMENT  
ACN 098 108 877  
UNIT 9, 15 FULLARTON ROAD  
KENT TOWN SA 5067

**To undertake the following water affecting activity:**

**Activity:** Well Construction and Backfill  
**Well Use:** Investigation

**CONDITIONS:**

1. The activity authorised by this permit must only be undertaken on the land described below:  
  
CT 5916/59  
Allotment 1 in Deposited Plan 63928  
Hundred of Port Adelaide
2. All work is to be carried out in accordance with the enclosed general specifications.
3. The well is not to penetrate beyond a maximum depth of 10 metres.
4. If the well is considered unsatisfactory, it may be abandoned and a replacement well may then be constructed provided that the abandoned well is backfilled prior to the drill rig leaving the site.
5. Water samples are required from all wells drilled in respect of this permit.
6. Strata samples are not required.
7. The licensed well driller must forward with his report a plan obtained from the permit holder, who must mark thereon the location of all wells drilled in respect of this permit.
8. All wells must be drilled vertical unless written permission is obtained from the Minister.
9. Additional land parcels that this activity is authorised to be undertaken on are as



shown on the map marked as appendix A.

**NOTES:**

1. Under section 202(1)(b)(ii) of the Natural Resources Management Act 2004, you have a right of appeal to the Environment, Resources and Development Court against the imposition of any condition on this permit. The appeal must be instituted within six weeks of the date of permit issue. The appeal must also be served upon this department within that time.
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Robert Freeman  
A/ COORDINATOR WATER LICENSING  
Delegate of Minister for Environment and Conservation

Date: 20/12/2007

DEPARTMENT OF WATER, LAND AND BIODIVERSITY CONSERVATION

RESOURCE ALLOCATION DIVISION  
GPO Box 2834 Adelaide SA 5001  
Ph: 8463 6913 Fax: 8463 6840

**PERMIT to undertake a WATER AFFECTING ACTIVITY**

pursuant to section 135 of the *Natural Resources Management Act 2004*

**WELL PERMIT**

Subject to full compliance with all the procedures, specifications and limitations contained or referred to, in the conditions set out below,

<b>Permit No:</b>	141401
<b>Expiry Date:</b>	20/12/2008

**Permission is hereby granted to:** RESOURCE AND ENVIRONMENTAL  
MANAGEMENT  
ACN 098 108 877  
UNIT 9, 15 FULLARTON ROAD  
KENT TOWN SA 5067

**To undertake the following water affecting activity:**

**Activity:** Well Construction and Backfill  
**Well Use:** Investigation

**CONDITIONS:**

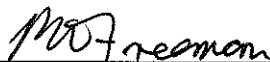
1. The activity authorised by this permit must only be undertaken on the land described below:  
  
CT 5916/59  
Allotment 1 in Deposited Plan 63928  
Hundred of Port Adelaide
2. All work is to be carried out in accordance with the enclosed general specifications.
3. The well is not to penetrate beyond a maximum depth of 10 metres.
4. If the well is considered unsatisfactory, it may be abandoned and a replacement well may then be constructed provided that the abandoned well is backfilled prior to the drill rig leaving the site.
5. Water samples are required from all wells drilled in respect of this permit.
6. Strata samples are not required.
7. The licensed well driller must forward with his report a plan obtained from the permit holder, who must mark thereon the location of all wells drilled in respect of this permit.
8. All wells must be drilled vertical unless written permission is obtained from the Minister.
9. Additional land parcels that this activity is authorised to be undertaken on are as

shown on the map marked as appendix A.

**NOTES:**

1. Under section 202(1)(b)(ii) of the Natural Resources Management Act 2004, you have a right of appeal to the Environment, Resources and Development Court against the imposition of any condition on this permit. The appeal must be instituted within six weeks of the date of permit issue. The appeal must also be served upon this department within that time.
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3. This well construction permit is not an authorisation for a person to enter private property and prior authority must be obtained from the land owner in all circumstances.
4. The issue of this permit does not negate the requirement to comply with the provisions of other Acts that may impact on the activity undertaken pursuant to this permit.

**TAKE NOTE that the permit holder, or a person acting on behalf of the permit holder, who contravenes or fails to comply with a condition of this permit is guilty of an offence, and such acts or omissions may result in the variation, suspension or revocation of the permit.**



Robert Freeman  
A/ COORDINATOR WATER LICENSING  
Delegate of Minister for Environment and Conservation

Date: 20/12/2007

# Bore Purging and Groundwater Sampling Data Sheet

General Information				Weather Conditions	
Client:	Walker Corporation			Rain:	—
Job Number:	GM - 01	Bore Locked (Y/N)	Y	Temperature:	25°C
Project:	GW Sampling	Well ID No.	MW-03	Wind Direction:	W
Location:	Buckland Park	Chem Kit No.	1	Wind Speed:	Slow
Depth to Groundwater (m-TOSC)		Well depth (m-top of casing)	9.91	Cloud Cover:	10%
Depth to Groundwater (m-pvc)	6.236	Free product thickness		Upwind Activities:	Farm
Depth to Groundwater (m-BGL)		RL from TOC		Location Conditions:	Dirt, Farmland

Field Comments	
Other Comments and Observations:	$r = 0.025$ $H = 9.91 - 6.236 = 3.674$ $R = 0.0635$ $h = 3.674$
- Bore Conditions	
- Fate of Tubing, etc. (left in hole/disposal)	
- Purge Volume Calculations in Liters (screened & unscreened sections)	$PV = [(3.674 \times \pi \times 0.025^2) + 0.2(\pi \times 3.674 \times (0.0635^2 - 0.025^2))] \times 1000$ $PV = 7.2 + 7.8$ $PV = 15 L$
where H = height of water column (m)	R = Bore Radius (m)
h = thickness of saturated filterpack (m)	r = PVC Radius (m)

Purging Information							
Date:	7/2/08						
Name:	David Poulsen, Wilbur Colaco						
Method:	12V Pump	Tubing Material:	Waters			Pump Depth:	
Start Time:	15:50	Finish Time:	16:08			Pump Speed:	
Purge Volume (L):	15	No times purged:	3			Total Purge Volumes (litres):	11.5
Time	Volume Removed (L)	pH	E.C. (mS/cm)	Redox (mV)	DO (ppM)	Temp (Cels)	Appearance
15:55	5 dry	7.48	10.60	51.6	/	19.6	Brown, turbid, No odour / Sheen
16:02	4 dry	7.37	10.96	60.8	/	19.6	" "
16:08	2.5 dry	7.33	10.86	64.4	/	19.4	" "
Purging should continue until measurements for pH are within 0.1 pH unit; EC is within 3%; Redox is within 10mV; DO is within 10% and Temperature is within 0.5 degC of the previous set of parameters							

Sampling Information							
Date:	7/2/08						
Name:	David Poulsen, Wilbur Colaco						
Method:	12V Pump	Tubing Material:	Waters			Pump Depth:	
Start Time:	16:14	Finish Time:	16:20			Pump Speed:	
Time	Volume Removed (L)	pH	E.C. (mS/cm)	Redox (mV)	DO (ppM)	Temp (Cels)	Colour Odour Turbidity
			As	Above			
Purger's Name:	David Poulsen	Signature		Date	7/2/08		
Sampler's Name:	David Poulsen	Signature		Date	7/2/08		
Checked by:		Signature		Date	11		



# Bore Purging and Groundwater Sampling Data Sheet

General Information			
Client:	Walker Corporation		
Job Number:	GM - 01	Bore Locked (Y/N)	Y
Project:	GW Sampling	Well ID No.	MW-04
Location:	Buckland Park	Chem Kit No.	1
Depth to Groundwater (m-TOSC)		Well depth (m-top of casing)	3.65
Depth to Groundwater (m-pvc)	1.690	Free product thickness	
Depth to Groundwater (m-BGL)		RL from TOC	

Weather Conditions	
Rain:	—
Wind Direction:	West
Temperature:	22°C
Wind Speed:	Modest
Cloud Cover:	80%
Upwind Activities:	Farming
Location Conditions:	
Dirt, Weeds	

Field Comments	
Other Comments and Observations:	
- Bore Conditions	$r = 0.025$ $H = 3.69 - 1.690 = 1.96$
- Fate of Tubing, etc. (left in hole/disposal)	$R = 0.0635$ $h = 1.96$
- Purge Volume Calculations in Liters (screened & unscreened sections)	$PV = [(1.96 \times \pi \times 0.025^2) + 0.2(\pi \times 1.96 \times (0.0635^2 - 0.025^2))] \times 1000$
	$PV = 3.84 + 4.19 = 8.04$
	$PV = 8L$

Purging Information							
Date:	7/2/08						
Method:	Water/Valve						
Start Time:	15:00						
Purge Volume (L):	8						
Name:	David Poulsen, Wilbur Colaco						
Tubing Material:	Watera						
Finish Time:	15:24						
No times purged:	4						
Pump Depth:							
Pump Speed:							
Total Purge Volumes (litres):	30						
Time	Volume Removed (L)	pH	E.C. (mS/cm)	Redox (mV)	DO (ppM)	Temp (Cels)	Appearance
15:10	8	7.37	30.8	110.3		23.8	Brown, High Turbidity, Odour/Screen
15:13	8	7.36	34.9	120.3		23.4	" "
15:16	6 dry	7.27	31.3	104.5		22.9	" "
15:20	8	7.27	34.9	103.8		19.9	" "
Purging should continue until measurements for pH are within 0.1 pH unit; EC is within 3%; Redox is within 10mV; DO is within 10% and Temperature is within 0.5 degC of the previous set of parameters							

Sampling Information							
Date:	7/2/08						
Method:	12V Pump						
Start Time:	15:25						
Name:	David Poulsen, Wilbur Colaco						
Tubing Material:	Watera						
Finish Time:	15:35						
Pump Depth:							
Pump Speed:							
Time	Volume Removed (L)	pH	E.C. (mS/cm)	Redox (mV)	DO (ppM)	Temp (Cels)	Colour Odour Turbidity
			As	Above			
Purger's Name:	David Poulsen	Signature		Date	7/2/08		
Sampler's Name:	David Poulsen	Signature		Date	7/2/08		
Checked by:		Signature		Date	11		



# Bore Purging and Groundwater Sampling Data Sheet

General Information				Weather Conditions	
Client:	Walker Corporation			Rain:	Wind Direction:
Job Number:	GM - 01	Bore Locked (Y/N)	Y	Temperature:	20°C
Project:	GW Sampling	Well ID No.	MW - 06	Cloud Cover:	80%
Location:	Buckland Park	Chem Kit No.	1	Upwind Activities:	(oad)
Depth to Groundwater (m-TOSC)		Well depth (m-top of casing)	3.68	Location Conditions:	
Depth to Groundwater (m-pvc)	1.540	Free product thickness		dirt/Weed/Salt tolerant vegetation	
Depth to Groundwater (m-BGL)		RL from TOC			

Field Comments	
Other Comments and Observations:	$r = 0.025$ $H = 3.68 - 1.540 = 2.14$ $R = 0.0635$ $h = 2.14$
- Bore Conditions	
- Fate of Tubing, etc. (left in hole/disposal)	
- Purge Volume Calculations in Liters (screened & unscreened sections)	$PV = [(0.14 \times \pi \times 0.025^2) + 0.2(2.14 \times \pi \times (0.0635^2 - 0.025^2))] \times 1000$ $PV = 4.20 + 4.58$ $PV = 8.8 L$
where H = height of water column (m)	R = Bore Radius (m)
h = thickness of saturated filterpack (m)	r = PVC Radius (m)

Purging Information							
Date:	7/2/08						
Method:	12V Pump			Name: David Poulsen, Wilbur Colaco		Tubing Material: Watara	
Start Time:	13:40		Finish Time: 14:00		Pump Depth:		
Purge Volume (L):	8.8		No times purged: 4 dry		Pump Speed:		
Total Purge Volumes (litres):		20					
Time	Volume Removed (L)	pH	E.C. (mS/cm)	Redox (mV)	DO (ppM)	Temp (Cels)	Appearance
13:47	6 dry	6.97	81.0	108.1		24.0	Brown, Hi Turbidity
13:50	5 dry	6.84	87.4	104.0		23.5	"
13:53	4.5 dry	6.82	92.2	90.2		23.5	"
13:58	4.5 dry	6.82	93.9	83.8		23.2	"
Purging should continue until measurements for pH are within 0.1 pH unit; EC is within 3%; Redox is within 10mV; DO is within 10% and Temperature is within 0.5 degC of the previous set of parameters							

Sampling Information							
Date:	7/2/08						
Method:	12V Pump			Name: David Poulsen, Wilbur Colaco		Tubing Material: Watara	
Start Time:	14:00		Finish Time: 14:15		Pump Depth:		
Pump Speed:							
Time	Volume Removed (L)	pH	E.C. (mS/cm)	Redox (mV)	DO (ppM)	Temp (Cels)	Colour Odour Turbidity
Purger's Name: David Poulsen		Signature		Date		7/2/08	
Sampler's Name: David Poulsen		Signature		Date		7/2/08	
Checked by:		Signature		Date		11	



DUP-I

### Bore Purging and Groundwater Sampling Data Sheet

General Information				Weather Conditions	
Client:	Walker Corporation			Rain:	-
Job Number:	GM - 01	Bore Locked (Y/N)	Y	Wind Direction:	W
Project:	GW Sampling	Well ID No.	MW-07	Temperature:	20°C
Location:	Buckland Park	Chem Kit No.	1	Cloud Cover:	90%
Depth to Groundwater (m-TOSC)		Well depth (m-top of casing)	3.98	Upwind Activities:	Salt Dam
Depth to Groundwater (m-pvc)	1.480	Free product thickness		Location Conditions:	Dirt, Wood, Farmland.
Depth to Groundwater (m-BGL)		RL from TOC			

Field Comments	
Other Comments and Observations:	
- Bore Conditions	$r = 0.025, H = 3.98 - 1.480 = 2.5$
- Fate of Tubing, etc. (left in hole/disposal)	$R = 0.0635, h = 2.5$
- Purge Volume Calculations in Liters (screened & unscreened sections)	$PV = [(2.5) \times \pi \times (0.025)^2] + 0.2 (\pi \times 2.5 \times (0.0635^2 - 0.025^2)) \times 1000$
	$PV = 4.9 + 5.3$
	$PV = 10.2 L$

Purging Information							
Date:	7/2/08						
Method:	12V Pump						
Name:	David Poulsen, Wilbur Colaco						
Tubing Material:	Waters						
Start Time:	12:30						
Finish Time:	13:03						
Purge Volume (L):	10.2						
No times purged:	5 dry						
Total Purge Volumes (litres):	18.5						
Time	Volume Removed (L)	pH	E.C. (mS/cm)	Redox (mV)	DO (ppM)	Temp (Cels)	Appearance
12:36	7.5 dry	6.86	97.9	153.4	/	22.0	Brown, Turbid, No Odour/Sheen
12:42	3.0 dry	6.84	102.0	81.0	/	22.3	"
12:50	2.5 dry	6.77	106.4	29.9	/	21.7	"
12:55	3.0 dry	6.79	106.3	12.8	/	21.8	"
12:58	2.5 dry	6.83	106.3	5.0	/	21.6	"
Purging should continue until measurements for pH are within 0.1 pH unit; EC is within 3%; Redox is within 10mV; DO is within 10% and Temperature is within 0.5 degC of the previous set of parameters							

Sampling Information							
Date:	7/2/08						
Method:	12V Pump						
Name:	David Poulsen, Wilbur Colaco						
Tubing Material:	Waters						
Start Time:	13:08						
Finish Time:	13:20						
Purge Volume (L):							
No times purged:							
Time	Volume Removed (L)	pH	E.C. (mS/cm)	Redox (mV)	DO (ppM)	Temp (Cels)	Colour Odour Turbidity
			As	Above			
Purger's Name:	David Poulsen		Signature	Date			
Sampler's Name:	David Poulsen		Signature	Date 7/2/08			
Checked by:			Signature	Date 7/2/08			
				Date 11			



# Bore Purging and Groundwater Sampling Data Sheet

General Information				Weather Conditions	
Client:	Walker Corporation			Rain:	-
Job Number:	GM - 01	Bore Locked (Y/N)	Y	Wind Direction:	W
Project:	GW Sampling	Well ID No.	MW 08	Temperature:	18°C
Location:	Buckland Park	Chem Kit No.	1	Cloud Cover:	100%
Depth to Groundwater (m-TOSC)		Well depth (m-top of casing)	4.25	Upwind Activities:	Farm
Depth to Groundwater (m-pvc)	2.289	Free product thickness		Location Conditions:	Farm
Depth to Groundwater (m-BGL)		RL from TOC			Dirt/Wood, Salt Pan Doms.

Field Comments	
Other Comments and Observations:	$r = 0.025$ $H = 4.25 - 2.289 = 1.961$ $R = 0.0635$ $h = 1.961$
- Bore Conditions	
- Fate of Tubing, etc. (left in hole/disposal)	
- Purge Volume Calculations in Liters (screened & unscreened sections)	$PV = [(1.961 \times \pi \times 0.025^2) + 0.2(1.961 \times \pi \times (0.0635^2 - 0.025^2))] \times 1000$ $PV = 3.85 + 4.19$ $PV = 8 L$
where H = height of water column (m)	R = Bore Radius (m)
h = thickness of saturated filterpack (m)	r = PVC Radius (m)

Purging Information							
Date:	7/2/08						
Method:	12V Pump						
Start Time:	11:40						
Purge Volume (L):	8						
Name:	David Poulsen, Wilbur Colaco						
Tubing Material:	Waters						
Finish Time:	11:59						
No times purged:	3 dry						
Pump Depth:							
Pump Speed:							
Total Purge Volumes (litres):	6						
Time	Volume Removed (L)	pH	E.C. (mS/cm)	Redox (mV)	DO (ppM)	Temp (Cels)	Appearance
11:45	4 dry	7.18	41.0	168.5		20.3	Brown, High Turbid, No Odour/Screen
11:50	1 dry	7.26	41.4	155.4		20.0	"
11:55	1 dry	7.28	40.9	155.5		20.4	"
Purging should continue until measurements for pH are within 0.1 pH unit; EC is within 3%; Redox is within 10mV; DO is within 10% and Temperature is within 0.5 degC of the previous set of parameters							

Sampling Information							
Date:	7/2/08						
Method:	12V Pump						
Start Time:	12:00						
Name:	David Poulsen, Wilbur Colaco						
Tubing Material:	Waters						
Finish Time:	12:30						
Pump Depth:							
Pump Speed:							
Time	Volume Removed (L)	pH	E.C. (mS/cm)	Redox (mV)	DO (ppM)	Temp (Cels)	Colour Odour Turbidity
			As	Above			Strong offensive smell.
Purger's Name:	David Poulsen	Signature		Date	7/2/08		
Sampler's Name:	David Poulsen	Signature		Date	7/2/08		
Checked by:		Signature		Date	11		





# Bore Purging and Groundwater Sampling Data Sheet

General Information				Weather Conditions	
Client:	Walker Corporation			Rain:	—
Job Number:	GM - 01	Bore Locked (Y/N)	Y	Temperature:	22°C
Project:	GW Sampling	Well ID No.	MW 09	Wind Speed:	NIL
Location:	Buckland Park	Chem Kit No.	1	Cloud Cover:	80%
Depth to Groundwater (m-TOSC)		Well depth (m-top of casing)	5.77	Upwind Activities:	
Depth to Groundwater (m-pvc)	3.619	Free product thickness		Location Conditions:	Farm land.
Depth to Groundwater (m-BGL)		RL from TOC			

Field Comments	
Other Comments and Observations:	$r = 0.025$ $H = 5.77 - 3.619 = 2.151$ $R = 0.0635$ $h = 2.151$
- Bore Conditions	
- Fate of Tubing, etc. (left in hole/disposal)	
- Purge Volume Calculations in Liters (screened & unscreened sections)	$PV = [(2.151 \times \pi \times 0.025^2) + 0.2(\pi \times 2.151 \times (0.0635^2 - 0.025^2))] \times 1000$ $PV = 4.2 + 4.6$ $PV = 8.8 L$

Purging Information							
Date:	7/2/08						
Method:	12V Pump			Name:	David Poulsen, Wilbur Colaco		
Start Time:	10:00		Tubing Material:	Watara		Pump Depth:	
Purge Volume (L):	8.8		Finish Time:	10:45		Pump Speed:	
			No times purged:	6 dry		Total Purge Volumes (litres):	17.5
Time	Volume Removed (L)	pH	E.C. (mS/cm)	Redox (mV)	DO (ppM)	Temp (Cels)	Appearance
10:05	7 dry	7.81	5.34	199.0		20.4	Brown, Silty, No Odour/Screen
10:10	3.5 dry	8.12	5.21	186.9		19.2	" "
10:15	0.5 dry	8.03	5.22	180.5		19.6	" "
10:25	1.5 dry	7.94	5.18	178.7		19.2	Clear, No Odour/Screen
10:35	2.5 dry	7.94	5.08	156.0		20.3	" "
10:40	2.5 dry	7.97	5.02	152.4		19.9	" "
Purging should continue until measurements for pH are within 0.1 pH unit; EC is within 3%; Redox is within 10mV; DO is within 10% and Temperature is within 0.5 degC of the previous set of parameters							

Sampling Information							
Date:	7/2/08						
Method:	12V Pump			Name:	David Poulsen, Wilbur Colaco		
Start Time:	10:45		Tubing Material:	Watara		Pump Depth:	
			Finish Time:	11:10		Pump Speed:	
Time	Volume Removed (L)	pH	E.C. (mS/cm)	Redox (mV)	DO (ppM)	Temp (Cels)	Colour Odour Turbidity
				As Above			
Purger's Name: David Poulsen		Signature		Date		7/2/08	
Sampler's Name: David Poulsen		Signature		Date		7/2/08	
Checked by:		Signature		Date		11	



DVP II

### Bore Purging and Groundwater Sampling Data Sheet

General Information				Weather Conditions	
Client:	Walker Corporation			Rain:	—
Job Number:	GM - 01	Bore Locked (Y/N)	N (Broken)	Wind Direction:	W
Project:	GW Sampling	Well ID No.	MW 11	Temperature:	22°C
Location:	Buckland Park	Chem Kit No.	1	Wind Speed:	Slow
Depth to Groundwater (m-TOSC)		Well depth (m-top of casing)	7.25	Cloud Cover:	50%
Depth to Groundwater (m-pvc)	4.264	Free product thickness		Upwind Activities:	Farm
Depth to Groundwater (m-BGL)		RL from TOC		Location Conditions:	Dirt/Wood Farmland.

Field Comments	
Other Comments and Observations:	$r = 0.025$ $H = 7.25 - 4.264 = 2.986$ $R = 0.0635$ $h = 2.986$
- Bore Conditions	
- Fate of Tubing, etc. (left in hole/disposal)	
- Purge Volume Calculations in Liters (screened & unscreened sections)	$PV = [(2.986 \times \pi \times 0.025^2) + 0.2(\pi \times 2.986 \times (0.0635^2 - 0.025^2))] \times 1000$ $PV = 5.86 + 6.39$ $PV = 12.2 L$
where H = height of water column (m)	R = Bore Radius (m)
h = thickness of saturated filterpack (m)	r = PVC Radius (m)

Purging Information							
Date:	7/2/08						
Method:	12V Pump			Name: David Poulsen, Wilbur Colaco		Tubing Material: Watara	
Start Time:	14:18		Finish Time: 14:35		Pump Depth:		
Purge Volume (L):	No times purged: 3			Total Purge Volumes (litres): 38.2			
Time	Volume Removed (L)	pH	E.C. (mS/cm)	Redox (mV)	DO (ppM)	Temp (Cels)	Appearance
14:20	12.2	7.82	12.99	58.4		19.7	Brown, High Turbidity, No Odour/Smell
14:25	13.0	7.70	12.73	62.8		19.5	" "
14:30	13.0	7.70	12.82	63.1		18.7	" "
Purging should continue until measurements for pH are within 0.1 pH unit; EC is within 3%; Redox is within 10mV; DO is within 10% and Temperature is within 0.5 degC of the previous set of parameters							

Sampling Information							
Date:	7/2/08						
Method:	12V Pump			Name: David Poulsen, Wilbur Colaco		Tubing Material: Watara	
Start Time:	14:35		Finish Time: 14:40		Pump Depth:		
Purge Volume (L):	No times purged: 3			Total Purge Volumes (litres): 38.2			
Time	Volume Removed (L)	pH	E.C. (mS/cm)	Redox (mV)	DO (ppM)	Temp (Cels)	Colour Odour Turbidity
			AS	Above			
Purger's Name: David Poulsen		Signature		Date		7/2/08	
Sampler's Name: David Poulsen		Signature		Date		7/2/08	
Checked by:		Signature		Date		11	



# Bore Purging and Groundwater Sampling Data Sheet

General Information				Weather Conditions	
Client:	Walker Corporation			Rain:	Wind Direction:
Job Number:	GM - 01	Bore Locked (Y/N)	Y	Temperature:	22°C
Project:	GW Sampling	Well ID No.	MW - 12	Wind Speed:	M/L
Location:	Buckland Park	Chem Kit No.	1	Cloud Cover:	80%
Depth to Groundwater (m-TOSC)		Well depth (m-top of casing)	4.73	Upwind Activities:	Farm
Depth to Groundwater (m-pvc)	2.442	Free product thickness		Location Conditions:	
Depth to Groundwater (m-BGL)		RL from TOC			Farmland
					Dirt / Woods

Field Comments	
Other Comments and Observations:	$r = 0.025$ $H = 4.73 - 2.442 = 2.288$ $R = 0.0635$ $h = 2.288$
- Bore Conditions	
- Fate of Tubing, etc. (left in hole/disposal)	
- Purge Volume Calculations in Liters (screened & unscreened sections)	$PV = [(2.288 \times \pi \times 0.025^2) + 0.2(\pi \times 2.288 \times (0.0635^2 - 0.025^2))] \times 1000$ $PV = 4.49 + 4.89 = 9.38$ $PV = 9.4 L$
$PV = [(H \times \pi \times r^2) + 0.2(h \times \pi \times (R^2 - r^2))] \times 1000$ where H = height of water column (m)      R = Bore Radius (m) h = thickness of saturated filterpack (m)      r = PVC Radius (m)	

Purging Information							
Date:	7/2/08						
Name:	David Poulsen, Wilbur Colaco						
Method:	12V Pump	Tubing Material:	Watera	Pump Depth:			
Start Time:	11:00	Finish Time:	11:15	Pump Speed:			
Purge Volume (L):	9.4	No times purged:	3	Total Purge Volumes (litres):	7.5		
Time	Volume Removed (L)	pH	E.C. (mS/cm)	Redox (mV)	DO (ppM)	Temp (Cels)	Appearance
11:05	4.5 dry	7.32	31.3	190.6	/	20.9	Brown, High Turbidity, No Odour/Sheen
11:10	1.5 dry	7.32	32.0	178.6	/	19.7	"
11:15	1.5 dry	7.29	32.2	176.8	/	20.0	"
Purging should continue until measurements for pH are within 0.1 pH unit; EC is within 3%; Redox is within 10mV; DO is within 10% and Temperature is within 0.5 degC of the previous set of parameters							

Sampling Information							
Date:	7/2/08						
Name:	David Poulsen, Wilbur Colaco						
Method:	12V Pump	Tubing Material:	Watera	Pump Depth:			
Start Time:	11:15	Finish Time:	11:20	Pump Speed:			
Time	Volume Removed (L)	pH	E.C. (mS/cm)	Redox (mV)	DO (ppM)	Temp (Cels)	Colour Odour Turbidity
			As	Above			
Purger's Name:	David Poulsen	Signature		Date	7/2/08		
Sampler's Name:	David Poulsen	Signature		Date	7/2/08		
Checked by:		Signature		Date	11		



# Bore Purging and Groundwater Sampling Data Sheet

General Information			
Client:	Walker Corporation		
Job Number:	GM - 01	Bore Locked (Y/N)	Y
Project:	GW Sampling	Well ID No.	MW-01
Location:	Buckland Park	Chem Kit No.	1
Depth to Groundwater (m-TOSC)		Well depth (m-top of casing)	10.30
Depth to Groundwater (m-pvc)	5.963	Free product thickness	
Depth to Groundwater (m-BGL)		RL from TOC	

Weather Conditions	
Rain:	-
Wind Direction:	N-W
Temperature:	28°
Wind Speed:	Strong
Cloud Cover:	Nil
Upwind Activities:	Farm
Location Conditions:	
Farmland	
Dist, weeds.	

Field Comments	
Other Comments and Observations:	
- Bore Conditions	$r = 0.025$ $H = 10.30 - 5.963 = 4.337$
- Fate of Tubing, etc. (left in hole/disposal)	$R = 0.0635$ $h = 4.337$
- Purge Volume Calculations in Liters (screened & unscreened sections)	$PV = [(4.337 \times \pi \times 0.025^2) + 0.2 \times \pi \times (0.0635^2 - 0.025^2)] \times 1000$
	$PV = 8.5 + 9.2$
	$PV = 17.9 L$

Purging Information							
Date:	13/2/08						
Method:	12V Pump						
Start Time:	14:00						
Purge Volume (L):	17.9						
Name:	David Poulsen, Wilbur Colaco						
Tubing Material:	Watera						
Finish Time:	14:50						
No times purged:	7 dry						
Total Purge Volumes (litres):	11.2						
Time	Volume Removed (L)	pH	E.C. (mS/cm)	Redox (mV)	DO (ppM)	Temp (Cels)	Appearance
14:05	8 Dry	6.90	11.26	151		20.1	Brown/Hi turbid, No odour/Sheen
14:13	1.0 Dry	7.06	11.35	102		19.6	"
14:26	1.0 Dry	6.90	11.38	100		19.2	"
14:30	0.5 Dry	7.26	11.34	45		19.6	"
14:35	0.2 Dry	7.27	11.37	49		19.2	Brown, Med Turbid, NO odour/Sheen
14:40	0.2 Dry	7.07	11.31	68		19.2	"
14:45	0.4 Dry	7.12	11.34	77		19.3	"
Purging should continue until measurements for pH are within 0.1 pH unit; EC is within 3%; Redox is within 10mV; DO is within 10% and Temperature is within 0.5 degC of the previous set of parameters							

Sampling Information							
Date:	13/2/08						
Method:	12V Pump						
Start Time:	14:50						
Name:	David Poulsen						
Tubing Material:	Watera						
Finish Time:	15:45						
Pump Depth:							
Pump Speed:							
Time	Volume Removed (L)	pH	E.C. (mS/cm)	Redox (mV)	DO (ppM)	Temp (Cels)	Colour Odour Turbidity
			NS	Above			
Purger's Name:	David Poulsen	Signature			Date	13/2/08	
Sampler's Name:	David Poulsen	Signature			Date	13/2/08	
Checked by:		Signature			Date	11	



# Bore Purging and Groundwater Sampling Data Sheet

*DUP 3*

General Information			
Client:	Walker Corporation		
Job Number:	GM - 01	Bore Locked (Y/N)	Y
Project:	GW Sampling	Well ID No.	MW - 02
Location:	Buckland Park	Chem Kit No.	1
Depth to Groundwater (m-TOSC)		Well depth (m-top of casing)	5.41
Depth to Groundwater (m-pvc)	2.00	Free product thickness	
Depth to Groundwater (m-BGL)		RL from TOC	

Weather Conditions	
Rain:	-
Wind Direction:	W
Temperature:	28°C
Wind Speed:	Moderate
Cloud Cover:	N/A
Upwind Activities:	Farm
Location Conditions:	
Fairland, Dirt, weeds	

Field Comments	
Other Comments and Observations:	
- Bore Conditions	$r = 0.025$ $H = 5.41 - 2.00 = 3.41$
- Fate of Tubing, etc. (left in hole/disposal)	$R = 0.0635$ $h = 3.41$
- Purge Volume Calculations in Liters (screened & unscreened sections)	$PV = [(H \times \pi \times r^2) + 0.2(h \times \pi \times (R^2 - r^2))] \times 1000$ $PV = [(3.41 \times \pi \times 0.025^2) + 0.2(3.41 \times \pi \times (0.0635^2 - 0.025^2))] \times 1000$ $PV = 6.7 + 7.3 = 14 L$
where H = height of water column (m)	R = Bore Radius (m)
h = thickness of saturated filterpack (m)	r = PVC Radius (m)

Purging Information							
Date:	13/2/08						
Method:	12V Pump						
Start Time:	13:10						
Purge Volume (L):	14.0						
Name:	David Poulsen, Wilbur Colaco						
Tubing Material:	Watera						
Finish Time:	13:35						
No times purged:	5 dry						
Total Purge Volumes (litres):	28						
Time	Volume Removed (L)	pH	E.C. (mS/cm)	Redox (mV)	DO (ppM)	Temp (Cels)	Appearance
13:15	10 Dry	7.65	8.67	136		23.0	Brown, silty, No odour/shreen
13:18	4 Dry	7.90	8.81	47		21.2	Pale Brown, Cloudy - 45 -
13:25	4 Dry	7.85	8.84	40		21.1	Almost Clear, - 45 -
13:28	5 Dry	7.79	8.84	20		21.3	Clear, No silt, No odour/shreen
13:32	5 Dry	7.81	8.87	18		21.4	"
Purging should continue until measurements for pH are within 0.1 pH unit; EC is within 3%; Redox is within 10mV; DO is within 10% and Temperature is within 0.5 degC of the previous set of parameters							

Sampling Information							
Date:	13/2/08						
Method:	12V Pump						
Start Time:	13:40						
Name:	David Poulsen, Wilbur Colaco						
Tubing Material:	Watera						
Finish Time:	14:00						
Pump Depth:							
Pump Speed:							
Time	Volume Removed (L)	pH	E.C. (mS/cm)	Redox (mV)	DO (ppM)	Temp (Cels)	Colour Odour Turbidity
<del>13:40</del>							
			15	Above			
Purger's Name:	David Poulsen		Signature			Date	13/2/08
Sampler's Name:	David Poulsen		Signature			Date	13/2/08
Checked by:			Signature			Date	11



# Bore Purging and Groundwater Sampling Data Sheet

General Information				Weather Conditions	
Client:	Walker Corporation			Rain: —	Wind Direction: N-E
Job Number:	GM - 01	Bore Locked (Y/N)	Y	Temperature: 22°C	Wind Speed: Strong
Project:	GW Sampling	Well ID No.	MW-04	Cloud Cover: Nil	Upwind Activities: Fast
Location:	Buckland Park	Chem Kit No.	1	Location Conditions:	
Depth to Groundwater (m-TOSC)		Well depth (m-top of casing)	3.65	Fairly windy	
Depth to Groundwater (m-pvc)	1.653	Free product thickness		Dirt	
Depth to Groundwater (m-BGL)		RL from TOC			

Field Comments	
Other Comments and Observations:	$r = 0.025$ $H = 3.65 - 1.653 = 1.997$
- Bore Conditions	$R = 0.0635$ $h = 1.997$
- Fate of Tubing, etc. (left in hole/disposal)	
- Purge Volume Calculations in Liters (screened & unscreened sections)	$PV = [(1.997 \times \pi \times 0.025^2) + 0.2(\pi \times 1.997 \times (0.0635^2 - 0.025^2))] \times 1000$
	$PV = 3.92 + 4.27 = 8.19 \approx 8.2 L$
where H = height of water column (m)	R = Bore Radius (m)
h = thickness of saturated filterpack (m)	r = PVC Radius (m)

Purging Information							
Date:	13/2/08						
Name:	David Poulsen, Wilbur Colaco						
Method:	Foot Valve	Tubing Material:	Watera	Pump Depth:			
Start Time:	9:50	Finish Time:	10:35	Pump Speed:			
Purge Volume (L):	8.2 L	No times purged:	7	Total Purge Volumes (litres):	52.2		
Time	Volume Removed (L)	pH	E.C. (mS/cm)	Redox (mV)	DO (ppM)	Temp (Cels)	Appearance
9:53	3.0 dm	7.15	39.2	144		20.4	Brown, Silty, No Odour/Screen
10:00	8.2	7.38	35.1	123		22.9	" "
10:05	8.2	7.23	35.7	108		23.0	" "
10:15	8.2	7.31	35.8	114		22.3	" "
10:20	8.2	7.22	35.8	105		23.1	" "
10:30	8.2	7.37	36.2	113		21.1	" "
10:35	8.2	7.40	36.1	104		21.5	" "
Purging should continue until measurements for pH are within 0.1 pH unit; EC is within 3%; Redox is within 10mV; DO is within 10% and Temperature is within 0.5 degC of the previous set of parameters							

Sampling Information							
Date:	13/2/08						
Name:	David Poulsen, Wilbur Colaco						
Method:	12V Pump	Tubing Material:	Watera	Pump Depth:			
Start Time:	10:38	Finish Time:	10:45	Pump Speed:			
Time	Volume Removed (L)	pH	E.C. (mS/cm)	Redox (mV)	DO (ppM)	Temp (Cels)	Colour Odour Turbidity
			As	Above			
Purger's Name: David Poulsen		Signature	Date		13/2/08		
Sampler's Name: David Poulsen		Signature	Date		13/2/08		
Checked by:		Signature	Date		11		



# Bore Purging and Groundwater Sampling Data Sheet

General Information				Weather Conditions	
Client:	Walker Corporation			Rain:	—
Job Number:	GM - 01	Bore Locked (Y/N)	Y	Wind Direction:	N
Project:	GW Sampling	Well ID No.	MW-05	Temperature:	28°C
Location:	Buckland Park	Chem Kit No.	1	Wind Speed:	Mod
Depth to Groundwater (m-TOSC)		Well depth (m-top of casing)	7.67	Cloud Cover:	20%
Depth to Groundwater (m-pvc)	3.865	Free product thickness		Upwind Activities:	Farming
Depth to Groundwater (m-BGL)		RL from TOC		Location Conditions:	Farmland Dirt, weeds

Field Comments	
Other Comments and Observations:	$r = 0.025$ $H = 7.67 - 3.865 = 3.805$ $R = 0.0635$ $h = 3.805$
- Bore Conditions	
- Fate of Tubing, etc. (left in hole/disposal)	
- Purge Volume Calculations in Liters (screened & unscreened sections)	$PV = [(3.805 \times \pi \times 0.025^2)] + 0.2(\pi \times 3.805 \times (0.0635^2 - 0.025^2)) \times 1000$ $PV = 7.47 + 8.14$ $PV = 15.6$
$PV = [(H \times \pi \times r^2) + 0.2(h \times \pi \times (R^2 - r^2))] \times 1000$	
where H = height of water column (m)	R = Bore Radius (m)
h = thickness of saturated filterpack (m)	r = PVC Radius (m)

Purging Information							
Date:	13/2/08						
Name:	David Poulsen, Wilbur Colaco						
Method:	12V Pump	Tubing Material:	Waters			Pump Depth:	
Start Time:	12:00	Finish Time:	12:25			Pump Speed:	
Purge Volume (L):	15.6	No times purged:	5 dry			Total Purge Volumes (litres):	37.5
Time	Volume Removed (L)	pH	E.C. (mS/cm)	Redox (mV)	DO (ppM)	Temp (Cels)	Appearance
12:05	9.0 dry	7.37	22.22	90		21.2	Brown Silty, No odour/shen
12:10	8.0 dry	7.73	24.6	16		19.8	" "
12:13	6.0 dry	7.64	24.6	35		19.4	" "
12:16	7.0 dry	7.45	24.6	72		19.1	" "
12:18	7.5 dry	7.50	24.6	62		18.9	" "
Purging should continue until measurements for pH are within 0.1 pH unit; EC is within 3%; Redox is within 10mV; DO is within 10% and Temperature is within 0.5 degC of the previous set of parameters							

Sampling Information							
Date:	13/2/08						
Name:	David Poulsen, Wilbur Colaco						
Method:	12V Pump	Tubing Material:	Waters			Pump Depth:	
Start Time:	12:40	Finish Time:	13:00			Pump Speed:	
Time	Volume Removed (L)	pH	E.C. (mS/cm)	Redox (mV)	DO (ppM)	Temp (Cels)	Colour Odour Turbidity
			As	Above			
Purger's Name:	David Poulsen	Signature:			Date:	13/2/08	
Sampler's Name:	David Poulsen	Signature:			Date:	13/2/08	
Checked by:		Signature:			Date:	11	



# Bore Purging and Groundwater Sampling Data Sheet

General Information				Weather Conditions	
Client:	Walker Corporation			Rain:	—
Job Number:	GM - 01	Bore Locked (Y/N)	Y	Wind Direction:	E
Project:	GW Sampling	Well ID No.	MW-06	Temperature:	20°C
Location:	Buckland Park	Chem Kit No.	1	Wind Speed:	Moderate
Depth to Groundwater (m-TOSC)		Well depth (m-top of casing)	3.68	Cloud Cover:	10%
Depth to Groundwater (m-pvc)	1.550	Free product thickness		Upwind Activities:	Farm
Depth to Groundwater (m-BGL)		RL from TOC		Location Conditions:	Fairland, weed, dirt

Field Comments	
Other Comments and Observations:	
- Bore Conditions	$r = 0.025$ $H = 3.68 - 1.550 = 2.13$
- Fate of Tubing, etc. (left in hole/disposal)	$R = 0.0635$ $h = 2.13$
- Purge Volume Calculations in Liters (screened & unscreened sections)	$PV = [(2.13 \times \pi \times 0.025^2) + 0.2(\pi \times 2.13 \times (0.0635^2 - 0.025^2))] \times 1000$
	$PV = 4.18 + 4.55 = 8.7 \text{ L}$
where H = height of water column (m)	R = Bore Radius (m)
h = thickness of saturated filterpack (m)	r = PVC Radius (m)

Purging Information							
Date:	13/2/08						
Name:	David Poulsen, Wilbur Colaco						
Method:	12V Pump	Tubing Material:	Waters			Pump Depth:	
Start Time:	8:15	Finish Time:	8:33			Pump Speed:	
Purge Volume (L):	8.7	No times purged:	5			Total Purge Volumes (litres):	43.5
Time	Volume Removed (L)	pH	E.C. (mS/cm)	Redox (mV)	DO (ppM)	Temp (Cels)	Appearance
8:16	8.7	6.64	105.4	269		21.3	Brown, Silty, No odour/screen
8:19	8.7	6.59	105.0	222		22.4	"
8:21	8.7	6.63	103.4	83		23.4	"
8:25	8.7	6.70	103.5	45		22.6	late Brown, Silty, No odour/screen
8:30	8.7	6.66	106.6	43		22.7	"
Purging should continue until measurements for pH are within 0.1 pH unit; EC is within 3%; Redox is within 10mV; DO is within 10% and Temperature is within 0.5 degC of the previous set of parameters							

Sampling Information							
Date:	13/2/08						
Name:	David Poulsen, Wilbur Colaco						
Method:	12V Pump	Tubing Material:	Waters			Pump Depth:	
Start Time:	8:40	Finish Time:	8:50			Pump Speed:	
Time	Volume Removed (L)	pH	E.C. (mS/cm)	Redox (mV)	DO (ppM)	Temp (Cels)	Colour Odour Turbidity
			AS	Above			
Purger's Name:	David Poulsen	Signature:	[Signature]		Date:	13/2/08	
Sampler's Name:	David Poulsen	Signature:	[Signature]		Date:	13/2/08	
Checked by:		Signature:	[Signature]		Date:	11	





# Bore Purging and Groundwater Sampling Data Sheet

General Information				Weather Conditions	
Client:	Walker Corporation			Rain:	—
Job Number:	GM - 01	Bore Locked (Y/N)	Y	Wind Direction:	NW
Project:	GW Sampling	Well ID No.	MW-08	Temperature:	22°C
Location:	Buckland Park	Chem Kit No.	1	Cloud Cover:	N/A
Depth to Groundwater (m-TOSC)		Well depth (m-top of casing)	4.25	Upwind Activities:	Farm
Depth to Groundwater (m-pvc)	2.295	Free product thickness		Location Conditions:	Fairland, Dirt, Weed.
Depth to Groundwater (m-BGL)		RL from TOC			

Field Comments	
Other Comments and Observations:	$r = 0.025$ $H = 4.25 - 2.295 = 1.955$ $R = 0.0635$ $h = 1.955$
- Bore Conditions	
- Fate of Tubing, etc. (left in hole/disposal)	
- Purge Volume Calculations in Liters (screened & unscreened sections)	$PV = [(C \times 1.955 \times \pi \times 0.025^2) + 0.2(\pi \times 1.955 \times (0.0635^2 - 0.025^2))] \times 1000$ $\times 1000$ $PV = 4.18 + 4.55 = 8.73$ $PV = 8.73$
where H = height of water column (m)	R = Bore Radius (m)
h = thickness of saturated filterpack (m)	r = PVC Radius (m)

Purging Information							
Date:	13/2/08						
Name:	David Poulsen, Wilbur Colaco						
Method:	12V Pump	Tubing Material:	Watera			Pump Depth:	
Start Time:	8:59	Finish Time:				Pump Speed:	
Purge Volume (L):	8.73	No times purged:	5 dry			Total Purge Volumes (litres):	17.5
Time	Volume Removed (L)	pH	E.C. (mS/cm)	Redox (mV)	DO (ppM)	Temp (Cels)	Appearance
9:02	5.5 dry	7.30	43.5	136		19.6	Pale Brown, Silty, No odour/Screen
9:10	2.5 dry	7.26	42.6	149		20.2	" "
9:15	3.0 dry	7.23	27.2	161		21.4	" "
9:25	3.5 dry	7.17	42.1	99		21.0	" "
9:30	3.0 dry	7.21	41.9	64		21.4	Pale brown, less silty, No odour/Screen
Purging should continue until measurements for pH are within 0.1 pH unit; EC is within 3%; Redox is within 10mV; DO is within 10% and Temperature is within 0.5 degC of the previous set of parameters							

Sampling Information							
Date:	13/2/08						
Name:	David Poulsen, Wilbur Colaco						
Method:	12V Pump	Tubing Material:	Watera			Pump Depth:	
Start Time:	9:33	Finish Time:	9:45			Pump Speed:	
Time	Volume Removed (L)	pH	E.C. (mS/cm)	Redox (mV)	DO (ppM)	Temp (Cels)	Colour Odour Turbidity
				Above			
Purger's Name: David Poulsen		Signature	Date		13/2/08		
Sampler's Name: David Poulsen		Signature	Date		13/2/08		
Checked by:		Signature	Date		11		



# Bore Purging and Groundwater Sampling Data Sheet

General Information				Weather Conditions	
Client:	Walker Corporation			Rain:	Wind Direction: <i>W</i>
Job Number:	GM - 01	Bore Locked (Y/N)	<i>W</i>	Temperature: <i>26°C</i>	Wind Speed: <i>Moderate</i>
Project:	GW Sampling	Well ID No.	<i>MW-11</i>	Cloud Cover: <i>Nil</i>	Upwind Activities:
Location:	Buckland Park	Chem Kit No.	1	Location Conditions: <i>Fairly level, Dirt, Weed.</i>	
Depth to Groundwater (m-TOSC)		Well depth (m-top of casing)	<i>7.25</i>		
Depth to Groundwater (m-pvc)	<i>4.280</i>	Free product thickness			
Depth to Groundwater (m-BGL)		RL from TOC			

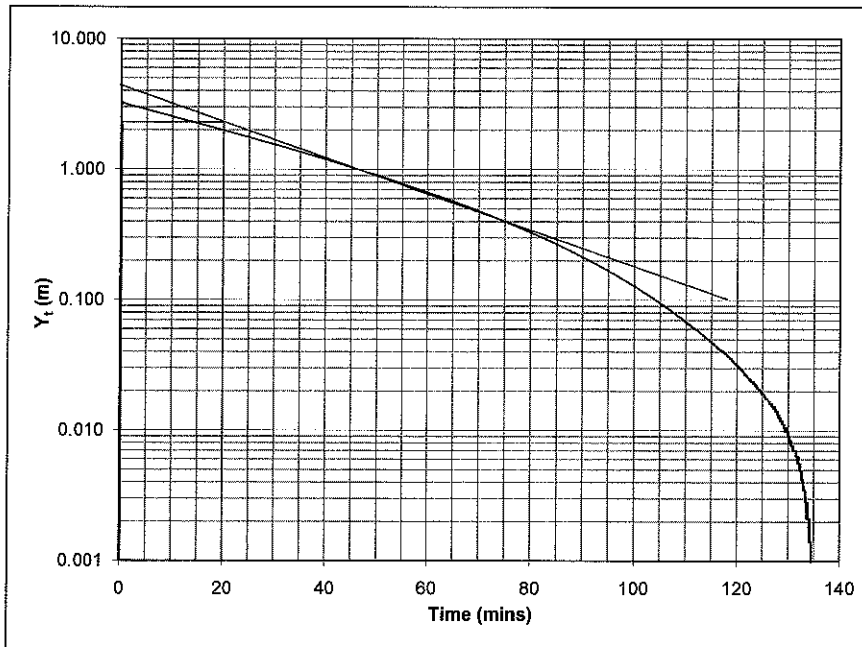
Field Comments	
Other Comments and Observations:	$r = 0.025$ $H = 7.25 - 4.280 = 2.97$ $R = 0.0635$ $h = 2.97$
- Bore Conditions	
- Fate of Tubing, etc. (left in hole/disposal)	
- Purge Volume Calculations in Liters (screened & unscreened sections)	$PV = [(2.97 \times \pi \times 0.025^2) + 0.2(2.97 \times \pi \times (0.0635^2 - 0.025^2))] \times 1000$
	$PV = 5.83 + 6.35$ $PV = 12.18 \approx 12.2L$

Purging Information							
Date: <i>13/2/08</i>	Name: David Poulsen, Wilbur Colaco						
Method: 12V Pump	Tubing Material: Watara			Pump Depth:			
Start Time: <i>11:05</i>	Finish Time: <i>11:28</i>			Pump Speed:			
Purge Volume (L): <i>12.2</i>	No times purged: <i>4</i>			Total Purge Volumes (litres): <i>50.4</i>			
Time	Volume Removed (L)	pH	E.C. (mS/cm)	Redox (mV)	DO (ppM)	Temp (Cels)	Appearance
<i>11:15</i>	<i>12.2</i>	<i>7.61</i>	<i>12.46</i>	<i>91</i>	<i>/</i>	<i>20.0</i>	<i>Drawn, Turbid, No</i>
<i>11:18</i>	<i>12.2</i>	<i>7.64</i>	<i>12.20</i>	<i>37</i>	<i>/</i>	<i>19.8</i>	<i>Screen</i>
<i>11:22</i>	<i>13.0</i>	<i>7.73</i>	<i>12.13</i>	<i>-1</i>	<i>/</i>	<i>19.7</i>	<i>"</i>
<i>11:28</i>	<i>13.0</i>	<i>7.75</i>	<i>12.28</i>	<i>-1</i>	<i>/</i>	<i>19.8</i>	<i>"</i>
Purging should continue until measurements for pH are within 0.1 pH unit; EC is within 3%; Redox is within 10mV; DO is within 10% and Temperature is within 0.5 degC of the previous set of parameters							

Sampling Information							
Date: <i>13/2/08</i>	Name: David Poulsen, Wilbur Colaco						
Method: 12V Pump	Tubing Material: Watara			Pump Depth:			
Start Time: <i>11:33</i>	Finish Time: <i>11:40</i>			Pump Speed:			
Time	Volume Removed (L)	pH	E.C. (mS/cm)	Redox (mV)	DO (ppM)	Temp (Cels)	Colour Odour Turbidity
<i>/</i>	<i>/</i>	<i>/</i>	<i>As</i>	<i>Above</i>	<i>/</i>	<i>/</i>	<i>/</i>
Purger's Name: David Poulsen	Signature	<i>[Signature]</i>		Date	<i>13/2/08</i>		
Sampler's Name: David Poulsen	Signature	<i>[Signature]</i>		Date	<i>13/2/08</i>		
Checked by:	Signature	<i>[Signature]</i>		Date	<i>11</i>		



Project Name: Buckland Park  
 Client: Walker Corporation  
 Date: 20-Feb-08  
 Time: 09:20  
 Well No. / Name: MWREM01  
 Depth to equilibrium water level (m RL): 5.976 mTOC  
 Type of test:  Rising head  Falling head  
 Well Completion:  Fully Penetrating  Partially Penetrating



$r_c$  = casing radius 0.025  
 $r_w$  = radial distance between undisturbed aquifer and well centre 0.0625  
 $L_o$  = length of intake 4.324  
 $H$  = saturated thickness of aquifer 5  
 $L_w$  = distance b/n water table and bottom of intake 4.324  
 $R_o$  = effective well radius 1.27  
 $t$  = time 20  
 $Y_o$  = initial drawdown 3.671  
 $Y_t$  = vertical distance between the water level in well at time t and equilibrium level 2.1  
 $L_e/r_w$  = 69.184  
 $A$  = dimensionless co-efficient that is a function of  $L_e/r_w$ , and  $L_w < H$  3.6  
 $B$  = dimensionless co-efficient that is a function of  $L_e/r_w$ , and  $L_w < H$  0.6  
 $C$  = dimensionless co-efficient that is a function of  $L_e/r_w$ , and  $L_w = H$  3.3

**If  $L_w < H$**

$$\ln(R_o/r_w) = \{1.1 \cdot [\ln(L_w/r_w)]^{-1} + A + B \cdot \ln[(H-L_w)/r_w] \cdot (L_o/r_w)^{-1}\}^{-1}$$

= 3.01 m

**If  $L_w = H$**

$$\ln(R_o/r_w) = \{1.1 \cdot [\ln(L_w/r_w)]^{-1} + C \cdot (L_o/r_w)^{-1}\}^{-1}$$

=  $L_w < H$  m

Reduced by: \_\_\_\_\_ Date: \_\_\_\_\_

Checked by: \_\_\_\_\_ Date: \_\_\_\_\_

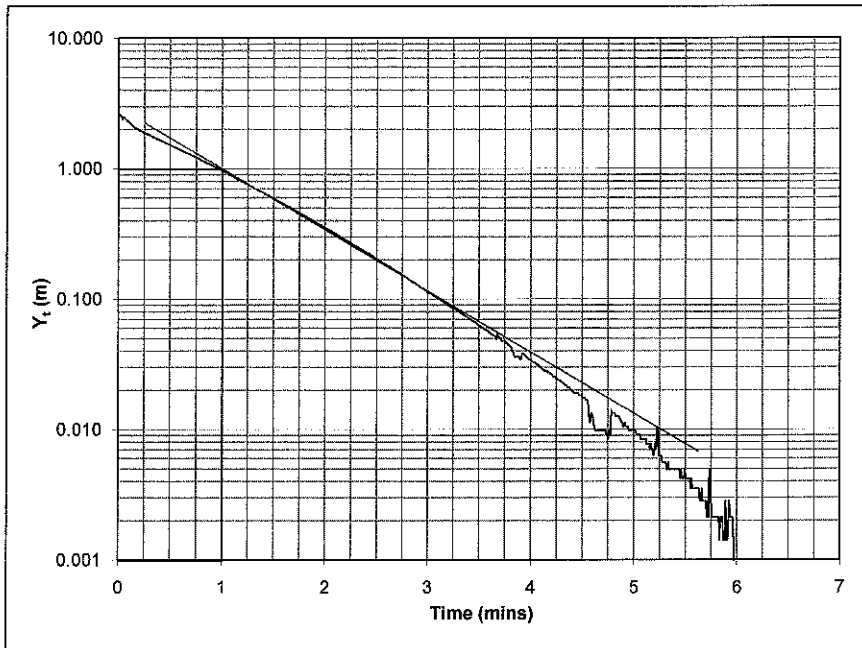
$K = [r_c^2 \cdot \ln(R_o/r_w)] 2L^{-1} \cdot t^{-1} \cdot \ln(Y_o/Y_t)$   
 = 6.07E-06 m/min  
 = 0.009 m/d

Reduced by: \_\_\_\_\_ Date: \_\_\_\_\_

Checked by: \_\_\_\_\_ Date: \_\_\_\_\_

Ref. Bouwer H. 1989. *The Bouwer and Rice Slug Test - an Update*. Ground Water. Vol.27, No.3. May - June 1989.  
 Kruseman G.P. and N.A. de Ridder. 1991. *Analysis and Evaluation of Pumping Test Data*. 2nd Ed. Int. Inst. For Land Reclamation and Improvement. Wageningen. The Netherlands.

Project Name: Buckland Park  
 Client: Walker Corporation  
 Date: 20-Feb-08  
 Time: 10:10  
 Well No. / Name: MWREM02  
 Depth to equilibrium water level (m RL): 2.023 mTOC  
 Type of test: Rising head  Well Completion: Fully Penetrating   
Falling head  Partially Penetrating



$r_c$ = casing radius	0.025
$r_w$ = radial distance between undisturbed aquifer and well centre	0.0625
$L_e$ = length of intake	3.387
$H$ = saturated thickness of aquifer	5
$L_w$ = distance b/n water table and bottom of intake	3.387
$R_e$ = effective well radius	0.79
$t$ = time	1
$Y_o$ = initial drawdown	2.645
$Y_t$ = vertical distance between the water level in well at time t and equilibrium level	1
$L_e/r_w$	54.192
$A$ = dimensionless co-efficient that is a function of $L_e/r_w$ and $L_w < H$	3.15
$B$ = dimensionless co-efficient that is a function of $L_e/r_w$ and $L_w < H$	1
$C$ = dimensionless co-efficient that is a function of $L_e/r_w$ and $L_w = H$	2.8

If  $L_w < H$

$$\ln(R_e/r_w) = \{1.1 \cdot [\ln(L_w/r_w)]^{-1} + A + B \cdot \ln[(H-L_w)/r_w] \cdot (L_e/r_w)^{-1}\}^{-1}$$

= **2.54 m**

If  $L_w = H$

$$\ln(R_e/r_w) = \{1.1 \cdot [\ln(L_w/r_w)]^{-1} + C \cdot (L_e/r_w)^{-1}\}^{-1}$$

= **Lw < H m**

Reduced by: \_\_\_\_\_ Date: \_\_\_\_\_

Checked by: \_\_\_\_\_ Date: \_\_\_\_\_

$$K = [r_c^2 \cdot \ln(R_e/r_w)] 2L^{-1} \cdot t^{-1} \cdot \ln(Y_o/Y_t)$$

= 2.28E-04 m/min

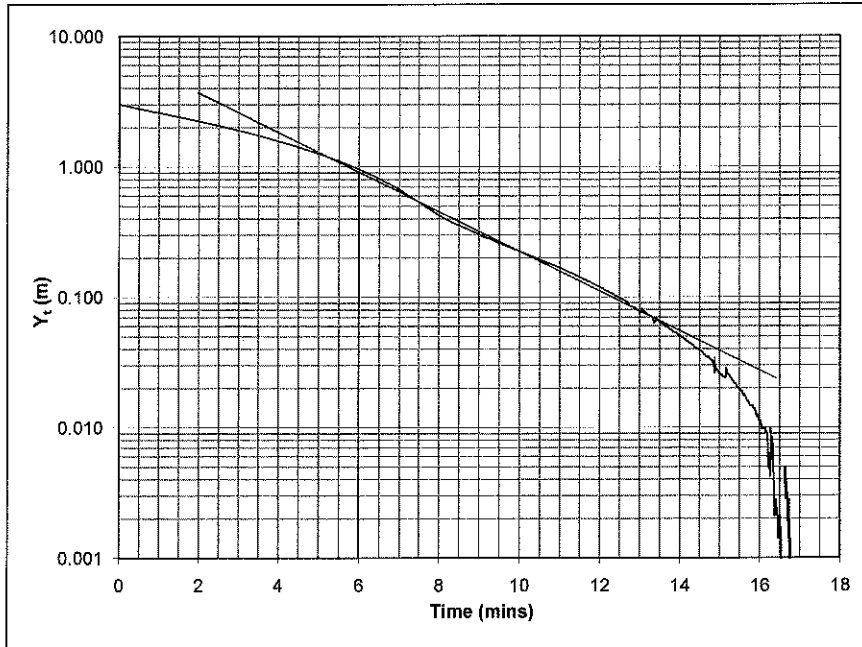
= **0.328** m/d

Reduced by: \_\_\_\_\_ Date: \_\_\_\_\_

Checked by: \_\_\_\_\_ Date: \_\_\_\_\_

Ref. Bouwer H. 1989. *The Bouwer and Rice Slug Test - an Update*. Ground Water. Vol.27, No.3. May - June 1989.  
 Kruseman G.P. and N.A. de Ridder. 1991. *Analysis and Evaluation of Pumping Test Data*. 2nd Ed. Int. inst. For Land Reclamation and Improvement. Wageningen. The Netherlands.

Project Name: Buckland Park  
 Client: Walker Corporation  
 Well No. / Name: MWREM03  
 Type of test:  Rising head  Falling head  
 Date: 20-Feb-08  
 Time: 12:58  
 Depth to equilibrium water level (m RL): 6.273 mTOC  
 Well Completion:  Fully Penetrating  Partially Penetrating



$r_c$ = casing radius	0.025
$r_w$ = radial distance between undisturbed aquifer and well centre	0.0625
$L_e$ = length of intake	3.637
$H$ = saturated thickness of aquifer	5
$L_w$ = distance b/n water table and bottom of intake	3.637
$R_e$ = effective well radius	1.05
$t$ = time	6
$Y_o$ = initial drawdown	3.026
$Y_t$ = vertical distance between the water level in well at time t and equilibrium level	0.9
$L_e/r_w$ = dimensionless co-efficient that is a function of $L_e/r_w$ and $L_w < H$	58.192
$A$ = dimensionless co-efficient that is a function of $L_e/r_w$ and $L_w < H$	3.25
$B$ = dimensionless co-efficient that is a function of $L_e/r_w$ and $L_w < H$	0.52
$C$ = dimensionless co-efficient that is a function of $L_e/r_w$ and $L_w = H$	2.9

**If  $L_w < H$**

$$\ln(R_e/r_w) = \{1.1 \cdot [\ln(L_w/r_w)]^{-1} + A + B \cdot \ln\{(H-L_w)/r_w\} \cdot (L_e/r_w)^{-1}\}^{-1}$$

= **2.82 m**

**If  $L_w = H$**

$$\ln(R_e/r_w) = \{1.1 \cdot [\ln(L_w/r_w)]^{-1} + C \cdot (L_e/r_w)^{-1}\}^{-1}$$

=  **$L_w < H$  m**

Reduced by: \_\_\_\_\_ Date: \_\_\_\_\_

Checked by: \_\_\_\_\_ Date: \_\_\_\_\_

$$K = [r_c^2 \cdot \ln(R_e/r_w)] 2L^{-1} \cdot t^{-1} \cdot \ln(Y_o/Y_t)$$

= 4.90E-05 m/min

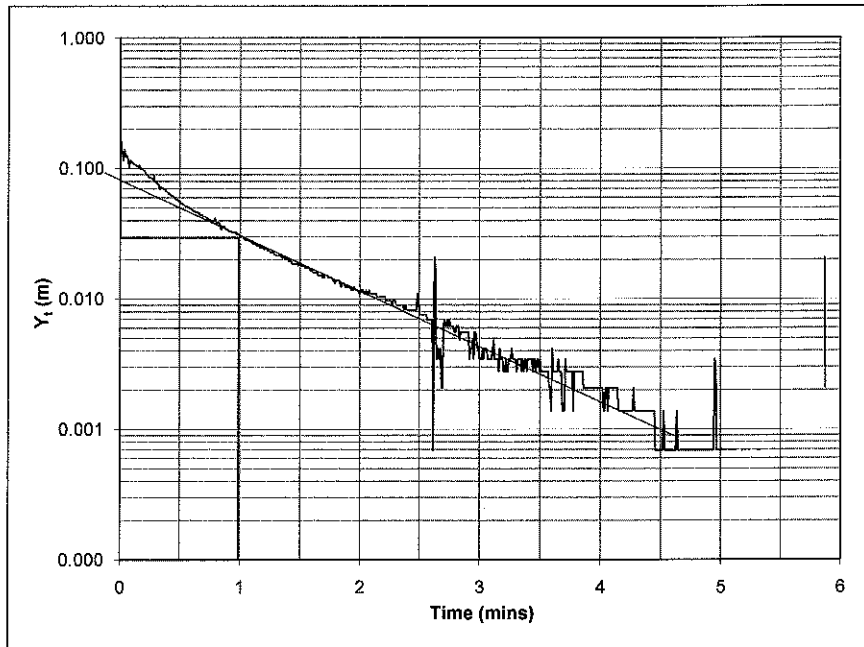
= **0.071** m/d

Reduced by: \_\_\_\_\_ Date: \_\_\_\_\_

Checked by: \_\_\_\_\_ Date: \_\_\_\_\_

Ref. Bouwer H. 1989. *The Bouwer and Rice Slug Test - an Update*. Ground Water. Vol.27, No.3. May - June 1989.  
 Kruseman G.P. and N.A. de Ridder. 1991. *Analysis and Evaluation of Pumping Test Data*. 2nd Ed. Int. Inst. For Land Reclamation and Improvement. Wageningen. The Netherlands.

Project Name: Buckland Park  
 Client: Walker Corporation  
 Date: 20-Feb-08  
 Time: 12:36  
 Well No. / Name: MWREM04  
 Depth to equilibrium water level (m RL): 1.654 mTOC  
 Type of test:  Rising head  Falling head  
 Well Completion:  Fully Penetrating  Partially Penetrating



$r_c$  = casing radius 0.025  
 $r_w$  = radial distance between undisturbed aquifer and well centre 0.0625  
 $L_o$  = length of intake 1.996  
 $H$  = saturated thickness of aquifer 5  
 $L_w$  = distance b/n water table and bottom of intake 1.996  
 $R_e$  = effective well radius 0.59  
 $t$  = time 1  
 $Y_o$  = initial drawdown 0.183  
 $Y_t$  = vertical distance between the water level in well at time t and equilibrium level 0.02  
 $L_o/r_w$  = 31.936  
 $A$  = dimensionless co-efficient that is a function of  $L_o/r_w$  and  $L_w < H$  2.5  
 $B$  = dimensionless co-efficient that is a function of  $L_o/r_w$  and  $L_w < H$  0.4  
 $C$  = dimensionless co-efficient that is a function of  $L_o/r_w$  and  $L_w = H$  2.05

If  $L_w < H$

$$\ln(R_e/r_w) = \{1.1 \cdot [\ln(L_w/r_w)]^{-1} + A + B \cdot \ln[(H-L_w)/r_w] \cdot (L_o/r_w)^{-1}\}^{-1}$$

= **2.25 m**

If  $L_w = H$

$$\ln(R_e/r_w) = \{1.1 \cdot [\ln(L_w/r_w)]^{-1} + C \cdot (L_o/r_w)^{-1}\}^{-1}$$

=  **$L_w < H$  m**

Reduced by: \_\_\_\_\_ Date: \_\_\_\_\_

Checked by: \_\_\_\_\_ Date: \_\_\_\_\_

$$K = [r_c^2 \cdot \ln(R_e/r_w)] 2L^{-1} \cdot t^{-1} \cdot \ln(Y_o/Y_t)$$

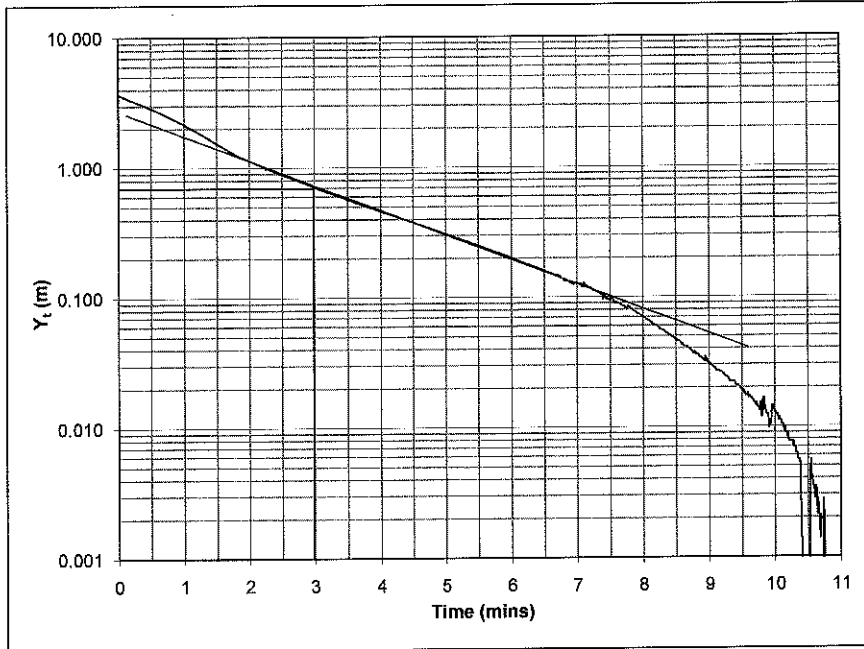
= 7.80E-04 m/min  
 = 1.123 m/d  
 (poor quality data, uncertain analysis)

Reduced by: \_\_\_\_\_ Date: \_\_\_\_\_

Checked by: \_\_\_\_\_ Date: \_\_\_\_\_

Ref. Bouwer H. 1989. *The Bouwer and Rice Slug Test - an Update*. Ground Water. Vol.27, No.3. May - June 1989.  
 Kruseman G.P. and N.A. de Ridder. 1991. *Analysis and Evaluation of Pumping Test Data*. 2nd Ed. Int. Inst. For Land Reclamation and Improvement. Wageningen. The Netherlands.

Project Name: Buckland Park  
 Client: Walker Corporation  
 Date: 20-Feb-08  
 Time: 11:00  
 Well No. / Name: MWREM05  
 Depth to equilibrium water level (m RL): 3.881 mTOC  
 Type of test: Rising head  Well Completion: Fully Penetrating   
Falling head  Partially Penetrating



$r_c$ = casing radius	0.025
$r_w$ = radial distance between undisturbed aquifer and well centre	0.0625
$L_e$ = length of intake	3.789
$H$ = saturated thickness of aquifer	5
$L_w$ = distance b/n water table and bottom of intake	3.789
$R_e$ = effective well radius	1.08
$t$ = time	3
$Y_o$ = initial drawdown	3.654
$Y_t$ = vertical distance between the water level in well at time t and equilibrium level	0.7
$L_e/r_w$ =	60.624
$A$ = dimensionless co-efficient that is a function of $L_e/r_w$ , and $L_w < H$	3.38
$B$ = dimensionless co-efficient that is a function of $L_e/r_w$ , and $L_w < H$	0.55
$C$ = dimensionless co-efficient that is a function of $L_e/r_w$ , and $L_w = H$	3.02

If  $L_w < H$

$$\ln(R_e/r_w) = \{1.1 \cdot [\ln(L_w/r_w)]^{-1} + A+B \cdot \ln[(H-L_w)/r_w] \cdot (L_e/r_w)^{-1}\}^{-1}$$

= **2.85 m**

If  $L_w = H$

$$\ln(R_e/r_w) = \{1.1 \cdot [\ln(L_w/r_w)]^{-1} + C \cdot (L_e/r_w)^{-1}\}^{-1}$$

= **Lw < H m**

Reduced by: \_\_\_\_\_ Date: \_\_\_\_\_

Checked by: \_\_\_\_\_ Date: \_\_\_\_\_

$$K = [r_c^2 \cdot \ln(R_e/r_w)] 2L^{-1} \cdot t^{-1} \cdot \ln(Y_o/Y_t)$$

= 1.30E-04 m/min

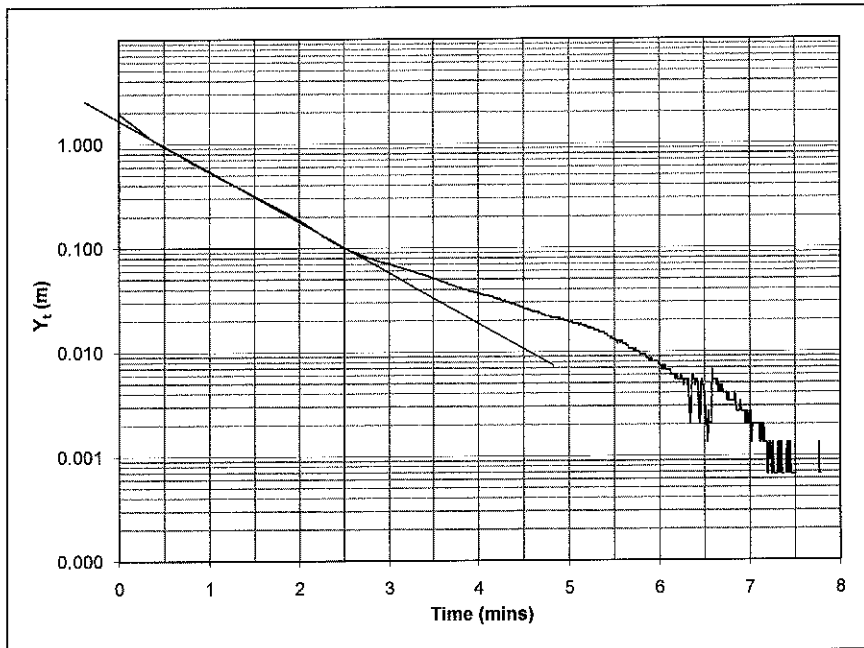
= **0.187** m/d

Reduced by: \_\_\_\_\_ Date: \_\_\_\_\_

Checked by: \_\_\_\_\_ Date: \_\_\_\_\_

Ref. Bouwer H. 1989. *The Bouwer and Rice Slug Test - an Update*. Ground Water. Vol.27, No.3. May - June 1989.  
 Kruseman G.P. and N.A. de Ridder. 1991. *Analysis and Evaluation of Pumping Test Data*. 2nd Ed. Int. Inst. For Land Reclamation and Improvement. Wageningen. The Netherlands.

Project Name: Buckland Park  
 Client: Walker Corporation  
 Date: 21-Feb-08  
 Time: 10:50  
 Well No. / Name: MWREM06  
 Depth to equilibrium water level (m RL): 1.555 mTOC  
 Type of test: Rising head  Falling head  Well Completion: Fully Penetrating  Partially Penetrating



$r_c$  = casing radius 0.025  
 $r_w$  = radial distance between undisturbed aquifer and well centre 0.0625  
 $L_e$  = length of intake 2.125  
 $H$  = saturated thickness of aquifer 5  
 $L_w$  = distance b/n water table and bottom of intake 2.125  
 $R_e$  = effective well radius 0.65  
 $t$  = time 2.5  
 $Y_o$  = initial drawdown 1.929  
 $Y_t$  = vertical distance between the water level in well at time t and equilibrium level 0.1  
 $L_e/r_w$  = 34  
 $A$  = dimensionless co-efficient that is a function of  $L_e/r_w$ , and  $L_w < H$  2.55  
 $B$  = dimensionless co-efficient that is a function of  $L_e/r_w$ , and  $L_w < H$  0.36  
 $C$  = dimensionless co-efficient that is a function of  $L_e/r_w$ , and  $L_w = H$  2.18

if  $L_w < H$

$$\ln(R_e/r_w) = \{1.1 \cdot [\ln(L_w/r_w)]^{-1} + A+B \cdot \ln[(H-L_w)/r_w] \cdot (L_e/r_w)^{-1}\}^{-1}$$

= **2.34 m**

if  $L_w = H$

$$\ln(R_e/r_w) = \{1.1 \cdot [\ln(L_w/r_w)]^{-1} + C \cdot (L_e/r_w)^{-1}\}^{-1}$$

= **Lw < H m**

Reduced by: \_\_\_\_\_ Date: \_\_\_\_\_  
 Checked by: \_\_\_\_\_ Date: \_\_\_\_\_

$$K = [r_c^2 \cdot \ln(R_e/r_w)] 2L^{-1} \cdot t^{-1} \cdot \ln(Y_o/Y_t)$$

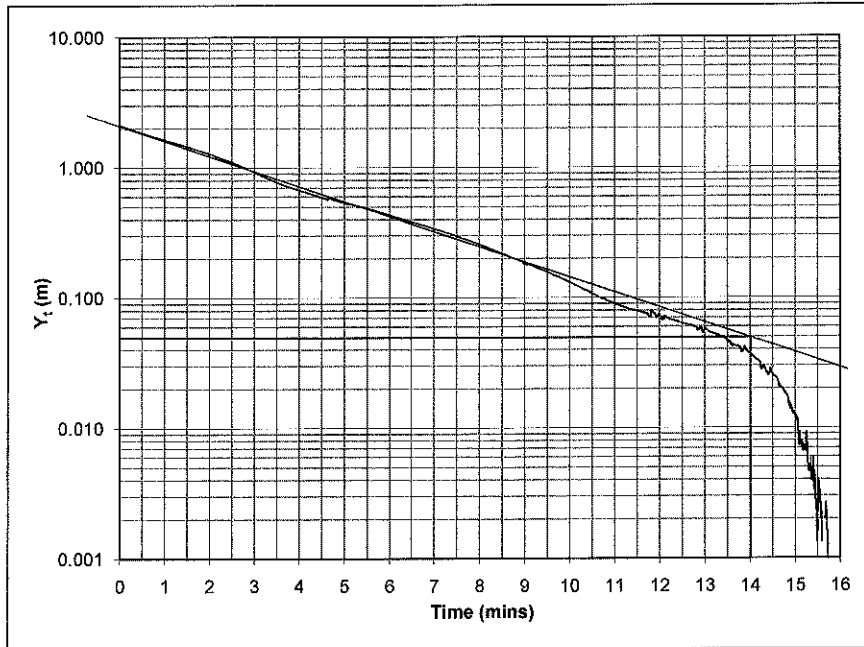
= 4.07E-04 m/min  
 = **0.586** m/d

Reduced by: \_\_\_\_\_ Date: \_\_\_\_\_  
 Checked by: \_\_\_\_\_ Date: \_\_\_\_\_

Ref. Bouwer H. 1989. *The Bouwer and Rice Slug Test - an Update*. Ground Water. Vol.27, No.3. May - June 1989.  
 Kruseman G.P. and N.A. de Ridder. 1991. *Analysis and Evaluation of Pumping Test Data*. 2nd Ed. Int. Inst. For Land Reclamation and Improvement. Wageningen. The Netherlands.



Project Name: Buckland Park  
 Client: Walker Corporation  
 Date: 21-Feb-08  
 Time: 10:15  
 Well No. / Name: MWREM07  
 Depth to equilibrium water level (m RL): 1.497 mTOC  
 Type of test:  Rising head  Falling head  
 Well Completion:  Fully Penetrating  Partially Penetrating



$r_c$ = casing radius	0.025
$r_w$ = radial distance between undisturbed aquifer and well centre	0.0625
$L_0$ = length of intake	2.483
$H$ = saturated thickness of aquifer	5
$L_w$ = distance b/n water table and bottom of intake	2.483
$R_0$ = effective well radius	0.73
$t$ = time	14
$Y_0$ = initial drawdown	2.106
$Y_t$ = vertical distance between the water level in well at time t and equilibrium level	0.05
$L_e/r_w$ = dimensionless co-efficient that is a function of $L_e/r_w$ , and $L_w < H$	39.728
$A$ = dimensionless co-efficient that is a function of $L_e/r_w$ , and $L_w < H$	2.75
$B$ = dimensionless co-efficient that is a function of $L_e/r_w$ , and $L_w < H$	0.41
$C$ = dimensionless co-efficient that is a function of $L_e/r_w$ , and $L_w = H$	2.4

**If  $L_w < H$**

$$\ln(R_e/r_w) = \{1.1 \cdot [\ln(L_w/r_w)]^{-1} + A+B \cdot \ln[(H-L_w)/r_w] \cdot (L_e/r_w)^{-1}\}^{-1}$$

= **2.46 m**

**If  $L_w = H$**

$$\ln(R_e/r_w) = \{1.1 \cdot [\ln(L_w/r_w)]^{-1} + C \cdot (L_e/r_w)^{-1}\}^{-1}$$

=  **$L_w < H$  m**

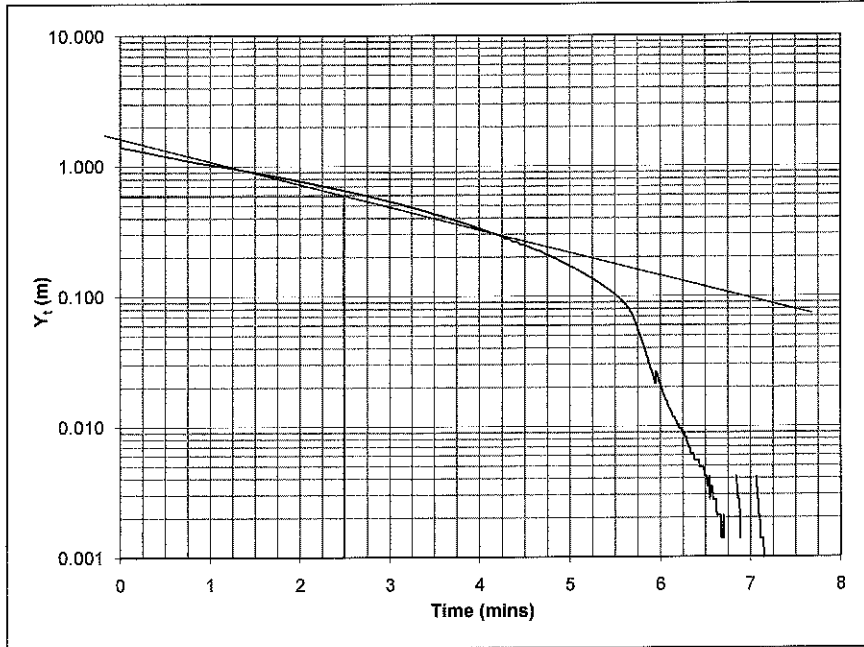
Reduced by: \_\_\_\_\_ Date: \_\_\_\_\_

Checked by: \_\_\_\_\_ Date: \_\_\_\_\_

$K = [r_c^2 \cdot \ln(R_e/r_w)] 2L^{-1} \cdot t^{-1} \cdot \ln(Y_0/Y_t)$		
= 8.28E-05	m/min	Reduced by: _____ Date: _____
= <b>0.119</b>	m/d	Checked by: _____ Date: _____

Ref. Bouwer H. 1989. *The Bouwer and Rice Slug Test - an Update*. Ground Water. Vol.27, No.3. May - June 1989.  
 Kruseman G.P. and N.A. de Ridder. 1991. *Analysis and Evaluation of Pumping Test Data*. 2nd Ed. Int. Inst. For Land Reclamation and Improvement. Wageningen. The Netherlands.

Project Name: Buckland Park  
 Client: Walker Corporation  
 Well No. / Name: MWREM08  
 Type of test:  Rising head  
 Falling head  
 Date: 21-Feb-08  
 Time: 09:45  
 Depth to equilibrium water level (m RL): 2.317 mTOC  
 Well Completion:  Fully Penetrating  
 Partially Penetrating



$r_c$ = casing radius	0.025
$r_w$ = radial distance between undisturbed aquifer and well centre	0.0625
$L_e$ = length of intake	1.933
$H$ = saturated thickness of aquifer	5
$L_w$ = distance b/n water table and bottom of intake	1.933
$R_e$ = effective well radius	0.59
$t$ = time	2.5
$Y_o$ = initial drawdown	1.408
$Y_t$ = vertical distance between the water level in well at time $t$ and equilibrium level	0.6
$L_e/r_w$ = dimensionless co-efficient that is a function of $L_e/r_w$ and $L_w < H$	30.928
$A$ = dimensionless co-efficient that is a function of $L_e/r_w$ and $L_w < H$	2.5
$B$ = dimensionless co-efficient that is a function of $L_e/r_w$ and $L_w < H$	0.36
$C$ = dimensionless co-efficient that is a function of $L_e/r_w$ and $L_w = H$	2.07

If  $L_w < H$

$$\ln(R_e/r_w) = \{1.1 \cdot [\ln(L_w/r_w)]^{-1} + A+B \cdot \ln\{(H-L_w)/r_w\} \cdot (L_e/r_w)^{-1}\}^{-1}$$

= 2.24 m

If  $L_w = H$

$$\ln(R_e/r_w) = \{1.1 \cdot [\ln(L_w/r_w)]^{-1} + C \cdot (L_e/r_w)^{-1}\}^{-1}$$

=  $L_w < H$  m

Reduced by: \_\_\_\_\_ Date: \_\_\_\_\_

Checked by: \_\_\_\_\_ Date: \_\_\_\_\_

$$K = [r_c^2 \cdot \ln(R_e/r_w)] 2L^{-1} \cdot t^{-1} \cdot \ln(Y_o/Y_t)$$

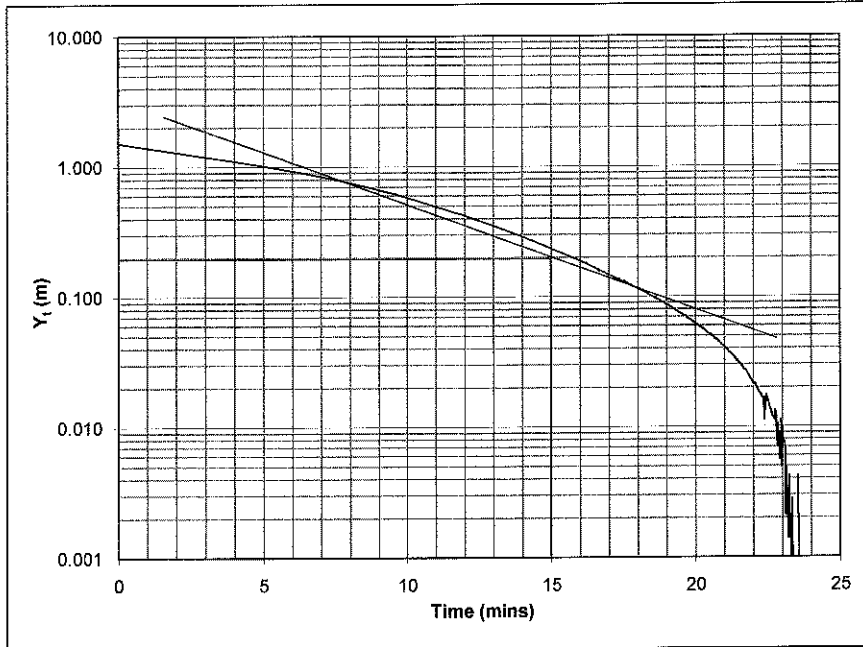
= 1.23E-04 m/min  
 = 0.178 m/d

Reduced by: \_\_\_\_\_ Date: \_\_\_\_\_

Checked by: \_\_\_\_\_ Date: \_\_\_\_\_

Ref. Bouwer H. 1989. *The Bouwer and Rice Slug Test - an Update*. Ground Water, Vol.27, No.3. May - June 1989.  
 Kruseman G.P. and N.A. de Ridder. 1991. *Analysis and Evaluation of Pumping Test Data*. 2nd Ed. Int. Inst. For Land Reclamation and Improvement. Wageningen. The Netherlands.

Project Name: Buckland Park  
 Client: Walker Corporation  
 Well No. / Name: MWREM09  
 Type of test:  Rising head  Falling head  
 Date: 21-Feb-08  
 Time: 16:04  
 Depth to equilibrium water level (m RL): 3.649 mTOC  
 Well Completion:  Fully Penetrating  Partially Penetrating



$r_c$ = casing radius	0.025
$r_w$ = radial distance between undisturbed aquifer and well centre	0.0625
$L_e$ = length of intake	2.121
$H$ = saturated thickness of aquifer	5
$L_w$ = distance b/n water table and bottom of intake	2.121
$R_e$ = effective well radius	0.64
$t$ = time	15
$Y_o$ = initial drawdown	1.408
$Y_t$ = vertical distance between the water level in well at time t and equilibrium level	0.2
$L_e/r_w$ = dimensionless co-efficient that is a function of $L_e/r_w$ and $L_w < H$	33.936
$A$ = dimensionless co-efficient that is a function of $L_e/r_w$ and $L_w < H$	2.55
$B$ = dimensionless co-efficient that is a function of $L_e/r_w$ and $L_w < H$	0.38
$C$ = dimensionless co-efficient that is a function of $L_e/r_w$ and $L_w = H$	2.18

If  $L_w < H$

$$\ln(R_e/r_w) = \{1.1 \cdot [\ln(L_w/r_w)]^{-1} + A+B \cdot \ln[(H-L_w)/r_w] \cdot (L_e/r_w)^{-1}\}^{-1}$$

= 2.32 m

If  $L_w = H$

$$\ln(R_e/r_w) = \{1.1 \cdot [\ln(L_w/r_w)]^{-1} + C \cdot (L_e/r_w)^{-1}\}^{-1}$$

=  $L_w < H$  m

Reduced by: \_\_\_\_\_ Date: \_\_\_\_\_

Checked by: \_\_\_\_\_ Date: \_\_\_\_\_

$$K = [r_c^2 \cdot \ln(R_e/r_w)] 2L^{-1} \cdot t^{-1} \cdot \ln(Y_o/Y_t)$$

= 4.46E-05 m/min

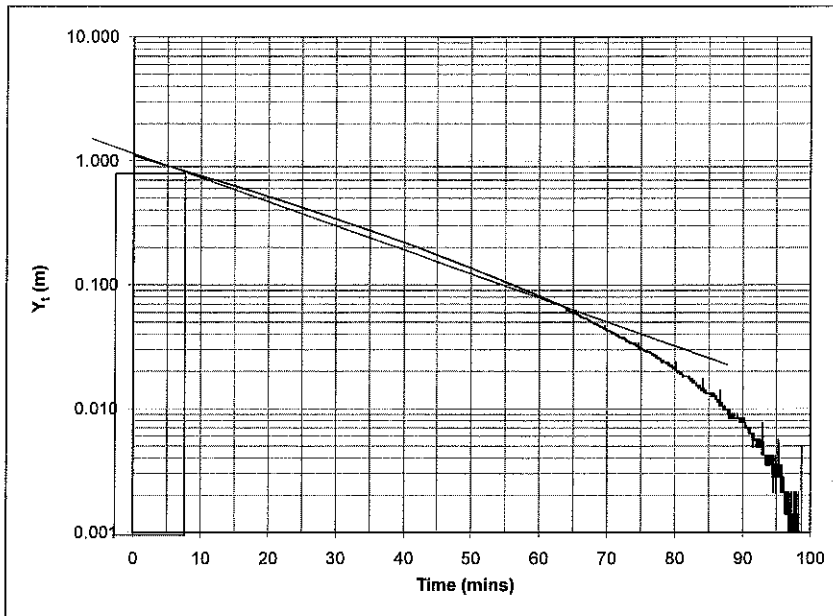
= **0.067** m/d

Reduced by: \_\_\_\_\_ Date: \_\_\_\_\_

Checked by: \_\_\_\_\_ Date: \_\_\_\_\_

Ref. Bouwer H. 1989. *The Bouwer and Rice Slug Test - an Update*. Ground Water, Vol.27, No.3, May - June 1989.  
 Kruseman G.P. and N.A. de Ridder. 1991. *Analysis and Evaluation of Pumping Test Data*. 2nd Ed. Int. Inst. For Land Reclamation and Improvement, Wageningen, The Netherlands.

Project Name: **Buckland Park** Date: 20-Feb-08  
 Client: **Walker Corporation** Time: 14:10  
 Well No. / Name: **PTA058** Depth to equilibrium water level (m RL): 6.34 mTOC  
 Type of test: Rising head  Well Completion: Fully Penetrating   
Falling head  Partially Penetrating



$r_c$ = casing radius	0.075
$r_w$ = radial distance between undisturbed aquifer and well centre	0.127
$L_w$ = length of intake	1.295
$H$ = saturated thickness of aquifer	5
$L_w$ = distance b/n water table and bottom of intake	1.295
$R_e$ = effective well radius	0.50
$t$ = time	10
$Y_o$ = initial drawdown	1.1
$Y_t$ = vertical distance between the water level in well at time $t$ and equilibrium level	0.8
$L_e/r_w$ =	10.19685039
$A$ = dimensionless co-efficient that is a function of $L_e/r_w$ and $L_w < H$	1.8
$B$ = dimensionless co-efficient that is a function of $L_e/r_w$ and $L_w < H$	0.25
$C$ = dimensionless co-efficient that is a function of $L_e/r_w$ and $L_w = H$	1.2

If  $L_w < H$

$$\ln(R_e/r_w) = \{1.1 \cdot [\ln(L_w/r_w)]^{-1} + A + B \cdot \ln[(H-L_w)/r_w] \cdot (L_e/r_w)^{-1}\}^{-1}$$

= **1.36 m**

If  $L_w = H$

$$\ln(R_e/r_w) = \{1.1 \cdot [\ln(L_w/r_w)]^{-1} + C \cdot (L_e/r_w)^{-1}\}^{-1}$$

=  **$L_w < H$  m**

Reduced by: \_\_\_\_\_ Date: \_\_\_\_\_

Checked by: \_\_\_\_\_ Date: \_\_\_\_\_

$$K = [r_c^2 \cdot \ln(R_e/r_w)] 2L^{-1} \cdot t^{-1} \cdot \ln(Y_o/Y_t)$$

= 9.44E-05 m/min

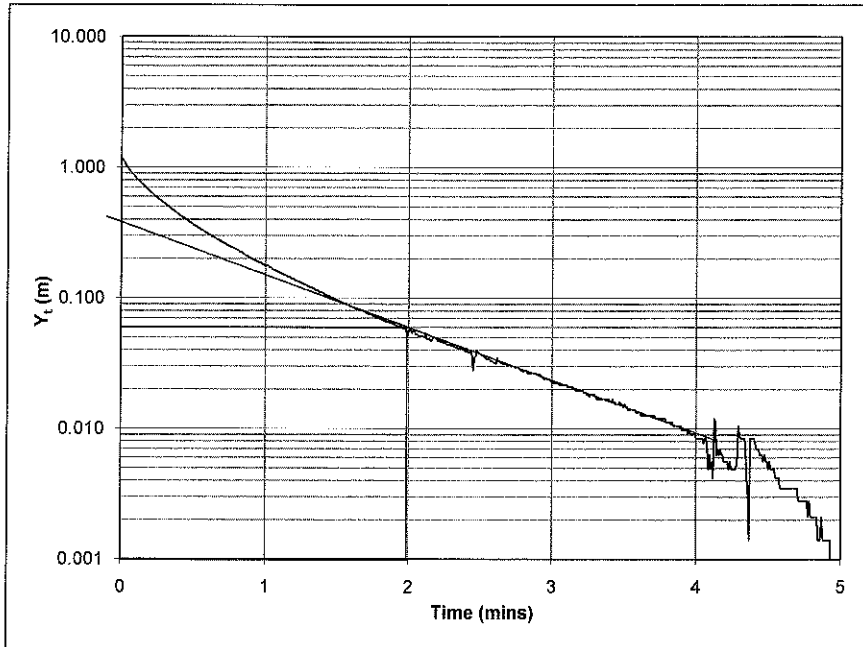
= **0.136** m/d

Reduced by: \_\_\_\_\_ Date: \_\_\_\_\_

Checked by: \_\_\_\_\_ Date: \_\_\_\_\_

Ref. Bouwer H. 1989. *The Bouwer and Rice Slug Test - an Update*. Ground Water. Vol.27, No.3. May - June 1989.  
 Kruseman G.P. and N.A. de Ridder. 1991. *Analysis and Evaluation of Pumping Test Data*. 2nd Ed. Int. Inst. For Land Reclamation and Improvement. Wageningen. The Netherlands.

Project Name: Buckland Park  
 Client: Walker Corporation  
 Date: 20-Feb-08  
 Time: 12:00  
 Well No. / Name: MWREM11  
 Depth to equilibrium water level (m RL): 4.307 mTOC  
 Type of test: Rising head  Falling head   
 Well Completion: Fully Penetrating   
 Partially Penetrating



$r_c$  = casing radius 0.025  
 $r_w$  = radial distance between undisturbed aquifer and well centre 0.0625  
 $L_e$  = length of intake 2.943  
 $H$  = saturated thickness of aquifer 5  
 $L_w$  = distance b/n water table and bottom of intake 2.943  
 $R_e$  = effective well radius 0.84  
 $t$  = time 2  
 $Y_o$  = initial drawdown 1.178  
 $Y_t$  = vertical distance between the water level in well at time t and equilibrium level 0.06  
 $L_e/r_w$  = 47.088  
 $A$  = dimensionless co-efficient that is a function of  $L_e/r_w$  and  $L_w < H$  2.9  
 $B$  = dimensionless co-efficient that is a function of  $L_e/r_w$  and  $L_w < H$  0.5  
 $C$  = dimensionless co-efficient that is a function of  $L_e/r_w$  and  $L_w = H$  2.6

If  $L_w < H$

$$\ln(R_e/r_w) = \{1.1 \cdot [\ln(L_w/r_w)]^{-1} + A + B \cdot \ln[(H-L_w)/r_w] \cdot (L_e/r_w)^{-1}\}^{-1}$$

= 2.60 m

If  $L_w = H$

$$\ln(R_e/r_w) = \{1.1 \cdot [\ln(L_w/r_w)]^{-1} + C \cdot (L_e/r_w)^{-1}\}^{-1}$$

=  $L_w < H$  m

Reduced by: \_\_\_\_\_ Date: \_\_\_\_\_

Checked by: \_\_\_\_\_ Date: \_\_\_\_\_

$$K = [r_c^2 \cdot \ln(R_e/r_w)] 2L^{-1} \cdot t^{-1} \cdot \ln(Y_o/Y_t)$$

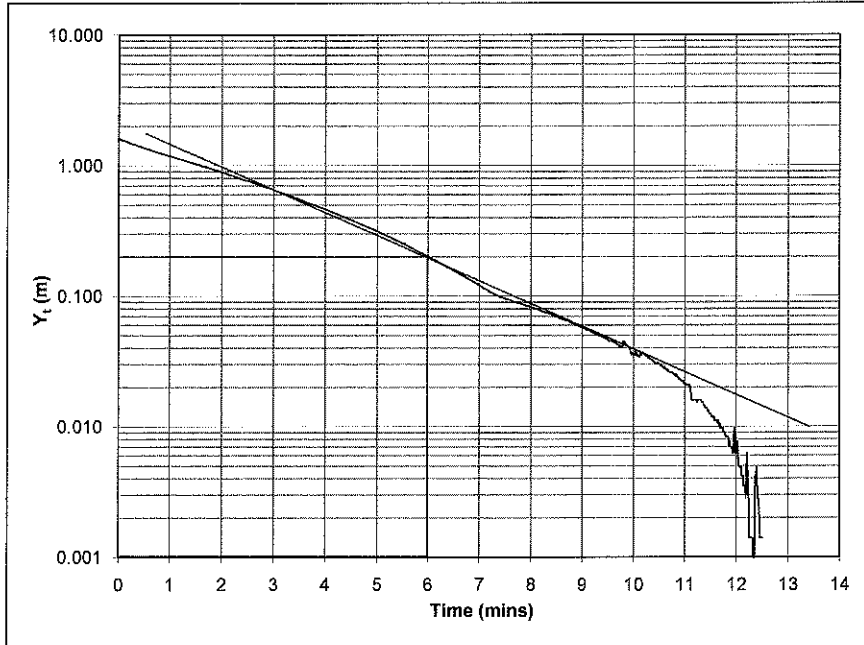
= 4.11E-04 m/min  
 = 0.592 m/d

Reduced by: \_\_\_\_\_ Date: \_\_\_\_\_

Checked by: \_\_\_\_\_ Date: \_\_\_\_\_

Ref. Bouwer H. 1989. *The Bouwer and Rice Slug Test - an Update*. Ground Water, Vol.27, No.3, May - June 1989.  
 Kruseman G.P. and N.A. de Ridder. 1991. *Analysis and Evaluation of Pumping Test Data*. 2nd Ed. Int. Inst. For Land Reclamation and Improvement. Wageningen. The Netherlands.

Project Name: Buckland Park  
 Client: Walker Corporation  
 Date: 21-Feb-08  
 Time: 08:35  
 Well No. / Name: MWREM12  
 Depth to equilibrium water level (m RL): 2.498 mTOC  
 Type of test: Rising head  Falling head  Well Completion: Fully Penetrating  Partially Penetrating



$r_c$ = casing radius	0.025
$r_w$ = radial distance between undisturbed aquifer and well centre	0.0625
$L_e$ = length of intake	2.232
$H$ = saturated thickness of aquifer	5
$L_w$ = distance b/n water table and bottom of intake	2.232
$R_e$ = effective well radius	0.66
$t$ = time	6
$Y_o$ = initial drawdown	1.581
$Y_t$ = vertical distance between the water level in well at time t and equilibrium level	0.2
$L_e/r_w$ =	35.712
$A$ = dimensionless co-efficient that is a function of $L_e/r_w$ and $L_w < H$	2.6
$B$ = dimensionless co-efficient that is a function of $L_e/r_w$ and $L_w < H$	0.4
$C$ = dimensionless co-efficient that is a function of $L_e/r_w$ and $L_w = H$	2.25

If  $L_w < H$

$$\ln(R_e/r_w) = \{1.1 \cdot [\ln(L_w/r_w)]^{-1} + A+B \cdot \ln[(H-L_w)/r_w] \cdot (L_e/r_w)^{-1}\}^{-1}$$

= **2.36 m**

If  $L_w = H$

$$\ln(R_e/r_w) = \{1.1 \cdot [\ln(L_w/r_w)]^{-1} + C \cdot (L_e/r_w)^{-1}\}^{-1}$$

=  **$L_w < H$  m**

Reduced by: \_\_\_\_\_ Date: \_\_\_\_\_

Checked by: \_\_\_\_\_ Date: \_\_\_\_\_

$$K = [r_c^2 \cdot \ln(R_e/r_w)] 2L^{-1} \cdot t^{-1} \cdot \ln(Y_o/Y_t)$$

= 1.14E-04 m/min

= **0.164** m/d

Reduced by: \_\_\_\_\_ Date: \_\_\_\_\_

Checked by: \_\_\_\_\_ Date: \_\_\_\_\_

Ref. Bouwer H. 1989. *The Bouwer and Rice Slug Test - an Update*. Ground Water. Vol.27, No.3. May - June 1989.  
 Kruseman G.P. and N.A. de Ridder. 1991. *Analysis and Evaluation of Pumping Test Data*. 2nd Ed. Int. Inst. For Land Reclamation and Improvement. Wageningen. The Netherlands.

## Environmental Division

### CERTIFICATE OF ANALYSIS

Work Order	: EM0800948	Page	: 1 of 13
Client	: RESOURCE & ENVIRON MANGMNT P/L	Laboratory	: Environmental Division Melbourne
Contact	: MR DAVID POULSEN	Contact	: Paul Loewy
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E-mail	: davidpoulsen@rem.com.au	E-mail	: paul.loewy@alsenviro.com
Telephone	: +61 08 8363 1777	Telephone	: +61-3-8549 9600
Facsimile	: +61 08 8363 1477	Facsimile	: +61-3-8549 9601
Project	: GM01	QC Level	: NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Order number	: ----	Date Samples Received	: 08-FEB-2008
C-O-C number	: ----	Issue Date	: 19-FEB-2008
Sampler	: DP/DN/WC	No. of samples received	: 12
Site	: ----	No. of samples analysed	: 12
Quote number	: AD/003a/07		

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. All pages of this report have been checked and approved for release.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results
- Surrogate Control Limits



NATA Accredited Laboratory 825

This document is issued in accordance with NATA accreditation requirements.

Accredited for compliance with ISO/IEC 17025.



#### Signatories

This document has been electronically signed by the authorized signatories indicated below. Electronic signing has been carried out in compliance with procedures specified in 21 CFR Part 11.

Signatories	Position	Accreditation Category
Dilani Fernando	Senior Inorganic Instrument Chemist	Inorganics
Marc Centner	Technical Manager	Organics
Terrance Hettipathirana	Senior ICP/MS Chemist	Inorganics
Xingbin Lin	Instrument Chemist	Organics

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Page : 3 of 13  
Work Order : EM0800948  
Client : RESOURCE & ENVIRON MANGMNT P/L  
Project : GM01

### General Comments

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

When date(s) and/or time(s) are shown bracketed, these have been assumed by the laboratory for process purposes.

Key : CAS Number = Chemistry Abstract Services number  
LOR = Limit of reporting

^ = This result is computed from individual analyte detections at or above the level of reporting

- EGO20-F: EM0800948 #004 & 009 have been diluted for analysis by ICP-MS and LORs have been raised accordingly.
- EK055G : EM0800948 #4 matrix spike failed for Ammonia as N due to sample matrix interference.
- EK055G: EM0800948 #1, #6 and #8 has been diluted prior to analysis due to matrix interferences. Hence, LOR has been raised accordingly.
- EK061G: EM0800948 #4 matrix spike failed for Total Kjeldahl Nitrogen as N due to sample matrix interference. This has been confirmed by re-digestion and re-analysis.
- EK067G: LOR has been raised for Total Phosphorus as P.
- EP075(SIM): Particular samples EM0800948 #8 required dilution prior to analysis due to matrix interferences. LOR values have been adjusted accordingly.
- EP202: Samples required dilution prior to extraction due to matrix interferences. LOR values have been adjusted accordingly.
- Ionic Balance out of acceptable limits due to analytes not quantified in this report.



## Analytical Results

Sub-Matrix: WATER		Client sample ID							
Compound	CAS Number	LOR	Unit	MW3	MW4	MW6	MW7	MW8	
				07-FEB-2008 15:00	07-FEB-2008 15:00	07-FEB-2008 15:00	07-FEB-2008 15:00	07-FEB-2008 15:00	
				EM0800948-001	EM0800948-002	EM0800948-003	EM0800948-004	EM0800948-005	
<b>ED037P: Alkalinity by PC Titrator</b>									
Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	----	----	148	<1	
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	<1	----	----	102	10	
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	495	----	----	<1	582	
Total Alkalinity as CaCO3	----	1	mg/L	495	----	----	247	592	
<b>ED040F: Dissolved Major Anions</b>									
Sulphate as SO4 2-	14808-79-8	1	mg/L	1060	----	----	8280	3390	
<b>ED045P: Chloride by PC Titrator</b>									
Chloride	16887-00-6	1	mg/L	787	----	----	57700	15100	
<b>ED093F: Dissolved Major Cations</b>									
Calcium	7440-70-2	1	mg/L	282	----	----	1340	367	
Magnesium	7439-95-4	1	mg/L	518	----	----	3930	1150	
Sodium	7440-23-5	1	mg/L	1660	----	----	33800	11900	
Potassium	7440-09-7	1	mg/L	76	----	----	1680	575	
<b>EG020F: Dissolved Metals by ICP-MS</b>									
Arsenic	7440-38-2	0.001	mg/L	<0.001	----	----	<0.010	<0.001	
Beryllium	7440-41-7	0.001	mg/L	<0.001	----	----	<0.010	<0.001	
Barium	7440-39-3	0.001	mg/L	0.064	----	----	0.091	0.068	
Cadmium	7440-43-9	0.0001	mg/L	<0.0001	----	----	<0.0010	0.0002	
Chromium	7440-47-3	0.001	mg/L	<0.001	----	----	<0.010	<0.001	
Cobalt	7440-48-4	0.001	mg/L	0.004	----	----	0.011	0.004	
Copper	7440-50-8	0.001	mg/L	0.003	----	----	0.036	0.011	
Lead	7439-92-1	0.001	mg/L	<0.001	----	----	0.123	<0.001	
Manganese	7439-96-5	0.001	mg/L	0.455	----	----	0.104	0.058	
Nickel	7440-02-0	0.001	mg/L	0.002	----	----	0.014	0.015	
Vanadium	7440-62-2	0.01	mg/L	<0.01	----	----	<0.10	<0.01	
Zinc	7440-66-6	0.005	mg/L	0.012	----	----	0.071	0.007	
<b>EG035F: Dissolved Mercury by FIMS</b>									
Mercury	7439-97-6	0.0001	mg/L	<0.0001	----	----	<0.0001	<0.0001	
<b>EK055G: Ammonia as N by Discrete Analyser</b>									
Ammonia as N	7664-41-7	0.010	mg/L	<0.100	----	----	0.411	0.145	
<b>EK057G: Nitrite as N by Discrete Analyser</b>									
Nitrite as N	----	0.010	mg/L	<0.010	----	----	<0.010	0.052	
<b>EK058G: Nitrate as N by Discrete Analyser</b>									
^ Nitrate as N	14797-55-8	0.010	mg/L	<0.010	----	----	<0.010	2.12	
<b>EK059G: NOx as N by Discrete Analyser</b>									
Nitrite + Nitrate as N	----	0.010	mg/L	<0.010	----	----	<0.010	2.18	
<b>EK061: Total Kjeldahl Nitrogen (TKN)</b>									



## Analytical Results

Compound	CAS Number	LOR	Unit	Client sampling date / time	MW3	MW4	MW6	MW7	MW8
Sub-Matrix: WATER									
Client sample ID									
Client sampling date / time									
CAS Number									
LOR									
Unit									
EM0800948-001									
EM0800948-002									
EM0800948-003									
EM0800948-004									
EM0800948-005									
EK061: Total Kjeldahl Nitrogen (TKN) - Continued									
Total Kjeldahl Nitrogen as N		0.1	mg/L		0.6			1.6	3.5
EK062: Total Nitrogen as N									
Total Nitrogen as N		0.1	mg/L		0.6			1.6	5.6
EK067G: Total Phosphorus as P by Discrete Analyser									
Total Phosphorus as P		0.01	mg/L		0.37			0.38	1.39
EK071G: Reactive Phosphorus as P by discrete analyser									
Reactive Phosphorus as P		0.010	mg/L		<0.010			0.015	0.023
EN055: Ionic Balance									
Total Anions		0.01	meq/L		54.2			1810	509
Total Cations		0.01	meq/L		131			1900	644
Ionic Balance		0.01	%		41.4			2.67	11.7
EP075(SIM)B: Polynuclear Aromatic Hydrocarbons									
Naphthalene	91-20-3	1.0	µg/L		<1.0			<1.0	<1.0
Acenaphthylene	208-96-8	1.0	µg/L		<1.0			<1.0	<1.0
Acenaphthene	83-32-9	1.0	µg/L		<1.0			<1.0	<1.0
Fluorene	86-73-7	1.0	µg/L		<1.0			<1.0	<1.0
Phenanthrene	85-01-8	1.0	µg/L		<1.0			<1.0	<1.0
Anthracene	120-12-7	1.0	µg/L		<1.0			<1.0	<1.0
Fluoranthene	206-44-0	1.0	µg/L		<1.0			<1.0	<1.0
Pyrene	129-00-0	1.0	µg/L		<1.0			<1.0	<1.0
Benz(a)anthracene	56-55-3	1.0	µg/L		<1.0			<1.0	<1.0
Chrysene	218-01-9	1.0	µg/L		<1.0			<1.0	<1.0
Benz(b)fluoranthene	205-99-2	1.0	µg/L		<1.0			<1.0	<1.0
Benz(k)fluoranthene	207-08-9	1.0	µg/L		<1.0			<1.0	<1.0
Benzo(a)pyrene	50-32-8	0.5	µg/L		<0.5			<0.5	<0.5
Indeno(1,2,3-cd)pyrene	193-39-5	1.0	µg/L		<1.0			<1.0	<1.0
Dibenz(a,h)anthracene	53-70-3	1.0	µg/L		<1.0			<1.0	<1.0
Benzo(g,h,i)perylene	191-24-2	1.0	µg/L		<1.0			<1.0	<1.0
EP080/071: Total Petroleum Hydrocarbons									
C6 - C9 Fraction		20	µg/L		<20			<20	<20
C10 - C14 Fraction		50	µg/L		<50			<50	50
C15 - C28 Fraction		100	µg/L		<100			<100	<100
C29 - C36 Fraction		50	µg/L		<50			<50	<50
EP080: BTEX									
Benzene	71-43-2	1	µg/L		<1			<1	<1
Toluene	108-88-3	2	µg/L		<2			<2	<2
Ethylbenzene	100-41-4	2	µg/L		<2			<2	<2



## Analytical Results

Sub-Matrix: WATER		Client sample ID		Client sampling date / time		Client sampling date / time		Client sampling date / time		Client sampling date / time		
Compound	CAS Number	LOR	Unit	MW3	MW4	MW6	MW7	MW8	MW3	MW4	MW6	
<b>EP080: BTEX - Continued</b>												
meta- & para-Xylene	108-38-3	106-42-3	2	µg/L	<2	<2	<2	<2	07-FEB-2008 15:00	07-FEB-2008 15:00	07-FEB-2008 15:00	07-FEB-2008 15:00
ortho-Xylene	95-47-6		2	µg/L	<2	<2	<2	<2	EM0800948-001	EM0800948-002	EM0800948-003	EM0800948-004
<b>EP202A: Phenoxycetic Acid Herbicides by LCMS</b>												
4-Chlorophenoxy acetic acid	122-88-3		10	µg/L	<20	<20	<20	<20				
2,4-DB	94-82-6		10	µg/L	<20	<20	<20	<20				
Dicamba	1918-00-9		10	µg/L	<20	<20	<20	<20				
Mecoprop	93-65-2		10	µg/L	<20	<20	<20	<20				
MCPA	94-74-6		10	µg/L	<20	<20	<20	<20				
2,4-DP	120-36-5		10	µg/L	<20	<20	<20	<20				
2,4-D	94-75-7		10	µg/L	<20	<20	<20	<20				
Triclopyr	55335-06-3		10	µg/L	<20	<20	<20	<20				
2,4,5-TP (Silvex)	93-72-1		10	µg/L	<20	<20	<20	<20				
2,4,5-T	93-76-5		10	µg/L	<20	<20	<20	<20				
MCPB	94-81-5		10	µg/L	<20	<20	<20	<20				
Picloram	1918-02-1		10	µg/L	<20	<20	<20	<20				
Clopyralid	1702-17-6		10	µg/L	<20	<20	<20	<20				
Fluroxypyr	69377-81-7		10	µg/L	<20	<20	<20	<20				
2,6-D	575-90-6		10	µg/L	<20	<20	<20	<20				
2,4,6-T	575-89-3		10	µg/L	<20	<20	<20	<20				
<b>EP075(SIM)S: Phenolic Compound Surrogates</b>												
Phenol-d6	13127-88-3		0.1	%	27.6							25.0
2-Chlorophenol-D4	93951-73-6		0.1	%	71.3							59.6
2,4,6-Tribromophenol	118-79-6		0.1	%	96.1							82.4
<b>EP075(SIM)T: PAH Surrogates</b>												
2-Fluorobiphenyl	321-60-8		0.1	%	114							104
Anthracene-d10	1719-06-8		0.1	%	106							79.8
4-Terphenyl-d14	1718-51-0		0.1	%	127							120
<b>EP080S: TPH(V)/BTX Surrogates</b>												
1,2-Dichloroethane-D4	17060-07-0		0.1	%	96.6						89.6	91.1
Toluene-D8	2037-26-5		0.1	%	87.0						88.4	81.2
4-Bromofluorobenzene	460-00-4		0.1	%	87.0						83.2	78.7
<b>EP202S: Phenoxycetic Acid Herbicide Surrogate</b>												
2,4-Dichlorophenyl Acetic Acid	19719-28-9		0.1	%	116							94.8



## Analytical Results

Sub-Matrix: WATER		Client sample ID						
Compound	CAS Number	LOR	Unit	MW9 07-FEB-2008 15:00 EM0800948-006	MW11 07-FEB-2008 15:00 EM0800948-007	MW12 07-FEB-2008 15:00 EM0800948-008	Dup1 07-FEB-2008 15:00 EM0800948-009	Dup2 07-FEB-2008 15:00 EM0800948-010
<b>ED037P: Alkalinity by PC Titrator</b>								
Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	----	<1	<1	----
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	375	----	350	26	----
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	37	----	82	202	----
Total Alkalinity as CaCO3	----	1	mg/L	412	----	432	228	----
<b>ED040F: Dissolved Major Anions</b>								
Sulphate as SO4 2-	14808-79-8	1	mg/L	349	----	2990	9820	----
<b>ED045P: Chloride by PC Titrator</b>								
Chloride	16887-00-6	1	mg/L	798	----	7920	58700	----
<b>ED093F: Dissolved Major Cations</b>								
Calcium	7440-70-2	1	mg/L	14	----	232	1540	----
Magnesium	7439-95-4	1	mg/L	18	----	673	4150	----
Sodium	7440-23-5	1	mg/L	1180	----	9330	38000	----
Potassium	7440-09-7	1	mg/L	32	----	192	1960	----
<b>EG020F: Dissolved Metals by ICP-MS</b>								
Arsenic	7440-38-2	0.001	mg/L	0.002	----	<0.001	<0.010	----
Beryllium	7440-41-7	0.001	mg/L	<0.001	----	<0.001	<0.010	----
Barium	7440-39-3	0.001	mg/L	0.055	----	0.045	0.097	----
Cadmium	7440-43-9	0.0001	mg/L	0.0001	----	<0.0001	<0.0010	----
Chromium	7440-47-3	0.001	mg/L	0.005	----	<0.001	0.014	----
Cobalt	7440-48-4	0.001	mg/L	<0.001	----	0.003	0.011	----
Copper	7440-50-8	0.001	mg/L	0.002	----	0.006	0.040	----
Lead	7439-92-1	0.001	mg/L	<0.001	----	0.003	0.016	----
Manganese	7439-96-5	0.001	mg/L	0.002	----	0.205	0.093	----
Nickel	7440-02-0	0.001	mg/L	<0.001	----	0.004	0.010	----
Vanadium	7440-62-2	0.01	mg/L	0.01	----	<0.01	<0.10	----
Zinc	7440-66-6	0.005	mg/L	0.009	----	0.009	<0.050	----
<b>EG035F: Dissolved Mercury by FIMS</b>								
Mercury	7439-97-6	0.0001	mg/L	<0.0001	----	<0.0001	<0.0001	----
<b>EK055G: Ammonia as N by Discrete Analyser</b>								
Ammonia as N	7664-41-7	0.010	mg/L	<0.100	----	<0.100	0.432	----
<b>EK057G: Nitrite as N by Discrete Analyser</b>								
Nitrite as N	----	0.010	mg/L	<0.010	----	0.040	<0.010	----
<b>EK058G: Nitrate as N by Discrete Analyser</b>								
^ Nitrate as N	14797-55-8	0.010	mg/L	0.695	----	1.02	0.046	----
<b>EK059G: NOx as N by Discrete Analyser</b>								
Nitrite + Nitrate as N	----	0.010	mg/L	0.695	----	1.06	0.046	----
<b>EK061: Total Kjeldahl Nitrogen (TKN)</b>								



## Analytical Results

Compound	CAS Number	LOR	Client sampling date / time		Unit	MW9	MW11	MW12	Dup1	Dup2
			Client sampling date / time	Client sample ID						
Sub-Matrix: WATER										
EK061: Total Kjeldahl Nitrogen (TKN) - Continued										
Total Kjeldahl Nitrogen as N	----	0.1	07-FEB-2008 15:00	EM0800948-006	mg/L	1.0	07-FEB-2008 15:00	EM0800948-008	07-FEB-2008 15:00	EM0800948-010
EK062: Total Nitrogen as N	----	0.1	07-FEB-2008 15:00	EM0800948-007	mg/L	1.7	07-FEB-2008 15:00	EM0800948-009	07-FEB-2008 15:00	EM0800948-011
EK067G: Total Phosphorus as P by Discrete Analyser										
Total Phosphorus as P	----	0.01	07-FEB-2008 15:00	EM0800948-006	mg/L	0.20	07-FEB-2008 15:00	EM0800948-008	07-FEB-2008 15:00	EM0800948-010
EK071G: Reactive Phosphorus as P by discrete analyser										
Reactive Phosphorus as P	----	0.010	07-FEB-2008 15:00	EM0800948-006	mg/L	0.047	07-FEB-2008 15:00	EM0800948-008	07-FEB-2008 15:00	EM0800948-010
EN055: Ionic Balance										
^ Total Anions	----	0.01	07-FEB-2008 15:00	EM0800948-006	meq/L	38.0	07-FEB-2008 15:00	EM0800948-008	07-FEB-2008 15:00	EM0800948-010
^ Total Cations	----	0.01	07-FEB-2008 15:00	EM0800948-006	meq/L	54.4	07-FEB-2008 15:00	EM0800948-008	07-FEB-2008 15:00	EM0800948-010
^ Ionic Balance	----	0.01	07-FEB-2008 15:00	EM0800948-006	%	17.7	07-FEB-2008 15:00	EM0800948-008	07-FEB-2008 15:00	EM0800948-010
EP075(SIM)B: Polynuclear Aromatic Hydrocarbons										
Naphthalene	91-20-3	1.0	07-FEB-2008 15:00	EM0800948-006	µg/L	<1.0	07-FEB-2008 15:00	EM0800948-008	07-FEB-2008 15:00	EM0800948-010
Acenaphthylene	208-96-8	1.0	07-FEB-2008 15:00	EM0800948-006	µg/L	<1.0	07-FEB-2008 15:00	EM0800948-008	07-FEB-2008 15:00	EM0800948-010
Acenaphthene	83-32-9	1.0	07-FEB-2008 15:00	EM0800948-006	µg/L	<1.0	07-FEB-2008 15:00	EM0800948-008	07-FEB-2008 15:00	EM0800948-010
Fluorene	86-73-7	1.0	07-FEB-2008 15:00	EM0800948-006	µg/L	<1.0	07-FEB-2008 15:00	EM0800948-008	07-FEB-2008 15:00	EM0800948-010
Phenanthrene	85-01-8	1.0	07-FEB-2008 15:00	EM0800948-006	µg/L	<1.0	07-FEB-2008 15:00	EM0800948-008	07-FEB-2008 15:00	EM0800948-010
Anthracene	120-12-7	1.0	07-FEB-2008 15:00	EM0800948-006	µg/L	<1.0	07-FEB-2008 15:00	EM0800948-008	07-FEB-2008 15:00	EM0800948-010
Fluoranthene	206-44-0	1.0	07-FEB-2008 15:00	EM0800948-006	µg/L	<1.0	07-FEB-2008 15:00	EM0800948-008	07-FEB-2008 15:00	EM0800948-010
Pyrene	129-00-0	1.0	07-FEB-2008 15:00	EM0800948-006	µg/L	<1.0	07-FEB-2008 15:00	EM0800948-008	07-FEB-2008 15:00	EM0800948-010
Benz(a)anthracene	56-55-3	1.0	07-FEB-2008 15:00	EM0800948-006	µg/L	<1.0	07-FEB-2008 15:00	EM0800948-008	07-FEB-2008 15:00	EM0800948-010
Chrysene	218-01-9	1.0	07-FEB-2008 15:00	EM0800948-006	µg/L	<1.0	07-FEB-2008 15:00	EM0800948-008	07-FEB-2008 15:00	EM0800948-010
Benz(b)fluoranthene	205-99-2	1.0	07-FEB-2008 15:00	EM0800948-006	µg/L	<1.0	07-FEB-2008 15:00	EM0800948-008	07-FEB-2008 15:00	EM0800948-010
Benzo(k)fluoranthene	207-08-9	1.0	07-FEB-2008 15:00	EM0800948-006	µg/L	<1.0	07-FEB-2008 15:00	EM0800948-008	07-FEB-2008 15:00	EM0800948-010
Benzo(a)pyrene	50-32-8	0.5	07-FEB-2008 15:00	EM0800948-006	µg/L	<0.5	07-FEB-2008 15:00	EM0800948-008	07-FEB-2008 15:00	EM0800948-010
Indeno(1,2,3-cd)pyrene	193-39-5	1.0	07-FEB-2008 15:00	EM0800948-006	µg/L	<1.0	07-FEB-2008 15:00	EM0800948-008	07-FEB-2008 15:00	EM0800948-010
Dibenz(a,h)anthracene	53-70-3	1.0	07-FEB-2008 15:00	EM0800948-006	µg/L	<1.0	07-FEB-2008 15:00	EM0800948-008	07-FEB-2008 15:00	EM0800948-010
Benzo(g,h,i)perylene	191-24-2	1.0	07-FEB-2008 15:00	EM0800948-006	µg/L	<1.0	07-FEB-2008 15:00	EM0800948-008	07-FEB-2008 15:00	EM0800948-010
EP080/071: Total Petroleum Hydrocarbons										
C6 - C9 Fraction	----	20	07-FEB-2008 15:00	EM0800948-006	µg/L	<20	07-FEB-2008 15:00	EM0800948-008	07-FEB-2008 15:00	EM0800948-010
C10 - C14 Fraction	----	50	07-FEB-2008 15:00	EM0800948-006	µg/L	<50	07-FEB-2008 15:00	EM0800948-008	07-FEB-2008 15:00	EM0800948-010
C15 - C28 Fraction	----	100	07-FEB-2008 15:00	EM0800948-006	µg/L	<100	07-FEB-2008 15:00	EM0800948-008	07-FEB-2008 15:00	EM0800948-010
C29 - C36 Fraction	----	50	07-FEB-2008 15:00	EM0800948-006	µg/L	<50	07-FEB-2008 15:00	EM0800948-008	07-FEB-2008 15:00	EM0800948-010
EP080: BTEX										
Benzene	71-43-2	1	07-FEB-2008 15:00	EM0800948-006	µg/L	<1	07-FEB-2008 15:00	EM0800948-008	07-FEB-2008 15:00	EM0800948-010
Toluene	108-88-3	2	07-FEB-2008 15:00	EM0800948-006	µg/L	<2	07-FEB-2008 15:00	EM0800948-008	07-FEB-2008 15:00	EM0800948-010
Ethylbenzene	100-41-4	2	07-FEB-2008 15:00	EM0800948-006	µg/L	<2	07-FEB-2008 15:00	EM0800948-008	07-FEB-2008 15:00	EM0800948-010



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 Work Order : EM0800948  
 Client : RESOURCE & ENVIRON MANGMNT P/L  
 Project : GM01

## Analytical Results

Sub-Matrix: WATER		Client sample ID						
Compound	CAS Number	LOR	Unit	MW9 07-FEB-2008 15:00 EM0800948-006	MW11 07-FEB-2008 15:00 EM0800948-007	MW12 07-FEB-2008 15:00 EM0800948-008	Dup1 07-FEB-2008 15:00 EM0800948-009	Dup2 07-FEB-2008 15:00 EM0800948-010
<b>EP080: BTEX - Continued</b>								
meta- & para-Xylene	108-38-3	106-42-3	2	µg/L	<2	<2	<2	<2
ortho-Xylene	95-47-6		2	µg/L	<2	<2	<2	<2
<b>EP202A: Phenoxycetic Acid Herbicides by LCMS</b>								
4-Chlorophenoxy acetic acid	122-88-3		10	µg/L	<20	<20	<20	<20
2,4-DB	94-82-6		10	µg/L	<20	<20	<20	<20
Dicamba	1918-00-9		10	µg/L	<20	<20	<20	<20
Mecoprop	93-65-2		10	µg/L	<20	<20	<20	<20
MCPA	94-74-6		10	µg/L	<20	<20	<20	<20
2,4-DP	120-36-5		10	µg/L	<20	<20	<20	<20
2,4-D	94-75-7		10	µg/L	<20	<20	<20	<20
Triclopyr	55335-06-3		10	µg/L	<20	<20	<20	<20
2,4,5-TP (Silvex)	93-72-1		10	µg/L	<20	<20	<20	<20
2,4,5-T	93-76-5		10	µg/L	<20	<20	<20	<20
MCPB	94-81-5		10	µg/L	<20	<20	<20	<20
Picloram	1918-02-1		10	µg/L	<20	<20	<20	<20
Clopyralid	1702-17-6		10	µg/L	<20	<20	<20	<20
Fluroxypyr	69377-81-7		10	µg/L	<20	<20	<20	<20
2,6-D	575-90-6		10	µg/L	<20	<20	<20	<20
2,4,6-T	575-89-3		10	µg/L	<20	<20	<20	<20
<b>EP075(SIM)S: Phenolic Compound Surrogates</b>								
Phenol-d6	13127-88-3		0.1	%	27.3	Not Determined	39.8	<20
2-Chlorophenol-D4	93951-73-6		0.1	%	76.3	77.8	72.5	<20
2,4,6-Tribromophenol	118-79-6		0.1	%	89.4	Not Determined	91.8	<20
<b>EP075(SIM)T: PAH Surrogates</b>								
2-Fluorobiphenyl	321-60-8		0.1	%	96.9	104	89.1	<20
Anthracene-d10	1719-06-8		0.1	%	90.9	104	88.8	<20
4-Terphenyl-d14	1718-51-0		0.1	%	112	116	112	<20
<b>EP080S: TPH(V)/BTEX Surrogates</b>								
1,2-Dichloroethane-D4	17060-07-0		0.1	%	92.5	101	90.9	100
Toluene-D8	2037-26-5		0.1	%	88.5	89.6	86.6	91.0
4-Bromofluorobenzene	460-00-4		0.1	%	85.6	87.6	82.7	87.4
<b>EP202S: Phenoxycetic Acid Herbicide Surrogate</b>								
2,4-Dichlorophenyl Acetic Acid	19719-28-9		0.1	%	104	108	77.0	<20



## Analytical Results

Compound	CAS Number	LOR	Client sample ID		Rinsate1	Trip Blank
			Client sampling date / time	Unit		
<b>ED037P: Alkalinity by PC Titrator</b>						
Hydroxide Alkalinity as CaCO3	DMO-210-001	1		mg/L	<1	
Carbonate Alkalinity as CaCO3	3812-32-6	1		mg/L	<1	
Bicarbonate Alkalinity as CaCO3	71-52-3	1		mg/L	<1	
Total Alkalinity as CaCO3	----	1		mg/L	<1	
<b>ED040F: Dissolved Major Anions</b>						
Sulphate as SO4 2-	14808-79-8	1		mg/L	<1	
<b>ED045P: Chloride by PC Titrator</b>						
Chloride	16887-00-6	1		mg/L	<1	
<b>ED093F: Dissolved Major Cations</b>						
Calcium	7440-70-2	1		mg/L	<1	
Magnesium	7439-95-4	1		mg/L	<1	
Sodium	7440-23-5	1		mg/L	<1	
Potassium	7440-09-7	1		mg/L	<1	
<b>EG020F: Dissolved Metals by ICP-MS</b>						
Arsenic	7440-38-2	0.001		mg/L	<0.001	
Beryllium	7440-41-7	0.001		mg/L	<0.001	
Barium	7440-39-3	0.001		mg/L	<0.001	
Cadmium	7440-43-9	0.0001		mg/L	<0.0001	
Chromium	7440-47-3	0.001		mg/L	<0.001	
Cobalt	7440-48-4	0.001		mg/L	<0.001	
Copper	7440-50-8	0.001		mg/L	<b>0.002</b>	
Lead	7439-92-1	0.001		mg/L	<0.001	
Manganese	7439-96-5	0.001		mg/L	<b>0.002</b>	
Nickel	7440-02-0	0.001		mg/L	<0.001	
Vanadium	7440-62-2	0.01		mg/L	<0.01	
Zinc	7440-66-6	0.005		mg/L	<b>0.011</b>	
<b>EG035F: Dissolved Mercury by FIMS</b>						
Mercury	7439-97-6	0.0001		mg/L	<0.0001	
<b>EK055G: Ammonia as N by Discrete Analyser</b>						
Ammonia as N	7664-41-7	0.010		mg/L	<0.010	
<b>EK057G: Nitrite as N by Discrete Analyser</b>						
Nitrite as N	----	0.010		mg/L	<0.010	
<b>EK058G: Nitrate as N by Discrete Analyser</b>						
^ Nitrate as N	14797-55-8	0.010		mg/L	<0.010	
<b>EK059G: NOx as N by Discrete Analyser</b>						
Nitrite + Nitrate as N	----	0.010		mg/L	<0.010	
<b>EK061: Total Kjeldahl Nitrogen (TKN)</b>						





### Analytical Results

Compound	CAS Number	LOR	Client sample ID		Rinsate1	Trip Blank	Unit
			Client sampling date / time	Unit			
Sub-Matrix: WATER							
EK061: Total Kjeldahl Nitrogen (TKN) - Continued							
Total Kjeldahl Nitrogen as N		0.1			<0.1		
EK062: Total Nitrogen as N							
^ Total Nitrogen as N		0.1			<0.1		
EK067G: Total Phosphorus as P by Discrete Analyser							
Total Phosphorus as P		0.01			<0.03		
EK071G: Reactive Phosphorus as P by discrete analyser							
Reactive Phosphorus as P		0.010			<0.010		
EN055: Ionic Balance							
Total Anions		0.01			<0.01		
Total Cations		0.01			<0.01		
Ionic Balance		0.01			<0.01		
EP075(SIM)B: Polynuclear Aromatic Hydrocarbons							
Naphthalene	91-20-3	1.0			<1.0		
Acenaphthylene	208-96-8	1.0			<1.0		
Acenaphthene	83-32-9	1.0			<1.0		
Fluorene	86-73-7	1.0			<1.0		
Phenanthrene	85-01-8	1.0			<1.0		
Anthracene	120-12-7	1.0			<1.0		
Fluoranthene	206-44-0	1.0			<1.0		
Pyrene	129-00-0	1.0			<1.0		
Benz(a)anthracene	56-55-3	1.0			<1.0		
Chrysene	218-01-9	1.0			<1.0		
Benzo(b)fluoranthene	205-99-2	1.0			<1.0		
Benzo(k)fluoranthene	207-08-9	1.0			<1.0		
Benzo(a)pyrene	50-32-8	0.5			<0.5		
Indeno(1,2,3-cd)pyrene	193-39-5	1.0			<1.0		
Dibenz(a,h)anthracene	53-70-3	1.0			<1.0		
Benzo(g,h,i)perylene	191-24-2	1.0			<1.0		
EP080/071: Total Petroleum Hydrocarbons							
C6 - C9 Fraction		20			<20	<20	
C10 - C14 Fraction		50			<50		
C15 - C28 Fraction		100			<100		
C29 - C36 Fraction		50			<50		
EP080: BTEX							
Benzene	71-43-2	1			<1	<1	
Toluene	108-88-3	2			<2	<2	
Ethylbenzene	100-41-4	2			<2	<2	



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 Work Order : EM0800948  
 Client : RESOURCE & ENVIRON MANGMNT P/L  
 Project : GM01

## Analytical Results

Sub-Matrix: WATER		Client sample ID		Client sampling date / time		Rinsate1		Trip Blank	
Compound	CAS Number	LOR	Unit	07-FEB-2008 15:00	EM0800948-011	EM0800948-012	08-FEB-2008	EM0800948-012	
<b>EP080: BTEX - Continued</b>									
meta- & para-Xylene	108-38-3	106-42-3	2	µg/L	<2	<2	<2	<2	
ortho-Xylene	95-47-6		2	µg/L	<2	<2	<2	<2	
<b>EP202A: Phenoxycetic Acid Herbicides by LCMS</b>									
4-Chlorophenoxy acetic acid	122-88-3		10	µg/L	<20	<20	<20	<20	
2,4-DB	94-82-6		10	µg/L	<20	<20	<20	<20	
Dicamba	1918-00-9		10	µg/L	<20	<20	<20	<20	
Mecoprop	93-65-2		10	µg/L	<20	<20	<20	<20	
MCPA	94-74-6		10	µg/L	<20	<20	<20	<20	
2,4-DP	120-36-5		10	µg/L	<20	<20	<20	<20	
2,4-D	94-75-7		10	µg/L	<20	<20	<20	<20	
Triclopyr	55335-06-3		10	µg/L	<20	<20	<20	<20	
2,4,5-TP (Silvex)	93-72-1		10	µg/L	<20	<20	<20	<20	
2,4,5-T	93-76-5		10	µg/L	<20	<20	<20	<20	
MCPB	94-81-5		10	µg/L	<20	<20	<20	<20	
Picloram	1918-02-1		10	µg/L	<20	<20	<20	<20	
Clopyralid	1702-17-6		10	µg/L	<20	<20	<20	<20	
Fluroxypyr	69377-81-7		10	µg/L	<20	<20	<20	<20	
2,6-D	575-90-6		10	µg/L	<20	<20	<20	<20	
2,4,6-T	575-89-3		10	µg/L	<20	<20	<20	<20	
<b>EP075(SIM)S: Phenolic Compound Surrogates</b>									
Phenol-d6	13127-88-3		0.1	%	27.3	27.3	27.3	27.3	
2-Chlorophenol-D4	93951-73-6		0.1	%	65.3	65.3	65.3	65.3	
2,4,6-Tribromophenol	118-79-6		0.1	%	75.2	75.2	75.2	75.2	
<b>EP075(SIM)T: PAH Surrogates</b>									
2-Fluorobiphenyl	321-60-8		0.1	%	86.5	86.5	86.5	86.5	
Anthracene-d10	1719-06-8		0.1	%	78.2	78.2	78.2	78.2	
4-Terphenyl-d14	1718-51-0		0.1	%	102	102	102	102	
<b>EP080S: TPH(V)/BTEX Surrogates</b>									
1,2-Dichloroethane-D4	17060-07-0		0.1	%	95.2	95.2	95.2	95.2	118
Toluene-D8	2037-26-5		0.1	%	90.2	90.2	90.2	90.2	102
4-Bromofluorobenzene	460-00-4		0.1	%	85.5	85.5	85.5	85.5	103
<b>EP202S: Phenoxycetic Acid Herbicide Surrogate</b>									
2,4-Dichlorophenyl Acetic Acid	19719-28-9		0.1	%	116	116	116	116	



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Client : RESOURCE & ENVIRON MANGMNT P/L  
Project : GM01

### Surrogate Control Limits

Sub-Matrix: WATER			
Compound	CAS Number	Recovery Limits (%)	
		Low	High
<b>EP075(SIM)S: Phenolic Compound Surrogates</b>			
Phenol-d6	13127-88-3	10	94
2-Chlorophenol-D4	93951-73-6	23	134
2,4,6-Tribromophenol	118-79-6	10	123
<b>EP075(SIM)T: PAH Surrogates</b>			
2-Fluorobiphenyl	321-60-8	43	116
Anthracene-d10	1719-06-8	27	133
4-Terphenyl-d14	1718-51-0	33	141
<b>EP080S: TPH(V)/BTEX Surrogates</b>			
1,2-Dichloroethane-D4	17060-07-0	70	130
Toluene-D8	2037-26-5	70	130
4-Bromofluorobenzene	460-00-4	70	130
<b>EP202S: Phenoxyacetic Acid Herbicide Surrogate</b>			
2,4-Dichlorophenyl Acetic Acid	19719-28-9	50.5	155

CHAIN OF CUSTODY FORM



From : Resource and Environmental Management Pty Ltd  
 ACN: 098 08 877  
 Suite 9, 15 Fullarton Road, Kent Town  
 ph: (08) 8363 1777 fax: (08) 8363 1477

LAB USE ONLY  
 QUOTE NUMBER  
 Job Code:  
 Due Date:  
 Custody seal intact? **4**  
 Sample cold? **4**  
 Received for Laboratory by:  
 Date: **2/8**  
 Time: **2/8**

Project No: **GM01**  
 Project Manager: ~~David Foster~~ **Stuart Richardson**  
 Sampler(s): **DP/DN/WC**  
 Checked:  
 Date: **7/2/08**

Size	Type	Preserv	Container Identification				
			Ammonia / Total N				
			P total				
			Carbons / Ammonia				
			Phos / Nitrate N				
			Metals (NEM 3-13)				
			TPA/SEX / PAH				
			Phenols / Acid				
			As Bicycles				

Lab Id	Date	Time	Matrix	Sample Identification	Comments	Tick required analytes					
	<b>7/2/08</b>		<b>W</b>								
<b>1</b>				<b>MW 3</b>		<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	
<b>2</b>				<b>MW 4</b>		<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	
<b>3</b>				<b>MW 6</b>		<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	
<b>4</b>				<b>MW 7</b>		<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	
<b>5</b>				<b>MW 8</b>		<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	
<b>6</b>				<b>MW 9</b>		<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	
<b>7</b>				<b>MW 11</b>		<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	
<b>8</b>				<b>MW 12</b>		<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	
<b>9</b>				<b>Dup 1</b>		<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	
<b>10</b>				<b>Dup 2</b>		<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	
<b>11</b>				<b>Rinse 1</b>		<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	
<b>12</b>				<b>Trap Blank</b>		<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	
<b>TOTAL</b>						<b>12</b>	<b>12</b>	<b>12</b>	<b>12</b>	<b>12</b>	

Environmental Division  
 Melbourne  
 Work Order  
**EM0800948**

Telephone : +61-3-8549 9600

Notes:  
 - Please provide results to REM by close of business:.....

**\* NOTE : SOME VERY HIGH SALINITIES NEED TO COMPENSATE TO GET CORRECT LOR'S.**

EMAIL : **CMF ALS 8/2/8 13°C**

**8.30.**



Environmental Division

**INTERPRETIVE QUALITY CONTROL REPORT**

<b>Work Order</b>	: <b>EM0800948</b>	<b>Page</b>	: 1 of 10
<b>Client</b>	: RESOURCE & ENVIRON MANGMNT P/L	<b>Laboratory</b>	: Environmental Division Melbourne
<b>Contact</b>	: MR DAVID POULSEN	<b>Contact</b>	: Paul Loewy
<b>Address</b>	: UNIT 9, 15 FULLARTON RD KENT TOWN SA, AUSTRALIA 5067	<b>Address</b>	: 4 Westall Rd Springvale VIC Australia 3171
<b>E-mail</b>	: davidpoulsen@rem.com.au	<b>E-mail</b>	: paul.loewy@alsenviro.com
<b>Telephone</b>	: +61 08 8363 1777	<b>Telephone</b>	: +61-3-8549 9600
<b>Facsimile</b>	: +61 08 8363 1477	<b>Facsimile</b>	: +61-3-8549 9601
<b>Project</b>	: GM01	<b>QC Level</b>	: NEPM 1999 Schedule B(3) and ALS QCS3 requirement
<b>Site</b>	: ----	<b>Date Samples Received</b>	: 08-FEB-2008
<b>C-O-C number</b>	: ----	<b>Issue Date</b>	: 19-FEB-2008
<b>Sampler</b>	: DP/DN/WC	<b>No. of samples received</b>	: 12
<b>Order number</b>	: ----	<b>No. of samples analysed</b>	: 12
<b>Quote number</b>	: AD/003a/07		

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. All pages of this report have been checked and approved for release.

This Interpretive Quality Control Report contains the following information:

- Analysis Holding Time Compliance
- Quality Control Parameter Frequency Compliance
- Brief Method Summaries
- Summary of Outliers



Page : 2 of 10  
 Work Order : EM0800948  
 Client : RESOURCE & ENVIRON MANGMNT P/L  
 Project : GM01

## Analysis Holding Time Compliance

The following report summarises extraction / preparation and analysis times and compares with recommended holding times. Dates reported represent first date of extraction or analysis and precludes subsequent dilutions and reruns. Information is also provided re the sample container (preservative) from which the analysis aliquot was taken. Elapsed period to analysis represents number of days from sampling where no extraction / digestion is involved or period from extraction / digestion where this is present. For composite samples, sampling date is assumed to be that of the oldest sample contributing to the composite. Sample date for laboratory produced leachates is assumed as the completion date of the leaching process. Outliers for holding time are based on USEPA SW 846, APHA, AS and NEPM (1999). A listing of breaches is provided in the Summary of Outliers.

Holding times for leachate methods (excluding elutriates) vary according to the analytes being determined on the resulting solution. For non-volatile analytes, the holding time compliance assessment compares the leach date with the shortest analyte holding time for the equivalent soil method. These soil holding times are: Organics (14 days); Mercury (28 days) & other metals (180 days). A recorded breach therefore does not guarantee a breach for all non-volatile parameters.

Matrix: **WATER**

Evaluation: \* = Holding time breach ; ✓ = Within holding time.

Method	Sample Date	Extraction / Preparation		Analysis	
		Date extracted	Due for extraction	Date analysed	Due for analysis
<b>ED037P: Alkalinity by PC Titrator</b>					
<b>Clear Plastic Bottle - Natural</b>	07-FEB-2008	---	---	14-FEB-2008	21-FEB-2008
MW3, MW8, MW12, Rinsate1					✓
<b>ED040F: Dissolved Major Anions</b>					
<b>Clear Plastic Bottle - Natural</b>	07-FEB-2008	---	---	13-FEB-2008	06-MAR-2008
MW3, MW8, MW12, Rinsate1					✓
<b>ED045P: Chloride by PC Titrator</b>					
<b>Clear Plastic Bottle - Natural</b>	07-FEB-2008	---	---	14-FEB-2008	06-MAR-2008
MW3, MW8, MW12, Rinsate1					✓
<b>ED093F: Dissolved Major Cations</b>					
<b>Clear Plastic Bottle - Natural</b>	07-FEB-2008	---	---	13-FEB-2008	06-MAR-2008
MW3, MW8, MW12, Rinsate1					✓
<b>EG020F: Dissolved Metals by ICP-MS</b>					
<b>Clear Plastic Bottle - Nitric Acid; Filtered</b>	07-FEB-2008	---	---	14-FEB-2008	05-AUG-2008
MW3, MW8, MW12, Rinsate1					✓



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 Client : RESOURCE & ENVIRON MANGMNT P/L  
 Project : GM01

Matrix: **WATER** Evaluation: \* = Holding time breach ; ✓ = Within holding time.

Method		Sample Date			Extraction / Preparation			Analysis		
Container / Client Sample ID(s)		Date extracted	Due for extraction	Evaluation	Date analysed	Due for analysis	Evaluation			
<b>EG035F: Dissolved Mercury by FIMS</b>										
Clear Plastic Bottle - Nitric Acid; Filtered	MW7, MW9, Dup1,	07-FEB-2008	-----	-----	13-FEB-2008	06-MAR-2008	-----	06-MAR-2008	-----	✓
<b>EK055G: Ammonia as N by Discrete Analyser</b>										
Clear Plastic Bottle - Sulphuric Acid	MW7, MW9, Dup1,	07-FEB-2008	-----	-----	12-FEB-2008	06-MAR-2008	-----	06-MAR-2008	-----	✓
<b>EK057G: Nitrite as N by Discrete Analyser</b>										
Clear Plastic Bottle - Natural	MW7, MW12, Dup1	07-FEB-2008	-----	-----	08-FEB-2008	09-FEB-2008	-----	09-FEB-2008	-----	✓
Clear Plastic Bottle - Natural	Rinsate1	07-FEB-2008	-----	-----	11-FEB-2008	09-FEB-2008	-----	09-FEB-2008	-----	✗
<b>EK059G: NOx as N by Discrete Analyser</b>										
Clear Plastic Bottle - Sulphuric Acid	MW7, MW9, Dup1,	07-FEB-2008	-----	-----	11-FEB-2008	06-MAR-2008	-----	06-MAR-2008	-----	✓
<b>EK061: Total Kjeldahl Nitrogen (TKN)</b>										
Clear Plastic Bottle - Sulphuric Acid	MW7, MW9, Dup1,	07-FEB-2008	14-FEB-2008	06-MAR-2008	15-FEB-2008	06-MAR-2008	-----	06-MAR-2008	-----	✓
<b>EK067G: Total Phosphorus as P by Discrete Analyser</b>										
Clear Plastic Bottle - Sulphuric Acid	MW7, MW9, Dup1,	07-FEB-2008	14-FEB-2008	06-MAR-2008	15-FEB-2008	06-MAR-2008	-----	06-MAR-2008	-----	✓
<b>EK071G: Reactive Phosphorus as P by discrete analyser</b>										
Clear Plastic Bottle - Natural	MW7, MW9, Dup1,	07-FEB-2008	-----	-----	11-FEB-2008	09-FEB-2008	-----	09-FEB-2008	-----	✗



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 Client : RESOURCE & ENVIRON MANGMNT P/L  
 Project : GM01

Matrix: **WATER** Evaluation: \* = Holding time breach ; ✓ = Within holding time.

Method		Sample Date			Extraction / Preparation		Analysis	
Container / Client Sample ID(s)		Date extracted	Due for extraction	Evaluation	Date analysed	Due for analysis	Evaluation	
<b>EP075(SIM)B: Polynuclear Aromatic Hydrocarbons</b>								
Amber Glass Bottle - Unpreserved	MW7, MW9, Dup1,	12-FEB-2008	14-FEB-2008	✓	13-FEB-2008	23-MAR-2008	✓	
<b>EP080/071: Total Petroleum Hydrocarbons</b>								
Amber Glass Bottle - Unpreserved	MW7, MW9, Dup1,	12-FEB-2008	14-FEB-2008	✓	13-FEB-2008	23-MAR-2008	✓	
Amber VOC Vial - HCl or NaHSO4	MW4, MW7, MW9, MW12, Dup2, Rinsate1	07-FEB-2008	---	----	14-FEB-2008	21-FEB-2008	✓	
Amber VOC Vial - HCl or NaHSO4	Trip Blank	08-FEB-2008	---	----	14-FEB-2008	22-FEB-2008	✓	
<b>EP080: BTEX</b>								
Amber VOC Vial - HCl or NaHSO4	MW4, MW7, MW9, MW12, Dup2, Rinsate1	07-FEB-2008	---	----	14-FEB-2008	21-FEB-2008	✓	
Amber VOC Vial - HCl or NaHSO4	Trip Blank	08-FEB-2008	---	----	14-FEB-2008	22-FEB-2008	✓	
<b>EP202A: Phenoxacetic Acid Herbicides by LCMS</b>								
Amber Glass Bottle - Unpreserved	MW7, MW9, Dup1,	07-FEB-2008	----	----	13-FEB-2008	14-FEB-2008	✓	





## Quality Control Parameter Frequency Compliance

The following report summarises the frequency of laboratory QC samples analysed within the analytical lot(s) in which the submitted sample(s) was(were) processed. Actual rate should be greater than or equal to the expected rate. A listing of breaches is provided in the Summary of Outliers.

Matrix: **WATER**

Evaluation: \* = Quality Control frequency not within specification ; ✓ = Quality Control frequency within specification.

Quality Control Sample Type	Method	Count			Rate (%)		Evaluation	Quality Control Specification
		QC	Regular	Actual	Expected			
<b>Laboratory Duplicates (DUP)</b>								
Alkalinity by PC Titrator	ED037-P	2	20	10.0	10.0	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement	
Ammonia as N by Discrete analyser	EK055G	1	7	14.3	10.0	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement	
Chloride by PC Titrator	ED045-P	2	20	10.0	10.0	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement	
Dissolved Mercury by FIMS	EG035F	2	18	11.1	10.0	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement	
Dissolved Metals by ICP-MS - Suite A	EG020A-F	2	20	10.0	10.0	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement	
Major Anions - Filtered	ED040F	2	17	11.8	10.0	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement	
Major Cations - Filtered	ED093F	2	13	15.4	10.0	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement	
Nitrite and Nitrate as N (NOx) by Discrete Analyser	EK059G	2	20	10.0	10.0	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement	
Nitrite as N by Discrete Analyser	EK057G	3	23	13.0	10.0	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement	
Phenoxyacetic Acid Herbicides (LCMS - Standard DL)	EP202-SL	2	20	10.0	10.0	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement	
Reactive Phosphorus as P-By Discrete Analyser	EK071G	2	10	20.0	10.0	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement	
Total Kjeldahl Nitrogen as N By Discrete Analyser	EK061G	2	16	12.5	10.0	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement	
Total Phosphorus as P By Discrete Analyser	EK067G	2	18	11.1	10.0	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement	
TPH Volatiles/BTEX	EP080	2	19	10.5	10.0	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement	
<b>Laboratory Control Samples (LCS)</b>								
Alkalinity by PC Titrator	ED037-P	1	20	5.0	5.0	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement	
Ammonia as N by Discrete analyser	EK055G	1	7	14.3	5.0	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement	
Chloride by PC Titrator	ED045-P	1	20	5.0	5.0	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement	
Dissolved Mercury by FIMS	EG035F	2	28	7.1	5.0	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement	
Dissolved Metals by ICP-MS - Suite A	EG020A-F	1	20	5.0	5.0	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement	
Major Anions - Filtered	ED040F	1	17	5.9	5.0	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement	
Major Cations - Filtered	ED093F	1	13	7.7	5.0	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement	
Nitrite and Nitrate as N (NOx) by Discrete Analyser	EK059G	1	20	5.0	5.0	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement	
Nitrite as N by Discrete Analyser	EK057G	2	23	8.7	5.0	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement	
PAH/Phenols (GC/MS - SIM)	EP075(SIM)	1	13	7.7	5.0	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement	
Phenoxyacetic Acid Herbicides (LCMS - Standard DL)	EP202-SL	1	10	10.0	5.0	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement	
Reactive Phosphorus as P-By Discrete Analyser	EK071G	1	16	6.3	5.0	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement	
Total Kjeldahl Nitrogen as N By Discrete Analyser	EK061G	1	18	5.6	5.0	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement	
Total Phosphorus as P By Discrete Analyser	EK067G	1	9	11.1	5.0	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement	
TPH - Semivolatile Fraction	EP071	1	19	5.3	5.0	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement	
TPH Volatiles/BTEX	EP080	1	19	5.3	5.0	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement	
<b>Method Blanks (MB)</b>								
Ammonia as N by Discrete analyser	EK055G	1	7	14.3	5.0	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement	
Chloride by PC Titrator	ED045-P	1	20	5.0	5.0	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement	
Dissolved Mercury by FIMS	EG035F	2	28	7.1	5.0	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement	
Dissolved Metals by ICP-MS - Suite A	EG020A-F	1	20	5.0	5.0	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement	
Major Anions - Filtered	ED040F	1	17	5.9	5.0	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement	
Major Cations - Filtered	ED093F	1	13	7.7	5.0	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement	
Nitrite and Nitrate as N (NOx) by Discrete Analyser	EK059G	1	20	5.0	5.0	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement	



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 Work Order : EM0800948  
 Client : RESOURCE & ENVIRON MANGMNT P/L  
 Project : GM01

Matrix: **WATER**  
 Evaluation: \* = Quality Control frequency not within specification ; ✓ = Quality Control frequency within specification.

Quality Control Sample Type		Count			Rate (%)		Quality Control Specification	
Analytical Methods	Method	QC	Regular	Actual	Expected	Rate (%)	Actual	Expected
<b>Method Blanks (MB) - Continued</b>								
Nitrite as N by Discrete Analyser	EK057G	2	23	8.7	5.0	✓		NEPM 1999 Schedule B(3) and ALS QCS3 requirement
PAH/Phenols (GC/MS - SIM)	EP075(SIM)	1	13	7.7	5.0	✓		NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Phenoxyacetic Acid Herbicides (LCMS - Standard DL)	EP202-SL	1	20	5.0	5.0	✓		NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Reactive Phosphorus as P-By Discrete Analyser	EK071G	1	10	10.0	5.0	✓		NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Total Kjeldahl Nitrogen as N By Discrete Analyser	EK061G	1	16	6.3	5.0	✓		NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Total Phosphorus as P By Discrete Analyser	EK067G	1	18	5.6	5.0	✓		NEPM 1999 Schedule B(3) and ALS QCS3 requirement
TPH - Semivolatile Fraction	EP071	1	9	11.1	5.0	✓		NEPM 1999 Schedule B(3) and ALS QCS3 requirement
TPH Volatiles/BTEX	EP080	1	19	5.3	5.0	✓		NEPM 1999 Schedule B(3) and ALS QCS3 requirement
<b>Matrix Spikes (MS)</b>								
Ammonia as N by Discrete analyser	EK055G	1	7	14.3	5.0	✓		ALS QCS3 requirement
Chloride by PC Titrator	ED045-P	1	20	5.0	5.0	✓		ALS QCS3 requirement
Dissolved Mercury by FIMS	EG035F	1	18	5.6	5.0	✓		ALS QCS3 requirement
Dissolved Metals by ICP-MS - Suite A	EG020A-F	1	20	5.0	5.0	✓		ALS QCS3 requirement
Nitrite and Nitrate as N (NOx) by Discrete Analyser	EK059G	1	20	5.0	5.0	✓		ALS QCS3 requirement
Nitrite as N by Discrete Analyser	EK057G	2	23	8.7	5.0	✓		ALS QCS3 requirement
Phenoxyacetic Acid Herbicides (LCMS - Standard DL)	EP202-SL	1	20	5.0	5.0	✓		ALS QCS3 requirement
Reactive Phosphorus as P-By Discrete Analyser	EK071G	1	10	10.0	5.0	✓		ALS QCS3 requirement
Total Kjeldahl Nitrogen as N By Discrete Analyser	EK061G	1	16	6.3	5.0	✓		ALS QCS3 requirement
Total Phosphorus as P By Discrete Analyser	EK067G	1	18	5.6	5.0	✓		ALS QCS3 requirement
TPH Volatiles/BTEX	EP080	1	19	5.3	5.0	✓		ALS QCS3 requirement



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 Work Order : EM0800948  
 Client : RESOURCE & ENVIRON MANGMNT P/L  
 Project : GM01

## Brief Method Summaries

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the US EPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request. The following report provides brief descriptions of the analytical procedures employed for results reported in the Certificate of Analysis. Sources from which ALS methods have been developed are provided within the Method Descriptions.

Analytical Methods	Method	Matrix	Method Descriptions
Alkalinity by PC Titrator	ED037-P	WATER	APHA 21st ed., 2320 B This procedure determines alkalinity by both manual measurement and automated measurement (e.g. PC Titrator) using pH 4.5 for indicating the total alkalinity end-point. This method is compliant with NEPM (1999) Schedule B(3) (Appdx. 2)
Major Anions - Filtered	ED040F	WATER	APHA 21st ed., 3120 Sulphur and/or Silicon content is determined by ICP/AES and reported as Sulphate and/or Silica after conversion by gravimetric factor.
Chloride by PC Titrator	ED045-P	WATER	APHA 21st ed., 4500 Cl - B. Automated Silver Nitrate titration.
Major Cations - Filtered	ED093F	WATER	APHA 21st ed., 3120; USEPA SW 846 - 6010 The ICP/AES technique ionises filtered sample atoms emitting a characteristic spectrum. This spectrum is then compared against matrix matched standards for quantification. This method is compliant with NEPM (1999) Schedule B(3) (Appdx. 2)
Dissolved Metals by ICP-MS - Suite A	EG020A-F	WATER	APHA 21st ed., 3125; USEPA SW846 - 6020; ALS QWI-EN/EG020: The ICPMS technique utilizes a highly efficient argon plasma to ionize selected elements. Ions are then passed into a high vacuum mass spectrometer, which separates the analytes based on their distinct mass to charge ratios prior to their measurement by a discrete dynode ion detector.
Dissolved Mercury by FIMS	EG035F	WATER	AS 3550, APHA 21st ed. 3112 Hg - B (Flow-injection (SnCl <sub>2</sub> )(Cold Vapour generation) AAS) FIM-AAS is an automated flameless atomic absorption technique. A bromate/bromide reagent is used to oxidise any organic mercury compounds in the filtered sample. The ionic mercury is reduced online to atomic mercury vapour by SnCl <sub>2</sub> which is then purged into a heated quartz cell. Quantification is by comparing absorbance against a calibration curve. This method is compliant with NEPM (1999) Schedule B(3) (Appdx. 2)
Ammonia as N by Discrete analyser	EK055G	WATER	APHA 21st ed., 4500 NH <sub>3</sub> +G Ammonia is determined by direct colorimetry by Seal Discrete Analyser. This method is compliant with NEPM (1999) Schedule B(3) (Appdx. 2)
Nitrite as N by Discrete Analyser	EK057G	WATER	APHA 21st ed., 4500 NO <sub>3</sub> -B. SEAL Method 2-018-1-L February 2003. Nitrite is determined by direct colorimetry by SEAL. This method is compliant with NEPM (1999) Schedule B(3) (Appdx. 2)
Nitrate as N by Discrete Analyser	EK058G	WATER	APHA 21st ed., 4500 NO <sub>3</sub> -F. SEAL Method 2-018-1-L February 2003. Nitrate is reduced to nitrite by way of a cadmium reduction column followed by quantification by SEAL. Nitrite is determined separately by direct colorimetry and result for Nitrate calculated as the difference between the two results. This method is compliant with NEPM (1999) Schedule B(3) (Appdx. 2)
Nitrite and Nitrate as N (NOx) by Discrete Analyser	EK059G	WATER	APHA 21st ed., 4500 NO <sub>3</sub> -F. SEAL Method 2-018-1-L February 2003. Combined oxidised Nitrogen (NO <sub>2</sub> +NO <sub>3</sub> ) is determined by Cadmium Reduction and direct colorimetry by SEAL. This method is compliant with NEPM (1999) Schedule B(3) (Appdx. 2)
Total Kjeldahl Nitrogen as N By Discrete Analyser	EK061G	WATER	APHA 21st ed., 4500-Norg-D25mL water samples are digested using a traditional Kjeldahl digestion followed by determination by Seal by Discrete Analyser. This method is compliant with NEPM (1999) Schedule B(3) (Appdx. 2)
Total Nitrogen as N (TKN + Nox) By Discrete Analyser	EK062G	WATER	APHA 21st ed., 4500 N org / NO <sub>3</sub> . This method is compliant with NEPM (1999) Schedule B(3) (Appdx. 2)
Total Phosphorus as P By Discrete Analyser	EK067G	WATER	APHA 21st ed., 4500 P-B&F This procedure involves sulphuric acid digestion of a 100mL sample to break phosphorus down to orthophosphate. The orthophosphate reacts with ammonium molybdate and antimony potassium tartrate to form a complex which is then reduced and its concentration measured at 880nm using Seal. This method is compliant with NEPM (1999) Schedule B(3) (Appdx. 2)



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 Client : RESOURCE & ENVIRON MANGMNT P/L  
 Project : GM01

Analytical Methods		Method	Matrix	Method Descriptions
Reactive Phosphorus as P-By Discrete Analyser	EK071G	WATER	APHA 21st ed., 4500 P-F Ammonium molybdate and potassium antimonyl tartrate reacts in acid medium with orthophosphate to form a heteropoly acid -phosphomolybdic acid - which is reduced to intensely coloured molybdenum blue by ascorbic acid. Quantification is by SEAL. This method is compliant with NEPM (1999) Schedule B(3) (Appdx. 2)	
Ionic Balance	EN055	WATER	APHA 21st Ed. 1030F. This method is compliant with NEPM (1999) Schedule B(3) (Appdx. 2)	
TPH - Semivolatle Fraction	EP071	WATER	USEPA SW 846 - 8015A The sample extract is analysed by Capillary GC/FID and quantification is by comparison against an established 5 point calibration curve of n-Alkane standards. This method is compliant with NEPM (1999) Schedule B(3) (Appdx. 2)	
PAH/Phenols (GC/MS - SIM)	EP075(SIM)	WATER	USEPA SW 846 - 8270D Sample extracts are analysed by Capillary GC/MS in SIM Mode and quantification is by comparison against an established 5 point calibration curve. This method is compliant with NEPM (1999) Schedule B(3) (Appdx. 2)	
TPH Volatiles/BTEX	EP080	WATER	USEPA SW 846 - 8260B Water samples are directly purged prior to analysis by Capillary GC/MS and quantification is by comparison against an established 5 point calibration curve. This method is compliant with NEPM (1999) Schedule B(3) (Appdx. 2)	
Phenoxyacetic Acid Herbicides (LCMS - Standard DL)	EP202-SL	WATER	In-House, LCMS (Electrospray in negative mode). After adding surrogate and acetic acid, water samples are injected on a C18 column for LC/MS determination.	
Preparation Methods		Method	Matrix	Method Descriptions
TKN/TP Digestion	EK061/EK067	WATER	APHA 21st ed., 4500 Norg - D; APHA 21st ed., 4500 P - H. This method is compliant with NEPM (1999) Schedule B(3) (Appdx. 2)	
Separatory Funnel Extraction of Liquids	ORG14	WATER	USEPA SW 846 - 3510B 500 mL to 1L of sample is transferred to a separatory funnel and serially extracted three times using 60mL DCM for each extract. The resultant extracts are combined, dehydrated and concentrated for analysis. This method is compliant with NEPM (1999) Schedule B(3) (Appdx. 2). ALS default excludes sediment which may be resident in the container.	



## Summary of Outliers

### Outliers : Quality Control Samples

The following report highlights outliers flagged in the Quality Control (QC) Report. Surrogate recovery limits are static and based on USEPA SW846 or ALS-QW/EN/38 (in the absence of specific USEPA limits). This report displays QC Outliers (breaches) only.

### Duplicates, Method Blanks, Laboratory Control Samples and Matrix Spikes

Matrix: **WATER**

Compound Group Name	Laboratory Sample ID	Client Sample ID	Analyte	CAS Number	Data	Limits	Comment
<b>Laboratory Control Spike (LCS) Recoveries</b>							
EP075(SIM)B: Polynuclear Aromatic Hydrocarbons	656898-006	----	Acenaphthylene	208-96-8	115 %	51.2-110%	Recovery greater than upper control limit
EP075(SIM)B: Polynuclear Aromatic Hydrocarbons	656898-006	----	Pyrene	129-00-0	126 %	64.2-115%	Recovery greater than upper control limit
<b>Matrix Spike (MS) Recoveries</b>							
EK055G: Ammonia as N by Discrete Analyser	EM0800948-004	MW7	Ammonia as N	7664-41-7	133 %	70-130%	Recovery greater than upper data quality objective
EK061: Total Kjeldahl Nitrogen (TKN)	EM0800948-004	MW7	Total Kjeldahl Nitrogen as N	----	61.0 %	70-130%	Recovery less than lower data quality objective

- For all matrices, no Method Blank value outliers occur.
- For all matrices, no Duplicate outliers occur.

### Regular Sample Surrogates

Sub-Matrix: **WATER**

Compound Group Name	Laboratory Sample ID	Client Sample ID	Analyte	CAS Number	Data	Limits	Comment
<b>Samples Submitted</b>							
EP075(SIM)S: Phenolic Compound Surrogates	EM0800948-008	MW12	Phenol-d6	13127-88-3	Not Determined	----	Surrogate recovery not determined due to (target or non-target) matrix interferences
EP075(SIM)S: Phenolic Compound Surrogates	EM0800948-008	MW12	2,4,6-Tribromophenol	118-79-6	Not Determined	----	Surrogate recovery not determined due to (target or non-target) matrix interferences

### Outliers : Analysis Holding Time Compliance

This report displays Holding Time breaches only. Only the respective Extraction / Preparation and/or Analysis component is/are displayed.

Matrix: **WATER**

Method Container / Client Sample ID(s)	Extraction / Preparation		Analysis	
	Date extracted	Due for extraction	Date analysed	Due for analysis
<b>EK057G: Nitrite as N by Discrete Analyser</b>				
Clear Plastic Bottle - Natural MW8,	----	----	11-FEB-2008	09-FEB-2008
Rinsate1	----	----	----	2
<b>EK071G: Reactive Phosphorus as P by discrete analyser</b>				



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 Work Order : EM0800948  
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 Project : GM01

Matrix: **WATER**

Method	Extraction / Preparation			Analysis	
	Date extracted	Due for extraction	Days overdue	Date analysed	Days overdue
<b>EK071G: Reactive Phosphorus as P by discrete analyser - Analysis Holding Time Compliance</b>					
<b>Clear Plastic Bottle - Natural</b> MW3, MW8, MW12, Rinsate1  MW7, MW9, Dup1,	----	----	----	11-FEB-2008	09-FEB-2008
					2

**Outliers : Frequency of Quality Control Samples**

The following report highlights breaches in the Frequency of Quality Control Samples.

- **No Quality Control Sample Frequency Outliers exist.**

Environmental Division

**CERTIFICATE OF ANALYSIS**

Work Order	: EM0801099	Page	: 1 of 10
Client	: RESOURCE & ENVIRON MANGMNT P/L	Laboratory	: Environmental Division Melbourne
Contact	: MR DAVID POULSEN	Contact	: Paul Loewy
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Facsimile	: +61 08 8363 1477	Facsimile	: +61-3-8549 9601
Project	: GM-01	QC Level	: NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Order number	: ----	Date Samples Received	: 14-FEB-2008
C-O-C number	: ----	Issue Date	: 25-FEB-2008
Sampler	: DP/WC	No. of samples received	: 10
Site	: ----	No. of samples analysed	: 9
Quote number	: ME/122/06		

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. All pages of this report have been checked and approved for release.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results
- Surrogate Control Limits



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This document is issued in accordance with NATA accreditation requirements.

Accredited for compliance with ISO/IEC 17025.



**Signatories**

This document has been electronically signed by the authorized signatories indicated below. Electronic signing has been carried out in compliance with procedures specified in 21 CFR Part 11.

Signatories	Position	Accreditation Category
Dilani Fernando	Senior Inorganic Instrument Chemist	Inorganics
Marc Centner	Technical Manager	Organics
Terrance Hettipathirana	Senior ICP/MS Chemist	Inorganics
Valda Chen	QC / OHS Officer	Inorganics
Xingbin Lin	Instrument Chemist	Organics

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Work Order : EM0801099  
Client : RESOURCE & ENVIRON MANGMNT P/L  
Project : GM-01

### General Comments

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

When date(s) and/or time(s) are shown bracketed, these have been assumed by the laboratory for process purposes.

Key : CAS Number = Chemistry Abstract Services number  
LOR = Limit of reporting

^ = This result is computed from individual analyte detections at or above the level of reporting

- **EG020-F: EM0801099-001 has been diluted for analysis by ICP-MS and LORs have been raised accordingly.**
- **EG035F: EM0801099-005 matrix spike failed for Mercury due to matrix interferences.**
- **EK055G: LOR has been raised for EM0801099 #3, #4, #5, #6, #7, #8 and #9 due to matrix interferences.**
- **EK061G: LOR raised for Total Kjeldahl Nitrogen as N.**
- **EP075SIM: Particular sample 'MW05' required dilution prior to analysis due to matrix interferences. LOR values have been adjusted accordingly.**
- **EP202: Samples required dilution due to matrix interferences. LOR values have been adjusted accordingly.**
- **EPO80 EMO801099-005 Poor water surrogate recoveries due to sample matrix interference. Confirmed by reanalysis.**
- **Ionic Balance out of acceptable limits for EM0801099 #1 & #9 due to analytes not quantified in this report.**



## Analytical Results

Sub-Matrix: WATER		Client sample ID		Client sampling date / time		Client sampling date / time		Client sampling date / time		Client sampling date / time		Client sampling date / time	
Compound	CAS Number	LOR	Unit	MW06	MW08	MW04	MW11	MW05	MW06	MW08	MW04	MW11	MW05
<b>ED037P: Alkalinity by PC Titrator</b>													
Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	266	652	397	329	496	266	652	397	329	496
Total Alkalinity as CaCO3	----	1	mg/L	266	652	397	329	496	266	652	397	329	496
<b>ED040F: Dissolved Major Anions</b>													
Sulphate as SO4 2-	14808-79-8	1	mg/L	6990	2570	2270	909	1850	6990	2570	2270	909	1850
<b>ED045P: Chloride by PC Titrator</b>													
Chloride	16887-00-6	1	mg/L	29000	14100	12100	3600	7690	29000	14100	12100	3600	7690
<b>ED093F: Dissolved Major Cations</b>													
Calcium	7440-70-2	1	mg/L	950	242	224	150	153	950	242	224	150	153
Magnesium	7439-95-4	1	mg/L	3570	928	486	277	516	3570	928	486	277	516
Sodium	7440-23-5	1	mg/L	21800	8920	8180	2290	5230	21800	8920	8180	2290	5230
Potassium	7440-09-7	1	mg/L	926	338	86	41	57	926	338	86	41	57
<b>EG020F: Dissolved Metals by ICP-MS</b>													
Arsenic	7440-38-2	0.001	mg/L	<0.010	----	0.001	<0.001	0.006	<0.010	----	0.001	<0.001	0.006
Beryllium	7440-41-7	0.001	mg/L	<0.010	----	<0.001	<0.001	<0.001	<0.010	----	<0.001	<0.001	<0.001
Barium	7440-39-3	0.001	mg/L	0.084	----	0.060	0.036	0.029	0.084	----	0.060	0.036	0.029
Cadmium	7440-43-9	0.0001	mg/L	<0.0010	----	<0.0001	<0.0001	<0.0001	<0.0010	----	<0.0001	<0.0001	<0.0001
Chromium	7440-47-3	0.001	mg/L	<0.010	----	0.002	0.003	0.005	<0.010	----	0.002	0.003	0.005
Cobalt	7440-48-4	0.001	mg/L	<0.010	----	<0.001	<0.001	0.001	<0.010	----	<0.001	<0.001	0.001
Copper	7440-50-8	0.001	mg/L	0.016	----	0.008	0.003	0.004	0.016	----	0.008	0.003	0.004
Lead	7439-92-1	0.001	mg/L	0.014	----	<0.001	<0.001	<0.001	0.014	----	<0.001	<0.001	<0.001
Manganese	7439-96-5	0.001	mg/L	0.268	----	0.006	0.007	0.036	0.268	----	0.006	0.007	0.036
Nickel	7440-02-0	0.001	mg/L	0.015	----	0.003	0.002	0.002	0.015	----	0.003	0.002	0.002
Vanadium	7440-62-2	0.01	mg/L	<0.10	----	0.01	0.01	0.02	<0.10	----	0.01	0.01	0.02
Zinc	7440-66-6	0.005	mg/L	0.302	----	<0.005	0.009	0.007	0.302	----	<0.005	0.009	0.007
<b>EG035F: Dissolved Mercury by FIMS</b>													
Mercury	7439-97-6	0.0001	mg/L	<0.0001	----	<0.0001	<0.0001	<0.0001	<0.0001	----	<0.0001	<0.0001	<0.0001
<b>EK055G: Ammonia as N by Discrete Analyser</b>													
Ammonia as N	7664-41-7	0.010	mg/L	0.610	----	<0.100	<0.100	<0.100	0.610	----	<0.100	<0.100	<0.100
<b>EK057G: Nitrite as N by Discrete Analyser</b>													
Nitrite as N	----	0.010	mg/L	<0.010	0.016	0.010	0.024	0.055	<0.010	0.016	0.010	0.024	0.055
<b>EK058G: Nitrate as N by Discrete Analyser</b>													
^ Nitrate as N	14797-55-8	0.010	mg/L	0.020	2.62	6.20	4.47	2.51	0.020	2.62	6.20	4.47	2.51
<b>EK059G: NOx as N by Discrete Analyser</b>													
Nitrite + Nitrate as N	----	0.010	mg/L	0.020	2.64	6.21	4.50	2.56	0.020	2.64	6.21	4.50	2.56
<b>EK061: Total Kjeldahl Nitrogen (TKN)</b>													



## Analytical Results

Compound	CAS Number	LOR	Client sampling date / time		Unit	Client sample ID					
			MW06	MW08		MW04	MW11	MW05			
<b>Sub-Matrix: WATER</b>											
<b>EK061: Total Kjeldahl Nitrogen (TKN) - Continued</b>											
Total Kjeldahl Nitrogen as N	----	0.1	mg/L	13-FEB-2008 15:00	2.0	13-FEB-2008 15:00	1.2	13-FEB-2008 15:00	0.6	13-FEB-2008 15:00	0.7
<b>EK062: Total Nitrogen as N</b>											
^ Total Nitrogen as N	----	0.1	mg/L	EM0801099-002	2.1	EM0801099-003	7.4	EM0801099-004	5.0	EM0801099-005	3.3
<b>EK067G: Total Phosphorus as P by Discrete Analyser</b>											
Total Phosphorus as P	----	0.01	mg/L	EM0801099-001	0.41	EM0801099-002	0.97	EM0801099-003	0.20	EM0801099-004	0.37
<b>EK071G: Reactive Phosphorus as P by discrete analyser</b>											
Reactive Phosphorus as P	----	0.010	mg/L	EM0801099-001	<0.010	EM0801099-002	0.011	EM0801099-003	<0.010	EM0801099-004	<0.010
<b>EN055: Ionic Balance</b>											
^ Total Anions	----	0.01	meq/L	EM0801099-001	970	EM0801099-002	464	EM0801099-003	127	EM0801099-004	265
^ Total Cations	----	0.01	meq/L	EM0801099-001	1310	EM0801099-002	485	EM0801099-003	131	EM0801099-004	279
^ Ionic Balance	----	0.01	%	EM0801099-001	14.9	EM0801099-002	2.25	EM0801099-003	1.48	EM0801099-004	2.52
<b>EP075(SIM)B: Polynuclear Aromatic Hydrocarbons</b>											
Naphthalene	91-20-3	1.0	µg/L	EM0801099-001	<1.0	EM0801099-002	<1.0	EM0801099-003	<1.0	EM0801099-004	<5.0
Acenaphthylene	208-96-8	1.0	µg/L	EM0801099-001	<1.0	EM0801099-002	<1.0	EM0801099-003	<1.0	EM0801099-004	<5.0
Acenaphthene	83-32-9	1.0	µg/L	EM0801099-001	<1.0	EM0801099-002	<1.0	EM0801099-003	<1.0	EM0801099-004	<5.0
Fluorene	86-73-7	1.0	µg/L	EM0801099-001	<1.0	EM0801099-002	<1.0	EM0801099-003	<1.0	EM0801099-004	<5.0
Phenanthrene	85-01-8	1.0	µg/L	EM0801099-001	<1.0	EM0801099-002	<1.0	EM0801099-003	<1.0	EM0801099-004	<5.0
Anthracene	120-12-7	1.0	µg/L	EM0801099-001	<1.0	EM0801099-002	<1.0	EM0801099-003	<1.0	EM0801099-004	<5.0
Fluoranthene	206-44-0	1.0	µg/L	EM0801099-001	<1.0	EM0801099-002	<1.0	EM0801099-003	<1.0	EM0801099-004	<5.0
Pyrene	129-00-0	1.0	µg/L	EM0801099-001	<1.0	EM0801099-002	<1.0	EM0801099-003	<1.0	EM0801099-004	<5.0
Benz(a)anthracene	56-55-3	1.0	µg/L	EM0801099-001	<1.0	EM0801099-002	<1.0	EM0801099-003	<1.0	EM0801099-004	<5.0
Chrysene	218-01-9	1.0	µg/L	EM0801099-001	<1.0	EM0801099-002	<1.0	EM0801099-003	<1.0	EM0801099-004	<5.0
Benzo(b)fluoranthene	205-99-2	1.0	µg/L	EM0801099-001	<1.0	EM0801099-002	<1.0	EM0801099-003	<1.0	EM0801099-004	<5.0
Benzo(k)fluoranthene	207-08-9	1.0	µg/L	EM0801099-001	<1.0	EM0801099-002	<1.0	EM0801099-003	<1.0	EM0801099-004	<5.0
Benzo(a)pyrene	50-32-8	0.5	µg/L	EM0801099-001	<0.5	EM0801099-002	<0.5	EM0801099-003	<0.5	EM0801099-004	<2.5
Indeno(1,2,3-cd)pyrene	193-39-5	1.0	µg/L	EM0801099-001	<1.0	EM0801099-002	<1.0	EM0801099-003	<1.0	EM0801099-004	<5.0
Dibenz(a,h)anthracene	53-70-3	1.0	µg/L	EM0801099-001	<1.0	EM0801099-002	<1.0	EM0801099-003	<1.0	EM0801099-004	<5.0
Benzo(g,h,i)perylene	191-24-2	1.0	µg/L	EM0801099-001	<1.0	EM0801099-002	<1.0	EM0801099-003	<1.0	EM0801099-004	<5.0
<b>EP080/071: Total Petroleum Hydrocarbons</b>											
C6 - C9 Fraction	----	20	µg/L	EM0801099-001	----	EM0801099-002	----	EM0801099-003	----	EM0801099-004	<20
C10 - C14 Fraction	----	50	µg/L	EM0801099-001	----	EM0801099-002	----	EM0801099-003	----	EM0801099-004	<50
C15 - C28 Fraction	----	100	µg/L	EM0801099-001	----	EM0801099-002	----	EM0801099-003	----	EM0801099-004	<100
C29 - C36 Fraction	----	50	µg/L	EM0801099-001	----	EM0801099-002	----	EM0801099-003	----	EM0801099-004	<50
<b>EP080: BTEX</b>											
Benzene	71-43-2	1	µg/L	EM0801099-001	----	EM0801099-002	----	EM0801099-003	----	EM0801099-004	<1
Toluene	108-88-3	2	µg/L	EM0801099-001	----	EM0801099-002	----	EM0801099-003	----	EM0801099-004	<2
Ethylbenzene	100-41-4	2	µg/L	EM0801099-001	----	EM0801099-002	----	EM0801099-003	----	EM0801099-004	<2



## Analytical Results

Sub-Matrix: WATER		Client sample ID									
Compound	CAS Number	LOR	Unit	Client sampling date / time	MW06	MW08	MW04	MW11	MW05		
					13-FEB-2008 15:00	13-FEB-2008 15:00	13-FEB-2008 15:00	13-FEB-2008 15:00	13-FEB-2008 15:00		
					EM0801099-001	EM0801099-002	EM0801099-003	EM0801099-004	EM0801099-005		
<b>EP080: BTEX - Continued</b>											
meta- & para-Xylene	108-38-3	106-42-3	2	µg/L	---	---	---	---	<2		<2
ortho-Xylene	95-47-6		2	µg/L	---	---	---	---	<2		<2
<b>EP202A: Phenoxycetic Acid Herbicides by LCMS</b>											
4-Chlorophenoxy acetic acid	122-88-3		10	µg/L	<20	---	<20	<20	<20		<20
2,4-DB	94-82-6		10	µg/L	<20	---	<20	<20	<20		<20
Dicamba	1918-00-9		10	µg/L	<20	---	<20	<20	<20		<20
Mecoprop	93-65-2		10	µg/L	<20	---	<20	<20	<20		<20
MCPA	94-74-6		10	µg/L	<20	---	<20	<20	<20		<20
2,4-DP	120-36-5		10	µg/L	<20	---	<20	<20	<20		<20
2,4-D	94-75-7		10	µg/L	<20	---	<20	<20	<20		<20
Triclopyr	55335-06-3		10	µg/L	<20	---	<20	<20	<20		<20
2,4,5-TP (Silvex)	93-72-1		10	µg/L	<20	---	<20	<20	<20		<20
2,4,5-T	93-76-5		10	µg/L	<20	---	<20	<20	<20		<20
MCPB	94-81-5		10	µg/L	<20	---	<20	<20	<20		<20
Picloram	1918-02-1		10	µg/L	<20	---	<20	<20	<20		<20
Clopyralid	1702-17-6		10	µg/L	<20	---	<20	<20	<20		<20
Fluroxypyr	69377-81-7		10	µg/L	<20	---	<20	<20	<20		<20
2,6-D	575-90-6		10	µg/L	<20	---	<20	<20	<20		<20
2,4,6-T	575-89-3		10	µg/L	<20	---	<20	<20	<20		<20
<b>EP075(SIM)S: Phenolic Compound Surrogates</b>											
Phenol-d6	13127-88-3		0.1	%	49.0	---	21.3	35.0	33.7		
2-Chlorophenol-D4	93951-73-6		0.1	%	94.0	---	67.5	76.4	97.3		
2,4,6-Tribromophenol	118-79-6		0.1	%	96.4	---	92.7	85.0	82.6		
<b>EP075(SIM)T: PAH Surrogates</b>											
2-Fluorobiphenyl	321-60-8		0.1	%	104	---	103	103	138		
Anthracene-d10	1719-06-8		0.1	%	103	---	102	94.0	130		
4-Terphenyl-d14	1718-51-0		0.1	%	109	---	111	102	Not Determined		
<b>EP080S: TPH(V)/BTX Surrogates</b>											
1,2-Dichloroethane-D4	17060-07-0		0.1	%	---	---	---	---	65.7		
Toluene-D8	2037-26-5		0.1	%	---	---	---	---	74.0		
4-Bromofluorobenzene	460-00-4		0.1	%	---	---	---	---	71.3		
<b>EP202S: Phenoxycetic Acid Herbicide Surrogate</b>											
2,4-Dichlorophenyl Acetic Acid	19719-28-9		0.1	%	96.1	---	98.7	131	116		



## Analytical Results

Sub-Matrix: WATER		Client sample ID			
Compound	CAS Number	LOR	Unit	Client sampling date / time	Client sampling date / time
<b>ED037P: Alkalinity by PC Titrator</b>					
Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	<1
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	<1	<1
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	514	523
Total Alkalinity as CaCO3	----	1	mg/L	514	523
<b>ED040F: Dissolved Major Anions</b>					
Sulphate as SO4 2-	14808-79-8	1	mg/L	762	731
<b>ED045P: Chloride by PC Titrator</b>					
Chloride	16887-00-6	1	mg/L	2260	2300
<b>ED093F: Dissolved Major Cations</b>					
Calcium	7440-70-2	1	mg/L	89	84
Magnesium	7439-95-4	1	mg/L	174	163
Sodium	7440-23-5	1	mg/L	1730	1680
Potassium	7440-09-7	1	mg/L	35	33
<b>EG020F: Dissolved Metals by ICP-MS</b>					
Arsenic	7440-38-2	0.001	mg/L	0.001	<0.001
Beryllium	7440-41-7	0.001	mg/L	<0.001	<0.001
Barium	7440-39-3	0.001	mg/L	0.183	0.088
Cadmium	7440-43-9	0.0001	mg/L	<0.0001	<0.0001
Chromium	7440-47-3	0.001	mg/L	<0.001	<0.001
Cobalt	7440-48-4	0.001	mg/L	0.031	0.002
Copper	7440-50-8	0.001	mg/L	0.006	0.004
Lead	7439-92-1	0.001	mg/L	<0.001	<0.001
Manganese	7439-96-5	0.001	mg/L	0.240	0.236
Nickel	7440-02-0	0.001	mg/L	0.016	0.002
Vanadium	7440-62-2	0.01	mg/L	0.01	0.01
Zinc	7440-66-6	0.005	mg/L	0.017	<0.005
<b>EG035F: Dissolved Mercury by FIMS</b>					
Mercury	7439-97-6	0.0001	mg/L	<0.0001	<0.0001
<b>EK055G: Ammonia as N by Discrete Analyser</b>					
Ammonia as N	7664-41-7	0.010	mg/L	<0.100	<0.100
<b>EK057G: Nitrite as N by Discrete Analyser</b>					
Nitrite as N	----	0.010	mg/L	1.05	0.814
<b>EK058G: Nitrate as N by Discrete Analyser</b>					
^ Nitrate as N	14797-55-8	0.010	mg/L	22.2	23.4
<b>EK059G: NOx as N by Discrete Analyser</b>					
Nitrite + Nitrate as N	----	0.010	mg/L	23.2	24.2
<b>EK061: Total Kjeldahl Nitrogen (TKN)</b>					



### Analytical Results

Compound	CAS Number	LOR	Client sampling date / time		Unit	MW02 13-FEB-2008 15:00 EM0801099-006	MW01 13-FEB-2008 15:00 EM0801099-007	DUP3 13-FEB-2008 15:00 EM0801099-008	RINSATE 13/2 13-FEB-2008 15:00 EM0801099-009	-----
			Client sample ID	Client sample date / time						
<b>Sub-Matrix: WATER</b>										
<b>EK061: Total Kjeldahl Nitrogen (TKN) - Continued</b>										
Total Kjeldahl Nitrogen as N	----	0.1	mg/L			1.9	0.6	2.2	<0.1	----
<b>EK062: Total Nitrogen as N</b>										
^ Total Nitrogen as N	----	0.1	mg/L			25.1	0.6	26.4	<0.1	----
<b>EK067G: Total Phosphorus as P by Discrete Analyser</b>										
Total Phosphorus as P	----	0.01	mg/L			0.09	0.57	0.01	<0.01	----
<b>EK071G: Reactive Phosphorus as P by discrete analyser</b>										
Reactive Phosphorus as P	----	0.010	mg/L			<0.010	0.032	0.011	<0.010	----
<b>EN055: Ionic Balance</b>										
^ Total Anions	----	0.01	meq/L			89.9	124	90.5	----	----
Total Anions	----	0.01	meq/L			----	----	----	<0.01	----
^ Total Cations	----	0.01	meq/L			94.9	134	91.4	----	----
Total Cations	----	0.01	meq/L			----	----	----	<0.01	----
^ Ionic Balance	----	0.01	%			2.72	3.60	0.49	----	----
Ionic Balance	----	0.01	%			----	----	----	<0.01	----
<b>EP075(SIM)B: Polynuclear Aromatic Hydrocarbons</b>										
Naphthalene	91-20-3	1.0	µg/L			<1.0	<1.0	<1.0	<1.0	----
Acenaphthylene	208-96-8	1.0	µg/L			<1.0	<1.0	<1.0	<1.0	----
Acenaphthene	83-32-9	1.0	µg/L			<1.0	<1.0	<1.0	<1.0	----
Fluorene	86-73-7	1.0	µg/L			<1.0	<1.0	<1.0	<1.0	----
Phenanthrene	85-01-8	1.0	µg/L			<1.0	<1.0	<1.0	<1.0	----
Anthracene	120-12-7	1.0	µg/L			<1.0	<1.0	<1.0	<1.0	----
Fluoranthene	206-44-0	1.0	µg/L			<1.0	<1.0	<1.0	<1.0	----
Pyrene	129-00-0	1.0	µg/L			<1.0	<1.0	<1.0	<1.0	----
Benzo(a)anthracene	56-55-3	1.0	µg/L			<1.0	<1.0	<1.0	<1.0	----
Chrysene	218-01-9	1.0	µg/L			<1.0	<1.0	<1.0	<1.0	----
Benzo(b)fluoranthene	205-99-2	1.0	µg/L			<1.0	<1.0	<1.0	<1.0	----
Benzo(k)fluoranthene	207-08-9	1.0	µg/L			<1.0	<1.0	<1.0	<1.0	----
Benzo(a)pyrene	50-32-8	0.5	µg/L			<0.5	<0.5	<0.5	<0.5	----
Indeno(1,2,3-cd)pyrene	193-39-5	1.0	µg/L			<1.0	<1.0	<1.0	<1.0	----
Dibenz(a,h)anthracene	53-70-3	1.0	µg/L			<1.0	<1.0	<1.0	<1.0	----
Benzo(g,h,i)perylene	191-24-2	1.0	µg/L			<1.0	<1.0	<1.0	<1.0	----
<b>EP080/071: Total Petroleum Hydrocarbons</b>										
C6 - C9 Fraction	----	20	µg/L			<20	60	<20	<20	----
C10 - C14 Fraction	----	50	µg/L			<50	<50	<50	<50	----
C15 - C28 Fraction	----	100	µg/L			<100	200	<100	<100	----
C29 - C36 Fraction	----	50	µg/L			<50	100	<50	<50	----
<b>EP080: BTEX</b>										



## Analytical Results

Compound	CAS Number	LOR	Unit	Client sample ID			
				Client sampling date / time	MW02	MW01	DUP3
Sub-Matrix: WATER							
EP080: BTEX - Continued							
Benzene	71-43-2	1	µg/L	<1	<1	<1	<1
Toluene	108-88-3	2	µg/L	6	51	<2	<2
Ethylbenzene	100-41-4	2	µg/L	<2	<2	<2	<2
meta- & para-Xylene	108-38-3	2	µg/L	<2	<2	<2	<2
ortho-Xylene	95-47-6	2	µg/L	<2	<2	<2	<2
EP202A: Phenoxyacetic Acid Herbicides by LCMS							
4-Chlorophenoxy acetic acid	122-88-3	10	µg/L	<20	<20	<20	<20
2,4-DB	94-82-6	10	µg/L	<20	<20	<20	<20
Dicamba	1918-00-9	10	µg/L	<20	<20	<20	<20
Mecoprop	93-65-2	10	µg/L	<20	<20	<20	<20
MCPA	94-74-6	10	µg/L	<20	<20	<20	<20
2,4-DP	120-36-5	10	µg/L	<20	<20	<20	<20
2,4-D	94-75-7	10	µg/L	<20	<20	<20	<20
Triclopyr	55335-06-3	10	µg/L	<20	<20	<20	<20
2,4,5-TP (Silvex)	93-72-1	10	µg/L	<20	<20	<20	<20
2,4,5-T	93-76-5	10	µg/L	<20	<20	<20	<20
MCPB	94-81-5	10	µg/L	<20	<20	<20	<20
Picloram	1918-02-1	10	µg/L	<20	<20	<20	<20
Clopyralid	1702-17-6	10	µg/L	<20	<20	<20	<20
Fluroxypyr	69377-81-7	10	µg/L	<20	<20	<20	<20
2,6-D	575-90-6	10	µg/L	<20	<20	<20	<20
2,4,6-T	575-89-3	10	µg/L	<20	<20	<20	<20
EP075(SIM)S: Phenolic Compound Surrogates							
Phenol-d6	13127-88-3	0.1	%	25.3	34.5	36.4	42.4
2-Chlorophenol-D4	93951-73-6	0.1	%	66.0	73.6	81.2	93.3
2,4,6-Tribromophenol	118-79-6	0.1	%	82.1	96.8	102	102
EP075(SIM)T: PAH Surrogates							
2-Fluorobiphenyl	321-60-8	0.1	%	92.6	85.0	91.4	104
Anthracene-d10	1719-06-8	0.1	%	94.0	91.7	95.2	101
4-Terphenyl-d14	1718-51-0	0.1	%	101	93.7	99.4	105
EP080S: TPH(V)/BTEX Surrogates							
1,2-Dichloroethane-D4	17060-07-0	0.1	%	83.6	82.5	76.9	86.7
Toluene-D8	2037-26-5	0.1	%	85.8	84.8	79.4	89.8
4-Bromofluorobenzene	460-00-4	0.1	%	85.2	82.4	77.2	87.6
EP202S: Phenoxyacetic Acid Herbicide Surrogate							
2,4-Dichlorophenyl Acetic Acid	19719-28-9	0.1	%	103	109	111	123



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 Work Order : EM0801099  
 Client : RESOURCE & ENVIRON MANGMNT P/L  
 Project : GM-01

### Surrogate Control Limits

Sub-Matrix: WATER		Recovery Limits (%)	
Compound	CAS Number	Low	High
<b>EP075(SIM)S: Phenolic Compound Surrogates</b>			
Phenol-d6	13127-88-3	10	94
2-Chlorophenol-D4	93951-73-6	23	134
2,4,6-Tribromophenol	118-79-6	10	123
<b>EP075(SIM)T: PAH Surrogates</b>			
2-Fluorobiphenyl	321-60-8	43	116
Anthracene-d10	1719-06-8	27	133
4-Terphenyl-d14	1718-51-0	33	141
<b>EP080S: TPH(V)/BTEX Surrogates</b>			
1,2-Dichloroethane-D4	17060-07-0	70	130
Toluene-D8	2037-26-5	70	130
4-Bromofluorobenzene	460-00-4	70	130
<b>EP202S: Phenoxyacetic Acid Herbicide Surrogate</b>			
2,4-Dichlorophenyl Acetic Acid	19719-28-9	50.5	155



1099

# CHAIN OF CUSTODY FORM

From : Resource and Environmental Management Pty Ltd  
ACN: 098 08 877  
Suite 9, 15 Fullarton Road, Kent Town  
ph: (08) 8363 1777 fax: (08) 8363 1477



resource and environmental management

### LAB USE ONLY

ALS QUOTE NUMBER ME/224/02

Job Code:  
Due Date:  
Custody seal intact?  
Sample cold?  
Received for Laboratory by:

Project No: GM-51  
Project Manager: David Roulsen  
Sampler(s): DP/WC  
Checked:  
Date: 13/2/08

Date:  
Time:

Lab identification	Date	Time	Matrix	Sample Identification	Comments	Tick required analytes
	13/2/08		W	MW06 ①	Environmental Division Melbourne Work Order <b>EM0801099</b>  Telephone : +61-3-8549 9600	Ammonia N / Total N Cations / Anions Available P / Nitrate N Metals (NEM-13) TPH/BTEX Phenxy Acid Herbicides / PAH
				MW08 ②		
				MW04 ③		
				MW01 ④		
				MW05 ⑤		
				MW02 ⑥		
				MW01 ⑦		
				Dup 3 ⑧		
				Rinsate 13/2/08		
				TRIP (extra sample) ⑩		
TOTAL						

Comments	Some high salinities; need to compensate to get correct results				
Size	8	9	8	5	8
Type					
Preserv					
Analytes					
Container Identification					
Sheet	1 of 1				

COC-RevA

\* Heavy Metals have been filtered in the field.

PL 14/2/08 8:30

Environmental Division

**INTERPRETIVE QUALITY CONTROL REPORT**

<b>Work Order</b>	: <b>EM0801099</b>	<b>Page</b>	: 1 of 9
<b>Client</b>	: RESOURCE & ENVIRON MANGMNT P/L	<b>Laboratory</b>	: Environmental Division Melbourne
<b>Contact</b>	: MR DAVID POULSEN	<b>Contact</b>	: Paul Loewy
<b>Address</b>	: UNIT 9, 15 FULLARTON RD KENT TOWN SA, AUSTRALIA 5067	<b>Address</b>	: 4 Westall Rd Springvale VIC Australia 3171
<b>E-mail</b>	: davidpoulsen@rem.com.au	<b>E-mail</b>	: paul.loewy@alsenviro.com
<b>Telephone</b>	: +61 08 8363 1777	<b>Telephone</b>	: +61-3-8549 9600
<b>Facsimile</b>	: +61 08 8363 1477	<b>Facsimile</b>	: +61-3-8549 9601
<b>Project</b>	: GM-01	<b>QC Level</b>	: NEPM 1999 Schedule B(3) and ALS QCS3 requirement
<b>Site</b>	: ----	<b>Date Samples Received</b>	: 14-FEB-2008
<b>C-O-C number</b>	: ----	<b>Issue Date</b>	: 25-FEB-2008
<b>Sampler</b>	: DP/WC	<b>No. of samples received</b>	: 10
<b>Order number</b>	: ----	<b>No. of samples analysed</b>	: 9
<b>Quote number</b>	: ME/122/06		

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. All pages of this report have been checked and approved for release.

This Interpretive Quality Control Report contains the following information:

- Analysis Holding Time Compliance
- Quality Control Parameter Frequency Compliance
- Brief Method Summaries
- Summary of Outliers



Page : 2 of 9  
 Work Order : EM0801099  
 Client : RESOURCE & ENVIRON MANGMNT P/L  
 Project : GM-01

## Analysis Holding Time Compliance

The following report summarises extraction / preparation and analysis times and compares with recommended holding times. Dates reported represent first date of extraction or analysis and precludes subsequent dilutions and reruns. Information is also provided re the sample container (preservative) from which the analysis aliquot was taken. Elapsed period to analysis represents number of days from sampling where no extraction / digestion is involved or period from extraction / digestion where this is present. For composite samples, sampling date is assumed to be that of the oldest sample contributing to the composite. Sample date for laboratory produced leachates is assumed as the completion date of the leaching process. Outliers for holding time are based on USEPA SW 846, APHA, AS and NEPM (1999). A listing of breaches is provided in the Summary of Outliers.

Holding times for leachate methods (excluding elutriates) vary according to the analytes being determined on the resulting solution. For non-volatile analytes, the holding time compliance assessment compares the leach date with the shortest analyte holding time for the equivalent soil method. These soil holding times are: Organics (14 days); Mercury (28 days); Mercury (180 days). A recorded breach therefore does not guarantee a breach for all non-volatile parameters.

Matrix: **WATER**

Evaluation: \* = Holding time breach ; ✓ = Within holding time.

Method	Container / Client Sample ID(s)	Extraction / Preparation			Analysis		
		Date extracted	Due for extraction	Evaluation	Date analysed	Due for analysis	Evaluation
<b>ED037P: Alkalinity by PC Titrator</b>							
<b>Clear Plastic Bottle - Natural</b>							
MW06, MW04, MW05, MW01, RINSATE 13/2	MW08, MW11, MW02, DUP3,	---	---	----	19-FEB-2008	27-FEB-2008	✓
<b>ED040F: Dissolved Major Anions</b>							
<b>Clear Plastic Bottle - Natural</b>							
MW06, MW04, MW05, MW01, RINSATE 13/2	MW08, MW11, MW02, DUP3,	---	---	----	19-FEB-2008	12-MAR-2008	✓
<b>ED045P: Chloride by PC Titrator</b>							
<b>Clear Plastic Bottle - Natural</b>							
MW06, MW04, MW05, MW01, RINSATE 13/2	MW08, MW11, MW02, DUP3,	---	---	----	19-FEB-2008	12-MAR-2008	✓
<b>ED093F: Dissolved Major Cations</b>							
<b>Clear Plastic Bottle - Natural</b>							
MW06, MW04, MW05, MW01, RINSATE 13/2	MW08, MW11, MW02, DUP3,	---	---	----	19-FEB-2008	12-MAR-2008	✓



Matrix: **WATER** Evaluation: \* = Holding time breach ; ✓ = Within holding time.

Method		Sample Date			Extraction / Preparation		Analysis	
Container / Client Sample ID(s)		Date extracted	Due for extraction	Evaluation	Date analysed	Due for analysis	Evaluation	
<b>EG020F: Dissolved Metals by ICP-MS</b>								
Clear Plastic Bottle - Filtered; Lab-acidified RINSATE 13/2		---	---	----	18-FEB-2008	11-AUG-2008	✓	
Clear Plastic Bottle - Nitric Acid; Filtered MW06, MW11, MW02, DUP3	MW04, MW05, MW01,	---	---	----	18-FEB-2008	11-AUG-2008	✓	
<b>EG035F: Dissolved Mercury by FIMS</b>								
Clear Plastic Bottle - Filtered; Lab-acidified RINSATE 13/2		----	----	----	15-FEB-2008	12-MAR-2008	✓	
Clear Plastic Bottle - Nitric Acid; Filtered MW06, MW11, MW02, DUP3	MW04, MW05, MW01,	----	----	----	15-FEB-2008	12-MAR-2008	✓	
<b>EK055G: Ammonia as N by Discrete Analyser</b>								
Clear Plastic Bottle - Sulphuric Acid MW06, MW11, MW02, DUP3,	MW04, MW05, MW01, RINSATE 13/2	----	----	----	15-FEB-2008	12-MAR-2008	✓	
<b>EK057G: Nitrite as N by Discrete Analyser</b>								
Clear Plastic Bottle - Natural MW06, MW04, MW05, MW02, MW01, RINSATE 13/2	MW08, MW11, MW02, DUP3,	----	----	----	14-FEB-2008	15-FEB-2008	✓	
<b>EK059G: NOX as N by Discrete Analyser</b>								
Clear Plastic Bottle - Natural MW08		----	----	----	14-FEB-2008	15-FEB-2008	✓	
Clear Plastic Bottle - Sulphuric Acid MW06, MW11, MW02, MW01, DUP3,	MW04, MW05, MW01, RINSATE 13/2	----	----	----	14-FEB-2008	12-MAR-2008	✓	
<b>EK061: Total Kjeldahl Nitrogen (TKN)</b>								
Clear Plastic Bottle - Sulphuric Acid MW04, MW05, MW01, RINSATE 13/2	MW11, MW02, DUP3,	18-FEB-2008	12-MAR-2008	✓	19-FEB-2008	12-MAR-2008	✓	
Clear Plastic Bottle - Sulphuric Acid MW06		19-FEB-2008	12-MAR-2008	✓	20-FEB-2008	12-MAR-2008	✓	



Page : 4 of 9  
 Work Order : EM0801099  
 Client : RESOURCE & ENVIRON MANGMNT P/L  
 Project : GM-01

Matrix: **WATER** Evaluation: \* = Holding time breach ; ✓ = Within holding time.

Method	Sample Date	Extraction / Preparation		Analysis	
		Date extracted	Due for extraction	Date analysed	Due for analysis
<b>EK067G: Total Phosphorus as P by Discrete Analyser</b>					
<b>Clear Plastic Bottle - Sulphuric Acid</b>					
MW04, MW05, MW01, RINSATE 13/2	13-FEB-2008	18-FEB-2008	12-MAR-2008	19-FEB-2008	12-MAR-2008
				✓	✓
<b>Clear Plastic Bottle - Sulphuric Acid</b>					
MW06	13-FEB-2008	19-FEB-2008	12-MAR-2008	20-FEB-2008	12-MAR-2008
				✓	✓
<b>EK071G: Reactive Phosphorus as P by discrete analyser</b>					
<b>Clear Plastic Bottle - Natural</b>					
MW08, MW11, MW05, MW01, RINSATE 13/2	13-FEB-2008	----	----	14-FEB-2008	15-FEB-2008
				----	✓
<b>EP075(SIM)B: Polynuclear Aromatic Hydrocarbons</b>					
<b>Amber Glass Bottle - Unpreserved</b>					
MW06, MW11, MW02, DUP3,	13-FEB-2008	15-FEB-2008	20-FEB-2008	17-FEB-2008	26-MAR-2008
				✓	✓
<b>EP080/071: Total Petroleum Hydrocarbons</b>					
<b>Amber Glass Bottle - Unpreserved</b>					
MW05, MW01, RINSATE 13/2	13-FEB-2008	15-FEB-2008	20-FEB-2008	18-FEB-2008	26-MAR-2008
				✓	✓
<b>Amber VOC Vial - HCl or NaHSO4</b>					
MW05, MW01, RINSATE 13/2	13-FEB-2008	---	---	18-FEB-2008	27-FEB-2008
				----	✓
<b>EP080: BTEX</b>					
<b>Amber VOC Vial - HCl or NaHSO4</b>					
MW05, MW01, RINSATE 13/2	13-FEB-2008	---	---	18-FEB-2008	27-FEB-2008
				----	✓
<b>EP202A: Phenoxycetic Acid Herbicides by LCMS</b>					
<b>Amber Glass Bottle - Unpreserved</b>					
MW06, MW11, MW02, DUP3,	13-FEB-2008	----	----	19-FEB-2008	20-FEB-2008
				----	✓



## Quality Control Parameter Frequency Compliance

The following report summarises the frequency of laboratory QC samples analysed within the analytical lot(s) in which the submitted sample(s) was(were) processed. Actual rate should be greater than or equal to the expected rate. A listing of breaches is provided in the Summary of Outliers.

Matrix: **WATER**

Evaluation: \* = Quality Control frequency not within specification ; ✓ = Quality Control frequency within specification.

Quality Control Sample Type Analytical Methods	Method	Count			Rate (%)		Evaluation	Quality Control Specification
		QC	Regular	Actual	Expected			
<b>Laboratory Duplicates (DUP)</b>								
Alkalinity by PC Titrator	ED037-P	2	12	16.7	10.0	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement	
Ammonia as N by Discrete analyser	EK055G	1	8	12.5	10.0	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement	
Chloride by PC Titrator	ED045-P	3	28	10.7	10.0	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement	
Dissolved Mercury by FIMS	EG035F	3	26	11.5	10.0	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement	
Dissolved Metals by ICP-MS - Suite A	EG020A-F	2	20	10.0	10.0	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement	
Major Anions - Filtered	ED040F	3	27	11.1	10.0	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement	
Major Cations - Filtered	ED093F	2	20	10.0	10.0	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement	
Nitrite and Nitrate as N (NOx) by Discrete Analyser	EK059G	1	9	11.1	10.0	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement	
Nitrite as N by Discrete Analyser	EK057G	1	9	11.1	10.0	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement	
Phenoxyacetic Acid Herbicides (LCMS - Standard DL)	EP202-SL	2	16	12.5	10.0	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement	
Reactive Phosphorus as P-By Discrete Analyser	EK071G	2	13	15.4	10.0	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement	
Total Kjeldahl Nitrogen as N By Discrete Analyser	EK061G	5	41	12.2	10.0	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement	
Total Phosphorus as P By Discrete Analyser	EK067G	3	18	16.7	10.0	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement	
TPH Volatiles/BTEX	EP080	2	18	11.1	10.0	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement	
<b>Laboratory Control Samples (LCS)</b>								
Alkalinity by PC Titrator	ED037-P	1	12	8.3	5.0	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement	
Ammonia as N by Discrete analyser	EK055G	1	8	12.5	5.0	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement	
Chloride by PC Titrator	ED045-P	2	28	7.1	5.0	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement	
Dissolved Mercury by FIMS	EG035F	3	27	11.1	5.0	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement	
Dissolved Metals by ICP-MS - Suite A	EG020A-F	1	20	5.0	5.0	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement	
Major Anions - Filtered	ED040F	2	27	7.4	5.0	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement	
Major Cations - Filtered	ED093F	1	20	5.0	5.0	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement	
Nitrite and Nitrate as N (NOx) by Discrete Analyser	EK059G	1	9	11.1	5.0	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement	
Nitrite as N by Discrete Analyser	EK057G	1	9	11.1	5.0	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement	
PAH/Phenols (GC/MS - SIM)	EP075(SIM)	1	17	5.9	5.0	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement	
Phenoxyacetic Acid Herbicides (LCMS - Standard DL)	EP202-SL	1	16	6.3	5.0	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement	
Reactive Phosphorus as P-By Discrete Analyser	EK071G	1	13	7.7	5.0	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement	
Total Kjeldahl Nitrogen as N By Discrete Analyser	EK061G	3	41	7.3	5.0	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement	
Total Phosphorus as P By Discrete Analyser	EK067G	2	18	11.1	5.0	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement	
TPH - Semivolatile Fraction	EP071	1	19	5.3	5.0	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement	
TPH Volatiles/BTEX	EP080	1	18	5.6	5.0	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement	
<b>Method Blanks (MB)</b>								
Ammonia as N by Discrete analyser	EK055G	1	8	12.5	5.0	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement	
Chloride by PC Titrator	ED045-P	2	28	7.1	5.0	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement	
Dissolved Mercury by FIMS	EG035F	3	27	11.1	5.0	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement	
Dissolved Metals by ICP-MS - Suite A	EG020A-F	1	20	5.0	5.0	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement	
Major Anions - Filtered	ED040F	2	27	7.4	5.0	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement	
Major Cations - Filtered	ED093F	1	20	5.0	5.0	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement	
Nitrite and Nitrate as N (NOx) by Discrete Analyser	EK059G	1	9	11.1	5.0	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement	



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 Work Order : EM0801099  
 Client : RESOURCE & ENVIRON MANGMNT P/L  
 Project : GM-01

Matrix: **WATER**  
 Evaluation: \* = Quality Control frequency not within specification ; ✓ = Quality Control frequency within specification.

Quality Control Sample Type		Count			Rate (%)		Quality Control Specification
Analytical Methods	Method	QC	Regular	Actual	Expected	Evaluation	
<b>Method Blanks (MB) - Continued</b>							
Nitrite as N by Discrete Analyser	EK057G	1	9	11.1	5.0	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
PAH/Phenols (GC/MS - SIM)	EP075(SIM)	1	17	5.9	5.0	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Phenoxyacetic Acid Herbicides (LCMS - Standard DL)	EP202-SL	1	16	6.3	5.0	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Reactive Phosphorus as P-By Discrete Analyser	EK071G	1	13	7.7	5.0	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Total Kjeldahl Nitrogen as N By Discrete Analyser	EK061G	3	41	7.3	5.0	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Total Phosphorus as P By Discrete Analyser	EK067G	2	18	11.1	5.0	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
TPH - Semivolatle Fraction	EP071	1	19	5.3	5.0	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
TPH Volatiles/BTEX	EP080	1	18	5.6	5.0	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
<b>Matrix Spikes (MS)</b>							
Ammonia as N by Discrete analyser	EK055G	1	8	12.5	5.0	✓	ALS QCS3 requirement
Chloride by PC Titrator	ED045-P	2	28	7.1	5.0	✓	ALS QCS3 requirement
Dissolved Mercury by FIMS	EG035F	1	20	5.0	5.0	✓	ALS QCS3 requirement
Dissolved Metals by ICP-MS - Suite A	EG020A-F	1	20	5.0	5.0	✓	ALS QCS3 requirement
Nitrite and Nitrate as N (NOx) by Discrete Analyser	EK059G	1	9	11.1	5.0	✓	ALS QCS3 requirement
Nitrite as N by Discrete Analyser	EK057G	1	9	11.1	5.0	✓	ALS QCS3 requirement
Phenoxyacetic Acid Herbicides (LCMS - Standard DL)	EP202-SL	1	16	6.3	5.0	✓	ALS QCS3 requirement
Reactive Phosphorus as P-By Discrete Analyser	EK071G	1	13	7.7	5.0	✓	ALS QCS3 requirement
Total Kjeldahl Nitrogen as N By Discrete Analyser	EK061G	3	41	7.3	5.0	✓	ALS QCS3 requirement
Total Phosphorus as P By Discrete Analyser	EK067G	2	18	11.1	5.0	✓	ALS QCS3 requirement
TPH Volatiles/BTEX	EP080	1	18	5.6	5.0	✓	ALS QCS3 requirement



## Brief Method Summaries

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the US EPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request. The following report provides brief descriptions of the analytical procedures employed for results reported in the Certificate of Analysis. Sources from which ALS methods have been developed are provided within the Method Descriptions.

Analytical Methods	Method	Matrix	Method Descriptions
Alkalinity by PC Titrator	ED037-P	WATER	APHA 21st ed., 2320 B This procedure determines alkalinity by both manual measurement and automated measurement (e.g. PC Titrate) using pH 4.5 for indicating the total alkalinity end-point. This method is compliant with NEPM (1999) Schedule B(3) (Appdx. 2)
Major Anions - Filtered	ED040F	WATER	APHA 21st ed., 3120 Sulphur and/or Silicon content is determined by ICP/AES and reported as Sulphate and/or Silica after conversion by gravimetric factor.
Chloride by PC Titrator	ED045-P	WATER	APHA 21st ed., 4500 Cl - B. Automated Silver Nitrate titration.
Major Cations - Filtered	ED093F	WATER	APHA 21st ed., 3120; USEPA SW 846 - 6010 The ICPAES technique ionises filtered sample atoms emitting a characteristic spectrum. This spectrum is then compared against matrix matched standards for quantification. This method is compliant with NEPM (1999) Schedule B(3) (Appdx. 2)
Dissolved Metals by ICP-MS - Suite A	EG020A-F	WATER	APHA 21st ed., 3125; USEPA SW846 - 6020; ALS QWI-EN/EG020: The ICPMS technique utilizes a highly efficient argon plasma to ionize selected elements. Ions are then passed into a high vacuum mass spectrometer, which separates the analytes based on their distinct mass to charge ratios prior to their measurement by a discrete dynode ion detector.
Dissolved Mercury by FIMS	EG035F	WATER	AS 3550, APHA 21st ed. 3112 Hg - B (Flow-injection (SnCl <sub>2</sub> )(Cold Vapour generation) AAS) FIM-AAS is an automated flameless atomic absorption technique. A bromate/bromide reagent is used to oxidise any organic mercury compounds in the filtered sample. The ionic mercury is reduced online to atomic mercury vapour by SnCl <sub>2</sub> which is then purged into a heated quartz cell. Quantification is by comparing absorbance against a calibration curve. This method is compliant with NEPM (1999) Schedule B(3) (Appdx. 2)
Ammonia as N by Discrete analyser	EK055G	WATER	APHA 21st ed., 4500 NH <sub>3</sub> +G Ammonia is determined by direct colorimetry by Seal Discrete Analyser. This method is compliant with NEPM (1999) Schedule B(3) (Appdx. 2)
Nitrite as N by Discrete Analyser	EK057G	WATER	APHA 21st ed., 4500 NO <sub>3</sub> -B. SEAL Method 2-018-1-L February 2003. Nitrite is determined by direct colorimetry by SEAL. This method is compliant with NEPM (1999) Schedule B(3) (Appdx. 2)
Nitrate as N by Discrete Analyser	EK058G	WATER	APHA 21st ed., 4500 NO <sub>3</sub> -F. SEAL Method 2-018-1-L February 2003. Nitrate is reduced to nitrite by way of a cadmium reduction column followed by quantification by SEAL. Nitrite is determined separately by direct colorimetry and result for Nitrate calculated as the difference between the two results. This method is compliant with NEPM (1999) Schedule B(3) (Appdx. 2)
Nitrite and Nitrate as N (NOx) by Discrete Analyser	EK059G	WATER	APHA 21st ed., 4500 NO <sub>3</sub> -F. SEAL Method 2-018-1-L February 2003. Combined oxidised Nitrogen (NO <sub>2</sub> +NO <sub>3</sub> ) is determined by Cadmium Reduction and direct colorimetry by SEAL. This method is compliant with NEPM (1999) Schedule B(3) (Appdx. 2)
Total Kjeldahl Nitrogen as N By Discrete Analyser	EK061G	WATER	APHA 21st ed., 4500-Norg-D25mL water samples are digested using a traditional Kjeldahl digestion followed by determination by Seal by Discrete Analyser. This method is compliant with NEPM (1999) Schedule B(3) (Appdx. 2)
Total Nitrogen as N (TKN + Nox) By Discrete Analyser	EK062G	WATER	APHA 21st ed., 4500 N org / NO <sub>3</sub> . This method is compliant with NEPM (1999) Schedule B(3) (Appdx. 2)
Total Phosphorus as P By Discrete Analyser	EK067G	WATER	APHA 21st ed., 4500 P-B&F This procedure involves sulphuric acid digestion of a 100mL sample to break phosphorus down to orthophosphate. The orthophosphate reacts with ammonium molybdate and antimony potassium tartrate to form a complex which is then reduced and its concentration measured at 880nm using Seal. This method is compliant with NEPM (1999) Schedule B(3) (Appdx. 2)





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 Work Order : EM0801099  
 Client : RESOURCE & ENVIRON MANGMNT P/L  
 Project : GM-01

Analytical Methods		Method	Matrix	Method Descriptions
Reactive Phosphorus as P-By Discrete Analyser	EK071G	WATER	APHA 21st ed., 4500 P-F Ammonium molybdate and potassium antimonyl tartrate reacts in acid medium with orthophosphate to form a heteropoly acid -phosphomolybdic acid - which is reduced to intensely coloured molybdenum blue by ascorbic acid. Quantification is by SEAL. This method is compliant with NEPM (1999) Schedule B(3) (Appdx. 2)	
Ionic Balance	EN055	WATER	APHA 21st Ed. 1030F. This method is compliant with NEPM (1999) Schedule B(3) (Appdx. 2)	
TPH - Semivolatle Fraction	EP071	WATER	USEPA SW 846 - 8015A The sample extract is analysed by Capillary GC/FID and quantification is by comparison against an established 5 point calibration curve of n-Alkane standards. This method is compliant with NEPM (1999) Schedule B(3) (Appdx. 2)	
PAH/Phenols (GC/MS - SIM)	EP075(SIM)	WATER	USEPA SW 846 - 8270D Sample extracts are analysed by Capillary GC/MS in SIM Mode and quantification is by comparison against an established 5 point calibration curve. This method is compliant with NEPM (1999) Schedule B(3) (Appdx. 2)	
TPH Volatiles/BTEX	EP080	WATER	USEPA SW 846 - 8260B Water samples are directly purged prior to analysis by Capillary GC/MS and quantification is by comparison against an established 5 point calibration curve. This method is compliant with NEPM (1999) Schedule B(3) (Appdx. 2)	
Phenoxyacetic Acid Herbicides (LCMS - Standard DL)	EP202-SL	WATER	In-House, LCMS (Electrospray in negative mode). After adding surrogate and acetic acid, water samples are injected on a C18 column for LC/MS determination.	
Preparation Methods		Method	Matrix	Method Descriptions
TKN/TP Digestion	EK061/EK067	WATER	APHA 21st ed., 4500 Norg - D; APHA 21st ed., 4500 P - H. This method is compliant with NEPM (1999) Schedule B(3) (Appdx. 2)	
Separatory Funnel Extraction of Liquids	ORG14	WATER	USEPA SW 846 - 3510B 500 mL to 1L of sample is transferred to a separatory funnel and serially extracted three times using 60mL DCM for each extract. The resultant extracts are combined, dehydrated and concentrated for analysis. This method is compliant with NEPM (1999) Schedule B(3) (Appdx. 2). ALS default excludes sediment which may be resident in the container.	



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 Client : RESOURCE & ENVIRON MANGMNT P/L  
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## Summary of Outliers

### Outliers : Quality Control Samples

The following report highlights outliers flagged in the Quality Control (QC) Report. Surrogate recovery limits are static and based on USEPA SW846 or ALS-QW/EN/38 (in the absence of specific USEPA limits). This report displays QC Outliers (breaches) only.

### Duplicates, Method Blanks, Laboratory Control Samples and Matrix Spikes

Matrix: **WATER**

Compound Group Name	Laboratory Sample ID	Client Sample ID	Analyte	CAS Number	Data	Limits	Comment
<b>Matrix Spike (MS) Recoveries</b>							
EK059G: NOX as N by Discrete Analyser	EM0801099-002	MW08	Nitrite + Nitrate as N	----	Not Determined	----	MS recovery not determined, background level greater than or equal to 4x spike level.

- For all matrices, no Method Blank value outliers occur.
- For all matrices, no Duplicate outliers occur.
- For all matrices, no Laboratory Control outliers occur.

### Regular Sample Surrogates

Sub-Matrix: **WATER**

Compound Group Name	Laboratory Sample ID	Client Sample ID	Analyte	CAS Number	Data	Limits	Comment
<b>Samples Submitted</b>							
EP075(SIM)T: PAH Surrogates	EM0801099-005	MW05	2-Fluorobiphenyl	321-60-8	138 %	43-116 %	Recovery greater than upper data quality objective
EP075(SIM)T: PAH Surrogates	EM0801099-005	MW05	4-Terphenyl-d14	1718-51-0	Not Determined	----	Surrogate recovery not determined due to (target or non-target) matrix interferences
EP080S: TPH(V)/BTEX Surrogates	EM0801099-005	MW05	1,2-Dichloroethane-D4	17060-07-0	65.7 %	70-130 %	Recovery less than lower data quality objective

### Outliers : Analysis Holding Time Compliance

This report displays Holding Time breaches only. Only the respective Extraction / Preparation and/or Analysis component is/are displayed.

- No Analysis Holding Time Outliers exist.

### Outliers : Frequency of Quality Control Samples

The following report highlights breaches in the Frequency of Quality Control Samples.

- No Quality Control Sample Frequency Outliers exist.

Environmental Division

**CERTIFICATE OF ANALYSIS**

Work Order : **EM0801691**  
 Client : **RESOURCE & ENVIRON MANGMNT P/L**  
 Contact : **MR DAVID POULSEN**  
 Address : **UNIT 9, 15 FULLARTON RD  
 KENT TOWN SA, AUSTRALIA 5067**  
 E-mail : **davidpoulsen@rem.com.au**  
 Telephone : **+61 08 8363 1777**  
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 Project : **GM-01 Re-batch EM0800948 & EM0801099**  
 Order number : **----**  
 C-O-C number : **----**  
 Sampler : **DP DN WC**  
 Site : **----**  
 Quote number : **ME/122/06**

Page : 1 of 6  
 Laboratory : Environmental Division Melbourne  
 Contact : Paul Loewy  
 Address : 4 Westall Rd Springvale VIC Australia 3171  
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 Telephone : +61-3-8549 9600  
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 QC Level : NEPM 1999 Schedule B(3) and ALS QCS3 requirement  
 Date Samples Received : 05-MAR-2008  
 Issue Date : 11-MAR-2008  
 No. of samples received : 14  
 No. of samples analysed : 14

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. All pages of this report have been checked and approved for release.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results
- Surrogate Control Limits



NATA Accredited Laboratory 825

This document is issued in accordance with NATA accreditation requirements.

Accredited for compliance with ISO/IEC 17025.

**Signatories**

This document has been electronically signed by the authorized signatories indicated below. Electronic signing has been carried out in compliance with procedures specified in 21 CFR Part 11.

Signatories	Position	Accreditation Category
Kumara Dadalage	Senior Organic Chemist	Organics



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Work Order : EM0801691  
Client : RESOURCE & ENVIRON MANGMNT P/L  
Project : GM-01 Re-batch EM0800948 & EM0801099

### **General Comments**

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

When date(s) and/or time(s) are shown bracketed, these have been assumed by the laboratory for process purposes. If the sampling time is 0:00 the information was not supplied by client.

Key :

CAS Number = Chemistry Abstract Services number

LOR = Limit of reporting

^ = This result is computed from individual analyte detections at or above the level of reporting



## Analytical Results

Sub-Matrix: WATER

Compound	CAS Number	LOR	Client sampling date / time		Client sample ID	
			MW04	MW06	MW01	MW02
			13-FEB-2008 15:00	13-FEB-2008 15:00	13-FEB-2008 15:00	13-FEB-2008 15:00
			EM0801691-001	EM0801691-002	EM0801691-003	EM0801691-004
			Unit	Unit	Unit	Unit
<b>EP068A: Organochlorine Pesticides (OC)</b>						
alpha-BHC	319-84-6	0.5	<0.5	<0.5	<0.5	<0.5
Hexachlorobenzene (HCB)	118-74-1	0.5	<0.5	<0.5	<0.5	<0.5
beta-BHC	319-85-7	0.5	<0.5	<0.5	<0.5	<0.5
gamma-BHC	58-89-9	0.5	<0.5	<0.5	<0.5	<0.5
delta-BHC	319-86-8	0.5	<0.5	<0.5	<0.5	<0.5
Heptachlor	76-44-8	0.5	<0.5	<0.5	<0.5	<0.5
Aldrin	309-00-2	0.5	<0.5	<0.5	<0.5	<0.5
Heptachlor epoxide	1024-57-3	0.5	<0.5	<0.5	<0.5	<0.5
trans-Chlordane	5103-74-2	0.5	<0.5	<0.5	<0.5	<0.5
alpha-Endosulfan	959-98-8	0.5	<0.5	<0.5	<0.5	<0.5
cis-Chlordane	5103-71-9	0.5	<0.5	<0.5	<0.5	<0.5
Dieldrin	60-57-1	0.5	<0.5	<0.5	<0.5	<0.5
4,4'-DDE	72-55-9	0.5	<0.5	<0.5	<0.5	<0.5
Endrin	72-20-8	0.5	<0.5	<0.5	<0.5	<0.5
beta-Endosulfan	33213-65-9	0.5	<0.5	<0.5	<0.5	<0.5
4,4'-DDD	72-54-8	0.5	<0.5	<0.5	<0.5	<0.5
Endrin aldehyde	7421-93-4	0.5	<0.5	<0.5	<0.5	<0.5
Endosulfan sulfate	1031-07-8	0.5	<0.5	<0.5	<0.5	<0.5
4,4'-DDT	50-29-3	2	<2	<2	<2	<2
Endrin ketone	53494-70-5	0.5	<0.5	<0.5	<0.5	<0.5
Methoxychlor	72-43-5	2	<2	<2	<2	<2
<b>EP080/071: Total Petroleum Hydrocarbons</b>						
C10 - C14 Fraction	----	50	<50	<50	<50	----
C15 - C28 Fraction	----	100	<100	<100	<100	----
C29 - C36 Fraction	----	50	<50	<50	<50	----
<b>EP068S: Organochlorine Pesticide Surrogate</b>						
Dibromo-DDE	21655-73-2	0.1	105	102	95.9	90.3
<b>EP068T: Organophosphorus Pesticide Surrogate</b>						
DEF	78-48-8	0.1	68.5	112	82.5	104



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 Work Order : EM0801691  
 Client : RESOURCE & ENVIRON MANGMINT P/L  
 Project : GM-01 Re-batch EM0800948 & EM0801099

## Analytical Results

Sub-Matrix: WATER

Compound	CAS Number	LOR	Client sampling date / time		Client sample ID		
			MW03	MW05	MW07	MW09	MW12
<b>EP068A: Organochlorine Pesticides (OC)</b>							
alpha-BHC	319-84-6	0.5	07-FEB-2008 15:00 EM0801691-006	13-FEB-2008 15:00 EM0801691-008	07-FEB-2008 15:00 EM0801691-010	07-FEB-2008 15:00 EM0801691-011	07-FEB-2008 15:00 EM0801691-013
Hexachlorobenzene (HCB)	118-74-1	0.5	<0.5	<0.5	<0.5	<0.5	<0.5
beta-BHC	319-85-7	0.5	<0.5	<0.5	<0.5	<0.5	<0.5
gamma-BHC	58-89-9	0.5	<0.5	<0.5	<0.5	<0.5	<0.5
delta-BHC	319-86-8	0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Heptachlor	76-44-8	0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Aldrin	309-00-2	0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Heptachlor epoxide	1024-57-3	0.5	<0.5	<0.5	<0.5	<0.5	<0.5
trans-Chlordane	5103-74-2	0.5	<0.5	<0.5	<0.5	<0.5	<0.5
alpha-Endosulfan	959-98-8	0.5	<0.5	<0.5	<0.5	<0.5	<0.5
cis-Chlordane	5103-71-9	0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Dieldrin	60-57-1	0.5	<0.5	<0.5	<0.5	<0.5	<0.5
4,4'-DDE	72-55-9	0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Endrin	72-20-8	0.5	<0.5	<0.5	<0.5	<0.5	<0.5
beta-Endosulfan	33213-65-9	0.5	<0.5	<0.5	<0.5	<0.5	<0.5
4,4'-DDD	72-54-8	0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Endrin aldehyde	7421-93-4	0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Endosulfan sulfate	1031-07-8	0.5	<0.5	<0.5	<0.5	<0.5	<0.5
4,4'-DDT	50-29-3	2	<2	<2	<2	<2	<2
Endrin ketone	53494-70-5	0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Methoxychlor	72-43-5	2	<2	<2	<2	<2	<2
<b>EP068S: Organochlorine Pesticide Surrogate</b>							
Dibromo-DDE	21655-73-2	0.1	96.8	101	103	94.3	92.4
<b>EP068T: Organophosphorus Pesticide Surrogate</b>							
DEF	78-48-8	0.1	109	52.1	116	106	Not Determined



Page : 5 of 6  
 Work Order : EM0801691  
 Client : RESOURCE & ENVIRON MANGMNT P/L  
 Project : GM-01 Re-batch EM0800948 & EM0801099

## Analytical Results

Compound	CAS Number	LOR	Client sampling date / time		Client sample ID		
			DUP1	DUP3	RINSATE1	RINSATE13/2	
<b>EP068A: Organochlorine Pesticides (OC)</b>							
alpha-BHC	319-84-6	0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Hexachlorobenzene (HCB)	118-74-1	0.5	<0.5	<0.5	<0.5	<0.5	<0.5
beta-BHC	319-85-7	0.5	<0.5	<0.5	<0.5	<0.5	<0.5
gamma-BHC	58-89-9	0.5	<0.5	<0.5	<0.5	<0.5	<0.5
delta-BHC	319-86-8	0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Heptachlor	76-44-8	0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Aldrin	309-00-2	0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Heptachlor epoxide	1024-57-3	0.5	<0.5	<0.5	<0.5	<0.5	<0.5
trans-Chlordane	5103-74-2	0.5	<0.5	<0.5	<0.5	<0.5	<0.5
alpha-Endosulfan	959-98-8	0.5	<0.5	<0.5	<0.5	<0.5	<0.5
cis-Chlordane	5103-71-9	0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Dieldrin	60-57-1	0.5	<0.5	<0.5	<0.5	<0.5	<0.5
4,4'-DDE	72-55-9	0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Endrin	72-20-8	0.5	<0.5	<0.5	<0.5	<0.5	<0.5
beta-Endosulfan	33213-65-9	0.5	<0.5	<0.5	<0.5	<0.5	<0.5
4,4'-DDD	72-54-8	0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Endrin aldehyde	7421-93-4	0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Endosulfan sulfate	1031-07-8	0.5	<0.5	<0.5	<0.5	<0.5	<0.5
4,4'-DDT	50-29-3	2	<2	<2	<2	<2	<2
Endrin ketone	53494-70-5	0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Methoxychlor	72-43-5	2	<2	<2	<2	<2	<2
<b>EP068S: Organochlorine Pesticide Surrogate</b>							
Dibromo-DDE	21655-73-2	0.1	89.1	94.2	80.8	97.8	97.8
<b>EP068T: Organophosphorus Pesticide Surrogate</b>							
DEF	78-48-8	0.1	73.4	108	91.3	111	111



Page : 6 of 6  
Work Order : EM0801691  
Client : RESOURCE & ENVIRON MANGMNT P/L  
Project : GM-01 Re-batch EM0800948 & EM0801099

### Surrogate Control Limits

Sub-Matrix: WATER		Recovery Limits (%)	
Compound	CAS Number	Low	High
EP068S: Organochlorine Pesticide Surrogate			
Dibromo-DDE	21655-73-2	49	130
EP068T: Organophosphorus Pesticide Surrogate			
DEF	78-48-8	53	140



**Steven McGrath**

**From:** David Poulsen [davidpoulsen@rem.com.au]  
**Sent:** Wednesday, 5 March 2008 12:36 PM  
**To:** Steven McGrath  
**Subject:** Additional Analysis for GM01 job

Hi Steven,

Further to our phone conversation just now, can you please arrange for the following additional analyses for my job GM01 (ALS work orders EM0800948 and EM0801099):

TPH C10 – C36 on samples + OC

- 1 MW04 1099-3
- 2 MW06 1099-1
- 3 MW11 1099-4

OCPs on (all samples)

- 4 MW01 1099-7
- 5 MW02 1099-6
- 6 MW03 948-1
- ~~7 MW04 1099-3~~
- 8 MW05 1099-5
- ~~9 MW06 1099-7~~
- 10 MW07 948-4
- ~~MW08 948-5~~
- 11 MW09 948-6
- ~~12 MW11 1099-4~~
- 13 MW12 948-8
- 14 Dup1 948-9
- ~~Dup2~~
- 15 Dup3 1099-8
- 16 Rinsate1 948-11
- 17 Rinsate13/2 1099-9

Environmental Division  
Melbourne  
Work Order

**EM0801691**



Telephone : + 61-3-8549 9600

Please don't hesitate to contact me with questions or for clarification.

Thanks very much,

**David Poulsen**  
Hydrogeologist  
resource and environmental management  
9. 15 Fullarton Road Kent Town 5067 South Australia  
p +61 8 8363 1777 | f +61 8 8363 1477 | [www.rem.com.au](http://www.rem.com.au)

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This e-mail has been swept by mimesweeper  
through the ALS North America gateway.  
\*\*\*\*\*



Environmental Division

**INTERPRETIVE QUALITY CONTROL REPORT**

Work Order	: EM0801691	Page	: 1 of 5
Client	: RESOURCE & ENVIRON MANGMNT P/L	Laboratory	: Environmental Division Melbourne
Contact	: MR DAVID POULSEN	Contact	: Paul Loewy
Address	: UNIT 9, 15 FULLARTON RD KENT TOWN SA, AUSTRALIA 5067	Address	: 4 Westall Rd Springvale VIC Australia 3171
E-mail	: davidpoulsen@rem.com.au	E-mail	: paul.loewy@alsenviro.com
Telephone	: +61 08 8363 1777	Telephone	: +61-3-8549 9600
Facsimile	: +61 08 8363 1477	Facsimile	: +61-3-8549 9601
Project	: GM-01 Re-batch EM0800948 & EM0801099	QC Level	: NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Site	: ----	Date Samples Received	: 05-MAR-2008
C-O-C number	: ----	Issue Date	: 11-MAR-2008
Sampler	: DP DN WC	No. of samples received	: 14
Order number	: ----	No. of samples analysed	: 14
Quote number	: ME/122/06		

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. All pages of this report have been checked and approved for release.

This Interpretive Quality Control Report contains the following information:

- Analysis Holding Time Compliance
- Quality Control Parameter Frequency Compliance
- Brief Method Summaries
- Summary of Outliers



Page : 2 of 5  
 Work Order : EM0801691  
 Client : RESOURCE & ENVIRON MANGMNT P/L  
 Project : GM-01 Re-batch EM0800948 & EM0801099

## Analysis Holding Time Compliance

The following report summarises extraction / preparation and analysis times and compares with recommended holding times. Dates reported represent first date of extraction or analysis and precludes subsequent dilutions and reruns. Information is also provided re the sample container (preservative) from which the analysis aliquot was taken. Elapsed period to analysis represents number of days from sampling where no extraction / digestion is involved or period from extraction / digestion where this is present. For composite samples, sampling date is assumed to be that of the oldest sample contributing to the composite. Sample date for laboratory produced leachates is assumed as the completion date of the leaching process. Outliers for holding time are based on USEPA SW 846, APHA, AS and NEPM (1999). A listing of breaches is provided in the Summary of Outliers.

Holding times for leachate methods (excluding elutriates) vary according to the analytes being determined on the resulting solution. For non-volatile analytes, the holding time compliance assessment compares the leach date with the shortest analyte holding time for the equivalent soil method. These soil holding times are: Organics (14 days); Mercury (28 days) & other metals (180 days). A recorded breach therefore does not guarantee a breach for all non-volatile parameters.

Matrix: **WATER**

Evaluation: \* = Holding time breach ; ✓ = Within holding time.

Method	Container / Client Sample ID(s)	Sample Date		Extraction / Preparation		Analysis		
		Date extracted	Due for extraction	Date analysed	Due for analysis	Evaluation	Evaluation	
<b>EP068A: Organochlorine Pesticides (OC)</b>								
<b>Amber Glass Bottle - Unpreserved</b>								
MW03, MW09, DUP1,	MW07, MW12, RINSATE1	07-FEB-2008	12-FEB-2008	14-FEB-2008	✓	06-MAR-2008	15-APR-2008	✓
<b>Amber Glass Bottle - Unpreserved</b>								
MW04, MW11, MW02, DUP3,	MW06, MW01, MW05, RINSATE13/2	13-FEB-2008	15-FEB-2008	20-FEB-2008	✓	06-MAR-2008	15-APR-2008	✓
<b>EP080/071: Total Petroleum Hydrocarbons</b>								
<b>Amber Glass Bottle - Unpreserved</b>								
MW04, MW11	MW06,	13-FEB-2008	15-FEB-2008	20-FEB-2008	✓	07-MAR-2008	15-APR-2008	✓



Page : 3 of 5  
 Work Order : EM0801691  
 Client : RESOURCE & ENVIRON MANGMNT P/L  
 Project : GM-01 Re-batch EM0800948 & EM0801099

## Quality Control Parameter Frequency Compliance

The following report summarises the frequency of laboratory QC samples analysed within the analytical lot(s) in which the submitted sample(s) was(where) processed. Actual rate should be greater than or equal to the expected rate. A listing of breaches is provided in the Summary of Outliers.

Matrix: **WATER**

Evaluation: \* = Quality Control frequency not within specification ; ✓ = Quality Control frequency within specification.

Quality Control Sample Type	Method	Count		Rate (%)		Evaluation
		QC	Regular	Actual	Expected	
<b>Analytical Methods</b>						
<b>Laboratory Control Samples (LCS)</b>						
Pesticides	EP068	1	14	7.1	5.0	✓
TPH - Semivolatile Fraction	EP071	1	3	33.3	5.0	✓
<b>Method Blanks (MB)</b>						
Pesticides	EP068	1	14	7.1	5.0	✓
TPH - Semivolatile Fraction	EP071	1	3	33.3	5.0	✓



Page : 4 of 5  
Work Order : EM0801691  
Client : RESOURCE & ENVIRON MANGMNT P/L  
Project : GM-01 Re-batch EM0800948 & EM0801099

## Brief Method Summaries

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the US EPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request. The following report provides brief descriptions of the analytical procedures employed for results reported in the Certificate of Analysis. Sources from which ALS methods have been developed are provided within the Method Descriptions.

<i>Analytical Methods</i>	<i>Method</i>	<i>Matrix</i>	<i>Method Descriptions</i>
Pesticides	EP068	WATER	USEPA SW 846 - 8270D Sample extracts are analysed by Capillary GC/MS and quantification is by comparison against an established 5 point calibration curve. This method is compliant with NEPM (1999) Schedule B(3) (Appdx. 2)
TPH - Semivolatile Fraction	EP071	WATER	USEPA SW 846 - 8015A The sample extract is analysed by Capillary GC/FID and quantification is by comparison against an established 5 point calibration curve of n-Alkane standards. This method is compliant with NEPM (1999) Schedule B(3) (Appdx. 2)

<i>Preparation Methods</i>	<i>Method</i>	<i>Matrix</i>	<i>Method Descriptions</i>
Separatory Funnel Extraction of Liquids	ORG14	WATER	USEPA SW 846 - 3510B 500 mL to 1L of sample is transferred to a separatory funnel and serially extracted three times using 60mL DCM for each extract. The resultant extracts are combined, dehydrated and concentrated for analysis. This method is compliant with NEPM (1999) Schedule B(3) (Appdx. 2). ALS default excludes sediment which may be resident in the container.



Page : 5 of 5  
 Work Order : EM0801691  
 Client : RESOURCE & ENVIRON MANGMNT P/L  
 Project : GM-01 Re-batch EM0800948 & EM0801099

## Summary of Outliers

### Outliers : Quality Control Samples

The following report highlights outliers flagged in the Quality Control (QC) Report. Surrogate recovery limits are static and based on USEPA SW846 or ALS-QW/EN/38 (in the absence of specific USEPA limits). This report displays QC Outliers (breaches) only.

#### Duplicates, Method Blanks, Laboratory Control Samples and Matrix Spikes

- For all matrices, no Method Blank value outliers occur.
- For all matrices, no Duplicate outliers occur.
- For all matrices, no Laboratory Control outliers occur.
- For all matrices, no Matrix Spike outliers occur.

#### Regular Sample Surrogates

Sub-Matrix: WATER

Compound Group Name	Laboratory Sample ID	Client Sample ID	Analyte	CAS Number	Data	Limits	Comment
<b>Samples Submitted</b>							
EP068T: Organophosphorus Pesticide Surrogate	EM0801691-008	MW05	DEF	78-48-8	52.1 %	53-140 %	Recovery less than lower data quality objective
EP068T: Organophosphorus Pesticide Surrogate	EM0801691-013	MW12	DEF	78-48-8	Not Determined	---	Surrogate recovery not determined due to (target or non-target) matrix interferences

### Outliers : Analysis Holding Time Compliance

This report displays Holding Time breaches only. Only the respective Extraction / Preparation and/or Analysis component is/are displayed.

- No Analysis Holding Time Outliers exist.

### Outliers : Frequency of Quality Control Samples

The following report highlights breaches in the Frequency of Quality Control Samples.

- No Quality Control Sample Frequency Outliers exist.

**DATA QUALITY SUMMARY REPORT - GROUNDWATER**

Project No: GM-01  
 Site: Buckland Park  
 Matrix: WATER  
 Primary Laboratory: ALS (Batch Nos: EM0800948, EM0801099 & EM0801691)  
 Secondary Laboratory: Labmark (Batch No: E036174)  
 11 x Ammonia/ Nitrate/ Nitrogen/ Phosphorous/ Major Ions/ Metals (13)/ TPH/ BTEX/ PAH's/ OCP's/ Phenoxy Acid Herbicides  
 No. of Tests Requested/ Reported: 3 in 11 samples were duplicated  
 Frequency of QA/QC undertaken: 1 in 10 samples is required to be duplicated  
 Frequency of QA/QC Required:

Data Quality Issue Assessed	Issue Reviewed	Results Acceptable	Comments
Sampling Technique	✓	✓	
Sample Holding Times	✓	✓	See Note 1
Analytical Procedures	✓	✓	See Note 2
Laboratory Limits of Reporting (below relevant guideline value)	✓	✓	See Note 3
Field Duplicate Agreement (RPD%)	✓	✓	See Note 4
Blank Sample Analysis			
Method Blank	NA	NA	
Rinsate Blank	✓	✓	See Note 5
Equipment Blank	NA	NA	
Laboratory Duplicate Agreement (RPD%)	✓	✓	
Matrix Spikes/Matrix Spike Duplicates	✓	✓	
Recovery Percentages	✓	✓	
Duplicate Agreement (RPD%)	✓	✓	
Surrogate Recoveries	✓	✓	
Other Issues			
Trip Blanks	✓	✓	See Note 6
Sample status	✓	✓	

**Other Observations:**

- Note 1:
- Some of the first batch of samples (EM0800948) were lost en route to the laboratory. Resampling of missing analytes occurred (EM0801099). All samples were analysed within holding times except for reactive phosphorous for samples in EM0800948, which were analysed 2 days outside of holding time.
  - OCP's were analysed on 6/3/08, within standard holding time, from extracts of original samples.
- Note 2: The ionic balance errors for MW3, MW9, MW12 and MW6 were reported to be greater than the 5% target amount due to analytes not quantified in the reported analysis. This is a limitation to the confidence that can be placed in the major ionic composition of these samples, but does not affect the validity of other samples or analytes.
- Note 3:
- LORs for some analytes in some samples were increased due to matrix interference (high sample salinity).
  - Increased LOR's occurred for Ammonia, Metals and Phenoxy Acid Herbicides
- Note 4:
- Three intra-laboratory duplicates (MW2, MW7 and MW11) and two inter-laboratory duplicates (MW7 and MW11) were undertaken as part of the sampling activities. For MW11 the primary and intra-lab duplicate samples were lost en route to the lab for all analytes except TPH and BTEX. So effectively, two intra-lab duplicates and one inter-lab duplicate have been reported, with the exception of TPH and BTEX for which all duplicates undertaken have been reported.
  - Elevated RPD's were identified between the primary (ALS) and the intra-laboratory duplicate (ALS) or the inter-laboratory duplicate (Labmark), for the following analytes:
    - Nitrate between the primary and intra-lab duplicate samples for MW7. However, the detected concentrations are close to the LOR and are well below the relevant guideline values for nitrate.
    - Total phosphorous between the primary and the intra-lab duplicate samples for MW2, however, the detected concentrations are close to the LOR so the actual exceedance is considered marginal. Total phosphorous between the primary and inter-lab duplicate samples for MW7, however, the exceedance is considered relatively small and neither value exceeded any of the relevant guideline values.
    - Reactive phosphorous between the primary and the intra-lab duplicate samples for MW7, however, the exceedance is marginal and the reported values are close to the LOR and well below the relevant guideline values.
    - Lead between the primary and intra and inter-laboratory duplicates for MW7. The intra- and inter- laboratory samples are more similar to, and considerably lower than, the primary sample, thus placing the validity of the primary sample into question. It is likely that the actual lead concentration is lower than the value reported for the primary sample.
    - Zinc between the primary and inter-lab duplicate samples for MW7. Also zinc between the primary and intra-lab duplicate samples for MW2.
    - Toluene between the primary and intra-lab duplicate samples for MW2. However, the reported values are near or below the LOR and well below the relevant guideline value.
- Note 5: Purging and sampling was undertaken using a 12 volt pump with dedicated LDPE tubing. The pump was decontaminated prior and following both sampling events, and a rinsate blank was taken after each sampling event by running demineralised water through the pump. The rinsate blanks were analysed for the same constituents as the groundwater samples collected using the pump. The rinsate results indicate that negligible contamination was introduced by the use of the pump in the sampled wells. Trace levels of copper, manganese and zinc were detected in the rinsate blank from the first sampling event, although the concentrations were all well below the relevant guideline values. For the second sampling event all analytes were reported at below detection limit in the rinsate blank.
- Note 6: Trip blanks were sent to the laboratories along with each batch of samples, and were analysed for volatile TPH and BTEX. All trip blank concentrations were reported below the LOR.

**Summary Comments:**

Groundwater analytical data can be used as a basis of interpretation, subject to the limitations outlined above.

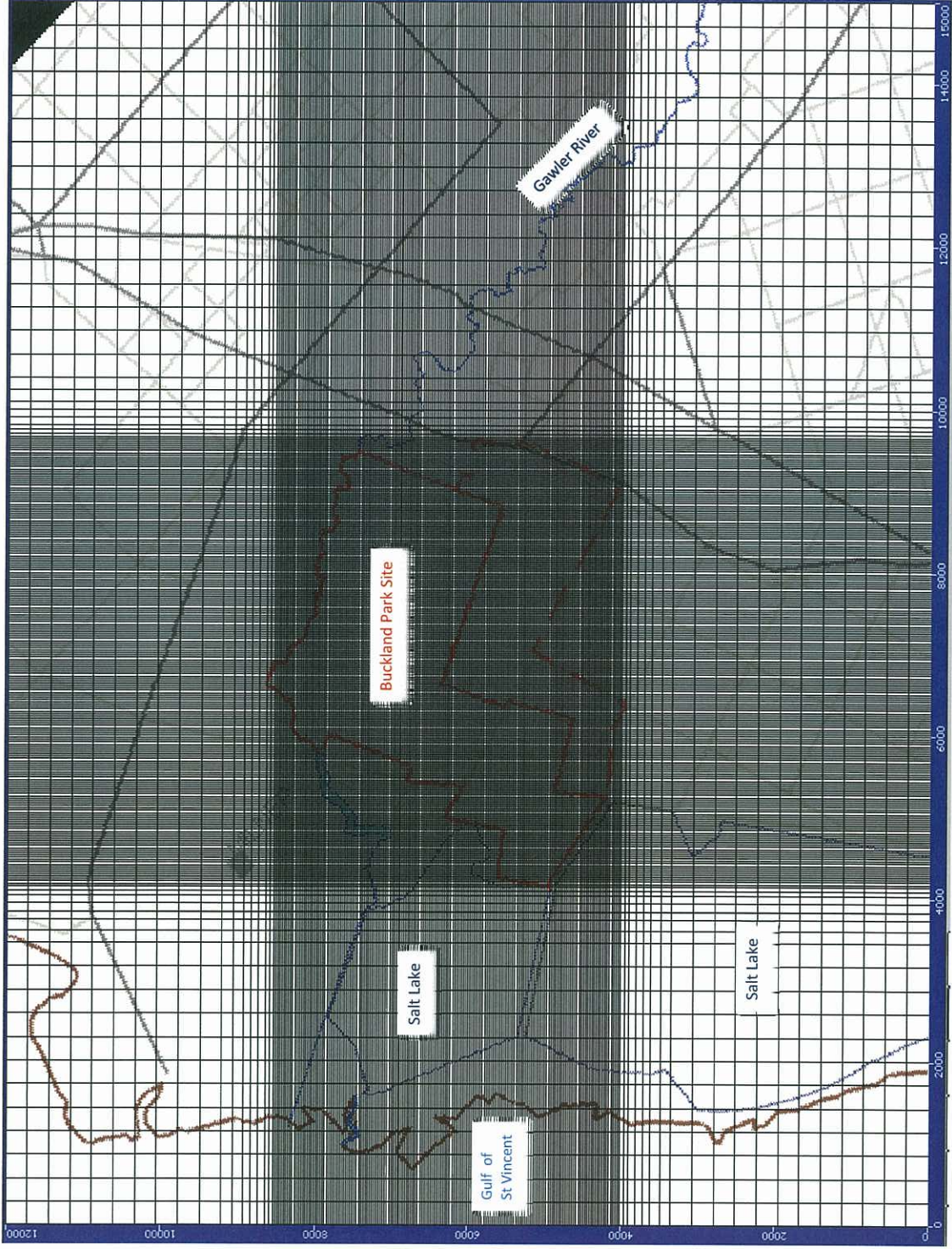
**Recommended Corrective Action:**

None

Checked:





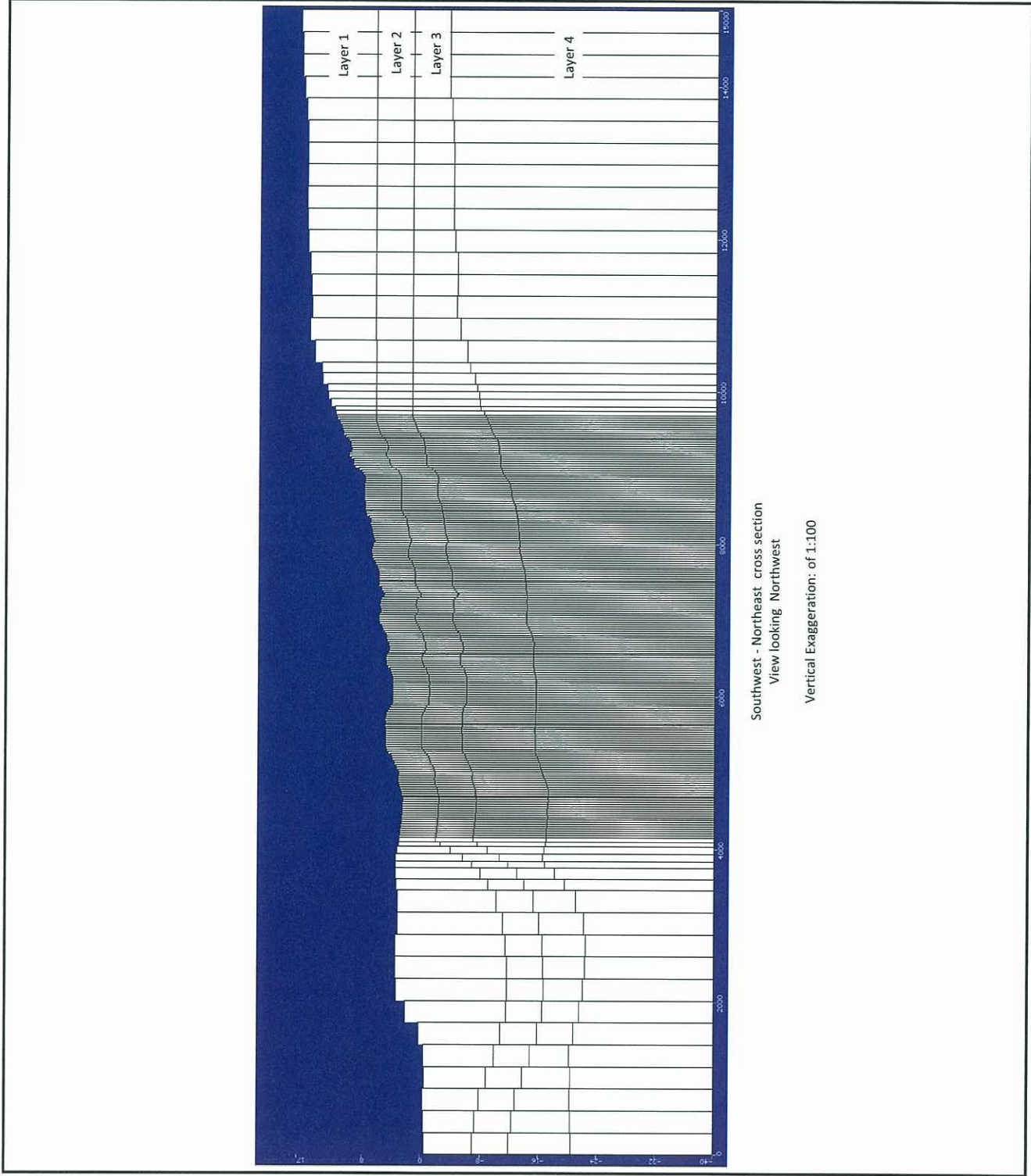


Buckland Park

### Model Grid - Plan View

Figure

# H.1



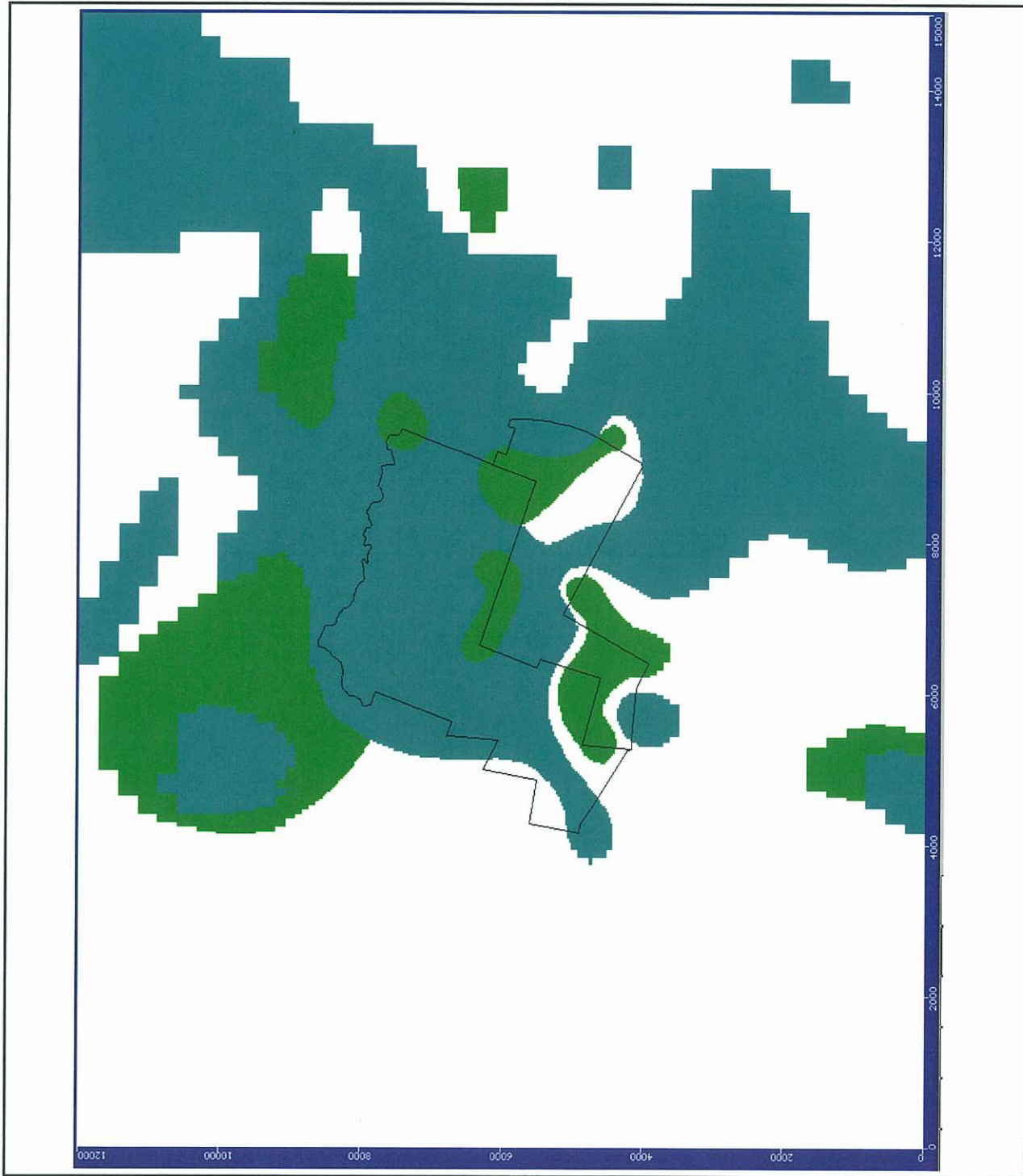
Buckland Park

**Model Grid - Cross  
Section View**

Figure

**H.2**





Buckland Park

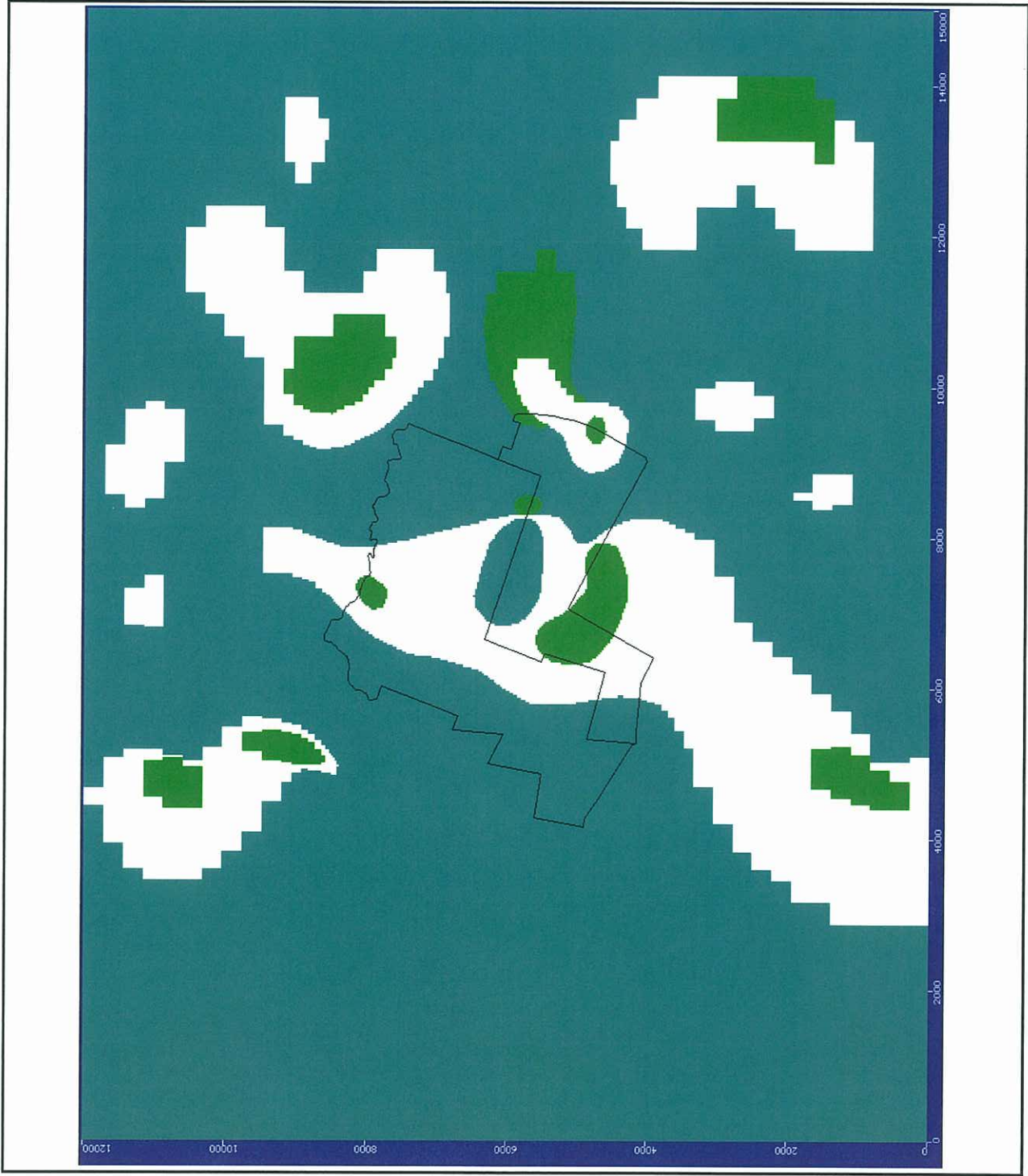
Modelled Hydraulic

Conductivity Zones - Layer 1 (0 - 5 m bgl)

Figure

H.3

July 2008



**Conductivity Zones**

Kx [m/d]	Ky [m/d]	Kz [m/d]	Color
1	1	1	White
0.0001	0.0001	1.5E-5	Dark Green
3	3	3	Medium Green
0.75	0.75	0.75	Light Green



Buckland Park

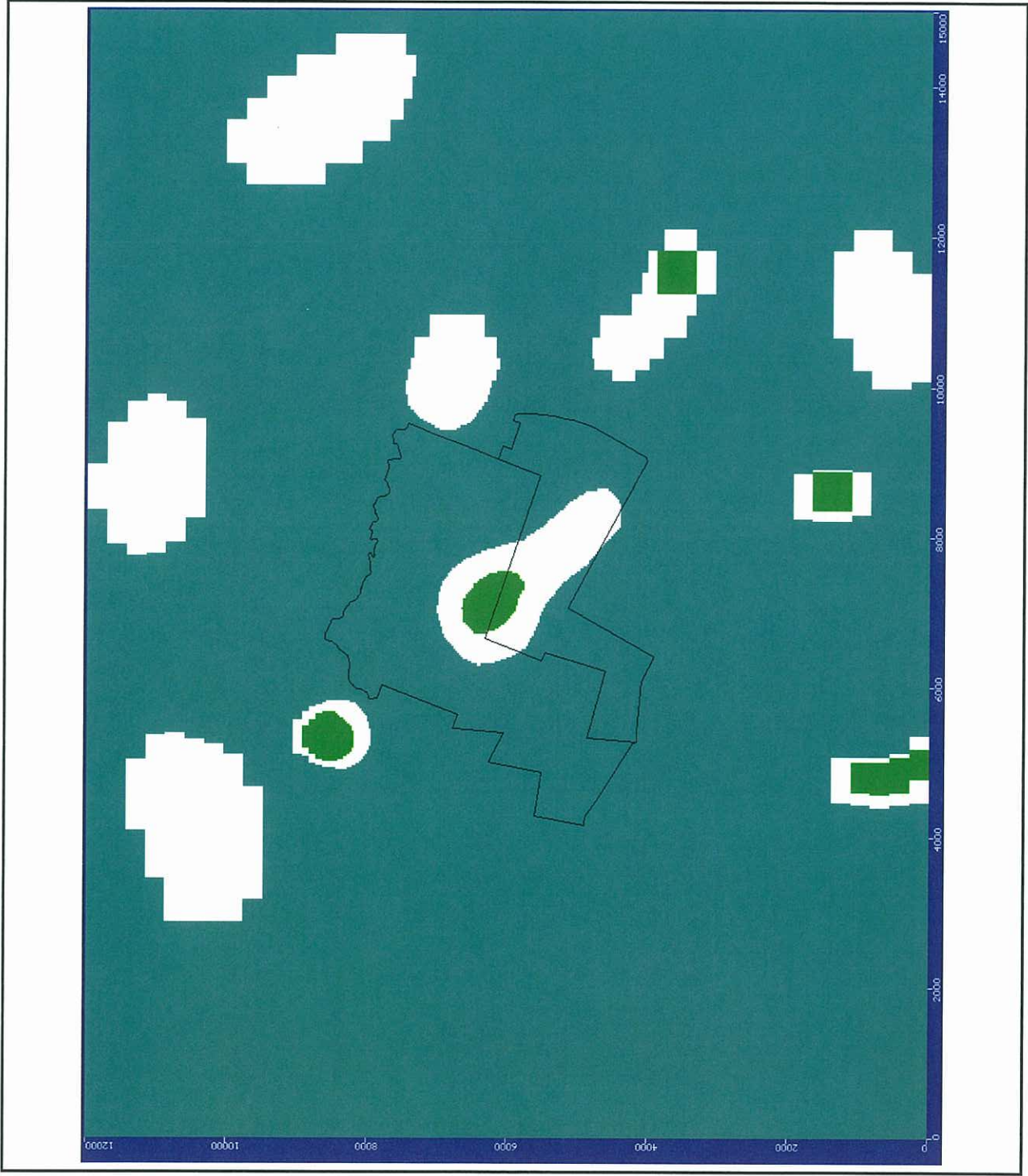
Modelled Hydraulic

Conductivity Zones - Layer 2 (5  
- 10 m bgl)

Figure

H.4

July 2008



**Conductivity Zones**

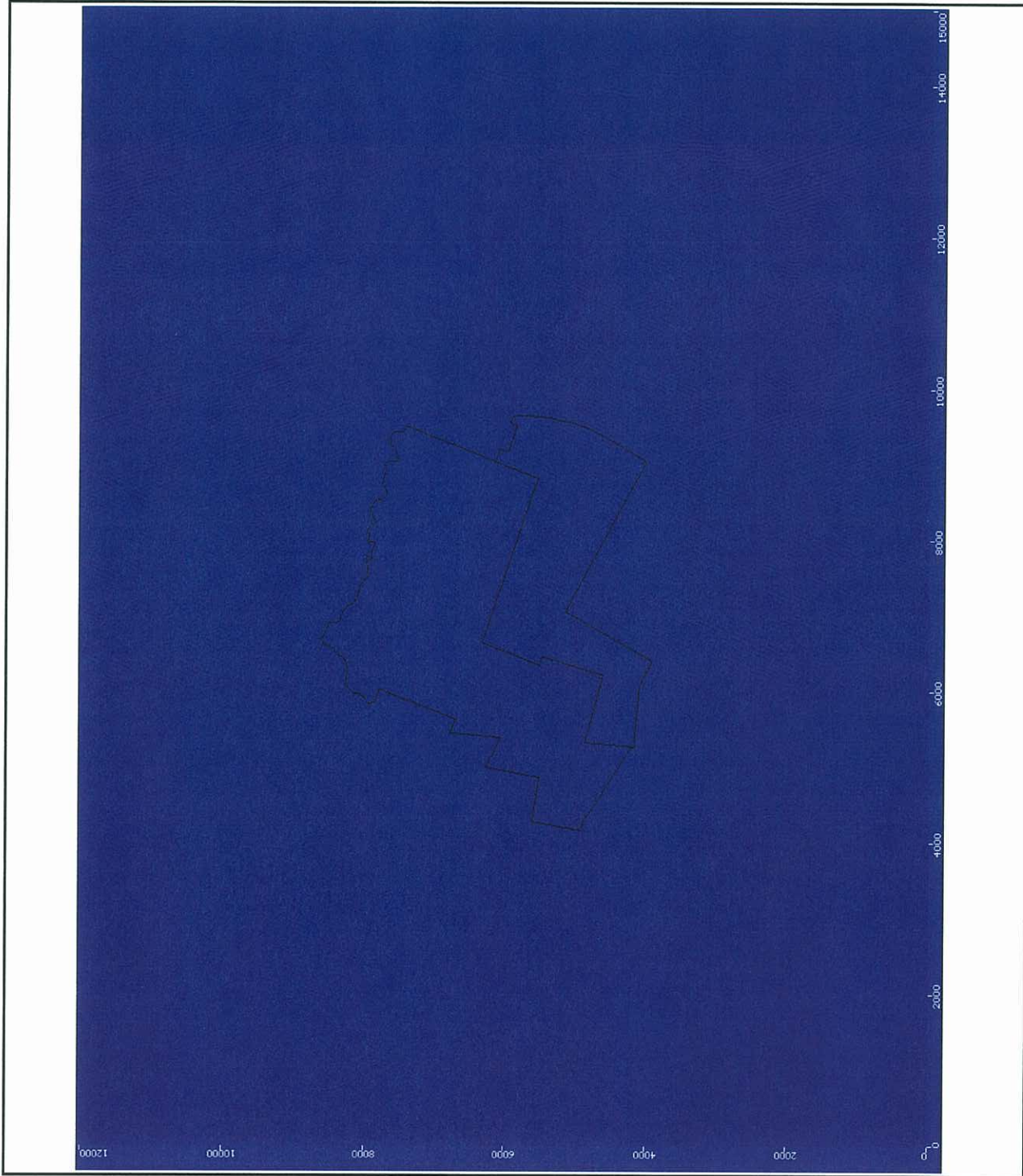
Kx [m/d]	Ky [m/d]	Kz [m/d]	Color
1	1	1	White
0.0001	0.0001	1.5E-5	Light Green
3	3	3	Dark Green
0.75	0.75	0.75	Teal



Buckland Park  
**Modelled Hydraulic  
 Conductivity Zones - Layer 3  
 (10 - 20 m bgl)**

Figure  
**H.5**  
 July 2008





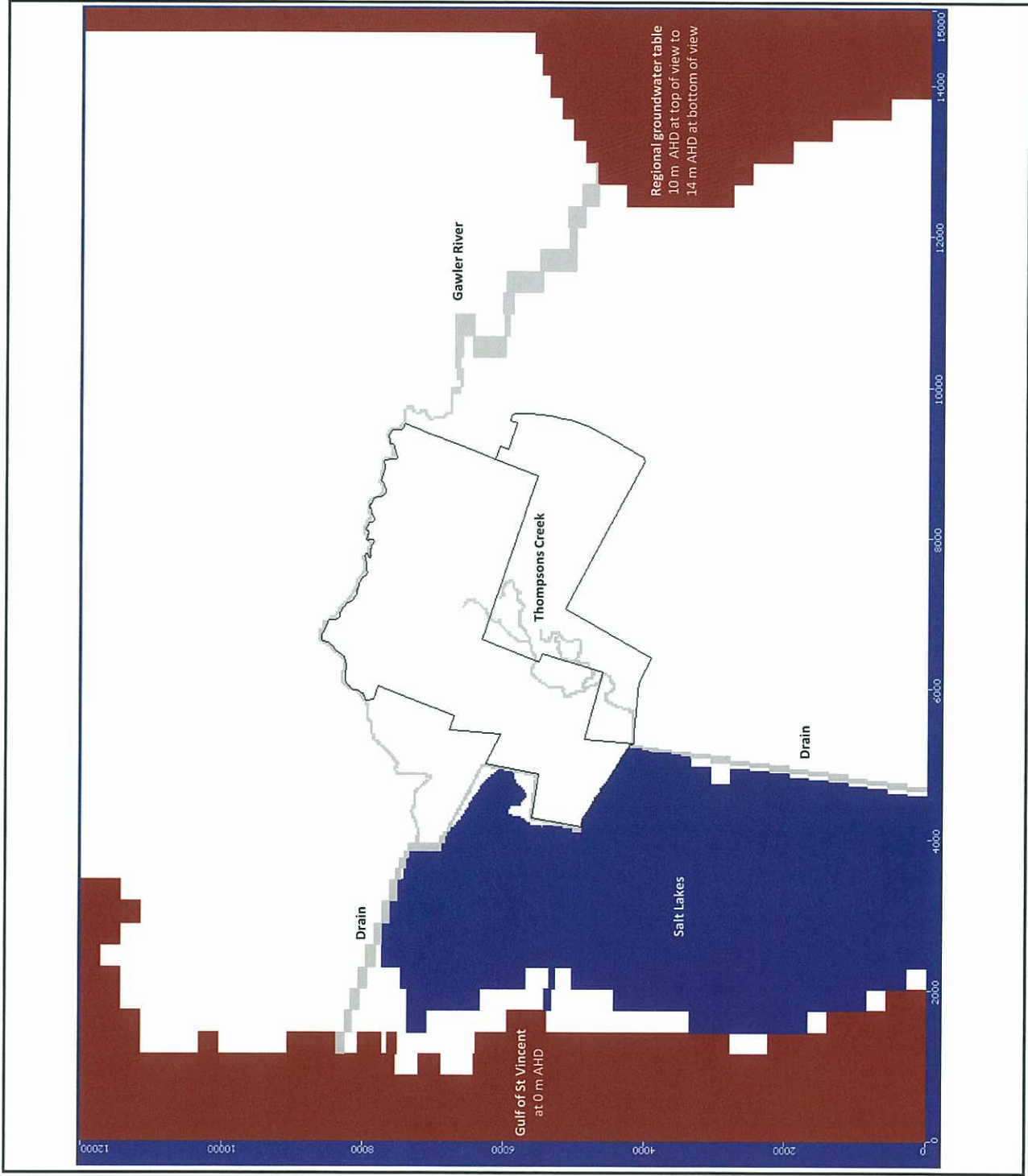
**Conductivity Zones**

Kx [m/d]	Ky [m/d]	Kz [m/d]	Color
1	1	1	White
0.0001	0.0001	1.5E-5	Dark Blue
3	3	3	Green
0.75	0.75	0.75	Light Blue



Buckland Park  
**Modelled Hydraulic  
 Conductivity Zones - Layer 4  
 (below 20 m bgl)**

Figure  
**H.6**  
 July 2008



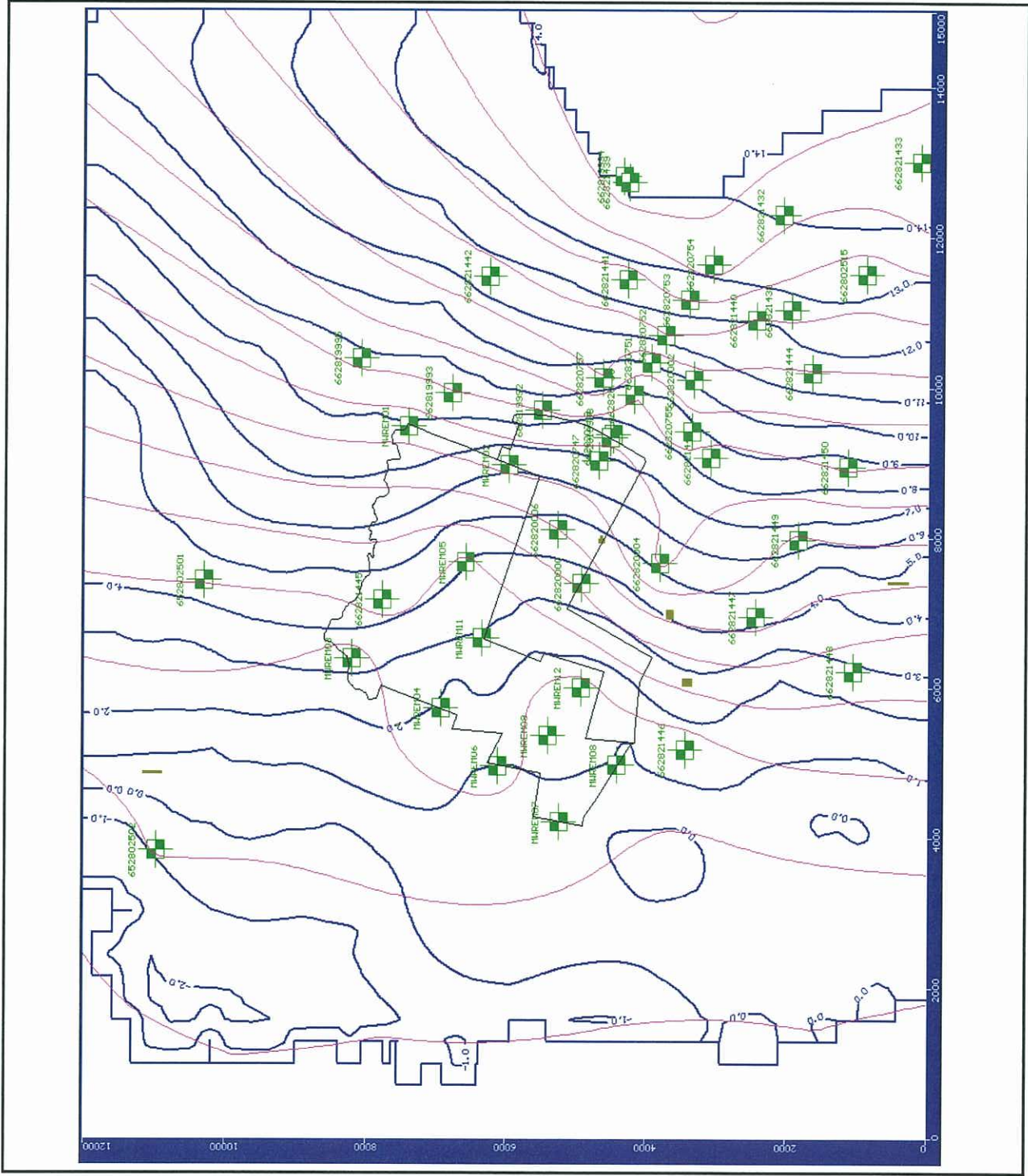
Buckland Park




**Constant Head, Rivers and  
Drains Boundary Conditions**

Figure

**H.7**

July 2008



-  Predicted Water Level Contour
-  Observed Water Level Contour
-  Water Level Observation Well Point



Buckland Park

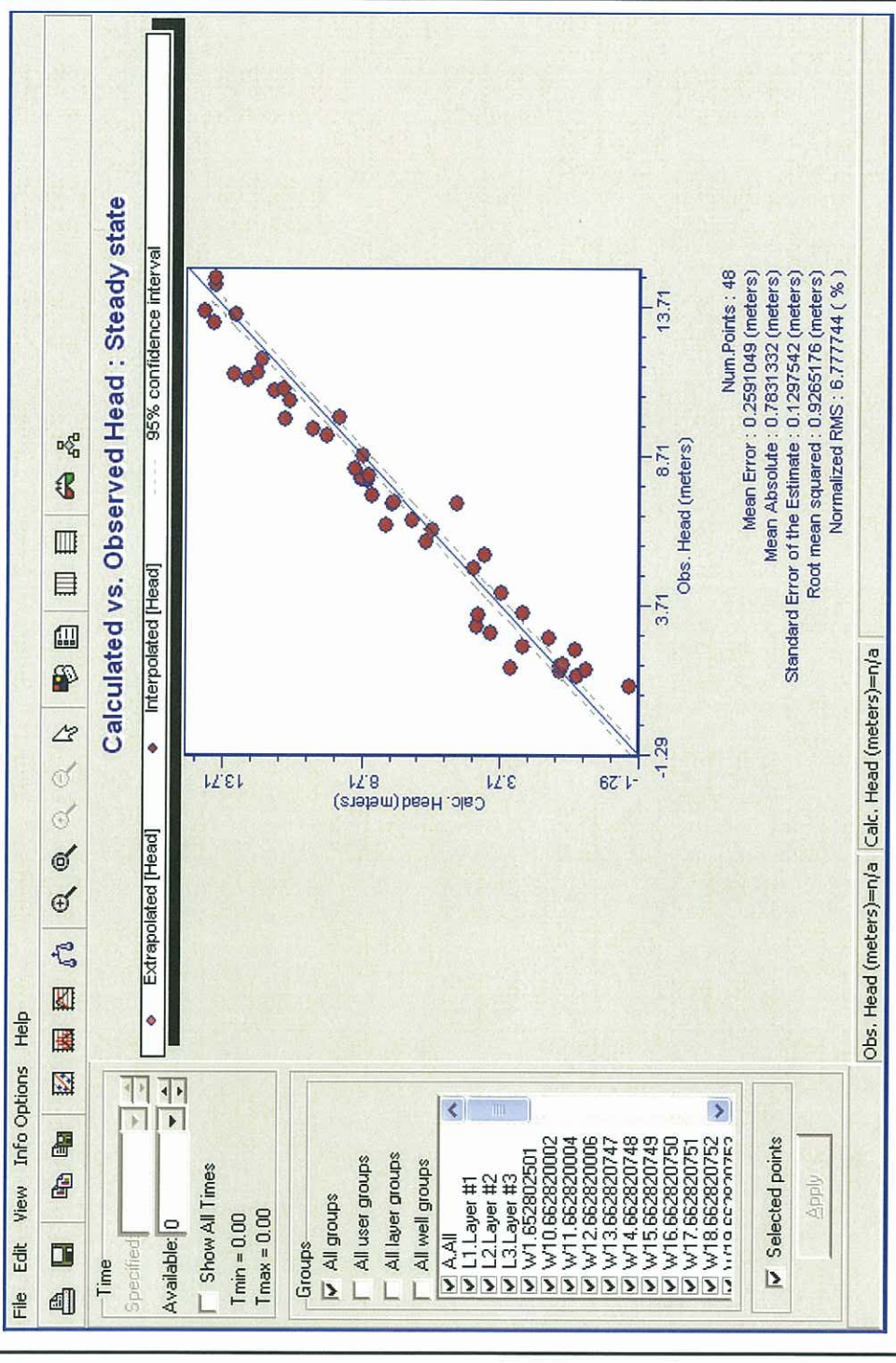
## Predicted and Observed Groundwater Level Contours

Figure

# H.8

July 2008





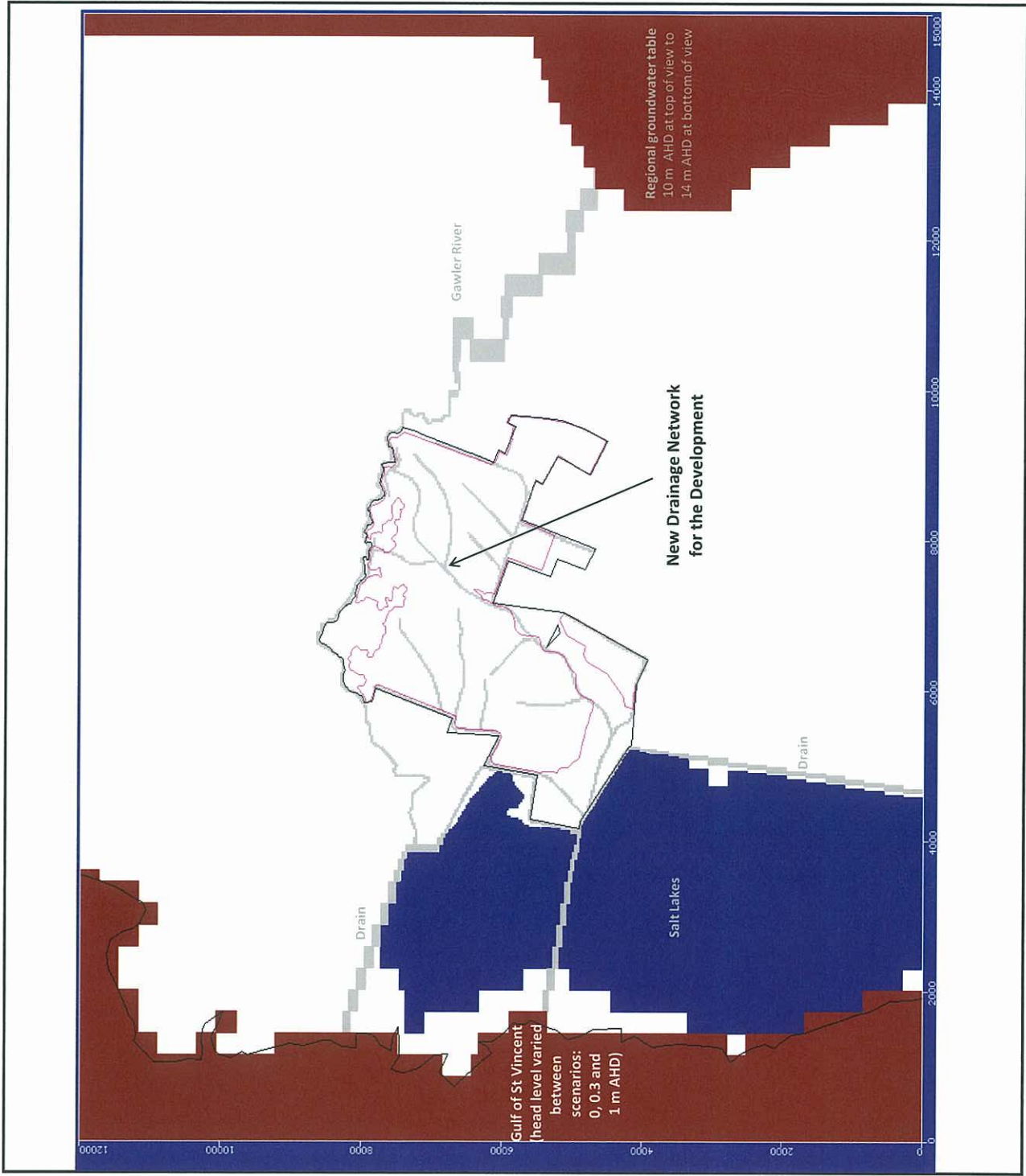
Buckland Park

**Predicted vs. Observed  
Groundwater Levels**

Figure

**H.9**

July 2008



Buckland Park  
**Scenario Modelling:  
Development Footprint and  
New Drainage Network**

# 1 OPTIONS FOR SALINITY MANAGEMENT

For development to proceed in areas that have a moderate to high risk of urban salinisation appropriate salinity risk management actions must be undertaken to address the identified level of risk.

A comprehensive urban salinity management approach should include groundwater recharge minimisation, adequate management of perched and/or regional groundwater and the use of improved construction materials to minimise potential impacts of urban salinity.

This supplementary information provides a brief overview of selected options for successful management of urban salinity risk.

## 1.1 Groundwater Recharge Minimisation

Education is the most effective tool available to facilitate the process of achieving real reductions in the amount of water that recharges the groundwater system in an urban environment. While there are many practical ways to reduce water requirements and improve water use efficiency, if the importance is not widely understood then achievements will be limited.

### 1.1.1 *Landscaping Design*

An immediate reduction in the water requirements of lawns, gardens and public open space can be achieved by appropriate water sensitive urban landscaping design. This may include:

- Smaller areas of lawn, a typically shallow rooted grass with high water requirements;
- Choice of lawn grass with lower water requirements;
- Choice of plants, shrubs and trees with low water requirements such as native species; and
- Choice of plants with greater root depth and capacity to use available water.

### 1.1.2 *Water Use Efficiency*

In all cases efficient water use practices should be adopted to minimise the potential for urban salinisation to occur. Essentially this involves matching lawn and garden watering regimes with actual plant water requirements. Options to improve water use efficiency include:

- The use of timers on all garden taps and sprinkler systems to avoid over watering, or the case where a tap is accidentally left running.

- Manual over-ride of automated watering systems when the additional water is not actually required, for example during and soon after a rain event.
- The use of soil moisture monitoring technology to inform the application of water to meet actual plant water requirements. Soil moisture probes can communicate directly with irrigation systems to create a fully automated “smart” irrigation system that operates according to plant water requirements.

### 1.1.3 *Household Grey Water Disposal*

Household grey water disposal in new residential developments occurs directly into the municipal system. However, this has not always been the case and in some instances on-site disposal of grey water has been facilitated by direct recharge to groundwater via a subsurface sump. While this practice may have sufficed in a low-density rural setting, in a high-density urban residential situation it is inappropriate and could result in the development of shallow regional or perched groundwater.

It should be a requirement in new developments that household grey water and septic tanks are connected directly to the piped municipal sewerage system.

### 1.1.4 *Stormwater Management*

Where there is potential for urban salinisation as a result of shallow groundwater, stormwater management should focus on the avoidance of pooling and the prevention of *in situ* recharge in salinity risk areas. This consideration should be included in the design of stormwater management structures both at the household (eg. roof runoff) and municipal (eg. wetlands) levels.

It should be a requirement in new developments that household roof drainage is collected into rainwater tanks or connected directly to the municipal stormwater system, rather than on site disposal in sillage pits.

## 1.2 **Perched Groundwater Management**

### 1.2.1 *Subsurface Drainage*

Where a subsurface low permeability clay layer occurs in the upper 4 m of the soil profile a subsurface drainage system is required to adequately manage perched groundwater that may develop.

A subsurface drainage system essentially involves the installation of a linear network of conduits, historically clay tiles but more recently including perforated poly pipe, that channels perched groundwater across the slope where collection occurs and main disposal piping diverts water for off site disposal via the municipal stormwater system.

In the USA the American Society of Civil Engineers has published standard guidelines for the design of urban subsurface drainage. In Australia subsurface drainage has been widely used in the agricultural industry, including irrigated vineyards in, for example, the Mildura region and best management practices have been developed in this context\*.

Subsurface drainage systems developed for the agricultural industry are widely available and are directly applicable to perched groundwater management under urban development, providing that appropriate design and installation occurs.

### 1.3 Shallow Regional Groundwater Management

In areas where shallow regional groundwater threatens urban development the depth to groundwater must be maintained below a level that would potentially impact on urban development.

#### 1.3.1 *Aquifer Dewatering*

Due to the regional scale of factors affecting recharge and flow of regional groundwater management options involving aquifer dewatering via subsurface drainage or pumping from wells will be ongoing and very expensive.

If salinisation occurs in existing urban developments due to shallow regional groundwater then aquifer dewatering may be the only option available for immediate remediation and management of the problem. However, this approach is not considered appropriate for ongoing pre-emptive management of the potential urban salinity risk presented by regional groundwater.

#### 1.3.2 *Imported Fill*

The use of imported fill to build up ground level and increase the depth to regional groundwater above the threshold level is potentially a viable option to allow urban development to proceed in areas where there is a shallow regional watertable.

To ensure success of this salinity risk management option it must be guided by a detailed hydrogeological investigation, both to determine the depth of fill material required across the site, which will depend on the depth to regional groundwater, and to identify and address any potential off site impacts resulting from disruption to groundwater flow.

### 1.4 Appropriate Construction Materials

New urban developments in areas at risk of urban salinisation should be built to withstand the effects of salinity. The use of improved construction

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\* Christen E. W., and Ayars J. E., (2001). "Subsurface Drainage System Design and Management in Irrigated Agriculture: Best Management Practices for Reducing Drainage Volume and Salt Load", CSIRO Land and Water, Technical Report 38/01, Griffith, NSW, September 2001.

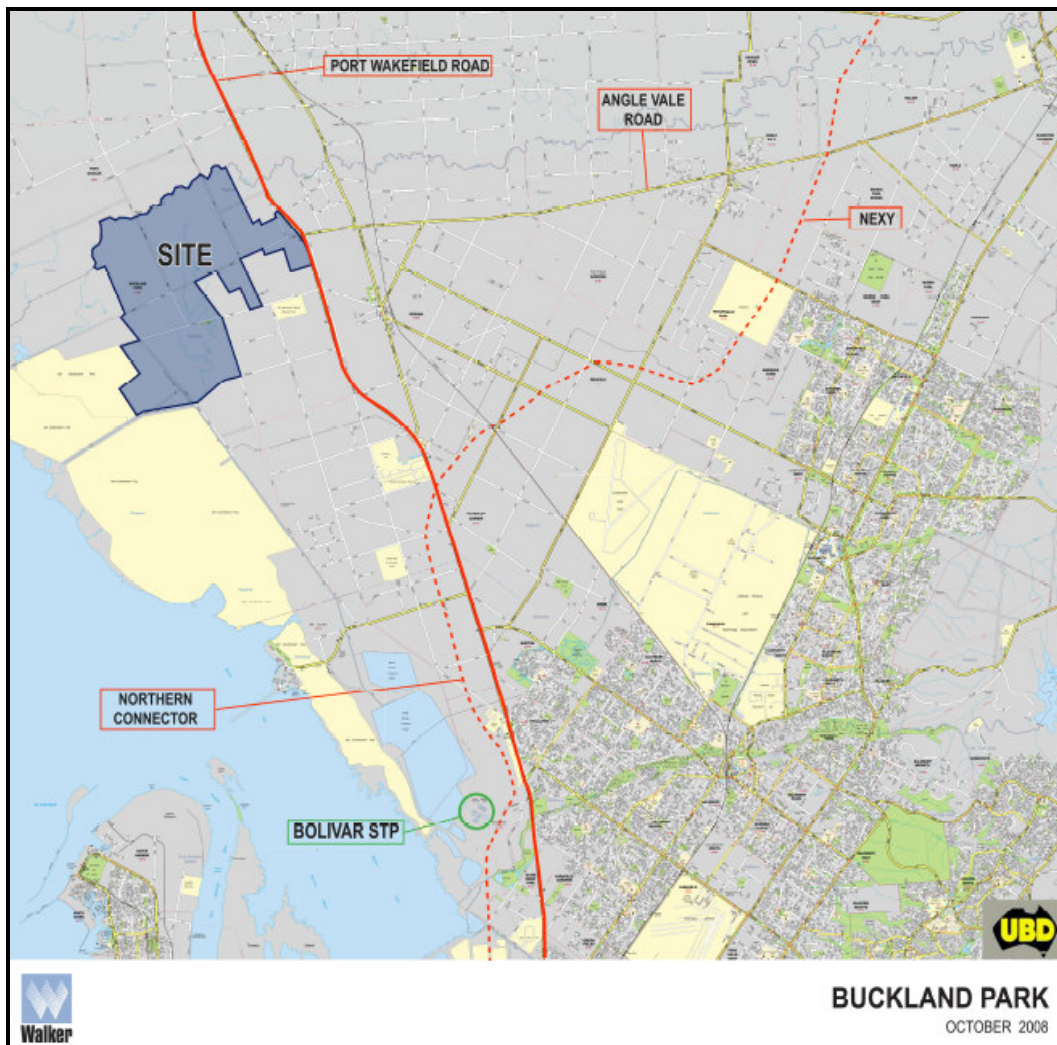
materials is a pre-emptive measure to assist in minimising the potential impacts of salinisation on housing and other infrastructure. This may include the use of better damp coursing and marine grade concrete in housing construction.



## PROPOSAL OVERVIEW

The Buckland Park proposal is a joint venture of partners Walker Corporation and Daycorp. The site has an area of 1,308 hectares

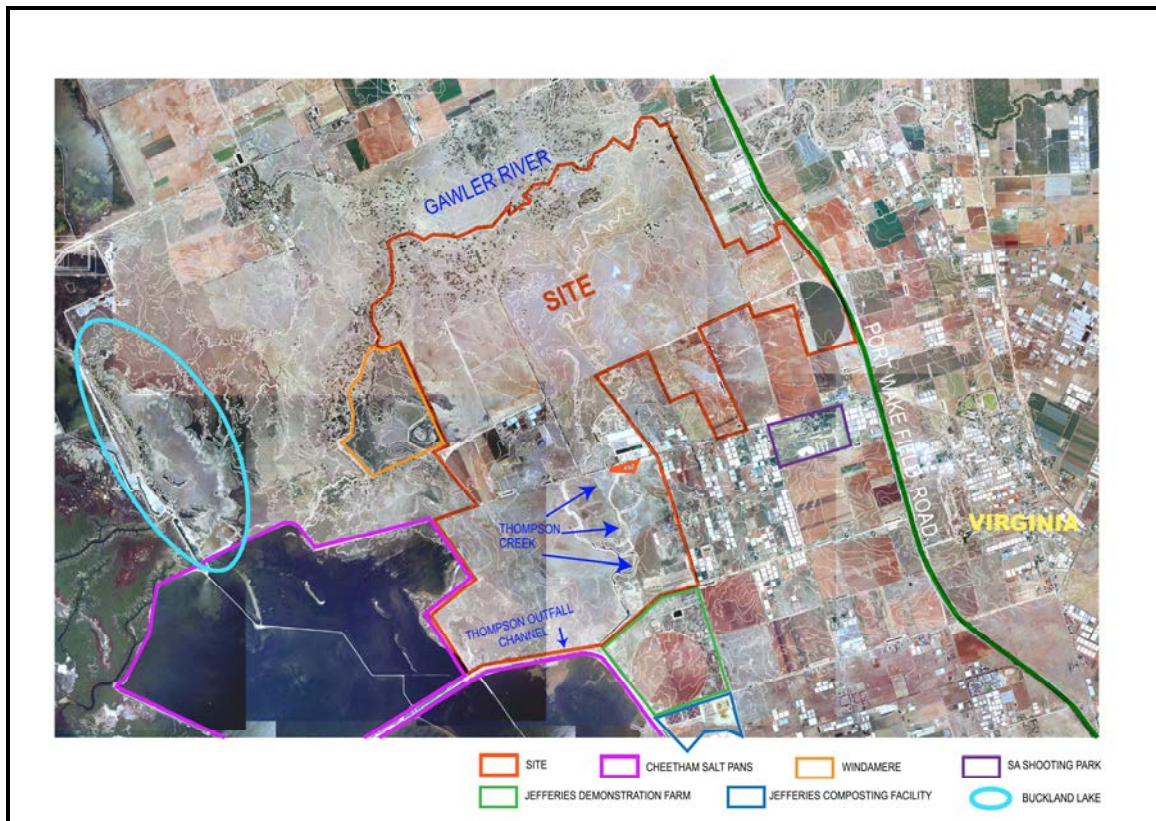
The site is located on Port Wakefield Road within the City of Playford, west of Virginia, and around 32 kilometres north of the Adelaide CBD, and 14 kilometres from Elizabeth, see Figure 1.



**Figure 1:** *Buckland Park Locality Plan*

The site is bounded by Port Wakefield Road, the Gawler River, Cheetham Salt Limited salt pans and horticultural activities. The site is between 2.5 and 4 kilometres from the Gulf St Vincent coastline. The site is relatively flat arable land primarily used for low intensity grazing.

Remnant native vegetation occupies parts of the site's north west and south west portions, which can be seen on the aerial photograph in Figure 2.



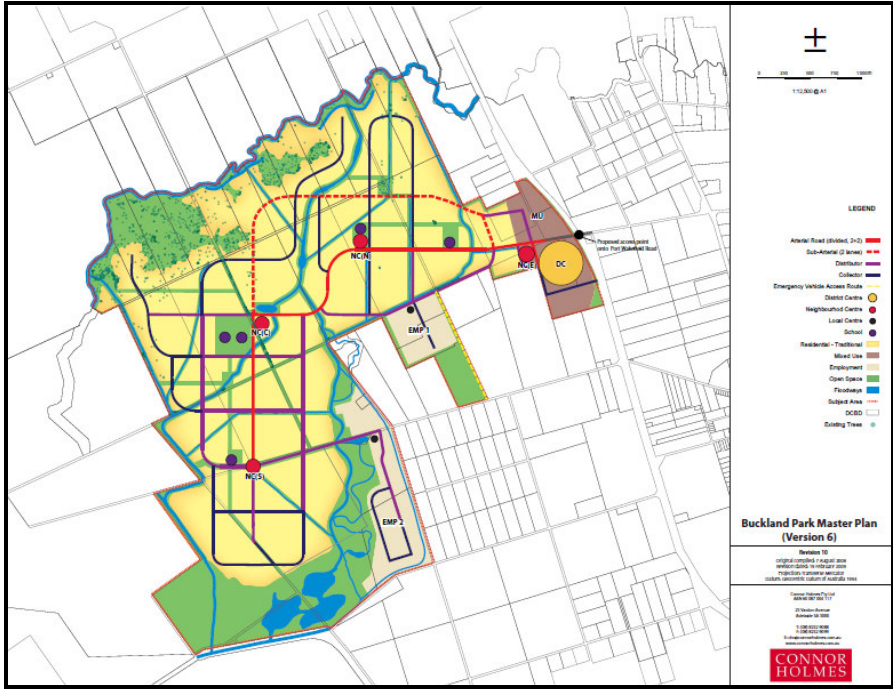
Aerial photo supplied by Walker Corporation

**Figure 2:** Site superimposed on aerial photograph

The Cheetham salt pans, adjoining the south west boundaries of the site, are man made structures.

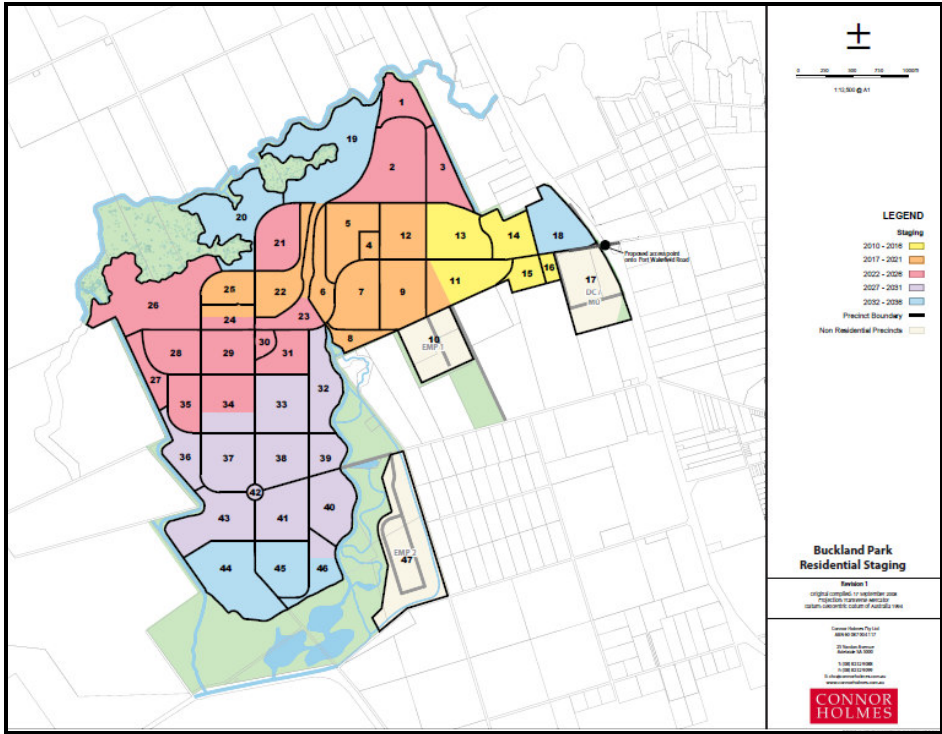
It is anticipated the proposal will comprise 12,000 residential allotments, with an average size of 500m<sup>2</sup>, supported with multiple purpose open space, and commercial, retail, community and employment uses. The proposal is illustrated in the Masterplan at Figure 3.





**Figure 3: Masterplan**

The proposal will be implemented in stages over a period of 25 years, the first stage is planned for 2010 to 2016, as illustrated in the staging plan below in Figure 4.



**Figure 4: Staging Plan**