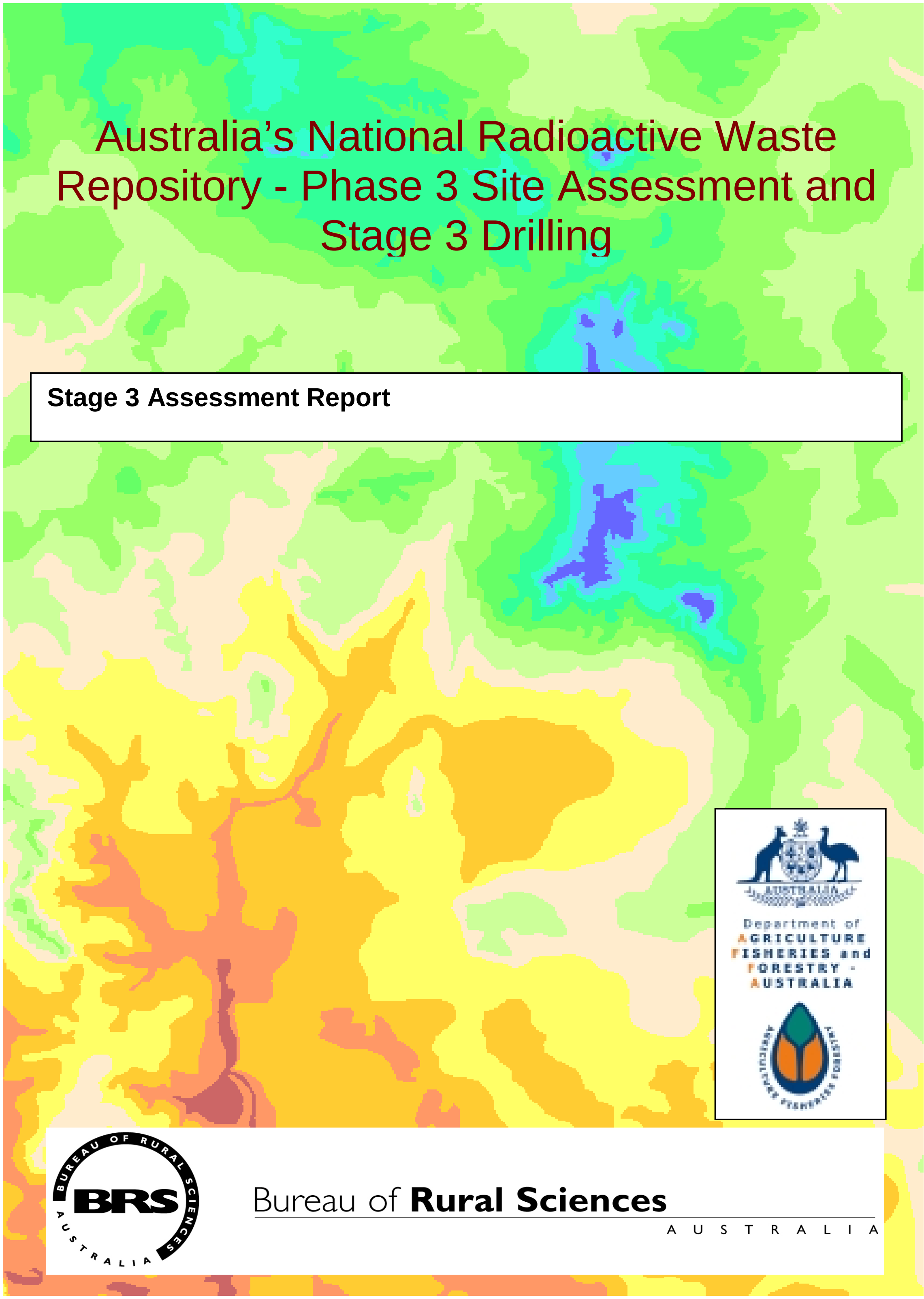

Australia's National Radioactive Waste Repository - Phase 3 Site Assessment and Stage 3 Drilling

Stage 3 Assessment Report

Department of
AGRICULTURE
FISHERIES and
FORESTRY -
AUSTRALIA

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AUSTRALIA

Summary

The results of Stage 3 drilling of three sites for the National Low-level and Short-lived Intermediate-level Radioactive Waste Repository Project were assessed against the geotechnical site selection criteria for a near-surface repository as outlined in the National Health and Medical Research Council *Code of Practice for the Near-surface Disposal of Radioactive Waste in Australia* (1992). The criteria relate to the groundwater, geological, geochemical and geotechnical conditions, and to the potential for valuable natural resources. In addition, comments are made relating to other selection criteria such as transport access and long-term control over the facility.

All three sites were found to be highly suitable for the siting of a near-surface radioactive waste repository. Site 52a has been selected as the preferred site because it better meets more of the selection criteria than the other two sites. Site 45a performed the next best, followed by Site 40a.

Site 52a performs the best against the selection criteria and is the preferred site because the surrounding landforms indicate superior surface drainage with little or no run on of water to the site from adjacent areas. The risk of ponding and damage to trench covers is therefore minimal. There is no hard silcrete in the trench zone and trenches could therefore be easily constructed. In addition, the geology and hydrogeological features mean that the groundwater flow characteristics can be modelled with more confidence than for the other sites. The site has superior transport access, with a bitumen road leading near to the site, and it has superior prospects for long-term control, being located on the Woomera Prohibited Area which has restricted public access.

Site 40a performed slightly less well against the selection criteria, mainly because it had more complicated surface features which could impound water on the site; and less clay in the trench and sub-trench zones, making trench construction less straightforward; and a greater distance over unformed roads for transport access. Site 45a ranked intermediate, having good surface drainage qualities but there was a greater prospect for run-on of rainfall to the site than for Site 52a.

All three sites have sufficient clay and other adsorbing materials in the profile to adequately retard radionuclides in the unlikely event of leakage from the repository trenches.

Introduction

Following assessment of technical results of Stage 2 drilling of five sites for Australia's low-level and short-lived intermediate-level radioactive waste, and taking into consideration comments received during stakeholder consultation, three sites were selected for further work – Sites 40a, 45a and 52a. Field investigations for **Stage 3** assessment of the three sites was completed in October 2000. This report presents the results of drilling during **Stage 3 assessments** and makes a recommendation on the preferred site for the repository. This report, combined with reports on **Stage 1 and Stage 2 assessments**, forms the interim **Final Report for Phase 3** of the siting project. The report is interim because of pending laboratory data for groundwater age and recharge profiles, and for drill logs to be transcribed to a publication standard. Monitoring of groundwater levels will also continue.

Stage 3 assessment consisted of twelve reverse-circulation percussion-hammer drill holes at each of the three sites short-listed from **Stage 2**. Four holes were drilled at an in-fill 750m spacing around the 1.5km perimeter and a further eight holes were drilled at a 250 m spacing about an inner 500 m square of each site. At all three sites a total of sixteen holes were drilled during **Phase 3 assessment**, including two diamond core holes, with the remainder by reverse-circulation percussion-hammer. One-metre interval samples were obtained and lithologically described from all percussion holes. The standing water level, air-lift yield and field salinity were recorded in each drill hole apart from the two cored holes at each site and the four external perimeter infill percussion holes. In addition, the elevation of each drill hole was surveyed and together these data were used to produce detailed (0.5m) topographic contours, and sub-surface (structure) contours and thickness (isopach) contours of the geological formations. The contours provided an excellent basis for interpreting the three-dimensional configuration of each site.

During Stage 3 the geotechnically-oriented criteria (NHMRC 1992); a, b, c, d, f and g, were reviewed for each site. The criteria relate to the groundwater, geological, geochemical and geotechnical conditions, and to the potential for valuable natural resources. The drilling and samples provided the information necessary to indicate the relative suitability of each site for the geological and physical criteria. Site suitability for the non-geotechnical criteria was established broadly during Stages 1 and 2 and will be determined in detail during an environmental impact assessment.

Figure 1 shows a typical scene across a site and **Map 1** shows the location of the Stage 3 sites. **Figure 2** shows the layout of the drill holes for all Phase 3 assessments.

Figure 1: Typical scene across a site

Map 1: Location of Sites 40a, 45a and 52a.

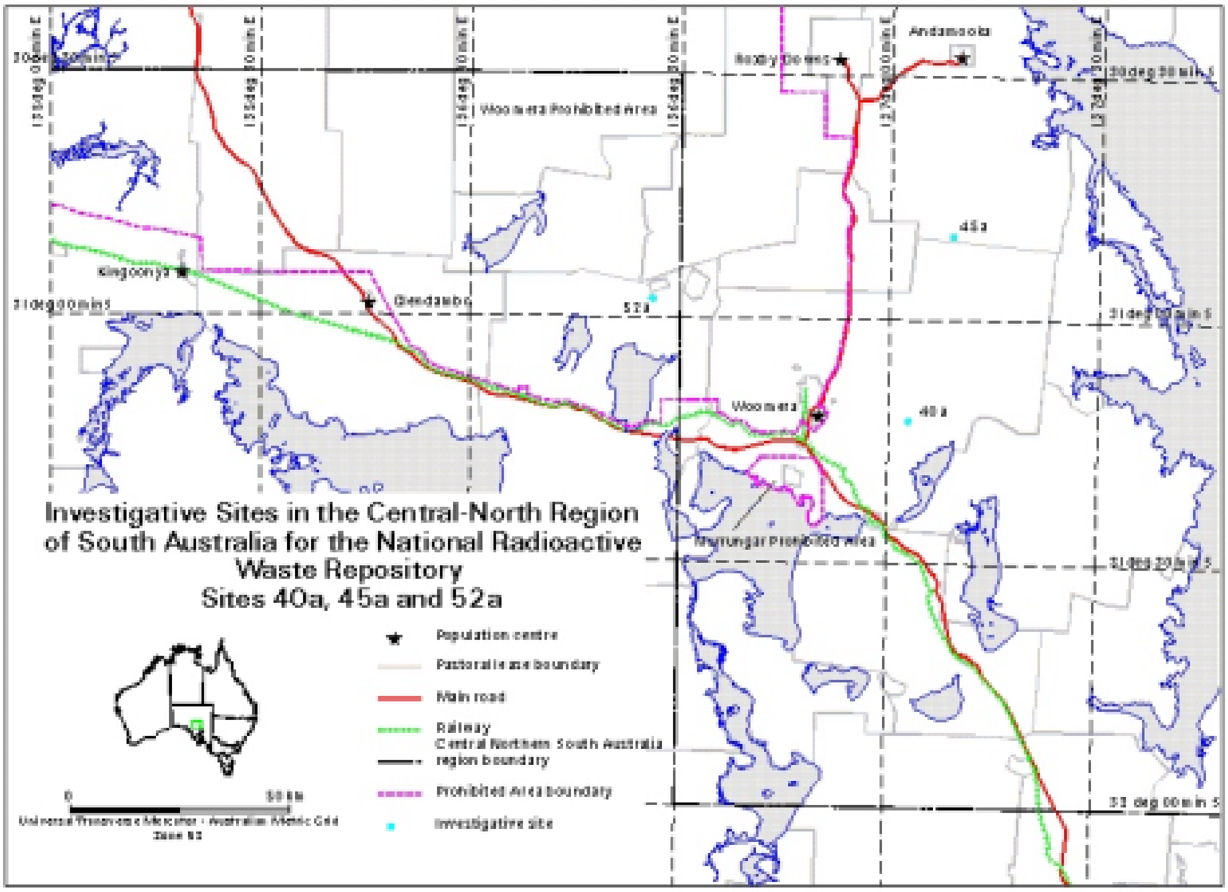
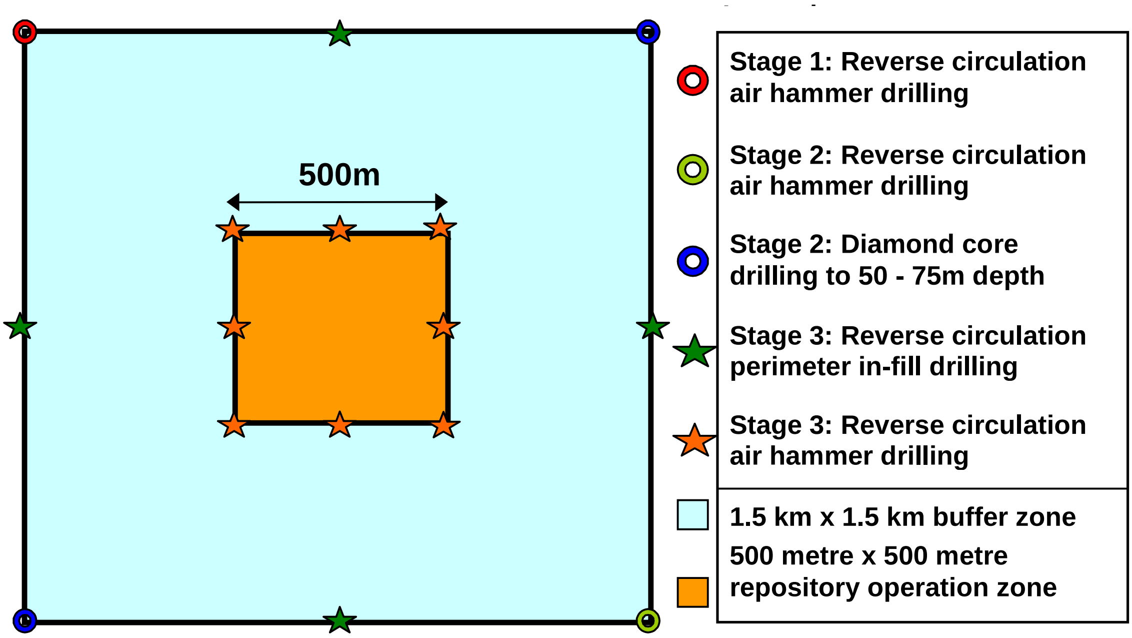


Figure 2: Stages 1, 2 & 3 Drilling Lay-out



Geomorphology and Hydrology

All three sites lie at elevations between 120 – 200m above sea-level on broad, elevated gibber plains which have clearly defined water drainage courses eventually falling 60 – 100m in height to larger regional drainage systems. The vegetation is sparse consisting mainly of salt bush, typically < 30cm height, and allied arid area grasses and forbs.

Gibbers vary in composition, size and angularity across and between sites. Gibber at Site 40a is mainly resilicified sandstone, ranging from small cobble to boulder size with a large proportion with a slabby form. At Site 45a the gibber has a similar composition but is typically smaller with most being large gravel to large cobble size and having a mainly flaggy form. Site 52a is distinctly different in having nodular silcrete and shale flakes smaller than cobble size.

The topography at each site is shown as contour plots in **Appendix 1**.

Site 40a is approximately 189m above sea level at its centre with a maximum relief of 4m over 0.5km. The surface and drainage features at Site 40a show the greatest variety of the three sites, with a slightly elevated ridge trending approximately north-south , a cane-grass swamp on the north-eastern boundary, and a subtle drainage depression which drains away from the western margin. There is a small area of upslope water catchment from which sustained, heavy rainfall could produce run-on to the site.

Site 45a is approximately 131m above sea level at its centre and has a maximum relief of 8m over 1.5km. The surface features define a clear, broad drainage path running from the south-east to the north-west. Of the three sites Site 45a has the largest upslope catchment area for rainwater run-on but this is compensated by the clear drainage path to conduct run-off from the site. The old Arcoona to Andamooka road crosses the outer north-western corner which concentrates localised rainfall before meeting the larger drainage path.

Site 52a is approximately 158m above sea level at its centre and has surface features which are the least distinct regarding a surface drainage path. The site has a very gentle slope to the east (12m over 1.5km) and it has the smallest catchment area for rainwater run-on. The site is directly adjacent to a formed gravel road along the northern edge.

Geology

The material samples from each Stage 3 drill hole site were geologically logged. **Table 1** summarises the stratigraphy from the Stage 3 reverse circulation drilling and geological logs are provided in **Appendix 2**.

The surface clays at each site are generally reddish brown of medium plasticity, sometimes gypsiferous, becoming more plastic with depth, and with minor calcrete nodules at the base. The Tertiary silcrete at Site 45a is hard in bands, whereas massive hard to very hard silcrete occupies the top 0.5 to 1 metre of the Tertiary sequence at Site 40a. The silcrete is generally ferruginised at the top and contains quartzite cobbles in many places. Softer, fractured silcrete and calcrete were observed at Site 52a.

Weathering in the Simmens Quartzite (**P**ws) is highly variable and the degree of weathering changes across Sites 40a and 45a. Where **P**ws is deeply weathered, it is replaced (in bands) by white kaolinitic clay and pale greenish grey clays of low to medium plasticity. **P**ws appears to be a diagenetic weathering surface of the Corraberra Sandstone (**P**wc).

The boundary between **P**ws and the Corraberra Sandstone (**P**wc) is somewhat arbitrary – it was designated primarily on lithology (a change to maroon, generally fissile, silicified sandstone with siltstone interbeds typical of the **P**wc red beds), but also on hardness. At all locations, unaltered **P**ws is consistently harder than **P**wc, but the latter member is harder in drilling than it appears in outcrop. **P**wc invariably contains micaceous siltstone interbeds and is generally flaggy (most rock chips fracture along bedding planes). Highly micaceous sandstone bands within the **P**wc sequence were intersected in 40aN. Interbedded chocolate brown, very puggy, micaceous sandstones and siltstones underlying the Mesozoic sediments at Site 52a are correlated with **P**wc because the stage 3 drilling encountered underlying Woomera Shale (**P**wm).

The Bulldog Shale (Kmb) intersected in Site 52a is a monotonous sequence of white massive mudstone and siltstone, grading to pale yellowish brown or grey mudstone at depth. The top is salinised and kaolinised by prolonged and intense weathering (bleaching) – it is also highly gypsiferous and ferruginised in the upper part of the section. X-ray diffraction identified amorphous, opaline silica but there has been no trace of macroscopic opaline material to suggest gem quality or economic worth in material from the diamond cores and the percussion chips. The lower part of Kmb contains well rounded cobbles and boulders of quartzite. Kmb conformably overlies weakly indurated lithic and quartzose sandstones of the Cadna-owie Formation (Kco), a coarsening upward sequence from clayey fine sands at the base to fine to medium sands at the top. Bands containing loose sand were encountered at the top of Kco in about half of the holes drilled.

Stratigraphy

Stage 3 drilling

Stage 3 drilling commenced on 28/8/00 at site 45a and finished on 24/9/00 at site 40a. Twelve reverse circulation percussion holes were drilled at sites 45a and 52a, and fourteen were drilled at site 40a. Sampling from the cyclone was done every metre. When target depth was reached (usually in the range 70-100m), the holes were purged. Drillholes on the perimeter (prefixed '15' were left open with only a 1.5m x 150mm PVC standpipe installed; the internal 500m square (prefixed '50' were cased with 100 mm PVC, slotted adjacent to water cuts and completed as observation piezometers. All piezometers were pumped for water chemistry and isotope sampling.

Although the reverse circulation method provided high-quality uncontaminated samples, the hammer, and sometimes the inner tubes, tended to become blocked in saturated fracture zones and puggy clay sections. This presented a major problem at site 52a because of the generally puggy nature of **P**wc, but far less so at the other two sites. Bands of dry, loose sand at the top of Kco necessitated water injection in about half the holes at site 52a. Samples were split on site into two large sub-samples – one for analytical purposes, and a reference sample which is currently stored in Woomera. From the residue, material was wet-sieved and then placed into plastic sample trays – these are available for inspection at the BRS Land and Water Sciences Division laboratory.

Site 40a was shifted immediately to the north of its former location because of recommendations from the final round of site clearances under the SA Heritage Act in April-May 2000. As a result, the drillhole '40N' (Stage 1) becomes '40aS', and the drillhole '40S' (Stage 2) becomes redundant. Tables 1a, 1b and 1c contain stratigraphic summaries from the stage 3 percussion drilling at sites 40a, 45a and 52a respectively. The reader is referred to the stage 1 and stage 2 drilling reports for additional stratigraphic information from these and other investigated sites.

Table 1: SUMMARY OF REVERSE CIRCULATION DRILLING IN STAGE 3

TABLE 1a (1): STRATIGRAPHY OUTER SQUARE SITE 40a

	40a15E	40a15S	40a15N	40a15W
Clay	0-2	0-2	0-2	0-3
Silcrete	-	2-6	2-5	3-7
Simmens Quartzite	2-37	6-39	5-42	7-29
Corraberra Sandstone	37-76+	39-70+	42-69	29-67+
Woomera Shale	-	-	69-90+	-

	40a15NE	40a15NW		

Clay	0-3	0-2		
Silcrete	3-4	2-4		
Simmens Quartzite	4-38	4-29		
Corraberra Sandstone	38-59+	29-70		
Woomera Shale	-	70-82+		

TABLE 1a (2): STRATIGRAPHY INNER SQUARE SITE 40a

	40a50NW	40a50N	40a50NE	40a50W
Clay	0-2	0-3.5	0-3.5	0-3
Silcrete	-	3.5-6	3.5-6	3-8
Simmens Quartzite	2-31	6-24	6-33	8-34
Corraberra Sandstone	31-76+	24-73	33-74	34-77+
Woomera Shale	-	73-75+	74-76+	-

	40a50SW	40a50S	40a50SE	40a50E
Clay	0-3	0-2	0-2	0-2
Silcrete	3-5	2-6	-	2-4
Simmens Quartzite	5-27	6-34	2-40	4-44
Corraberra Sandstone	27-76	34-76	40-79	44-77
Woomera Shale	76-82+	76-82+	79-82+	77-82+

TABLE 1b (1): STRATIGRAPHY OUTER SQUARE SITE 45a

	45a15N	45a15W	45a15S	45a15E
Clay	0-2	0-3	0-2	0-3
Silcrete	2-6	3-6	2-4	3-6
Simmens Quartzite	6-26	6-31	4-18	6-36
Corraberra Sandstone	26-89+	31-70+	18-70+	36-70+

TABLE 1b (2): STRATIGRAPHY INNER SQUARE SITE 45a

	45a50NW	45a50N	45a50NE	45a50W
Clay	0-3	0-3	0-3	0-3
Silcrete	3-7	3-6	3-7	3-6
Simmens Quartzite	7-33	6-21	7-26	6-24
Corraberra Sandstone	33-76+	21-87+	26-89+	24-94+

	45a50SW	45a50S	45a50SE	45a50E
Clay	0-2	0-2	0-2	0-3
Silcrete	2-5	2-7	2-6	3-7
Simmens Quartzite	5-27	7-28	6-29	7-27
Corraberra	27-100+	28-76+	29-82+	27-82+

Sandstone				

TABLE 1c (1): STRATIGRAPHY OUTER SQUARE SITE 52a

	52a15NE	52a15NW	52a15SW	52a15SE
Clay	0-3	0-1.7	0-2.5	0-1
Silcrete	3-7*	1.7-2*	2.5-4.5*	1-2*
Bulldog Shale	7-13	2-16	4.5-23	2-19
Cadna-owie Formation	13-41	16-38	23-42	19-39
Corraberra Sandstone	41-65	38-75	42-67	39-74
Woomera Shale	65-70+	75-100+	67-70+	74-76+

TABLE 1c (2): STRATIGRAPHY INNER SQUARE SITE 52a

	52a50E	52a50NE	52a50N	52a50NW
Clay	0-1	0-1	0-1	0-2
Silcrete	1-2**	-	1-4*	2-4*
Bulldog Shale	2-14	1-13	4-15	4-19
Cadna-owie Formation	14-43	13-43	15-41	19-40
Corraberra Sandstone	43-65	43-65	41-66	40-64+
Woomera Shale	65-88+	65-76+	66-82+	-

	52a50W	52a50SW	52a50S	52a50SE
Clay	0-1	0-1	0-3	0-2.5
Silcrete	1-4***	1-3**	3-8**	2.5-4**
Bulldog Shale	4-23	3-23	8-27	4-20
Cadna-owie Formation	23-41	23-43	27-45	20-41
Corraberra Sandstone	41-64+	43-76+	45-82	41-64+
Woomera Shale	-	-	82-88+	-

Notes: * Silcrete soft and fractured.
** Loose calcrete, generally with fractured silcrete at base.
*** Silcrete and ferricrete.

Structure contour and isopach maps based on the detailed stratigraphic information obtained from the stage 3 and earlier drilling are shown in Appendix 3. The 1:10 000 scale base Simmens Quartzite map structure contour and isopach maps for site 40a (Appendix 3.1 and 3.2) show……….(*interpretation to follow*).

At site 45a, the 1:10 000 scale base **P**ws structure contour map (Appendix 3.3) indicates the surface dips from its highest elevation (115 m AHD) along the southern side of the outer square towards the northwest and east (lowest elevation 95 m), with a saddle at 105 m underlying most of the inner square . The geometry of base **P**ws appears to partially mimic the topography in the western half of the study area but its gradient is about twice as steep as the topography. However, there is negligible correlation between the topography and the pattern of the base **P**ws contours in the eastern half – this is because the structure contours define a chemical alteration surface, not a depositional one. The **P**ws isopachs for site 45a (Appendix 3.4) show the unit is thinnest (15 m) in the northeast quadrant of the inner square and along the southern boundary of the outer square. The detailed stage 3 drilling has delineated three distinct layers of clay mineralogical phases in the Simmens Quartzite at site 45a. The uppermost one third to half is characterised by pale grey to white, dominantly kaolinitic (non-plastic) clay with traces of pale greenish grey clay of low plasticity. The middle part of the section is composed of strong greenish grey and pistachio green clays of low to medium plasticity which probably contain significant illite interstratified with kaolinite. The basal part of the section, generally only a few metres thick, is characterised by yellowish grey clays of low plasticity and hydrated iron oxides. Generally the top half to two thirds of the clay bands in **P**ws are gypsiferous.

1:10 000 scale base Kmb structure contour map for site 52a (Appendix 3.5) shows the surface dips from 146 m AHD in the eastern and western corners of the outer square towards the southern part of the inner square where its minimum is 136 m. The configuration of base Kmb bears no relationship to the topography which falls from west to east. The Kmb isopachs (Appendix 3.6) depict Kmb as thinning from around 20 m in the southwest to 5 m in the eastern corner of the outer square. The structure contour map for base Kco at site 52a (Appendix 3.7) indicates the depositional surface dips from a maximum elevation of 124 m AHD in the southwest of the outer square towards the northeast where a minimum of 108 m occurs about midway between the inner and outer squares. Again there is negligible correlation between the topography and the base of the Cadna-owie Formation. The Kco isopachs (Appendix 3.8) show the unit thickening from almost 40 m in the east to less than 20 m in the south and southwest. The total thickness of the Mesozoic sequence (Kmb and Kco combined) varies between 35 and 45 m (see Mz isopachs, Appendix 3.9). The Mesozoic sediments at site 52a represent an isolated outlier of the western Eromanga Basin. They cannot extend for a large distance beyond the outer square because the area is completely surrounded by outcropping and subcropping Proterozoic rocks within a few kilometres.

Bands of dry, cohesionless fine sands occur at the top of Kco and, to a lesser extent, near the base of Kmb. Typically the bands are a few centimetres thick but individual beds range up to 30 cm in the southwest part of site 52a. The bands in Kmb are gritty and resemble ‘rock flour’ in appearance, and grain size ranges from coarse silt to very fine sand. In Kco the grain size ranges from fine to medium sand and the material is quartzose in composition; it is interbedded with very weakly cemented sandstones. Appendix 3.10 shows the occurrence and thickness of the dry, loose coarse silt – fine to medium sand bands at site 52a. They occur in a NW-SE arcuate band and attain a maximum thickness of 12 m along the southern and southwestern edges of the inner square. None of this unconsolidated material was detected in the northeastern half of the inner square.

All stage 3 drillholes at the three sites fully or partially penetrated the Corraberra Sandstone (**P**wc). **P**wc invariably contains micaceous siltstone interbeds and is generally flaggy (during percussion drilling most rock chips fracture along bedding planes). Highly micaceous sandstone bands within the **P**wc sequence were intersected at site 40a and variable but low concentrations of pyrite were dectected there between 35 and 45 m below ground surface. At site 40a, the pyritic zone in **P**wc grades down to a chocolate brown fine sandstone with claystone interbeds. **P**wc appears to be thickest (>75 m) and most homogenous at site 45a. At site 52a, micas in **P**wc are mostly degraded to illite which is responsible for its puggy nature in the saturated zone. **P**wc at site 52a also contains abundant chocolate brown interbedded mudstones. Base **P**wc structure contours and isopachs for site 52a are shown in Appendices 3.11 and 3.12. These maps show **P**wc is uniformly thin over the site (25 – 35 m) with a concave morphology, dipping shallowly from the southwest and northeast towards the southern half of the inner square.

HYDROGEOLOGY

Pwc is the regional unconfined aquifer at sites 40a and 45a. Groundwater flows through distinct fracture zones and rises in a standpipe to equilibrate with the regional hydrostatic pressure, or watertable. At site 52a, **P**wc is unconfined in the southwestern half of the outer square and under most of the inner square, and semi-confined elsewhere with the watertable lying in Kco (samples at the base of Kco were moist but did not appear to be saturated). Although the basal section of Kco is partially saturated at 52a, it is not hydraulically connected to the extensive aquifers of the Eromanga Basin to the west, nor is there any groundwater flow northward to the GAB from this area.

Stage 1 and stage 2 drilling indicated yields from all bores in **P**wc were low (< 1L/sec) and salinities were high (>= 8,000 mg/L TDS), and that, in general, yields are higher west of the Woomera – Roxby Downs Road than the east. Stage 3 drilling has not changed this picture. **Table 2** summarises the interim hydrogeology with standing water levels, estimates of air-lift yield, and field salinity measurements. **Appendix 4** shows contours of the potentiometric surface and groundwater flow directions at each of the sites.

TABLE 2a (1): HYDROGEOLOGY OUTER SQUARE SITE 40a

	40a15E	40a15S	40a15N	40a15W
Unsaturated zone (m)	65.1	69.4	65.8	n/a
Estimated salinity by refractometer (ppm)	21,500	n/a	26,000	n/a
Airlift yield (L/sec)	0.1	n/a	0.1	n/a

	40a15NE	40a15NW		
Unsaturated zone (m)	n/a	**65.8**		
Estimated salinity by refractometer (ppm)	n/a	25,500		
Airlift yield (L/sec)	n/a	0.01		

TABLE 2a (2): HYDROGEOLOGY INNER SQUARE SITE 40a

	40a50NW	40a50N	40a50NE	40a50W
Unsaturated zone (m)	63.6	66.7	66.5	67.5
Estimated salinity by refractometer (ppm)	22,000	24,000	22,000	14,500
Airlift yield (L/sec)	0.1	0.1	0.1	0.1

	40a50SW	40a50S	40a50SE	40a50E
Unsaturated zone (m)	66.4	68.7	67.5	67.9
Estimated salinity by refractometer (ppm)	20,000	22,000	20,000	20,000
Airlift yield (L/sec)	0.01	0.2	0.15	0.25

TABLE 2b (1): HYDROGEOLOGY OUTER SQUARE SITE 45a

	45a15N	45a15W	45a15S	45a15E
Unsaturated zone (m)	51.1	51.7	56.4	56.5
Estimated salinity by refractometer (ppm)	17,000	23,000	14,000	9,000
Airlift yield (L/sec)	0.05	0.25	0.08	0.08

TABLE 2b (2): HYDROGEOLOGY INNER SQUARE SITE 45a

	45a50NW	45a50N	45a50NE	45a50W
Unsaturated zone (m)	51.8	53.5	53.4	54.3
Estimated salinity by refractometer (ppm)	14,000	8,000	9,000	20,000
Airlift yield (L/sec)	0.4	0.05	0.05	0.05

	45a50SW	45a50S	45a50SE	45a50E
Unsaturated zone (m)	55.2	55.5	55.1	54.9
Estimated salinity by refractometer (ppm)	17,000	18,000	18,000	12,000

Airlift yield (L/sec)	0.05	0.4	0.05	0.25

TABLE 2c (1): HYDROGEOLOGY OUTER SQUARE SITE 52a

	52a15NE	52a15NW	52a15SW	52a15SE
Unsaturated zone (m)	43.2	39.0	n/a*	40.0
Estimated salinity by refractometer (ppm)	15,000	n/a*	n/a*	16,000
Airlift yield (L/sec)	1.5	0.05	0.5	0.4

* Uncased, hole collapsed.

TABLE 2c (2): HYDROGEOLOGY INNER SQUARE SITE 52a

	52a50E	52a50NE	52a50N	52a50NW
Unsaturated zone (m)	40.4	40.0	42.2	42.0
Estimated salinity by refractometer (ppm)	16,000	18,000	15,000	17,000
Airlift yield (L/sec)	0.05	0.5	0.1	0.3

	52a50W	52a50SW	52a50S	52a50SE
Unsaturated zone (m)	43.6	43.6	44.6	42.4
Estimated salinity by refractometer (ppm)	18,000	18,000	18,000	17,000
Airlift yield (L/sec)	0.5	0.25	0.25	0.75

The resolution of the refractometer measurements in Tables 2a (1) to 2c(2) is +- 500 ppm, and the readings may be slightly erroneous due to turbidity. Chemical analyses of the groundwaters are shown in **Appendix 5**. Basically all are Na-Cl type waters with subsidiary Ca-SO_4.

The potentiometry at site 45a (Appendix 4.2) indicates a dominantly SW to NE and E groundwater flow direction. The flow lines switch from NW to E along the northern edge of the outer square. Site 45a lies very close to a major groundwater divide in a flow field with the regional flow direction to the north then north east and discharge ultimately into Lake Torrens, 25 km to the north east. There is a head drop of 3 m across the outer square and the hydraulic gradient ranges from 1:170 in the south east quadrant to 1:400 along the SW-NE diagonal. The change in hydraulic gradient probably reflects a permeability contrast in **P**wc. The groundwater ‘drain’ running in an arc from 45a15SW through 45a50NW to 45a15NE (Appendix 4.2) suggests this is a zone of higher permeability (increased fracturing) because of the low gradient and the comparatively higher airlift yields obtained from these piezometers. Assuming a ‘background’ hydraulic conductivity of 0.05 m/day and 0.1 m/day for the more permeable section, and an effective porosity of 0.01, a lateral groundwater velocity of around 10 m/year is indicated for site 45a. The groundwater salinity at site 45a shows the greatest variation of the three sites investigated. Total dissolved salts range from 23,000 mg/L in the west of the outer square to between 8,000 and 9,000 mg/L on the eastern side (Appendix 4.3). The potentiometry indicates that the pod of ‘fresher’ water in the east cannot represent local recharge – it may be a pulse from an abnormally large rainfall event which occurred over a century ago and has travelled as an un-mixed package down gradient, or it may simply be an artefact of less salts available for dissolution in the aquifer in the eastern part of the study area.

The groundwater flow direction at site 52a is SW to NE (Appendix 4.4), sympathetic with the topographic gradient. The head drop is 10 m over 1.5 km with a fairly uniform hydraulic gradient of 1:150, apart from a SW – NE groundwater ‘mound’ in the inner square. The mounding develops where the watertable switches from **P**wc to Kco, and indicates the **P**wc fractures are actually more permeable than the basal section of Kco. Site 52a lies a few kilometres north of a major groundwater divide – the regional flow line through 52a is about 100 km long, heading northeast toward Olympic Dam and beyond that to its discharge zone in Lake Torrens. The lateral groundwater velocity beneath site 52a is estimated to be around 20 m/year. Airlift yields are reasonably consistent at around 0.4 L/sec and the groundwater salinity is uniform over the study area, averaging 16,000 mg/L TDS.

Groundwater Recharge

Three methods were used to estimate groundwater recharge:

1. Chloride mass balance in the saturated zone.
2. Chloride mass balance (coupled with moisture and bulk density) profiling in the unsaturated zone (**Appendix 6**).
3. Groundwater age estimation using the unstable isotopes ^{36}Cl and ^{14}C (**Appendix 7**).

In related experiments, CSIRO/ANSTO measured deep drainage at 1.5 m beneath clays at Pimba. Deep drainage below a non-vegetated desert loam was estimated to be 0.2 mm/year and two orders of magnitude less for a vegetated (*Atriplex*) surface (deep drainage provides an upper bound for recharge).

1. Chloride mass balance – saturated zone

Chloride mass balance in the saturated zone is the simplest technique for recharge estimation. The method assumes one-dimensional piston flow and produces a lumped historic recharge rate damped against variations in rainfall and weather patterns, and chloride input. The method also assumes that evaporated rainfall and dryfall are the sole sources of chloride to the system. Using an “average annual” rainfall of 180 mm at sites 40a and 45a, and 190 mm at site 40a, coupled with an average annual atmospheric Cl input of 4 mg/L (combined wet and dry fall), and mean Cl concentrations of 13,000, 12,000 and 8,500 mg/L in groundwaters at sites 40a, 45a and 52a respectively, the chloride mass balance method gives a recharge rate of 0.06 mm/year at sites 40a and 45a, and 0.09 mm/year at site 52a. Within the limits of accuracy of the method, the chloride mass balance technique thus gives indicative recharge rates of the order of 0.05 mm/year in areas underlain by **P**ws/**P**wc and about 0.1 mm/year in an area underlain by Kmb/Kco/**P**wc. If effective porosity of **P**ws, **P**wc and Kmb is assumed to be 0.01, and 0.05 in Kco, the wetting front velocity is about 6 mm/year at sites 40a and 45a, and 3 mm/year at site 52a. Hence it would take 11,000 years for infiltration through the 67 m-thick unsaturated zone at site 40a, 9,000 years to infiltrate the 55 m-thick unsaturated zone at site 45a and 14,000 years through 41 m of unsaturated zone at site 52a.

2. Chloride mass balance – unsaturated zone

For the unsaturated zone profiling, cubes of diameter 3 to 5cm were cut at selected intervals from the drillcore at two diagonally opposite cored holes in the outer squares at sites 40a, 45a and 52a. Chloride concentrations in the unsaturated zone, calculated from 1:5 dilutions, are shown in Appendix 6.1. Since sites 40a and 45a are composed of similar lithologies, they will be described first.

At site 40a, chloride concentrations of the order of 35,000 mg/L were measured in the surface clays of both drillholes (40aE and 40aW). Very high chloride concentrations were recorded in the Simmens Quartzite, peaking at 0.5 Kg/L at 11m depth in both drillholes. These values are probably more apparent than real because of the extremely low gravimetric moistures in the quartzite matrix. Thereafter, there was negligible correlation in depth vs chloride concentrations between the two drillholes. In 40aE, chloride concentrations fell to around 25,000 mg/L between 15 and 10m before rising to 0.35 Kg/L in a secondary peak between 24 and 35m; the underlying Corraberra Sandstone had chloride concentrations of around 0.1 Kg/L down to 42m and then fell steeply to around 5000 mg/L to the bottom of the hole at 49m. In 40aW, chloride concentrations in the Simmens Quartzite exceeded 0.1 Kg/L down to 25m, whereupon they fell to around 35,000 mg/L to the contact with the Corraberra Sandstone at 34m; chlorinities in **P**wc were generally higher than 0.1 Kg/L throughout the cored section to 51m.

Chloride concentrations in the surface clays at site 45a vary from 30,000 mg/L at drillhole 45aNW to in excess of 100,000 mg/L at 45aSE. As at site 40a, chlorinities in the Simmens Quartzite are highly variable between drillholes at site 45a. In drillhole 45aNW, the background chloride concentration in

Pws is around 5000 mg/L apart from spikes of 50,000 mg/L at 6m and 30,000 mg/L at 16m. Background chloride concentrations then rise gradually below the Corraberra Sandstone contact (at 24m) to 9000 mg/L at the bottom of the hole at 43m, with a spike of 48,000 mg/L at 36m. However in drillhole 45aSE, chlorinities are reasonably constant between 30,000 and 40,000 mg/L throughout **P**ws. Below the Pwc contact at 25m, chloride concentrations show a sustained rise, peaking close to 0.6 Kg/L at 36-38m before falling to around 30,000 mg/L at the bottom of the hole at 47m. Thus, the essential difference between the site 45a drillholes is that 45aNW contains layers of lower chlorinity water in **P**ws than 45aSE, and the latter contains appreciably higher chloride concentrations in **P**wc.

Volumetric moisture contents for the cores from sites 40a and 45a are shown in Appendix 6.2. Clay bands in **P**ws in drillhole 40aE have volumetric moistures ranging between 0.2 and 0.4, whereas moistures in the quartzite are very low, ~0.01. Two clay bands near the base of **P**ws in drillhole 40aW have moisture contents between 0.4 and 0.5, and again very low moistures in the quartzite. Clayey bands in **P**wc in 40aE have moisture contents ~0.2 and very low (~0.01) moistures in the silicified sandstone beds, whereas **P**wc moistures are uniformly low (0.01 to 0.04) in 40aW.

Volumetric moisture contents in **P**ws at 45aNW show a similar pattern to site 40a, with moistures in the range ~0.25 to ~0.35 in the clay bands and around 0.01 in the quartzite layers. In common with site 40a, volumetric moistures in the **P**ws clay seams tend to be higher in the bottom half of the unit, reflecting the higher plasticity and greater water holding capacity of the (greenish) illite clays over kaolinite. In 45aSE, the generally higher volumetric moistures (0.2 to 0.35) in **P**ws are a consequence of the greater proportion of clay relative to 45aNW. As in drillhole 40aE, volumetric moisture contents in **P**wc at site 45a are erratic, ranging from 0.2 to 0.3 in clayey layers to ~0.01 in clean silicified sandstone beds.

Appendix 6.3 shows plots of cumulative water against cumulative chloride. Drillholes 40aE and 40aW show a similar multi-segmented form. Steep rises in cumulative chloride occur in both drill cores in certain sections of **P**ws (7 to 16m and 19 to 24m in 40aE, 10 to 25m in 40aW) coinciding with quartzite-rich zones having negligible clay bands. As noted earlier, the calculated chloride concentrations derived from 1:5 dilutions of the quartzite pore fluids are suspect because small errors in 1:5 eluent concentration or in gravimetric moisture content have the potential to generate large errors in the converted data.

If recharge is solely by piston flow and the chloride flux at ground surface has been constant, cumulative chloride as a function of cumulative water should be a straight line. Therefore, either (1) the assumption of recharge by piston flow at site 40a is not valid, or (2) the chloride flux has not been constant through time, or (3) not all the chloride comes from atmospheric sources. An alternative explanation is the cumulative chloride values in the quartzite-rich zones of **P**ws are invalid, ie the chloride mass balance method is strictly not applicable here. If this is correct, we may still use the chloride and moisture characteristics of the clayey zones of **P**ws to estimate recharge. This gives a reasonably uniform estimated recharge of 0.02 mm/year for both 40aE and 40aW, assuming a chloride accession rate of 0.76 $gm^{-2}yr^{-1}$.

The slope of the cumulative chloride curve for drillhole 45aSE (Appendix 6.3) is about 4 times that of 45aNW, but both plots display a greater degree of linearity than the site 40a drillholes. Also, cumulative water for site 45a is about double that of site 40a. Both of these factors reflect the generally higher clay content in **P**ws at site 45a relative to site 40a. Again, assuming piston flow recharge and a constant chloride flux rate through time, recharge rates of 0.02 mm/year for drillhole 45aSE are indicated, whereas 45aNW gives a recharge rate of 0.02 mm/year through the surface clay, but an apparent admittance rate of 0.17 mm/year through **P**ws. This seems to indicate preferential flow or possibly a different palaeorecharge regime, and illustrates the marked salinity variations in the unsaturated zone across the site.

Chloride concentrations are between 50,000 and 100,000 mg/L in the surface clays at site 52a (Appendix 6.1), similar to site 45a. Thereafter, chloride concentrations decrease in the Bulldog Shale, to nearly 30,000 mg/L through the thin section of Kmb at drillhole 52aNE, and to an average of 20,000 mg/L in drillhole 52aSW. The generally downward trend in chloride concentration with depth continues through the Cadna-owie Formation – in drillhole 52aNE, average chlorinity is 25,000 mg/L in the upper half of Kco (to 31m depth) and then displays a sustained fall to 7000 mg/L, continuing into **P**wc. Apart from an anomolous spike of 80,000 mg/L at 23.5m, the same general pattern of decreasing Cl with depth is displayed in Kco at drillhole 52aSW. Here, chlorinity drops from around 20,000 mg/L at the top of Kco to 12,000 mg/L at the base at 48m. The downward trend continues into **P**wc, where the average pore-water chloride concentration is 8000 mg/L.

Chloride profiles in drillholes 52aNE and 52aSW display greater homogeneity than at site 40a and 45a, a consequence of different lithologies, and are easier to interpret. At 52a, the bulge in chloride in the top $1^{1}/_{2}$ metres represents concentration by evapo-transpiration of vegetation (*Atriplex*). The background level of ~20,000 mg/L in Kmb and the upper section of Kco represents the equilibrium chloride concentration below the root zone, and it is this value which should be used for mass balance calculations. The downward trends in chloride concentration in the lower section of Kco and in **P**wc represent diffusive loss of chloride to the watertable (the watertable lies about 40m below ground surface).

Volumetric moisture contents in Kmb beneath the root zone are reasonably uniform, between 0.4 and 0.5, in both 52aNE and 52aSW (appendix 6.2). Kco is characterised by generally erratic moistures, ranging from ~0.4 in clayey bands to ~0.05 in the clean sand(stone) layers – drillhole 52aNE shows more uniformity than 52aSW because of the former's higher sand proportion. Both of the 52a cores show rising volumetric moistures in the basal section of Kco and in **P**wc.

In contrast to sites 40a and 45a, cumulative chloride as a function of cumulative water is approximately linear throughout the unsaturated zone at site 52a (Appendix 6.3). Mass balance calculations give a recharge rate of 0.03 mm/year for 52aNE and 0.05 mm/year for 52aSW (Kmb and upper Kco). Inflexion points in the cumulative plots occur where diffusive losses of chloride to the fresher watertable start to operate in the basal part of the Kco aquifer.

3. Groundwater age estimation - ^{36}Cl and ^{14}C

(Awaiting interpretation of data)

Recharge processes indicated by deviation of the stable isotopes δ^{18}O and δD from the meteoric water line

Oxygen–18 and deuterium data for all bores pumped during stage 1, 2 and 3 drilling are shown in Appendix 8. The regional groundwaters have δ^{18}O values ranging from $-6^{0}/_{00}$ (Paradise Well, near site 10a) to $-1^{0}/_{00}$ (12SE) and δ^{2}H values ranging from $-44^{0}/_{00}$ to $-21^{0}/_{00}$ for the same wells. Figure 3 shows a plot of the δ^{18}O and δ^{2}H groundwater values and their positions relative to the Adelaide and Alice Springs Meteoric Water Lines. All groundwater samples plot to the right of the meteoric water lines in Fig 3, indicating fractionation by evapo-transpiration of infiltrating rainwater prior to recharge of the aquifers. The eight samples from site 52a are heavier (ie more evaporated) than those from 45a and 40a (there was only one sample collected from site 40a).

Also shown in Fig 3 are the isotopic compositions of the long-term monthly amount weighted means for Adelaide and Alice Springs rainfall. Both show increasing depletion in the stable isotopes with rainfall intensity. The intercept of the groundwater evaporation line and the meteoric water lines should define the recharge threshold. According to Fig 3, recharge only occurs after amounts of at least 80mm in a single month for rainfall emanating from the south (Adelaide – winter maximum) or for higher intensity events of 100-150mm in a single month for rainfall emanating from the north (Alice Springs – summer maximum). Figure 4 shows the frequency of rainfall events which exceeded 80mm in a single month for Andamooka (record 1965-1998) and Woomera (1895-1998). The majority are summer thunderstorm events, and these higher intensity rainfalls appear to be more frequent at Andamooka (11 events over 33 years) compared to Woomera (15 events over 103 years), despite there being no significant difference in average annual rainfall between the two stations. The implication here is that the potential for recharge at site 45a (closest to Andamooka) is higher than at sites 52a or 40a. Whether or not this actually occurs depends on the substrate permeability.

Figure 3 Oxygen-18 and Deuterium values of regional groundwater samples relative to Adelaide and Alice Springs Meteoric Water Lines

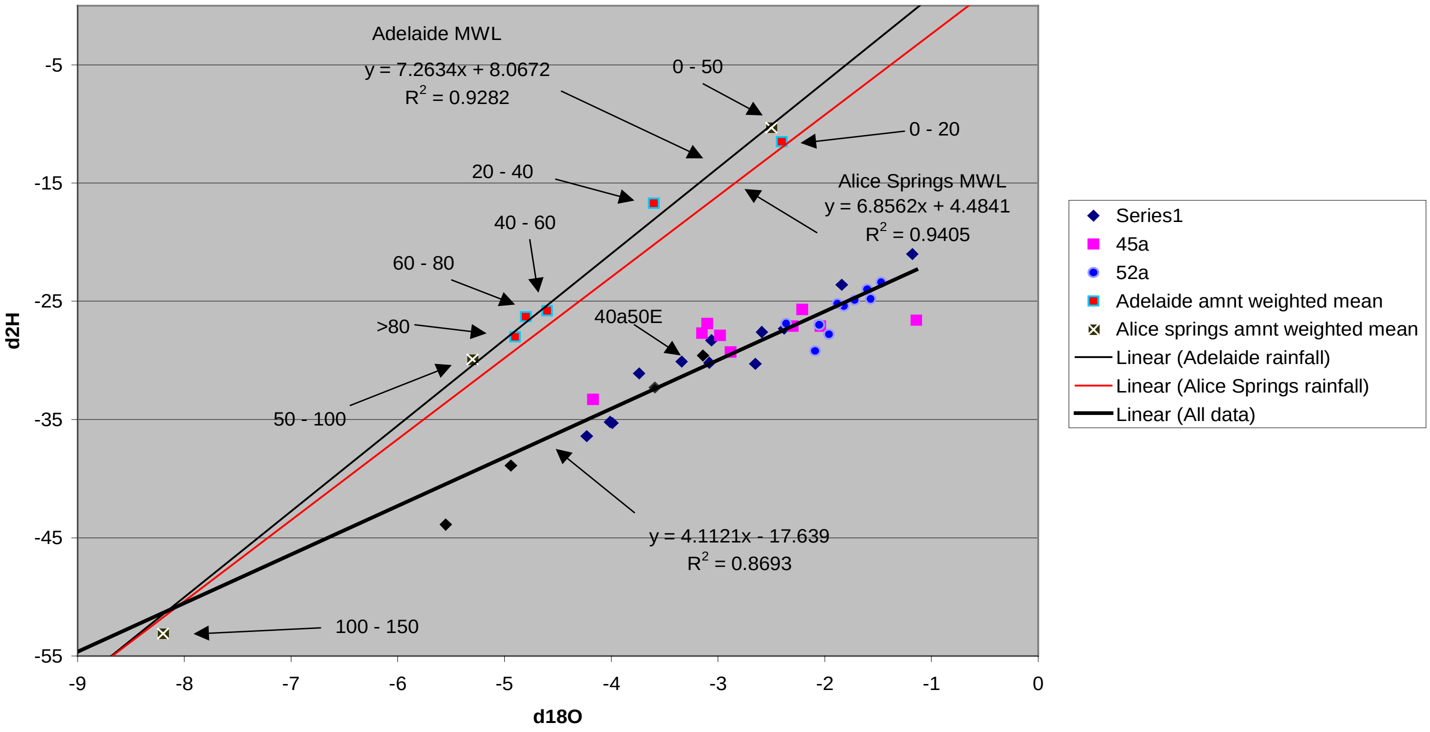


Figure 4a Andamooka Monthly Rainfall > 80mm (1965-1998)

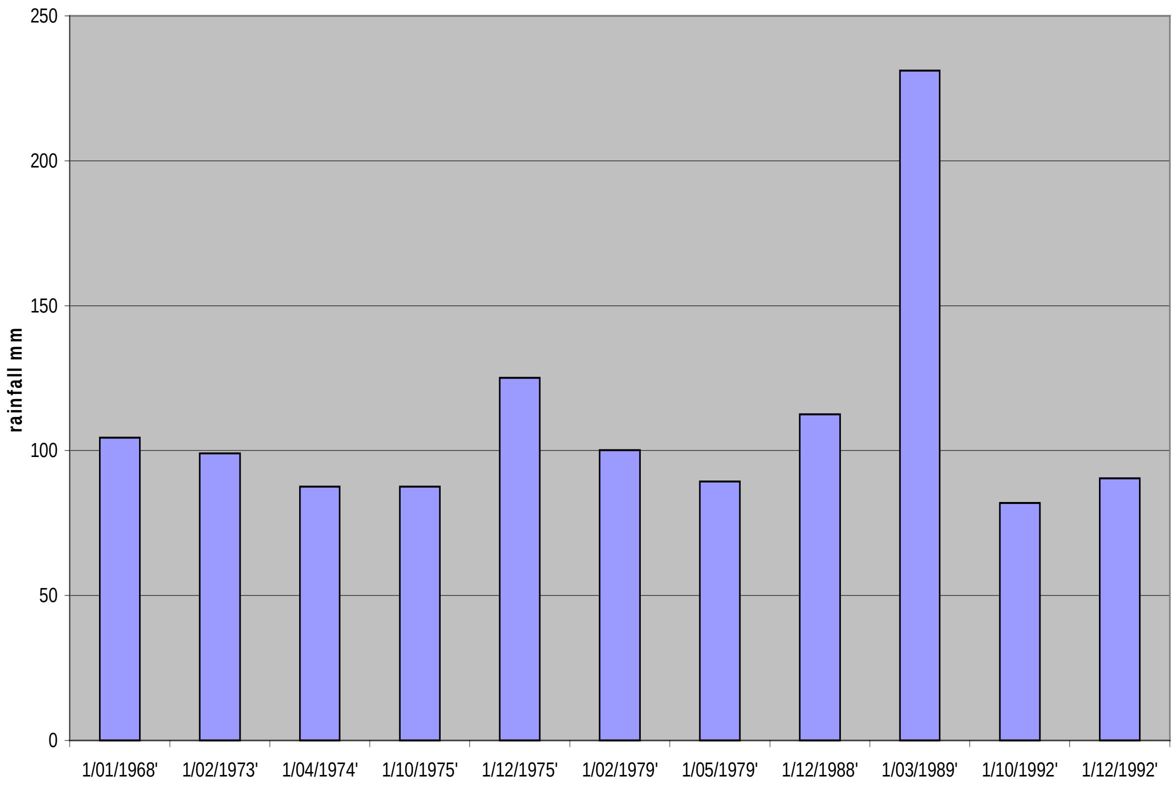
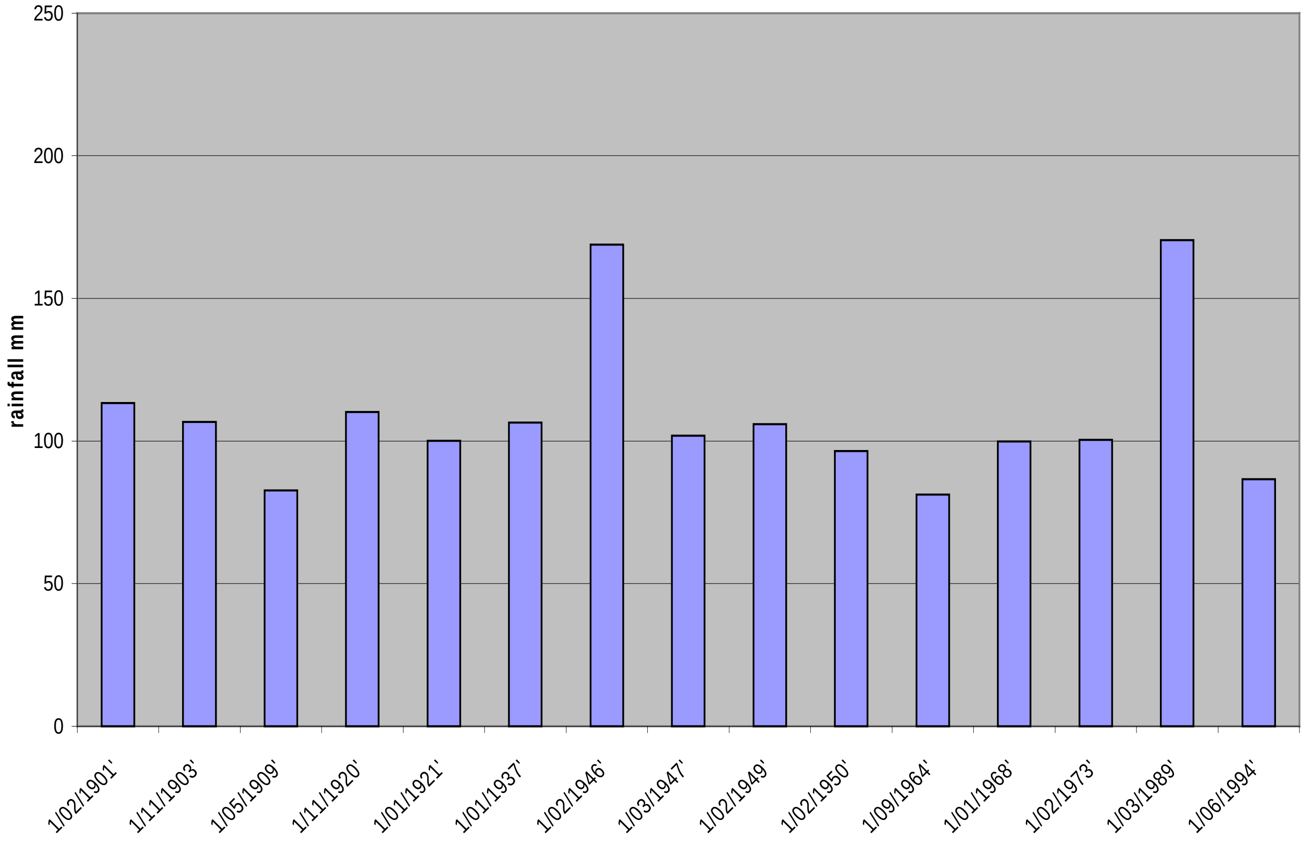


Figure 4b Woomera Monthly Rainfall > 80mm (1895-1998)



Summary of recharge rates and groundwater residence times

Comparisons of recharge rates estimated by chloride mass balance in the saturated and unsaturated zone are shown in Table 2d. Also shown are estimated and observed groundwater ages based on residence times in the unsaturated zone under conditions of one-dimensional vertical piston flow-type recharge.

TABLE 2d: RECHARGE RATES AND GROUNDWATER AGES/RESIDENCE TIMES

Recharge rates (mm/year)

Method	Site 40a	Site 45a	Site 52a
Cl mass balance (sat. zone)	0.06	0.06	0.09
Cl mass balance (unsat. Zone)	0.02	0.02 – 0.17*	0.03 – 0.05

Residence times in unsaturated zone (years)

Cl mass balance (sat. zone)	11,000	9,000	14,000
Cl mass balance (unsat. Zone)	33,000	3,000* - 27,000	25,000 – 42,000
Carbon-14	N/a	>30,000	>30,000
Chlorine-36	N/a	<100,000	N/a

*probably via preferential flow path

There is a marked discrepancy between the recharge rates estimated by chloride mass balance in the saturated and unsaturated zones. More credibility should be placed on the unsaturated zone analyses, especially for site 52a. The chloride and moisture vs depth patterns, and the linearity of the cumulative chloride profile support the assumption of piston flow-type recharge at site 52a. These plots also indicate the presence of a diffusion gradient to a fresher watertable. Therefore, the saturated zone consists of a mixed groundwater system with two end members – (1) a downward piston-type flux with residence times of 25,000 to 40,000 years in the unsaturated zone, and (2) a lateral throughflow component of lower chlorinity whose residence time in the saturated zone may be as short as 800 years after infiltration (based on a regional groundwater velocity of 7 m/year in **P**wc in response to a head drop of 24m from the groundwater divide 6 km to the SW).

The chloride and moisture vs depth patterns indicate the chloride mass balance technique (for both saturated and unsaturated zones) is strictly not appropriate for recharge estimation at sites 40a and 45a. Even allowing for experimental error, pore fluids in the tight quartzite layers in **P**ws appear to be of brine-like composition. These fluids are not in equilibrium with modern groundwater and their age is unknown. It is likely that chloride is diffused into the unsaturated zone from these layers and this violates the assumption of the sole source of chloride being atmospheric input. In addition, the chloride and moisture patterns in drillhole 45aNW strongly suggest the existence of preferential flow paths in **P**ws, violating the assumption of piston flow. The conceptual model for evolution of groundwater at sites 40a and 45a is therefore a ternary mixing system, composed of the following end members:

(1) non-uniform recharge through clay and clayey sandstone bands in **P**ws at a rate of about 0.02 mm/year and residence times in the unsaturated zone of the order of 30,000 years;
(2) a lateral throughflow component of lower chlorinity which has probably been recharged locally through preferential flow paths (eg. fractures, porous sandstone bands);
(3) diffusion of salts from tight sections of quartzite in **P**ws.

Radionuclide sorption

The ability of the geologic materials to adsorb radionuclides and to retard their movement relative to water movement is an important characteristic for the repository site selection. ANSTO and CSIRO have measured radionuclide retardation properties of representative samples from the drilling program in the CNSA region and used the results to compare the properties of the profiles at sites 40a, 45a and 52a.

ANSTO and CSIRO, with the assistance of BRS, selected 37 drill samples as being representative of the lithologies present across sites in CNSA. These samples were from 10 drill holes and at depths from 1.5 m to 77.5 m. Batch and column experiments were used to determine the retardation of radionuclides cobalt-60 and cesium-137 in the drill samples from the field. Cobalt-60 and cesium-137 have readily detectable gamma rays, will be present in the waste for disposal at the repository and are each representative of the chemistry of a class of radionuclides.

Batch experiments were undertaken with two different background electrolytes (NaCl at 0.5 M and saturated gypsum $CaSO_4$ solution). NaCl represents the major salt component of infiltrating and ground waters, and gypsum ($CaSO_4$) is abundant in many of the profiles. For cobalt, where the distribution coefficient is strongly pH dependent, the distribution coefficients in NaCl were measured at both the equilibrium pH of the samples and at a pH of about 6.75.

The results for the range of samples selected gave a good indication of the relative radionuclide retardation in the types of geological material expected in and below the repository zone. The results are for samples that were heavily comminuted by the reverse circulation percussion drilling program which produces samples that are relatively clean and not contaminated by material from above the indicated depth, but are substantially physically modified. This comminution does not affect the mineralogy, even though structure is greatly altered. The conclusions presented here assume that the comminution of the samples does not significantly change the relative adsorptive properties of the materials.
The distribution coefficients measured in the laboratory batch experiments show that:

- trace cesium-137 is retarded in all profiles;
- retardation of trace cobalt-60 is more variable and depends on the pH. For some samples from greater than 30 m, the equilibrium pH was less than 5, suggesting oxidation of contained pyritic

material during drilling, storage and/or experiment. Since this oxidation will not occur unless the material is broken up and exposed to the atmospheric oxygen and these samples are from a depth that will not be disturbed in repository construction, the assessment should be based on the experiments with controlled pH. Under the controlled pH conditions, the distribution coefficient for cobalt-60 exceeded 50 mL/g for all formations;

- the Simmens quartzite formation has a reasonable retardation due to the many clay bands;
- the Bulldog shale has reasonable levels of retardation, with the retardation decreasing to a low value near the bottom of the formation;
- some of the Cadna-owie sandstone has low retardation;
- the Corraberra formation seems favourable for retention of the studied radionuclides, presumably due to the presence of various minor phases such as mica and oxides which have good characteristics. The Corraberra underlying site 52a performed particularly well for a sandstone at retaining the radionuclides.

The relative radionuclide retardation properties of the profiles at sites 40a, 45a and 52a have been inferred using comparisons of the Simmens, Bulldog, Cadna-owie and Corraberra formations that appear at these sites. Overall, the three sites appear to have reasonable retardation properties and include surface layers of highly retarding material.

Lack of information on the hydraulic properties of profiles below the soil layer means that estimates of the rate of migration of the radionuclides in these profiles is uncertain. In the desert loams of the region, however, deep drainage at 1.5 m below non-vegetated surfaces is only about 0.1% of rainfall (about 0.2 mm/year; cf. groundwater recharge rates estimated by chloride mass balance of 0.05 mm/year). The measured properties of a clay material very similar to site 52a, and historical daily rainfall and evaporation data over a period of 29 years at the site indicate that, if the site is well vegetated, then the cumulative deep drainage is of order 10^{-3} mm/year. As a result, residence times for water in the vadose zone above the water table are very great.

In conclusion:

a) all three sites have sufficient clay and other adsorbing materials in the profile to adequately retard radionuclides;

b) site 52a has morphological and chemical properties consistent with a very low recharge;

c) the radionuclide retardation data of the samples analysed does not provide a basis to rank any of the sites as significantly more favourable in terms of ability to retard nuclides.

A summary of distribution coefficients from batch experiments is shown in **Appendix 9**.

Geotechnical assessment

Various methods were used to obtain information about the geotechnical properties at each site. The observations made from the drilling included:

1. an assessment of rock hardness during reverse circulation drilling (**Appendix 10**);
2. an estimate of the proportion of sand to clay/silt fractions for the top 40 m of each hole from the rock chip samples by texture (**Appendix 11)**.

The hardness assessments are qualitative and are based soley on the drilling rate experienced using one compressor on the rig. As noted earlier, **P**ws, and to a lesser extent, **P**wc, are characterised by hard to very hard bands of silicified sandstone and quartzite, interlayered with much softer clay bands. Proportions of hard to soft lithologies vary both laterally and with depth. For this reason, the following hardness categories were adopted for the drilling program:

SOFT
SMHB = soft with minor hard bands (soft>>hard)
ASHB = alternating soft and hard bands (soft>hard)
HBANDS = hard bands (soft~hard)
AHSB = alternating hard and soft bands (hard>soft)
HARD

VHARD = very hard

For the VERY HARD category it was necessary to use both compressors and maximum revolutions. The rocks were very abrasive on the hammer. It must be emphasised that the hardness characteristics represent conditions at one point of the site only. However, the general trend observed was one of increasing hardness of both **P**ws and **P**wc southward. The degrees of hardness may be approximately equated with excavatability/rippability by class 200C bulldozer as follows:

SOFT	No ripping should be required – excavation by Caterpiller D8/D9 (or equivalent) bulldozer blade or scraper.
SMHB	Light ripping with D8/D9 (3 tyne) may be required.
ASHB	Light to moderate ripping with D8/D9 (1-3 tyne) required.
HBANDS	Heavy ripping with D8/D9 (single tyne) required.
AHSB	Heavy ripping with blasting to loosen.
HARD	Heavy ripping with blasting to loosen, may require fragmentation blasting.
VHARD	Fragmentation blasting required.

Metre by metre hardness characteristics for the three sites to a depth of 20 m are shown in **Appendix 10**. Site 52a had the highest proportion of soft rocks in the top 20 m, around 80%, with the harder layers occurring in the near-surface fractured silcrete or as thin silicified bands in the Bulldog Shale. Site 45a generally had hard to soft ratios of around 60:40 in the top 20 m (although the eastern and northern areas were characterized by very hard sections of **P**wc at depth which would not affect trench construction). The general pattern at site 45a is one of hard quartzite layers in the silcrete which would probably require heavy ripping for 3 to 4 m beneath the clay. Beneath the silcrete, **P**ws is generally softer because of its clay bands but if some of the hard quartzite layers prove to be laterally extensive, some blasting to loosen may be required. (*site 40a exhibited the hardest rocks in the top 20 m. Ian to comment?)*

Suitability of drill sites

The drilling results permit a semi-quantitative ranking to be made of their suitability for a repository, based solely on geological and hydrogeological criteria. In order to rank them objectively, the following ratings for hardness in the top 20 m, lithology (above and below a 20-metre deep trench), thickness of the unsaturated zone below 20 m, and water quality/yield were used :

Hardness	Rating	% silt + clay	Rating	Unsaturated zone below 20 m	Rating
VHARD	0	<5	0	0 – 5 (m)	0
HARD	1	5 – 10	1	5 – 6	1
AHSB	3	10 – 20	2	6 – 7	2
HBANDS	4	20 – 30	3	7 – 8	3
ASHB	6	30 – 40	4	8 – 9	4
SMHB	8	40 – 50	5	9 – 10	5
SOFT	10	50 – 60	6	10 – 11	6
		60 – 70	7	11 – 12	7
		70 – 80	8	12 – 13	8
		80 – 90	9	13 – 14	9
		>90	10	>14	10

Groundwater quality (mg/L TDS)	Rating	Airlift yield (L/sec)	Rating
<3000	0	>5	0
3000 – 7000	1	1 – 5	1
7000 – 12,000	2	0.5 – 1	2
12,000 – 20,000	3	0.2 – 0.5	3
20,000 – 35,000	4	0.1 – 0.2	4
>35,000	5	<0.1	5

Under this scheme, the maximum possible score is 50 if the percentage silt + clay is counted twice, ie. for 20 m above and below the base of the trench, and salinity/yield are combined. Percentage silt + clay is a field surrogate for adsorption. The suitability matrices are shown in Tables 3.1 to 3.3. Table 3.4 shows a summary of grand means and standard deviations of the ratings for the three sites.

TABLE 3.1: SUITABILITY OF SITE 40a DRILLHOLES BASED ON FIELD PARAMETERS (GEOLOGY AND HYDROGEOLOGY)

Field Parameter	**40a15NE**	**40a15SE**	**40a15S**	**40a15W**	**40a50W**	**40a50NW**	**40a50N**	**40a50NE**	**40a50E**
Hardness (0 –10)	3	45	3	8	5	4	2	4	4
% Silt + Clay 0 – 20 m (0 – 10)	3	3	3	3	3	3	3	3	3
% Silt + Clay 20 – 40 m (0- 10)	2	2	5	2	3	2	3	3	3
Unsat. Zone Below 20 m (0 – 10)	10	10	10	10	10	10	10	10	10
Water quality (0 – 5)*	3	4	4	3	3	4	4	4	4
Airlift yield (0 – 5)*	5	5	5	4	4	4	4	4	3
Score (max. 50)	**26**	**28**	**29**	**30**	**28**	**27**	**26**	**28**	**27**

* from driller or other estimates

Field Parameter	**40a50SE**	**40a50S**	**40a50SW**	**40a15E**	**40a15NW**	**40a15N**
Hardness (0 –10)	4	3	4	4	2	4
% Silt + Clay 0 – 20 m (0 – 10)	3	3	4	3	3	3
% Silt + Clay 20 – 40 m (0- 10)	4	4	3	3	4	3
Unsat. Zone Below 20 m (0 – 10)	10	10	10	10	10	10
Water quality (0 – 5)*	4	4	4	4	4	4
Airlift yield (0 – 5)*	4	4	5	4	5	4
Score (max. 50)	**29**	**28**	**30**	**28**	**28**	**28**

- from driller or other estimates

TABLE 3.2: SUITABILITY OF SITE 45a DRILLHOLES BASED ON FIELD PARAMETERS (GEOLOGY AND HYDROGEOLOGY)

Field Parameter	**45a15N**	**45a15W**	**45a15S**	**45a15E**	**45a50NW**	**45a50N**
Hardness (0 –10)	4	5	6	4	4	5
% Silt + Clay 0 – 20 m (0 – 10)	4	5	6	4	5	5
% Silt + Clay 20 – 40 m (0- 10)	3	5	2	3	3	2
Unsat. Zone Below 20 m (0 – 10)	10	10	10	10	10	10
Water quality (0 – 5)	3	4	3	2	3	2
Airlift yield (0 – 5)	5	3	5	5	3	5
Score (max. 50)	**29**	**32**	**32**	**28**	**28**	**29**

Field Parameter	**45a50NE**	**45a50W**	**45a50SW**	**45a50S**	**45a50SE**	**45a50E**
Hardness (0 –10)	5	6	4	5	4	4
% Silt + Clay 0 – 20 m (0 – 10)	5	5	4	4	3	4
% Silt + Clay 20 – 40 m (0- 10)	3	3	2	3	3	3
Unsat. Zone Below 20 m (0 – 10)	10	10	10	10	10	10

Water quality (0 – 5)	2	4	3	3	3	3
Airlift yield (0 – 5)	5	5	1	5	3	3
Score (max. 50)	**28**	**32**	**24**	**30**	**26**	**27**

TABLE 3.3: SUITABILITY OF SITE 52a DRILLHOLES BASED ON FIELD PARAMETERS (GEOLOGY AND HYDROGEOLOGY)

Field Parameter	**52a15NE**	**52a15NW**	**52a15SW**	**52a15SE**	**52a50E**	**52a50NE**
Hardness (0 –10)	8	10	9	10	7	8
% Silt + Clay 0 – 20 m (0 – 10)	5	6	8	6	5	4
% Silt + Clay 20 – 40 m (0- 10)	2	1	3	2	2	2
Unsat. Zone Below 20 m (0 – 10)	10	10	10	10	10	10
Water quality (0 – 5)	3	3	3	3	3	3
Airlift yield (0 – 5)	1	5	3	3	5	3
Score (max. 50)	**29**	**35**	**36**	**34**	**32**	**30**

Field Parameter	**52a50N**	**52a50NW**	**52a50W**	**52a50SW**	**52a50S**	**52a50SE**
Hardness (0 –10)	8	9	9	8	9	9
% Silt + Clay 0 – 20 m (0 – 10)	5	7	7	8	6	6
% Silt + Clay 20 – 40 m (0- 10)	2	2	2	2	3	3
Unsat. Zone Below 20 m (0 – 10)	10	10	10	10	10	10
Water quality (0 – 5)	3	3	3	3	3	3
Airlift yield (0 – 5)	4	3	3	3	3	2
Score (max. 50)	**32**	**34**	**34**	**34**	**34**	**33**

TABLE 3.4: GRAND MEANS AND STANDARD DEVIATIONS OF RATINGS BASED ON GEOLOGICAL AND HYDROGEOLOGICAL PARAMETERS

Field parameter	40a (n=15)	45a (n=12)	52a (n=12)
Hardness 0-20m	3.9 ± 1.4	4.7 ± 0.8	**8.7 ± 0.9**
Silt + clay 0-20m	3.0± 0.4	4.5 ± 0.8	**6.1 ± 1.2**
Silt + clay 20-40m	**3.1 ± 0.9**	2.9 ± 0.8	2.2 ± 0.6
Unsat zone >20m	10	10	10
Water quality	**3.8 ± 0.4**	2.9 ± 0.7	3.0 ± 0
Yield	**4.3 ± 0.6**	4.0 ± 1.4	3.2 ± 1.1
Score	28.0 ± 1.2	28.8 ± 2.5	**33.1 ± 2.0**

For the hardness criterion, Table 3.4 shows the mean rating for site 52a is significantly better than sites 40a and 45a. This is a consequence of the dominance of the Bulldog Shale in the top 20 m at site 52a, and its relative softness, compared to the Simmens Quartzite at sites 40a and 45a. In practical terms this translates to be able to excavate a trench at site 52a by bulldozer blade with perhaps some light ripping, whereas extensive ripping would be required over parts of site 45a and over most of site 40a. The homogeneous, fine-grained nature of the Bulldog Shale is the reason why site 52a also rates significantly higher than site 40a for the silt + clay 0 – 20m criterion, and marginally higher than site 45a. For the silt + clay 20-40m criterion, the mean rating for 40a is actually the highest, but it is not significantly better than the other sites. The reason for site 40a's prominence here lies in the micaceous and weathered nature of **P**wc in the subtrench; the mean rating for site 52a is lowest because of the lack of clay in the upper section of Kco. The water quality and yield criteria are not useful discriminators between the sites because basically none of the water is viable for pastoral use and the unpredictable yields (indicated by large variances, particularly at site 45a) render the resource unattractive for industrial use. In terms of grand mean scores, site 52a is significantly higher than the other two sites, primarily due to its softer and finer-grained lithology in the top 20 metres. When security and access considerations are taken into account, the superiority of site 52a is further enhanced.

Performance assessment

All the NHMRC (1992) selection criteria were again considered for the three sites, this time drawing on the additional information from Stage 3 drilling. Assessment of the other non-geotechnical criteria remained unchanged because the Stage 3 drilling did not provide additional information relevant to their revision. All three sites performed excellently for all the geotechnical considerations and some noteworthy characteristics used to rank each site are summarised below:

Criterion 'a' – flooding and surface run-off.

The surface landforms at the three sites indicate that each would shed heavy and sustained rainfall rather than holding water to cause surface flooding.

Site 40a contains the greatest surface form diversity. There is a large canegrass swamp on its eastern edge and a subtle surface depression which leads west to the head of Rocky Creek. The site slopes to the west by 3m over 1 km (<1deg.).

Site 45a slopes from the south to the northwest with a total relief of 8m over 1.7 km. There is a small run-on catchment area to the East but there is a clear movement path across the site to shed water.

Site 52a has little headward catchment for rainfall to run-on to the site. Gilgai depressions and 'crabholes' in calcretes tend to cause minor short-term puddling on-site following rain. The site slopes from the west to the east with a total relief of 12m over 2.1 km (<1deg.).

In an extremely heavy and/or sustained rainfall scenario run-on and run-off will be shed to adjacent drainage lines and very much lower lying areas faster than water can accumulate at any of the sites.

Criterion 'b' – watertable; **Criterion 'c'** – groundwater modelling; **Criterion 'f'** – water quality.

All the sites well exceed the criterion requirement of a water table more than 5 metres below the buried waste.

At Site 40a the water table is deepest and lies at more than 65m depth. It has a slight gradient and flow direction to the west. The **P**wc aquifer is unconfined with groundwater storage and transmission within bedding plane partings and small fracture apertures . Water yield is very low, ranging from 0.01 m – 0.25 litres/sec with a very high salinity > 20,000 ppm. The unsaturated zone residence time is estimated to be 11,000 – 33,000 years and the time from recharge to discharge at Lake Windabout is estimated to be nearly 10,000 years.

The water table at Site 45a lies between 51.1 – 56.5m and has a 3m head drop across the site and an easterly to north-easterly flow direction. The **P**wc aquifer is unconfined and, like Site 40a, groundwater storage and transmission occurs primarily within bedding plane partings and low-angle small fracture apertures . The groundwater yield ranges from 0.05 – 1.5 litres/sec with a salinity ranging from 8,000 to 23,000 ppm The unsaturated zone residence time is estimated to be 9,000 – 27,000 years (although there may be preferred flow paths where residence times could be as low as 3,000 years) and the time to discharge in Lake Torrens at 5,000 years.

At Site 52a the water table lies between 39 – 44.6m having a head drop of 10m across the site (1.5 km) and flow direction to the north-east. The unconfined aquifer in the north eastern one third of the outer square and in the inner square is the Cadna-owie Formation, in which groundwater transmission and storage occurs in inter-granular pore spaces of the sediments. Elsewherethe unconfined aquifer at site 52a is the fracture zone of the Corraberra Sandstone . The groundwater yield ranges from 0.05 – 1.5 litres/sec but is mostly around 0.4 L/sec, and salinity is uniform across the area, averaging 16,000 ppm. The unsaturated zone residence time is estimated to be

14,000 – 42,000 years and the time from recharge to ultimate discharge at Lake Torrens is estimated to be of the order of 50,000 years.

Criterion 'c' – radionuclide sorption and repository operation.

The radionuclide retardation data of the representative material samples does not provide a basis to rank any of the sites as significantly more favourable in terms of ability to retard nuclides. All samples demonstrated significant ability to adsorb both Cobalt and Cesium radioisotopes (Appendix 9), however quartzose sands at the top of Kco have the lowest distribution coefficients for both cesium and cobalt. The Corraberra Sandstone performed well in tests for the retention of radionuclides, particularly at Site 52a.

At Sites 40a and 45a the excavation zone for a disposal trench will intersect from 2 – 5m thickness of hard silcrete in a zone from 2 – 8m depth.

At Site 40a a trench up to 20m deep would be hosted entirely within the intercalated variably-silicified and unsilicified sandstones and clay bands of the Simmens Quartzite Formation. Below the trench, from at least 24m depth, the Corraberra Sandstone is more than 30m thick consisting of interlayered micaceous sandstones and clays.

Site 45a is similar except that within the trench zone there is a greater proportion of intercalated clay and the underlying Corraberra Sandstone sequence is less micaceous and shallower from a minimum of 21m depth. A trench design to 15m depth would increase the depth from the base of the trench to the contact zone between the Simmens and Corraberra Formations, and would result in the base of the trench being seated in the most plastic clay and zone of highest adsorption of the Simmens Quartzite. The proportion of hard, silicified sediments was intermediate throughout the depth profile, but, in general, harder rocks exist at depth in the northern and eastern parts of the site.

Site 52a does not intersect hard materials in the trench zone. A trench up to 15m deep could be hosted entirely in the Bulldog Shale. The Bulldog Shale is underlain at a gradational contact with interlayered sands and clays of the Cadna-owie Formation which is 18 – 30m thick and extends from 14m to 27m depth. The groundwater level was shallowest, but lying at more than 39m depth, within primary pores at the base of the Cadna-owie Formation and fractures in the Corraberra Sandstone.

Table 4 summaries the ranking determined by the Technical Assessment Group for each geotechnical criterion.

TABLE 4: ASSESSMENT OF GEOTECHNICAL CRITERIA

Criterion/Site Number:	40a	45a	52a
a (surface drainage etc)	3	2	1
b (water table)	1	1	1
c (groundwater modelling)	3	2	1
d (seismicity, tectonism)	1	1	1
f (groundwater quality)	1	1	1
g (trench operation)	3	2	1
Sum result: (lowest best)	12	9	6
Preference:	3	2	1

Based on the assessment of the geotechnically-based selection criteria all three sites performed well and are considered suitable for the repository.

Site 52a was chosen because it better met more of the selection criteria.

The TAG considered that Site 40a was the least favourable but still suitable site, mainly because it had more complicated surface features, and less clay in the trench and sub-trench zones, and a greater distance for transport access across rough roads. Site 45a ranked intermediate, having good surface drainage qualities but there was some prospect for run-on of rainfall to the site. Site 52a was chosen because the surrounding landforms indicate superior surface drainage (little or no run-on), there is no hard silcrete in the trench zone and the site has superior transport access and prospects for security.

Conclusion

Performance assessment of the geotechnical criteria based on Stage 3 drilling assessment demonstrates that all three sites are highly suitable. Site 52a was selected as the preferred site because it better met more of the selection criteria, followed by Site 45a, then Site 40a.

Site 52a performs the best against the selection criteria and is the preferred site because the surrounding landforms indicate superior surface drainage with little or no run on of water to the site from adjacent areas. The risk of damage to trench covers is therefore minimal. There is no hard silcrete in the trench zone and trenches could therefore be easily constructed. In addition, the geology and hydrogeological features mean that the groundwater characteristics can be modelled with more confidence than for the other sites. The site has superior transport access, with a bitumen road leading near to the site, and it has superior prospects for long-term control, being located on the Woomera Prohibited Area which has restricted public access.

Site 40a performed slightly less well against the selection criteria, mainly because it had more complicated surface features which could impound water on the site; and less clay in the trench and sub-trench zones, making trench construction less straightforward; and a greater distance for transport access. Site 45a ranked intermediate, having good surface drainage qualities but there was a greater prospect for run-on of rainfall to the site than for Site 52a.

All three sites have sufficient clay and other adsorbing materials in the profile to adequately retard radionuclides in the unlikely event of leakage from the repository trenches.

Appendix 1: Surface topography

Appendix 2: Geologists’ drill logs

Appendix 3: 1:10 000 scale structure contour and isopach maps

Appendix 4: Contours of potentiometric surface and groundwater flow directions

Appendix 5: Chemical analyses of groundwaters

(Sample analyses by BRS Water Chemistry Laboratory. All analytes in mg/L)

Lab ID	SAMPID	ANALYTE	VALUE	COMPDATE
990500	7SW	TDS	19500.000	08-Dec-1999
990500	7SW	LabPH	7.090	08-Dec-1999
990500	7SW	LabEC	28600.000	08-Dec-1999
990500	7SW	TOTALK	198.750	08-Dec-1999
990500	7SW	Phenol.ALK	ND	08-Dec-1999
990500	7SW	I	ND	08-Dec-1999
990500	7SW	F	-5.000	08-Dec-1999
990500	7SW	Cl	8510.000	08-Dec-1999
990500	7SW	Br	-5.000	08-Dec-1999
990500	7SW	NO3	-5.000	08-Dec-1999
990500	7SW	PO4	-5.000	08-Dec-1999
990500	7SW	SO4	1910.000	08-Dec-1999
990500	7SW	Ca	1510.000	08-Dec-1999
990500	7SW	Mg	501.000	08-Dec-1999
990500	7SW	Na	4500.000	08-Dec-1999
990500	7SW	K	51.300	08-Dec-1999
990500	7SW	Si	8.050	08-Dec-1999
990500	7SW	S	753.000	08-Dec-1999
990500	7SW	Al	0.157	08-Dec-1999
990500	7SW	Fe	13.700	08-Dec-1999
990500	7SW	Mn	1.810	08-Dec-1999
990500	7SW	Cu	0.016	08-Dec-1999
990500	7SW	Zn	1.000	08-Dec-1999
990500	7SW	Sr	17.500	08-Dec-1999
990500	7SW	Li	0.124	08-Dec-1999
990500	7SW	B	5.350	08-Dec-1999
990500	7SW	Ba	0.106	08-Dec-1999
990500	7SW	AnCatRat	0.000	08-Dec-1999
990500	7SW	S/SO4Rat	1.181	08-Dec-1999
990500	7SW	TOTHARD	5833.588	08-Dec-1999
990500	7SW	TDSCNRAT	0.682	08-Dec-1999
990500	7SW	TDSRATIO	1.141	08-Dec-1999
990501	14NW	TDS	8290.000	08-Dec-1999
990501	14NW	LabPH	7.010	08-Dec-1999
990501	14NW	LabEC	12200.000	08-Dec-1999
990501	14NW	TOTALK	126.250	08-Dec-1999
990501	14NW	Phenol.ALK	ND	08-Dec-1999
990501	14NW	I	ND	08-Dec-1999
990501	14NW	F	-2.500	08-Dec-1999
990501	14NW	Cl	2810.000	08-Dec-1999
990501	14NW	Br	-2.500	08-Dec-1999
990501	14NW	NO3	-2.500	08-Dec-1999
990501	14NW	PO4	-2.500	08-Dec-1999
990501	14NW	SO4	1640.000	08-Dec-1999
990501	14NW	Ca	521.000	08-Dec-1999
990501	14NW	Mg	110.000	08-Dec-1999
990501	14NW	Na	1680.000	08-Dec-1999
990501	14NW	K	34.500	08-Dec-1999
990501	14NW	Si	7.440	08-Dec-1999

990501	14NW	S	545.000	08-Dec-1999
990501	14NW	Al	0.115	08-Dec-1999
990501	14NW	Fe	6.490	08-Dec-1999
990501	14NW	Mn	0.377	08-Dec-1999
990501	14NW	Cu	0.039	08-Dec-1999
990501	14NW	Zn	0.727	08-Dec-1999
990501	14NW	Sr	5.150	08-Dec-1999
990501	14NW	Li	0.054	08-Dec-1999
990501	14NW	B	5.310	08-Dec-1999
990501	14NW	Ba	0.043	08-Dec-1999
990501	14NW	AnCatRat	0.000	08-Dec-1999
990501	14NW	S/SO4Rat	0.996	08-Dec-1999
990501	14NW	TOTHARD	1753.917	08-Dec-1999
990501	14NW	TDSCNRAT	0.680	08-Dec-1999
990501	14NW	TDSRATIO	1.207	08-Dec-1999

990502	16SE	TDS	12600.000	08-Dec-1999
990502	16SE	LabPH	7.060	08-Dec-1999
990502	16SE	LabEC	18300.000	08-Dec-1999
990502	16SE	TOTALK	365.000	08-Dec-1999
990502	16SE	Phenol.ALK	ND	08-Dec-1999
990502	16SE	I	ND	08-Dec-1999
990502	16SE	F	-2.500	08-Dec-1999
990502	16SE	Cl	4620.000	08-Dec-1999
990502	16SE	Br	6.800	08-Dec-1999
990502	16SE	NO3	-2.500	08-Dec-1999
990502	16SE	PO4	-2.500	08-Dec-1999
990502	16SE	SO4	2210.000	08-Dec-1999
990502	16SE	Ca	888.000	08-Dec-1999
990502	16SE	Mg	271.000	08-Dec-1999
990502	16SE	Na	2960.000	08-Dec-1999
990502	16SE	K	36.100	08-Dec-1999
990502	16SE	Si	10.100	08-Dec-1999
990502	16SE	S	824.000	08-Dec-1999
990502	16SE	Al	0.183	08-Dec-1999
990502	16SE	Fe	6.670	08-Dec-1999
990502	16SE	Mn	0.536	08-Dec-1999
990502	16SE	Cu	0.014	08-Dec-1999
990502	16SE	Zn	0.751	08-Dec-1999
990502	16SE	Sr	10.500	08-Dec-1999
990502	16SE	Li	0.075	08-Dec-1999
990502	16SE	B	7.430	08-Dec-1999
990502	16SE	Ba	0.070	08-Dec-1999
990502	16SE	AnCatRat	0.000	08-Dec-1999
990502	16SE	S/SO4Rat	1.117	08-Dec-1999
990502	16SE	TOTHARD	3333.314	08-Dec-1999
990502	16SE	TDSCNRAT	0.689	08-Dec-1999
990502	16SE	TDSRATIO	1.127	08-Dec-1999

990503	13SE	TDS	29100.000	08-Dec-1999
990503	13SE	LabPH	6.840	08-Dec-1999
990503	13SE	LabEC	42100.000	08-Dec-1999
990503	13SE	TOTALK	317.500	08-Dec-1999
990503	13SE	Phenol.ALK	ND	08-Dec-1999
990503	13SE	I	ND	08-Dec-1999
990503	13SE	F	-5.000	08-Dec-1999

990503	13SE	Cl	12500.000	08-Dec-1999
990503	13SE	Br	-5.000	08-Dec-1999
990503	13SE	NO3	-5.000	08-Dec-1999
990503	13SE	PO4	-5.000	08-Dec-1999
990503	13SE	SO4	3030.000	08-Dec-1999
990503	13SE	Ca	1350.000	08-Dec-1999
990503	13SE	Mg	480.000	08-Dec-1999
990503	13SE	Na	8150.000	08-Dec-1999
990503	13SE	K	35.100	08-Dec-1999
990503	13SE	Si	5.980	08-Dec-1999
990503	13SE	S	1160.000	08-Dec-1999
990503	13SE	Al	0.592	08-Dec-1999
990503	13SE	Fe	22.100	08-Dec-1999
990503	13SE	Mn	0.581	08-Dec-1999
990503	13SE	Cu	0.088	08-Dec-1999
990503	13SE	Zn	1.300	08-Dec-1999
990503	13SE	Sr	24.800	08-Dec-1999
990503	13SE	Li	0.060	08-Dec-1999
990503	13SE	B	8.700	08-Dec-1999
990503	13SE	Ba	0.137	08-Dec-1999
990503	13SE	AnCatRat	0.000	08-Dec-1999
990503	13SE	S/SO4Rat	1.147	08-Dec-1999
990503	13SE	TOTHARD	5347.590	08-Dec-1999
990503	13SE	TDSCNRAT	0.691	08-Dec-1999
990503	13SE	TDSRATIO	1.132	08-Dec-1999

990504	13SE (dup)	TDS	29300.000	08-Dec-1999
990504	13SE (dup)	LabPH	6.860	08-Dec-1999
990504	13SE (dup)	LabEC	41900.000	08-Dec-1999
990504	13SE (dup)	TOTALK	315.000	08-Dec-1999
990504	13SE (dup)	Phenol.ALK	ND	08-Dec-1999
990504	13SE (dup)	I	ND	08-Dec-1999
990504	13SE (dup)	F	-5.000	08-Dec-1999
990504	13SE (dup)	Cl	12400.000	08-Dec-1999
990504	13SE (dup)	Br	-5.000	08-Dec-1999
990504	13SE (dup)	NO3	-5.000	08-Dec-1999
990504	13SE (dup)	PO4	-5.000	08-Dec-1999
990504	13SE (dup)	SO4	3020.000	08-Dec-1999
990504	13SE (dup)	Ca	1340.000	08-Dec-1999
990504	13SE (dup)	Mg	529.000	08-Dec-1999
990504	13SE (dup)	Na	7860.000	08-Dec-1999
990504	13SE (dup)	K	35.200	08-Dec-1999
990504	13SE (dup)	Si	5.830	08-Dec-1999
990504	13SE (dup)	S	1210.000	08-Dec-1999
990504	13SE (dup)	Al	0.500	08-Dec-1999
990504	13SE (dup)	Fe	23.500	08-Dec-1999
990504	13SE (dup)	Mn	0.610	08-Dec-1999
990504	13SE (dup)	Cu	0.123	08-Dec-1999
990504	13SE (dup)	Zn	1.740	08-Dec-1999
990504	13SE (dup)	Sr	25.300	08-Dec-1999
990504	13SE (dup)	Li	0.080	08-Dec-1999
990504	13SE (dup)	B	9.000	08-Dec-1999
990504	13SE (dup)	Ba	0.149	08-Dec-1999
990504	13SE (dup)	AnCatRat	0.000	08-Dec-1999
990504	13SE (dup)	S/SO4Rat	1.200	08-Dec-1999
990504	13SE (dup)	TOTHARD	5524.402	08-Dec-1999

990504	13SE (dup)	TDSCNRAT	0.699	08-Dec-1999
990504	13SE (dup)	TDSRATIO	1.156	08-Dec-1999

990505	13SE(Sp.)	TDS	ND	08-Dec-1999
990505	13SE(Sp.)	LabPH	ND	08-Dec-1999
990505	13SE(Sp.)	LabEC	ND	08-Dec-1999
990505	13SE(Sp.)	TOTALK	ND	08-Dec-1999
990505	13SE(Sp.)	Phenol.ALK	ND	08-Dec-1999
990505	13SE(Sp.)	I	ND	08-Dec-1999
990505	13SE(Sp.)	F	14.400	08-Dec-1999
990505	13SE(Sp.)	Cl	9850.000	08-Dec-1999
990505	13SE(Sp.)	Br	11.200	08-Dec-1999
990505	13SE(Sp.)	NO3	-5.000	08-Dec-1999
990505	13SE(Sp.)	PO4	-5.000	08-Dec-1999
990505	13SE(Sp.)	SO4	2390.000	08-Dec-1999
990505	13SE(Sp.)	Ca	1080.000	08-Dec-1999
990505	13SE(Sp.)	Mg	564.000	08-Dec-1999
990505	13SE(Sp.)	Na	5020.000	08-Dec-1999
990505	13SE(Sp.)	K	262.000	08-Dec-1999
990505	13SE(Sp.)	Si	2.720	08-Dec-1999
990505	13SE(Sp.)	S	709.000	08-Dec-1999
990505	13SE(Sp.)	Al	6.600	08-Dec-1999
990505	13SE(Sp.)	Fe	38.600	08-Dec-1999
990505	13SE(Sp.)	Mn	13.300	08-Dec-1999
990505	13SE(Sp.)	Cu	6.460	08-Dec-1999
990505	13SE(Sp.)	Zn	15.000	08-Dec-1999
990505	13SE(Sp.)	Sr	11.460	08-Dec-1999
990505	13SE(Sp.)	Li	0.034	08-Dec-1999
990505	13SE(Sp.)	B	4.590	08-Dec-1999
990505	13SE(Sp.)	Ba	0.226	08-Dec-1999
990505	13SE(Sp.)	AnCatRat	ND	08-Dec-1999
990505	13SE(Sp.)	S/SO4Rat	ND	08-Dec-1999
990505	13SE(Sp.)	TOTHARD	ND	08-Dec-1999
990505	13SE(Sp.)	TDSCNRAT	ND	08-Dec-1999
990505	13SE(Sp.)	TDSRATIO	ND	08-Dec-1999

990506	12SE	TDS	110000.000	08-Dec-1999
990506	12SE	LabPH	6.710	08-Dec-1999
990506	12SE	LabEC	132000.000	08-Dec-1999
990506	12SE	TOTALK	152.500	08-Dec-1999
990506	12SE	Phenol.ALK	ND	08-Dec-1999
990506	12SE	I	ND	08-Dec-1999
990506	12SE	F	-10.000	08-Dec-1999
990506	12SE	Cl	54500.000	08-Dec-1999
990506	12SE	Br	44.900	08-Dec-1999
990506	12SE	NO3	-10.000	08-Dec-1999
990506	12SE	PO4	-10.000	08-Dec-1999
990506	12SE	SO4	5240.000	08-Dec-1999
990506	12SE	Ca	1270.000	08-Dec-1999
990506	12SE	Mg	2530.000	08-Dec-1999
990506	12SE	Na	33300.000	08-Dec-1999
990506	12SE	K	154.000	08-Dec-1999
990506	12SE	Si	21.900	08-Dec-1999
990506	12SE	S	2020.000	08-Dec-1999
990506	12SE	Al	0.200	08-Dec-1999

990506	12SE	Fe	6.540	08-Dec-1999
990506	12SE	Mn	1.480	08-Dec-1999
990506	12SE	Cu	0.011	08-Dec-1999
990506	12SE	Zn	1.070	08-Dec-1999
990506	12SE	Sr	17.400	08-Dec-1999
990506	12SE	Li	1.990	08-Dec-1999
990506	12SE	B	3.550	08-Dec-1999
990506	12SE	Ba	0.035	08-Dec-1999
990506	12SE	AnCatRat	0.000	08-Dec-1999
990506	12SE	S/SO4Rat	1.155	08-Dec-1999
990506	12SE	TOTHARD	13589.730	08-Dec-1999
990506	12SE	TDSCNRAT	0.833	08-Dec-1999
990506	12SE	TDSRATIO	1.132	08-Dec-1999

990507	10N	TDS	15600.000	08-Dec-1999
990507	10N	LabPH	7.050	08-Dec-1999
990507	10N	LabEC	23200.000	08-Dec-1999
990507	10N	TOTALK	123.750	08-Dec-1999
990507	10N	Phenol.ALK	ND	08-Dec-1999
990507	10N	I	ND	08-Dec-1999
990507	10N	F	-2.500	08-Dec-1999
990507	10N	Cl	6310.000	08-Dec-1999
990507	10N	Br	6.400	08-Dec-1999
990507	10N	NO3	-2.500	08-Dec-1999
990507	10N	PO4	-2.500	08-Dec-1999
990507	10N	SO4	1880.000	08-Dec-1999
990507	10N	Ca	1170.000	08-Dec-1999
990507	10N	Mg	283.000	08-Dec-1999
990507	10N	Na	3740.000	08-Dec-1999
990507	10N	K	28.200	08-Dec-1999
990507	10N	Si	3.470	08-Dec-1999
990507	10N	S	743.000	08-Dec-1999
990507	10N	Al	0.154	08-Dec-1999
990507	10N	Fe	9.060	08-Dec-1999
990507	10N	Mn	0.581	08-Dec-1999
990507	10N	Cu	0.025	08-Dec-1999
990507	10N	Zn	0.817	08-Dec-1999
990507	10N	Sr	13.600	08-Dec-1999
990507	10N	Li	0.040	08-Dec-1999
990507	10N	B	7.210	08-Dec-1999
990507	10N	Ba	0.047	08-Dec-1999
990507	10N	AnCatRat	0.000	08-Dec-1999
990507	10N	S/SO4Rat	1.184	08-Dec-1999
990507	10N	TOTHARD	4086.884	08-Dec-1999
990507	10N	TDSCNRAT	0.672	08-Dec-1999
990507	10N	TDSRATIO	1.157	08-Dec-1999

Lab ID	SAMPID	ANALYTE	VALUE	COMPDATE
990508	The Pines	TDS	8310.000	08-Dec-1999
990508	The Pines	LabPH	7.040	08-Dec-1999
990508	The Pines	LabEC	12600.000	08-Dec-1999
990508	The Pines	TOTALK	117.500	08-Dec-1999
990508	The Pines	Phenol.ALK	ND	08-Dec-1999
990508	The Pines	I	ND	08-Dec-1999
990508	The Pines	F	-2.500	08-Dec-1999
990508	The Pines	Cl	3080.000	08-Dec-1999
990508	The Pines	Br	6.200	08-Dec-1999

990508	The Pines	NO3	-2.500	08-Dec-1999
990508	The Pines	PO4	-2.500	08-Dec-1999
990508	The Pines	SO4	1260.000	08-Dec-1999
990508	The Pines	Ca	371.000	08-Dec-1999
990508	The Pines	Mg	220.000	08-Dec-1999
990508	The Pines	Na	1650.000	08-Dec-1999
990508	The Pines	K	21.100	08-Dec-1999
990508	The Pines	Si	16.000	08-Dec-1999
990508	The Pines	S	432.000	08-Dec-1999
990508	The Pines	Al	0.097	08-Dec-1999
990508	The Pines	Fe	0.083	08-Dec-1999
990508	The Pines	Mn	2.630	08-Dec-1999
990508	The Pines	Cu	0.026	08-Dec-1999
990508	The Pines	Zn	0.971	08-Dec-1999
990508	The Pines	Sr	5.820	08-Dec-1999
990508	The Pines	Li	0.055	08-Dec-1999
990508	The Pines	B	2.070	08-Dec-1999
990508	The Pines	Ba	0.036	08-Dec-1999
990508	The Pines	AnCatRat	0.000	08-Dec-1999
990508	The Pines	S/SO4Rat	1.027	08-Dec-1999
990508	The Pines	TOTHARD	1832.347	08-Dec-1999
990508	The Pines	TDSCNRAT	0.660	08-Dec-1999
990508	The Pines	TDSRATIO	1.243	08-Dec-1999

990509	45NW	TDS	16100.000	08-Dec-1999
990509	45NW	LabPH	7.020	08-Dec-1999
990509	45NW	LabEC	24200.000	08-Dec-1999
990509	45NW	TOTALK	170.000	08-Dec-1999
990509	45NW	Phenol.ALK	ND	08-Dec-1999
990509	45NW	I	ND	08-Dec-1999
990509	45NW	F	-2.500	08-Dec-1999
990509	45NW	Cl	6670.000	08-Dec-1999
990509	45NW	Br	7.300	08-Dec-1999
990509	45NW	NO3	-2.500	08-Dec-1999
990509	45NW	PO4	-2.500	08-Dec-1999
990509	45NW	SO4	1870.000	08-Dec-1999
990509	45NW	Ca	1130.000	08-Dec-1999
990509	45NW	Mg	371.000	08-Dec-1999
990509	45NW	Na	3960.000	08-Dec-1999
990509	45NW	K	38.100	08-Dec-1999
990509	45NW	Si	5.840	08-Dec-1999
990509	45NW	S	737.000	08-Dec-1999
990509	45NW	Al	0.169	08-Dec-1999
990509	45NW	Fe	0.842	08-Dec-1999
990509	45NW	Mn	1.500	08-Dec-1999
990509	45NW	Cu	0.023	08-Dec-1999
990509	45NW	Zn	1.290	08-Dec-1999
990509	45NW	Sr	15.400	08-Dec-1999
990509	45NW	Li	0.103	08-Dec-1999
990509	45NW	B	5.100	08-Dec-1999
990509	45NW	Ba	0.095	08-Dec-1999
990509	45NW	AnCatRat	0.000	08-Dec-1999
990509	45NW	S/SO4Rat	1.181	08-Dec-1999
990509	45NW	TOTHARD	4349.388	08-Dec-1999
990509	45NW	TDSCNRAT	0.665	08-Dec-1999
990509	45NW	TDSRATIO	1.139	08-Dec-1999

990513	Paradise	TDS	4710.000	09-Sep-1999
990513	Paradise	LabPH	7.500	09-Sep-1999
990513	Paradise	LabEC	7700.000	09-Sep-1999
990513	Paradise	TOTALK	182.500	09-Sep-1999
990513	Paradise	Phenol.ALK	ND	09-Sep-1999
990513	Paradise	I	ND	09-Sep-1999
990513	Paradise	F	3.900	09-Sep-1999
990513	Paradise	Cl	1850.000	09-Sep-1999
990513	Paradise	Br	-1.250	09-Sep-1999
990513	Paradise	NO3	53.400	09-Sep-1999
990513	Paradise	PO4	-1.250	09-Sep-1999
990513	Paradise	SO4	494.000	09-Sep-1999
990513	Paradise	Ca	279.000	09-Sep-1999
990513	Paradise	Mg	58.700	09-Sep-1999
990513	Paradise	Na	981.000	09-Sep-1999
990513	Paradise	K	4.700	09-Sep-1999
990513	Paradise	Si	19.400	09-Sep-1999
990513	Paradise	S	170.000	09-Sep-1999
990513	Paradise	Al	0.076	09-Sep-1999
990513	Paradise	Fe	0.078	09-Sep-1999
990513	Paradise	Mn	-0.030	09-Sep-1999
990513	Paradise	Cu	0.102	09-Sep-1999
990513	Paradise	Zn	0.448	09-Sep-1999
990513	Paradise	Sr	3.700	09-Sep-1999
990513	Paradise	Li	0.017	09-Sep-1999
990513	Paradise	B	2.490	09-Sep-1999
990513	Paradise	Ba	0.020	09-Sep-1999
990513	Paradise	AnCatRat	-4.373	09-Sep-1999
990513	Paradise	S/SO4Rat	1.031	09-Sep-1999
990513	Paradise	TOTHARD	938.390	09-Sep-1999
990513	Paradise	TDSCNRAT	0.612	09-Sep-1999
990513	Paradise	TDSRATIO	1.228	09-Sep-1999

20000290	10aN	TDS	16700.000	07-Jun-2000
20000290	10aN	LabPH	6.870	07-Jun-2000
20000290	10aN	LabEC	27900.000	07-Jun-2000
20000290	10aN	TOTALK	126.250	07-Jun-2000
20000290	10aN	Phenol.ALK	ND	07-Jun-2000
20000290	10aN	I	ND	07-Jun-2000
20000290	10aN	F	5.750	07-Jun-2000
20000290	10aN	Cl	9430.000	07-Jun-2000
20000290	10aN	Br	5.100	07-Jun-2000
20000290	10aN	NO3	-2.500	07-Jun-2000
20000290	10aN	PO4	-2.500	07-Jun-2000
20000290	10aN	SO4	1930.000	07-Jun-2000
20000290	10aN	Ca	1490.000	07-Jun-2000
20000290	10aN	Mg	397.000	07-Jun-2000
20000290	10aN	Na	4870.000	07-Jun-2000
20000290	10aN	K	32.900	07-Jun-2000
20000290	10aN	Si	6.970	07-Jun-2000
20000290	10aN	S	779.000	07-Jun-2000
20000290	10aN	Al	0.095	07-Jun-2000
20000290	10aN	Fe	8.440	07-Jun-2000
20000290	10aN	Mn	0.715	07-Jun-2000
20000290	10aN	Cu	0.008	07-Jun-2000

20000290	10aN	Zn	0.619	07-Jun-2000
20000290	10aN	Sr	16.700	07-Jun-2000
20000290	10aN	Li	0.047	07-Jun-2000
20000290	10aN	B	5.590	07-Jun-2000
20000290	10aN	Ba	0.046	07-Jun-2000
20000290	10aN	AnCatRat	1.692	07-Jun-2000
20000290	10aN	S/SO4Rat	1.209	07-Jun-2000
20000290	10aN	TOTHARD	5355.376	07-Jun-2000
20000290	10aN	TDSCNRAT	0.599	07-Jun-2000
20000290	10aN	TDSRATIO	0.916	07-Jun-2000

20000291	33S	TDS	18200.000	06-Jun-2000
20000291	33S	LabPH	6.690	06-Jun-2000
20000291	33S	LabEC	30300.000	06-Jun-2000
20000291	33S	TOTALK	73.750	06-Jun-2000
20000291	33S	Phenol.ALK	ND	06-Jun-2000
20000291	33S	I	ND	06-Jun-2000
20000291	33S	F	6.900	06-Jun-2000
20000291	33S	Cl	10400.000	06-Jun-2000
20000291	33S	Br	6.700	06-Jun-2000
20000291	33S	NO3	-2.500	06-Jun-2000
20000291	33S	PO4	-2.500	06-Jun-2000
20000291	33S	SO4	1930.000	06-Jun-2000
20000291	33S	Ca	1540.000	06-Jun-2000
20000291	33S	Mg	442.000	06-Jun-2000
20000291	33S	Na	5310.000	06-Jun-2000
20000291	33S	K	45.300	06-Jun-2000
20000291	33S	Si	6.020	06-Jun-2000
20000291	33S	S	774.000	06-Jun-2000
20000291	33S	Al	0.109	06-Jun-2000
20000291	33S	Fe	9.650	06-Jun-2000
20000291	33S	Mn	0.388	06-Jun-2000
20000291	33S	Cu	0.010	06-Jun-2000
20000291	33S	Zn	0.604	06-Jun-2000
20000291	33S	Sr	16.600	06-Jun-2000
20000291	33S	Li	0.068	06-Jun-2000
20000291	33S	B	6.220	06-Jun-2000
20000291	33S	Ba	0.051	06-Jun-2000
20000291	33S	AnCatRat	1.454	06-Jun-2000
20000291	33S	S/SO4Rat	1.201	06-Jun-2000
20000291	33S	TOTHARD	5665.536	06-Jun-2000
20000291	33S	TDSCNRAT	0.601	06-Jun-2000
20000291	33S	TDSRATIO	0.923	06-Jun-2000

20000292	41W	TDS	19900.000	03-Jun-2000
20000292	41W	LabPH	6.800	03-Jun-2000
20000292	41W	LabEC	33100.000	03-Jun-2000
20000292	41W	TOTALK	203.750	03-Jun-2000
20000292	41W	Phenol.ALK	ND	03-Jun-2000
20000292	41W	I	ND	03-Jun-2000
20000292	41W	F	8.700	03-Jun-2000
20000292	41W	Cl	11900.000	03-Jun-2000
20000292	41W	Br	6.900	03-Jun-2000
20000292	41W	NO3	-3.000	03-Jun-2000
20000292	41W	PO4	-3.000	03-Jun-2000
20000292	41W	SO4	2130.000	03-Jun-2000

20000292	41W	Ca	1520.000	03-Jun-2000
20000292	41W	Mg	812.000	03-Jun-2000
20000292	41W	Na	5590.000	03-Jun-2000
20000292	41W	K	39.400	03-Jun-2000
20000292	41W	Si	8.610	03-Jun-2000
20000292	41W	S	835.000	03-Jun-2000
20000292	41W	Al	0.148	03-Jun-2000
20000292	41W	Fe	14.600	03-Jun-2000
20000292	41W	Mn	0.565	03-Jun-2000
20000292	41W	Cu	0.027	03-Jun-2000
20000292	41W	Zn	0.633	03-Jun-2000
20000292	41W	Sr	18.400	03-Jun-2000
20000292	41W	Li	0.266	03-Jun-2000
20000292	41W	B	2.960	03-Jun-2000
20000292	41W	Ba	0.023	03-Jun-2000
20000292	41W	AnCatRat	0.284	03-Jun-2000
20000292	41W	S/SO4Rat	1.174	03-Jun-2000
20000292	41W	TOTHARD	7139.256	03-Jun-2000
20000292	41W	TDSCNRAT	0.601	03-Jun-2000
20000292	41W	TDSRATIO	0.900	03-Jun-2000
20000293	52aSE	TDS	15800.000	11-Jun-2000
20000293	52aSE	LabPH	6.770	11-Jun-2000
20000293	52aSE	LabEC	26300.000	11-Jun-2000
20000293	52aSE	TOTALK	110.000	11-Jun-2000
20000293	52aSE	Phenol.ALK	ND	11-Jun-2000
20000293	52aSE	I	ND	11-Jun-2000
20000293	52aSE	F	-2.500	11-Jun-2000
20000293	52aSE	Cl	9120.000	11-Jun-2000
20000293	52aSE	Br	5.600	11-Jun-2000
20000293	52aSE	NO3	-2.500	11-Jun-2000
20000293	52aSE	PO4	-2.500	11-Jun-2000
20000293	52aSE	SO4	1620.000	11-Jun-2000
20000293	52aSE	Ca	1380.000	11-Jun-2000
20000293	52aSE	Mg	613.000	11-Jun-2000
20000293	52aSE	Na	4030.000	11-Jun-2000
20000293	52aSE	K	49.000	11-Jun-2000
20000293	52aSE	Si	6.290	11-Jun-2000
20000293	52aSE	S	645.000	11-Jun-2000
20000293	52aSE	Al	0.111	11-Jun-2000
20000293	52aSE	Fe	12.700	11-Jun-2000
20000293	52aSE	Mn	0.451	11-Jun-2000
20000293	52aSE	Cu	0.011	11-Jun-2000
20000293	52aSE	Zn	0.665	11-Jun-2000
20000293	52aSE	Sr	14.900	11-Jun-2000
20000293	52aSE	Li	0.183	11-Jun-2000
20000293	52aSE	B	4.580	11-Jun-2000
20000293	52aSE	Ba	0.029	11-Jun-2000
20000293	52aSE	AnCatRat	0.441	11-Jun-2000
20000293	52aSE	S/SO4Rat	1.193	11-Jun-2000
20000293	52aSE	TOTHARD	5970.194	11-Jun-2000
20000293	52aSE	TDSCNRAT	0.601	11-Jun-2000
20000293	52aSE	TDSRATIO	0.936	11-Jun-2000
20000294	10aS	TDS	15900.000	08-Jun-2000
20000294	10aS	LabPH	6.900	08-Jun-2000

20000294	10aS	LabEC	26500.000	08-Jun-2000
20000294	10aS	TOTALK	138.750	08-Jun-2000
20000294	10aS	Phenol.ALK	ND	08-Jun-2000
20000294	10aS	I	ND	08-Jun-2000
20000294	10aS	F	-2.500	08-Jun-2000
20000294	10aS	Cl	9080.000	08-Jun-2000
20000294	10aS	Br	5.100	08-Jun-2000
20000294	10aS	NO3	-2.500	08-Jun-2000
20000294	10aS	PO4	-2.500	08-Jun-2000
20000294	10aS	SO4	1820.000	08-Jun-2000
20000294	10aS	Ca	1420.000	08-Jun-2000
20000294	10aS	Mg	407.000	08-Jun-2000
20000294	10aS	Na	4340.000	08-Jun-2000
20000294	10aS	K	35.400	08-Jun-2000
20000294	10aS	Si	8.060	08-Jun-2000
20000294	10aS	S	697.000	08-Jun-2000
20000294	10aS	Al	0.110	08-Jun-2000
20000294	10aS	Fe	5.750	08-Jun-2000
20000294	10aS	Mn	1.160	08-Jun-2000
20000294	10aS	Cu	0.012	08-Jun-2000
20000294	10aS	Zn	0.713	08-Jun-2000
20000294	10aS	Sr	17.000	08-Jun-2000
20000294	10aS	Li	0.059	08-Jun-2000
20000294	10aS	B	4.570	08-Jun-2000
20000294	10aS	Ba	0.037	08-Jun-2000
20000294	10aS	AnCatRat	-0.475	08-Jun-2000
20000294	10aS	S/SO4Rat	1.147	08-Jun-2000
20000294	10aS	TOTHARD	5221.766	08-Jun-2000
20000294	10aS	TDSCNRAT	0.600	08-Jun-2000
20000294	10aS	TDSRATIO	0.925	08-Jun-2000

20000295	45aSW	TDS	24200.000	17-Jun-2000
20000295	45aSW	LabPH	5.940	17-Jun-2000
20000295	45aSW	LabEC	40300.000	17-Jun-2000
20000295	45aSW	TOTALK	68.750	17-Jun-2000
20000295	45aSW	Phenol.ALK	ND	17-Jun-2000
20000295	45aSW	I	ND	17-Jun-2000
20000295	45aSW	F	11.100	17-Jun-2000
20000295	45aSW	Cl	16200.000	17-Jun-2000
20000295	45aSW	Br	9.500	17-Jun-2000
20000295	45aSW	NO3	-4.000	17-Jun-2000
20000295	45aSW	PO4	-4.000	17-Jun-2000
20000295	45aSW	SO4	2480.000	17-Jun-2000
20000295	45aSW	Ca	1800.000	17-Jun-2000
20000295	45aSW	Mg	563.000	17-Jun-2000
20000295	45aSW	Na	7490.000	17-Jun-2000
20000295	45aSW	K	52.400	17-Jun-2000
20000295	45aSW	Si	7.150	17-Jun-2000
20000295	45aSW	S	887.000	17-Jun-2000
20000295	45aSW	Al	0.178	17-Jun-2000
20000295	45aSW	Fe	39.700	17-Jun-2000
20000295	45aSW	Mn	1.280	17-Jun-2000
20000295	45aSW	Cu	0.031	17-Jun-2000
20000295	45aSW	Zn	0.776	17-Jun-2000
20000295	45aSW	Sr	24.100	17-Jun-2000
20000295	45aSW	Li	0.098	17-Jun-2000

20000295	45aSW	B	3.380	17-Jun-2000
20000295	45aSW	Ba	0.045	17-Jun-2000
20000295	45aSW	AnCatRat	-4.865	17-Jun-2000
20000295	45aSW	S/SO4Rat	1.071	17-Jun-2000
20000295	45aSW	TOTHARD	6813.034	17-Jun-2000
20000295	45aSW	TDSCNRAT	0.600	17-Jun-2000
20000295	45aSW	TDSRATIO	0.845	17-Jun-2000
20000296	14aNW	TDS	11000.000	14-Jun-2000
20000296	14aNW	LabPH	6.650	14-Jun-2000
20000296	14aNW	LabEC	18400.000	14-Jun-2000
20000296	14aNW	TOTALK	100.000	14-Jun-2000
20000296	14aNW	Phenol.ALK	ND	14-Jun-2000
20000296	14aNW	I	ND	14-Jun-2000
20000296	14aNW	F	-2.000	14-Jun-2000
20000296	14aNW	Cl	5110.000	14-Jun-2000
20000296	14aNW	Br	3.000	14-Jun-2000
20000296	14aNW	NO3	-2.000	14-Jun-2000
20000296	14aNW	PO4	-2.000	14-Jun-2000
20000296	14aNW	SO4	2320.000	14-Jun-2000
20000296	14aNW	Ca	1030.000	14-Jun-2000
20000296	14aNW	Mg	133.000	14-Jun-2000
20000296	14aNW	Na	3220.000	14-Jun-2000
20000296	14aNW	K	45.400	14-Jun-2000
20000296	14aNW	Si	7.000	14-Jun-2000
20000296	14aNW	S	898.000	14-Jun-2000
20000296	14aNW	Al	0.081	14-Jun-2000
20000296	14aNW	Fe	9.010	14-Jun-2000
20000296	14aNW	Mn	0.324	14-Jun-2000
20000296	14aNW	Cu	0.016	14-Jun-2000
20000296	14aNW	Zn	0.599	14-Jun-2000
20000296	14aNW	Sr	8.590	14-Jun-2000
20000296	14aNW	Li	0.036	14-Jun-2000
20000296	14aNW	B	3.010	14-Jun-2000
20000296	14aNW	Ba	0.052	14-Jun-2000
20000296	14aNW	AnCatRat	2.293	14-Jun-2000
20000296	14aNW	S/SO4Rat	1.160	14-Jun-2000
20000296	14aNW	TOTHARD	3119.604	14-Jun-2000
20000296	14aNW	TDSCNRAT	0.598	14-Jun-2000
20000296	14aNW	TDSRATIO	0.923	14-Jun-2000
20000297	52aNW	TDS	14100.000	12-Jun-2000
20000297	52aNW	LabPH	6.750	12-Jun-2000
20000297	52aNW	LabEC	23500.000	12-Jun-2000
20000297	52aNW	TOTALK	116.250	12-Jun-2000
20000297	52aNW	Phenol.ALK	ND	12-Jun-2000
20000297	52aNW	I	ND	12-Jun-2000
20000297	52aNW	F	-2.500	12-Jun-2000
20000297	52aNW	Cl	7780.000	12-Jun-2000
20000297	52aNW	Br	5.400	12-Jun-2000
20000297	52aNW	NO3	-2.500	12-Jun-2000
20000297	52aNW	PO4	-2.500	12-Jun-2000
20000297	52aNW	SO4	1380.000	12-Jun-2000
20000297	52aNW	Ca	1190.000	12-Jun-2000
20000297	52aNW	Mg	438.000	12-Jun-2000
20000297	52aNW	Na	3680.000	12-Jun-2000

20000297	52aNW	K	40.400	12-Jun-2000
20000297	52aNW	Si	9.840	12-Jun-2000
20000297	52aNW	S	558.000	12-Jun-2000
20000297	52aNW	Al	0.091	12-Jun-2000
20000297	52aNW	Fe	10.200	12-Jun-2000
20000297	52aNW	Mn	0.321	12-Jun-2000
20000297	52aNW	Cu	0.011	12-Jun-2000
20000297	52aNW	Zn	0.661	12-Jun-2000
20000297	52aNW	Sr	12.700	12-Jun-2000
20000297	52aNW	Li	0.124	12-Jun-2000
20000297	52aNW	B	3.980	12-Jun-2000
20000297	52aNW	Ba	0.037	12-Jun-2000
20000297	52aNW	AnCatRat	1.174	12-Jun-2000
20000297	52aNW	S/SO4Rat	1.211	12-Jun-2000
20000297	52aNW	TOTHARD	4775.114	12-Jun-2000
20000297	52aNW	TDSCNRAT	0.600	12-Jun-2000
20000297	52aNW	TDSRATIO	0.967	12-Jun-2000
20000298	45NW	TDS	14300.000	18-Jun-2000
20000298	45NW	LabPH	6.720	18-Jun-2000
20000298	45NW	LabEC	23800.000	18-Jun-2000
20000298	45NW	TOTALK	163.750	18-Jun-2000
20000298	45NW	Phenol.ALK	ND	18-Jun-2000
20000298	45NW	I	ND	18-Jun-2000
20000298	45NW	F	-2.500	18-Jun-2000
20000298	45NW	Cl	7640.000	18-Jun-2000
20000298	45NW	Br	4.800	18-Jun-2000
20000298	45NW	NO3	-2.500	18-Jun-2000
20000298	45NW	PO4	-2.500	18-Jun-2000
20000298	45NW	SO4	1890.000	18-Jun-2000
20000298	45NW	Ca	1070.000	18-Jun-2000
20000298	45NW	Mg	364.000	18-Jun-2000
20000298	45NW	Na	4210.000	18-Jun-2000
20000298	45NW	K	33.300	18-Jun-2000
20000298	45NW	Si	5.430	18-Jun-2000
20000298	45NW	S	741.000	18-Jun-2000
20000298	45NW	Al	0.070	18-Jun-2000
20000298	45NW	Fe	7.500	18-Jun-2000
20000298	45NW	Mn	0.950	18-Jun-2000
20000298	45NW	Cu	0.010	18-Jun-2000
20000298	45NW	Zn	0.595	18-Jun-2000
20000298	45NW	Sr	13.300	18-Jun-2000
20000298	45NW	Li	0.088	18-Jun-2000
20000298	45NW	B	4.290	18-Jun-2000
20000298	45NW	Ba	0.028	18-Jun-2000
20000298	45NW	AnCatRat	1.741	18-Jun-2000
20000298	45NW	S/SO4Rat	1.174	18-Jun-2000
20000298	45NW	TOTHARD	4170.742	18-Jun-2000
20000298	45NW	TDSCNRAT	0.601	18-Jun-2000
20000298	45NW	TDSRATIO	0.935	18-Jun-2000

Lab ID	SAMPID	ANALYTE	VALUE
20000299	45aNE	TDS	12700.000
20000299	45aNE	LabPH	6.160
20000299	45aNE	LabEC	21200.000
20000299	45aNE	TOTALK	42.500

20000299	45aNE	Phenol.ALK	ND
20000299	45aNE	I	ND
20000299	45aNE	F	-2.500
20000299	45aNE	Cl	6610.000
20000299	45aNE	Br	-2.500
20000299	45aNE	NO3	-2.500
20000299	45aNE	PO4	-2.500
20000299	45aNE	SO4	2130.000
20000299	45aNE	Ca	1200.000
20000299	45aNE	Mg	198.000
20000299	45aNE	Na	3760.000
20000299	45aNE	K	38.700
20000299	45aNE	Si	6.600
20000299	45aNE	S	834.000
20000299	45aNE	Al	0.078
20000299	45aNE	Fe	9.200
20000299	45aNE	Mn	0.479
20000299	45aNE	Cu	0.013
20000299	45aNE	Zn	0.890
20000299	45aNE	Sr	14.300
20000299	45aNE	Li	0.042
20000299	45aNE	B	5.910
20000299	45aNE	Ba	0.034
20000299	45aNE	AnCatRat	1.926
20000299	45aNE	S/SO4Rat	1.173
20000299	45aNE	TOTHARD	3811.764
20000299	45aNE	TDSCNRAT	0.599
20000299	45aNE	TDSRATIO	0.909

20000300	14aSE	TDS	15500.000
20000300	14aSE	LabPH	6.650
20000300	14aSE	LabEC	25900.000
20000300	14aSE	TOTALK	128.750
20000300	14aSE	Phenol.ALK	ND
20000300	14aSE	I	ND
20000300	14aSE	F	-2.500
20000300	14aSE	Cl	8550.000
20000300	14aSE	Br	4.800
20000300	14aSE	NO3	-2.500
20000300	14aSE	PO4	-2.500
20000300	14aSE	SO4	1990.000
20000300	14aSE	Ca	1730.000
20000300	14aSE	Mg	348.000
20000300	14aSE	Na	4150.000
20000300	14aSE	K	35.100
20000300	14aSE	Si	6.630
20000300	14aSE	S	792.000
20000300	14aSE	Al	0.105
20000300	14aSE	Fe	0.638
20000300	14aSE	Mn	0.764
20000300	14aSE	Cu	0.028
20000300	14aSE	Zn	0.749
20000300	14aSE	Sr	17.200
20000300	14aSE	Li	0.046
20000300	14aSE	B	4.670
20000300	14aSE	Ba	0.119

20000300	14aSE	AnCatRat	1.918
20000300	14aSE	S/SO4Rat	1.192
20000300	14aSE	TOTHARD	5752.874
20000300	14aSE	TDSCNRAT	0.598
20000300	14aSE	TDSRATIO	0.918

Lab ID	SAMPID	ANALYTE	VALUE	SAMPDATE
20000386	52a5SE	TDS	20500.000	14-Sep-2000
20000386	52a5SE	LabPH	6.730	14-Sep-2000
20000386	52a5SE	LabEC	23300.000	14-Sep-2000
20000386	52a5SE	TOTALK	122.500	14-Sep-2000
20000386	52a5SE	Phenol.ALK	ND	14-Sep-2000
20000386	52a5SE	I	ND	14-Sep-2000
20000386	52a5SE	F	ND	14-Sep-2000
20000386	52a5SE	Cl	8840.000	14-Sep-2000
20000386	52a5SE	Br	9.500	14-Sep-2000
20000386	52a5SE	NO3	-2.500	14-Sep-2000
20000386	52a5SE	PO4	-2.500	14-Sep-2000
20000386	52a5SE	SO4	1710.000	14-Sep-2000
20000386	52a5SE	Ca	1390.000	14-Sep-2000
20000386	52a5SE	Mg	475.000	14-Sep-2000
20000386	52a5SE	Na	3850.000	14-Sep-2000
20000386	52a5SE	K	41.900	14-Sep-2000
20000386	52a5SE	Si	10.700	14-Sep-2000
20000386	52a5SE	S	581.000	14-Sep-2000
20000386	52a5SE	Al	0.208	14-Sep-2000
20000386	52a5SE	Fe	19.200	14-Sep-2000
20000386	52a5SE	Mn	0.548	14-Sep-2000
20000386	52a5SE	Cu	0.184	14-Sep-2000
20000386	52a5SE	Zn	0.934	14-Sep-2000
20000386	52a5SE	Sr	17.700	14-Sep-2000
20000386	52a5SE	Li	0.146	14-Sep-2000
20000386	52a5SE	B	3.890	14-Sep-2000
20000386	52a5SE	Ba	0.049	14-Sep-2000
20000386	52a5SE	AnCatRat	-1.865	14-Sep-2000
20000386	52a5SE	S/SO4Rat	1.018	14-Sep-2000
20000386	52a5SE	TOTHARD	5426.880	14-Sep-2000
20000386	52a5SE	TDSCNRAT	0.880	14-Sep-2000
20000386	52a5SE	TDSRATIO	1.251	14-Sep-2000
20000387	52a5NW	TDS	16000.000	16-Sep-2000
20000387	52a5NW	LabPH	6.840	16-Sep-2000
20000387	52a5NW	LabEC	22400.000	16-Sep-2000
20000387	52a5NW	TOTALK	122.500	16-Sep-2000
20000387	52a5NW	Phenol.ALK	ND	16-Sep-2000
20000387	52a5NW	I	ND	16-Sep-2000
20000387	52a5NW	F	ND	16-Sep-2000
20000387	52a5NW	Cl	8390.000	16-Sep-2000
20000387	52a5NW	Br	7.200	16-Sep-2000
20000387	52a5NW	NO3	-2.500	16-Sep-2000
20000387	52a5NW	PO4	-2.500	16-Sep-2000
20000387	52a5NW	SO4	1740.000	16-Sep-2000
20000387	52a5NW	Ca	1250.000	16-Sep-2000
20000387	52a5NW	Mg	465.000	16-Sep-2000
20000387	52a5NW	Na	3850.000	16-Sep-2000

20000387	52a5NW	K	43.400	16-Sep-2000
20000387	52a5NW	Si	12.700	16-Sep-2000
20000387	52a5NW	S	596.000	16-Sep-2000
20000387	52a5NW	Al	0.192	16-Sep-2000
20000387	52a5NW	Fe	12.600	16-Sep-2000
20000387	52a5NW	Mn	0.397	16-Sep-2000
20000387	52a5NW	Cu	0.100	16-Sep-2000
20000387	52a5NW	Zn	0.924	16-Sep-2000
20000387	52a5NW	Sr	16.000	16-Sep-2000
20000387	52a5NW	Li	0.156	16-Sep-2000
20000387	52a5NW	B	4.290	16-Sep-2000
20000387	52a5NW	Ba	0.040	16-Sep-2000
20000387	52a5NW	AnCatRat	-1.139	16-Sep-2000
20000387	52a5NW	S/SO4Rat	1.026	16-Sep-2000
20000387	52a5NW	TOTHARD	5036.120	16-Sep-2000
20000387	52a5NW	TDSCNRAT	0.714	16-Sep-2000
20000387	52a5NW	TDSRATIO	1.011	16-Sep-2000
20000388	52a5N	TDS	16000.000	21-Sep-2000
20000388	52a5N	LabPH	6.940	21-Sep-2000
20000388	52a5N	LabEC	21400.000	21-Sep-2000
20000388	52a5N	TOTALK	126.250	21-Sep-2000
20000388	52a5N	Phenol.ALK	ND	21-Sep-2000
20000388	52a5N	I	ND	21-Sep-2000
20000388	52a5N	F	ND	21-Sep-2000
20000388	52a5N	Cl	8430.000	21-Sep-2000
20000388	52a5N	Br	5.960	21-Sep-2000
20000388	52a5N	NO3	-2.500	21-Sep-2000
20000388	52a5N	PO4	-2.500	21-Sep-2000
20000388	52a5N	SO4	1790.000	21-Sep-2000
20000388	52a5N	Ca	1160.000	21-Sep-2000
20000388	52a5N	Mg	433.000	21-Sep-2000
20000388	52a5N	Na	3650.000	21-Sep-2000
20000388	52a5N	K	42.800	21-Sep-2000
20000388	52a5N	Si	10.400	21-Sep-2000
20000388	52a5N	S	562.000	21-Sep-2000
20000388	52a5N	Al	0.185	21-Sep-2000
20000388	52a5N	Fe	9.080	21-Sep-2000
20000388	52a5N	Mn	0.388	21-Sep-2000
20000388	52a5N	Cu	0.011	21-Sep-2000
20000388	52a5N	Zn	0.897	21-Sep-2000
20000388	52a5N	Sr	15.700	21-Sep-2000
20000388	52a5N	Li	0.159	21-Sep-2000
20000388	52a5N	B	4.480	21-Sep-2000
20000388	52a5N	Ba	0.036	21-Sep-2000
20000388	52a5N	AnCatRat	-4.570	21-Sep-2000
20000388	52a5N	S/SO4Rat	0.941	21-Sep-2000
20000388	52a5N	TOTHARD	4679.614	21-Sep-2000
20000388	52a5N	TDSCNRAT	0.748	21-Sep-2000
20000388	52a5N	TDSRATIO	1.027	21-Sep-2000
20000389	52a5W	TDS	18000.000	21-Sep-2000
20000389	52a5W	LabPH	6.750	21-Sep-2000
20000389	52a5W	LabEC	23500.000	21-Sep-2000

20000389	52a5W	TOTALK	106.250	21-Sep-2000
20000389	52a5W	Phenol.ALK	ND	21-Sep-2000
20000389	52a5W	I	ND	21-Sep-2000
20000389	52a5W	F	ND	21-Sep-2000
20000389	52a5W	Cl	8830.000	21-Sep-2000
20000389	52a5W	Br	7.720	21-Sep-2000
20000389	52a5W	NO3	-2.500	21-Sep-2000
20000389	52a5W	PO4	-2.500	21-Sep-2000
20000389	52a5W	SO4	1850.000	21-Sep-2000
20000389	52a5W	Ca	1240.000	21-Sep-2000
20000389	52a5W	Mg	485.000	21-Sep-2000
20000389	52a5W	Na	3990.000	21-Sep-2000
20000389	52a5W	K	45.700	21-Sep-2000
20000389	52a5W	Si	9.410	21-Sep-2000
20000389	52a5W	S	598.000	21-Sep-2000
20000389	52a5W	Al	0.202	21-Sep-2000
20000389	52a5W	Fe	10.600	21-Sep-2000
20000389	52a5W	Mn	0.513	21-Sep-2000
20000389	52a5W	Cu	0.023	21-Sep-2000
20000389	52a5W	Zn	1.060	21-Sep-2000
20000389	52a5W	Sr	17.400	21-Sep-2000
20000389	52a5W	Li	0.175	21-Sep-2000
20000389	52a5W	B	5.120	21-Sep-2000
20000389	52a5W	Ba	0.034	21-Sep-2000
20000389	52a5W	AnCatRat	-2.347	21-Sep-2000
20000389	52a5W	S/SO4Rat	0.968	21-Sep-2000
20000389	52a5W	TOTHARD	5093.510	21-Sep-2000
20000389	52a5W	TDSCNRAT	0.766	21-Sep-2000
20000389	52a5W	TDSRATIO	1.090	21-Sep-2000
20000390	52a5E	TDS	17000.000	22-Sep-2000
20000390	52a5E	LabPH	7.000	22-Sep-2000
20000390	52a5E	LabEC	22600.000	22-Sep-2000
20000390	52a5E	TOTALK	126.250	22-Sep-2000
20000390	52a5E	Phenol.ALK	ND	22-Sep-2000
20000390	52a5E	I	ND	22-Sep-2000
20000390	52a5E	F	ND	22-Sep-2000
20000390	52a5E	Cl	9370.000	22-Sep-2000
20000390	52a5E	Br	6.190	22-Sep-2000
20000390	52a5E	NO3	-2.500	22-Sep-2000
20000390	52a5E	PO4	-2.500	22-Sep-2000
20000390	52a5E	SO4	1760.000	22-Sep-2000
20000390	52a5E	Ca	1340.000	22-Sep-2000
20000390	52a5E	Mg	441.000	22-Sep-2000
20000390	52a5E	Na	3770.000	22-Sep-2000
20000390	52a5E	K	44.700	22-Sep-2000
20000390	52a5E	Si	9.470	22-Sep-2000
20000390	52a5E	S	552.000	22-Sep-2000
20000390	52a5E	Al	0.194	22-Sep-2000
20000390	52a5E	Fe	6.080	22-Sep-2000
20000390	52a5E	Mn	0.502	22-Sep-2000
20000390	52a5E	Cu	0.044	22-Sep-2000
20000390	52a5E	Zn	0.986	22-Sep-2000
20000390	52a5E	Sr	17.600	22-Sep-2000
20000390	52a5E	Li	0.151	22-Sep-2000

20000390	52a5E	B	4.040	22-Sep-2000
20000390	52a5E	Ba	0.049	22-Sep-2000
20000390	52a5E	AnCatRat	-6.165	22-Sep-2000
20000390	52a5E	S/SO4Rat	0.940	22-Sep-2000
20000390	52a5E	TOTHARD	5162.018	22-Sep-2000
20000390	52a5E	TDSCNRAT	0.752	22-Sep-2000
20000390	52a5E	TDSRATIO	1.012	22-Sep-2000

20000391	52a5S	TDS	16500.000	23-Sep-2000
20000391	52a5S	LabPH	6.890	23-Sep-2000
20000391	52a5S	LabEC	22800.000	23-Sep-2000
20000391	52a5S	TOTALK	118.750	23-Sep-2000
20000391	52a5S	Phenol.ALK	ND	23-Sep-2000
20000391	52a5S	I	ND	23-Sep-2000
20000391	52a5S	F	ND	23-Sep-2000
20000391	52a5S	Cl	8830.000	23-Sep-2000
20000391	52a5S	Br	6.460	23-Sep-2000
20000391	52a5S	NO3	-2.500	23-Sep-2000
20000391	52a5S	PO4	-2.500	23-Sep-2000
20000391	52a5S	SO4	1840.000	23-Sep-2000
20000391	52a5S	Ca	1230.000	23-Sep-2000
20000391	52a5S	Mg	516.000	23-Sep-2000
20000391	52a5S	Na	3810.000	23-Sep-2000
20000391	52a5S	K	44.700	23-Sep-2000
20000391	52a5S	Si	8.280	23-Sep-2000
20000391	52a5S	S	609.000	23-Sep-2000
20000391	52a5S	Al	0.201	23-Sep-2000
20000391	52a5S	Fe	11.600	23-Sep-2000
20000391	52a5S	Mn	0.467	23-Sep-2000
20000391	52a5S	Cu	0.011	23-Sep-2000
20000391	52a5S	Zn	0.988	23-Sep-2000
20000391	52a5S	Sr	17.600	23-Sep-2000
20000391	52a5S	Li	0.207	23-Sep-2000
20000391	52a5S	B	5.120	23-Sep-2000
20000391	52a5S	Ba	0.036	23-Sep-2000
20000391	52a5S	AnCatRat	-3.411	23-Sep-2000
20000391	52a5S	S/SO4Rat	0.991	23-Sep-2000
20000391	52a5S	TOTHARD	5196.198	23-Sep-2000
20000391	52a5S	TDSCNRAT	0.724	23-Sep-2000
20000391	52a5S	TDSRATIO	1.009	23-Sep-2000

20000392	52a5SW	TDS	16500.000	24-Sep-2000
20000392	52a5SW	LabPH	6.880	24-Sep-2000
20000392	52a5SW	LabEC	22600.000	24-Sep-2000
20000392	52a5SW	TOTALK	110.000	24-Sep-2000
20000392	52a5SW	Phenol.ALK	ND	24-Sep-2000
20000392	52a5SW	I	ND	24-Sep-2000
20000392	52a5SW	F	ND	24-Sep-2000
20000392	52a5SW	Cl	8900.000	24-Sep-2000
20000392	52a5SW	Br	6.640	24-Sep-2000
20000392	52a5SW	NO3	-2.500	24-Sep-2000
20000392	52a5SW	PO4	-2.500	24-Sep-2000
20000392	52a5SW	SO4	1940.000	24-Sep-2000
20000392	52a5SW	Ca	1160.000	24-Sep-2000

20000392	52a5SW	Mg	527.000	24-Sep-2000
20000392	52a5SW	Na	3840.000	24-Sep-2000
20000392	52a5SW	K	47.200	24-Sep-2000
20000392	52a5SW	Si	7.140	24-Sep-2000
20000392	52a5SW	S	627.000	24-Sep-2000
20000392	52a5SW	Al	0.184	24-Sep-2000
20000392	52a5SW	Fe	10.800	24-Sep-2000
20000392	52a5SW	Mn	0.514	24-Sep-2000
20000392	52a5SW	Cu	0.011	24-Sep-2000
20000392	52a5SW	Zn	0.981	24-Sep-2000
20000392	52a5SW	Sr	17.300	24-Sep-2000
20000392	52a5SW	Li	0.233	24-Sep-2000
20000392	52a5SW	B	5.700	24-Sep-2000
20000392	52a5SW	Ba	0.033	24-Sep-2000
20000392	52a5SW	AnCatRat	-4.301	24-Sep-2000
20000392	52a5SW	S/SO4Rat	0.968	24-Sep-2000
20000392	52a5SW	TOTHARD	5066.706	24-Sep-2000
20000392	52a5SW	TDSCNRAT	0.730	24-Sep-2000
20000392	52a5SW	TDSRATIO	1.001	24-Sep-2000

20000393	52a5NE	TDS	15000.000	25-Sep-2000
20000393	52a5NE	LabPH	7.000	25-Sep-2000
20000393	52a5NE	LabEC	20900.000	25-Sep-2000
20000393	52a5NE	TOTALK	111.250	25-Sep-2000
20000393	52a5NE	Phenol.ALK	ND	25-Sep-2000
20000393	52a5NE	I	ND	25-Sep-2000
20000393	52a5NE	F	ND	25-Sep-2000
20000393	52a5NE	Cl	8040.000	25-Sep-2000
20000393	52a5NE	Br	6.770	25-Sep-2000
20000393	52a5NE	NO3	-2.500	25-Sep-2000
20000393	52a5NE	PO4	-2.500	25-Sep-2000
20000393	52a5NE	SO4	1790.000	25-Sep-2000
20000393	52a5NE	Ca	1060.000	25-Sep-2000
20000393	52a5NE	Mg	461.000	25-Sep-2000
20000393	52a5NE	Na	3610.000	25-Sep-2000
20000393	52a5NE	K	41.900	25-Sep-2000
20000393	52a5NE	Si	7.220	25-Sep-2000
20000393	52a5NE	S	589.000	25-Sep-2000
20000393	52a5NE	Al	0.177	25-Sep-2000
20000393	52a5NE	Fe	8.920	25-Sep-2000
20000393	52a5NE	Mn	0.388	25-Sep-2000
20000393	52a5NE	Cu	0.020	25-Sep-2000
20000393	52a5NE	Zn	0.908	25-Sep-2000
20000393	52a5NE	Sr	16.200	25-Sep-2000
20000393	52a5NE	Li	0.249	25-Sep-2000
20000393	52a5NE	B	5.580	25-Sep-2000
20000393	52a5NE	Ba	0.031	25-Sep-2000
20000393	52a5NE	AnCatRat	-3.382	25-Sep-2000
20000393	52a5NE	S/SO4Rat	0.986	25-Sep-2000
20000393	52a5NE	TOTHARD	4545.218	25-Sep-2000
20000393	52a5NE	TDSCNRAT	0.718	25-Sep-2000
20000393	52a5NE	TDSRATIO	0.995	25-Sep-2000

20000394	45a5NW	TDS	12500.000	28-Sep-2000

20000394	45a5NW	LabPH	5.840	28-Sep-2000
20000394	45a5NW	LabEC	17700.000	28-Sep-2000
20000394	45a5NW	TOTALK	26.250	28-Sep-2000
20000394	45a5NW	Phenol.ALK	ND	28-Sep-2000
20000394	45a5NW	I	ND	28-Sep-2000
20000394	45a5NW	F	ND	28-Sep-2000
20000394	45a5NW	Cl	6130.000	28-Sep-2000
20000394	45a5NW	Br	4.230	28-Sep-2000
20000394	45a5NW	NO3	-2.500	28-Sep-2000
20000394	45a5NW	PO4	-2.500	28-Sep-2000
20000394	45a5NW	SO4	2170.000	28-Sep-2000
20000394	45a5NW	Ca	1390.000	28-Sep-2000
20000394	45a5NW	Mg	212.000	28-Sep-2000
20000394	45a5NW	Na	2820.000	28-Sep-2000
20000394	45a5NW	K	39.200	28-Sep-2000
20000394	45a5NW	Si	7.010	28-Sep-2000
20000394	45a5NW	S	741.000	28-Sep-2000
20000394	45a5NW	Al	0.257	28-Sep-2000
20000394	45a5NW	Fe	39.600	28-Sep-2000
20000394	45a5NW	Mn	1.160	28-Sep-2000
20000394	45a5NW	Cu	0.069	28-Sep-2000
20000394	45a5NW	Zn	1.160	28-Sep-2000
20000394	45a5NW	Sr	20.900	28-Sep-2000
20000394	45a5NW	Li	0.074	28-Sep-2000
20000394	45a5NW	B	6.620	28-Sep-2000
20000394	45a5NW	Ba	0.059	28-Sep-2000
20000394	45a5NW	AnCatRat	-1.902	28-Sep-2000
20000394	45a5NW	S/SO4Rat	1.023	28-Sep-2000
20000394	45a5NW	TOTHARD	4343.846	28-Sep-2000
20000394	45a5NW	TDSCNRAT	0.706	28-Sep-2000
20000394	45a5NW	TDSRATIO	0.978	28-Sep-2000

20000395	45a5S	TDS	16500.000	05-Oct-2000
20000395	45a5S	LabPH	6.450	05-Oct-2000
20000395	45a5S	LabEC	23000.000	05-Oct-2000
20000395	45a5S	TOTALK	133.950	05-Oct-2000
20000395	45a5S	Phenol.ALK	ND	05-Oct-2000
20000395	45a5S	I	ND	05-Oct-2000
20000395	45a5S	F	ND	05-Oct-2000
20000395	45a5S	Cl	8260.000	05-Oct-2000
20000395	45a5S	Br	4.930	05-Oct-2000
20000395	45a5S	NO3	-2.500	05-Oct-2000
20000395	45a5S	PO4	-2.500	05-Oct-2000
20000395	45a5S	SO4	2630.000	05-Oct-2000
20000395	45a5S	Ca	1140.000	05-Oct-2000
20000395	45a5S	Mg	290.000	05-Oct-2000
20000395	45a5S	Na	4513.000	05-Oct-2000
20000395	45a5S	K	39.200	05-Oct-2000
20000395	45a5S	Si	7.610	05-Oct-2000
20000395	45a5S	S	902.000	05-Oct-2000
20000395	45a5S	Al	0.243	05-Oct-2000
20000395	45a5S	Fe	23.900	05-Oct-2000
20000395	45a5S	Mn	0.989	05-Oct-2000
20000395	45a5S	Cu	0.150	05-Oct-2000
20000395	45a5S	Zn	0.937	05-Oct-2000

20000395	45a5S	Sr	20.500	05-Oct-2000
20000395	45a5S	Li	0.094	05-Oct-2000
20000395	45a5S	B	4.850	05-Oct-2000
20000395	45a5S	Ba	0.039	05-Oct-2000
20000395	45a5S	AnCatRat	-2.180	05-Oct-2000
20000395	45a5S	S/SO4Rat	1.027	05-Oct-2000
20000395	45a5S	TOTHARD	4040.800	05-Oct-2000
20000395	45a5S	TDSCNRAT	0.717	05-Oct-2000
20000395	45a5S	TDSRATIO	0.973	05-Oct-2000

20000396	45a5SW	TDS	18000.000	05-Oct-2000
20000396	45a5SW	LabPH	6.340	05-Oct-2000
20000396	45a5SW	LabEC	24800.000	05-Oct-2000
20000396	45a5SW	TOTALK	166.250	05-Oct-2000
20000396	45a5SW	Phenol.ALK	ND	05-Oct-2000
20000396	45a5SW	I	ND	05-Oct-2000
20000396	45a5SW	F	ND	05-Oct-2000
20000396	45a5SW	Cl	9490.000	05-Oct-2000
20000396	45a5SW	Br	5.530	05-Oct-2000
20000396	45a5SW	NO3	-2.500	05-Oct-2000
20000396	45a5SW	PO4	-2.500	05-Oct-2000
20000396	45a5SW	SO4	2750.000	05-Oct-2000
20000396	45a5SW	Ca	1270.000	05-Oct-2000
20000396	45a5SW	Mg	339.000	05-Oct-2000
20000396	45a5SW	Na	4930.000	05-Oct-2000
20000396	45a5SW	K	48.000	05-Oct-2000
20000396	45a5SW	Si	7.350	05-Oct-2000
20000396	45a5SW	S	933.000	05-Oct-2000
20000396	45a5SW	Al	0.254	05-Oct-2000
20000396	45a5SW	Fe	20.400	05-Oct-2000
20000396	45a5SW	Mn	1.230	05-Oct-2000
20000396	45a5SW	Cu	0.052	05-Oct-2000
20000396	45a5SW	Zn	0.925	05-Oct-2000
20000396	45a5SW	Sr	20.200	05-Oct-2000
20000396	45a5SW	Li	0.101	05-Oct-2000
20000396	45a5SW	B	5.330	05-Oct-2000
20000396	45a5SW	Ba	0.034	05-Oct-2000
20000396	45a5SW	AnCatRat	-3.362	05-Oct-2000
20000396	45a5SW	S/SO4Rat	1.016	05-Oct-2000
20000396	45a5SW	TOTHARD	4567.192	05-Oct-2000
20000396	45a5SW	TDSCNRAT	0.726	05-Oct-2000
20000396	45a5SW	TDSRATIO	0.951	05-Oct-2000

20000397	45a5SE	TDS	19000.000	06-Oct-2000
20000397	45a5SE	LabPH	6.410	06-Oct-2000
20000397	45a5SE	LabEC	25000.000	06-Oct-2000
20000397	45a5SE	TOTALK	141.250	06-Oct-2000
20000397	45a5SE	Phenol.ALK	ND	06-Oct-2000
20000397	45a5SE	I	ND	06-Oct-2000
20000397	45a5SE	F	ND	06-Oct-2000
20000397	45a5SE	Cl	9890.000	06-Oct-2000
20000397	45a5SE	Br	3.210	06-Oct-2000
20000397	45a5SE	NO3	-2.500	06-Oct-2000
20000397	45a5SE	PO4	-2.500	06-Oct-2000
20000397	45a5SE	SO4	2320.000	06-Oct-2000

20000397	45a5SE	Ca	1490.000	06-Oct-2000
20000397	45a5SE	Mg	271.000	06-Oct-2000
20000397	45a5SE	Na	4780.000	06-Oct-2000
20000397	45a5SE	K	55.200	06-Oct-2000
20000397	45a5SE	Si	7.710	06-Oct-2000
20000397	45a5SE	S	778.000	06-Oct-2000
20000397	45a5SE	Al	0.246	06-Oct-2000
20000397	45a5SE	Fe	15.700	06-Oct-2000
20000397	45a5SE	Mn	1.240	06-Oct-2000
20000397	45a5SE	Cu	0.087	06-Oct-2000
20000397	45a5SE	Zn	1.200	06-Oct-2000
20000397	45a5SE	Sr	24.300	06-Oct-2000
20000397	45a5SE	Li	0.108	06-Oct-2000
20000397	45a5SE	B	3.680	06-Oct-2000
20000397	45a5SE	Ba	0.072	06-Oct-2000
20000397	45a5SE	AnCatRat	-3.793	06-Oct-2000
20000397	45a5SE	S/SO4Rat	1.005	06-Oct-2000
20000397	45a5SE	TOTHARD	4836.508	06-Oct-2000
20000397	45a5SE	TDSCNRAT	0.760	06-Oct-2000
20000397	45a5SE	TDSRATIO	1.006	06-Oct-2000

20000398	45a5E	TDS	9000.000	08-Oct-2000
20000398	45a5E	LabPH	6.250	08-Oct-2000
20000398	45a5E	LabEC	11800.000	08-Oct-2000
20000398	45a5E	TOTALK	121.250	08-Oct-2000
20000398	45a5E	Phenol.ALK	ND	08-Oct-2000
20000398	45a5E	I	ND	08-Oct-2000
20000398	45a5E	F	ND	08-Oct-2000
20000398	45a5E	Cl	3300.000	08-Oct-2000
20000398	45a5E	Br	6.620	08-Oct-2000
20000398	45a5E	NO3	-2.500	08-Oct-2000
20000398	45a5E	PO4	-2.500	08-Oct-2000
20000398	45a5E	SO4	2020.000	08-Oct-2000
20000398	45a5E	Ca	505.000	08-Oct-2000
20000398	45a5E	Mg	125.000	08-Oct-2000
20000398	45a5E	Na	2020.000	08-Oct-2000
20000398	45a5E	K	33.000	08-Oct-2000
20000398	45a5E	Si	7.660	08-Oct-2000
20000398	45a5E	S	702.000	08-Oct-2000
20000398	45a5E	Al	0.226	08-Oct-2000
20000398	45a5E	Fe	13.200	08-Oct-2000
20000398	45a5E	Mn	1.140	08-Oct-2000
20000398	45a5E	Cu	0.177	08-Oct-2000
20000398	45a5E	Zn	1.380	08-Oct-2000
20000398	45a5E	Sr	12.400	08-Oct-2000
20000398	45a5E	Li	0.064	08-Oct-2000
20000398	45a5E	B	3.970	08-Oct-2000
20000398	45a5E	Ba	0.064	08-Oct-2000
20000398	45a5E	AnCatRat	-5.122	08-Oct-2000
20000398	45a5E	S/SO4Rat	1.041	08-Oct-2000
20000398	45a5E	TOTHARD	1775.735	08-Oct-2000
20000398	45a5E	TDSCNRAT	0.763	08-Oct-2000
20000398	45a5E	TDSRATIO	1.114	08-Oct-2000

20000399	45a5NE	TDS	9000.000	08-Oct-2000
20000399	45a5NE	LabPH	6.840	08-Oct-2000

20000399	45a5NE	LabEC	12200.000	08-Oct-2000
20000399	45a5NE	TOTALK	86.250	08-Oct-2000
20000399	45a5NE	Phenol.ALK	ND	08-Oct-2000
20000399	45a5NE	I	ND	08-Oct-2000
20000399	45a5NE	F	ND	08-Oct-2000
20000399	45a5NE	Cl	3400.000	08-Oct-2000
20000399	45a5NE	Br	15.400	08-Oct-2000
20000399	45a5NE	NO3	5.700	08-Oct-2000
20000399	45a5NE	PO4	-2.500	08-Oct-2000
20000399	45a5NE	SO4	2500.000	08-Oct-2000
20000399	45a5NE	Ca	543.000	08-Oct-2000
20000399	45a5NE	Mg	129.000	08-Oct-2000
20000399	45a5NE	Na	2180.000	08-Oct-2000
20000399	45a5NE	K	38.000	08-Oct-2000
20000399	45a5NE	Si	8.720	08-Oct-2000
20000399	45a5NE	S	874.000	08-Oct-2000
20000399	45a5NE	Al	0.177	08-Oct-2000
20000399	45a5NE	Fe	8.360	08-Oct-2000
20000399	45a5NE	Mn	1.510	08-Oct-2000
20000399	45a5NE	Cu	0.120	08-Oct-2000
20000399	45a5NE	Zn	0.785	08-Oct-2000
20000399	45a5NE	Sr	15.100	08-Oct-2000
20000399	45a5NE	Li	0.057	08-Oct-2000
20000399	45a5NE	B	4.880	08-Oct-2000
20000399	45a5NE	Ba	0.050	08-Oct-2000
20000399	45a5NE	AnCatRat	-5.789	08-Oct-2000
20000399	45a5NE	S/SO4Rat	1.047	08-Oct-2000
20000399	45a5NE	TOTHARD	1887.093	08-Oct-2000
20000399	45a5NE	TDSCNRAT	0.738	08-Oct-2000
20000399	45a5NE	TDSRATIO	1.015	08-Oct-2000

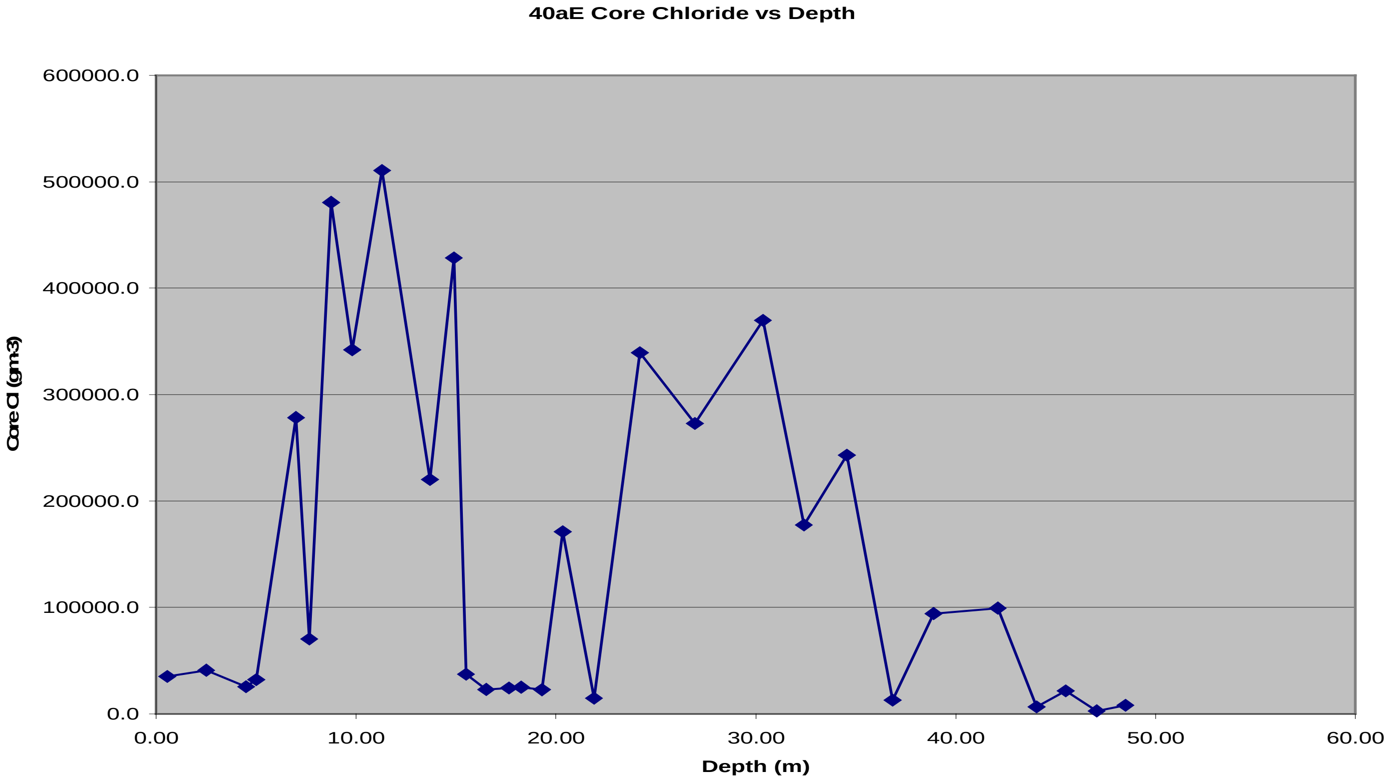
20000400	45a5N	TDS	9000.000	09-Oct-2000
20000400	45a5N	LabPH	6.370	09-Oct-2000
20000400	45a5N	LabEC	11800.000	09-Oct-2000
20000400	45a5N	TOTALK	73.750	09-Oct-2000
20000400	45a5N	Phenol.ALK	ND	09-Oct-2000
20000400	45a5N	I	ND	09-Oct-2000
20000400	45a5N	F	ND	09-Oct-2000
20000400	45a5N	Cl	3500.000	09-Oct-2000
20000400	45a5N	Br	-2.500	09-Oct-2000
20000400	45a5N	NO3	-2.500	09-Oct-2000
20000400	45a5N	PO4	-2.500	09-Oct-2000
20000400	45a5N	SO4	2110.000	09-Oct-2000
20000400	45a5N	Ca	469.000	09-Oct-2000
20000400	45a5N	Mg	176.000	09-Oct-2000
20000400	45a5N	Na	2100.000	09-Oct-2000
20000400	45a5N	K	42.000	09-Oct-2000
20000400	45a5N	Si	7.860	09-Oct-2000
20000400	45a5N	S	732.000	09-Oct-2000
20000400	45a5N	Al	0.188	09-Oct-2000
20000400	45a5N	Fe	22.900	09-Oct-2000
20000400	45a5N	Mn	1.210	09-Oct-2000
20000400	45a5N	Cu	0.162	09-Oct-2000
20000400	45a5N	Zn	1.040	09-Oct-2000
20000400	45a5N	Sr	10.300	09-Oct-2000
20000400	45a5N	Li	0.069	09-Oct-2000

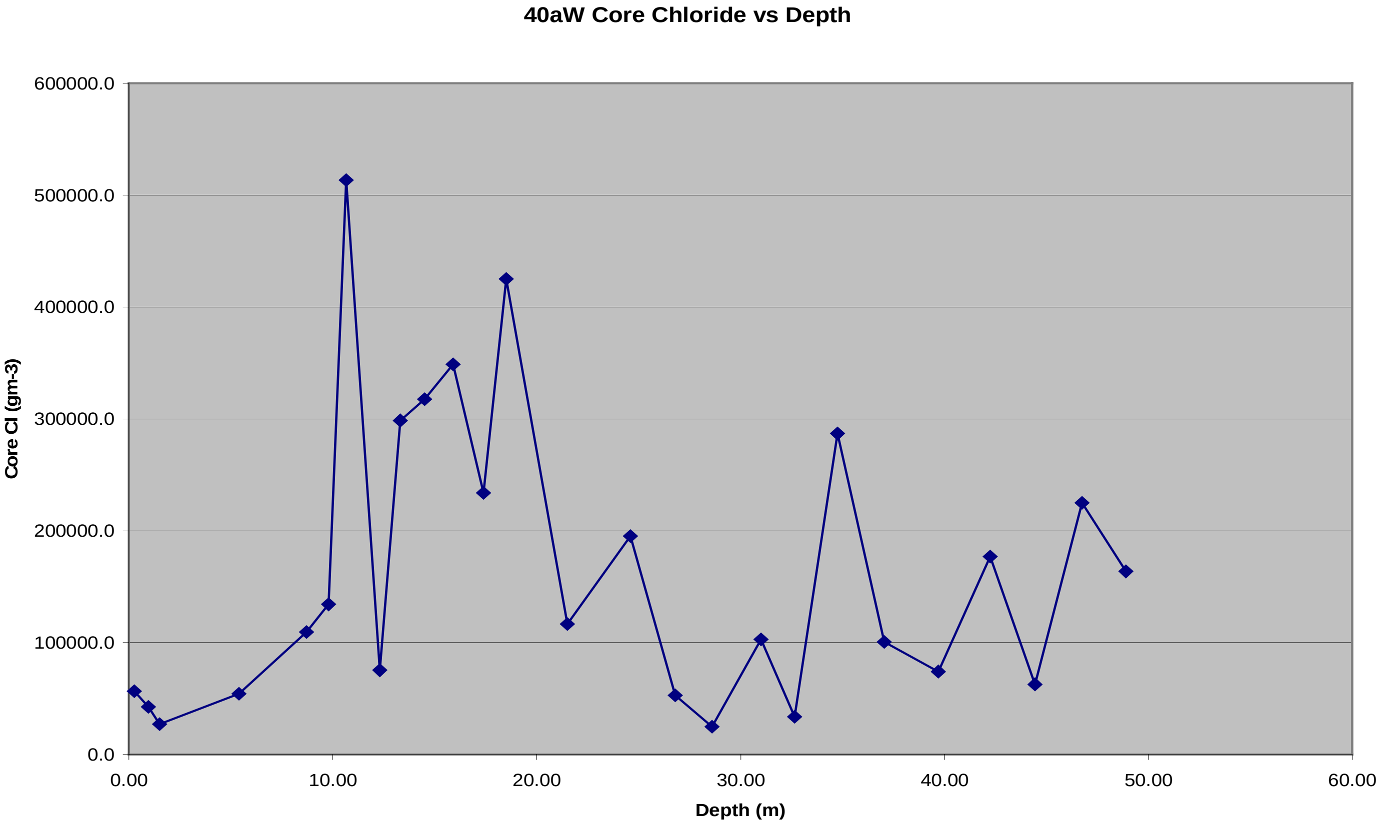
20000400	45a5N	B	9.040	09-Oct-2000
20000400	45a5N	Ba	0.038	09-Oct-2000
20000400	45a5N	AnCatRat	-5.024	09-Oct-2000
20000400	45a5N	S/SO4Rat	1.039	09-Oct-2000
20000400	45a5N	TOTHARD	1895.861	09-Oct-2000
20000400	45a5N	TDSCNRAT	0.763	09-Oct-2000
20000400	45a5N	TDSRATIO	1.066	09-Oct-2000

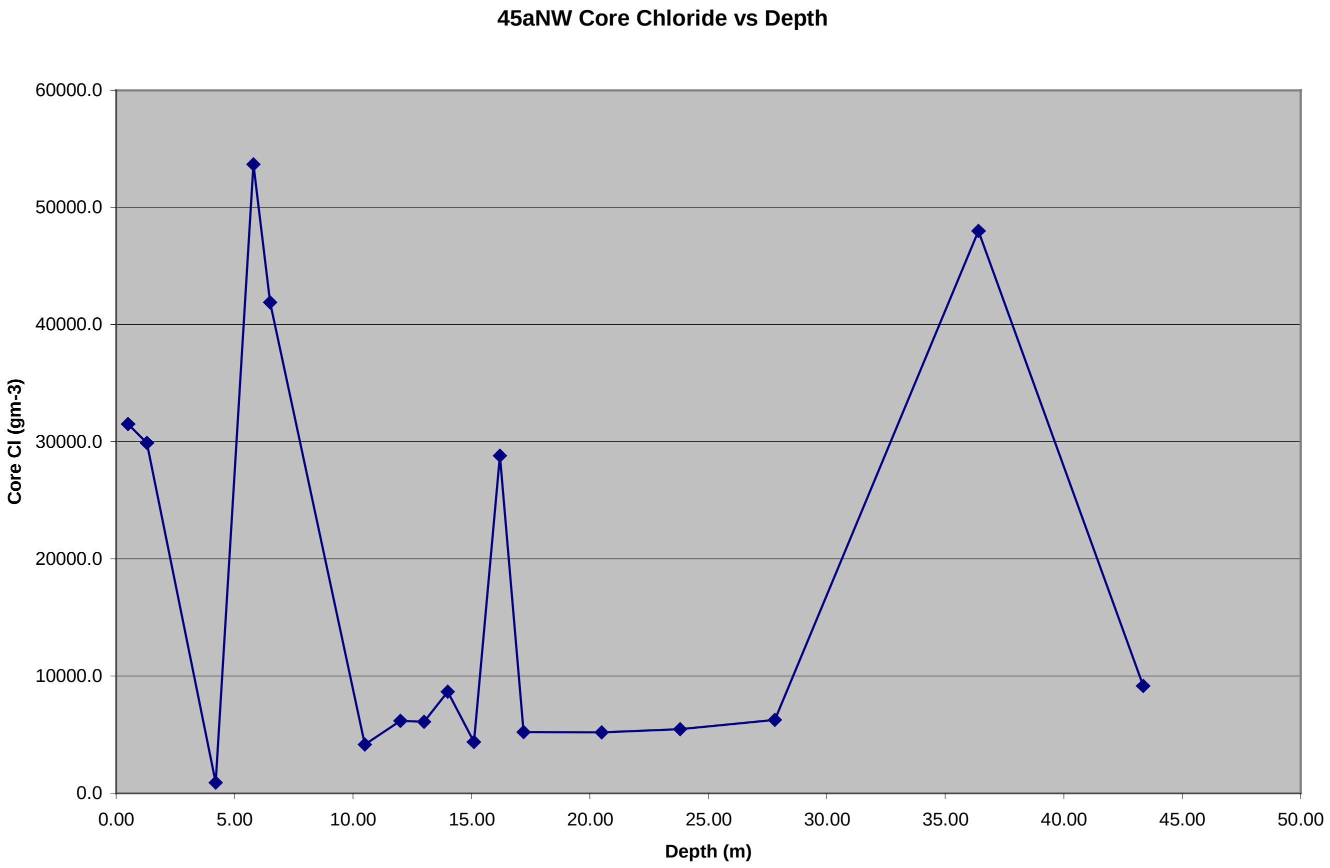
20000401	40a5E	TDS	22000.000	14-Oct-2000
20000401	40a5E	LabPH	6.590	14-Oct-2000
20000401	40a5E	LabEC	29200.000	14-Oct-2000
20000401	40a5E	TOTALK	273.750	14-Oct-2000
20000401	40a5E	Phenol.ALK	ND	14-Oct-2000
20000401	40a5E	I	ND	14-Oct-2000
20000401	40a5E	F	ND	14-Oct-2000
20000401	40a5E	Cl	11900.000	14-Oct-2000
20000401	40a5E	Br	9.200	14-Oct-2000
20000401	40a5E	NO3	-2.500	14-Oct-2000
20000401	40a5E	PO4	-2.500	14-Oct-2000
20000401	40a5E	SO4	2510.000	14-Oct-2000
20000401	40a5E	Ca	1430.000	14-Oct-2000
20000401	40a5E	Mg	754.000	14-Oct-2000
20000401	40a5E	Na	5330.000	14-Oct-2000
20000401	40a5E	K	35.300	14-Oct-2000
20000401	40a5E	Si	13.400	14-Oct-2000
20000401	40a5E	S	846.000	14-Oct-2000
20000401	40a5E	Al	0.265	14-Oct-2000
20000401	40a5E	Fe	15.500	14-Oct-2000
20000401	40a5E	Mn	0.853	14-Oct-2000
20000401	40a5E	Cu	0.082	14-Oct-2000
20000401	40a5E	Zn	0.952	14-Oct-2000
20000401	40a5E	Sr	22.200	14-Oct-2000
20000401	40a5E	Li	0.200	14-Oct-2000
20000401	40a5E	B	4.260	14-Oct-2000
20000401	40a5E	Ba	0.038	14-Oct-2000
20000401	40a5E	AnCatRat	-3.601	14-Oct-2000
20000401	40a5E	S/SO4Rat	1.010	14-Oct-2000
20000401	40a5E	TOTHARD	6675.682	14-Oct-2000
20000401	40a5E	TDSCNRAT	0.753	14-Oct-2000
20000401	40a5E	TDSRATIO	0.995	14-Oct-2000

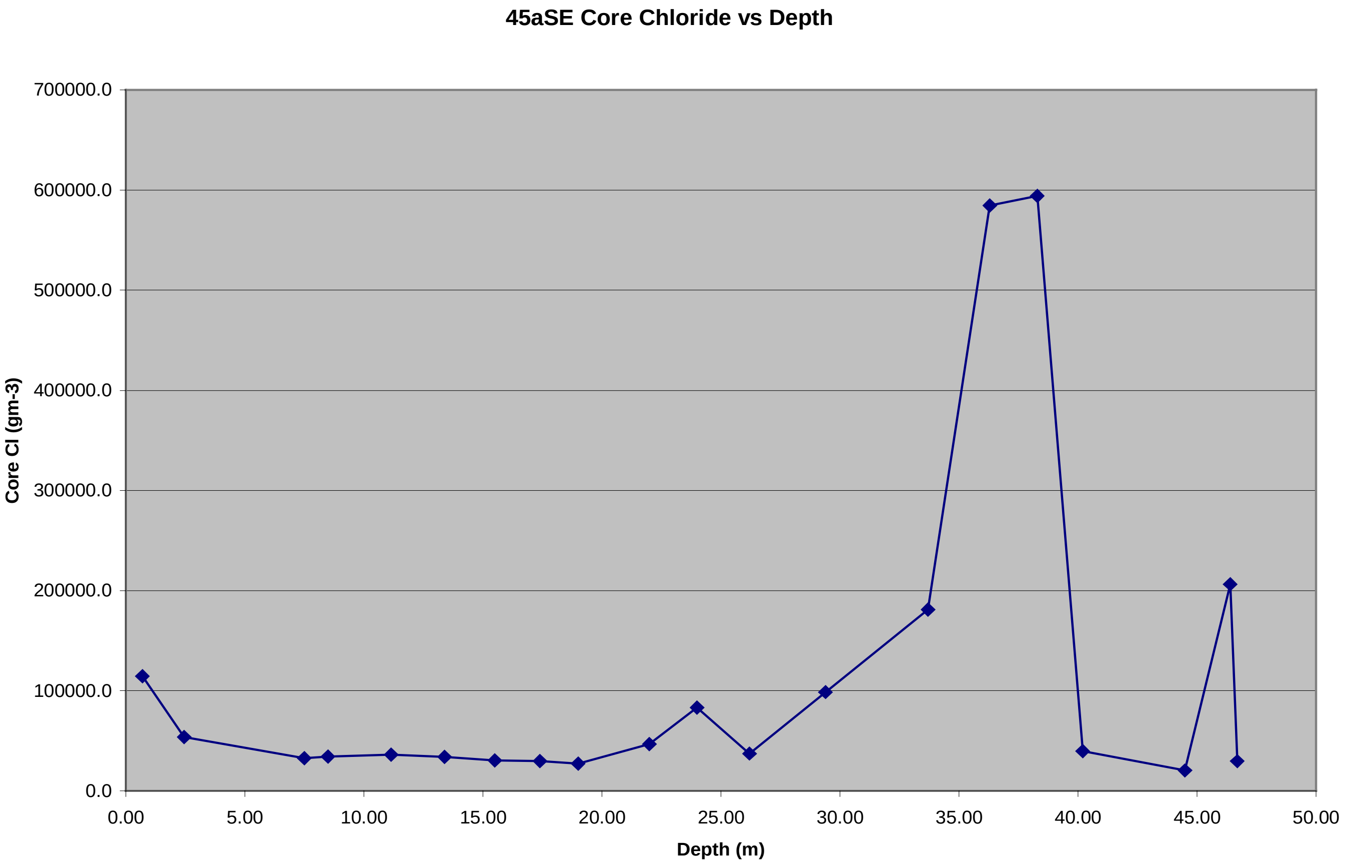
Appendix 6: Chloride concentrations, volumetric moisture contents and cumulative water/chloride plots (unsaturated zone)

6.1: Chloride Concentrations

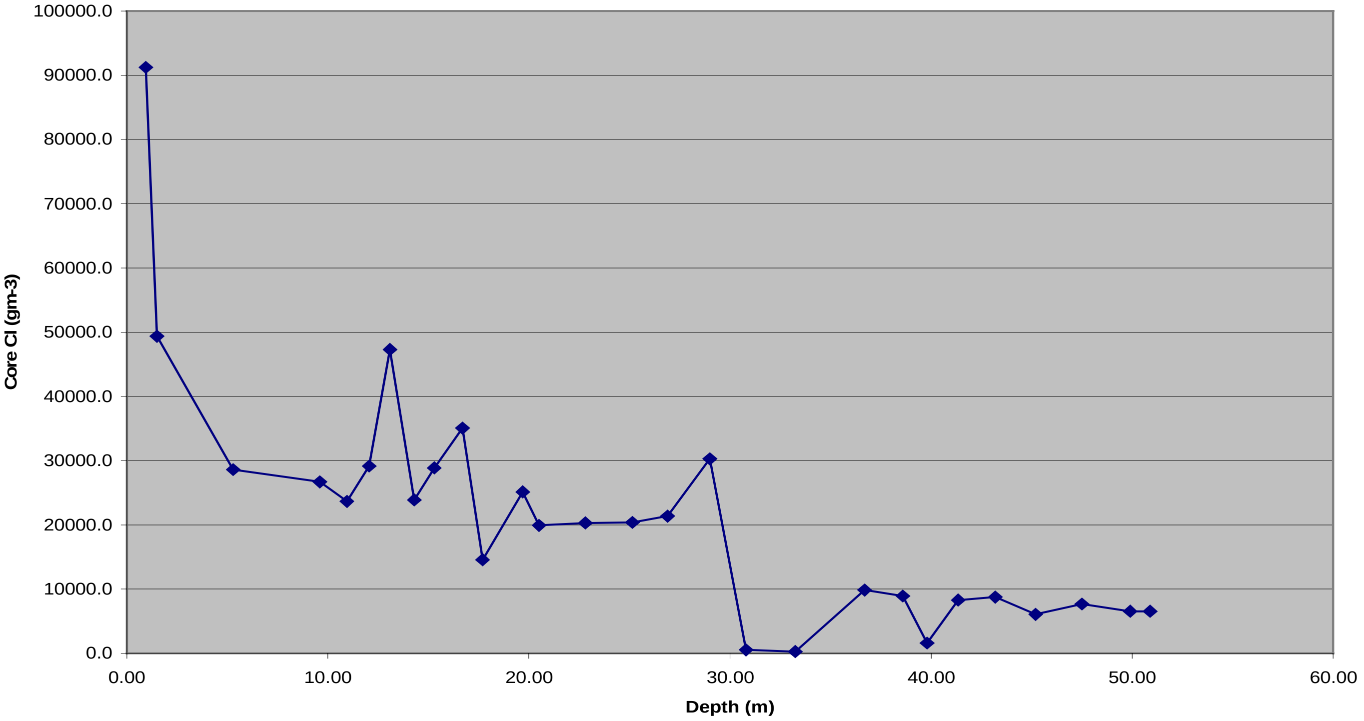




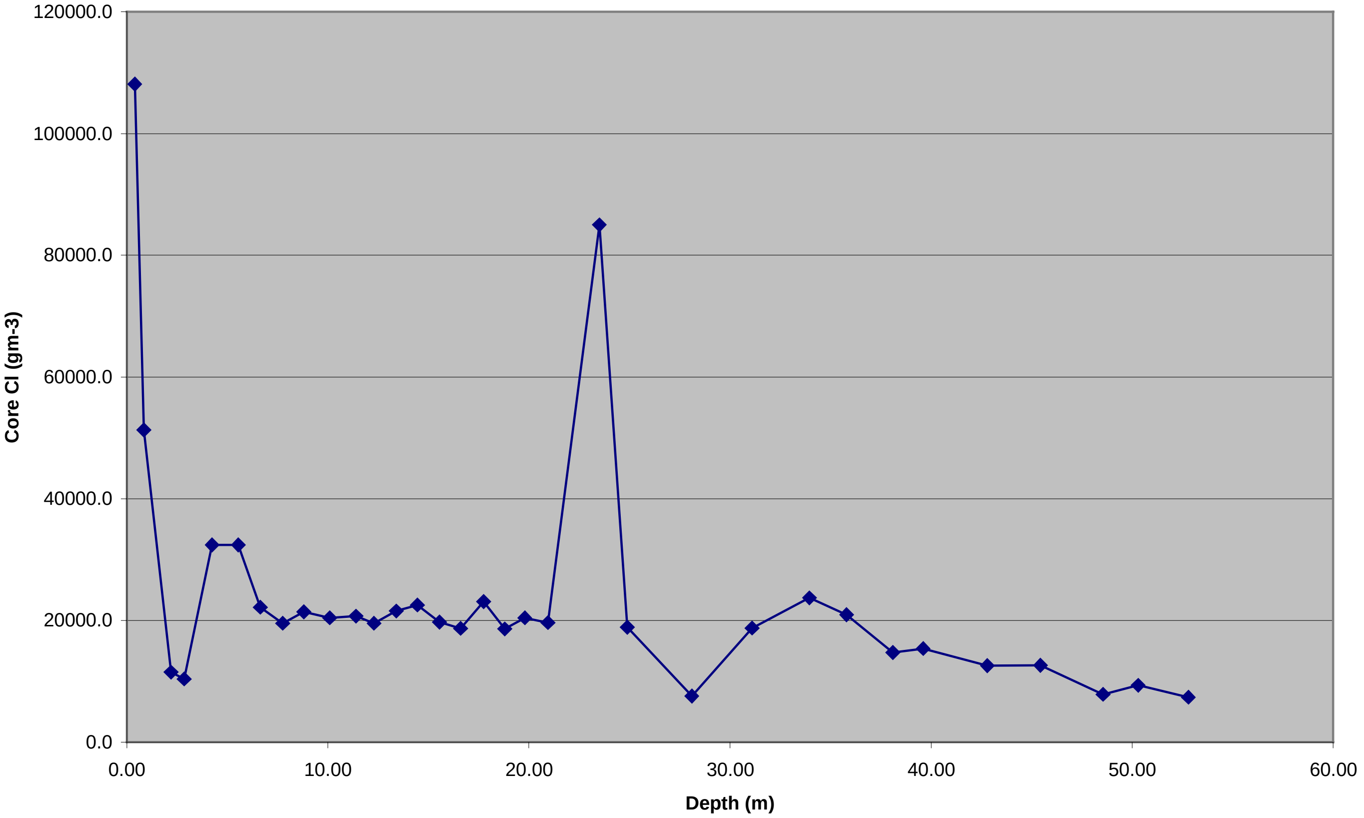

45aNW Core Chloride vs Depth
Core Cl (gm-3)
60000.0
50000.0
40000.0
30000.0
20000.0
10000.0
0.0
0.00
5.00
10.00
15.00
20.00
25.00
30.00
35.00
40.00
45.00
50.00
Depth (m)


45aSE Core Chloride vs Depth
Core Cl (gm-3)
700000.0
600000.0
500000.0
400000.0
300000.0
200000.0
100000.0
0.0
0.00
5.00
10.00
15.00
20.00
25.00
30.00
35.00
40.00
45.00
50.00
Depth (m)

52aNE Core Chloride vs Depth

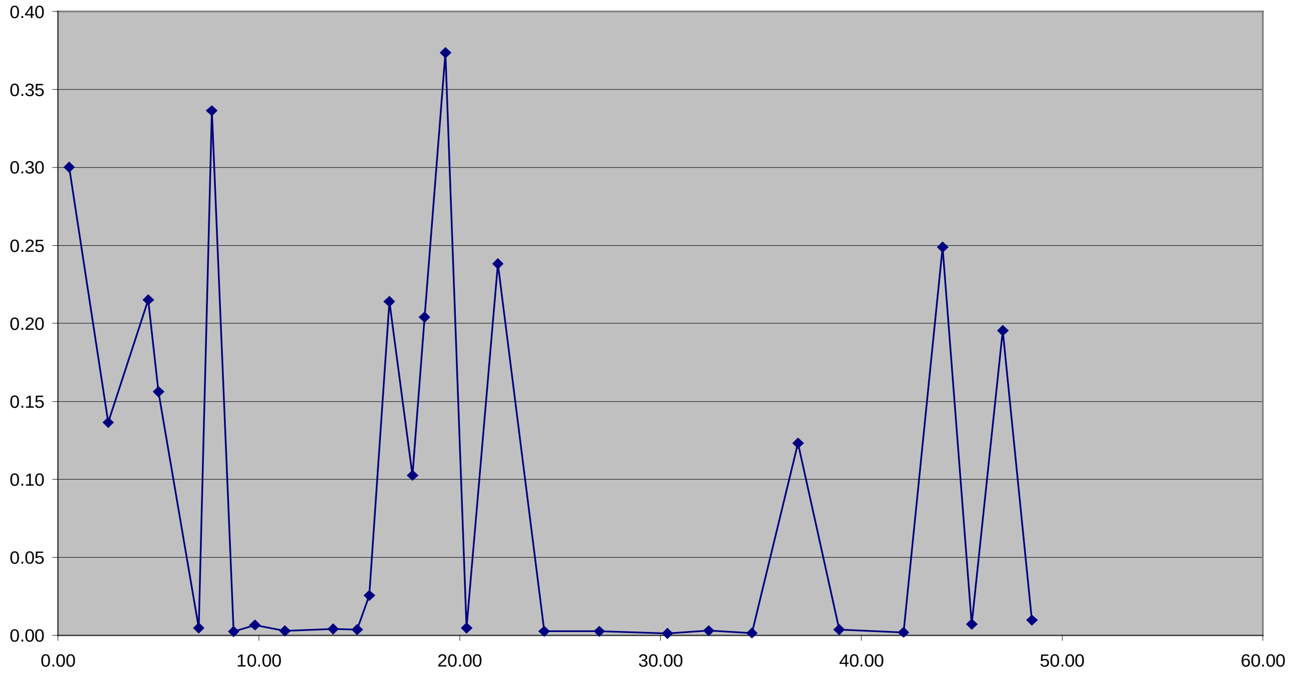


52aSW Core Chloride vs Depth

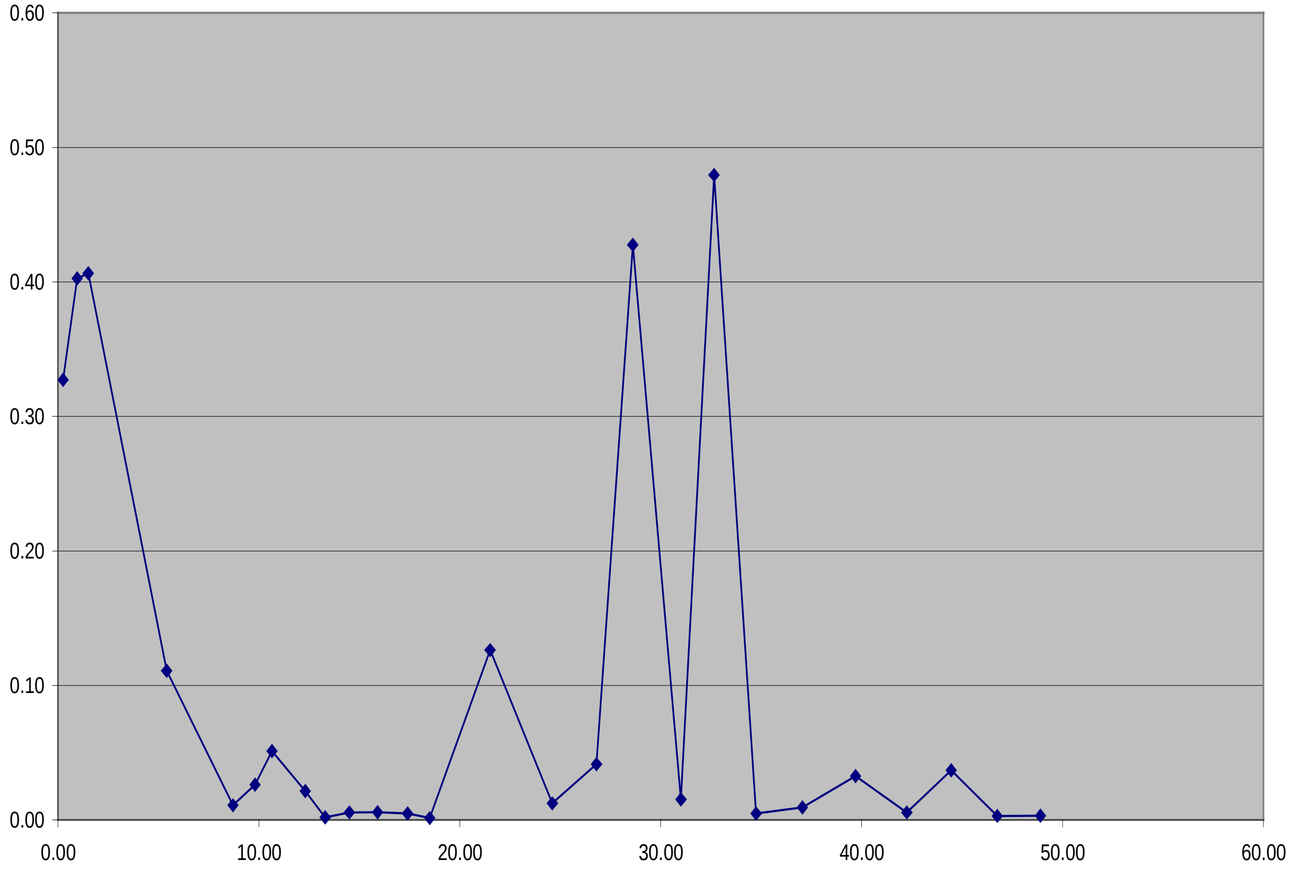


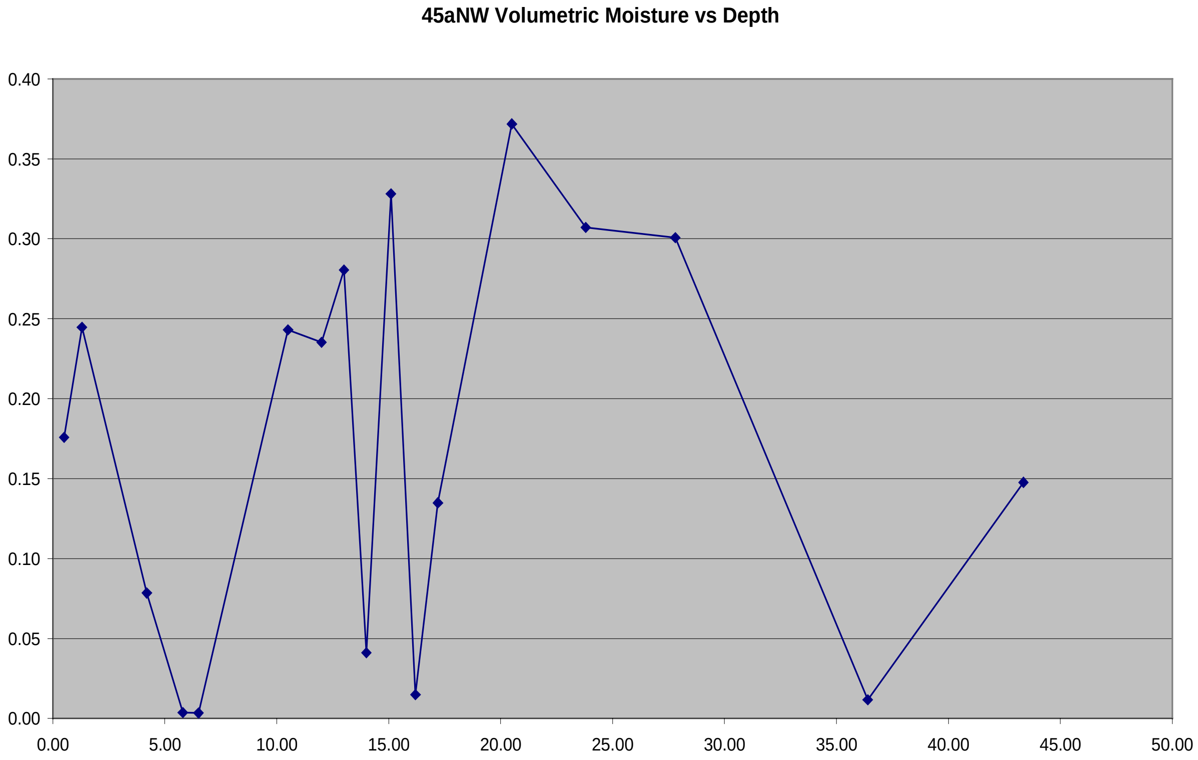
6.2: Volumetric Moisture Contents

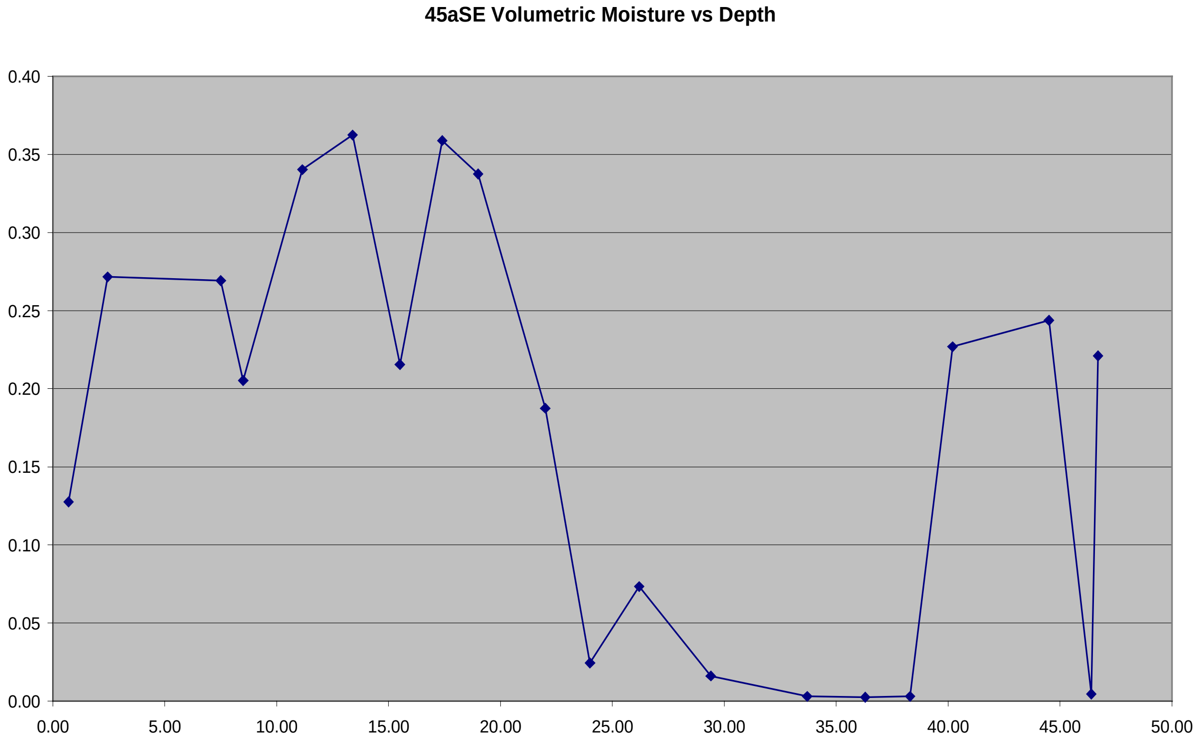
40aE Volumetric Moisture vs Depth



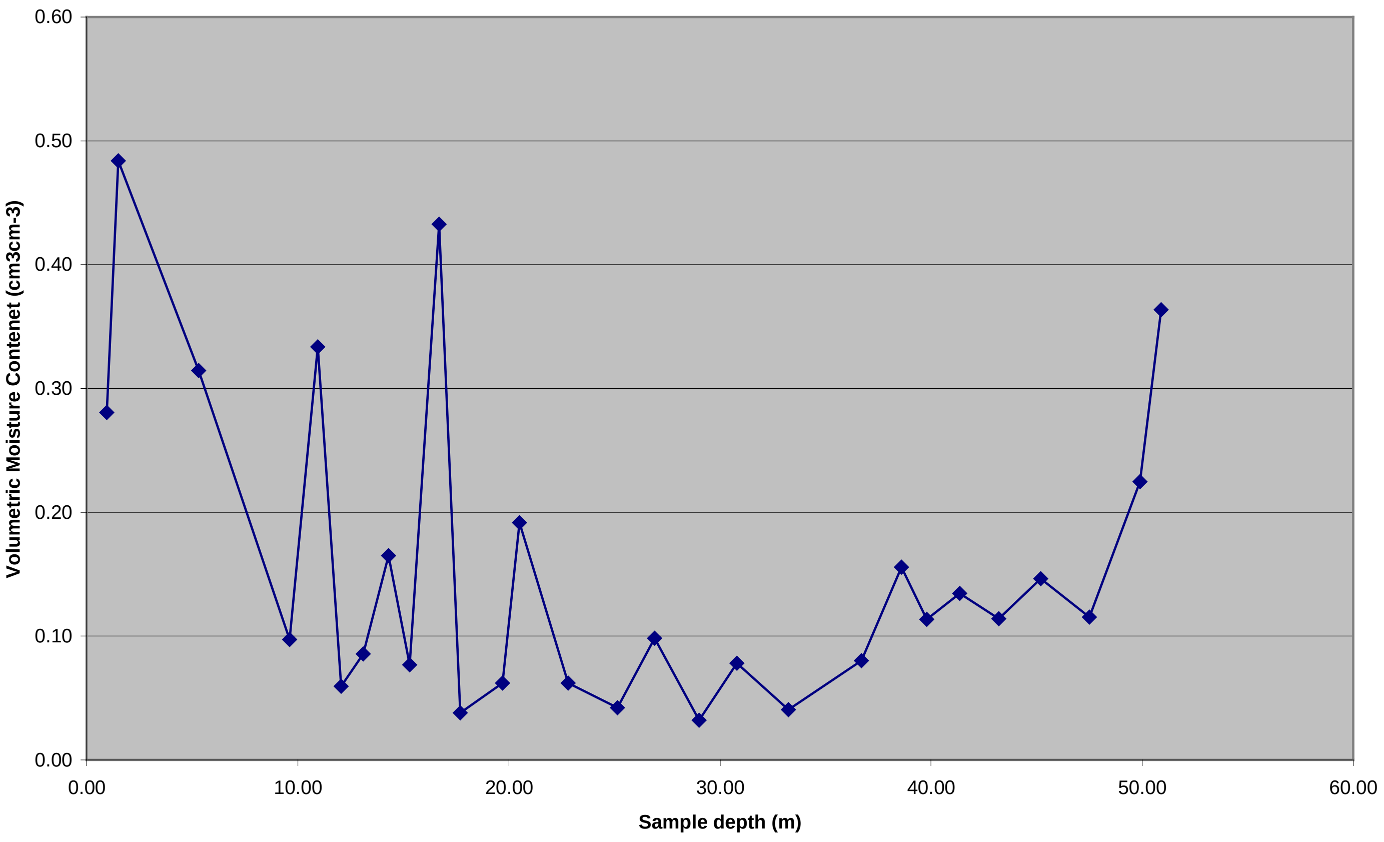
40aW Volumetric Moisture vs Depth



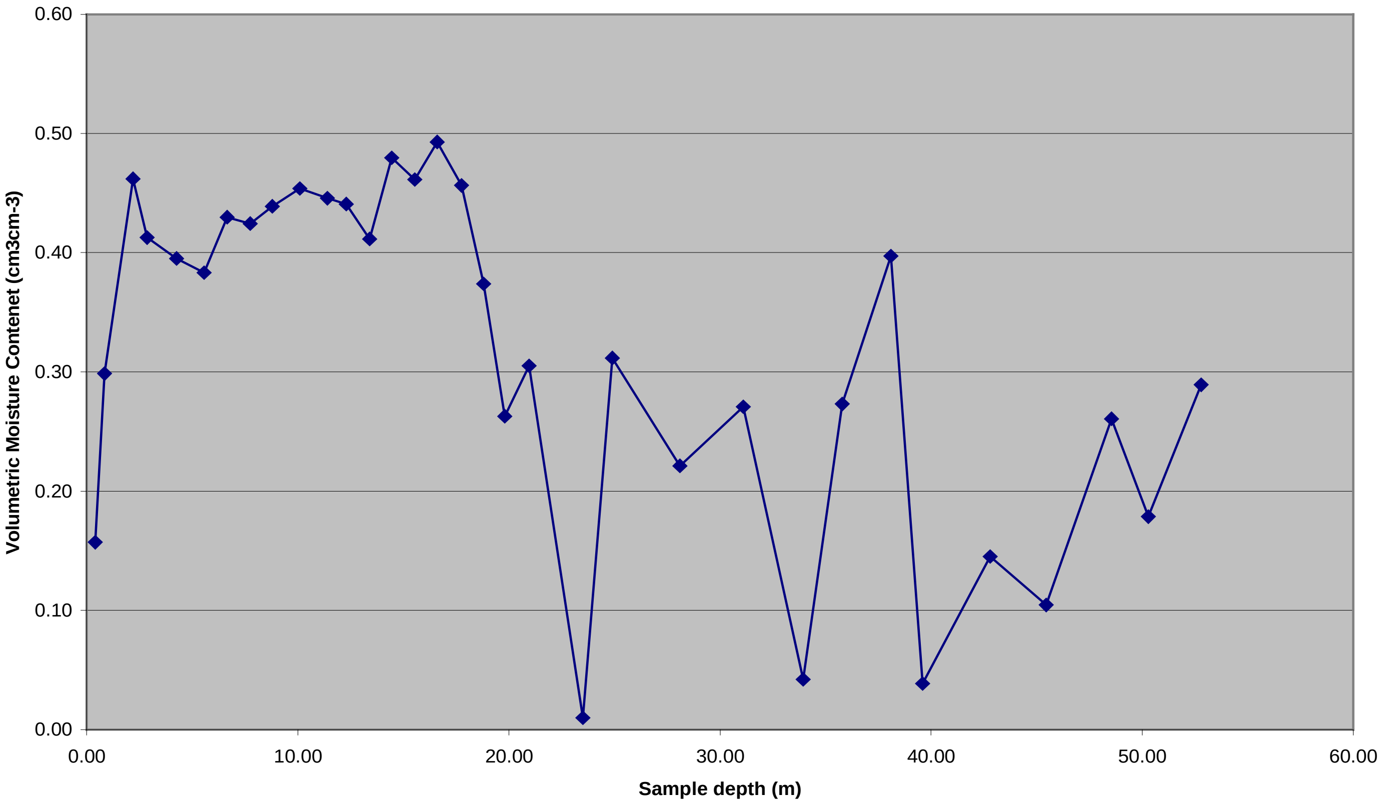

45aNW Volumetric Moisture vs Depth
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
0.00
5.00
10.00
15.00
20.00
25.00
30.00
35.00
40.00
45.00
50.00


45aSE Volumetric Moisture vs Depth
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
0.00
5.00
10.00
15.00
20.00
25.00
30.00
35.00
40.00
45.00
50.00

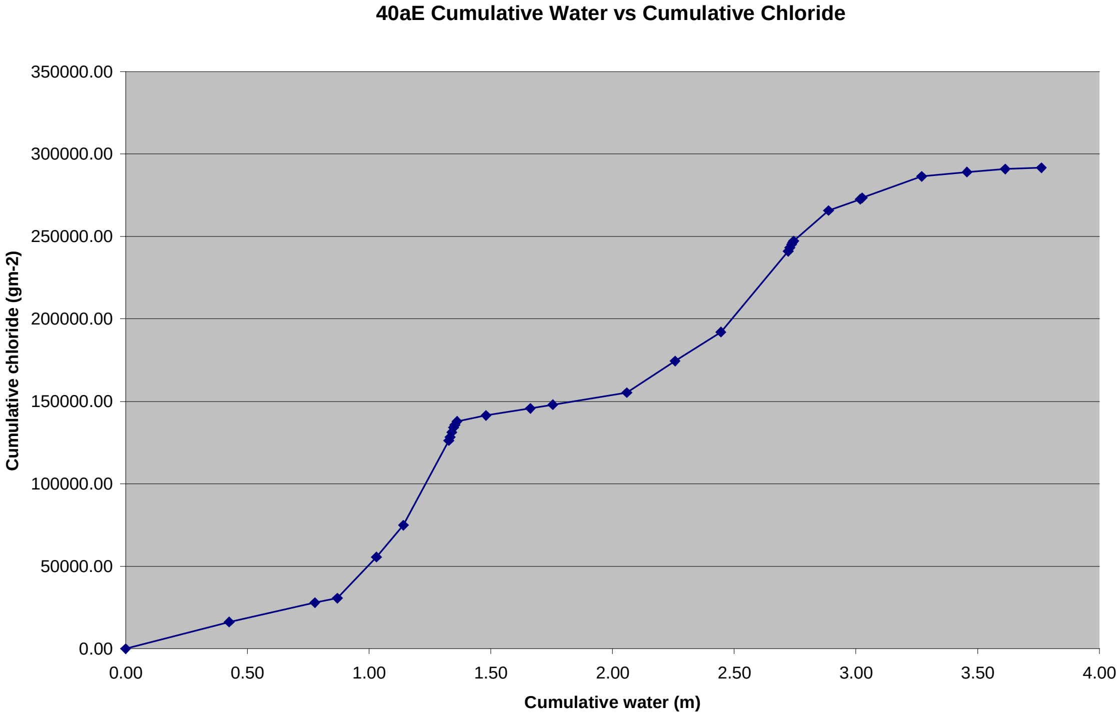
52aNE Volumetric Moisture vs Depth

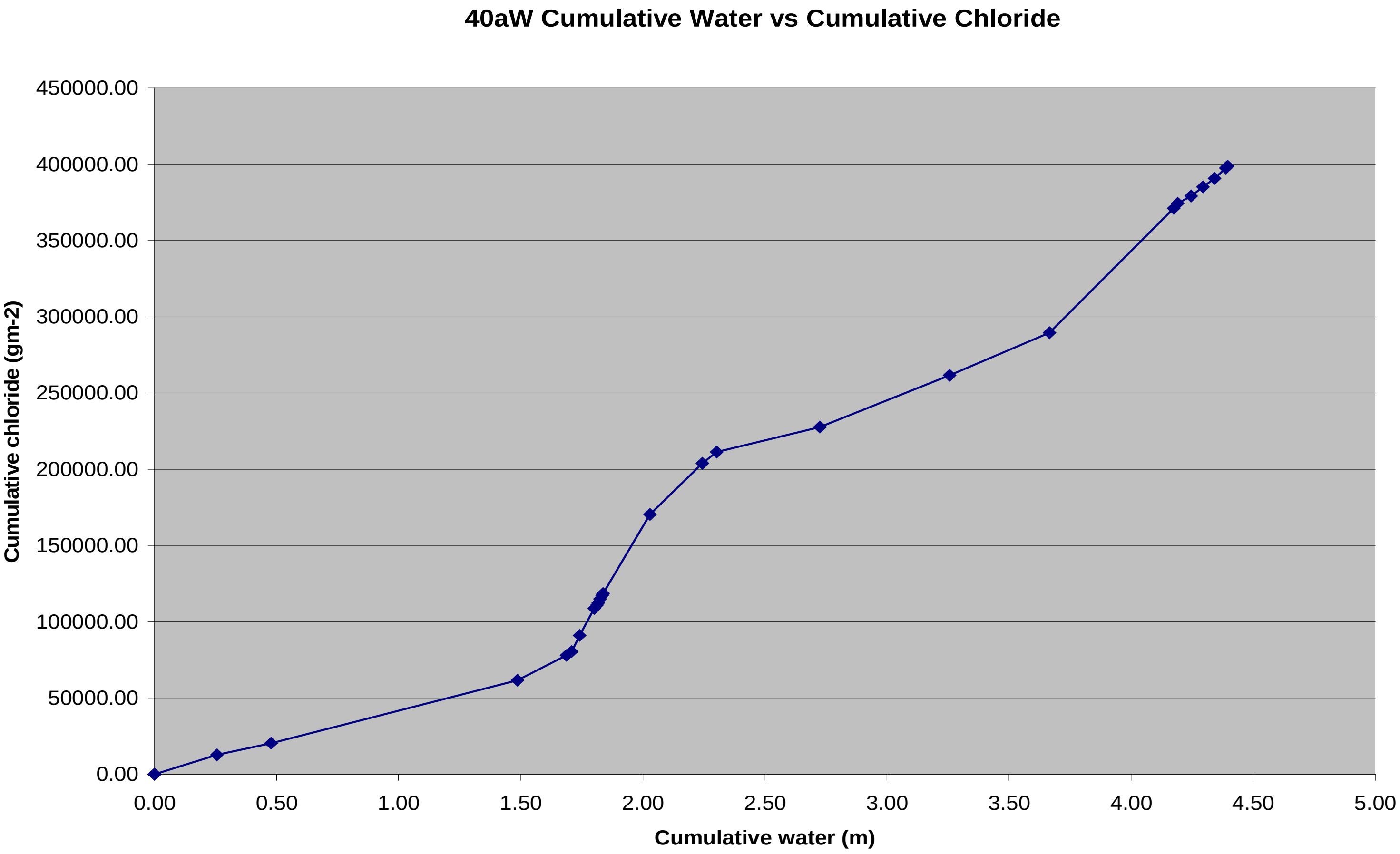


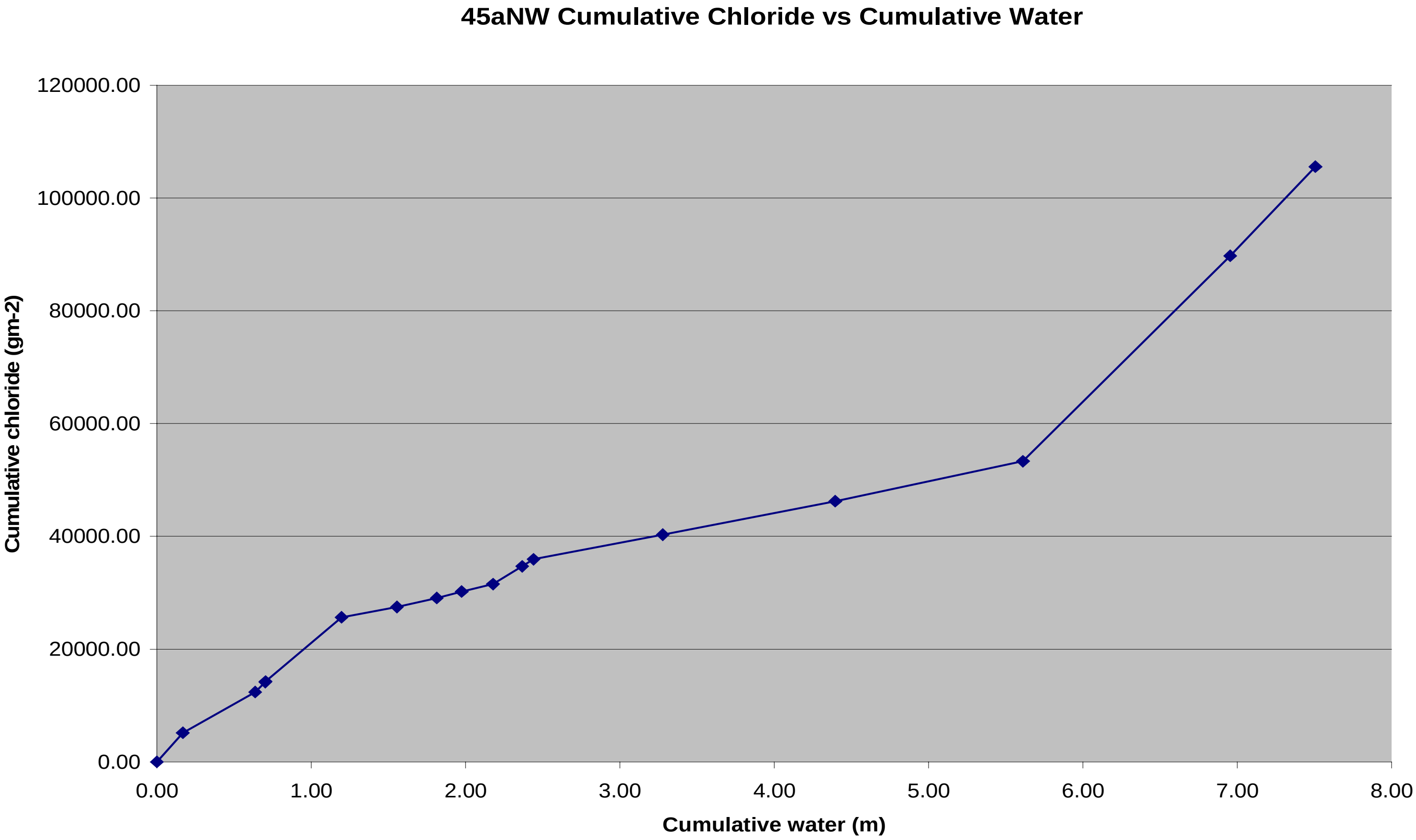
52aSW Volumetric Moisture vs Depth

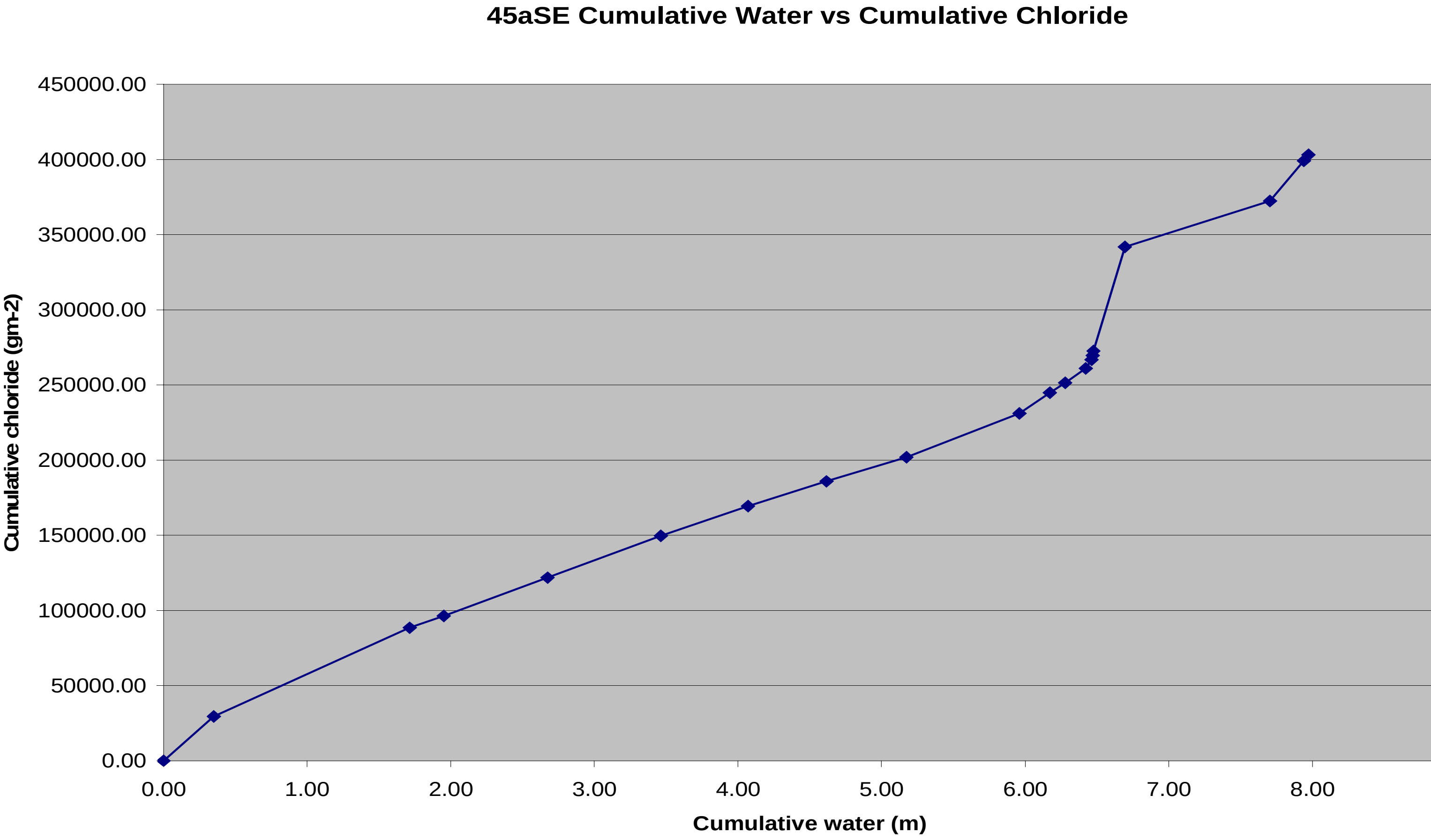


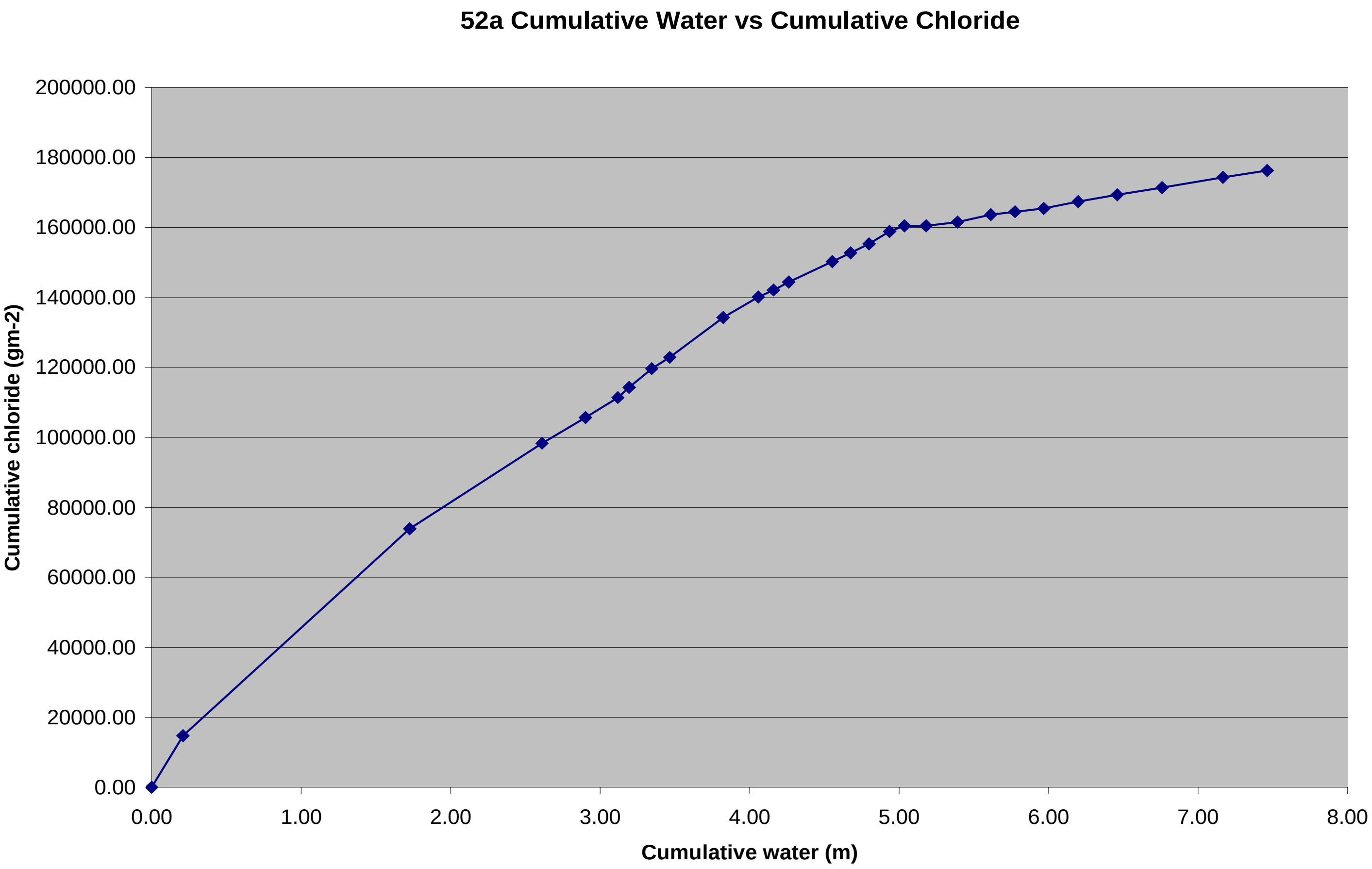
6.3: Cumulative Water – Cumulative Chloride

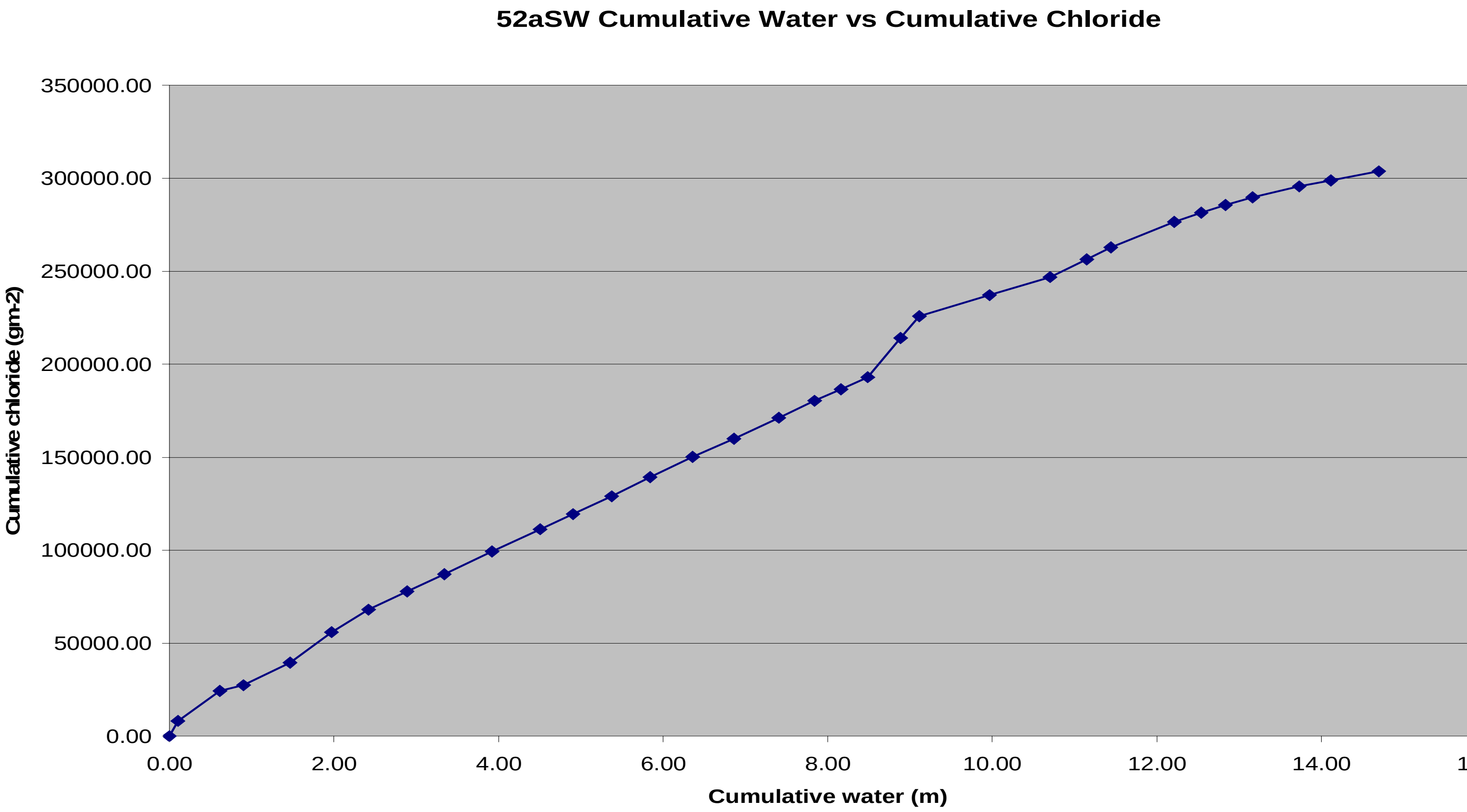





45aNW Cumulative Chloride vs Cumulative Water
Cumulative chloride (gm-2)
0.00
20000.00
40000.00
60000.00
80000.00
100000.00
120000.00
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
Cumulative water (m)


45aSE Cumulative Water vs Cumulative Chloride
Cumulative chloride (gm-2)
0.00
50000.00
100000.00
150000.00
200000.00
250000.00
300000.00
350000.00
400000.00
450000.00
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
Cumulative water (m)


52a Cumulative Water vs Cumulative Chloride
Cumulative chloride (gm-2)
200000.00
180000.00
160000.00
140000.00
120000.00
100000.00
80000.00
60000.00
40000.00
20000.00
0.00
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
Cumulative water (m)


52aSW Cumulative Water vs Cumulative Chloride
Cumulative chloride (gm-2)
350000.00
300000.00
250000.00
200000.00
150000.00
100000.00
50000.00
0.00
0.00
2.00
4.00
6.00
8.00
10.00
12.00
14.00
1
Cumulative water (m)

Appendix 7: Chlorine-36 and Carbon-14 data

Appendix 8: Oxygen-18 and Deuterium data

Sample no.	Borehole	Oxygen 18 $^{0}/_{00}$SMOW	Deuterium $^{0}/_{00}$SMOW
990500	7SW	-3.14	-29.6
990501	14NW	-3.74	-31.1
990502	16SE	-4.01	-35.2
990503	13SE	-1.84	-23.6
990506	12SE	-1.18	-21
990507	10N	-3.06	-28.3
990508	THE PINES	-4.94	-38.9
990509	45NW	-3.59	-32.3
990513	PARADISE WELL	-5.55	-43.9
20000290	10aN	-3.08	-30.2
20000291	33S	-2.38	-27.3
20000292	41W	-3.99	-35.3
20000293	52aSE	-1.96	-27.8
20000294	10aS	-4.23	-36.4
20000295	45aSW	-1.14	-26.6
20000296	14aNW	-2.59	-27.6
20000297	52aNW	-2.09	-29.2
20000299	45aNE	-2.88	-29.3
20000300	14aSE	-2.65	-30.3
20000386	52a50SE	-1.47	-23.4
20000387	52a50NW	-1.6	-24
20000388	52a50N	-1.82	-25.4
20000389	52a50W	-1.72	-24.9
20000390	52a50E	-1.57	-24.8
20000391	52a50S	-1.88	-25.2
20000392	52a50SW	-2.05	-27
20000393	52a50NE	-2.36	-26.9
20000394	45a50NW	-2.98	-27.9
20000395	45a50S	-2.21	-25.7
20000396	45a50SW	-2.3	-27.1
20000397	45a50SE	-2.04	-27.1
20000398	45a50E	-3.1	-26.9
20000399	45a50NE	-3.15	-27.7
20000400	45a50N	-4.17	-33.3
30000401	40a50E	-3.34	-30.1

Appendix 9: Distribution Coefficients (from report ANSTO/C649)

K_d values (mL/g) measured using the batch technique, samples ordered by formation. The initial solution added was 0.5 M NaCl or saturated $CaSO_4$. The pH is the pH of the sample in equilibrium with these solutions, and in one experiment the pH was controlled to between 6.5 and 7.

Hole	Depth	Formation	Description	**K_d** Trace Cs in NaCl	**K_d** Trace Cs in $CaSO_4$	**K_d** 1 mmol/L Cs in NaCl	**pH** Trace Co in NaCl	**K_d** Trace Co in NaCl	**K_d** Trace Co pH controlled in NaCl	**pH** Trace Co in $CaSO_4$	**K_d** Trace Co in $CaSO_4$
13	7.5	Sim	Clay in Qz	513	1776	2.1	6.77	79	79	7.24	68
16	10.5	Sim	Clay in Qz	854	2812	2.7	7.54	395	142	7.51	164
12	9.5	Sim	Clay in Qz	633	3379	1.8	6.71	79	79	7.38	110
13	10.5	Sim	Clay in Qz	586	1963	1.2	6.76	61	61	6.89	20
13	21.5	Sim	GreyGrnClay	545	2704	1.5	6.63	95	96	6.71	31
14	13.5	Sim	GreyGrnClay	959	2734	2.2	5.82	20	79	6.38	14
14	19.5	Sim	GreyGrnClay	671	3281	1.5	6.00	14	43	6.72	16
14	23.5	Sim	GreyGrnClay	690	6969	2.9	5.61	16	93	6.11	16
7	9.5	Sim	Qzite	154	1155	1.5	6.43	122	197	6.97	97
10	23.5	Sim	Qzite	182	1042	0.4	5.92	14	23	6.63	4
16	30.5	Sim	Qzite	747	4392	2.1	4.00	4	56	3.96	8
16	24.5	Sim	Shale / sulf	1231	6879	4.3	6.95	424	423	6.72	168
16	37.5	Sim	Shale / sulf	789	3911	2.5	4.57	6	191	4.49	4
52aNW	3.5	Bul	Siltstone	489	2473	15.1	8.21	2231	1458	8.09	3381
52aSE	3.5	Bul	Siltstone	557	1917	8.5	8.28	1418	1299	8.38	2603
52aSE	14.5	Bul	Mudstone	550	2359	16.2	6.28	6	54	6.89	14
52aNW	15.5	Bul	Mudstone	388	2017	4.2	5.70	5	82	6.70	13
52aSE	15.5	Bul	Siltstone	390	1720	2.4	6.23	15	44	6.79	12
52aNW	31.5	Cad	Sandstone	34	144	0.6	6.21	6	13	7.01	7
52aNW	42.5	Cad	Blue clay	447	1359	1.7	3.90	0	44	3.99	1
52aSE	31.5	Cad	Sdstone/sand	1112	3681	3.7	7.33	467	352	7.56	337

Distribution coefficients **Continued**

Hole	Depth	Formation	Description	**K_d** Trace Cs in NaCl	**K_d** Trace Cs in $CaSO_4$	**K_d** 1 mmol/L Cs in NaCl	**pH** Trace Co in NaCl	**K_d** Trace Co in NaCl	**K_d** Trace Co pH controlled in NaCl	**pH** Trace Co in $CaSO_4$	**K_d** Trace Co in $CaSO_4$
14	28.5	Cor	Sdstone	1290	4200	4.1	5.46	14	134	6.14	16
13	31.5	Cor	Sdstone	449	1964	1.7	6.65	80	80	6.69	39
14	40.5	Cor	Sdstone	628	2222	1.4	5.50	15	122	5.51	22
16	46.5	Cor	Sdstone	1107	3326	3.1	5.87	92	269	5.66	88
14	55.5	Cor	Sdstone	466	1668	1.6	6.77	271	271	6.47	94
16	77.5	Cor	Sdstone	447	1721	1.2	6.85	219	219	6.87	120
14	32.5	Cor	Siltstone	1706	5660	5.2	6.60	133	139	6.28	45
14	33.5	Cor	Siltstone	1304	5666	4.7	6.45	135	213	6.89	154
40	45.5	Cor	Mica sandst	1590	7645	10.7	6.77	771	771	6.99	870
41	31.5	Cor	Mica sandst	386	2942	3.7	6.65	221	308	6.86	223
52aNW	50.5	Cor	Siltstone	2502	3571	9.9	8.72	3347	1029	8.03	1518
52aSE	43.5	Cor	Siltstone	1883	5464	6.2	8.21	2487	1330	8.13	2519
52aSE	50.5	Cor	Shale	1680	8585	6.1	8.93	4652	877	8.44	2226
16	1.5	Qc	Clay	647	4299	16.7	8.49	4464	1543	8.12	5530
12	1.5	Qc	Clay	512	5062	23.3	7.93	1962	1315	8.48	6234
16	2.5	Ts	silc	239	1754	5.3	7.28	2268	1776	6.81	2349

Sim – Simmens
Bul – Bulldog
Cad – Cadna-owie
Cor – Corraberra
Qc – Quaternary (surface clay)
Ts – silcrete

Appendix 10: Qualitative rock hardness in top 20 metres assessed from stage 3 drilling conditions

Abbreviations:	
SMHB	soft with minor hard bands (soft >> hard)
ASHB	alternating soft and hard bands (soft > hard)
HBANDS	hard bands (soft ~ hard)
AHSB	alternating hard and soft bands (hard > soft)

10.1 SITE 40a

40a15NE	40a15SE	40a15S	40a15W	40a50W	40a50NW	40a50N	40a50NE	40a50E
0-4 SOFT	0-3 SOFT	0-2 SOFT	0-3 SOFT	0-3 SOFT	0-3 SOFT	0-3 SOFT	0-3 SOFT	0-2 SOFT
4-16 HARD	3-5 ASHB	2-5 HARD	3-20+ SMHB	3-16 HBANDS	3-20 AHSB	3-20+ HARD	3-6 HARD	2-4 HARD
16-20+ ASHB	5-20 AHSB	5-16 HARD		16-20+ ASHB	20+ ASHB		6-20+ AHSB	4-20+ AHSB
	20+ ASHB	16-20+ SMHB						

40a50**SE**	**40a50S**	**40a50SW**	**40a15E**	40a15**NW**	**40a15N**
0-3 SOFT	0-2 SOFT	0-3 SOFT	0-2 SOFT	0-2 SOFT	0-3 SOFT
3-4 HARD	2-5 HARD?	3-5 HARD	2-4 HARD	2-5 HARD?	3-7 HARD
4-20 AHSB	5-16 HARD	5-18 AHSB	4-20+ AHSB	5-20+ HARD	7-16 AHSB
	16-20+ SMHB	18-20+ SMHB			16-20+ ASHB

10.2 SITE 45a

45a15N	45a15W	45a15S	45a15E	45a50NW	45a50N
0-2 SOFT	0-2.5 SOFT	0-1.5 SOFT	0-3 SOFT	0-2.5 SOFT	0-3 SOFT
2-12 AHSB	2.5-4 HBANDS	1.5-5 AHSB	3-14 AHSB	2.5-17 AHSB	3-4 HBANDS
12-15 HBANDS	4-5.5 AHSB	5-7 HBANDS	14-15 HBANDS	17-18 HBANDS	4-6 AHSB
15-16 AHSB	5.5-12 HBANDS	7-8 SOFT	15-20+ AHSB	18-20+ AHSB	6-10 HBANDS
16-19 HBANDS	12-15 SMHB	8-10 SMHB			10-13 ASHB
19-20+ AHSB	15-19 HBANDS	10-11 HBANDS			13-17 HBANDS
	19-20+ SMHB	11-14 SMHB			17-18 SMHB
		14-15 ASHB			18-20+ HBANDS
		15-16 SMHB			
		16-18 HBANDS			
		18-19 AHSB			
		19-20 ASHB			

45a50NE	45a50W	45a50SW	45a50S	45a50SE	45a50E
0-3 SOFT	0-2.5 SOFT	0-2 SOFT	0-2 SOFT	0-1.5 SOFT	0-2.5 SOFT
3-5 SMHB	2.5-6 AHSB	2-4.5 AHSB	2-7 AHSB	1.5-9 AHSB	2.5-12 AHSB

5-9 AHSB	6-18 ASHB	4.5-7 HARD	7-17 HBANDS	9-10 ASHB	12-14 HBANDS
9-18 HBANDS	18-20 SMHB	7-18.5 HBANDS	17-20+ ASHB	10-20+ HBANDS	14-15 AHSB
18-20 ASHB		18.5-20 ASHB			15-18 HBANDS
19-20+ AHSB					18-20+ ASHB

10.3 SITE 52a

52a15NE	**52a15NW**	**52a15SW**	**52a15SE**	**52a50E**	**52a50NE**
0-3 SOFT	0-1 SOFT	0-2.5 SOFT	0-1 SOFT	0-7 SOFT	0-1 SOFT
3-7 HBANDS	1-3 SMHB	2.5-4.5 ASHB	1-2 ASHB	7-11 SMHB	1-6.5 SMHB
7-8 SOFT	3-12 SOFT	4.5-7 SMHB	2-5 SMHB	11-15 ASHB	6.5-8 SOFT
8-12 SMHB	12-15 SMHB	7-19 SOFT	5-20 SOFT	15-20+ HBANDS	8-14 SMHB
12-13 ASHB	15-20+ SOFT	19-20+ SMHB			14-20+ ASHB
13-15 SMHB					
15-20+ SOFT					

52a50N	**52a50NW**	**52a50W**	**52a50SW**	**52a50S**	**52a50SE**
0-2 SOFT	0-2 SOFT	0-1 SOFT	0-1 SOFT	0-3 SOFT	0-4 SMHB
2-10 SMHB	2-5.5 SMHB	1-3 ASHB	1-3 ASHB	3-8 SMHB	4-17 SOFT
10-13 SOFT	5.5-14 SOFT	3-4 HBANDS	3-16 SMHB	8-10 SOFT	17-18 SMHB
13-16 SMHB	14-16 SMHB	4-5 SMHB	16-18 SOFT	10-11 SMHB	18-19 SOFT
16-20+ ASHB	16-17 SOFT	5-9 SOFT	18-19 SMHB	11-19 SOFT	19-20+ SMHB
	17-18 SMHB	9-13.5 SMHB	19-20 SOFT	19-20+ SMHB	
	18-20+ SOFT	13.5-20+ SOFT			

Appendix 11: Estimated Silt + Clay-size percentages, stage 3 drillholes, by visual inspection and texture

11.1 Site 40a

Interval	**40a15 NE**	**40a15 SE**	**40a15 S**	**40a15W**	**40a50W**	**40a50 NW**	**40a50 N**	**40a50 NE**	**40a50 E**	**40a50 SE**
0-1m	100	100	90	90	90	90	90	100	90	70
1-2m	90	90	90	90	90	80	80	90	80	50
2-3	80	90	10	90	80	10	90	90	80	30
3-4	20	30	30	30	10	10	80	20	20	20
4-5	20	20	10	20	10	10	30	20	20	10
5-6	30	10	10	10	10	10	10	10	20	10
6-7	50	10	10	10	10	10	10	10	20	20
7-8	40	20	10	10	10	10	10	10	10	20
8-9	30	20	30	10	10	20	20	10	20	30
9-10	30	20	30	30	20	10	20	10	20	30
10-11	30	10	20	30	10	10	20	20	20	20
11-12	20	20	10	20	10	30	20	20	30	20
12-13	20	20	20	20	20	20	30	20	30	30
13-14	20	30	30	20	20	10	20	30	20	20
14-15	20	20	20	30	10	20	20	20	50	30
15-16	20	10	30	20	20	30	20	20	30	30
16-17	20	10	20	20	30	20	20	20	30	20
17-18	10	10	10	20	30	30	20	30	30	20
18-19	10	30	20	20	30	50	30	20	30	30
19-20	10	20	10	20	40	10	40	40	30	40
20-21	30	10	30	20	20	10	20	40	30	20
21-22	30	10	30	10	20	10	10	30	40	50
22-23	20	10	30	10	20	30	20	20	30	50
23-24	20	20	20	20	30	30	40	30	10	20
24-25	20	10	10	10	50	30	50	20	20	20
25-26	10	20	20	20	30	30	40	60	20	20
26-27	20	20	20	20	30	10	40	40	50	70
27-28	30	20	30	20	20	20	20	30	50	60
28-29	20	10	30	60	10	20	20	20	20	60
29-30	20	10	30	50	20	50	30	20	30	20
30-31	20	10	10	20	50	40	30	30	20	20
31-32	30	30	20	20	40	20	10	50	20	30
32-33	20	30	30	30	30	20	30	50	30	40
33-34	40	20	20	20	30	30	30	40	50	70
34-35	20	10	10	10	30	30	30	40	50	60
35-36	20	10	20	10	40	20	40	30	40	50
36-37	20	10	20	10	20	10	30	60	40	80
37-38	30	20	20	10	10	20	30	40	30	40
38-39	40	30	30	10	10	10	10	20	30	40
39-40	30	40	30	20	10	20	20	20	30	40
Mean 0-20	33.5	29.5	25.5	30.5	28	29.5	34	30.5	34	27.5
Mean 21-40	24.5	17.5	48	19.5	26	23	27.5	34.5	32	43

Interval	**40a50S**	**40a50SW**	**40a15E**	**40a15NW**	**40a15N**	**40N=40aS**	**40aN**
0-1	80	90	70	90	90	90	50
1-2	80	90	60	80	80	90	0
2-3	10	70	50	30	20	90	0
3-4	20	70	40	20	20	0	0
4-5	10	20	20	20	10	0	0
5-6	10	20	20	30	20	10	0
6-7	20	20	20	20	20	20	0
7-8	10	30	20	30	30	0	10
8-9	20	30	20	30	20	20	10

9-10	20	30	20	30	20	30	30
10-11	30	30	30	30	20	20	10
11-12	40	30	20	40	50	30	10
12-13	30	30	30	30	50	30	90
13-14	30	30	20	30	40	30	10
14-15	40	20	20	30	30	0	10
15-16	20	40	30	30	20	0	10
16-17	20	20	20	20	30	10	10
17-18	30	20	20	30	30	20	60
18-19	80	20	50	30	40	40	20
19-20	50	40	30	20	30	50	20
20-21	60	30	20	30	30	10	0
21-22	40	30	30	20	50	0	0
22-23	50	40	30	50	40	10	0
23-24	30	30	30	90	30	20	20
24-25	40	20	40	40	40	20	30
25-26	30	30	80	30	30	30	0
26-27	60	30	20	20	10	20	30
27-28	50	50	50	20	30	30	40
28-29	30	40	30	30	20	30	50
29-30	20	30	50	70	40	30	70
30-31	20	30	30	50	40	10	30
31-32	30	20	30	60	20	20	0
32-33	30	30	20	40	50	10	0
33-34	30	40	30	30	20	10	0
34-35	40	50	20	30	30	30	20
35-36	30	40	30	30	40	20	0
36-37	40	20	40	10	30	30	0
37-38	50	30	30	10	40	40	10
38-39	40	30	40	40	40	10	0
39-40	20	20	30	30	10	0	0
Mean 0-20	32.5	37.5	30.5	33.5	33.5	29	17.5
Mean 21-40	37	32	34	36.5	32	19	15

11.2 Site 45a

Interval	**45a15N**	**45a15W**	**45a15S**	**45a15E**	**45a50NW**	**45a50N**
0-1 (m)	90	90	90	90	90	90
1-2	90	90	50	90	90	90
2-3	0	50	10	90	50	90
3-4	0	10	0	10	10	10
4-5	0	0	0	0	10	0
5-6	10	20	10	0	0	0
6-7	20	30	20	10	40	10
7-8	30	20	90	10	60	30
8-9	30	30	70	20	10	40
9-10	40	30	70	30	20	30
10-11	30	30	10	30	20	50
11-12	20	30	90	20	20	70
12-13	50	90	80	30	30	50
13-14	40	60	70	30	70	30
14-15	40	90	60	60	80	30
15-16	10	30	90	40	60	30
16-17	40	30	50	40	60	30
17-18	40	30	50	30	40	80
18-19	40	30	20	30	30	40
19-20	10	80	60	40	30	20
20-21	30	90	20	30	30	20
21-22	20	90	10	30	40	40

22-23	20	90	0	40	30	30
23-24	30	80	0	30	30	30
24-25	10	70	0	20	30	20
25-26	80	80	0	20	30	30
26-27	20	90	10	30	30	10
27-28	10	40	10	30	40	10
28-29	30	50	10	40	30	10
29-30	10	50	10	30	30	10
30-31	30	10	10	30	20	20
31-32	40	20	20	30	20	10
32-33	20	20	10	20	20	10
33-34	20	30	20	30	20	10
34-35	20	10	20	40	20	10
35-36	20	10	10	20	20	20
36-37	10	0	10	40	20	10
37-38	10	0	20	20	20	10
38-39	10	0	10	10	10	0
39-40	10	0	10	10	10	0
Mean 0-20	**32**	**44**	**50**	**35**	**41**	**41**
Mean 20-40	**23**	**42**	**11**	**28**	**25**	**16**

Interval	**45a50NE**	**45a50W**	**45a50SW**	**45a50S**	**45a50SE**	**45a50E**
0-1 (m)	90	90	90	90	90	90
1-2	90	90	90	90	60	90
2-3	90	50	20	20	10	60
3-4	60	10	10	10	0	10
4-5	40	0	0	0	0	0
5-6	10	0	0	0	0	0
6-7	10	10	10	0	10	0
7-8	10	30	30	20	20	10
8-9	20	20	20	20	20	10
9-10	30	30	20	40	80	30
10-11	50	50	30	20	20	10
11-12	20	30	30	40	20	20
12-13	40	30	30	20	20	40
13-14	30	30	20	10	10	30
14-15	40	60	20	50	10	30
15-16	30	30	20	30	20	20
16-17	30	40	30	30	10	30
17-18	30	20	40	80	20	30
18-19	40	80	50	30	20	80
19-20	40	90	70	40	10	70
20-21	80	40	20	50	20	80
21-22	40	30	20	40	20	80
22-23	30	40	20	30	70	20
23-24	20	50	20	20	20	20
24-25	10	40	30	20	10	30
25-26	20	40	10	20	40	20
26-27	20	30	80	20	30	20
27-28	10	30	30	20	20	20
28-29	20	30	40	40	30	30
29-30	10	20	10	20	40	30
30-31	10	20	20	20	10	20
31-32	20	20	10	40	20	20
32-33	10	20	10	10	40	20

33-34	20	20	10	10	30	20
34-35	10	30	10	40	20	20
35-36	10	20	10	20	10	20
36-37	10	10	10	10	10	20
37-38	10	10	0	10	10	10
38-39	20	10	10	20	10	10
39-40	10	10	10	10	0	0
Mean 0-20	**40**	**40**	**32**	**32**	**23**	**33**
Mean 20-40	**20**	**26**	**19**	**24**	**23**	**26**

11.3 Site 52a

Interval	**52a15NE**	**52a15NW**	**52a15SW**	**52a15SE**	**52a50E**	**52a50NE**
0-1 (m)	90	90	90	90	90	90
1-2	90	70	90	70	10	10
2-3	90	10	50	10	80	0
3-4	10	10	10	0	80	0
4-5	20	80	50	0	80	0
5-6	20	80	80	70	80	0
6-7	30	80	80	70	80	40
7-8	80	80	80	80	60	70
8-9	80	80	80	80	70	70
9-10	80	90	80	70	70	80
10-11	80	80	80	80	70	80
11-12	80	80	80	70	10	80
12-13	50	70	80	80	0	70
13-14	10	20	80	80	0	60
14-15	10	60	80	80	0	10
15-16	10	80	80	70	10	10
16-17	20	10	80	60	0	10
17-18	10	10	80	60	0	20
18-19	20	20	80	60	0	0
19-20	10	0	60	0	0	0
20-21	10	10	70	10	0	0
21-22	10	10	80	0	0	0
22-23	0	10	70	0	0	0
23-24	10	10	10	0	0	0
24-25	0	10	20	0	10	80
25-26	0	10	70	0	20	0
26-27	0	10	10	0	10	0
27-28	0	10	80	0	10	10
28-29	0	10	0	0	10	0
29-30	10	10	0	10	10	10
30-31	70	0	0	40	10	10
31-32	40	0	10	10	10	10
32-33	30	0	40	40	20	40
33-34	20	10	10	40	0	10
34-35	70	20	20	10	0	40
35-36	10	10	10	20	60	0
36-37	10	20	20	10	60	0
37-38	10	10	10	20	10	40
38-39	10	0	10	10	20	20
39-40	0	0	0	10	10	30
Mean 0-20	**45**	**55**	**74**	**59**	**40**	**35**
Mean 20-40	**16**	**9**	**27**	**12**	**14**	**15**

Interval	**52a50N**	**52a50NW**	**52a50W**	**52a50SW**	**52a50S**	**52a50SE**
0-1 (m)	90	90	90	90	90	30
1-2	90	90	10	10	90	10
2-3	30	20	0	0	90	0
3-4	20	20	0	70	30	0
4-5	10	70	70	80	10	80
5-6	0	80	60	80	0	80
6-7	70	80	60	80	0	80
7-8	70	70	70	80	0	80
8-9	70	80	80	70	80	80
9-10	70	80	80	80	80	80
10-11	80	80	80	80	50	80
11-12	70	80	80	80	70	80
12-13	70	70	80	70	80	80
13-14	60	70	80	80	80	70
14-15	40	70	80	80	80	60
15-16	10	60	70	80	70	50
16-17	10	70	80	80	80	50
17-18	0	40	80	80	60	60
18-19	10	60	80	60	80	50
19-20	0	10	70	80	50	0
20-21	0	10	40	70	50	10
21-22	0	20	80	50	40	0
22-23	0	10	50	80	30	0
23-24	0	10	0	0	60	40
24-25	50	10	20	0	30	30
25-26	0	10	20	10	40	10
26-27	10	10	10	0	70	70
27-28	0	0	0	0	20	10
28-29	10	10	10	0	10	0
29-30	10	10	10	10	0	0
30-31	10	10	10	10	10	10
31-32	20	10	10	0	10	10
32-33	0	30	10	10	10	80
33-34	20	10	30	0	10	70
34-35	20	60	0	0	0	60
35-36	20	10	0	10	10	40
36-37	20	0	10	10	10	0
37-38	30	10	10	0	10	10
38-39	30	40	10	0	10	10
39-40	10	10	10	10	10	0
Mean 0-20	**44**	**65**	**65**	**71**	**59**	**55**
Mean 20-40	**13**	**15**	**17**	**14**	**22**	**23**