SITE ASSESSMENT GUIDANCE A CASE STUDY (OUIREEJ SCRAP YARD)

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الخلاصة:

اصبحت عمليات التقطيع والتفكيك(صناعة السكراب Scrap industry) من العمليات الرائجة في الصناعة العراقية مؤخرا فهناك مجاميع متخصصة من الافراد تخصصت في مثل هذا النوع من الصناعة ولاسيما صناعة تقطيع وتفكيك او تفصيخ الاجهزة الصناعية والاليات المدنية والعسكرية لاعادة استخدامها اما كماهي او كمواد اولية تدخل في صناعات اخرى من خلال عمليات بيع رائجة وصلت اعمالها عبر الحدود العراقية.

ومما يزيد من مخاطر تلوث البيئة هو خلط الاليات العسكرية المحترقة والمهشمة وما تحمله من ذخائر واسلحة مع السيارات المدنية المحطمة والمحترقة وبقاياها من عمليات التفخيخ واجهزة ومعدات لمنشات التصنيع العسكري وما تحويه من مواد كيمياوية تاهت اسمائها ومناشئها واختلطت انواعها في خضم المجموع الهائل من المخلفات الملقاة في الساحات المفتوحة .وفى ضوء الصعوبات الراهنة وافتقاد الامن ولاسيما في مناطق اطراف بغداد اصبح التركيز مقصورا على توفير المتطلبات القصيرة والمتوسطة المدى فقط كالسيطرة على استخدام المواقع نفسها ،أو تحديد استخدام الارض،أو منح اجازة مرخصة لاشخاص محددين للتصرف بالمخلفات من تقطيع او بيع اوغيرها من الفعاليات المشابهة. ان عملية بيع المخلفات واللاليات بالجملة بانواعها المختلفة بعد تجميعها في ساحات خاصة وعلى الرغم من فائدتها في تنظيف البيئة سيما وان تم اعادة استخدامها تبقى عمليا محدودة ولايمكن تحقيقها محليا لا على المدى القريب ولا المتوسط لصعوبة السيطرة على المواقع كما ان عملية تنظيف كافة ساحات تجميع المخلفات (السكراب) مثل ساحة تجميع السكراب في منطقة عويريج قد تكون غير ممكنة ايضا في الوقت الحاضر .

تم اجراء تقييم بيئي لاحد مواقع تجميع المخلفات والاليات المدنية والعسكرية وضمن محافظة بغداد واظهرت نتائج فحص عينات الماء والتربة الماخوذة من الموقع ، ان الموقع ملوث بدرجة متوسطة بـPCBs و الزيوت المعدنية و بشكل اساسي النحاس و الرصاص والانتيمون والزنك وان عملية خلط المخلفات والاليات العسكرية مع المدنية ادت الى ارتفاع معدلات التلوث والخطورة .

اظهرت نتائج الفحوصات ان مستويات التلوث في الموقع واطئة نسبيا، غير ان التلوث بـPCBs كان واسع الانتشار فقد تم اكتشافه في ثمان مواقع من اصل اثنتي عشرموقع وبلغ اعلى تركيز له 23 μ g /kgوكذلك اظهرت التحاليل تلوث المياه السطحية في الموقع تلوث طفيف بالمعادن الثقيلة والزيوت المعدنية.

ABSTRACT

Scrap metal export is currently one of the few thriving industries in Iraq. Looters and legitimate operators are together effectively demolishing many of the old industrial facilities in order to retrieve the metal contained in buildings, processes and storage equipments and vehicles.

The mixing of civilian and military scrapping operations such as that occurring at Ouireej is exacerbating the problem. The situation is particularly difficult for Iraq, given the rapid growth of the scrap industry and the lack of security.

In view of the current difficulties, the focus was on practical short to medium term improvements such as controlling access to sites, land use zoning, licensing and export controls. The wholesale reform of the scrap metal industry to improve environmental practices, whilst desirable, is also probably not feasible in the short to medium term. The remediation of working scrap sites, such as Ouireej is also probably unfeasible at present. Laboratory analysis of shallow

soil detected contamination by PCBs, mineral oil and heavy metals, principally copper, lead, antimony and Zinc.

The detected levels of all contaminants were relatively low. But PCB contamination was relatively widespread, being detected in eight soil samples with a maximum concentration of 23 μg/kg. Laboratory analysis of rainwater ponds on the site indicated marginal contamination by heavy metals and mineral oils

KEYWORD

Scrap, Military scrap, Ouireej, Site assessment, Contamination, Weapons of Mass Destruction (WMD), Risk. PCB

INTRODUCTION

Iraq has significant legacy of contaminated and derelict industrial and military sites. Many facilities are unlikely to re-start operation but apportion of the sites in urban areas may be developed for other uses.

These sites have major problems with hazardous wastes but generally lesser problems with contaminated soil and water. In a minority of cases, the sites represent a severe risk to human health, specifically to site workers and trespassers (UNEP, 2005).

The background of conflict in Iraq since 1980 has also contributed to the environmental problems. As Iraq is a relatively industrialized country, with tens of thousands of industrial sites, it is considered too large and costly to address in a uniform manner, i.e. by assessing and cleaning up every site.

International experience (UNEP, 2005) indicates that whilst a large percentage of industrial sites may have ground contamination or problems with hazardous waste management, only a very small fraction represent such an immediate and grave threat to human health or to the environment that urgent action is warranted. To be most effective, efforts in Iraq should be focused on first identifying and addressing the most urgent cases.

Iraq is unique in that its industrial sites have been under some form of international monitoring and assessment since 1991, for military reasons. The 15-year search for weapons of mass destruction (WMD) covered potential chemical, biological and nuclear weapons research and manufacturing programs across Iraq.

The hundreds of contaminated sites through Iraq require characterization and assessment before remediation systems are designed and implemented. In some cases, no clean up maybe the best alternative to protect public health and the environment. Nonetheless, the complexity of contaminated sites requires a multiphase assessment process in which the sites are identified, screened, and characterized.

SCRAP METAL INDUSTRIES

Although scrap yards are recognized worldwide as important source of water pollution, land contamination and hazardous waste (Watts, 1997), yet military scrap and scrap yards in Iraq present a number of additional hazards (ISEPI, 1994) including:

- Explosion and fire risks from munitions
- Unusual concentration of toxic chemicals (e.g. each T72 tank contains up to 150 liters of pure polychlorinated biphenyls PCB)
- Asbestos (again from tanks and military vehicles)
- Depleted uranium (DU) fragments in destroyed tanks and vehicles

Separation of military and civilian scrap operation could reduce the scale of the problem. The great majority of scrap metal generated is linked to civilian vehicles and derelict industries.

Within the military scrap category, a large amount (such as trucks, building materials) does not represent any additional hazard over civilian scrap. These materials could be left to the civilian scrap industry.

SITE ASSESSMENT GUIDANCE

Assessment strategy

The assessment strategy for the scrap yard industry needs to address the issues of location and prioritization (ISO/IEC 17025, 1999).

- Location. The number and position of all scrap yards in Iraq dealing with military equipment is unknown. There is no central register and many operations are small and temporary in nature.
- Prioritization. The list of physical and chemical hazards associated with scrap yards is long. It can be assumed that environmental conditions within the scrap yards are very poor and likely to remain so until an organized system of environmental regulation is implemented. Before this occurs, any comprehensive assessment and cleanup work is likely to be wasted effort as ongoing scrap yard operations will simply continue to contaminate the areas in which they work.

The recommended activities for scrap yards site assessments are as follows:

Site mapping project: The objective of site-mapping project is to broadly understand the contamination situation within and immediately surrounding the site. Detailed assessment of the surface waters, soil, and groundwater over all of the sites is excluded on the grounds of scale. Enquiries and escorted site visits should be able to establish the overall location and pattern of contamination sources on the site. In particular, the number and types of military vehicles should be estimated and counted. The density of vehicles/scrap should be estimated, by counting the number within defined areas say 50m by 50m. The results of the survey should be developed as a series of maps with accompanying notes on the activities and materials involved. Some very limited general sampling of soil and water is recommended to obtain a general idea of the composition and peak concentrations of the contamination.

Military vehicle area survey: The objective of the survey is to obtain detailed data on the actual environmental conditions immediately surrounding stored and dismantled military vehicles. The survey should focus on the ground surface within 25m of the target vehicle. Scrapped military vehicles, particularly tanks, should not be entered due to the multiple risks from depleted uranium (DU), unexploded ordnance (UXO), asbestos, and chemicals.

Local watercourse survey: Watercourses on or very close to the major scrap yards should be assessed for contamination migrating offsite. In this case, sediment sampling is as important as water sampling as PCBs will mainly be found in the sediments.

GENERAL GUIDANCE

Investigation techniques: Efforts should be focused on non-intrusive sampling (i.e. avoid extensive digging). Surface soil samples can be taken by hand. Open watercourses can be sampled by hand. For intermittent watercourses such as storm water drains, sediment sampling may be useful (Watts, 1997).

Sample analysis techniques: The wide range of chemicals potentially present means that sample analysis should also be wide ranging. The following laboratory analyses and analyses suites are recommended (ASTEM, 2004):

- pH and alkalinity
- Aluminum
- Heavy metals including Vanadium
- Uranium
- Volatile Organic Compounds (VOCs) by GC MS
- Total Petroleum Hydrocarbons by GC and IR (both methods)
- Nitrogen compounds - Total Nitrogen, Oxides of Nitrogen , Ammonium,
- Inorganic ions - Chloride, phosphate, sulfate, calcium, magnesium, salinity, conductivity
- Polar organics - alcohols and glycols and poly chlorinated biphenyls (PCBs).

On site, testing is suitable for pH, surface water parameters, and volatile organics. VOCs such as toluene can be tested onsite using a Photo-lionization Detector.

Hazardous material sampling: The main objective of the hazardous material sampling programme is to obtain an accurate assessment of the type of hazardous waste disposed at the site. In particular, visible oils and oily stains should be sampled to test for PCBs from the scrapping of military vehicles (watts, 1997).

Water monitoring and sampling: The objectives of the water monitoring and sampling is to obtain an indication of the mobility of the contamination in the water phase in any standing water on site or in drains leading from the site (ISO/IEC 17025, 1999)..
Water monitoring and sampling will be located using the list of Assessment Target Areas. For monitoring, use the Troll 9000 for all samples. Avoid putting the Troll 9000 into any pools of chemicals, as this will damage it (UNEP, 2005).

CASE STUDY (SCRAP YARD OF OUIREEJ):

Ouireej is one of the largest military scrap yards in Baghdad. It s location is about 20 km to the west of Baghdad, in the alluvial plain southwest of the River Tigris. The region is under the responsibility of Al-Rasheed municipality (figure 1). It used to be an open land intended to be distributed to create a living zone. After the conflict, the land turned to be an open landfill, or a scrap yard collecting solid waste and hazardous wastes

The site was allocated as one of the main dumping and processing sites for military scrap arising from the conflict of the subsequent destruction of the Iraq arsenal, scrapped in an uncontrolled manner, resulting in localized contamination, potential to affect surface and shallow soils, surface water (drainage ditches flow to Tigris) and shallow groundwater.

The principal source of hazards is the open dumping of highly toxic chemical wastes and the dispersal of such wastes by looting, demolition, or weather.

The site was damaged or in an environmentally poor condition due to either looting, fire, conflict or poor operating practices. At the peak of activity, the site held hundreds of items of potentially hazardous military hardware including tanks missiles, yet it still containing unexploded ordnance and hazardous chemicals.

Two people were reportedly killed, by explosions and by poisoning, in the uncontrolled scrap metal recovery operations that occurred over the period mid 2003- early 2005 (UNEP, 2005). The surrounding land use is a mixture of industrial residential and agricultural. There are some houses on and adjacent to the site. The margins of the site also appear to be used for dumping of construction debris. The site is very sparsely occupied and there is a great deal of vacant or unused land.

Site assessment strategy: The work was carried out over the period January 2004 to July 2005 in Iraq, with support activities in Jordan, Switzerland, and United Kingdom. The assessment strategy for the site was as the assessment of the whole site in moderate detail, with detailed assessment of the numerous hotspots and any standing water.

Assessment target areas and contaminants: The key assessment targets approach was to divide the site into 9 general zones as follows:

North

1. Northwest	2. North	3. North East
4. West	5. Central	6. East
7.SouthWest	8.South	9.SouthEast

South

In addition to the 9 general zones there were three items which required individual assessment:

10. The new housing onsite
11. The standing water (ponds)
12. External control points.

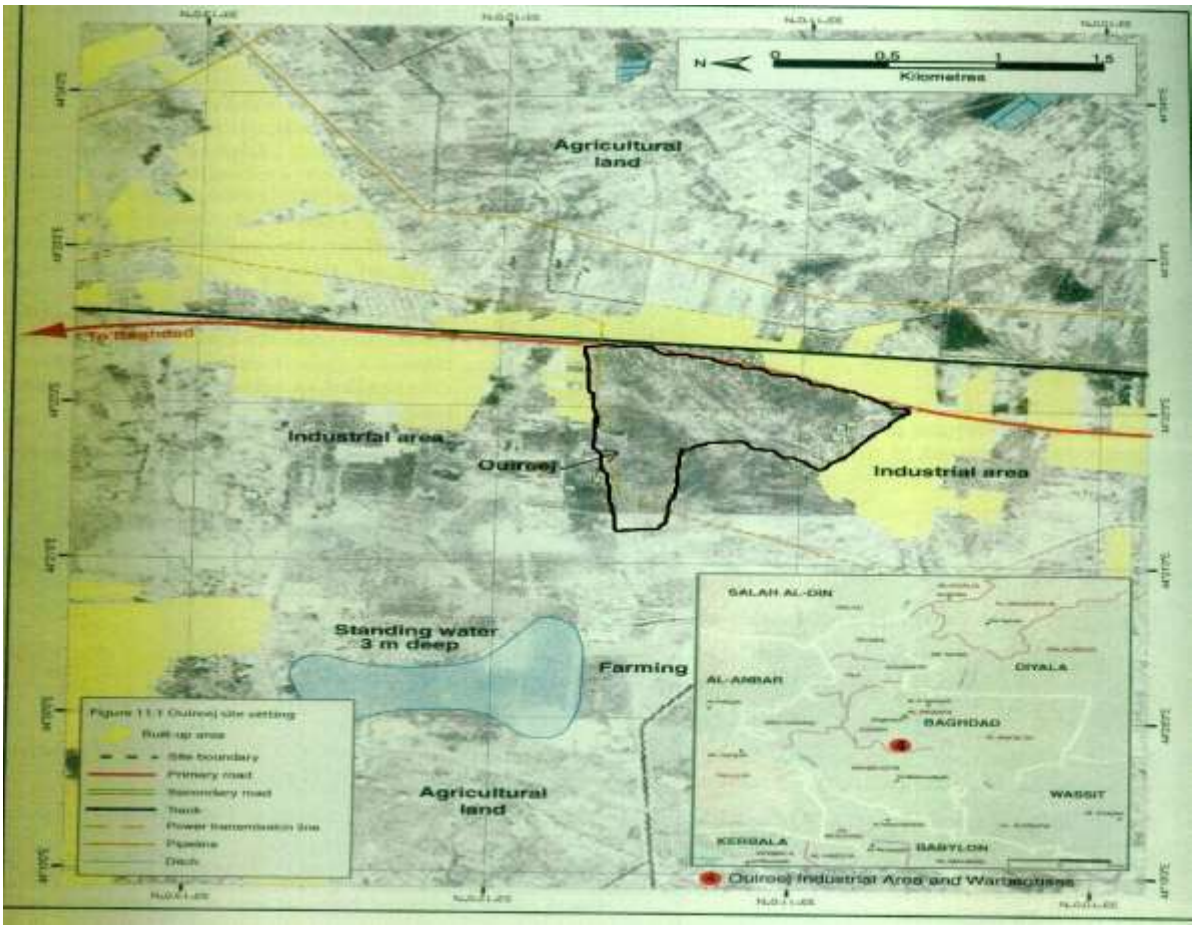

Fig. 1 Ouireej yard location (UNEP, 2005)

Overview of techniques: The following techniques were used on the site;

1. Soil sampling
2. Hazardous material sampling
3. Water sampling

Sampling on site was of soils, hazardous materials, and waters from wells and ponds where applicable. Hand auger equipment and hand tools such as trowels were used to collect soil and hazardous material samples. Drum keys, grounding wires, hand pumps, disposable bailers and a flap gouge auger was used, to take representative samples of the contents of barrels and containers for identification through off-site laboratory chemical analysis. Disposable bailers were used to sample groundwater from wells, and disposable plastic containers were used, where appropriate, to take samples from standing water bodies, sumps, and tanks, logged, and packed for export by air fright to the international laboratories.

Water quality was tested onsite with the Troll 9000. Probes were used to measure pH, temperature, dissolved oxygen, and oxygen-reduction potential. Soil vapor was measured using Photo Ionization Detector (PID) for detection of volatile organic compounds.

Chemical analysis: Samples were exported via airfreight and analyzed at three commercial analytical laboratories in the United Kingdom. Alcontrol laboratory in Chester, united Kingdom, carried out the standard analysis and coordinated the specialist analyses (Tables 1a, 2a, 3a and 4a in appendix A). Alcontrol is accredited to the ISO 17027 standard (ISO/ IEC 17025, 1999).

There is no Iraqi legislation or guidance material regarding acceptable levels of risk from hazardous waste or contaminated land. Existing formal standards from the UK (ASTEM, 2004), USA, Australia and the Netherlands were considered suitable as initial guidelines but are also considered to be generally too stringent and therefore too costly to be implemented in Iraq at present. International standards such as the WHO drinking water standards (WHO 1998) are relevant mainly as end –user standards rather than directly applicable to contaminated land.

For safety reasons samples with potentially high concentrations of cyanide or organic mercury were unsuitable for the standard process of quartering grinding and acid digestion.

Hazardous samples were dispatched to London Scandinavian Metallurgical Company Ltd. for elemental analysis by x-Ray Fluorescence spectroscopy (XRF) and X-Ray Diffraction (XRD). Samples for organic mercury were dispatched to Mountain Heath Service laboratory for specialized treatment and analysis.

Iraq has no screening system so an appropriate substitute was needed. The systems used for this project were the current (National Environmental Protection Australian Council Schedule B1 and B7a, 1999) and Dutch (Netherlands Government Gazette, 2000) standards and accompanying guidance. For the Australian system, the Health Investigation Limits A were used for soil screening and the ground water Investigation Limits (drinking water) were used for waters. These values represent the levels above which contamination is considered significant enough to warrant further investigation and assessment. For the Dutch system, the soil remediation intervention values were used as terms of references

More general terms (A. Richard and P.E. Conway, 1982) are used as follow:

1. Uncontaminated- Any contamination, if detected, is below the selected international standards
2. Slightly contaminated- Contamination is present, but in limited volumes and at concentrations limited to 1-10 times the selected international standards
3. Moderately contaminated- Contamination is present, in limited volumes and at concentrations 1-100 times the selected international standards
4. Heavily contaminated- Contamination is present in large volumes and over large areas and at concentrations, which can exceed 100 times the selected international standards.

Site Assessment activities: Ouireej site was visited for general fact-findings, Table 1 details sampling and monitoring activities of the April and May 2005 site visits.

Table 1 Site assessment activities

Sample type/ activity	Number of samples or points
Soil	148
Waste chemicals	10
Surface water	3
Ground water	6

FINDINGS

Although hazardous wastes are present on the site, they are not present as large discrete stockpiles, but scattered as fragments, barrels, and small piles. The most common type of waste appears to be scattered burnt residues from uncontrolled burning of the non-metallic parts of the scrapped vehicles.

Shallow soil contamination is present at numerous points throughout the site, as evidenced by encrustations of metal oxides, oil stains and discolored ground. Laboratory analysis of shallow soil detected contamination by PCBs, mineral oil and heavy metals, principally copper, lead, antimony and Zinc.

The detected levels of all contaminants were relatively low. PCB contamination was relatively widespread, being detected in eight soil samples with a maximum concentration of 23 μg/kg. Laboratory analysis of rainwater ponds on the site indicated marginal contamination by heavy metals and mineral oils. In summary, the limited sampling indicates that:

1. The site in its current state represents a moderate risk to human health, primarily to site workers, and to site residents.
2. The principal toxicity risk was from direct contact with, and inhalation of chemicals in the process of transporting, cutting, sorting and burning the scrap.
3. Explosion and fire risks from UXO present on the site were expected but could not be quantified.
4. The mixing of civilian and military scrapping activities increased the scale of the problem
5. The observed house building on a working military scrap yard site with UXO risks is creating new risks and issues.

CONCLUSIONS

The scrap operations on site reached a peak in late 2003 and throughout 2004 and that the amount of scrap on site at time of investigation (June 2005) represents only 25% of the original volume. The scrapping operations apparently closed down due to a combination of dwindling economic return and pressure from the municipalities. The site in its current state represents a **moderate** risk to human health, principally to site workers, but also to site residents, and the mixing of civilian and military scrapping activities is increasing the scale of the problem.

RECOMMENDATIONS

The recommendations, in summary, are :

1. To separate the military and civilian operations and the residential development to mitigate the obvious risks of combining all these land uses. **Separation of the hazardous military scrap from other material by relocation.**
2. **Secure fencing** would be a simple but cost effective method for reducing the risk of exposure for most site workers and all of the nearby residents.
3. Maintenance of this separation would need to be enforced by commercial means, e.g. **only one contractor is allowed to deal with military scrap and is paid to manage the issue.**
4. The current building of new houses in the scrap yard area should be stopped or managed to include **land re-zoning** and **site cleanup** prior to redevelopment.
5. In the longer term, national, strategies, policies, **legislation, and enforcement are needed for hazardous waste management and contaminated land**. There is currently no specialist technical capacity in Iraq to take any quick corrective action on highly hazardous waste. This would need to be developed prior to conducting any such works. A new hazardous waste treatment and disposal facility should be built for mainly inorganic wastes with most organic chemical wastes being incinerated in a nominated cement plant furnace.

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ACRONYMS

BTEX: Benzene, Toluene, Methylbenzene, and Xylem
DRO: Diesel Range Organics
DU: Depleted Uranium
EPH: Extractable Petroleum Hydrocarbons
GCMs: Gas Chromatography Mass Spectrometer
GRO: Gasoline Range Organics
IR: Infra Red
ISO: International Standards
PCBs: Poly Chlorinated Biphenyls

PID: Photo Ionization Detector
SVOCs: Semi Volatile Organic Compounds
UXO: Unexploded Ordinance
VOCs: Volatile Organic Compound
WMD: Weapon of Mass Destruction
XRD: X-Ray Diffraction
XRF: X-Ray Fluorescence spectroscopy

Appendix 1

Table 1a Summary of Laboratory analyses for soils

Metals (all results in mg/kg)	No. of samples analyzed	No. detected above MDL	All concentration mg/kg	
			Minimum detected concentrations	Maximum detected concentrations
Arsenic	50	50	4	19
Beryllium	50	0	<	<
Cadmium	50	3	3	11
Chromium	50	50	49	138
Copper	50	50	13	1738
Mercury	50	0	<	<
Nickel	50	50	65	209
Lead	50	50	6	1291
Antimony	50	50	3	55
Selenium	50	0	<	<
Silver	50	0	<	<
Thallium	50	0	<	<
Zinc	50	50	41	1381
Hydrocarbons and VOCS (µg/kg unless stated)				
EPH (DRO)(C10-C40)(mg/kg)	49	42	7	118679
GRO (C4-C10)	13	1	<	44
GRO (C10-C12)	13	0	<	<
Benzene	13	0	<	<
Toluene	13	2	4	44
Ethyl benzene	13	1	<	2
M & P xylene	13	1	<	10
O xylene	13	1	<	3
MTBE	13	0	<	<
PCBs (all results in µg/kg)				
Total of 7 congener PCBs	29	8	1	23
SVOCs (all results in µg/kg)				
Anthracene	18	2	121	352
Benzo(a)anthracene	18	1	<	326
Benzo(a)pyrene	18	0	<	<
Benzo(ghi)perlyene	18	0	<	<
Benzo(k)fluranthene	18	0	<	<
Chrysene	18	1	<	1841
Fluranthene	18	2	185	233
Indeno(1/2/3-cd)pyrene	18	0	<	<
Naphthalene	18	2	215	1400
Phenathrene	18	4	271	2096
Pyrene	18	3	145	890
2-methylnaphthalene	18	1	<	2025
Bis(2-ethylhexyl)phthalate	18	6	919	13118

DNn-butyl phthalate	18	2	3192	7209
SVOC TICs (all results in mg/kg)				
C14-c24 Hydrocarbons	5	3	13.2	93.3
C12-C30 Hydrocarbons	5	1	<	60778.4
C14-C30 Hydrocarbons	5	1	<	6341.5
Other parameters (mg/kg unless stated)				
Calcium	14	14	37530	66630
Magnesium	14	14	9330	16300
Potassium	14	14	1579	10619
Sodium	14	14	3614	22317
Bicarbonate alkalinity as $CaCO_3$	14	14	89	874
Sulphate SO_4 (mg/l)	14	14	3126	115500
Acid soluble sulphide	5	0	<	<
Chloride	13	13	2100	43908
Acid soluble carbonate (%)	14	14	18.47	35.23
pH	17	17	7.21	8.38
Total sulphur (%)	5	5	0.12	1.38
Asbestos	17	0	<	<

Table 2a Screening process for soils

Metals (all results in mg/kg)	Dutch criteria for soils	No. of samples exceeding Dutch criteria	Australian criteria for soils	No. of samples exceeding Australian criteria
Arsenic	55	0	100	0
Beryllium	30	0	20	0
Cadmium	12	0	20	0
Chromium	380	0	Nc	0
Copper	190	2	1000	1
Mercury	10	0	15	0
Nickel	210	0	600	0
Lead	530	3	300	2
Antimony	15	2	Nc	0
Selenium	100	0	Nc	0
Silver	15	0	Nc	0
Thallium	15	0	Nc	0
Zinc	720	3	7000	0
Hydrocarbons and VOCS (µg/kg unless stated)				
EPH (DRO)(C10-C40)(mg/kg)	5000	5	5600	5
GRO (C4-C10)	nc	0	nc	0
GRO (C10-C12)	nc	0	nc	0
Benzene	1	0	nc	0
Toluene	130	0	nc	0
Ethyl benzene	50	0	nc	0

M & P xylene	25	0	nc	0
O xylene	nc	0	nc	0
MTBE	nc	0	nc	0
PCBs (mg/kg)				
Total of 7 congener PCBs	1	8	10	3
SVOCs (all results in µg/kg)				
PAH sum of 10	40	0	nc	0
Chlorophenols	10	0	nc	0
Chlorobenzenes	30	0	nc	0
Phthalates	60	0	nc	0
SVOC TICs (all results in mg/kg)				
C14-c24 Hydrocarbons	Nc	0	nc	0
C12-C30 Hydrocarbons	Nc	0	nc	0
C14-C30 Hydrocarbons	nc	0	nc	0
Other parameters (mg/kg unless stated)				
Sulphate SO_4 (mg/l)	nc	0	2000	14
Acid soluble sulphide	nc	0	nc	0
Asbestos	nc	0	nc	0

Table 3a Summary of laboratory analyses for waters

Metals (all results in µg/l)	No. of samples analyzed	No. detected above MDL	Minimum detected concentrations	Maximum detected concentrations
Arsenic	3	3	20	83
Beryllium	3	0	<	<
Cadmium	3	1	<	6.3
Chromium	3	3	3	11
Copper	3	3	4	27
Mercury	3	0	<	<
Nickel	3	3	17	62
Lead	3	2	3	38
Antimony	3	2	13	13
Selenium	3	3	38	203
Silver	3	0	<	<
Thallium	3	1	<	2
Zinc	3	3	21	7258
Hydrocarbons and VOCs (µg/l unless stated)				
EPH (DRO)(C10-C40)(mg/kg)	3	2	898	1950
GRO (C4-C10)	2	0	<	<
GRO (C10-C12)	2	0	<	<
Benzene	2	0	<	<
Toluene	2	0	<	<
Ethyl benzene	2	0	<	<
M & P xylene	2	0	<	<
O xylene	2	0	<	<

MTBE	2	0	<	<
SVOCs (all results in µg/l)				
Anthracene	3	0	<	<
Benzo(a)anthracene	3	0	<	<
Benzo(a)pyrene	3	0	<	<
Benzo(ghi)perlyene	3	0	<	<
Benzo(k)fluranthene	3	0	<	<
Chrysene	3	0	<	<
Fluranthene	3	0	<	<
Indeno(1/2/3-cd)pyrene	3	0	<	<
Naphthalene	3	0	<	<
Phenathrene	3	0	<	<
Other parameters (mg/l unless stated)				
Calcium	3	3	852	1868
Magnesium	3	3	1051	5869
Potassium	3	3	93	690
Sodium	3	3	12188	18375
Carbonate alkalinity as CaCO3	3	0	<	<
Bicarbonate alkalinity as $CaCO_3$	3	3	160	370
Sulphate SO_4 (mg/l)	3	3	4307	15019
Chloride	3	3	6489	>40000
pH	3	3	7.73	8.14

Table 4a Screening Process for waters

Metals (all results in µg/l)	Dutch criteria for ground water	No. of samples exceeding Dutch criteria	Australian criteria for ground waters	No. of samples exceeding Australian criteria
Arsenic	60	1	7	3
Beryllium	15	0	nc	0
Cadmium	6	1	2	1
Chromium	30	0	nc	0
Copper	75	0	2000	0
Mercury	0.3	0	1	0
Nickel	75	0	20	1
Lead	75	0	10	1
Antimony	20	0	3	2
Selenium	160	1	10	3
Silver	40	0	100	0
Thallium	7	0	nc	0
Zinc	800	1	3000	1
Hydrocarbons and VOCS (µg/l unless stated)				
EPH (DRO)(C10-C40)(mg/kg)	600	2	nc	0
GRO (C4-C10)	nc	0	nc	0

GRO (C10-C12)	nc	0	nc	0
Benzene	30	0	1	0
Toluene	1000	0	800	0
Ethyl benzene	150	0	300	0
M & P xylene	70	0	600	0
O xylene	nc	0	nc	0
MTBE	nc	0	nc	0
SVOCs (all results in µg/l)				
Anthracene	5	0	nc	0
Benzo(a)anthracene	0.5	0	nc	0
Benzo(a)pyrene	0.05	0	nc	0
Benzo(ghi)perlyene	0.05	0	nc	0
Benzo(k)fluranthene	0.05	0	nc	0
Chrysene	0.2	0	nc	0
Fluoranthene	1	0	nc	0
Indeno(1/2/3-cd)pyrene	0.05	0	nc	0
Naphthalene	70	0	nc	0
Phenathrene	5	0	nc	0
Other parameters (mg/l unless stated)				
Chloride	nc	0	250000	0

nc:Not detected.