Department of Environmental Protection

CONSULTATIVE ENVIRONMENTAL REVIEW

REHABILITATION OF OMEX CONTAMINATED SITE BELLEVUE

VW1100/100-RP-01-001

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INVITATION

The Environmental Protection Authority (EPA) invites people to make a submission on this proposal.

This document describes a proposal by The Waste Management Division of the Department of Environmental Protection (DEP) to remediate contaminated lands at Bellevue. The site was previously used for the recycling of waste oils. Treatment of the waste oils and lubricants involved the use of sulphuric acid and resulted in waste byproducts. This waste material which contained a number of contaminants was disposed into an unlined, disused clay pit located on-site. The land is to be remediated to a standard which will allow residential development of the area, however it should be noted that residential may not be the final land use.

In accordance with the Environmental Protection Act, this document has been prepared to describe the proposal and its likely effects on the environment. The document is available for a public review period of seven weeks from 9 January 1999, closing on 26 February 1999.

Comments from government agencies and from the public will assist the EPA to prepare an assessment report in which it will make recommendations to the Minister for the Environment.

Why write a submission?

A submission is a way to provide information, express your opinion and put forward your suggested course of action - including any alternative approach. It is useful if you indicate any suggestions you have to improve the proposal.

All submissions received by the EPA will be acknowledged. Submissions will be treated as public documents unless provided and received in confidence subject to the requirements of the Freedom of Information Act, and may be quoted in full or in part in each report.

Why not join a group?

If you prefer not to write your own comments, it may be worthwhile joining with a group or other groups interested in making a submission on similar issues. Joint submissions may help to reduce the workload for an individual or group, as well as increase the pool of ideas and information. If you form a small group (up to 10 people) please indicate all the names of the participants. If you group is larger, please indicate how many people your submission represents.

Developing a submission

You may agree or disagree with, or comment on, the general issues discussed in the document or the specific proposals. It helps if you give reasons for your conclusions, supported by relevant data. You may make an important contribution by suggesting ways to make the proposal environmentally more acceptable.

When making comments on specific proposals in the document:

- clearly state your point of view;
- indicate the source of your information or argument if this is applicable;
- suggest recommendations, safeguards or alternatives.

Points to keep in mind

By keeping the following points in mind, you will make it easier for your submission to be analysed:

- attempt to list points so that the issues raised are clear. A summary of your submission is helpful;
- refer each point to the appropriate section, chapter or recommendation in the document;
- if you discuss different sections of the document, keep them distinct and separate, so there is no confusion as to which section you are considering;
- attach any factual information you may wish to provide and give details of the source. Make sure your information is accurate.

Remember to include:

- your name,
- address,
- date, and
- whether you want your submission to be confidential.

The closing date for submission is 26 February 1999.

Submissions should be addressed to:

The Chairman
Environmental Protection Authority
Westralia Square
8th Floor
141 St Georges Terrace
PERTH WA 6000

Attention: Ray Claudius

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EXECUTIVE SUMMARY

This Consultative Environmental Review (CER) describes a proposal by the Waste Management Division of the Department of Environmental Protection (DEP) to remediate contaminated lands at the Omex site located in Bellevue. The site was previously used for the recycling of waste oils. Treatment of the waste oils and lubricants involved the use of sulphuric acid and resulted in waste byproducts. This waste material was mainly disposed into an unlined, disused clay pit located on-site. Waste material was also disposed on-site in a smaller purpose - built pit and at a nearby landfill facility.

A number of environmental issues are posed by the presence of oil wastes at the site. These include atmospheric emissions, and contamination of the soil and underlying groundwater. In order to minimise human health risks associated with the potential release of gases and other airborne contaminants from the pit, a sand and plastic liner was installed over the pit in February 1996.

Environmental investigations have been performed on the site since 1988. Investigations have been undertaken on the contents of the pit, air emissions, extensive soil and groundwater sampling both on-site and off-site.

The waste material within the pits consists of sludge interspersed with sand and rubble. This sludge is acidic and contains hydrocarbons and metals, in particular lead. The liquid content of the pit is comprised of oil and acidic groundwater contaminated with hydrocarbons and metals. The estimated respective quantities of liquid and solid waste present within the major pit are 4,400 kilolitres and 14,600 m^3.

The underlying groundwater is contaminated with hydrocarbons and nickel which has compromised its potential future use. A plume of contaminated groundwater exists within the upper part of the Leederville Formation aquifer which has extended off-site for an approximate distance of 100 m southwest of the pit.

Contamination of the natural soils has also occurred due to waste spreading from the confines of the pit and spillage and leakage from the now demolished oil refinery and oil storage facilities such as above ground storage tanks. The extent of contaminated soil which contains contaminant concentrations in excess of the proposed response level is estimated at between 10,000 m^3 and 13,500 m^3.

The Western Australian Government has committed to remove the contents of the pit and rehabilitate the site to a standard suitable for residential development by the end of 1999. To facilitate remediation of the site, an underground containment barrier will surround the pit to provide long term environmental security by isolating the underlying contaminated groundwater and preventing further contamination of the aquifer. The EPA has already provided informal advice on the installation of this containment wall which is now proceeding separately from this review process.

This CER describes a remediation strategy to remove the contents of the pit, clean-up soil and groundwater contamination in conformance with criteria developed for the protection of human health. Upon remediation of the site, a validation program will be implemented to demonstrate compliance with the criteria outlined in this CER.

The remediation approach put forward which best satisfies the constraints and conditions of the rehabilitation project is the proposed landfill disposal option. In general, the proposed approach to remediation of the Omex site is described as follows:

- remove the entire liquid and solid content of the pits;
- remove soil contamination above the proposed response level;
- validate removal of the contents of the pit and soil contamination;
- fill the excavations with certified clean fill;
- isolate significant groundwater contamination underlying the pit within the containment wall; and
- restrict the use of contaminated groundwater permanently inside the containment wall and with regard to outside of the containment wall, until monitoring shows that the quality is acceptable for irrigation.

For the main pit, this will involve removal and treatment of the liquid waste component prior to excavation of the solid waste. The liquid wastes would first be recovered, pretreated on-site and then taken to a liquid waste treatment facility. The solid waste would be treated on-site with alkali compounds to neutralise the waste. The treated waste would then be transported by road to a suitable landfill facility.

Outside the pit area, it is proposed to remove contaminated soil above proposed health risk criteria to a depth of 3.5 m. This soil's low level contaminant characteristics dictate that it will not require treatment. The contaminated soil would then be transported by road to a suitable landfill facility.

A health risk assessment of the contamination present at the site was undertaken as part of the remediation evaluation process. The proposed clean-up criteria for soil contamination external to the pit, are to a depth of 3.5 m and are based on recognised soil response levels used for the protection of human health. Management of air emissions from the site during clean-up will be kept within criteria specifically developed for the protection of public health.

Environmental and health issues relating to air emissions, dust, noise, vibration, surface runoff, transportation and safety are outlined along with management procedures to minimise potential impacts.

Whilst this proposal is considered the most practical approach in light of the reviews conducted to date, other viable approaches and technologies which are raised at the tender stage will also be given due consideration. The waste contents of the pit will be removed no matter what remediation approach is finally adopted.

Site remediation will be performed by a suitably qualified contractor who will be selected from a tender review. The successful contractor will be required to remediate the Omex site in accordance with the response levels and management commitments outlined in this CER. These response levels and management commitments will, in the form of the final Ministerial Conditions for the project, form the specification for the remediation. These Ministerial Conditions will be audited by an EPA appointed environmental auditor.

The proponent considers this proposal will have a positive impact on the environment and public health of nearby residents by removing the waste materials from the Omex site. The environmental management procedures outlined in this document will ensure that the rehabilitation of the Omex site is carried out in a safe manner which will not present a risk to workers, the public or the environment.

The clean-up will enable redevelopment of the site. The redevelopment is being undertaken under a separate process and beyond the scope of this assessment.

On the following pages are two tables. The first table lists the environmental management provisions which the Waste Management Division is committed to implement to the standard required by the key agencies listed in the table.

The second table lists the guidelines for the preparation of this CER which are issued by the EPA. It provides a full cross reference so the reader can easily find where each matter raised in the guidelines is addressed in the CER.

TABLE 1
LIST OF ENVIRONMENTAL COMMITMENTS

Commitment	Category	Topic	Objectives	Proposed Management Commitments	Key Agency *
1.	Pollution Potential	Environmental Sampling	• To assess the nature and extent of Omex waste contamination at the Adelaide Street landfill facility.	• Undertake soil and groundwater sampling.	EPA
2.	Pollution Potential	Remedial Works	• To minimise the exposure of workers, the public and the environment to contaminated materials	• Removal of contaminated material in accordance with the site management techniques described in the CER • All contaminated material removed from the site will be disposed of in accordance with Landfill Waste Classification and Waste Definitions.	DEP EPA Worksafe -WA
3.	Waste Management	Contaminated Soil Transport	• To minimise the risk of transporting contaminated material from the site.	• All contaminated material transported from the site will be carried in appropriately equipped and labelled trucks in a manner consistent with the Dangerous Goods Regulations.	DEP DME
4.	Waste Management	Destination of Waste Materials	• To ensure all contaminated material from the site is managed and disposed in a manner which reduces environmental impact and risk to human health.	• The ultimate destination of all contaminated material will be selected on the basis of criteria set by the Landfill Waste Classification and Waste Definitions.	DEP
5.	Pollution Potential	Dust Discharges	• To ensure that dust discharges during implementation of the project comply with regulatory standards.	• Dust discharges from the site will be kept within EPA criteria.	DEP
6.	Pollution Potential	Noise Emissions	• To ensure that noise emissions during implementation of the project comply with regulatory standards.	• Noise emissions from the site will be kept within the Noise Regulations. • Undertake noise monitoring to demonstrate compliance. • Noise management if values exceeded.	DEP
7.	Conformance	Air Emissions	• To ensure air emissions during implementation of the project comply with criteria set for the protection of human health.	• Air emissions from the site will be kept within the guidelines. • Undertake air monitoring to demonstrate compliance.	EPA HDWA

Commitment	Category	Topic	Objectives	Proposed Management Commitments	Key Agency *
8.	Conformance	Vibration	• To ensure vibration does not affect residents or damage nearby properties.	• Vibration will be kept to a minimum and comply with the Australian Standard.	DEP
9.	Conformance	Occupational Health	• To ensure remedial works are carried out in a safe manner.	• An Occupational Health and Safety Plan will be developed and implemented prior to remedial works commencing.	Worksafe -WA EPA
10.	Conformance	Remedial Works	• To ensure compliance with EPA approved clean-up criteria.	• A validation program of remedial works will be implemented to demonstrate compliance with EPA site clean-up criteria.	EPA
11.	Conformance	Groundwater Quality	• To ensure future groundwater quality and levels comply with predictions described in the CER.	• Undertake groundwater monitoring.	EPA WRC
12.	Conformance	Performance Review	• To ensure the conditions of approval for the project are achieved.	• The EPA will advise on the success of the remediation in meeting the conditions of approval for this project.	EPA
13.	Conformance	Validation Report	• To document site clean-up has been performed in accordance with EPA requirements	• A report at the completion of the validation program will be submitted to the EPA which will provide evidence of conformance to the commitments and Ministerial Conditions for the project.	EPA

* Agency Summary:

DEP	Department of Environmental Protection
DME	Department of Minerals and Energy
EPA	Environmental Protection Authority
HDWA	Health Department of Western Australia
Worksafe WA	
WRC	Water and Rivers Commission

TABLE 2
ENVIRONMENTAL PROTECTION AUTHORITY GUIDELINES
REFERENCE GUIDE

CONTENT		**SCOPE OF WORK**		
Factor	**Site Specific Factor**	**EPA Objective**	**Work Required for the Environmental Review**	**CER Reference**
POLLUTION MANAGEMENT				
Soil contamination	Heavy metals, phenols, polycyclic aromatic hydrocarbons, petroleum. hydrocarbons, sulphur.	Ensure the rehabilitation of the site to an acceptable standard that is compatible with the intended land use, consistent with appropriate criteria including ANZECC guidelines, health risk assessment criteria and applicable international standards.	Outline sampling methods, results of analysis and methodology for defining contaminants with quality assurance program.	Sections 2.5, 3.2, 3.3, 3.4, 4.5 Appendix B Appendix D
			Identify location, depth, estimated quantities and chemical and physical characteristics of contaminants, including health implications.	Sections 3.2, 4.1, 4.2
			Present results of technology trials conducted to determine most appropriate method of treatment and disposal of contaminated material.	Section 5.7
			Undertake a risk assessment of the various proposed methods of treatment of contaminated material prior to transport off site.	Sections 5.3, 5.4, 5.5, 5.8
			Provide information on the method and procedures for removal of pit content and removal of other Omex related contamination, as well as method and procedures for offsite disposal.	Sections 3.5, 5.4, 6.3, 6.4, 6.7 Appendix E
Soil			Undertake a health risk assessment to identify pathways whereby contaminants may threaten the health of future site residents and	Sections 3.4, Appendix B

CONTENT		SCOPE OF WORK		
Factor	**Site Specific Factor**	**EPA Objective**	**Work Required for the Environmental Review**	**CER Reference**
contamination continued			the local environment. Identify the appropriate standard to be used for the cleanup, based on the results of a health risk assessment. Describe validation of cleanup. Identify the site or sites to be used for disposal of removed wastes.	Sections 3.4, Appendix B Sections 6.3.2, 6.4.2, 7.10, 7.11 Section 3.5
Groundwater quality	Contaminated groundwater beneath the site in Guildford formation and Leederville aquifer. Groundwater down gradient of the site.	Maintain or improve the quality of groundwater to ensure that existing and potential uses, including ecosystem maintenance are protected, consistent with the draft WA Guidelines for Fresh and Marine Waters (EPA 1993).	Identify existing groundwater quality and location of contaminant plumes and proposed remediation of contaminated groundwater both inside and outside the proposed containment wall. Describe proposed cleanup standard for groundwater based on health risk assessment. Identify proposed measures to prevent further groundwater contamination due to cleanup activities. Describe validation of remediation.	Sections 4.4, 6.5, Appendix C Section 6.5 Section 6.5 Sections 6.5.1, 6.5.2

CONTENT		SCOPE OF WORK		
Factor	**Site Specific Factor**	**EPA Objective**	**Work Required for the Environmental Review**	**CER Reference**
Air emissions	Particles and dust	Ensure that the dust levels generated by the proposal do not cause health problems, or adversely impact upon welfare and amenity, by meeting statutory requirements and acceptable standards.	Identify potential dust sources including contaminated material on site.	Sections 4.5, 7.2, 7.3
			Propose methods for the control of dust to minimise potential impacts on health or amenity of nearby residents and users of the adjacent bowling club.	Sections 6.6.1, 7.2, 7.3
			Provide details of monitoring of offsite dust impacts.	Section 6.6.2, 7.2
			Outline contingency plan in the event that contaminated dust is detected offsite to ensure that the health and well being of local residents and landusers is safeguarded.	Section 3.4.2, 7.2
	Odour	Odours emanating from the proposed development should not adversely affect the health, welfare and amenity of surrounding land users.	Identify sources of odour and measures to be employed to minimise odour generation during remediation of the site, including methods of dealing with removal of the HDPE liner.	Sections 4.5, 7.2
			Outline contingency plan in the event that unacceptable odour is detected offsite.	Section 3.4.2, 7.2

CONTENT		SCOPE OF WORK		
Factor	**Site Specific Factor**	**EPA Objective**	**Work Required for the Environmental Review**	**CER Reference**
Air emissions (continued)	Volatile gases and other airborne gases and odour.		Identify whether, toxic gases and other airborne contaminants, including HCl and H2S04, are likely to be released during the site cleanup.	Sections 4.5, 7.2
			Detail the proposed measures to minimise impact of gases on residents and users of the adjacent bowling club and commercial operators.	Section 6.6.1, 7.2
			Provide details of monitoring to detect gases offsite.	Section 6.6.2, 7.2
			Outline contingency plan in the event that unacceptable levels of gases are detected offsite to ensure the health and well-being of local residents and landusers.	Section 3.4.2, 7.2

CONTENT		SCOPE OF WORK		
Factor	**Site Specific Factor**	**EPA Objective**	**Work Required for the Environmental Review**	**CER Reference**
Noise and vibration	Impacts on residents and users of adjacent bowling club.	Protect the amenity of nearby residents from noise and vibration impacts resulting from activities associated with the proposal by ensuring that noise and vibration levels meet statutory requirements and acceptable standards.	Describe the numbers and type of equipment to be used on site, heavy vehicles used for transport of waste off site and the hours of operation. Demonstrate that assigned noise levels will be met at the boundary of the premises.	Sections 6.3, 7.4
			Describe the equipment or methods to be used on site which may result in ground vibration, the steps to be taken to minimise impacts and steps to be taken in the event that vibration impacts are felt off site.	Section 7.5

CONTENT		**SCOPE OF WORK**		
Factor	**Site Specific Factor**	**EPA Objective**	**Work Required for the Environmental Review**	**CER Reference**
SOCIAL SURROUNDINGS				
Transport of waste	Transport and disposal of contaminated material.		Undertake a risk assessment of various methods considered for transport for contaminated material from the site.	Section 6.7
			Detail proposed methods for offsite disposal and transport of contaminated material. Identify suitable landfill site(s) and transport routes.	Sections 3.5, 3.6, 7.7, 7.8
			Detail the packaging or containment to be used for transport of contaminated waste to ensure that no leakage or dust lift-off occurs during transport.	Section 7.7
			Prepare a contingency plan to deal with spillage of waste in the event of a road accident during transport of contaminated waste.	Section 7.7
	Road traffic safety.	Ensure that roads are maintained or improved and road traffic managed to meet an adequate standard of safety.	Describe proposed methods for the management of increased vehicular movements associated with the remediation process to minimise impacts.	Section 7.8

SECTION 1
INTRODUCTION

1.1 INTRODUCTION

In December 1997, the Waste Management Division of the Department of Environmental Protection: DEP (the proponent) referred two parts of the proposed Omex site remediation project to the Environmental Protection Authority (EPA) for assessment under the Environmental Protection Act, 1986. The project consists of two distinct phases, these being:

1. the installation of an underground containment wall surrounding the major pit to prevent any further migration of contaminants and to facilitate the removal of contaminated material; and

2. rehabilitation of the site, including removal of the contents of the major pit.

The EPA set an "Informal Review with Public Advice" level of assessment for construction of the containment wall as it was considered that there were beneficial outcomes with minimal environmental effects associated with this part of the project.

The remediation phase of the project was given a formal level of assessment due to the potential for adverse environmental impacts. This level of assessment requires the preparation and release of this documentation to the public for comment. In response to this requirement, this Consultative Environmental Review (CER) has been prepared. It describes the proposal to remediate contaminated lands which make up the Omex site in Bellevue and related wastes disposed at the Adelaide Street landfill facility.

The EPA required that the DEP prepare this CER in order to provide information about the project to the general public and to assist the EPA in the preparation of an Assessment Report for the Minister for the Environment. The public are encouraged to provide written comment to the EPA as part of the environmental review process during the public review period. The assessment process is described in more detail in Section 1.4.

Although the future land use for the site has not yet been determined, the land is to be remediated to a standard suitable for residential purposes as put forward by the Western Australian Planning Commission: Improvement Plan No.30. This CER has been designed to meet the requirements of the EPA in accordance with guidelines issued by the Authority (Appendix A).

The EPA guidelines have listed preliminary environmental factors which need to be addressed in this CER. These include soil and groundwater contamination; air emissions such as dust, odours, gases and vapours; noise and vibration; and the transport of waste material from the site.

1.2 OBJECTIVES OF THE CER

The CER has been prepared in accordance with the guidelines issued by the EPA (Appendix A) with the following objectives:

- to place this proposal in the context of the local and regional environment;
- to explain the issues, decisions and alternatives which led to the choice of this proposal at this place and at this time;
- to set out the specific environmental impacts that the proposal may have; and
- for each impact, to describe how the proponent would avoid, mitigate or ameliorate that impact.

1.3 LEGISLATIVE REQUIREMENTS

The key environmental legislation which applies to the Omex site rehabilitation is the *Environmental Protection Act, 1986* which contains provisions for evaluating the environmental impact of projects. Under the Act, the EPA can require a proponent to prepare documentation for evaluation through the environmental approval process. The Act provides powers for the prevention, control and abatement of discharges into, and polluting of, the environment.

Other legislation which applies to the Omex site rehabilitation includes:

- *Explosives and Dangerous Goods Act, 1961*
- *Health Act, 1911*
- *Occupational, Safety and Health Act, 1984*
- *Road Traffic Act, 1974*
- *Rights in Water and Irrigation Act, 1914*
- *Western Australian Planning Commission Act, 1985*
- *Dangerous Goods Regulations, 1992*
- *Environmental Protection (Noise) Regulations, 1997*
- *Environmental Protection (Liquid Waste) Regulations; 1996*

1.4 ASSESSMENT PROCESS

A development proposal is initially referred to the EPA where a decision on the level of assessment is made. The EPA may elect not to assess the proposal, set a formal level of assessment or provide an informal review. A formal level of assessment will require the preparation of a report which may be in the form of a Consultative Environmental Review (CER), Public Environmental Review (PER) or Environmental Review and Management Programme (ERMP). The level of assessment can be appealed to the Minister for the Environment. These formal assessment documents are required to provide information on environmental implications relating to the proposal and outline procedures for environmental management including monitoring. They are structured and intended for distribution to the general public for review and comment.

The public review process commences with the EPA approving the release of the CER for review. Written submissions from individuals, groups and government departments can be made to the EPA during the four week public review period.

The proponent is then given an opportunity to respond to the points raised in the public submissions and these responses are then incorporated into the EPA assessment of that proposal. Subsequently the EPA reports to the Minister for the Environment on the environmental factors relevant to the proposal and on the conditions and procedures to which the proposal should be subject, if implemented.

Having received advice from the EPA, the Minister then decides whether to grant approval for the project to proceed. The EPA is usually advised in its assessments by the DEP.

The regulatory authority responsible for managing contaminated sites is the Pollution Prevention Division of the DEP. This body is a separate division to the proponent (Waste Management Division). Normally the Evaluation Division of the DEP would assess the proposed remediation and provide advice to the EPA. In this case, as the proponent for this proposal is the Waste Management Division of the DEP, the EPA will seek independent advice regarding assessment of the proposal. Independent advice will be obtained from a suitably qualified environmental consultant.

The Environmental Impact Assessment (EIA) approval process is illustrated in Figure 1.

1.5 TIMING OF THE PROPOSAL

Construction of the containment wall is scheduled to be completed by December 1998. Implementation of the remediation phase of the project will commence once the containment wall has been completed and immediately after all necessary environmental and planning approvals have been obtained. The remediation phase is scheduled to commence in the autumn of 1999 and be finalised by December 1999.

1.6 ENVIRONMENTAL ISSUES

A number of environmental issues are posed by the presence of oil wastes at the site. These include atmospheric emissions, and contamination of the soil and underlying groundwater. In order to minimise human health risks associated with the potential release of gases and other airborne contaminants from the major pit, a graded sand and plastic HDPE liner was placed over the existing superficial sand cover in February 1996. Of primary concern now is the actual oil waste material and the fate of contaminants present within the soil and underlying groundwater.

The oil waste material and associated contaminated soil have the potential to pose a threat to human health through direct contact, and can also provide an on-going source for groundwater contamination. The waste material and contaminated soil is sufficiently covered at present to prevent such direct contact. The proposed measures for the extraction, treatment and disposal of the contaminated materials are designed to ensure on-going protection of human health and the environment during the clean-up operation.

Contamination of the underlying groundwater has the potential to degrade groundwater quality to a level which can compromise its intended use. The intended use for the groundwater in the vicinity is domestic irrigation as the quality of the existing uncontaminated groundwater resources in the immediate area is unsuitable for potable supplies. However, the confined groundwater system within the Leederville Formation is ultimately used for potable supplies some 20 km downgradient of the site.

The shallow unconfined groundwater system within the Guildford Clay flows towards the Helena River which could be considered a potential receptor. However, investigations have shown minimal contaminant migration in this direction due to the low transmissivity of this aquifer.

1.7 REMEDIATION STRATEGY

The remediation strategy related to the waste contents of the pit, soil and groundwater contamination incidental to the presence of the waste is described in detail in Section 6. An outline is provided in the following Table 3.

Table 3 summarises the clean-up strategy proposed for the contents of the pit and contaminated areas associated with the past operations of waste oil recycling at the Omex site.

1.8 TENDERING PROCESS

The remediation will be performed by a contractor selected by the proponent. Tenders will be called for the remediation, based on the Ministerial Conditions as a result of the assessment process. Tenderers will be required to tender on the remediation approach as set out in the Ministerial Conditions. However it is envisaged that there will be some variation in the methods employed to meet the performance criteria as set by the Ministerial Conditions. Each tender will be required to fully describe all the procedures proposed and to identify perceived areas of risk and how these are to be managed, monitored and controlled. Full details will be required of any proposed verification testing for procedures considered unproven by the tenderer, DEP, or its consultants.

Tender documents will be prepared by DEP Waste Management Division consultants and reviewed by the EPA's Independent External Auditor before tenders are called. Tenders will be evaluated and a report providing recommendations on the tenderers will be provided to the Waste Management Division by its consultants. The report will be reviewed by the EPA's Independent Auditor and referred back to DEP for final consideration of tenders.

The successful remediation contractor will be required to remediate the Omex site to the response criteria set out in the Ministerial Conditions for public review purposes. The CER sets out criteria in Table 5, Section 3. The specification for the remediation contract will be based on the Ministerial Conditions provided in the final approval for the project. For public review purposes the management commitments considered by the proponent to meet remediation requirements are set out in Table 1.

1.9 LAND DEVELOPMENT PROCESS

The land is to be remediated to enable redevelopment of the site. The redevelopment is in accordance with the Western Australian Planning Commission (WAPC): Improvement Plan No.30. The redevelopment is being undertaken under a separate process to the remediation and is beyond the scope of this CER.

1.10 DOCUMENT STRUCTURE

The following sections provide information on the proposed remediation strategy. Section 2 provides background to the proposal in relation to the site history, hydrogeology and investigations of contamination. Section 3 sets out the criteria used for assessing contamination. Section 4 describes the nature and extent of the contamination. Section 5 compares the options for remediating the contamination leading to a recommended approach described in Section 6. The approach to environmental management is set out in Section 7 and the commitments to meet this approach are made in Section 8.

References are provided in Section 9 followed by abbreviations and referral to figures in the report. Appendices present the EPA Guidelines for this proposal, the health risk assessment, groundwater model, quality assurance program and the proposed excavation strategies.

TABLE 3
REMEDIATION STRATEGY

LOCATION	APPROACH	PERFORMANCE INDICATOR
MAJOR PIT		
Liquid Waste *4,400 m^3*	• dewater to base of major pit. • estimated recovery rate of up to 30% of liquid in the pit (1,300m^3). • pretreat on-site to stabilise pH, possible oil separation. • transport liquid waste to liquid waste treatment plant.	• liquid level in pit reduced to below pit floor. • no free liquid during solid waste removal. • pH of between 2 and 12. • acceptance at treatment facility.
Solid Waste *17,000 m^3*	• excavate solid waste in a 'dry' condition. • temporary on-site storage. • treatment with lime or equivalent. • cart to landfill. • backfill with clean soil. • install graded clay cap to manage drainage.	• no free liquid. • safe containment. • pH above ???. • acceptance at landfill facility. • satisfy clean-fill criteria. • no infiltration of surface water.
Air Emissions	• minimise exposure of pit to atmosphere. • use suppression techniques where required. • monitor air on and off site. • enact contingency plan if air quality is unacceptably impact upon.	• maintain maximum coverage. • minimise air emissions. • satisfy air emission criteria. • respond to alert levels set at 20% of criteria..
OUTSIDE OF PIT		
Soil Contamination *13,500 m^3*	• excavate contaminated soil above response criteria to a maximum depth of 3.5 m. • temporary on-site storage. • cart to landfill. • backfill with clean soil.	• soil at 0-3.5 m depth does not exceed response criteria. • safe containment. • acceptance at landfill facility. • satisfy clean-fill criteria.
Groundwater Contamination *20,000m^2*	• contain groundwater beneath the pit with the containment wall. • groundwater outside of wall to disperse and degrade with time. • exclude use of groundwater through existing regulations. • monitor groundwater until restrictions can be lifted.	• negligible groundwater movement within containment wall. • evidence of reduction in contaminant levels. • no issuing of abstraction licences. • satisfy groundwater criteria.
Air Emissions	• use suppression techniques where required. • monitor air on and off site. • enact contingency plan if air quality is unacceptably impact upon.	• minimise air emissions. • satisfy air emission criteria. • respond to alert levels set at 20% of criteria.

SECTION 2
BACKGROUND

2.1 LOCATION

The Omex site is located 17 km east of the Perth central business district (Figure 2) in a mixed residential and commercial area of the suburb of Bellevue. The Omex re-refinery site is shown on Figure 3 and is defined as locations:

- Lot 57 Clayton Street
- Lot 58 Clayton Street
- Lot 60 Clayton Street
- Lot 61 Purton Place
- Lots 48 to 56 Henkin Street

Lots 48 to 56 Henkin Street adjacent to the Omex site have now been acquired by the Government and the residents relocated. These properties are included in the WAPC Improvement Plan.

Other properties which have been identified as contaminated or will be affected by the remediation phase are:

- Lot 136 Clayton Street
- Lot 130 Purton Place

The Omex site is bounded by Clayton Street to the south, Henkin Street to the west, Purton Place to the north, and the Peak Petroleum site (Lot 136 Clayton St.) and Bellevue Sporting Club (Lot 130 Purton Pl.) to the east.

The Adelaide Street Landfill site used for the disposal of oil wastes is located approximately 4 km south of the Omex site.

2.2 SITE LAYOUT

The site layout, including existing and demolished structures, is shown on Figure 3.

The major waste oil residue pit occupies the central parts of Lots 60 and 61, with the western margin extending near the boundaries of Lots 51 and 52. A secondary residue pit known as Minor Pit No.1 is located at the north east boundary of Lot 60.

A shed associated with a now demolished plaster factory occupies the north eastern section of Lot 61. A shallow sump has been constructed near the western boundary of Lot 61 to drain surface runoff from the plastic liner covering the major pit.

The now demolished original oil re-refinery building was located immediately north of the existing oil redrumming shed up to the southern boundary of the major pit. A bunded oil storage facility now occupies the western part of this area. The eastern section of the re-refinery site is mostly covered with a paved concrete surface and is used for the storage of packaged oil drums. The main office building is situated immediately south of the redrumming shed on Lot 57.

On the western boundary of Lot 136 is a bunded above ground diesel storage area. Two diesel dispensers are located 10 m to 15 m south west of this storage area on Lot 58.

An abandoned clay pit known as Pit No.3 occupies the southern portion of Lot 130. This pit was used up until the 1960's for the disposal of plaster wastes and some sewage sludge. The contents of the pit have been investigated in detail and are not contaminated with Omex oil waste material.

A number of shallow (<1 m depth) open drains were connected to the major pit in the past. A drain existed between the major pit and Pit No.3 which was most likely used to control excess surface water as this pit was being infilled with plaster waste. Another drain existed north of the major pit and was used to drain local stormwater. All open drains were backfilled prior to 1976 based on aerial photograph interpretation.

Lot 136 contains an open sump known as Minor Pit No.2. The exact use of this pit is not clear but was most likely used for stormwater control from nearby paved surfaces and the adjacent Drum Store. The contents of this pit have been investigated and are <u>not</u> contaminated with Omex oil waste material.

Lots 48 to 56 Henkin St. contain six dwellings . These premises will be vacated prior to commencement of the remediation phase.

2.3 SITE HISTORY

This section describes the history of the site. It is a summary of key events which was determined by review of local and regulatory authority records, aerial photographs and informal interviews with the site owner and local members of the community. A detailed site history is provided by Golder (1997).

Information regarding the early history of the major pit is limited but it was believed to have been excavated before the 1940's for clay. The depth of the mining excavation was limited to less than 10 m, most likely due to the quality of the clay and an increase of the inflow of groundwater into the pit.

The Western Oil Refining Co. Pty Ltd commenced waste oil recycling operations in 1955 and continued operating on the site up until 1979. The recycling process termed the 'contact method' involved the re-refining of used lubricating oils by applying concentrated sulphuric acid to remove non-oil material and unstable oil. The resulting sludge consisted of a bitumen and oil residue, spent Fullers Earth (used to filter the oil) and acidic wastewater.

In 1979, the recycling activities of the refinery ceased and the company's activity changed to blending of new products only. The refinery building was demolished and a new redrumming facility built immediately to the south (see Figure 3).

From 1976 onwards the major pit was progressively backfilled with building rubble, sand, clay, plaster wastes, car bodies and drums. The minor pit No.1 was excavated prior to this date and was also used at the time for waste oil disposal.

Waste oil overflowed from a bund surrounding the major pit in late 1988/early 1989 and spread onto adjoining Lots 51 and .52 Henkin St. Two seepage trenches were constructed on Lot 51 Henkin St to contain the oil overflow from the major pit. Soon after, the waste oils were reportedly removed from the two properties and replaced with soil scrapings from the perimeter of the major pit.

In 1989, approximately 1,000 m^3 of waste oil sludge was disposed at the nearby Hazelmere landfill site located at Adelaide Street in the suburb of Hazelmere (approximately 4 km south of the Omex site). The exact location of this waste is not known but it is believed to have been deposited in two areas in the eastern part of the landfill. By late 1989, the major pit and minor pit No.1 had been backfilled with yellow sand fill.

Environmental investigations commenced in 1988 following the major overflow event. A summary of environmental investigations to date is provided in Section 3. In January 1994, investigations at Lots 51 and 52 Henkin St. revealed contamination levels which were considered to pose a significant health risk, prompting the Shire of Swan to proclaim these locations unfit for human habitation.

An impervious 1 mm thickness HDPE plastic liner was placed over the major pit in February 1996. A 0.1 m to 0.5 m clean sand cover underlies the liner to provide grade where surface water runoff is directed to a shallow sump located on Lot 61 Purton Pl.

On 9 October 1997 the Premier of WA announced a \$6.9 Million government funded remediation of the site to be completed by December 1999 (DEP, 1997a).

2.4 HYDROGEOLOGY

The area is part of the extensive Mesozoic sedimentary basin that dominates the geology of the Swan Coastal Plain. The site is underlain by Quaternary superficial sediments (Guildford Clay) which in turn are underlain by the Cretaceous Leederville Formation.

At the site the Guildford Clay consists of about a 16m thickness of sandy clay and clayey sand with minor sand beds with a saturated thickness of 13 m. Laterally discontinuous sand beds form minor individual aquifers. The direction of groundwater flow in the Guildford Clay is to the southwest towards the Helena River (GSWA, 1995).

The Leederville Formation, a major aquifer, consists of interbedded sands and clays. The aquifer has a potentiometric head of 15m AHD (Surface Level 19m AHD) and a regional groundwater flow direction to the west at about 1 - 4 m/year.

The high clay content within the Guildford Clay limits ground water supplies suitable for domestic bores to the upper part of the Leederville Formation aquifer. Salinity levels are fresh to marginal in the Guildford Clay (890 - 4 000 mg/L TDS), and marginal in the Leederville aquifer (1 000 - 1 200 mg/L TDS) (Golder, 1997; GSWA, 1995).

A cross sectional representation of site geology depicting the major pit is shown on Figure 4.

2.4.1 Dewatering Potential

The issue of the need for groundwater inflow control was clearly identified by Golder (1997) and dewatering trials were undertaken to estimate the requirements. Groundwater inflow control is important to the remediation strategy for the following reasons:

1. The solid wastes in the major pit are largely submerged below the watertable, hence excavation without groundwater inflow control will produce a large excess of liquid waste to be treated and disposed of. In addition, the excavation will be difficult to validate in terms of removal of all wastes and impacted soil from the wall of the excavation. There is a very high risk of excessive quantities of liquid waste and associated problems of disposal of solid waste with a high free liquid content.

2. The wastes as a whole, are expected to produce a strong odour of sulphur and oil once excavated. Should large quantities of waste be exposed or agitated, this may pose a health hazard for site workers and local residents. These problems will be partially alleviated by control of groundwater inflow. The majority of the liquid wastes in the pit could be removed with the existing cover system intact via a closed system of bores or covered sumps connected to a piped storage plant. After the liquid wastes have been removed, the solid waste will have a lower odour potential and should be capable of being excavated within small open sections with the remainder of the pit covered or backfilled with clean fill. Without groundwater inflow control, the waste would be excavated as a slurry with possibly the entire pit area open to the atmosphere.

The results of the dewatering trials conducted by Golder (1997) indicated that a conventional approach to dewatering with an array of pumping bores outside of the major pit would not be feasible for the following reasons:

- the aquifer to be dewatered is generally low yielding, though highly variable in hydraulic properties; and

- at least eight pumping bores located around the perimeter would be required pumping at a low rate of 9.5 kL/day each for a period of about 30 days to lower the watertable to below the base of the pit floor. This indicates a total volume of water to be removed and treated on site of approximately 2,300 kL.

2.4.2 Containment Option

In discussion of remediation options (Golder, 1997), an alternative approach to conventional dewatering was proposed. The alternative approach involved the installation of a low permeability, chemical resistant grout curtain or slurry wall sealed in to the shallowest continuous clay layer beneath the major pit (at about 30 m depth).

This structure could be constructed using proven technology and would surround the pit and significantly reduce the lateral and vertical inflow of groundwater into the pit during removal of the liquid waste component and excavation of the solid waste. It would therefore greatly reduce the risks involved in estimating liquid waste quantities to be excavated and treated, and also allow for deepening of the excavation if required.

This option was considered as a prerequisite to any remediation option involving removal of the waste material from the major pit. This structure alone with a suitable impermeable surface cover would act as barrier and contain the most contaminated groundwater existing beneath the pit. The containment system would have a secondary benefit in terms of preventing further migration of contaminated groundwater into both the regional Leederville and superficial Guildford Clay aquifers.

2.5 ENVIRONMENTAL INVESTIGATIONS

The Omex site is contaminated with waste chemical compounds resulting from the past oil recycling activities and represents a significant point source of contamination to groundwater in the local area.

The nature and extent of this contamination has been the subject of a number of government funded environmental investigations since 1988. These investigations were initiated due to concerns for the health of nearby residents and possible impacts on the underlying groundwater.

The following sections describe the results of environmental investigations and provide an assessment of the contamination status of the material within the pit, the surrounding soil and underlying groundwater, against relevant human health and environmental protection criteria. Environmental and geotechnical investigations conducted to date are summarised on Table 4.

TABLE 4
SUMMARY OF ENVIRONMENTAL INVESTIGATIONS TO DATE

DATE	INVESTIGATION
1988	Environmental Protection Authority (EPA) sampled an oil seep on surface of major pit.
1989	Consultants SK defined perimeter of the major pit. Pit depth estimated < 20 m. *Osborne Ceilings Clay Pit Investigation, Lot 60/61 Clayton St., Bellevue. Sinclair Knight and Partners. May 1998.*
1990	Consultants D&M drilled and tested perimeter soils to 9 m depth. No groundwater data provided. *Report on Preliminary Investigation: Bellevue Residue Pit for Omex Petroleum Pty Ltd. GRC-Dames & Moore. December 1990.*
1992	Geological Survey of WA (GSWA) recommended further work to EPA to define and monitor contamination.
January 1994	Chemistry Centre WA (CCWA) investigated shallow soil contamination west of the major pit for EPA. Air sampling also performed. *Lots 50, 51 and 52 Henkin St., Bellevue Site Assessment. Chemistry Centre of Western Australia. Report No. 93E1628.*
February 1994	GSWA performed a bore census. Two bores installed in Leederville Formation aquifer, one on the Omex site ('OMEX' bore) which is abandoned and an operational bore on Goodchild Oval.
November 1994	GSWA/CCWA sampled 'OMEX' bore for DEP.
1995	Curtin University of Technology Geophysical trial survey of major pit revealed possible presence of ferrous materials within fill on southern section of pit.
March to August 1995	GSWA/CCWA performed extensive groundwater and soil investigations related to the site and major pit. Depth of pit determined by drilling to be at 6.9 m and volume of contaminated fill estimated to be 12,400m^3. *Assessment Report Omex Pit Site, Bellevue. Chemistry Centre of Western Australia. Report No. 94E1873; Report on an Investigation of Contamination in a pit at the Omex Site. Chemistry Centre of Western Australia. Report No 94E2002; Investigation of Groundwater and Soil Contamination at the Omex Site, Clayton Street, Bellevue. Geological Survey of Western Australia, Hydrogeology Report No. 1995/41.*
June1996	Water and Rivers Commission (WRC) performed verge sampling of the surface soil at 41 locations south and west of the site and found no contamination associated with the Omex site. *Report on 41 Samples from Bellevue. Chemistry Centre of Western Australia. Report No. 95EH0507.*

TABLE 4 Continued

DATE	INVESTIGATION
July to November 1996	Golder performed extensive groundwater and soil investigations both on-site and immediately off-site. Groundwater contamination detected off-site. *Extent of Contamination and Options for Remediation: Omex Petroleum Site. Golder Associates. Report No. 96640252-2, February 1997.*
August 1996	WRC investigated vertical extent of groundwater contamination within Leederville Formation aquifer by deep drilling to 68 m. Two monitoring bores installed and tested beneath the likely zone of contamination. *Extent of Contamination and Options for Remediation: Omex Petroleum Site. Golder Associates. Report No. 96640252-2, February 1997.*
February 1998	CMPS&F performed superficial soil sampling at 18 locations including the primary school and found no contamination. *Report to the Department of Environmental Protection on Backyard Sampling in Bellevue Area. Report No. VW1079, February 1998.*
March 1998	CMPS&F performed soil investigations at the on-site Oil Redrumming Facility on-site. *Environmental Site Assessment: Omex Oil Redrumming Facility. CMPS&F Environmental. Report No. VW1093, April 1998.*
April 1998	CMPS&F installed 7 bores around the perimeter of the major pit into the Leederville aquifer, three were sampled for groundwater. A geotechnical study was commissioned to ascertain the true dimensions of the major pit which are; an average depth of 7.3 m, 2,800 m^2 area and volume of 12,200 m^3. *Omex Site Containment Wall Construction Specification: Attachment A. CMPS&F Environmental. Report VW1100.CWA, April 1998.*
May to July 1998	CMPS&F performed extensive off-site groundwater investigations of the Leederville aquifer. *Assessment of Off-site Groundwater Contamination from the Omex Site. CMPS&F Environmental. Report No. VW1134, August 1998.*

2.5.1 Environmental Sampling Quality Control

Environmental sampling requires specific sampling techniques and a high level of quality control. Sampling protocols ensure that the samples submitted for laboratory analysis have been sampled in the appropriate manner and are truly representative of the conditions. Quality control includes laboratory reanalysis of a number of samples and decontamination procedures for sampling equipment to ensure there has been no cross contamination between sample locations.

With regard to those studies that have been used to determine the contamination status of the site, soil and groundwater samples were taken in accordance with an appropriate quality assurance plan. This plan details the methods of sampling, handling and transport of samples and decontamination or cleaning procedures for sampling equipment.

All samples were analysed at quality controlled NATA (National Association of Testing Authorities) registered laboratories. Samples were transported in cooled, insulated containers and were analysed within their appropriate holding times.

The details of the quality assurance program for the major investigations is provided in Appendix D.

SECTION 3
CONTAMINATION ASSESSMENT GUIDELINES

3.1 INTRODUCTION

This section describes the toxicology of the contaminants detected at the Omex site and the criteria used to assess the contamination. Criteria exists for the assessment of soil and groundwater contamination from both an environmental and human health perspective. Allowable air emissions are outlined for both occupational and public health exposure. Criterion used to determine acceptability of liquid waste for disposal at the treatment facility and the class of landfill the solid waste is suitable for are also described.

These criteria are then applied to the contamination detected at the site as described in detail in Section 4.

3.2 ENVIRONMENTAL CONTAMINANTS

The potential environmental and health implications associated with contaminants detected at the site are outlined below.

3.2.1 Heavy Metals

Heavy metals are found naturally in the environment in soil, water and the atmosphere in various forms but usually in small quantities. A number of these metals are essential for the healthy function of organisms, however in larger quantities heavy metals can be toxic to humans and other organisms.

Some heavy metals are unable to be metabolised and thus accumulate in organisms during their lifetime, in particular aquatic fauna from polluted environments. Whilst the contaminant may not be toxic in small quantities, organisms at the higher end of the food chain such as fish may accumulate sufficient levels via ingestion of other organisms, for heavy metal toxicity to develop. This is termed bioaccumulation.

The effect of heavy metals on humans varies depending on the form or compound the metal is in. If inhaled, some forms of heavy metals can cause respiratory disease including cancer and bronchitis. Skin contact with particular heavy metal compounds can lead to skin conditions such as dermatitis. Various diseases including brain damage, cancer and organ damage may result from ingestion of certain heavy metals. Lead in particular is linked with decreased IQ values in small children.

3.2.2 Hydrocarbons

The term hydrocarbons encompasses many natural and manufactured organic substances, including liquid and gaseous substances such as oils, volatile spirits and natural gas. Hydrocarbons can cause environmental harm through the chemical and physical nature of the various compounds. Hydrocarbons may be accumulated through the food chain and are often found to be persistent in the environment.

Oil can cause environmental damage, particularly when in aquatic systems. Oil forms an oxygen barrier on the water surface preventing the transfer of oxygen between the atmosphere and the water, thus depriving the aquatic organisms of oxygen. Organisms which come into contact with floating hydrocarbons, become coated and often die as a result of impaired mobility and body functions. Some hydrocarbons become incorporated into sediments and persist in the environment, others are water soluble and enter the food chain. Bioaccumulation of hydrocarbons just like heavy metals can cause harmful effects to organisms higher up in the food chain.

Inhalation of some forms of volatile hydrocarbons by humans can cause respiratory irritation or affect the nervous system. Some hydrocarbon compounds are carcinogenic and mutagenic.

3.2.3 Acid

Strong acids are highly corrosive and can produce burns. Acidic conditions in water can kill aquatic life and also mobilise heavy metals.

3.2.4 Sulphur

Sulphate has the potential to reduce to sulphides under anoxic conditions such as those which occur within swamps and produce hydrogen sulphide gas (rotten egg smell). In some people, elevated sulphate levels in foods can lead to allergic reactions.

Sulphur dioxide is a gas produced primarily from the combustion of hydrocarbons. Although sulphur dioxide is not highly toxic, low levels can cause a decrease in lung function and produce respiratory irritation (Bronchospasm) in susceptible people such as asthmatics.

The effects of sulphur dioxide on plants include leaf necrosis from high level acute exposure and chlorosis or yellowing of the plant leaf from chronic exposure.

3.3 ENVIRONMENTAL ASSESSMENT CRITERIA

Environmental assessment criteria can be effectively divided into two distinct categories:

1. an investigation level, if exceeded, should be used as the basis for further evaluation of the risks to potential receptors which maybe the environment or human health.

2. an action level where concentrations or the bioavailability of the contaminant represents a risk to the environment or human health. Such levels prompt action or a response which will necessitate some form of remediation or management. In terms of a response criteria, this value is normally based on an action level for a particular landuse and environmental setting.

3.3.1 Soil Contamination

The risks associated with contaminated soil/material relate to adverse effects on human health and environmental damage to flora and fauna.

Human exposure may arise from repeated direct contact over a long period of time with the contaminated soil/material or via continued consumption of produce grown in such soils. Environmental damage may take the form of phytotoxicity to plants or toxicological effects on soil microorganisms.

The threshold criteria for assessing the need for remediation will be based on maintaining the utility of the land for residential use, consistent with the commitment made by the proponent. This will be achieved by removing all the waste material and contaminated soil within and adjacent to the pit which represents a real risk to human health.

The contamination status of the remaining surface soils on-site will be assessed using demonstrated criteria developed for the protection of human health where there is potential for direct contact. Contaminated soil at depth which is unlikely to come into contact with normal human activity has been evaluated using a health risk assessment approach (Appendix B). This approach assesses the risk to human health associated with exposure to residual soil contamination.

Western Australia's position on soil contamination is outlined in the public position paper; Contaminated Sites; Assessment and management of contaminated land and groundwater in Western Australia, May 1997 (DEP, 1997c).

Key elements of the position paper relevant to this proposal are stated in Position Numbers 3 and 14.

- ***Position No 3*** *: A contaminated site is defined as 'A site at which hazardous substances occur in soil or groundwater at concentrations above background levels and where assessment indicates it poses, or has the potential to pose, an unacceptable risk to human health or the environment'.*

- ***Position No 14*** *: It is proposed to introduce a scheme for defining investigation and remediation levels based on the approach recommended in the ANZECC/NHMRC Guidelines for the Assessment and Management of Contaminated Sites. This scheme consists of two complementary approaches:*

  1. *the first approach involves using generic criteria for the protection of human health and the environment. At present, generic soil investigation criteria will be based on national criteria developed by ANZECC/NHMRC in the Guidelines for the Assessment and Management of Contaminated Sites.*

  2. *the second approach recognises that the effects of contamination vary considerably depending upon site specific factors. Under this approach the generic criteria are used as guidance values to highlight issues of possible concern and trigger the need for further investigation.*

3.3.2 Soil Assessment Criteria

Western Australia currently employs the Australian and New Zealand Guidelines for the Assessment of Contaminated Sites (ANZECC/NHMRC 1992) and in their absence for certain chemical compounds, the Dutch Guidelines for Soil Remediation (1983) for the assessment of soil contamination.

The ANZECC guidelines include Environment Investigation Threshold (B) levels and Proposed Health Investigation Level Guidelines. Where contamination is identified at concentrations in excess of the thresholds, further investigation and evaluation on a site-specific basis may be warranted. A site-specific evaluation would include a consideration of future site use, human health risks and other impacts on the nominated beneficial uses.

The ANZECC Health Investigation Level Guidelines apply to lead, cadmium, arsenic and benzo(a)pyrene which are frequently occurring contaminants of significance. These levels have been developed using a health risk assessment approach and can only be applied with reference to particular exposure settings.

Where no Environmental Investigation Threshold is nominated, the ANZECC guideline recommends use of the Dutch B guidelines. It should be noted that the listed concentrations are "investigation thresholds" and indicate the soil contaminant concentration level above which further investigation is required. They are not intended to be regarded as absolute upper bound concentration levels which must not be exceeded.

The Dutch (The Netherlands Department of Housing, Physical Planning and the Environment) guidelines which have been widely used for assessing appropriate levels for a range of contaminants in soils, nominate various action levels for a range of contaminants. The Dutch A levels represent a background or reference value. The Dutch B levels represent an investigation threshold, above which further consideration of the impact of contamination or land use is warranted. Contaminant levels below Dutch B are generally considered acceptable for sensitive landuses such as residential. The Dutch C levels represent a threshold of contamination at which clean-up is likely to be required. Levels below Dutch C are generally considered appropriate for a commercial or industrial land use.

The Risk Assessment and Environmental Quality Division of the Minister of Housing, Spatial Planning and Environment in the Netherlands has provided a revised version of the 1983 Dutch guidelines known as the 1994 Environmental Quality Objectives. The former "A, B and C" criteria have been replaced by target and intervention values. Target levels indicate the concentration of a contaminant in which the risk of adverse effects on the ecosystem and functional properties of the environment are considered to be negligible. The intervention levels are considered contaminant concentrations which represent serious environmental pollution and therefore will require "clean-up" or remediation. The Dutch Intervention criteria are specifically based on Dutch conditions and are not used or referenced in Western Australia. However they do provide an indication of what constitutes an action or clean-up level.

The soil criteria used for assessing the presence of contamination at the Omex site will be based on the ANZECC B guidelines, and in the absence of relevant ANZECC levels, the 1983 Dutch B criteria. This criteria is for assessment purposes only and are not to be viewed as clean-up criteria. Response levels or remediation goals are based on a number of factors and are derived for protecting likely receptors be they environmental or human.

The response levels for the Omex site is based on protection of human health as this is the principal receptor. The development of a site specific response level is discussed in Section 3.4.1.

The assessment criteria applicable to the contaminants found on-site are presented on Table 5. This includes the proposed health based response level.

3.3.3 Groundwater Contamination

Risks associated with contaminated groundwater relate to the final destination of the groundwater. The use of such groundwater for drinking or irrigation purposes may result in human exposure via ingestion, direct contact or by consumption of home-grown produce.

Where contaminated groundwater is discharging into an aquatic environment such as a river system, the contaminants may compromise the integrity of that ecosystem and represent a possible exposure route to humans via consumption of aquatic life or recreation activities.

The assessment of groundwater contamination is based on preventing any further degradation of the groundwater quality. A bore census of the area was conducted by the Water and Rivers Commission in 1994 which found only one active bore on Goodchild Oval (Golder, 1997). Significant groundwater contamination beneath the major pit will be isolated by means of a containment wall (discussed in S.6.2).

Western Australia's position on groundwater contamination is outlined in the public position paper; Assessment and management of contaminated land and groundwater in Western Australia, May 1997 (DEP, 1997c).

The approach to groundwater contamination is stated in Position No 8. The relevant points applicable to this proposal are:

- *Beneficial use - The management of contaminated groundwater will be based on the beneficial use concept. Different areas of groundwater will be protected to different levels based on the existing or potential beneficial use of the groundwater in question.*

- *Investigation levels - At present, investigation levels will be based on existing criteria contained in the ANZECC National Water Quality Management Strategy - Australian Water Quality Guidelines for Fresh and Marine Waters. However, investigation levels will be based on groundwater criteria to be developed under the proposed National Environment Protection Measure for contaminated sites when this process is completed.*

- *Clean-up criteria - Will apply at the point of abstraction or where the groundwater is having its effect.*

3.3.4 Groundwater Assessment Criteria

The selection of appropriate acceptance criteria for groundwater is dependent on the beneficial use of the groundwater to be protected. Relevant limits are applied depending on whether there is direct usage of groundwater for potable or irrigation supplies, or whether groundwater is discharging to a freshwater or marine environment.

It should be noted that the background groundwater quality in the immediate local area, in both the shallow unconfined and deeper confined aquifer is marginal in terms of salinity (refer S.2.4), and is unlikely to be widely used locally as a potable or irrigation supply. However, this location is an area of recharge into the Leederville confined aquifer. At some 20 km downgradient of the site, this aquifer is used for potable supplies.

The DEP currently employs the Draft Western Australian Water Quality (WAWQ) Guidelines for Fresh and Marine Waters (EPA, 1993), an adaptation with minimal change from the Australian Water Quality (AWQ) Guidelines for Fresh and Marine Waters (ANZECC, 1992) for assessing water quality inclusive of irrigation and untreated drinking water. The WAWQ Guidelines provide water quality criteria for a number of contaminants. In the absence of draft WAWQ Guidelines for a particular chemical compound, the 1983 and updated 1994 Dutch guidelines are used. The Dutch groundwater protection criteria follow the same framework as discussed previously with the soil acceptance criteria (S 3.3.2).

The WAWQ Guidelines for Raw Water for Drinking Water Supply are used for assessing the quality of groundwater in locations where it maybe used as an unregulated drinking water supply, for irrigation, or recreational use such as soaks or for filling domestic swimming pools. These criteria are more onerous than for protection of irrigation water supplies only. Application of these criteria afford a conservative approach to assessing groundwater quality in the area surrounding the Omex site.

The groundwater criteria used for assessing the contamination status of the Omex site will be based on the Draft Western Australian Water Quality (WAWQ) Guidelines for Fresh and Marine Waters; Raw Water for Drinking Water Supply, and in the absence of relevant WAWQ Guidelines, the 1983 Dutch B criteria.

The groundwater assessment criteria applicable to the contaminants found on-site are presented in Table 6.

3.4 HEALTH RISK ASSESSMENT

Health risk assessment (HRA) is commonly used to assess the health and ecological impacts associated with contaminated soil and groundwater. This process allows for the development of site-specific risk-based criteria which can be applied as response levels for remedial works (ie clean-up criteria for remediation or levels requiring management action).

Health risk assessment is a primary component in an overall risk-based approach to decision making which seeks to manage risk to human health and facilitate redevelopment of contaminated land. Determining the level of risk of an adverse effect on human health uses a structured and well-recognised process outlined in the ANZECC Guidelines for the Assessment and Management of Contaminated Sites (1992).

The principal components of this process are:

- hazard identification;
- exposure assessment;
- toxicity evaluation;
- risk characterisation.

The health risk assessment process is illustrated on Figure 5.

An important tenet of health risk assessment is that the underlying objective is to effectively protect the most sensitive individuals in the exposed population (for example children or the elderly). In protecting the more sensitive receptor groups in the population it is assumed that the general population is hence sufficiently protected.

Health risk assessment seeks to determine the intake of a chemical by an individual and how this level compares to a nominal dose that is considered acceptable. With respect to soil contamination, exposure may be estimated via a range of routes, including ingestion of soil, inhalation of volatiles or particulates, dermal absorption and food chain exposure.

In assessing possible adverse effects on human health, consideration is given to a range of carcinogenic and non-carcinogenic effects. It is often the carcinogenic effects that are limiting in terms of possible adverse effects.

The advantage of using a health risk assessment model is that specific criteria can be determined for various land uses such as residential, commercial and public open space. Setting specific criteria for a given land use determines the level of remediation required to achieve protection of human health.

The HRA performed for the Omex site is presented as Appendix B.

3.4.1 HRA Based Soil Response Levels

Methodology

The receptor group of concern identified from the HRA is future residents living on the remediated Omex site. Young children of about 2 years old (toddlers) are known to have the largest incidental ingestion of soil, therefore this subgroup of future residents has been identified as the one requiring greatest level of protection.

The rate of incidental ingestion of soil by toddlers has been conservatively estimated at 100 mg/day (ANZECC/NHMRC, 1992) which is approximately four times higher than the adult rate. With their lower body weight and higher daily incidental ingestion of soil, it is considered that young children are at greater risk from soil contaminants than adults.

To nominate protective levels of human health in soils, the exposure to residual soil contaminants by future site users is managed according to an applicable exposure setting. The applicable exposure setting for the proposed residential redevelopment will be based on *exposure setting A* from Imray and Langley (1996). This setting is described as a *'Standard' residential with garden/accessible soil (home-grown produce contributing less than 10% of fruit and vegetable intake; no poultry): this category includes children's day-care centres, preschools and primary schools.*

On the basis of the above assumptions, response levels have been developed which correspond to negligible risk for a future child resident. Where contamination exceeds response levels, remediation or management action is required to protect human health.

Criteria

The following hazardous substances were found in the contaminated soil at the Omex site and are described in detail in Section 4:

- lead in particular and other heavy metals;
- hydrocarbons:
  - ⇒ heavy fraction component of total petroleum hydrocarbons (TPH),
  - ⇒ benzene, toluene, ethylbenzene and xylenes (BTEX),
  - ⇒ polycyclic aromatic hydrocarbons (PAH);
- phenols; and
- acidity.

Table 5 summarises protective levels for the contaminants of concern identified at the Omex site.

It is proposed that these response levels are applied as clean-up criteria to all soils down to a depth of 3.5 metres. Soils contaminated at concentrations above these levels may be allowed to remain at greater depth (>3.5 m) as these are unlikely to be brought to the surface on land used for residential purposes. For high concentrations of volatile contaminants left below 3.5 m, it would be necessary to demonstrate that these concentrations could be left without ill effect.

Conditions will be placed on the remediated sections of the site that contain contamination below the nominated 3.5 m clean-up depth to ensure there is no potential for direct human contact with the soil.

3.4.2 Air Emission Standards

Air emissions from the site are currently not of concern as the major pit is sealed to the atmosphere by a vented soil and HDPE lined cover. Air emissions can potentially become an issue during the remediation phase once the material is uncovered. This section provides the air quality standards which would apply to the clean-up once remedial works commenced.

The standards adopted for allowable air emissions emanating from the Omex site at the site boundary during remedial works is based on a health risk assessment (HRA) approach. This health risk approach ensures protection of the most sensitive receptors such as asthmatics or those with respiratory problems. The standards for air emissions set for the protection of public health are shown in Table 7. These are derived from nationally (National Environmental Protection Measure for Ambient Air Quality, 1998) or internationally recognised criteria (IRIS, USEPA, 1998). The HRA performed for the Omex site is presented as Appendix B.

As a safety measure to prevent hazardous air emissions from ever occurring, alert and action thresholds are nominated. The alert threshold is set at 20% of the air emission standard which notifies the presence of elevated levels which will prompt more detailed attention to control measures. An action threshold of 5 times the air emission standard represents immediate action and closure of site operations.

Occupational exposure for air emissions in Western Australia is set by Worksafe WA. The relevant standards for known contaminants are included in Table 7.

TABLE 7
AIR EMISSION STANDARDS

All results expressed as micrograms per cubic metre unless stated otherwise.

TIME	Sulphur dioxide[A] (ppm)	Lead[AB]	Fine Particulates[AC]	Benzene[D]	PAHs[E]
PUBLIC HEALTH					
1 Hour	0.2				
1 Day	0.08		50	1,000	
1 Year	0.02	0.5			0.3
OCCUPATIONAL					
8 hour	2	150	5000	16,000	NC
ALERT LEVEL	0.04	0.1	10	200	0.06
ACTION LEVEL	1	2.5	250	5,000	1.5

Notes

A, National Environmental Protection Measure for Ambient Air Quality, 1998

B, reported as a fraction of total suspended particulate material.

C, measured as PM_{10} material. PM_{10} is fine particulate material with an aerodynamic diameter of 10 μm or less. Particles of this size can be harmful as they are capable of penetrating deeply into the lung.

D, level previously acceptable to the DEP for a school nearby to a service station undergoing remediation.

E, measured as the sum of the levels of benzo(b)fluoranthene, benzo(k)fluoranthene and benzo(a)pyrene. The level nominated corresponds to an estimated incremental lifetime risk of cancer of 1 in 10^{-5}. Data adapted from Integrated Risk Information System, United States Environmental Protection Agency.

NC, No criteria.

3.5 LANDFILL DISPOSAL CRITERIA

This section describes the criteria used to assess the hazard posed by contaminated wastes and soil in terms of disposal of the material to landfill. The objective of the landfill disposal or waste classification criteria is to ensure that wastes are disposed to appropriately managed landfills so as not to create leachate which may have an unacceptable health or environmental impact. This is achieved by ensuring waste is disposed to a landfill which has been designed to safely accommodate such material.

In Western Australia, waste is disposed in accordance with the requirements of the Department of Environmental Protection 'Landfill Waste Classification and Waste Definitions, 1996' as endorsed by the EPA.

Landfill classification is determined by the level of containment of waste the facility can offer. The higher the class of landfill, the more secure the facility. Contaminated soil is disposed to various classes of landfill dependent upon the severity of the contamination. The higher the class of landfill, the greater the level of contaminated soil it can accommodate.

- Class II Landfill — low hazard waste (type 1), Class II wastes.
- Class III Landfill — low hazard waste (type 1), Class III wastes.
- Class IV Landfill — low hazard waste (type 2).
- Class V Landfill — intractable waste only.

Currently in the state there are only two approved Class III and one approved Class V landfill facilities. The Class III facilities are within the metropolitan region at Red Hill and Baldivis, whereas the Class V facility is in the Goldfields region at a location near Mount Walton East. The existing Red Hill Class III landfill site contains a secured Class IV landfill cell which is capable of containing high level contaminated soil.

Low level contaminated soil (Class II) is sometimes suitable for use as a special fill. Special fill can be used in locations such as in road and bridge construction or as a fill material at depth.

Conditions within landfills tend to be acidic due to the decomposition of organic wastes. Such acidity can mobilise toxic components in buried waste material including contaminated soil. This is particularly relevant to heavy metals which can be mobilised in acidic conditions. To assess the leaching potential of such waste, tests known as the Toxicity Characteristic Leaching Procedure (TCLP) which emulate landfill conditions are performed.

To reduce the leachable component of contaminated soils, chemical stabilisation can be undertaken. This reduces the mobility of the contaminant and thus makes it suitable for disposal to landfill.

In order for contaminated soil to be disposed to a landfill facility, the material must satisfy two sets of criteria:

1. Total contaminant concentrations must be below the maximum criteria set for that particular class of landfill, and

2. The leachable fraction extract (TCLP result) must be below the maximum criteria set for that particular class of landfill.

The landfill assessment criteria applicable to the contaminants found on-site are presented on Table 8. Although no criteria exist for pH, it is important that no additional acidity is introduced into a landfill, therefore as a minimum, the pH of the waste material should be above 4 prior to landfill acceptance.

TABLE 8
LANDFILL DISPOSAL CRITERIA

All soil results expressed as milligrams per kilogram.
All TCLP results expressed as milligrams per litre.

CONTAMINANT	CLASS II		CLASS III		CLASS IV		CLASS V	
	SOIL	TCLP	SOIL	TCLP	SOIL	TCLP	SOIL	TCLP
HEAVY METALS								
Cadmium (Cd)	5	0.02	50	0.2	500	2	>500	>2
Chromium (Cr)	250	0.5	2500	5	25000	50	>25000	>50
Copper (Cu)	100	20	1000	200	10000	2000	>10000	>2000
Lead (Pb)	300	0.1	3000	1	30000	10	>30000	>10
Nickel (Ni)	100	0.2	1000	2	10000	20	>10000	>20
Zinc (Zn)	500	50	5000	500	50000	5000	>50000	>5000
HYDROCARBONS								
Volatile TPH (C_6-C_9)	100	NC	1000	NC	10000	NC	>10000	NC
Semi-volatile TPH (C_{10}+)	1000	NC	10000	NC	100000	NC	>100000	NC
Benzene	NC	0.01	NC	0.1	NC	1	NC	>1
Total PAH	20	NC	200	NC	2000	NC	>2000	NC
Benzo(a)pyrene	NC	0.0001	NC	0.001	NC	0.01	NC	>0.01
Total Phenols	1	NC	10	NC	100	NC	>100	NC
OTHER								
PCB	<2	NC	<50	NC	<50	NC	>50	NC

3.6 LIQUID WASTE DISPOSAL CRITERIA

The Forrestdale Liquid Waste Treatment Facility accepts certain liquid wastes for treatment and disposal. The facility is licensed to receive liquid wastes from industry and commercial premises.

The facility cannot accept the following:

- chlorinated organics;
- ancillary organics such as aromatics, esters, nitriles, ethers, isocyanates, nitrophenols, halogenated hydrocarbons and nitroso amines;
- radioactive;
- flammables;
- explosives; and
- liquids with a pH <2 or >12.5 or excessive concentrations of cyanide (>5 mg/l) and hexavalent chromium (>100 mg/l).

In terms of the Omex liquid waste, only the criteria related to pH is applicable as the waste is principally oil and acidic water with relatively low levels of heavy metals. A full characterisation of the oil and liquid component of the Omex waste is presented in Section 4.2.

SECTION 4
NATURE AND EXTENT OF CONTAMINATION

4.1 INTRODUCTION

This section sets out the nature and extent of contamination that has been identified as part of this assessment in association with the Omex waste pits. Section 4.2 describes the waste pits in detail which are identified as:

- the Major Pit containing acidic oil sludges to an approximate depth of 7 m; and
- the Minor Pit No.1 containing acidic oil sludges to an approximate depth of 2 m.

Separate from the pits, waste oil sludge from the Omex site has been inappropriately disposed of at:

- the Adelaide Street Landfill facility.

In addition to the oil sludge, there is contaminated soil which is detailed in Section 4.3. This includes soil contaminated by:

- seepage from the Major Pit into the surrounding soil;
- surface overflows from the Major Pit onto adjoining ground;
- movement of waste into drainage channels leading from the Major Pit; and
- seepage from the Minor Pit No.1 into the surrounding soil.

Soil contamination also exists on-site due to past processing activities associated with the Omex operations:

- the oil re-refinery site; and
- the oil redrumming facility.

An abandoned clay pit adjacent to the Omex site within the Sporting Club property was used for the disposal of plaster waste and sewage sludge which is identified as Minor Pit No.3.

Investigations have also identified soil contamination associated with the operation of the adjacent service station:

- in a open sump known as Minor Pit No.2; and
- in surface soils near the diesel storage tanks and dispenser.

TABLE 5
SOIL CRITERIA

All results expressed as milligrams per kilogram.

CONTAMINANT	ANZECC B GUIDELINES	DUTCH B CRITERIA	HEALTH-BASED SOIL INVESTIGATION LEVEL	DUTCH C CRITERIA	DUTCH INTERVENTION CRITERIA	PROPOSED HRA BASED RESPONSE LEVELS
	INVESTIGATION LEVELS			ACTION LEVEL		
	ENVIRONMENTAL		HEALTH			
HEAVY METALS						
Cadmium (Cd)	3	5	*20*	20	12	**20**
Chromium (Cr^{3+})	50	250	*12%*	800	380	**12%**
Copper (Cu)	60	100	*1000*	500	190	**1000**
Lead (Pb)	300	150	*300*	600	530	**300**
Nickel (Ni)	60	100	*600*	500	210	**600**
Zinc (Zn)	200	500	*7000*	3000	720	**7000**
HYDROCARBONS						
Volatile (C_6-C_9)	NC	100	65	500	NC	**65**
Semi-volatile (C_{10}+)	NC	1000	*1000*	5000	NC	**1000**
Benzene	1	0.5	*1*	5	1	**1**
Ethylbenzene	NC	5	*50*	50	50	**50**
Toluene	NC	3	*130*	30	130	**130**
Xylenes	NC	5	*25*	50	25	**25**
Total PAH	NC	20	*20*	200	40	**20**
Benzo(a)pyrene	NC	1	*1*	10	NC	
Total Phenols	NC	1	*8500*	10	40	
OTHERS						
Sulphate (SO_4)	2000	NC	*NC*	NC	*NC*	**2000**
Soil Acidity (pH)	NC	NC	*NC*	NC	*NC*	**<5-9>**

Note : NC = No criteria applicable

TABLE 6
GROUNDWATER CONTAMINATION
ASSESSMENT CRITERIA

All levels expressed as micrograms per litre.

CONTAMINANT	AWQ / DRAFT WAWQ RAW WATER GUIDELINES	DUTCH B CRITERIA
	MAXIMUM LEVEL	
HEAVY METALS		
Arsenic (As)	50	30
Cadmium (Cd)	5	2.5
Chromium (Cr)	50	50
Copper (Cu)	1000	50
Lead (Pb)	50	50
Nickel (Ni)	100/20[2*]	50
Zinc (Zn)	5000	200
HYDROCARBONS		
Total (TPH)	NC	600[1]
Volatile (C_6-C_9)	NC	40
Semi-volatile (C_{10}+)	NC	200
Benzene	10	1
Ethylbenzene	300[2]	20
Toluene	800[2]	15
Xylenes	600[2]	20
Total PAH	NC	10
Benzo(a)pyrene	0.01	0.2
Total Phenols	2	15
OTHERS		
PCB	0.1	0.2
Sulphate (SO_4)	400000	NC
pH	6.5-8.5	NC

Notes 1 Dutch Intervention Criteria

2 NHMRC/ARMCANZ Australian Drinking Water Guidelines

* More stringent value used in groundwater computer model to ensure no possible exposure to values above WAWQ raw water guidelines.

As discussed in Section 2.4, the site is underlain by the Guildford Clay and the Leederville Formation. Section 4.4 describes the groundwater contamination in the aquifers associated with these formations in the vicinity of the Omex site. In addition, predictions are made to the fate of the contaminated groundwater after the source of contamination has been removed.

The other potential source of contamination is from airborne emissions from the contaminated wastes contained within the oil sludge pits. Both environmental investigations and laboratory testing has been undertaken on the waste to assess the likely levels of air emissions once the waste is uncovered. The potential airborne contaminants are discussed in Section 4.5.

Section 4.6 summarises the Omex-related contamination in terms of waste, soil and groundwater contamination and airborne emissions.

4.2 WASTE OIL PITS

As discussed previously in Section 2.2 there are two significant pits containing waste material on the Omex site: the Major Pit and Minor Pit No.1. Their locations are shown on Figure 3.

4.2.1 Major Pit

In 1989, Sinclair Knight and Partners undertook investigations to define the boundary of the major pit. This was performed by test pitting at 27 locations to a depth of 2 m. The boundary of the pit was defined as equivalent to that shown on a 1963 aerial photograph. The slope of the pit sides was estimated at 70 degrees.

In order to better assess the dimensions of the major pit, a comprehensive geotechnical investigation was undertaken in April 1998 (CMPS&F, 1998a) which involved the use of a cone penetrometer to define the depth of the base and side slopes of major pit. Based on all investigations to date, the dimensions of the major pit are set out in Table 9:

TABLE 9
DIMENSIONS OF MAJOR PIT

DIMENSION	m.
Maximum Length	70
Maximum Width	40
Area	2,000m^2
Maximum Depth	9.2
Average Depth of Pit Base	7.3
Estimated Volume	14,600m^3
Installed Sand Cover	2,000m^3

Three monitoring bores have been installed within the major pit. One was installed as part of the 1995 GSWA investigations and two recently with the containment wall design investigation work (CMPS&F, 1998a).

Both the 1995 and 1998 investigations indicated that the contents of the pit contained oil sludges and fill material consisting of sand and rubble. The liquid content of the pit consisted of both waste oil and contaminated groundwater. Solid waste samples were recovered from the entire pit profile and from the natural clayey sand and sands at the base of the pit.

Estimated quantities of liquid and solid waste present within the major pit are shown in Table 10:

TABLE 10
CONTENTS OF MAJOR PIT

VOLUME		m^3
Solid Waste		13,100
Rubble		1,500
Soil Trim		1,400
Sand Cover	50% contaminated	1,000
Liquid Waste	total	4,400
	Up to 30% recoverable	1,300

Soil trim refers to the natural soil from the wall of the pit which happens to be removed in the process of excavating the pit. The soil trim in the top 3.5 m is included in the contaminated soil calculations presented in Section 4.2.

The chemical nature of the waste material including the liquids is :

- Acidic sludge and fill material with a low pH around 2, containing elevated levels of heavy fraction hydrocarbons including PAHs and heavy metals, in particular lead.
- Viscous heavy fraction oil containing petroleum compounds, PAHs, phenols and some minor levels of heavy metals, in particular lead.
- Acidic groundwater with a pH of 1, containing elevated levels of heavy fraction hydrocarbons, PAHs, phenols and heavy metals; in particular cadmium, chromium, lead, molybdenum and zinc.

A comparison of the solid waste materials found within the Major Pit is provided as Table 11 with the liquid waste on Table 12. Table 11 also compares the materials found in the major pit with landfill waste acceptance criteria. The three solid waste samples represent composites taken at three different locations over the entire contaminated profile of the pit. The liquid waste was recovered from one of the bores as part of the 1996 Golder investigations. The dimensions of the major and minor pit No. 1 are shown on a cross sectional view as Figures 6A and 6B respectively.

4.2.2 Minor Pit No.1

The dimensions of Pit No.1 were assessed during the 1995 investigation (GSWA, 1995) and are based on aerial photograph interpretation and drilling observations. This minor pit is shallow with 0.5 m cover of sand fill, an overall depth of 2 m and area of 280 m^2. The volume of waste oil and cover material is estimated to be 500 m^3. The contamination status of the cover is not known, however given the time it has been in place it is very likely to be contaminated. There is contaminated soil outside of the pit, this is discussed in Section 4.3.4.

One bore was installed through the middle of the pit to a depth of 12 m to test the quality of the underlying soil and groundwater. Visual observations suggested that the waste contents within Pit No. 1 are similar to what is found in the major pit. The waste material does not contain any free liquids/oil and rubble type material. Approximately 500 m^3 of waste material from this pit is expected to be disposed to landfill.

4.2.3 Adelaide Street Landfill

Approximately 1,000 m^3 of oil sludge wastes were disposed to the Adelaide Street landfill facility in 1989. The Omex waste material taken to the Adelaide Street landfill is believed to have been disposed at two locations at the eastern part of the landfill and is now covered with an estimated 6 m cover of landfill. The exact location is not known but is believed to occur within a total area of 8,500 m^2 which is underlain by clayey soils (D&M, 1992). The landfill operator believes the waste will be able to be located initially by odour and subsequently visual. No testing has been performed to characterise the nature of the waste material.

The landfill operator has a licence to recover and recycle the rubble component of the wastes above the Omex waste in the landfill, which is expected to be completed in two years time (pers com Kevin Pollack, Westgroup) and work on removing this material can then be undertaken under a separate contract. Once the cover of landfill has been sufficiently reduced, site investigations will be undertaken to accurately locate and characterise this waste material.

Although there has been no sampling of the waste contents disposed within the Adelaide Street landfill, the contaminant characteristics are expected to be similar to those observed in the major pit. Anecdotal accounts describe the waste as consisting of a sludge type physical structure (D&M, 1992). Approximately 1,000 m^3 of oil wastes from the landfill will need to be recovered and treated prior to appropriate disposal. The general location of the Adelaide Street landfill facility is shown on Figure 2-Site Locality.

TABLE 11
CHARACTERISTICS OF OMEX SOLID WASTE

All soil results expressed as milligrams per kilogram.
All TCLP results expressed as milligrams per litre.

CONTAMINANT	CLASS II LANDFILL		CLASS III LANDFILL		CLASS IV LANDFILL		CLASS V LANDFILL		SAMPLE CM A Northern End			SAMPLE CM B Southern End			SAMPLE OM 2 Centre
	SOIL	TCLP	SOIL	TCLP	SOIL	TCLP	SOIL	TCLP	SOIL	TCLP	TCLP*	SOIL	TCLP	TCLP*	SOIL
HEAVY METALS															
Arsenic (As)	30	0.07	300	0.7	3000	7	>3000	>7	1	0.02	0.02	1	<0.01	<0.01	#
Cadmium (Cd)	5	0.02	50	0.2	500	2	>500	>2	<0.1	<0.002	<0.002	<0.1	<0.002	<0.002	1.1
Chromium (Cr)	250	0.5	2500	5	25000	50	>25000	>50	36	**1.4**	<0.01	13	**0.77**	0.04	52
Copper (Cu)	100	20	1000	200	10000	2000	>10000	>2000	7	0.04	0.02	22	0.15	0.01	110
Lead (Pb)	300	0.1	3000	1	30000	10	>30000	>10	190	**0.60**	**0.13**	**1200**	**2.8**	**2.3**	**1200**
Mercury (Hg)	2	0.01	20	0.1	200	1	>200	>1	<0.02	<0.0002	<0.0002	<0.02	<0.0002	<0.0002	NT
Nickel (Ni)	100	0.2	1000	2	10000	20	>10000	>20	4	0.13	<0.01	2	0.06	<0.01	21
Zinc (Zn)	500	50	5000	500	50000	5000	>50000	>5000	420	17	0.56	170	9.4	1.7	**690**
HYDROCARBONS															
Volatile TPH (C_6-C_9)	100	NC	1000	NC	10000	NC	>10000	NC	14	NT	NT	79	NT	NT	NT
Semi-volatile TPH (C_{10}+)	1000	NC	10000	NC	100000	NC	>100000	NC	1100	NT	NT	**9400**	NT	NT	#
Benzene	NC	0.01	NC	0.1	NC	1	NC	>1	0.24	0.004	0.002	2.5	**0.025**	0.007	NT
Total PAH	20	NC	200	NC	2000	NC	>2000	NC	18	NT	NT	**45.8**	NT	NT	#
Benzo(a)pyrene	NC	0.0001	NC	0.001	NC	0.01	NC	>0.01	0.8	<0.0001	<0.0001	1.6	<0.0001	<0.0001	NT
Total Phenols	1	NC	10	NC	100	NC	>100	NC	<0.2	NT	NT	**1.6**	NT	NT	NT
OTHERS															
PCB	<2	NC	<50	NC	<50	NC	>50	NC	NT	NT	NT	NT	NT	NT	<0.1

NOTES
* - Lime Treated Sample
# - Validity of Results Uncertain
NC-No Criteria Established
NT-Not Tested for.

99	Bold indicates suitable for disposal to Class III Landfill
99	Shading and bold indicates suitable for Disposal to Class IV Landfill

TABLE 12
CHARACTERISTICS OF OMEX LIQUID WASTE

All oil results expressed as milligrams per kilogram.
All water results expressed as micrograms per litre.

	WATER SAMPLE base of monitor bore OM2	OIL SAMPLE top of monitor bore OM2	OIL SAMPLE base of monitor bore OM2	LIQUID WASTE DISPOSAL CRITERIA
HEAVY METALS				
Aluminium, Al	8,000	270	320	NC
Arsenic, As	0.030	<10	<10	NC
Boron, B	8	0.5	0.8	NC
Barium, Ba	0.5	19	16	NC
Cadmium, Cd	0.2	0.1	0.2	NC
Calcium	500	16	32	NC
Chromium, Cr	20	10	8.7	100,000*
Copper, Cu	2	5.0	6.8	NC
Iron, Fe	6,700	84	190	NC
Lead, Pb	8.3	520	730	NC
Magnesium	800	7	24	NC
Manganese	22	0.6	1.1	NC
Mercury	<0.005	n/a	n/a	NC
Molybdenum	3.6	1.6	1.9	NC
Nickel, Ni	5	0.3	0.4	NC
Potassium, K	98	2	4	NC
Sodium, Na	690	20	15	NC
Tin, Sn	0.04	11	10	NC
Vanadium, V	11	1.9	1.6	NC
Zinc, Zn	440	3.3	14	NC
HYDROCARBONS				
PAH, total	281	1.790	1,370	NC
Aliphatic, hydrocarbons	5,560	23,300	23,600	CNA
Complex hydrocarbons	14,000	740,000	680,000	NC
BTEX, total	110	1,500	2,900	CNA
Benzene	11	36	62	CNA
Toluene	32	220	440	CNA
Ethylbenzene	<1	190	350	CNA
Xylene	71	1,100	2,000	CNA
Phenols, total	5,200	85	100	CNA

TABLE 12 Continued

	WATER SAMPLE base of monitor bore OM2	OIL SAMPLE top of monitor bore OM2	OIL SAMPLE base of monitor bore OM2	LIQUID WASTE DISPOSAL CRITERIA
OTHERS				
Sulphur, S	22,000	18,900	18,800	NC
Cyanide, total	<0.05	<2.0	<2.0	5,000
PCB, total	<0.2	<1	<1	CNA
OCs, total	<0.2	<1	<1	CNA
OPs, total	<2	<2	<1	CNA
Other tests – various units				
pH	1.0	4.0	5.0	2 – 12.5
Conductivity, mS/m	6,630	NA	NA	NC
Total Dissolved Solids, mg/l	87,000	NA	NA	NC
SG at 20°C	NA	0.9083	0.9138	NC
Density, kg/L at 20°C	NA	0.9067	0.9122	NC
Viscosity, cSt at 20°C	NA	441	479	NC
Flash Point, closed cup, °C	NA	>100	>100	Not Flammable

NOTES
- * as hexavalent chromium.
- CNA Concentrate Not Acceptable
- NA Not Applicable
- NC No Criteria

CNA refers to concentrated or full strength chemicals as distinct from trace or parts per million levels.

4.3 SOIL CONTAMINATION

Soil contamination associated with the waste oil re-refining and oil product storage (redrumming) operations has been the subject of three major recent investigations in 1995, 1996 and 1998 (GSWA 1995, Golder 1997 and CMPS&F 1998a &1998b) and some minor earlier assessment work (SK 1989, D&M 1990 & CCWA 1994). The 1989 to 1993 investigations focused on the major pit and Lots 51 and 52 Henkin St. The 1995 and 1996 investigations concentrated on defining the extent of contamination associated with the waste pits, drains and any spillage onto surrounding lands. The 1998 investigations included further characterisation of the contents of the major pit, the quality of the spoil from the proposed containment wall, excavation process and the status of the soil beneath the redrumming facility.

The following is an outline of the soil contamination associated with the Omex site. It is based on the specific findings and assessments made from the information gained from all the investigation work performed to date. The estimated extent of soil contamination is shown on Figure 7. Table 13 provides a volume estimate of the quantity of contaminated soil above the proposed response levels to 3.5 m depth which are nominated in Table 2 - Section 3.3.1. It should be noted that the soil contamination represents impact due to the Omex waste material. The level of contamination found in the soil does not represent the same level of contamination found in the Omex waste material.

TABLE 13
CONTAMINATED SOIL VOLUMES

LOCATION	AREA m^2	CLEAN-UP VOLUME m^3
Surrounding Major pit	1,000 to 2,000	3,500 to 7,000
Surface Spillage from Major pit	700	270
Drains - to Pit No.3	40	20
- north of Major pit	20	<10
Minor Pit No.1	700	1,800
Oil Re-refinery	1,200	3,000
Oil Redrumming Facility	100	500
Adelaide Street Landfill	8,500	1000
APPROXIMATE TOTAL	12,000-13,000	10,000-13,500

Note : A number of contaminated areas overlap which have not been separated in the area calculations. Does not include waste content of pits.

The following sections describe in detail the level and extent of contamination detected in the particular areas and provide the rationale to the volumes nominated. The criteria used to assess contamination is based on the investigation levels nominated on Table 5 which are generally ANZECC B Guidelines and Dutch B for hydrocarbons.

4.3.1 Seepage from Major Pit

The natural soils at the base of the pit at approximately 7 m below ground level contain elevated levels of PAHs only, at 23 times the ANZECC HIL Guideline (GSWA, 1995).

Wastes in the pit have laterally impacted on the soil in the pit wall. Shallow testing performed along the pit boundary (<2.5 m distance from the pit wall) at three locations to depths of 1.5 m to 2 m indicated weak acidity (5-6) and levels of heavy metals and heavy fraction hydrocarbons at concentrations below ANZECC B and Dutch B criteria (SK, 1989).

Soil tested over the depth of the pit and in close proximity to the walls (at a typical distance of 5 m), indicated respective levels of PAHs and heavy fraction hydrocarbons up to 12 and 5 times the ANZECC B/Dutch B criteria. Sampling at more distant locations up to 20 m from the edge of the pit indicated no contamination (GSWA, 1995 & Golder, 1997).

As part of the containment barrier design, a number of soil bores were installed generally within 5 m of the pit boundary to the base of the Upper Leederville Formation (ULF). Logging of these bores indicated soil contamination in definite bands related to the more permeable sections of the soil profile. The surficial clays tended to be free of visible contamination. This layered sequence of contamination extended to the base of the ULF in areas along the south west boundary of the pit (CMPS&F, 1998a).

Sampling performed 15 m downgradient of the major pit indicated trace levels of heavy fraction hydrocarbons to a depth of at least 2.5 m. Drilling logs indicate oil staining along fissures to a depth of 4 m. This contamination could be associated with either seepage from the major pit, undocumented surface flows of oil waste from the major pit or from oil storage areas near the demolished oil re-refinery. There exists a high potential for soil contamination above the environmental investigation level for this area (approximately 150m^2).

Based on the low permeability of the surficial clays and field observations, the lateral extent of soil contamination from the pit boundary is considered to be in the order of 5 m on the upgradient side of the pit to 10 m on the downgradient side. Therefore a preliminary estimate of between 3,500 m^3 to 7,000 m^3 of soil immediately adjacent to the major pit is potentially impacted with contamination which exceeds the proposed response level. It should be noted that this area of contamination is made up of thin layers of contaminated soil interspersed within the relatively uncontaminated bulk of the soil profile.

The assessment of contamination surrounding the major pit has been based on:

- 1989: three test pits to 2 m. All were tested for heavy metals, pH and hydrocarbons.
- 1995: five soil bores to 12 m. All were tested for heavy metals, sulphur, hydrocarbons including PAHs, and PCBs.
- 1996: four soil bores with three shallow to 12 m and one deeper to 30 m. All were tested for heavy metals, pH, sulphur, hydrocarbons including PAHs, phenols and BTEX.
- 1998: seven deep soil bores to 30 m. Visual characterisation performed.

4.3.2 Surface Spillage from Major Pit

Surface flows of waste oil from the major pit impacted adjoining Lots 51 and 52 Henkin Street in late 1988. Investigations performed in 1993 and 1997 indicated contaminated surface fill and an infilled seepage trench of oil waste material on the central portion of Lot 51 Henkin St.

Soil fill from the Omex site was used to cover the natural soil surface on Lots 51 and 52 following the major waste oil flow event from the major pit in 1988/89. The waste oil was partly removed and then covered with a 0.15 m to 0.2 m layer of fill. This fill was tested only for pH and heavy metals and was found to be mildly acidic (pH 3-6) with elevated concentrations of lead at up to 6 times ANZECC B Guidelines (CCWA, 1994). The areal extent of the fill is estimated at less than 700 m^2 resulting in a volume estimate of 150 m^3 of material above the proposed response level.

The seepage trenches were most likely excavated to help contain the flow from the major pit. The dimensions of the southern seepage trench are estimated at 3.5 m by 15 m by 1.6 m deep, based on test pitting and the 1989 aerial photograph. The trench is covered with a 0.2 m to 0.4 m layer of fill (Golder, 1997). The northern trench is estimated to be about half the size of the southern trench based on aerial photographs. The total volume of material above the proposed clean-up criteria is estimated at 120 m^3.

The waste material contained within the trenches exhibits contaminant characteristics similar to the contents of the major pit. The material is 16% heavy fraction hydrocarbon by dry weight and contains levels of PAHs, volatile hydrocarbons (BTEX), phenols, sulphur and the heavy metals; lead and zinc above ANZECC B/Dutch B criteria (Golder, 1997). Testing performed as part of the 1993 investigation also confirmed the contaminated nature of the material with lead levels up to 4 times ANZECC B Guidelines (CCWA, 1994). The concentrated nature of the material would require disposal to landfill.

The contamination status of the fill overlying the seepage trenches is considered low with levels of hydrocarbons and heavy metals below ANZECC B/Dutch B criteria (Golder, 1997). However, the testing performed in 1993 on the surface fill material indicates elevated lead concentrations above ANZECC B Guidelines in two out of seven samples (CCWA, 1994). The fill appears to contain 'hot spots' of lead contamination, therefore the entire fill is considered to be potentially impacted.

The assessment of contamination associated with surface spillage from the major pit has been based on:

- 1993: eight shallow soil bores up to 1 m. All were tested for heavy metals and pH.
- 1996: two soil bores to 11 m and two test pits up to 40 m in lateral distance and 1.6 m depth. All were tested for heavy metals, pH, sulphur, hydrocarbons including PAHs, phenols and BTEX.

4.3.3 Abandoned Drainage Channels

Test pitting of the two known open drains (the drain connecting the major pit with Pit No.3 and the northern drain from the major pit) revealed the presence of contamination associated with the waste contents of the major pit (Golder, 1997).

The infilled drain connecting with Pit No.3 has a cover of clean fill with a layer of oil and plaster wastes encountered at depths ranging between 0.5 m and 2 m below ground level. The extent of the waste layer is approximately 0.2 m to 0.6 m in thickness with an average width of 2 m. The length of the drain is of the order of 20 m. Therefore approximately 20 m^3 of material above the proposed response level occurs within this drain. That part of the drain which is within the 5 m contaminated buffer surrounding the major pit has been excluded from the calculations. Contaminated fill and oil staining of the natural ground extends a short distance, about 5 m, on to Lot 130 and is currently covered by about 2 m of clean sand fill.

The waste material contains elevated levels of heavy fraction hydrocarbons (85 times), phenols (27 times), sulphur (37 times) and lead (2 times) above ANZECC B/Dutch B criteria. The concentrated nature of the material would require disposal to landfill.

The natural soil surrounding the drain contents contains levels of hydrocarbons and heavy metals below ANZECC B/Dutch B criteria. Concentrations of sulphur are above ANZECC B Guidelines but are not considered to be a human health issue. The contamination status of the fill overlying the drain is not known but is considered to be low based on visual observations.

The infilled drain north of the major pit has a cover of clean fill with a layer of lightly contaminated sediments at 0.5 m to 0.9 m below ground level. The contamination status of this material is considered low with levels of heavy metals below ANZECC B Guidelines. The likely volume of material above the proposed clean-up criteria within this drain is <10 m^3 based on 0.4 m depth by 1 m width, over a distance of 20 m as per the Pit No.3 drain. That part of the drain which is within the 5 m contaminated buffer surrounding the major pit has been excluded from the calculations.

Contaminant concentrations in the surrounding soil are very low with only elevated levels of phenols at 2 times Dutch B criteria in an existing surface drain, and some heavy fraction hydrocarbons below criteria in the surface fill adjacent to the western boundary fence of Lot 61 Purton Pl.

The assessment of contamination associated with the abandoned drains has been based on:

- 1996: three test pits up to 19 m in lateral distance and 2.3 m depth. All were tested for heavy metals, pH, sulphur, hydrocarbons including PAHs, phenols and BTEX.

4.3.4 Seepage from Minor Pit No.1

The vertical extent of soil contamination beneath this pit extends to a depth of 12 m where levels of PAHs exceed ANZECC HIL Guidelines by 7 times at 4-7 m and 10 times at 9-12 m (GSWA, 1995). The extent of contamination is expected to be similar to the major pit with definite bands of contamination related to the more permeable sections of the soil profile and with a lateral penetration of 5 m.

As the pit is within 5 m of the major pit, the resulting volume estimate is based on soil contamination beneath the pit and on three boundaries. Therefore approximately 1,800 m^3 of soil is potentially affected with levels above the proposed response level to a depth of 3.5 m. The contents of the pit are described along with the major pit in Section 4.1.

The assessment of contamination associated with minor pit No.1 has been based on:

- 1995: one soil bore to 12 m. Tested for heavy metals, sulphur, hydrocarbons including PAHs, and PCBs.

4.3.5 Oil Re-Refinery Site

Investigations have been conducted on two occasions beneath the demolished oil re-refinery (GSWA, 1995 & CMPS&F, 1998b).

The 1995 investigation was undertaken at depth (4-12 m) beneath the western wing of the refinery where concentrations of PAHs exceed the ANZECC HIL Guidelines by 14 times at 4-7 m and 12 times at 9-12 m. It is unclear whether this contamination is associated with lateral movement from the major pit or direct surface spillage from the refinery.

The 1998 investigation concentrated on the shallow soils (<2.5 m) at the eastern section of the refinery well outside the limit of potential contaminant migration from the major pit. Soil contamination in the form of elevated levels of heavy fraction hydrocarbons up to 22% by dry weight at 0.8 m declining to 3 times and 1.5 times the Dutch B criteria at 1.5 m and 2.5 m respectively. Concentrations of lead ranged up to 31 times ANZECC B Guidelines at 0.5 m reducing to trace levels at 1.5 m. PAH and phenol concentrations were generally low with maximum surficial (<1 m) levels 3 times respective ANZECC HIL and B Guidelines for both contaminants.

The extent of surficial contamination above the proposed response level is estimated at 1,500 m^3 for the eastern section and most likely similar for the western section resulting in a total of 3,000 m^3.

The extent of contamination detected at depth (>4 m) beneath the western part of the refinery site is most likely associated with contaminant migration from the major pit, a distance of some 8 m from the wall of the pit.

The assessment of contamination associated with the oil re-refinery has been based on:

- 1995: one soil bore to 12 m. Tested for heavy metals, sulphur, hydrocarbons including PAHs, and PCBs.
- 1998b: eleven shallow soil bores up to 2.5 m depth. All were tested for a combination of heavy metals, and hydrocarbons including PAHs and phenols.

4.3.6 Oil Redrumming Facility

Contamination was detected along the western boundary with the warehouse and bunded oil storage compound to a depth of 5 m below ground level. Heavy fraction hydrocarbons ranged from 46 times Dutch B criteria at 0.5 m to 33 times the criteria at 2 m. The volume of contamination of material above the proposed response level within Lot 57 Clayton St is estimated at 250 m^3 (CMPS&F, 1998b). The extent of contamination onto adjoining Lots 54 and 55 Henkin St. has not been determined but is expected to be similar to what has been detected. Therefore a total of some 500 m^3 of soil has been impacted from the operations of the redrumming facility.

Testing performed 12 m west of the redrumming facility on Lot 54 Henkin St indicated some low levels of PAHs at 2 times ANZECC HIL Guidelines at 5-8 m (GSWA, 1995). This contamination is most likely associated with groundwater contamination from the oil storage area and/or major pit.

The contamination status of the soil beneath the actual redrumming facility and bunded oil storage area is considered low as only trace levels of hydrocarbons and heavy metals were detected to a depth of 2 m.

The assessment of contamination associated with the oil redrumming facility has been based on:

- 1998b: eleven shallow soil bores up to 2 m. All were tested for a combination of heavy metals, and hydrocarbons including PAHs and phenols.

4.3.7 Minor Pit No. 3

Three soil bores have been installed through the contents of the pit to a depth of 12.5 m (Golder, 1997 & CMPS&F, 1998a). The pit contains plaster wastes to a depth of approximately 7 m where sewage sludge residues were encountered. The chemical characteristics of the plaster waste are high concentrations of sulphate, trace levels of heavy metals, hydrocarbons and phenols. The material is neutral in terms of acidity.

The sewage material has a neutral pH and contains elevated levels of zinc at 3 times ANZECC B Guidelines (Golder, 1997). This is as expected as sewage waste is known to contain elevated levels of heavy metals. The natural underlying soils show no evidence of contamination.

Shallow soil sampling was performed near the demolished plaster factory which is now part of the northwest bowling green. Elevated cadmium level between 5 and 25 times ANZECC B Guidelines were detected. This is most likely associated with a build up of contaminants from fertiliser application, or the cadmium was already present in the fill used to construct the bowling green. It should be noted that significant levels of cadmium are not found in the solid component of Omex oil wastes. The investigations do not indicate any Omex - related contamination.

The assessment of contamination associated with the plaster waste Pit No.3 has been based on:

- 1996: four soil bores, three shallow to 1 m and one to 12.5 m. Three of the bores were tested for heavy metals, pH, sulphur, hydrocarbons including PAHs, phenols and BTEX.
- 1998b: two soil bores up to 6.5 m. All were tested for lead, pH and hydrocarbons including PAHs and phenols.

4.3.8 Minor Pit No.2

A soil bore was installed downgradient and immediately adjacent to the pit. Elevated levels of heavy fraction hydrocarbons were detected in the top metre at 2 times Dutch B criteria. Hydrocarbon impact extends to 5 m depth but at concentrations below the criteria. Heavy metal and sulphate concentrations were below ANZECC B Guidelines (Golder, 1997). The lateral extent of contamination is expected to be minimal with an estimate volume of 100 m^3. The contamination is associated with fuel spillage probably from the nearby drum store and not the oil wastes from the Omex site. Therefore this contamination is excluded from the proposed Omex site rehabilitation project but should be addressed by the property owners.

A sediment sample (0.5 -1 m) was recovered from the open pit which was found to contain levels of semi-volatile hydrocarbons, phenols and lead below ANZECCB/Dutch B criteria (CMPS&F, 1998a).

The assessment of contamination associated with the minor Pit No.2 has been based on:

- 1996: one soil bore to 12.5 m. Tested for heavy metals, pH, sulphur, hydrocarbons including PAHs, phenols and BTEX.
- 1998b: one soil bores to 1 m. Tested for lead, pH and hydrocarbons including PAHs and phenols.

4.3.9 Fuel Storage Tanks and Dispenser

Surface soil contamination was detected 5 m north of the bunded compound near a fuel loading point. The top metre is contaminated with heavy fraction hydrocarbons at 8 times Dutch B criteria. Contaminant levels decline to levels below criteria at 3 m (Golder, 1997). The extent of contamination is considered minor and occupies no more than 50 m^2 resulting in a volume estimate of 150 m^3. This contamination is associated with refuelling activities at the petrol station site. Therefore this contamination is excluded from the proposed Omex site rehabilitation project but should be addressed by the property owners.

The two diesel dispensers are located on Lot 58 Clayton St. Two soil sample locations within close proximity exhibited levels of hydrocarbons below Dutch B criteria.

The assessment of contamination associated with the refuelling infrastructure has been based on:

- 1996: one soil bore to 12 m. Tested for heavy metals, pH, sulphur, hydrocarbons including PAHs, phenols and BTEX.
- 1998b: one soil bores to 1 m. Tested for hydrocarbons including PAHs and phenols.

4.4 GROUNDWATER CONTAMINATION

Groundwater contamination associated with the waste oil re-refining and oil product storage (redrumming) operations has been the subject of two comprehensive investigations in 1995 and 1996 (GSWA 1995 & Golder 1997). These investigations included the superficial unconfined aquifer Guildford Clay and the underlying Leederville confined aquifer. Investigations associated with the containment wall design (CMPS&F, 1998a) included the installation of three monitor bores adjacent to the major pit and within the Leederville aquifer. Extensive off-site groundwater monitoring of the upper part of the confined aquifer was undertaken in mid 1998 (CMPS&F, 1998c).

The following is an outline of the testing undertaken and groundwater contamination identified in the vicinity of the Omex site. It is based on the specific findings and assessments made from the information gained from all the investigation work performed to date. The extent of groundwater contamination is shown on Figure 8. The contamination is defined as elevated levels of contaminants which preclude its use as a resource for either potable or irrigation supplies. The assessment criteria applicable to the contaminants found on-site are presented on Table 6 in Section 3.3.

The following sections describe in detail the level and extent of contamination detected in both the Guildford Clay and Leederville Formation aquifers.

4.4.1 Guildford Clay

The Guildford Clay consist of a layered, interfingered, sequence of sand, clay beds and sandy clay beds which are not isolated from each other. The physical structure of this aquifer adds complexity to the interpretation of groundwater flow, and of a consequence, any contaminant transport. Groundwater flow is in a west southwesterly direction.

Upgradient of Major Pit

Upgradient of the sources of contamination, groundwater contains elevated levels of sulphate, some of which may be attributable to elevated natural levels and the disposal of plaster waste in Pit No.3. These 'background levels' are up to 2 times the raw water drinking guidelines. The pH of the groundwater is almost neutral with a value around 6. Low levels of phenols between 2 and 6 times the raw water guidelines were also detected. Heavy metal concentrations are at trace levels (Golder, 1997).

Adjacent to Major pit

Groundwater adjacent to the major pit contains elevated levels of hydrocarbons including polcyclic aromatic hydrocarbons and phenols. Concentrations of volatile and heavy fraction hydrocarbons exceed Dutch Intervention criteria (no raw water guidelines) by up to 40 times (Golder, 1997). PAH and sulphate levels are above relevant criteria by up to 6 and 32 times respectively (GSWA, 1995). Golder (1997) advised that water samples tested for PAHs and heavy metals in 1995 contained high sediment loads which may have overestimated concentrations. Testing in 1996 confirmed heavy metal concentrations at trace levels.

Minor Pit No.1

Testing in 1995 indicated that the groundwater beneath Minor Pit No1 contained minor levels of PAHs and sulphate at 5 times the relevant criterion (GSWA, 1995). Golder(1997) outlined that the high sediment loads in the 1995 samples may have led to overestimated concentrations. Given this and the elevated background levels of sulphate, it appears that there is minimal Omex-related groundwater contamination beneath Minor Pit No.1.

1988/89 Surface Spill

Monitoring of the groundwater beneath the area of the 1988 surface spillage and subsequent containment within two separate trenches show no evidence of significant contamination. However, elevated concentrations of phenols and sulphate at 12 and 4 times the raw water guidelines were detected (Golder, 1997). The contamination is not considered significant as it is twice the background levels for these compounds.

Oil Re-refinery Site

Groundwater quality beneath the western part of the oil re-refinery building contains trace levels of hydrocarbons, significant heavy metal and sulphate concentrations, and minor levels of PAHs up to 3 times relevant criterion (GSWA, 1995). As discussed previously, sampling procedures in 1995 may have overestimated metal concentrations, however the orders of magnitude observed still represent a significant contamination issue. Monitoring performed at the eastern end of the re-refinery showed elevated levels of phenols at 10 times the raw water guidelines or twice the background level (Golder, 1997). The observed groundwater contamination at the western part of the re-refinery is most likely associated with contaminant migration from the major pit.

Oil Redrumming Facility

Within 5 m of the oil storage area (35 m from the major pit), significant hydrocarbon contamination was detected in the groundwater at concentrations up to 80 times the Dutch Intervention criteria (no raw water guidelines). Sulphate levels were at 2 times the raw water guidelines.

Minor Pit No.3

The groundwater beneath the plaster waste pit contains sulphate and phenol levels at 4 and 6 times the raw water guidelines respectively (Golder, 1997). This is <u>not</u> associated with the operations of the Omex site.

Minor Pit No.2

The groundwater quality immediately downgradient of Minor Pit No.2 (< 3 m) contains elevated levels of heavy fraction hydrocarbons at 2 times Dutch Intervention criteria and and phenols at 10 times the raw water guidelines. Sulphate concentrations are at 2 times the raw water guidelines (Golder, 1997).

Off-Site

Groundwater quality downgradient of the site along the eastern side of Henkin St., a distance of between 55 m and 90 m from the major pit, shows no evidence of significant contamination with trace levels of heavy fraction hydrocarbons below Dutch Intervention criteria and minor concentrations of phenols up to 5 times raw water guidelines which is within the background levels. Sulphate concentrations are within the observed 'background levels' at 2 times the raw water guidelines (Golder, 1997).

The presence of hydrocarbons is most likely associated with surface spillage from the oil storage area as groundwater monitoring closer to the pit and upgradient of the oil storage area indicates no such contamination.

Conclusions

Based on the monitoring performed to date, the Guildford Clay aquifer shows little evidence of extensive or significant groundwater contamination due to Omex-related materials. The most significant groundwater contamination is associated within close proximity to the oil waste pits and the oil storage area. This is as expected due to the low permeability of the aquifer which has retarded the migration of contaminants from the various sources.

The elevated levels of phenols and sulphate detected at numerous locations cannot be attributed to the waste oil disposal. The presence of sulphate is due to a combination of sources; the plaster waste in Pit No.3, sulphuric acid from the waste oil pits and natural sources within the aquifer. The acidic liquid waste within the pit has increased the levels of sulphate with groundwater downgradibility up to 16 times the normal 'background concentrations' immediately upgradient of the pit. The natural phenol levels in the groundwater could be due to decomposition of soil organic matter and are as high as 6 times the raw water guidelines.

The most appropriate indicators of groundwater contamination migration from the Omex site in the Guildford Clay aquifer are a low pH and hydrocarbons including polcyclic aromatic hydrocarbons.

Contaminant migration in the Guildford Clays has been observed at a distance of 60 m downgradient from the nearest potential source of contamination being the oil storage area near the oil redrumming facility, or 90 m from the major pit.

4.4.2 Leederville Formation

The Leederville Formation underlying the Omex site is a multi-layered aquifer and consists of the Upper Leederville Formation (ULF) aquifer and the Lower Leederville Formation (LLF) aquifer (see Figure 4). The depth to the ULF is approximately 16 m below ground level with a thickness of 10 m of sand and minor clay. The LLF is separated from the ULF by about a 2 m thick layer of black clay.

The ULF aquifer is in direct hydraulic connection with the overlying Guildford Clay aquifer whereas the LLF aquifer is isolated by the low permeability sequence of clays, claystone and siltstone. Due to the direct hydraulic connection between the Guildford Clay and ULF, there is a real potential for contaminant migration of leachate principally from the major pit. However, the potential for contaminant migration from the ULF into the LLF is considered very low due to the impermeable nature of the clays separating the two sequences. Groundwater flow within a 0.5 km radius of the site is observed to be in a south westerly direction as compared to the westerly regional groundwater flow direction.

Upper Leederville Formation

Sixteen monitoring bores have been installed within the ULF as part of the 1995, 1996 and more recent 1998 containment wall design and off site groundwater investigations. Five bores are located around the perimeter of the major pit, one 35 m downgradient of the pit and ten off-site in both a westerly and southerly direction. One of the off-site monitor bores located at the corner of Helen and Henkin Streets was installed in the first sequence of the LLF sands below the clay base of the ULF.

The LLF monitor bore was installed adjacent to a contaminated bore in the overlying ULF and was found to contain no evidence of contamination (CMPS&F, 1998a).

Two of the monitor bores are on the upgradient side of the major pit at distances from 3 m to 10 m. Low levels of phenols were detected up to 3 times the raw water guidelines but within background levels. The pH of the groundwater is slightly acidic at 5.5, not atypical of uncontaminated groundwater. Trace levels of heavy metals were detected with sulphate concentrations between 15% and 50% of the raw water guidelines (Golder, 1997 & CMPS&F, 1998a). Groundwater at these locations is <u>not</u> considered to be affected by the Omex waste leachate.

Three monitoring bores are located on the downgradient side of the pit at distances of some 4 m to 8 m from the pit boundary. Concentrations of sulphate were up to 23 times the raw water guidelines. Elevated levels of heavy metals in particular chromium, nickel and zinc were observed in both bores up to 4 times the raw water guidelines. Concentrations of hydrocarbons exceeded Dutch Intervention criteria by up to 4 times. PAH concentrations were detected at trace levels below Dutch B criteria in only one bore. Phenols were not observed above the detection limit set at the raw water guidelines of 2 ug/l (GSWA, 1995; Golder, 1997 & CMPS&F, 1998a). Groundwater was acidic with a pH of 3.2.

A monitor well located 35 m downgradient of the major pit in a south westerly direction exhibited trace levels of heavy metals and heavy fraction hydrocarbons including PAHs below relevant criterion. Sulphate levels were at 20 times the raw water guidelines. Groundwater pH was acidic at a value of 3 (GSWA, 1995).

Three monitoring bores are located along the eastern boundary of Henkin Street at a distance of 55 m and 90 m downgradient of the major pit. Groundwater is acidic with a pH of 3 increasing to 5 at the most distant bore. Elevated levels of the heavy metals nickel and zinc up to 2 times the raw water guidelines were recorded. Concentrations of heavy fraction hydrocarbons exceeded Dutch Intervention criteria by up to 4 times. Respective phenol and sulphate levels were up to 14 and 7 times the raw water guidelines (Golder, 1997 & CMPS&F, 1998c).

A further two monitoring bores are located along Helen Street at distances of 105 m and 165 m west of the major pit. Groundwater quality indicated no contamination and was within normal background levels with sulphate concentrations at less than 20% of the raw water guidelines (CMPS&F, 1998c).

Three monitoring bores were installed south of the site along Clayton Street and Henkin Street. Groundwater pH is close to neutral with levels of heavy metals below raw water guidelines. Low concentrations of heavy fraction hydrocarbons below Dutch Intervention criteria were detected in a monitor bore 80 m downgradient of the major pit. Sulphate levels ranged up to 3 times the raw water guidelines (CMPS&F, 1998c).

A monitor bore was installed at the Bellevue Primary School located approximately 440 m west of the major pit showed no evidence of contamination (CMPS&F, 1998c).

A domestic bore used for irrigation purposes which is located approximately 250 m southwest of the major pit shows no evidence of contamination with only low levels of sulphate at 50% of the raw water guidelines (GSWA, 1995). The quality is consistent with that observed upgradient of the major pit.

Lower Leederville Formation

As mentioned previously, one of the off-site monitor bores located at the corner of Helen and Henkin Streets was installed in the first sequence of the LLF sands at a depth of up to 6 m below the clay base of the ULF. The LLF monitor bore was installed adjacent to a contaminated bore in the overlying ULF and was found to contain no evidence of contamination (CMPS&F, 1998a).

Two deeper monitoring bores were installed 3 m south east of the major pit screened within two sections of the aquifer at an approximate depth of 15 m and 40 m below the base of the ULF aquifer (or 40 m and 65 m BGL: below ground level).

Trace levels of metals and heavy fraction hydrocarbons were detected at both depth intervals below relevant criterion. Phenols were detected from the 65 m BGL depth interval at concentrations 5 times above the raw water guidelines. Groundwater pH from both depth intervals is near neutral at 6.3-6.6. Sulphate concentrations are between 10% and 20% of the raw water guidelines (Golder, 1997).

The presence of these trace levels of compounds is normal and is due to the carbonaceous pyritic nature of the aquifer matrix, and is <u>not</u> associated with leachate from the oil re-refining wastes.

Conclusions

Contaminants from the oil re-refinery operations have affected groundwater within the upper part of the Leederville Formation aquifer. The high TDS content of the groundwater within the waste oil pit (87,000 mg/l) has the potential to migrate by gravity flow into the ULF aquifer through the Guildford Clay by displacing the underlying less dense groundwater (1,000-2,000 mg/l).

The groundwater quality within the ULF aquifer immediately adjacent to the major pit contains high levels of heavy metals and sulphate. Groundwater quality within the ULF aquifer downgradient of the major pit has clearly been degraded as demonstrated by significant increases in acidity, total dissolved solids and levels of sulphate, phenols, hydrocarbons and heavy metals.

The off-site extent of contaminant migration from the Omex site is estimated to extend up to 150 m southwest of the major pit. It should be noted that the leading edge of the plume is characterised by the presence of sulphate only. Elevated heavy metal and hydrocarbon levels above the relevant criterion are restricted to within 100 m of the major pit with increasingly significant concentrations closer to the major pit. Contamination is contained within the ULF aquifer.

4.4.3 Fate of Groundwater Contamination

In order to determine the fate of the contaminants present within the ULF aquifer and how the containment wall will prevent any further on-going contamination of this aquifer, groundwater fate and transport computer modelling was performed to predict the movement of the contaminated groundwater plume.

Groundwater fate and transport modelling involves application of a 3-dimensional steady state groundwater computer model which can simulate the transport of organic and inorganic contaminants. The computer model uses local hydrogeological data and the chemical properties of the contaminants to predict the breakdown and movement of the groundwater plume over time.

The contaminants of concern used in the modelling exercise are nickel and TPH (Total Petroleum Hydrocarbons) as these compounds are shown to be migrating from the site. The criteria used in the model for assessing impact on the groundwater are the Dutch B criteria for TPH and the NHMRC Drinking Water Guidelines for nickel. There are no WAWQ Raw Water Guidelines for TPH. The NHMRC value for nickel was used rather than the WAWQ Raw Water Guideline. As this figure is lower and more conservative, application of this criteria provides a high level of surety and ensures no potential users will come into contact with nickel contamination in excess of the WAWQ Raw Water Guidelines. The predicted extent of the groundwater plume in 50 years time is shown against the current situation on Figure 8.

In 25 years the groundwater plume will have migrated a further 300 m downgradient of its present day position. By 50 years the leading front of the plume will be approximately 800 m south west of the Omex site boundary and ceases to migrate any further. It is predicted that in the 50-100 years time period, the plume will degrade in size and magnitude.

The groundwater model is presented as Appendix C, the pertinent results of the modelling are as follows:

- the groundwater model was able to match the observed groundwater flow and distribution of contamination across the study area;
- the presence of the containment barrier which has isolated the source will allow the plume to dissipate and recede with time. Modelling showed that the behaviour of nickel and TPH was similar and that overall, there is a reduction in the contaminant concentration over time but with an enlargement of the plume dimensions;

- modelling results indicate that elevated levels of nickel and TPH in the groundwater plume will preclude its use for the entire modelling period (100 years);

Overall the groundwater plume is shown to move relatively slowly and the contaminants appear to be relatively persistent. The slow movement of the plume is attributed to the low hydraulic gradient in the ULF aquifer.

4.5 AIRBORNE EMISSIONS

Airborne emissions from the waste pit at the Omex site were the subject of numerous complaints made by local residents when the oil re-refinery was operating. At this time the major pit was filled with liquid wastes open to the atmosphere. No air monitoring data is available for this period when the pit was uncovered. A superficial covering of yellow sand was placed over the pit in 1989.

In March 1995, air monitoring was performed both up and down wind at the perimeter of the major pit prior to the vented plastic cover being installed. PAHs and lead in airborne dust were detected at concentrations considered to be environmentally significant but below the recognised health exposure standards. Some very low levels of chloride (possible indication of hydrochloric acid) and the presence of organo-sulphur compounds were also observed. The presence of chloride was reassessed subsequent to the monitoring and considered to be related to atmospheric salt (NaCl) aerosols. No organic hydrocarbons were detected (CCWA, 1995).

A purpose built plastic and sand cover was installed over the major pit in February 1996. This was designed to prevent vapour emission and surface water inflow to the major pit. Vapours are currently vented to the atmosphere after passing through a charcoal canister which cleans the air.

During the 1996 environmental investigations, air monitoring was undertaken during the 19 days of drilling, trenching and groundwater test pumping. Air monitoring at four locations around the major pit indicated trace levels of heavy metals in the dust which are most likely related to normal background levels. The natural uncontaminated clays contain trace quantities of metals. No volatile hydrocarbons were detected and acid vapour concentrations were an order of magnitude below recognised occupational health criteria (Golder, 1997).

Air monitoring was undertaken at four location around the major pit over two days in April 1998 for volatile hydrocarbons and acid vapours. The results obtained were consistent with the 1996 observations (CCWA, 1998).

In order to determine the potential nature and extent of air emissions during remedial works, testing was performed both in the field and in the laboratory The field tests involved on-site sampling of the air in all the monitor bores installed within the pit. Laboratory testing was performed on a number of the most contaminated waste material samples and involved complete analysis for all volatile organic gases.

Testing has shown that the significant air emissions likely to be encountered during clean-up will be elevated levels of sulphur dioxide gas and particulates (as dust) which may contain heavy metals and PAHs. It should also be noted that air emissions from the pit may also contain trace levels of organo-sulphur compounds. These sulphur compounds tend to have extremely low odour thresholds which although not hazardous, are malodorous.

The specific findings and details of these air monitoring events are provided in the respective reports and summarised in the Health Risk Assessment presented as Appendix B. It should be noted that several light industrial premises within the area have the potential to produce odorous airborne emissions. These include nearby plastic welding and bituminous painting of steel pickets.

4.6 SUMMARY OF OMEX-RELATED CONTAMINATION

Tables 14, 15 and 16 set out a summary of the nature and extent of Omex-related contamination. This amounts to approximately 23,000 m^3 of solid and liquid waste from the pits on-site and what has been disposed at the Adelaide Street landfill facility. The waste is in the form of oily sludge, contaminated fill and liquid oil. In addition, there is an estimated 13,000 m^3 of contaminated soil which has been affected by the waste (Table 14).

Contamination of the groundwater in the Guildford Clay occurs up to 90 m downgradient of the major pit and is in the form of hydrocarbons and acidity. Sulphate and phenols are also present. In the Upper Leederville Formation, contamination in the form of sulphate has migrated up to 150 m south west of the major pit. Heavy metal and hydrocarbon contamination extends up to 100 m from the major pit (Table 15).

Airborne emissions from the waste material appear to be confined to PAHs and lead in dust, sulphur dioxide, organo-sulphur compounds and trace levels of chloride (Table 10).

TABLE 14
SUMMARY OF OMEX-RELATED WASTE AND SOIL CONTAMINATION

SOURCE OF WASTE	ESTIMATED VOLUME m^3	NATURE OF CONTAMINATION
CONTENTS OF PITS		
Major Pit	17,000 solid 4,400 liquid	acidic oily sludge, oil and groundwater with heavy fraction hydrocarbons, phenols and heavy metals.
Minor Pit No.2	700	
Adelaide Street Landfill	1,000	
SUBTOTAL	*18,700 solid* *4,400 liquid*	
CONTAMINATED SOIL		
Seepage from major pit	7,000	elevated PAHs below pit base, trace heavy metals and hydrocarbons at walls near surface, PAHs and heavy fraction hydrocarbons at depth.
Surface spillage from major pit	270	elevated PAHs, volatile hydrocarbons, phenols, sulphur and heavy metals.
Abandoned drainage channels	20	elevated heavy fraction hydrocarbons, phenols, sulphur and lead.
Seepage from minor pit	1,800	elevated PAHs and heavy fraction hydrocarbons expected.
Oil Re-refinery site	3,000	elevated PAHs, heavy fraction hydrocarbons and lead.
Oil Redrumming Facility	500	elevated heavy fraction hydrocarbons and PAHs.
SUBTOTAL	*12,590*	
APPROXIMATE TOTAL	**31,290 solid** **4,400 liquid**	

TABLE 15
SUMMARY OF OMEX-RELATED GROUNDWATER CONTAMINATION

SOURCE OF WASTE	NATURE OF CONTAMINATION
GUILDFORD CLAY	
Adjacent to major pit	elevated levels of volatile and heavy fraction hydrocarbons, PAHs, phenols and sulphate.
Downgradient of major pit (55 - 90 m)	trace levels of heavy fraction hydrocarbons, minor concentrations of phenols.
Minor Pit No.1	minor levels of PAHs and sulphate.
Surface spillage from major pit	minor levels of phenols and sulphate.
Oil Re-refinery site	western end: elevated heavy metal and sulphate concentrations, minor PAHs and trace heavy fraction hydrocarbons. eastern end: elevated phenol levels.
Oil Redrumming Facility	elevated levels of heavy fraction hydrocarbons.
UPPER LEEDERVILLE FORMATION	
Downgradient of major pit (4 - 8 m)	elevated sulphate, heavy metals (Cr, Ni, Zn), minor hydrocarbon concentrations, pH of 3.2.
Downgradient of major pit (35 m)	elevated sulphate, trace levels of heavy metals, heavy fraction hydrocarbons, pH of 3.
Downgradient of major pit (55 - 90 m)	elevated phenol and sulphate concentrations, minor levels of heavy metals (Ni, Zn) and heavy fraction hydrocarbons, pH of 3 - 5.
Downgradient of major pit (250 m)	no evidence of contamination.
LOWER LEEDERVILLE FORMATION	
3 m from the major pit	no Omex-related contamination, trace levels of heavy metals, hydrocarbons and phenols consistent with carbonaceous puritic nature of aquifer.
Downgradient of major pit (60 m)	no evidence of contamination.

TABLE 16
SUMMARY OF OMEX-RELATED AIRBORNE EMISSIONS

SOURCE OF WASTE	NATURE OF CONTAMINATION
Major pit uncovered.	complaints of nuisance odour.
Major Pit prior to installation of vented cover, sand cover only.	PAHs and lead in dust, organo-sulphur compound present.
Major pit with vented cover 1996	trace levels of heavy metals not related to the pit, no volatile hydrocarbon or acid vapours.
Major pit with vented cover 1998	sulphur dioxide, no acid vapours.
Laboratory testing	elevated sulphur dioxide, possible trace levels of malodorous organo-sulphur compounds.

SECTION 5
REMEDIATION OPTIONS

5.1 INTRODUCTION

This section describes the available remediation options for rehabilitating the Omex site to a condition suitable for residential purposes. The remainder of this section identifies the general requirements that the remediation strategy needs to meet while Section 5.2 sets out the EPA's preferred strategies for remediation. Section 5.3 summarises the potential remediation options and Section 5.4 examines options for excavating the waste from the pit. Various remediation options for treating contaminated soil and groundwater are also assessed and are discussed in detail in Sections 5.5 (soil) and 5.6 (liquid waste/groundwater).

It is important to note that the final remediation program selected for site rehabilitation must satisfy the following general requirements:

- The site once remediated must be suitable for residential purposes.
- The waste material contained within the pits is to be removed from the site in accordance with the statement issued by the Minister for the Environment.
- The remediation process must be safe for all project personnel and for the general public. Particular attention must be paid to :-

  ⇒ Vapours and nuisance odours;
  ⇒ Noise emissions;
  ⇒ Vibration; and
  ⇒ Dust emissions.

- The nature of the waste material will require the development of a comprehensive occupational health and safety (OHS) plan. Remediation strategies must limit risk to the public and to workers in accordance with standards acceptable to Worksafe Western Australia.
- In the event that the waste is removed from the site for treatment at another location, that the treatment location must not inadvertently become contaminated.
- Where possible, recycling of the oil wastes should be considered.
- Proposal for handling the waste material must take into account its acidity which will make it highly corrosive of plant and equipment.
- The waste material must be in a condition suitable for transport and acceptance at the disposal/treatment facility. It must comply with the relevant transport codes and landfill disposal criteria.

5.2 CONTAMINATED SITES POLICY

This section outlines current government policy on the management of contaminated sites in Western Australia. The EPA's position on the approach to site remediation is outlined in detail in Interim Policy No 17; 'A Site Remediation Hierarchy for Contaminated Sites, July 1997', and in the DEP public position paper; Assessment and management of contaminated land and groundwater in Western Australia, May 1997 (Position No 13).

The following guidelines are used by the EPA during the assessment of any proposal relating to the remediation of a contaminated site:

- *contaminated soil will preferably be either treated on-site and the contaminants reduced to acceptable levels or be treated off-site and returned for reuse after the contaminants have been reduced to acceptable levels;*

- *the EPA prefers proponents to seek other options rather than either disposal to an approved landfill or the implementation of 'cap and contain' isolation measures. These options will only be considered if treatment of the contaminated material is not practicable, and will need to be undertaken in an environmentally acceptable manner; and*

- *remediation should be undertaken in accordance with the best advice about available techniques and options.*

5.3 SUMMARY

Based on a review of the potential options available to remediate the Omex site, the following remediation options are considered viable from both a technical and cost perspective. It should be noted that the containment wall will be in place prior to remediation commencing. Therefore the potential options are based on the presence of the containment wall. The potential remediation options are :

1. Do nothing.

2. Isolate and retain in-situ.

3. On site treatment and containment.

4. Incineration.

5. Removal to a suitable landfill with or without treatment.

The 1997 Golder Report considered six options for dealing with the contamination on site ranging from do-nothing to removal off-site. Each option was subject to a ranking matrix in order to derive an acceptability index which would be viewed as the most acceptable approach to remediation. The six options considered were:

1. Do Nothing.
2. Isolate In-situ.
3. On-site Treatment and Containment.
4. Incineration.
5. Removal to Local Landfill.
6. Removal to Mt Walton East IWDF.

The acceptability matrix included the 12 issues which were weighted in descending importance and were awarded a rating between 1 and 10. These issues in order of weighting were :

1. Groundwater protection.
2. Public health risk (real).
3. Public health risk (perceived).
4. Public acceptance.
5. Technical viability.
6. Additional hazards created.
7. Anticipated cost.
8. Time scale involved.
9. Future monitoring costs.
10. Ability to demonstrate success.
11. Future public liabilities.
12. Possibility to use site later for other purposes.

The option considered to be most acceptable was Option 6 or removal off-site to Mt Walton East IWDF.

In April 1997, the Contaminated Sites Branch of the DEP forwarded two remediation recommendations to the Minister for the Environment for consideration. The options were outlined as A and B.

Option A is described as Option 2 in the Golder report. This involved the installation of a groundwater containment wall around the major pit and retention of the existing HDPE cover. The waste contents of the pit would remain contained on-site.

Option B is described as Option 6 in the Golder report and includes a containment wall with removal of the waste contents of the pit off-site to landfill.

Option B was selected as this remediated the site to residential levels and minimised future liabilities.

Option 5 which equates to Option B with the exception that waste material can be disposed to a suitable landfill, rather than Mt Walton East IWDF, is considered to be the preferred option. This opinion was based on technical advice provided to the Minister for the Environment.

Option 5 comprises three distinct phases to the remediation works:

1. Excavation and removal of the waste material.

2. Treatment of the waste material.

3. Transport of the waste material to disposal site.

5.4 APPROACH TO EXCAVATION

The approach to excavating both the pit and surrounding contaminated soil is outlined in this section.

5.4.1 Excavation of the Pit

In order to effectively remove the waste contents of the pit for treatment there is a need to separate the liquid and solid components of the contamination. The approach to excavating the contents of the pit and associated soil contamination is outlined in this section.

Variants of the approach to performing excavations are described in the following sub-sections. These sub-sections consider the excavation and material handling aspects of the liquid and solid waste streams.

There are two basic approaches to removing contamination contained within the major pit:

1. Excavate the solid waste - remove the liquid content - treat - dispose.

2. Remove the liquid content - excavate the solid waste - treat - dispose.

Taken one step further, the two basic approaches can be subdivided into four strategies:

- Excavate and treat solid waste, dispose of solid waste then:

  A. treat liquids in-situ then remove and dispose.
  B. remove liquids first, treat, then dispose.

- Remove and treat liquids, dispose of liquid waste then:

  C. excavate and treat solid waste then dispose.
  D. treat solid waste in-situ, excavate and then dispose.

Liquid wastes require pretreatment on-site as the Liquid Waste Treatment Facility cannot accept acidic material (Omex non-oil liquids pH of 1).

The proposed scope of works need not necessarily preclude other variations which run along similar lines, for example treatment technologies may vary. A flowchart detailing the four strategies is shown on Figure 9.

The main difference between the strategies is the order of the work, ie whether to excavate solids or remove the liquids first. Each strategy will have risks either real or perceived, and advantages or disadvantages over each other. An evaluation of each of the strategies is provided in Appendix E.

It would appear that removing the liquids first over excavating soil has the advantage on two key issues:

1. odour production would be greatly reduced. Even though odour levels may be below health guidelines from either method, a reduction of the general public's exposure to nuisance odour offers a clear advantage; and

2. a decrease in the amount of free liquid generated during excavation and transport of the solid material as the oil/water content in the soil matrix would be lower. Decreasing the amount of free liquid reduces the health risk to site personnel from accidental contact and cross contamination of clean locations from spillage.

Any contaminated material destined for landfill will require removal or a reduction of the liquid content as liquid waste will not be accepted at landfill (Department of Environmental Protection 'Landfill Waste Classification and Waste Definitions, 1996').

Therefore Strategy C : *remove and treat liquid wastes followed by disposal, remove and treat solids followed by disposal to landfill* is nominated as the preferred approach to removing the waste material.

5.4.2 Excavation of Contaminated Soil

The status of the contaminated soil surrounding the pit does not require treatment prior to disposal off-site. The proposed depth of excavation of 3.5 m will not encounter groundwater so dewatering is not an issue as with the major pit. Therefore the process of excavating this soil will be relatively straight forward. The soil will be removed, stockpiled according to level of contamination and disposed of to the appropriate class of landfill.

5.5 SOIL/WASTE MATERIAL TREATMENT OPTIONS

The solids content of the pits consists of fill material with oil containing heavy metals, sulphuric acid, phenols and polycylic aromatic hydrocarbons absorbed onto it.

The soil contamination outside of the pits is principally comprised of heavy fraction hydrocarbons including PAHs (polycyclic aromatic hydrocarbons), phenols and heavy metals.

There are a number of potential methods to treat both the solid contents of the waste oil pits and impacted soil. A full description of the various treatment technologies and any risks to the environment or human health posed by that technology are also discussed. The potential treatment options are outlined as follows:

- Stabilisation/solidification
- Soil washing
- Soil fractionation
- Incineration and thermal treatments
- Bioremediation
- Vitrification
- Ecologic process
- Disposal to landfill

5.5.1 Stabilisation/solidification

Chemicals can be applied to the soil to reduce the availability of the contaminant to the environment. Solidification/stabilisation refers to chemical treatment processes that chemically reduce the mobility of the hazardous constituent. Reduced leachability is accomplished by the formation of a lattice structure and/or chemical bonds that bind the contaminants and thereby limit the amount that can be leached when in contact with water or a mild acid solution.

Chemical fixation utilises cementing agents such as Portland cement, fly ash, quick lime or limestone, blast furnace slag and other forms of activated silica which bind the contaminants (especially heavy metals) to the soil particles.

Treatment by chemical stabilisation techniques in particular polymerisation can be expensive and is generally not suitable for organic contamination such as the hydrocarbons found at the Omex site.

5.5.2 Soil Washing

Extractant solvents such as water, surfactants and acids are flushed through the contaminated material, either in-situ or ex-situ, to remove the contaminants from the soil or waste.

Ex-situ processes can be very effective in removing heavy metals from permeable soils such as sand. The process is not effective in fine soils such as clay. Soil washing does create a wastewater stream which requires treatment and disposal.

Soil washing is expensive but is effective in removing both organic and inorganic compounds from reasonably permeable soil or wastes. The Omex waste is generally not suitable for this approach.

5.5.3 Soil Fractionation

Soil fractionation uses mineral processing technology to remove contaminants that are bound to the soil particles. Separation of particles is based on differences in physical properties such as grain size and specific gravity.

The limitation with this process is that the contaminant must be associated with a particular soil characteristic for separation to be possible. This technology can be expensive and has not readily been used in Australia. The Omex waste is generally not suitable for this approach.

5.5.4 Incineration and Thermal Treatment

Heat is used to destroy organic and some inorganic compounds. Incineration relies on very high temperatures whereas thermal treatments utilise lower temperatures, pyrolysis and high pressure.

These processes are ideally suited for organic compounds such as hydrocarbons and pesticides. The technology is relatively expensive and generally only used for intractable wastes. Heavy metals such as those found in the Omex wastes are not destroyed in the process.

Waste can be treated by low rate injection into cement kilns or a purpose built burner to supplement energy needs. Air emissions may be an issue with such a destruction method.

5.5.5 Bioremediation

Bioremediation relies on the ability of microbial organisms to break down contaminants into harmless byproducts. This can be achieved either in or ex-situ, however the latter is generally considered more effective.

Bioremediation is ideally suited to organic compounds such as some of the hydrocarbons found in the Omex waste. They can also be utilised to convert some heavy metal compounds into less toxic forms. However, most heavy metals will actually adversely affect the process of bioremediation.

A time period is involved in bioremediating organic contaminants, especially with regard to resistant compounds. In addition to the time involved, a large area of land needs to be dedicated for the process.

Bioremediation projects performed within WA indicate that high concentrations of heavy fraction oils are in some cases uneconomical to bioremediate. Bioremediation of wastes with low concentrations has been successful.

Analysis suggests that 74% of the Omex oil waste matrix consists of heavy fraction oil which will resist bioremediation. The impact of acidity on the bioremediation process is a complication that may limit its application at the Omex site.

5.5.6 Vitrification

Vitrification of contaminated soil melts the soil and contaminants into a glass like structure. This is very expensive and is best suited for radioactive wastes and some metallic contaminants.

5.5.7 Ecologic Process

The Ecologic process is based on gas phase thermo-chemical reaction of hydrogen with organic and chlorinated compounds. The process involves the heating of waste material or contaminated soil to 800°C under a hydrogen atmosphere at which temperature organic and chlorinated organic contaminants become volatile. The contaminants, once in the gas phase, react with the hydrogen to reduce the organic compounds to lighter non-chlorinated organics including methane. These lighter products can be used as an energy source for the system operation.

The process has been developed in Canada, and Ecologic (Australia) Pty Ltd operates a facility in Western Australia using the process.

The process is suitable for handling a range of organic wastes which can be found on site, including polycyclic aromatic hydrocarbons and phenols, assuming that appropriate materials handling and preparation systems are provided. The process cannot be used to treat heavy metal contamination such as the lead found in the Omex wastes. Thus technical evidence indicates that the system is most likely unsuitable for the Omex waste material.

5.5.8 Landfill Disposal

This approach is cost effective compared with technological approaches described above. The removal of contaminated soil ensures sites are cleaned up to stringent standards with no future potential liabilities.

Disposing of contaminated soil to landfill places pressure on the capacity of these facilities. Some contaminants such as heavy metals are better suited to landfill disposal as they cannot be treated easily compared to organic compounds which can potentially be bioremediated.

Dependent upon the severity of the contamination, the soil is disposed to various classes of landfill ranging from inert to putrescible to intractable. Soil with very low levels of contamination maybe able to be used as special purpose fill for road construction or in deep excavations.

Acidic wastes such as the Omex material require pretreatment or pH adjustment prior to disposal as the acidic nature of the waste can remobilise heavy metals within the landfill.

Managed landfill disposal offers a reliable and secure approach to dealing with contaminants that have the potential to persist in the environment.

5.5.9 Conclusion

Landfill disposal with alkali pretreatment of the waste is considered the most appropriate treatment option for the Omex waste as it removes the source of contamination permanently from the site. This option forms the basis for the remediation tender, however other options will not be excluded if it is shown that they can satisfy the performance criteria set out in the Ministerial Conditions.

5.6 LIQUID WASTE/GROUNDWATER REMEDIATION OPTIONS

The liquid waste within the major pit is principally comprised of oil in the form of heavy fraction hydrocarbons with minor quantities of volatile compounds, sulphur and heavy metals.

The groundwater surrounding the major pit and the water content within the pit contain elevated levels of hydrocarbons, sulphate and heavy metals.

There are a number of potential methods to remediate the liquid waste contents of the pit and the site groundwater. A full description of the various treatment technologies and any risks to the environment or human health posed by that technology are also discussed. The potential treatment options are outlined as follows:

- Pump and treat
- Fuel Blending
- Air sparging
- Bioremediation
- Containment
- Natural attenuation and dispersion

5.6.1 Pump and Treat

The pump and treat option involves removing the liquid waste and contaminants within the groundwater by subjecting it to a number of processes, dependent upon the particular contaminant.

For acidic waters, heavy metals can be removed using standard water treatment technologies such as pH correction, (possibly with coagulation to precipitate metals) combined with a separation unit (Dissolved Air Filtration Unit, DAF or Filtration). Microfiltration techniques can also be used.

Oils can be removed with separators. Hydrocarbons dissolved within groundwater can be removed through air stripping of volatile compounds and carbon adsorption treatment processes.

Pump and treat technology is effective but does incur high on-going maintenance costs associated with the groundwater removal. Such remediation options are best suited for high concentrations of contaminants in a permeable aquifer.

5.6.2 Fuel Blending

This option is applicable only to the waste oil component and should be viewed as recycling rather than a treatment technology. Oil waste is used as fuel additive at Power Stations or at other industrial fuel programs.

Potential problems are principally with regard to the quality of the oil and whether the characteristics of the oil and presence of contaminants are suitable for blending purposes.

5.6.3 Air Sparging

Air sparging is an in-situ method of remediating volatile organics by aerating the groundwater within the aquifer. This process is best suited for volatile organics in a permeable aquifer.

Establishment and running costs are high with this system and the technology has a number of limitations.

5.6.4 Bioremediation

Bioremediation relies on the natural bacteria present within the groundwater to degrade or breakdown the contaminants into harmless compounds. Bioremediation technologies rely on accelerating the natural process by enhancing the environmental conditions for the bacteria.

Application of oxygen and nutrients into the contaminated groundwater promotes bacterial growth and degradation of the contaminant. Bioremediation is principally employed on petroleum hydrocarbons and has proved to be very successful.

5.6.5 Containment

Containment techniques prevent groundwater flow by either creating a physical or hydraulic barrier.

Physical barriers rely on structures such as sheet piles, clay grouts and synthetic liners.

Hydraulic barriers alter or prevent groundwater flow and halt the migration of contamination. Pumps and interception trenches are used as hydraulic barriers.

Containment approaches are expensive and best suited to gross levels of contaminants that resist degradation. They do afford a high level of security from any on-going pollution of the environment by isolating the waste. The containment system may preclude the use of the land from any development other than passive recreation or such.

5.6.6 Natural Attenuation and Dispersion

Natural attenuation and dispersion means allowing the contaminant to degrade and disperse naturally over time. Bacteria will degrade organic compounds and dispersion into uncontaminated groundwater will dilute ambient contaminant concentrations.

This option excludes the groundwater within the major pit and is really only viable for low levels of contaminants and where the groundwater is not moving into an adjacent sensitive environment. A cost associated with the existence of contaminants in the groundwater is that it may restrict the use of the resource for purposes such as irrigation.

5.6.7 Conclusion

The liquid waste within the major pit will be recovered and put through a pH adjustment treatment and transported off-site for further treatment at the Forrestdale Liquid Waste Treatment Plant.

Containment in the form of the cement bentonite slurry wall will limit the volume of waste liquids extracted from the pit by preventing ingress and dilution by surrounding groundwater. The containment barrier will also serve to isolate the underlying groundwater beneath the base of the pit from entering the aquifer.

Groundwater contamination outside of the containment barrier will disperse and degrade with time to acceptable levels. Groundwater usage will be restricted in the contaminated area until monitoring shows otherwise.

This option forms the basis for the remediation tender, however other options will not be excluded if it is shown that they can satisfy the performance criteria set out in the Ministerial Conditions.

5.7 TECHNOLOGY TRIALS

Submissions were sought from industry to trial possible treatment processes for the waste material. Interested parties were invited to register and be provided with an information kit from the proponent. The information kit detailed the contaminant characteristics of the waste and results of preliminary pretreatment with alkali material.

There were approximately 35 responses received detailing potential technologies, however no respondents committed to trials at this preliminary stage. Many of the respondents proposed in-situ treatment or on-site containment. As one of the key elements of the remediation is off-site removal of the waste contents of the pit, these approaches could not satisfy the project requirements. Technology trials may be undertaken once tenders have been called for performing the site clean-up.

The proponent has performed some lime neutralisation testing which showed that the addition of alkali material reduced the leachate potential of the waste material, thus making it suitable for disposal to landfill. Application rates of 1:16 and 1:6 of lime to sludge waste were applied which increased the pH and resulted in significant reductions in heavy metal leachate potential by up to 97% (CMPS&F, 1998e). These results were provided in the information kit and have been shown previously on Table 11 in Section 4.2. Sample CM A represents the 1:6 ratio and CM B the 1:16 ratio. It has been calculated that a limestone to waste ratio of 1:4 would achieve appropriate pH adjustment (7-8) and minimise leachate potential.

5.8 RECOMMENDED REMEDIATION APPROACH

The remediation approach put forward which best satisfies the constraints and conditions outlined in Section 5.1 is the proposed landfill disposal option No. 5 incorporating handling Strategy C. This involves the removal and treatment of liquids on-site, the disposal of liquid waste off-site, the excavation and treatment of solid waste on-site and its disposal to landfill.

Liquids in the pit would be removed prior to excavation of solids. The waste would be pretreated to ensure the pH is acceptable for receival at the Liquid Waste Treatment Facility.

Soil contamination outside of the pit would be dealt with as per the solid waste material with the exception of no on-site treatment as the soil would be suitable for direct disposal to landfill.

Groundwater contamination outside of the containment barrier surrounding the pit would not be treated and allowed to disperse with time. Measures will be implemented to prevent access to contaminated groundwater.

Air emissions from the pit both on-site and off-site are a management issue for the remediation contractor. Removal of the liquids before excavating the solids will reduce the potential for odour generation.

This approach will form the base case for tendering the project, as described in Section 1 - 8. Methods used to achieve rehabilitation of the site will need to satisfy the requirements outlined earlier in Section 5.1. Whilst the recommended remediation option and excavation strategy is considered the most practical approach in light of the reviews conducted to date, other viable approaches and technologies which are raised at the tender stage will also be given due consideration. However such alternatives must meet the Ministerial Conditions by demonstrating that the same environmental outcomes can be achieved. Any alternative approach to site remediation must include removal of the waste contents of the major and minor pits.

A full description of the proposed remediation approach including control of air emissions, groundwater and treatment processes is described in the following Section 6. The proposed remediation approach will not represent a risk to the local environment or the health of residents and provides the security of removing the source of contamination from the site.

SECTION 6
REMEDIATION APPROACH

6.1 INTRODUCTION

This section describes in detail the proposed approach to remediation based on the landfill option outlined in Section 5.7. Included is the approach to validating that the remedial works have been completed in accordance with the proposed clean-up objectives.

Section 6.2 provides an overview of the proposed approach to remediation. Details regarding pit remediation are provided in Section 6.3. This section describes how the remedial works are likely to be undertaken.

The approach to dealing with soil contamination is discussed in Section 6.4 inclusive of a remediation plan and validation of remedial works. Section 6.5 provides a discussion on the management of groundwater and its monitoring. Section 6.6 outlines the management and monitoring of airborne emissions.

Transportation of the waste, inclusive of an evaluation of road compared to rail, is discussed in Section 6.7. Environmental management of the remediation is dealt with in detail in Section 7.

6.2 GENERAL CONCEPT

The following is an overview of the proposed remediation approach which is shown on Figure 10 -General Concept for Containment and Remediation. The figure illustrates both the containment and remediation phases of the site rehabilitation.

6.2.1 Containment Phase

- <u>Current Condition</u>

The current situation is that the waste is contained within a disused clay pit approximately 7m in depth, covered with a soil cap and plastic membrane. A body of significantly contaminated groundwater occurs both in the underlying unconfined Guildford Clay and confined Leederville Formation aquifers. The extent of groundwater contamination in the Guildford Clay is less extensive.

- <u>Containment</u>

A containment barrier will surround the major waste pit and extend from the surface to the clays at the base of the confined aquifer. This will contain and isolate the waste material and groundwater beneath the pit.

6.2.2 Remediation Phase

- De-watering

This view indicates the process of de-watering the liquid component of the waste prior to excavation. The liquid level will be reduced to below the pit floor at a depth of approximately 10 m below ground level. The liquid will be comprised of oil and contaminated groundwater, a total approximate volume of 4,400 m^3. This liquid will be treated on-site to adjust the pH for transport to the Forrestdale Liquid Waste Treatment Facility.

- Excavation

Once the pit has been de-watered to below the pit base and is drained of excess liquid to sufficiently render the waste material "spadeable", the waste will be excavated from the pit, treated on site as required and removed off site for disposal. A sump will need to be installed within the base of the pit to collect any runoff or seepage.

- Backfill

The excavated pit will initially be backfilled with clean fill from the base to within 3 m of ground level with a 3 m cover of compacted clay placed over the backfill. In order to facilitate future development on the surface, the top 3m of the containment barrier will be removed and also backfilled with compacted clay. The compacted clay cover will ensure continuity of the relatively impervious natural surface provided by the existing 5 m to 7 m of clay.

Contaminated groundwater at depth (>10 m) will remain within the containment cell, capped by a compacted clay cover. The containment wall is designed to prevent seepage through the pit area. The clay cover will be slightly raised to ensure surface runoff away from the remediated pit. In addition, the redevelopment of the site and the associated drainage works will be required to direct stormwater away from the pit. Rainfall infiltration of the impervious clay cover will be negligible thus preventing a rise in the underlying water table.

6.3 PIT REMEDIATION PROGRAM

This section provides a broad description of how the proposed remediation process for the pit would be undertaken. The waste material to be removed will consist of contaminated oil, groundwater, soil and rubble which will be acidic.

A containment wall will be installed around the perimeter of the major pit to a depth of approximately 30 m and will extend 1 m into the confining clay layer. The containment wall will be of bentonite slurry and is scheduled to be completed by December 1998 in preparation for remedial works. The design details are provided in the Preliminary Design Report for Containment Barrier, CMPS&F, May 1998.

The liquid material will firstly be recovered, with sumps or pits installed beneath the existing cover. The waste liquids will be pumped to either an on-site storage tank or directly into tankers for immediate transport to a treatment facility. The transfer of liquid from pit to tank/tanker will be conducted within a closed environment to minimise the release of emissions to the atmosphere. Any venting of storage tanks would take place via carbon filters. The waste will be taken to the Forrestdale Liquid Waste Treatment Facility.

Pipe work, storage tanks, oil/water separators and the liquid transfer area should all be contained within an appropriately bunded location so as to contain any accidental spills. Liquid waste tankers will leave the site via a simple washdown area. The tankers to be used will be constructed to resist acid corrosion unless there is pretreatment performed on-site.

Liquid and groundwater extraction within the pit area enclosed by the containment wall will continue until the water level reaches the known base of the pit. Once the liquid content of the pit has been removed, earthworks will commence on the solid contents within the pit. The existing HDPE liner will be removed in sections as the face of the excavation is worked. This will keep the amount of exposed waste material to a minimum.

A ramp may need to be constructed into the pit to allow access for an excavator and dump trucks. As the excavation progresses, a 0.5m thick crushed limestone pad will be placed at the base of the remediated sections following validation inspection, to enable the excavator and dump trucks to operate effectively.

The excavator will load directly into trucks within the confines of the pit. Any large rubble which cannot be broken up by the excavator will be pushed to one side and broken up by a machine mounted rock breaker at a convenient time.

Trucks will exit the pit area via a simple wash down system en route to the treatment process. The wash down will be contained, with any drainage back to the pit.

Limestone or any other suitable alkali material will be used to neutralise the acidity in the solid waste and absorb any excess liquid contained within that waste.

Limestone will be stockpiled on site and loaded into the trommel hopper with a front end loader.

The waste material will be delivered into a hopper by dump trucks via a loading ramp. The hopper will deliver the waste material into a mixing trommel which will operate in the same manner as a concrete batching plant. The waste material will be mixed with an alkali material for approximately 2 minutes in a ratio of 1 part limestone to 4 parts of waste to achieve a stabilised pH of 8.

The treated waste will then be discharged directly into a truck for transport to landfill or contained within appropriate temporary storage facilities.

The treated waste must satisfy both a pH of 8 and have no free liquid. Failure to meet either of these criteria will necessitate retreatment of the waste. Centrifuging or the addition of saponite (highly water absorbent clay) or other water absorbent material may be necessary to remove excess moisture.

Trucks will exit the site through a simple wash down system to remove adhered soil with wash down water contained.

On completion of the days work, the pit will be recovered with a roll up/ roll out type cover so that air emissions are kept to a minimum.

An illustration of the excavation process is shown as Figure 11.

6.3.1 Clean-up Strategy

The proposed approach to pit remediation is described as follows:

- remove the entire liquid and solid content of the pits;
- lime treat the solid component of the waste on-site;
- pretreat the liquid waste component on-site or take in untreated form directly to the treatment facility;
- dispose the liquid waste at the Forrestdale treatment facility following on-site pH adjustment, some potential to recycle oil component;
- characterise the solid waste following treatment and dispose to the appropriate class of landfill;
- contaminated solids destined for disposal to landfill will be assessed in accordance with the requirements of the Department of Environmental Protection 'Landfill Waste Classification and Waste Definitions, 1996';
- reinstate the excavations with fill sourced either on or off-site and which is certified as 'clean' in accordance with the Department of Environmental Protection Landfill Waste Classification and Waste Definitions (Amendment 1 of 1998) clean landfill assessment criteria; and
- install a 3 m clay cover with suitable drainage over the reinstated pit to prevent ingress of water.

6.3.2 Validation of Remedial Works

Validation of pit remediation will be undertaken following excavation and removal of contaminated material. This will be based on the visual observation of all fill material back to natural ground surface. The natural soil from the wall and base of the pit will be subject to visual inspection by an EPA representative and analytical validation within the top 3.5 m. Geotechnical testing will also be performed to confirm the base as natural soil.

The specific approach to analytical validation of natural soils is described in the following soil section (S. 6.4.2).

6.4 SOIL REMEDIATION PROGRAM

6.4.1 Remediation Plan

The proposed remediation plan for contaminated soil in areas adjacent to the pit and other locations across the site is described as follows:

- locations with contaminant concentrations above the proposed response level to a depth of 3.5 m will be removed;
- contaminated soils will be segregated and disposed to the appropriate class of landfill;
- contaminated soil destined for disposal to landfill will be assessed in accordance with the requirements of the Department of Environmental Protection 'Landfill Waste Classification and Waste Definitions, 1996';
- any contaminated soil that exhibits a high leachate potential which is unlikely to satisfy the TCLP test will be chemically stabilised in a manner similar to the pit waste prior to landfill disposal;
- soil disturbed to access contaminated soil, but which itself has levels of contaminants which satisfy the definition of 'clean soil' as distinct from the HRA based response level, once validated, can be used elsewhere across the site: and
- reinstate the excavations with fill sourced either on or off-site and which is certified as 'clean' in accordance with the Department of Environmental Protection Landfill Waste Classification and Waste Definitions (Amendment 1 of 1998) clean landfill assessment criteria.

The proposed response level for soil contamination to a depth of 3.5 m are the proposed HRA based soil clean-up levels outlined in Table 5, Section 3.3.2.

For soil contamination at depth in excess of 3.5 m, the HRA proposes no response level based on the premise that there are no volatile compounds or "free phase" hydrocarbons left below this depth. Such volatile compounds have the potential to migrate up through the soil (especially permeable sands) and vent into the atmosphere. Investigations have shown no such contamination within the soil which is a clay with low permeability.

"Clean fill" as distinct from the HRA based response level is defined as soil containing levels of contaminants which do not exceed the clean fill criteria nominated in the Department of Environmental Protection 'Landfill Waste Classification and Waste Definitions, 1996'; Amendment 1 of 1998.

6.4.2 Validation of Remedial Works

Validation of soil remediation will involve the analytical testing of remaining soils following excavation of the contaminated soil. This will be compared with the proposed response level to demonstrate compliance.

The location will be considered to be 'decontaminated' or remediated when the soil contaminant concentrations in the validation samples are below the relevant proposed response level. The proposed response level has been previously described in Table 5, Section 3.3.2.

Validation sampling will be performed in accordance with a recognised statistically based approach. Such an approach to validation sampling of excavations and stockpiles is outlined in the NSW Environmental Protection Authority Contaminated Sites Sampling Design Guidelines, September 1995. In order to provide final environmental clearance, on-site visual inspections by an EPA representative will also be conducted during the remediation phase.

Following remediation, a report will be submitted to the EPA for verification. This report will include a description of the remedial works, field observations including a pictorial record, results of validation sampling, quantities and classification of contaminated soil including disposal records.

6.5 GROUNDWATER REMEDIATION PROGRAM

Significantly contaminated groundwater (other than the liquid waste contained within the pit) occurs beneath the major pit which will be permanently isolated within the containment barrier. In addition, groundwater in the immediate vicinity of the Omex site is not currently being used or posing a threat to any known uses including ecosystem support. Given that future access can be controlled with existing regulations, there are no proposed clean-up criteria for contaminated groundwater. Groundwater contamination will be managed as detailed in the following management plan.

Application of the 3.5 m response level depth criterion will result in some low level soil contamination remaining at depth outside of the containment wall. However, the Water and Rivers Commission (WRC) has evaluated the proposed remediation plan for the Omex site and believes "that the major pit is the only significant source of contamination to the Leederville aquifer" (WRC, 1998). Groundwater monitoring will be performed to demonstrate this conclusion.

6.5.1 Management Plan

The proposed approach to managing groundwater contamination is:

- in locations where there is groundwater contamination above levels considered suitable for irrigation purposes, the use of that groundwater resource in the immediate area will be restricted until monitoring shows otherwise.

Caveats placed on groundwater usage will be applied or removed on particular locations in response to changes in groundwater quality. This will be performed through the existing licensing provisions of the WRC.

The groundwater modelling (refer Appendix C) shows that the contamination plume is moving relatively slowly and dispersing with time. In 50 years the plume will have degraded in concentration but will have extended in size and migrated some 800 m further in a south-westerly direction. The only user identified as potentially impacted will be the Goodchild Oval bore. The exact construction details of the bore are not known, but is believed to have been partially installed within the Upper Leederville Formation.

6.5.2 Groundwater Monitoring

In order to confirm the fate of contaminants as predicted in the groundwater modelling exercise described in Section 4.4.3 and Appendix C, monitoring of the groundwater will need to be undertaken.

Groundwater monitoring will involve on-going testing of groundwater downgradient of the site and within the major pit to confirm the integrity of the containment wall. Groundwater monitoring of both the unconfined Guildford and confined Upper Leederville Formation is proposed. The frequency of testing and location of monitoring will be determined in consultation with the EPA and WRC. Results of the monitoring programme will be evaluated and assessed against the relevant protection criteria and reported to the EPA and WRC.

Monitoring will continue until contaminant concentrations have conclusively been demonstrated for a period of three years to comply with the prevailing irrigation quality criteria. Thereafter, any further groundwater testing will be confined to the major pit and adjoining monitor bores.

6.6 AIRBORNE EMISSIONS

The waste material contains gases which will be released during the excavation of the major pit. These gases have the potential to cause nuisance and represent a health risk in sufficient concentration.

6.6.1 Management Plan

The proposed approach to managing airborne emissions is:

- expose the minimal amount of waste material during excavation;
- cover any stockpiled waste material;and
- utilise vapour suppression methods when handling odourous waste material.

6.6.2 Monitoring of Air Emissions

Air monitoring will involve continuous testing for sulphur dioxide which is the primary air emission of concern. This will be performed both on-site in areas with a high potential such as near the pit and off-site with regard to exposure to the public. Other airborne contaminants will also be monitored on a regular basis.

The details of the proposed air monitoring program are outlined in Section 7.2.

6.7 TRANSPORTATION OF WASTE

Under the Dangerous Goods regulations administered by the Department of Minerals and Energy (DME), the solid component of the Omex waste is not classified as a 'dangerous good'. Nevertheless trucks and drivers will operate according to best practice and will be required to adhere to the safe practices outlined in the regulations.

Liquid wastes will be transported in accordance with the Environmental Protection (Liquid Waste) Regulations, 1996. Due to the low pH (1) of the non-oil liquid wastes, pretreatment will be required as the Forrestdale Liquid Waste Treatment Plant is not licensed to accept such acidic waste.

Truck drivers will also be required to comply with an Occupational Health and Safety (OHS) Plan developed specifically for the remediation project.

To prevent the accidental spillage or release of waste material in transit including vapour emissions, the following factors have been considered:

- Number of times the material is handled; e.g. loading and unloading will be kept to a minimum as a reduction in the amount of handling will reduce the risks of accidental spillage.

- The acidic nature of the waste material represents a corrosion potential and risk to human health on contact. In addition, the physical structure will determine the type of containers used to hold the waste. The moisture content of the solid waste will be as low as possible, for ease of handling, and to reduce the potential of spillage.

- Loads of waste will be appropriately covered to avoid the release of dust, vapours or fumes.

- Vehicles will be tracked in transit and an emergency response plan implemented to ensure prompt spill response and minimal subsequent clean-up time in the unlikely event of an accidental spillage.

The details of handling and shipment of waste are described in Section 7.7.

Where waste is to be disposed to a local landfill, the use of road transport is the only available option. However, if there is some highly contaminated waste which must be disposed of at the Mt Walton East IWDF, this waste could be transported by either road or rail depending on the relative merits of each option.

Where waste is to be disposed to Mt Walton East IWDF, the waste will be required to be contained in secured temporary storage. In addition, the transportation of this waste will require environmental clearance prior to shipment off-site. Testing to date indicates that the Omex waste will not be required to be disposed at the Mt Walton East IWDF (refer Table 11, S 4.2).

The Golder Report (1997) recommends a combination of road and rail transportation of the waste to the Mt Walton East IWDF. The evaluation process for selecting a combination of road and rail transport in preference to road only was not forwarded.

Rhone-Poulenc Chimie commissioned a study (D & M, 1997) analysing the risks of transporting low level radioactive gauge residue from a proposed plant in Pinjarra to the Mt Walton East IWDF. Conclusions derived from the qualitative risk analysis are:

- Door to door road transport can be managed as the safest and most efficient transport option.
- A decision to require rail transport for the contaminated material based on public perceptions, could have significant implications for other sites and hazardous goods.

It is acknowledged that the incidence of rail accidents in Western Australia is statistically less than that for heavy haulage on roads. However, it is the handling element that represents the greatest potential for accidental spillage.

Use of rail would involve loading onto road transport at the Omex site and shipment to the Kewdale rail freight terminal where the waste would then be off-loaded onto rail cars. From Kewdale the waste material would then be railed to Southern Cross where it would be off-loaded onto road trucks and transported by road to Mt Walton East via Boorabbin.

The road/rail transport option therefore involves a greater number of handling events; a total of four loading and four off-loading compared with two should the waste be transported by road directly to Mt Walton East. Road/rail transportation also still involves some 250 km of loaded road transportation or 40 % of the total journey. The total distance for the road only option is 550 km.

In view of the foregoing and given that the risks of spillage during loading and off-loading are doubled for the road/rail option compared with the road only option, the road only transportation option to the Mt Walton East IWDF is considered to represent the least risk to both the community and the environment.

Depending on the final remediation approach adopted, possible transport scenarios for the waste material are:

- Transport waste material in an untreated form directly to the disposal site.
- Transport waste material in an untreated form and treat at disposal site
- Treat waste material on site and transport to the disposal site.

SECTION 7
ENVIRONMENTAL MANAGEMENT

7.1 INTRODUCTION

During the remediation of the site, a number of environmental and social impacts could potentially arise which require management. This section describes in detail the management of these issues ranging from the control of air emissions to public and worker safety. The issues requiring management are identified as:

- nuisance odours and vapours;
- dust and noise emissions;
- vibration from machinery;
- handling of waste material;
- transport of contaminated waste and soil;
- stabilisation of earthworks;
- control of surface runoff;
- increased vehicle traffic;
- public and worker safety; and
- site security.

An important factor with regard to the above is the proximity of existing residential areas to the site. At the start of remedial works, the nearest residences will be within 80 m of the western margin of the major pit.

The source of these issues and their management are discussed in the following sub-sections.

7.2 AIR EMISSIONS

Potential exists for the release of gases, odours and vapours from the waste material during the remediation. This will occur when the pit is open. The following measures will be employed to minimise the release of such emissions:

- sumps will be installed beneath the existing cover so that the liquid waste can be pumped directly from the pit to a storage tank/tanker. Therefore the transfer of liquid waste from pit to tank will be conducted within a closed environment;

- the cover will be resealed around the pump pipework or any other intrusion;

- venting of any storage containers will be via carbon filters designed to remove gases and vapours;

- the HDPE cover will be removed in a manner that limits the release of emissions to acceptable levels. This will be done in sections as the face of the excavation is worked;
- on completion of work, the pit will be covered with a removable cover so that odour emissions are kept to a minimum; and
- there will be regular air monitoring which will be continuously compared against nominated alert and action levels (refer Table 7, S 3.4.2 for details).

Continuous monitoring for sulphur dioxide and intermittent monitoring of lead, PAHs and fine particulates will be undertaken at the site boundary during removal of contaminated material. Should levels of these compounds be identified above the relevant criteria shown on Table 7, operations will cease until the release of gases is managed to acceptable levels. This may include covering the source, vapour extraction and treatment, or other appropriate management procedures. Once the remedial works are underway the EPA may request that other gases are tested for as part of the air monitoring program.

Proposed air monitoring locations include inside the Omex site adjacent to the working pit, the trommel and stockpiles of contaminated material. Other sites are along the Omex site boundary in a downwind location and at the primary school.

Air monitoring and laboratory testing of the waste material have indicated no flammable compounds. The flashpoint of the waste material is very high, therefore the issue of fire hazard is considered low. However the presence of oil does represent a potential fire hazard, the management of which is discussed in Section 7.9.

A contingency plan to deal with vapour control will be incorporated into the contractor's OHS plan.

7.3 DUST

The operations of trucks and earthmoving equipment has the potential to generate contaminated and nuisance dust.

Management of dust from contaminated areas subject to earthmoving activities and from contaminated stockpiles is an important environmental consideration, as there is the possibility of contaminated material being inadvertently spread from uncontrolled airborne dust emissions.

The proposed remediation program will be managed to prevent dust emissions. The solid waste excavated from the pit will contain residual oil and water. The presence of moisture within the solids should minimise dust emissions during excavation.

Dust may be generated from the limestone pad placed on the pit base by the earthmoving operation, this will be suppressed with water sprays. Water which may seep through the limestone pad will be collected by the ongoing dewatering programme and therefore will subsequently be treated.

Trucks and roads will be wetted down where necessary and fine water sprays will be employed to minimise dust generation in working areas. Application of a fine water spray will prevent water runoff from occurring in these areas.

The contractor will be required to comply with the Department of Environmental Protection's Land Development Sites and Impacts on Air Quality Guidelines for fugitive dust emissions, 1996 and Interim Policy No 18; 'Air Quality Impacts from Development Sites', July 1997'. The acceptable limit for dust concentration in the atmosphere is 1,000 ug/m^3 measured over a 15 minute time period. This limit applies to total dust only, contaminants and fine particulate material contained within the dust are to be assessed against the much more stringent health based criteria outlined previously in Section 3.4.2.

The following actions may also be undertaken to manage dust generation:

- in dry conditions; access tracks, roads, stockpiles and operational areas will be kept damp with the use of water trucks. This will be especially applicable to contaminated areas. A water truck will be available throughout the remediation phase;
- stockpiles of contaminated material and limestone will be kept covered when inactive;
- wind fencing will be placed around the site boundary and on the periphery of contaminated areas undergoing excavation;
- intermittent monitoring of dust emissions for the presence of potential airborne contaminants from the waste material;
- response monitoring of reported incidences relating to nuisance dust emissions from the site;
- a vehicle wash down pond will be provided on the exit route from the site to remove excess soil adhering to vehicles;
- all machinery used in contaminated zones will be thoroughly cleaned by high pressure water spray or equivalent prior to leaving that location to prevent the spread of contaminated material. Any residual material captured from cleaning the machinery during washdown will be disposed of appropriately.

7.4 NOISE

Noise will be generated by earthmoving machinery, treatment equipment and trucks moving to and from the site. The immediate area surrounding the site will be vacant with the nearest residential property at a distance of 80 m from the western boundary of the major pit.

The majority of the earthworks will be conducted inside the pit below the natural ground level. The pit should therefore provide noise attentuation and reduce the noise emissions from the site.

Some noise will be generated from the trommel used to treat the waste. The level of noise is similar to mobile batching plants which operate in the metropolitan region.

All contractors working on-site will be obliged to meet the requirements of *Environmental Protection (Noise) Regulations, EPA, 1997.* In order to achieve this and minimise disruption to residents, the following actions to mitigate noise emissions will be employed:

- machinery will generally operate only during daylight hours between 0700 and 1800 hours Monday through to Saturday;
- all equipment including trucks will be in good working order with effective silencers; and
- occupational noise exposure will be in compliance with Worksafe WA requirements thus limiting the potential for off-site impacts.

The remediation contractor will be required to undertake noise monitoring to the satisfaction of the EPA to provide evidence of compliance with the noise regulations. Modifications to equipment will be required if noise levels are found to exceed the regulatory standard.

7.5 VIBRATION

Vibration will be generated by earthmoving machinery, trucks, the trommel and compaction equipment associated with the remediation program. Contractors will be obliged to take every reasonable effort to minimise vibration.

The temporary presence of excavators and trucks is a common practice within residential areas. Vibration from the trommel used to treat the waste will be similar to mobile batching plants which operate in the metropolitan region. Vibration is not expected to be a significant issue in the remediation process.

In order to control vibration and reduce or eliminate possible complaints or damages claims, the contractor will be required to comply with the requirements of *AS 2670.2 - Evaluation of Human Exposure to Whole Body Vibration*.

7.6 SURFACE RUNOFF

Remediation of the site will be managed to prevent or minimise stormwater runoff from entering areas of exposed contaminated waste. Conversely any runoff generated from waste stockpile and operational areas will be contained on-site and disposed of according to the level of contamination.

This will be performed by directing runoff which enters the pit into a sump where it can be pumped out for appropriate disposal. Stockpiled areas will be placed on a hardstand surface or compacted limestone base and have a perimeter drain which is directed into the pit or a purpose built sump.

Following remediation, surface runoff will be directed off the backfilled pit as described previously in Section 6.2.

7.7 CONTAMINATED SOIL TRANSPORT

All contaminated material will be transported in accordance with best working practices to minimise the risk to human health and the environment along the proposed transport route as noted in Section 6.7. The management of transporting the soil is outlined in this section.

The possibility of spillage of solid waste material during transit will be minimised by ensuring the loads are covered and the trucks are not fully laden. In the event of an overturned vehicle, the waste product will be in solid form which removes the potential for extensive spillage and spread of contamination. Liquid wastes will be transported in accordance with the Liquid Waste Regulations.

The following practices will be employed to minimise the risk of accidental spillage whilst the waste is in transit and to ensure the waste is disposed at the appropriate destination:

- a record of the contaminant characteristics for all waste transported from the site will be kept in a Waste Transport Register (WTR). This will ensure that the waste is disposed to the appropriate class of landfill;
- all waste material will be subject to a consignment system that allows the tracing of all loads from the site to ensure all material reaches the appropriate destination. The practice of consigning loads will allow for a record of the fate of all materials removed from the site, this will be supplied to the site superintendent (DEP representative) as required;
- under no circumstances should any material be able to leak or escape from the transport vehicles; therefore contaminated material will be transported in covered, properly sealed trucks for solids and licensed tankers for liquid wastes;
- the transport program will include the use of purpose built covers or vapour suppression compounds as necessary to control odours, fumes and dust;

- all trucks will be loaded well within the volume and weight capacity for that vehicle to limit the potential for accidental spillage on route;
- trucks will be inspected prior to departure to ensure cover and tailgates are secured;
- a road sweeper will be used on a regular basis to clean public roads in the immediate vicinity of the site;
- all drivers will undertake a briefing prior to commencement of work, and each truck will be equipped with a two way radio to enable contact to be maintained at all times;
- an emergency response plan will be drafted for dealing with accidental spillage on route which will include; basic spill containment equipment on all trucks and chains of command including contact names and telephone numbers for clean-up crews and the emergency authorities. The hazard potential of any material will be known to the emergency response team via the materials register. The remediation contractor will be responsible for the clean-up of all spills; and
- a vehicle wash down pond will be provided on the exit route from the landfill facility to remove potentially contaminated soil adhering to vehicles.

7.8 TRANSPORT ROUTE

The contaminated material will be transported to the appropriate class of landfill. The landfill site for Class V material will be the Mt. Walton IWDF (Intractable Waste Disposal Facility)and for Class IV material, it is most likely that it will be the local Red Hill facility located on the fringes of the metropolitan area. Low level contaminated material (Class II or III) can potentially be disposed at any of a number of local landfill facilities.

With regard to lower classes of waste, the selection of landfill sites have not yet been determined and will be subject to a tender process which will be performed prior to remedial works commencing.

The transport route to the relevant landfill site will be determined in consultation with the DME and EPA. Although the Omex wastes are not 'dangerous goods', the route will be selected consistent with the DME Guidance Note T117: *Recommendations for Route Selection for the transport of Dangerous Goods in the Perth Metropolitan Area.* These guidelines recommend that the transport route is kept to the major road network and that congested and environmentally sensitive areas are avoided.

The most appropriate immediate transport route from the site onto the major arterial road network is:

- exit northern part of Omex site onto Purton Pl and west along Rason Pde to Clayton St;
- west along Clayton St to Robinson Rd;
- north along Robinson Rd (no eastern access to Great Eastern Hwy);
- west along Elgee Rd;
- north along Bushby St;
- enter and travel east along Great Eastern Hwy onto the Roe Hwy intersection; and
- north along Roe Hwy to Red Hill or continue east on Great Eastern Hwy to Mt. Walton East IWDF.

The return route to the site will be as the departure route with the exception of entering directly onto Robinson Rd from Great Eastern Hwy.

The proposed immediate transport route from the site will utilise existing main roads and should not adversely impact on road safety. The projected additional traffic volume arising during the remediation phase will be between 100 and 150 movements per day over a period of between three and four months. This represents 2% of the existing daily weekday traffic volume along Clayton Street near the Omex site which is in the order of 7,500. The primary school site located on Clayton Street will be avoided. The proposed route is shown on Figure 12.

Truck operators will be required to comply with the Road Traffic Act (1974).

7.9 PUBLIC AND WORKER SAFETY

The proposed remedial works will involve the excavation and handling of waste oils, solids and water which may contain significant levels of contaminants. Owing to the nature and the level of contamination, there exists the possibility for adverse health effects in unprotected personnel excavating or working in close proximity to such material.

The potential contaminants which maybe encountered are: acidic solids and water, inorganic substances such as heavy metals; hydrocarbons including phenols and polycyclic aromatic hydrocarbons; and acid gases such as sulphur dioxide.

Heavy machinery will be operating on the site with transportation trucks entering and leaving during the remedial works. As the waste material is removed from the pit, the excavation will become a deep (up to a maximum of 10 m) confined work space.

The oil component of the pit represents a potential fire hazard, however tests have shown that the flashpoint is well above 100 °C (Golder, 1997). The remediation contractor will be required to provide for fire management as part of a site specific Occupational Health and Safety (OHS) Plan.

Safe working practices will ensure that the health of site workers and the public are protected. Contractors performing the remedial works will be required to prepare an OHS plan which will be forwarded to Worksafe WA and the EPA for their review and advice prior to commencement of remedial works. The purpose of the OHS plan is to indicate the monitoring and safety requirements for handling contaminated materials. Remedial work that involves the disturbance of contaminated materials will not be allowed until such time as the OHS Plan has been approved by the project superintendent who represents the proponent on-site.

The main method of ensuring the health and safety of the public and site personnel will be to protect against possible exposure to contaminated materials.

The degree of protection required is determined by knowledge of:

1. contamination levels;
2. effects from exposure to these contaminants; and
3. level of risk associated with exposure to the contaminants.

In order to protect the public and site personnel, the elimination or limitation of potential exposure pathways is required. This will be achieved using health and safety measures outlined in the following sections.

7.9.1 Worker Health and Safety Measures

In addition to chemical hazards associated with the waste material, necessary precautions will need to be taken with regard to the following physical hazards:

- operation of heavy plant equipment including excavators, pumps, etc;
- working near deep excavations;
- overhead power lines;
- underground services (including gas and electricity); and
- handling of excavated materials particularly any heavy buried structures or buried pipes that may be encountered.

The safety of all personnel on site will be the responsibility of the contractor, as previously mentioned, will be required to develop and implement an OHS plan. To ensure that remedial works are undertaken safely and in the manner outlined in this remediation plan - a Project Health and Safety Officer (PHSO) shall be appointed.

The PHSO will have the authority to direct work, including stoppages, as and when contaminated material is encountered, and therefore will work in close liaison with the contractor's representative.

The following necessary health and safety measures will be applied according to the nature of the material being handled and the particular tasks being undertaken with regard to that material. The actual measures implemented will be determined by the PHSO in consultation with Worksafe WA and the EPA. The proposed health and safety measures are:

- Education and training prior to any remedial works to ensure that all personnel are aware of the nature of the materials on-site, the exposure risks, exposure routes, and the precautions to minimise both on-site and off-site exposure, and the risks associated with transporting waste materials off-site.

- Site safety will be supervised by the PHSO who will be permanently on-site during working hours to provide advice and undertake any necessary monitoring.

- Responsibility and management of personal health and safety will be clearly defined for all personnel working on-site.

- Monitoring of the health of site personnel may be carried out from the initial stage to the completion of works in order to assess levels of exposure, and to ensure that health and safety measures are effective.

- Areas known to contain contaminated materials will be clearly identified as "contamination zones". Only authorised personnel will work in contamination zones, and only under supervision wearing the appropriate safety equipment.

- Personnel and all site visitors will be required to wear at a minimum; protection comprising hard hats and safety boots. Site personnel working in contaminated zones may in addition need to wear overalls, gloves, acid resistant boots, safety glasses or goggles/face visor, disposable protective suits and respirators.

- Environmental monitoring within the pit for hazardous levels of air emissions and oxygen content due to the confined space.

- Operators of mobile plant and equipment will be required to keep doors and windows closed and remain in the cab at all times whilst in contaminated zones. Oxygen respirators may be required when operating in the pit.

- On leaving contamination zones, personnel will be required to change in a decontamination area. All protective clothing will be placed in the decontamination area for disposal and/or cleaning.

- An emergency shower and eye wash point will be provided on-site in case of emergencies.

- A complete first aid kit fully complying with regulatory requirements will be available on-site at all times.

- Communication equipment eg; portable telephones will be made available at all times for use in an emergency situation.
- Eating, drinking, smoking and application of sunscreens and cosmetics will be restricted to designated areas.
- Separate eating and ablution facilities will be provided in areas away from the contaminated zones.
- An emergency response plan will be drafted which will include the alert and action thresholds for protection from air emissions (Section 3.4.2), chains of command including contact names and telephone numbers, and a detailed emergency response to potential events including site evacuation.

7.9.2 Public Safety Measures

To prevent possible direct exposure of hazardous materials to the public, access to the entire Omex site will be restricted. This will primarily be achieved through the provision of perimeter security fencing, an appropriate buffer zone and placement of warning signs outlining the potential danger.

Security of the site to prevent unauthorised access will be achieved with a 2.1 m high perimeter security fence and manually controlled access during working hours. All gates to the site will be locked outside normal working hours. Security patrols will be utilised outside of working hours.

Adequate signage will be posted regularly along the site boundary warning the public to keep out of the site by advising the danger of the site operations and the presence of contaminated material.

The public will be further protected from unacceptable air emissions from the site during the excavation of the pit by the program of monitoring and management of operations outlined in Section 7.2.

7.10 ENVIRONMENTAL SUPERVISION

To ensure that remedial works are performed to best practice and undertaken according to the approach outlined in this CER, the remediation of the site will be carried out under the guidance of an Environmental Supervisor independent of the contractor responsible for the remedial works. The presence of an Environmental Supervisor will be dictated by the works in progress, and it is not expected that the position will be required at all times.

The Environmental Supervisor will be a representative of the proponent and have the authority to dictate works through the site superintendent, including any necessary stoppages for environmental reasons, as and when the situation requires.

The tasks for the Environmental Supervisor will be as follows:

- Review the WTR records for all waste consignment to ensure compliance with the disposal requirements.
- Regularly inspect all plant and equipment working in contaminated areas to ensure adequate cleaning prior to movement out of contamination zones in order to prevent transfer of contaminants to clean areas.
- Undertake environmental monitoring within the site and on the boundaries for dust, noise and air emissions as required, and report all results to the Site Engineer and Superintendent.

7.11 ENVIRONMENTAL AUDITOR

The EPA will select and appoint a suitability qualified expert with experience in the management and remediation of contaminated sites to act as environmental auditor.

The role of the environmental auditor will be to verify the success of the site rehabilitation by inspecting the works and reviewing analytical results from time to time.

SECTION 8
COMMITMENTS

The proponent, The Waste Management Division of the Department of Environmental Protection is committed to ensuring that the remediation of the Omex site is performed in an environmentally responsible manner; and makes the following commitments:

1. The proponent will undertake soil and groundwater sampling to assess the nature and extent of oil waste contamination disposed at the Adelaide Street landfill facility. This will be performed to the requirements of the Environmental Protection Authority prior to any remedial works commencing at the landfill facility.

2. The removal of all contaminated material from the Omex site will be performed in accordance with the management techniques described in this Consultative Environmental Review. Prior to any remedial works, the proponent will prepare a detailed works program for the remediation to the requirements of the EPA.

3. All contaminated material transported from the site will be carried in appropriately equipped and labelled trucks in a manner consistent with the relevant codes that relate to the transport of the material. This will be performed in a manner consistent with the ADG Code (Australian Code for the transport of Dangerous Goods by road and rail) which is administered by the Department of Minerals and Energy.

4. The ultimate destination of all waste materials will be selected on the basis of waste acceptance criteria set by the Department of Environmental Protection. The proponent will consult with the Department of Environmental Protection during the remediation phase.

5. Dust discharges from the site will be kept within the relevant criteria set by the Department of Environmental Protection guidelines for: Land Development Sites and Impacts on Air Quality Guidelines for fugitive dust emissions.

6. Noise emissions from the site will comply with the Environmental Protection (Noise) Regulations, EPA, 1997. A noise monitoring program will be implemented during remedial works.

7. An air monitoring program will be implemented during remedial works to monitor for air emissions. Details of the monitoring program will be included in the works program forwarded to WorkSafe WA and the Environmental Protection Authority prior to commencement of remedial works.

8. Vibration from the site will comply with the requirements of Australian Standard AS 2670.2.

9. The remediation contractor will prepare a site specific Occupational Health and Safety (OHS) Plan prior to any remedial works commencing. This will be performed to the satisfaction of the proponent and the requirements of WorkSafe WA and the Environmental Protection Authority.

10. A remedial validation program inclusive of analytical and geotechnical testing will be implemented to confirm site remediation has been achieved. Results of this program will be reported to the Environmental Protection Authority upon completion of remedial works.

11. Groundwater quality and watertable levels will be monitored during and after remedial works to confirm the predictions described in the CER. Results of this monitoring will be reported to the Environmental Protection Authority and Water and Rivers Commission upon completion of remedial works, and thereafter, during the post remediation phase.

12. The proponent will fund the employment by the EPA of an independent auditor selected by the EPA to verify the success of the site rehabilitation in meeting the conditions of approval for this project.

13. A report will be prepared by the proponent at the completion of the remediation program which will provide evidence of conformance to the commitments and Ministerial Conditions set for the project. This report will be provided to the Environmental Protection Authority.

SECTION 9
REFERENCES

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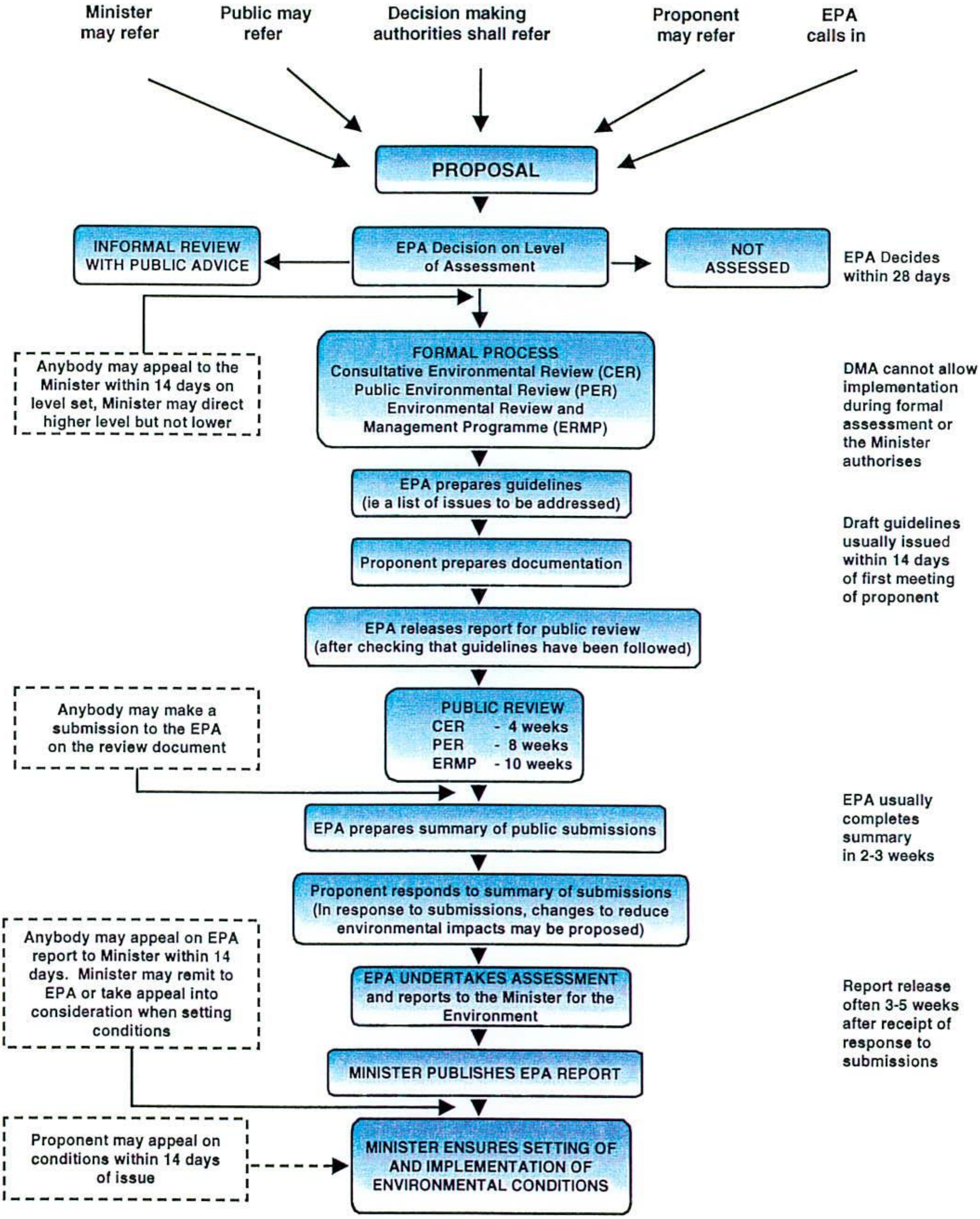
ABBREVATIONS

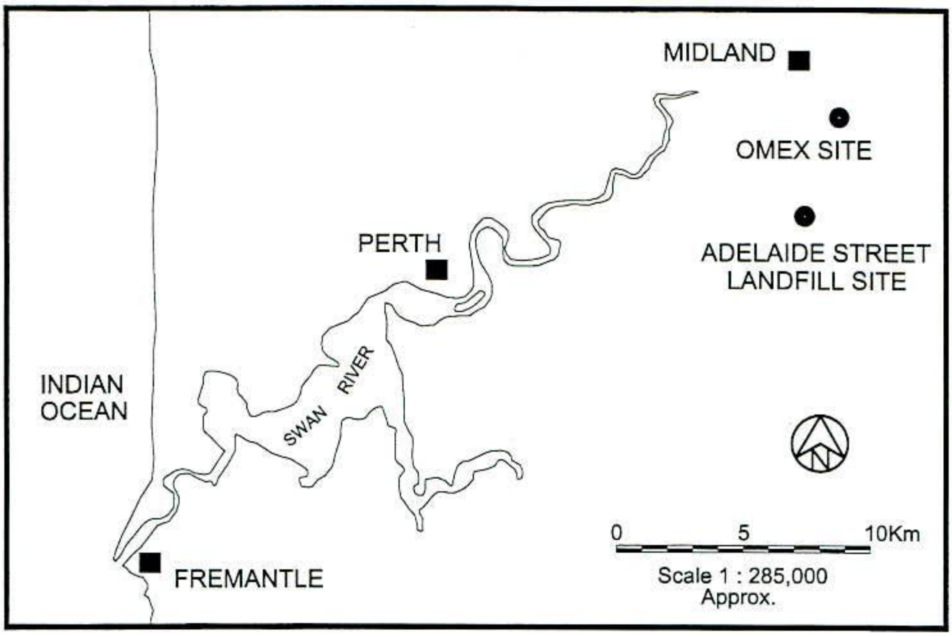
ADG	Australian Dangerous Goods
AHD	Australian Height Datum
ANZECC	Australian and New Zealand Environment and Conservation Council
AWQG	Australian Water Quality Guidelines
CCWA	Chemistry Centre (WA)
CER	Consultative Environmental Review
D&M	Dames & Moore
DEP	Department of Environmental Protection
DME	Department of Minerals and Energy
EMP	Environmental Management Plan
EPA	Environmental Protection Authority
ERMP	Environmental Review and Management Program
GSWA	Geological Survey Western Australia
HCL	Hydrochloric Acid
HDPE	High Density Polyethylene
HRA	Health Risk Assessment
IWDF	Intractable Waste Disposal Facility
LLF	Lower Leederville Formation
NATA	National Association of Testing Authorities
NHMRC	National Health and Medical Council
OHS	Occupational Health and Safety
PAH	Polycyclic Aromatic Hydrocarbons
PCB	Polychlorinated Biphenyls
PER	Public Environmental Review
PHSO	Project Health and Safety Officer
SK	Sinclair Knight and Partners
TCLP	Toxicity Characteristic Leaching Procedure
TDS	Total Dissolved Solids
TPH	Total Petroleum Hydrocarbons
ULF	Upper Leederville Formation
WAPC	Western Australian Planning Commission
WAWQG	Western Australian Water Quality Guidelines
WRC	Water and Rivers Commission
WTR	Waste Transport Register

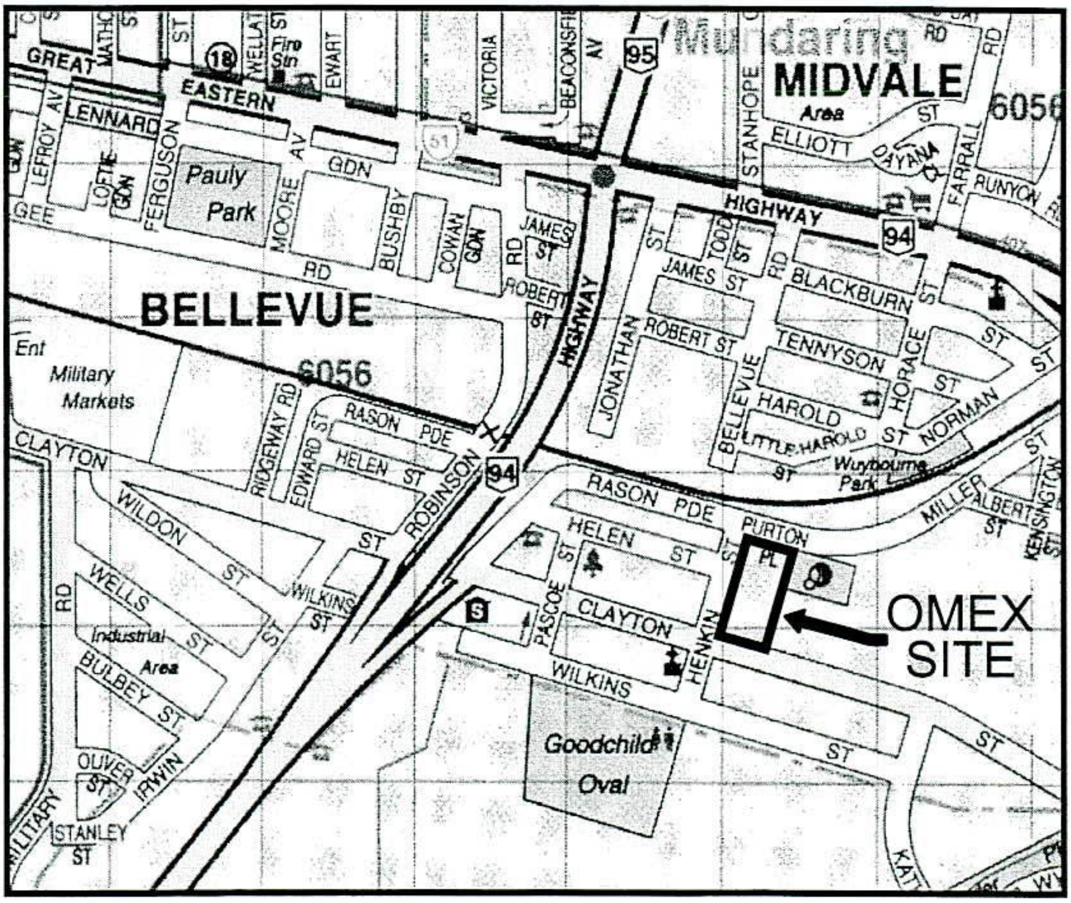
FIGURES

Figure 1

EIA PROCESS FLOW CHART







SOURCE: UBD STREET DIRECTORY

0 250m 500m
Scale

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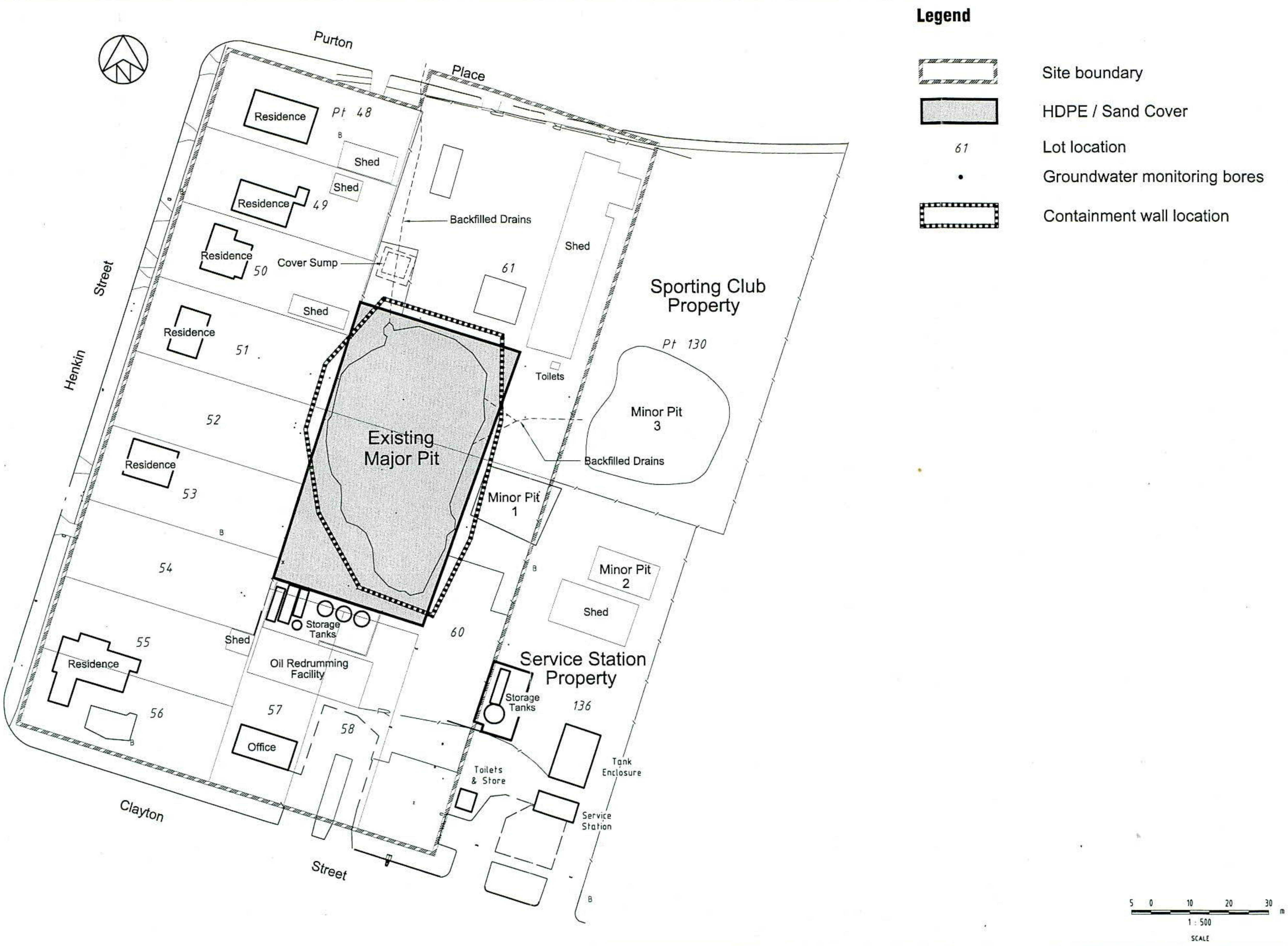
TITLE
OMEX SITE
LOCALITY MAPS

SIZE	PROJECT No	DRAWING No	SHEET No	REV
	VW1100	FIGURE 2	OF	A



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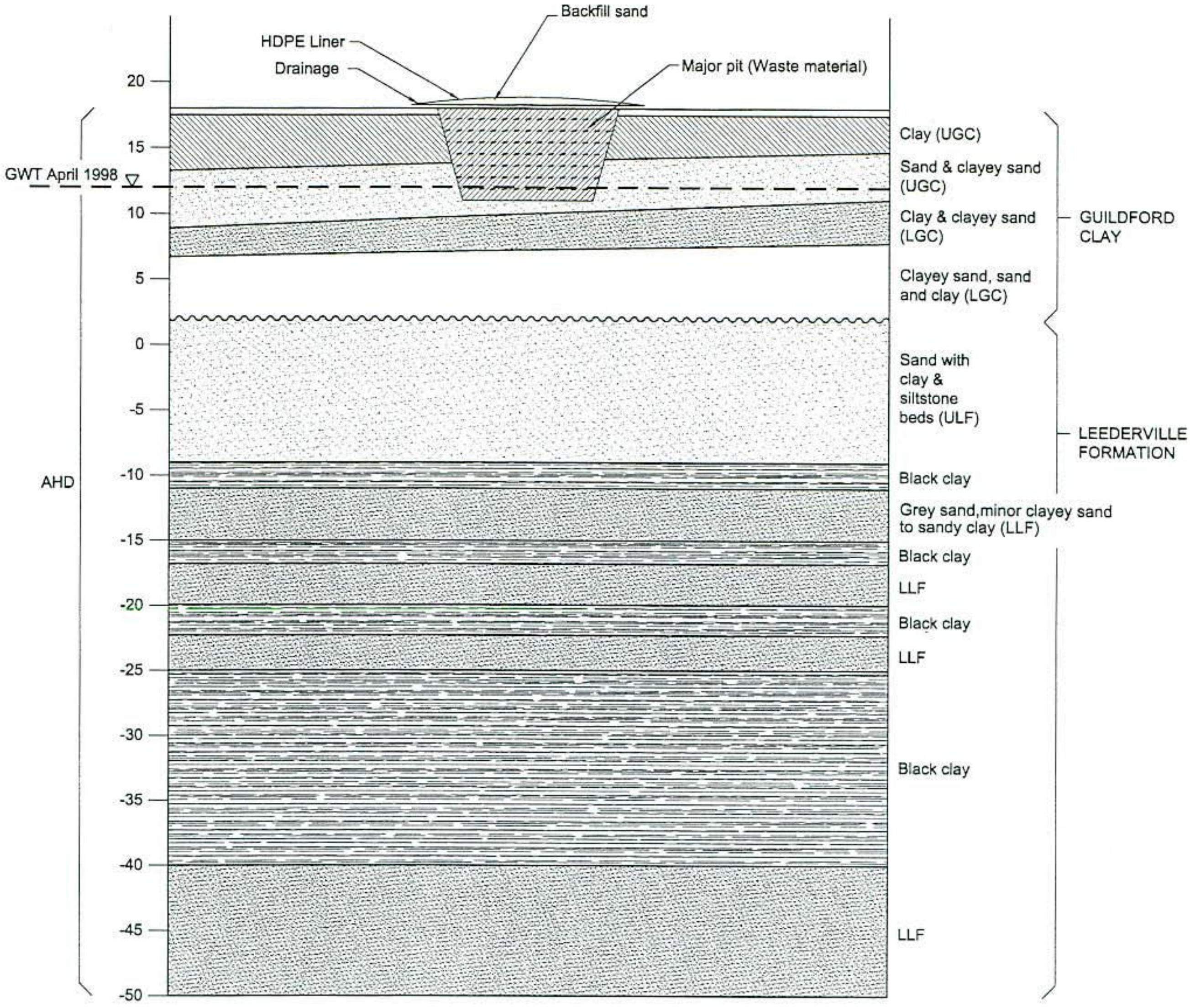
TITLE
OMEX SITE
SITE LAYOUT

SIZE	PROJECT No	DRAWING No	SHEET No	REV
	VW1100	FIGURE 3	OF	A

TYPICAL CROSS SECTION



Legend

UGC - Upper Guildford Clay
LGC - Lower Guildford Clay
ULF - Upper Leederville Formation
LLF - Lower Leederville Formation
GWT - Groundwater Table
AHD - Australian Height Datum

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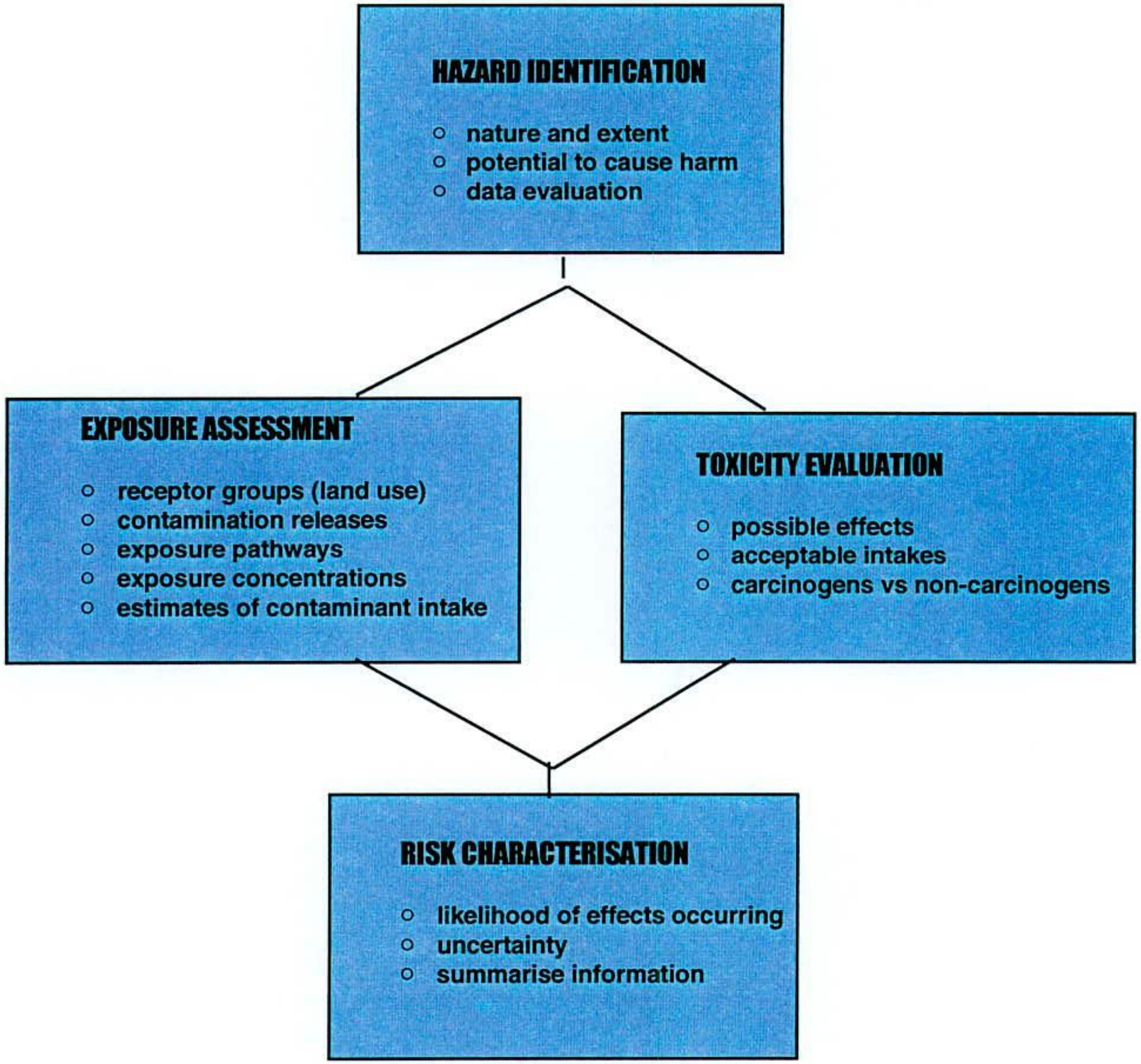
TITLE
OMEX SITE
GEOLOGICAL CROSS SECTION

SIZE	PROJECT No	DRAWING No	SHEET No	REV
	RW1100	FIGURE 4	OF	A

Figure 5

HEALTH RISK ASSESSMENT PROCESS



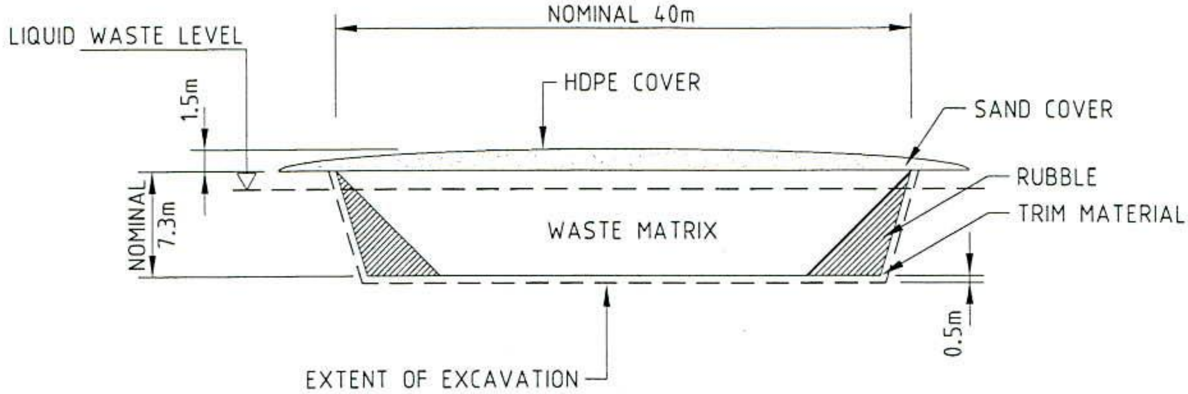


FIGURE 6A - MAJOR PIT CONFIGURATION

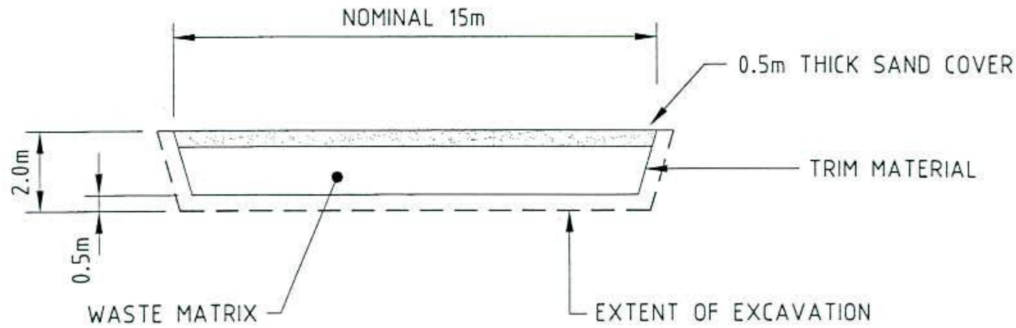


FIGURE 6B - MINOR PIT No1 CONFIGURATION

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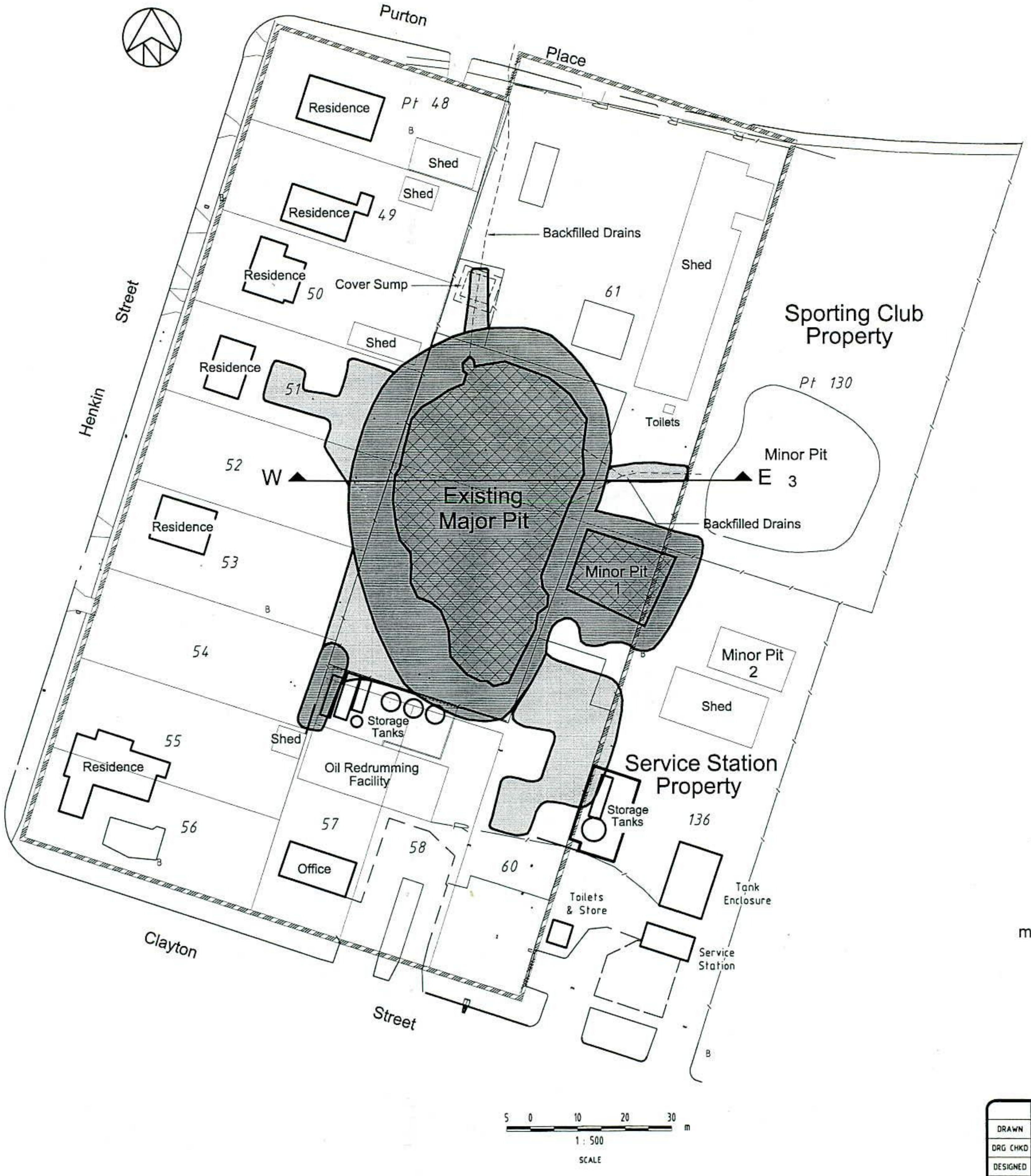
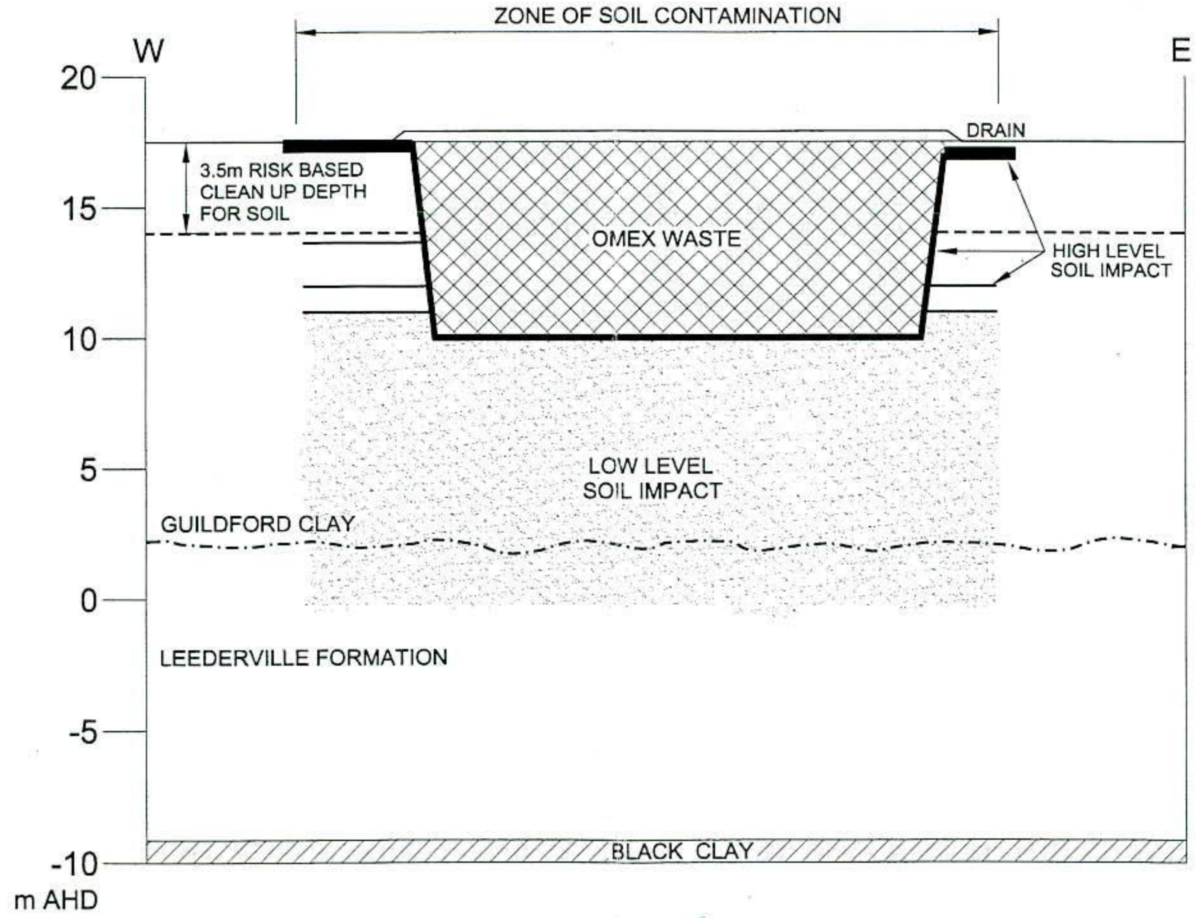
TITLE
OMEX SITE
PIT CONFIGURATION

SIZE	PROJECT No	DRAWING No	SHEET No	REV
	VW1100	FIGURE 6	OF	A



Plan Legend

- Site boundary
- Inferred extent of soil contamination shallow (<3m)
- Inferred extent of soil contamination to depth (<12m)
- Omex waste matrix



SCHEMATIC CROSS SECTION
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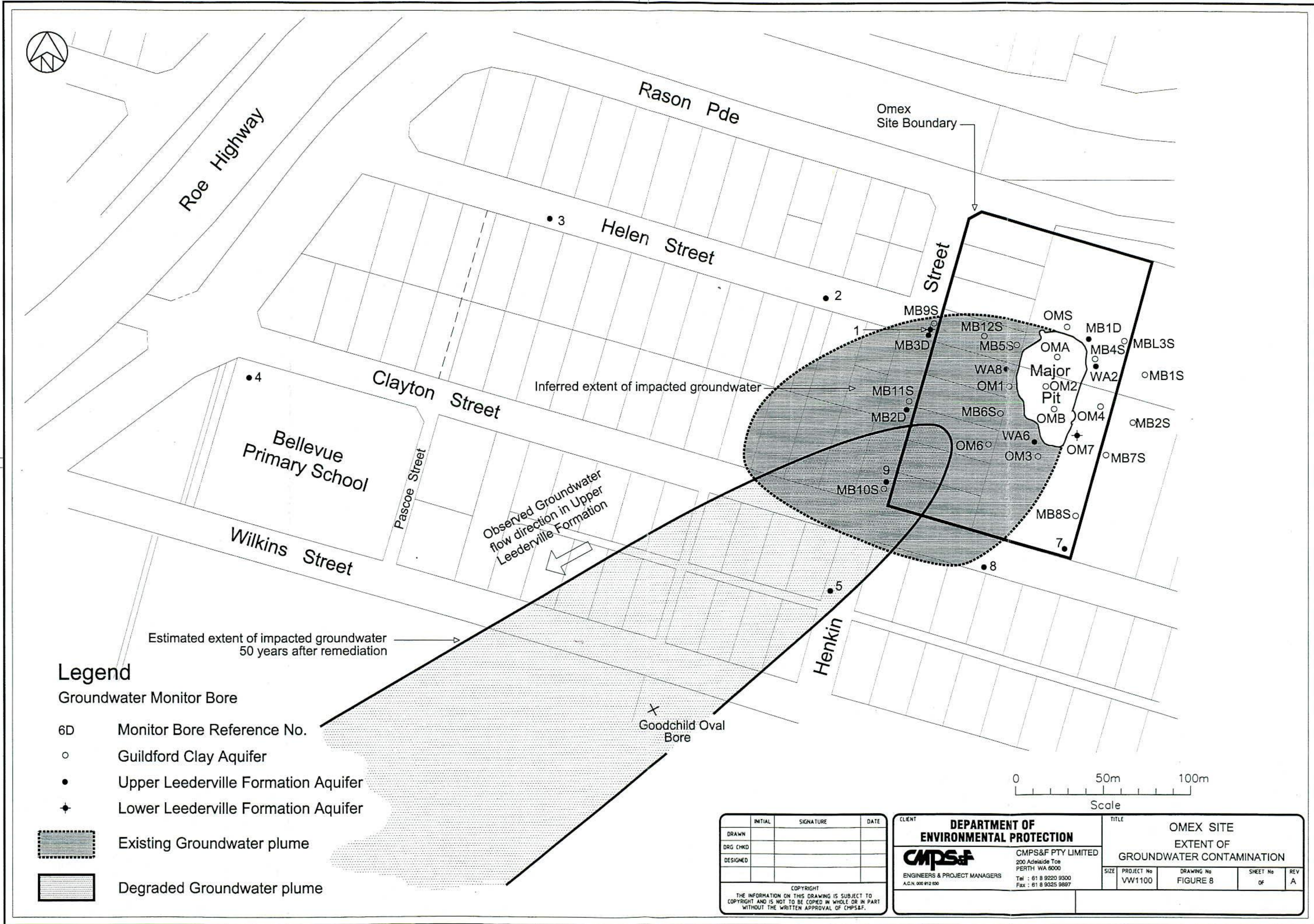
TITLE
OMEX SITE
EXTENT OF SOIL CONTAMINATION

SIZE	PROJECT No	DRAWING No	SHEET No	REV
	VW1100	FIGURE 7	OF	A



Rason Pde
Roe Highway
Helen Street
Clayton Street
Wilkins Street
Pascoe Street
Henkin
Street
Omex
Site Boundary
Bellevue
Primary School
Inferred extent of impacted groundwater
Observed Groundwater flow direction in Upper Leederville Formation
Estimated extent of impacted groundwater 50 years after remediation
Goodchild Oval
Bore
Major
Pit
1
2
3
4
5
7
8
9
MB9S
MB3D
MB12S
MB5S
OMS
MB1D
MB4S
MBL3S
OMA
WA8
WA2
MB1S
OM1
OM2
MB11S
MB2D
MB6S
OMB
OM4
MB2S
WA6
OM6
OM3
OM7
MB7S
MB10S
MB8S
Legend
Groundwater Monitor Bore
6D Monitor Bore Reference No.
Guildford Clay Aquifer
Upper Leederville Formation Aquifer
Lower Leederville Formation Aquifer
Existing Groundwater plume
Degraded Groundwater plume
0
50m
100m
Scale
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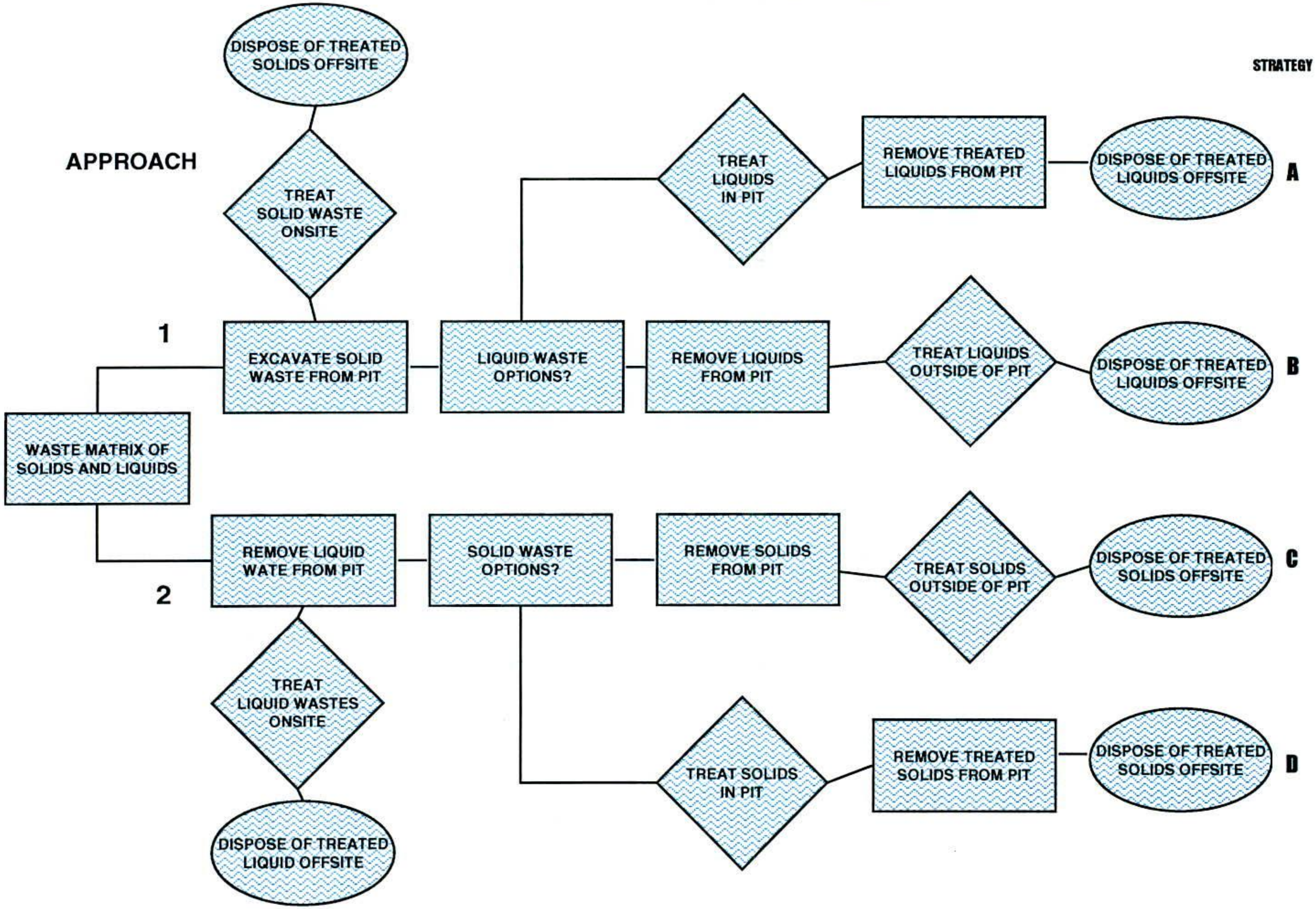
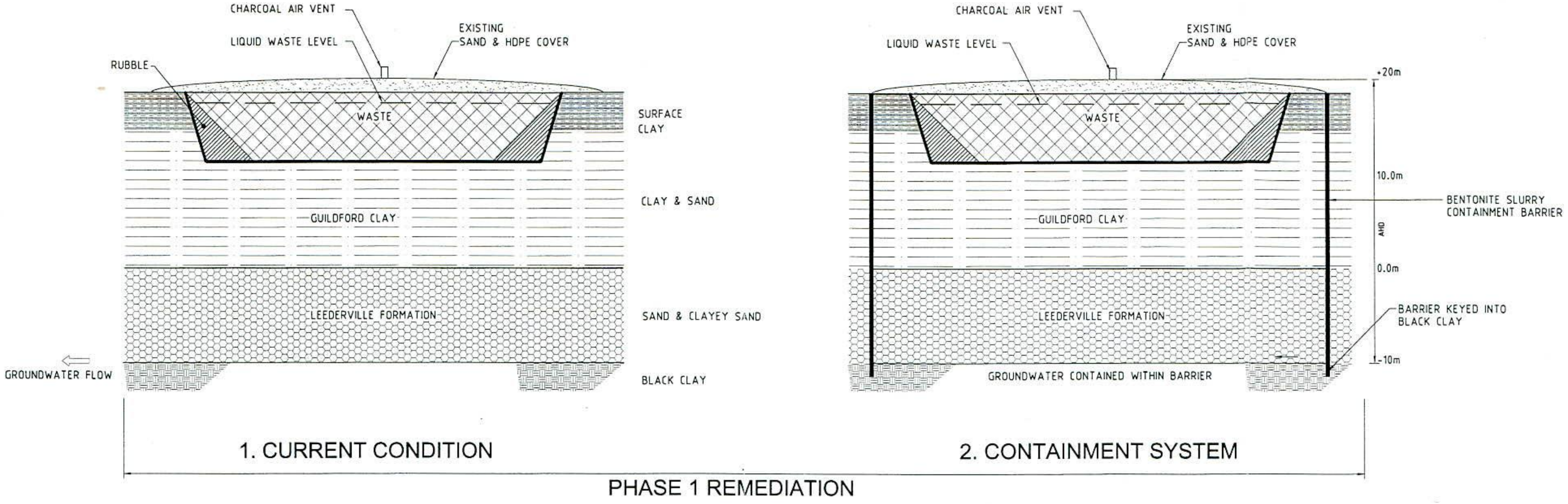
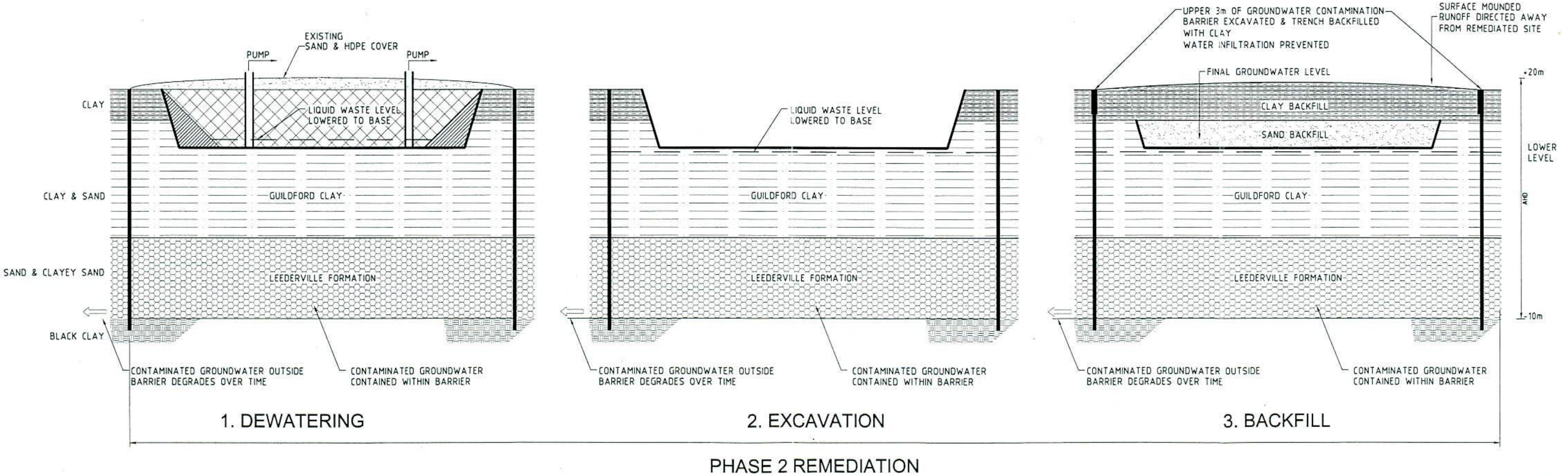
TITLE
OMEX SITE
EXTENT OF
GROUNDWATER CONTAMINATION
SIZE
PROJECT No
VW1100
DRAWING No
FIGURE 8
SHEET No
OF
REV
A

Figure 9

OPTION 5 - REMOVAL TO LANDFILL







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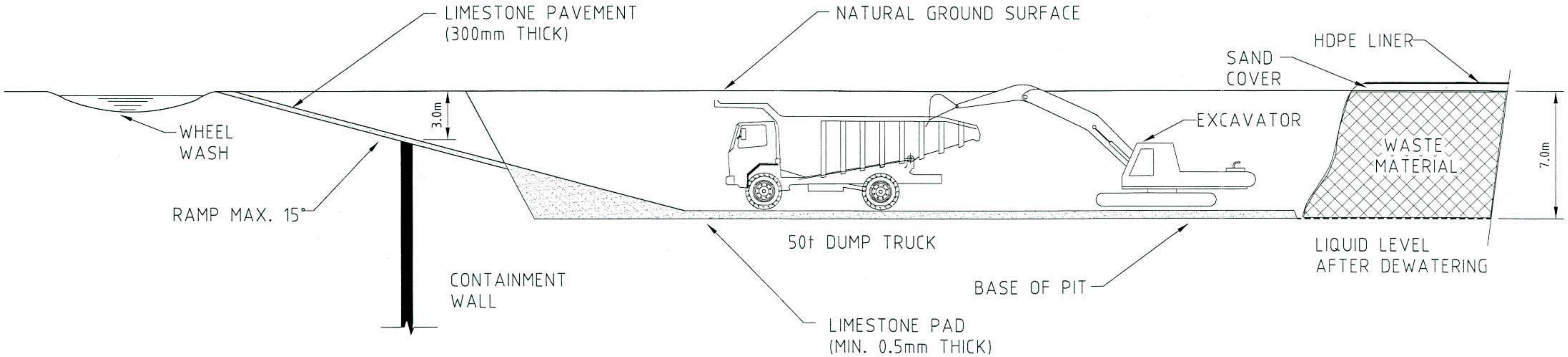
TITLE
OMEX SITE
GENERAL CONCEPT
CONTAINMENT & REMEDIATION

SIZE	PROJECT No	DRAWING No	SHEET No	REV
	VW1100	FIGURE 10	OF	A

EXCAVATION PROCESS



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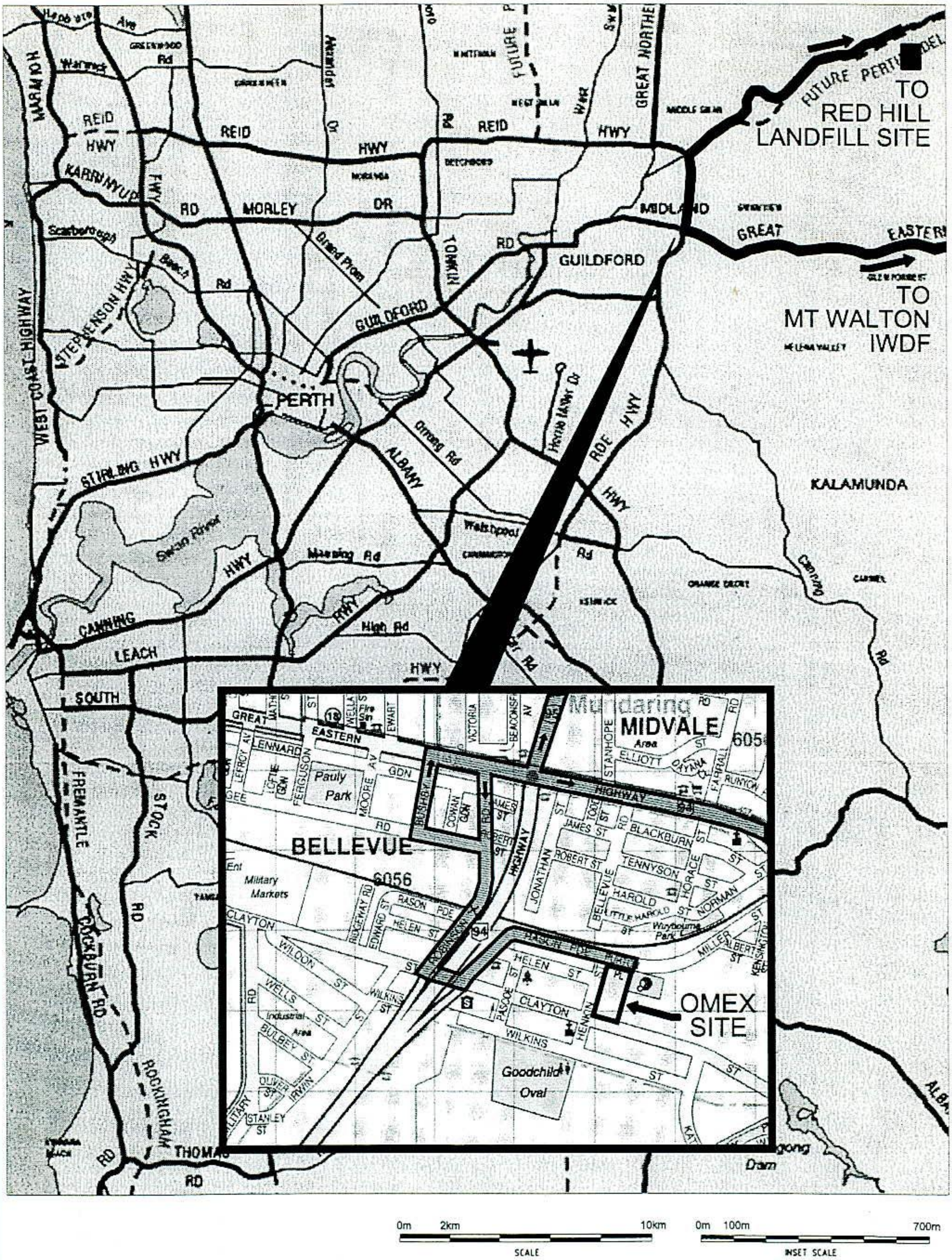
TITLE
OMEX SITE
EXCAVATION PROCESS

SIZE	PROJECT No	DRAWING No	SHEET No	REV
	VW1100	FIGURE 11	OF	A



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TITLE
OMEX SITE
PROPOSED TRANSPORT ROUTE

SIZE	PROJECT No	DRAWING No	SHEET No	REV
	VW1100	FIGURE 12	OF	A

APPENDIX A

Environmental Protection Authority
Guidelines

REHABILITATION OF OMEX CONTAMINATED SITE, BELLEVUE

(Assessment Number 1180)

Part A	Specific Guidelines for the preparation of the Consultative Environmental Review
Attachment 1	Project location map
Attachment 2	Interim EPA Policy for EIA No 17
Part B	Generic Guidelines for the preparation of an environmental review document
Attachment 3	Example of the invitation to make a submission
Attachment 4	Advertising the environmental review

These guidelines are provided for the preparation of the proponent's environmental review document. The specific environmental factors to be addressed are identified in Part A. The generic guidelines for the format of an environmental review document are provided in Part B.

The environmental review document must address all elements of Part 'A' and Part 'B' of these guidelines prior to approval being given to commence the public review.

Part A: Specific Guidelines for the preparation of the Consultative Environmental Review

1. The proposal

The Waste Management Division of the Department of Environmental Protection (DEP) (the proponent) intends to remediate contaminated land at Bellevue. The project area is indicated on the attached plan (Attachment 1).

The land is to be remediated for a future use yet to be determined, but will be to residential standard. The proposal covers land previously used for recycling of waste oil and adjacent lands. Treatment of used oils and lubricants with sulphuric acid, and dumping of byproducts into a disused clay pit on site has resulted in contamination of soil and groundwater. Contaminants include heavy metals, phenols, polycyclic aromatic hydrocarbons, petroleum hydrocarbons and sulphur. Water samples taken from the main pit are highly acidic.

The proponent also referred a proposal to build a below ground containment wall around the major contaminated pit to the EPA in December 1997. As contaminants in the major pit are below the water table, excavation of contaminated material is not possible without dewatering. The purpose of the containment wall is to prevent lateral movement of contaminants into the Leederville aquifer, and to facilitate dewatering of the major pit.

The EPA has set a level of assessment of "Informal Review with Public Advice" for construction of the containment wall. A number of appeals were lodged with the Minister for the Environment against this level of assessment, however these appeals were dismissed.

As the Waste Management Division of the DEP is the proponent for the Omex remediation, the EPA will be provided with resources to allow the Chairman to engage an independent advisor for the assessment of this proposal, in addition to the services provided by the Evaluation Division of the DEP.

The proponent should supply the project officer with an electronic copy of the document for use on Macintosh, Microsoft Word Version 6, and any scanned figures. Where possible, figures should be reproducible in a black and white format.

2. Environmental factors relevant to this proposal

At this preliminary stage, the Environmental Protection Authority (EPA) believes the relevant environmental factors, objectives and work required is as detailed in the table below:

CONTENT		SCOPE OF WORK	
Factor	**Site specific factor**	**EPA objective**	**Work required for the environmental review**
POLLUTION MANAGEMENT			
Soil contamination	Heavy metals, phenols, polycyclic aromatic hydrocarbons, petroleum hydrocarbons, sulphur	Ensure the rehabilitation of the site to an acceptable standard that is compatible with the intended land use, consistent with appropriate criteria including ANZECC guidelines, health risk assessment criteria and applicable international standards.	Outline of sampling methods, results of analysis and methodology for defining contaminants with quality assurance program. Identification of location, depth, estimated quantities and chemical and physical characteristic of contaminants, including health implications. Present results of technology trials conducted to determine most appropriate method of treatment and disposal of contaminated material. Undertake a risk assessment of the various proposed methods of treatment of contaminated material prior to transport off site. Detail information on the method and procedures for removal of pit content and removal of other Omex related contamination, as well as method and procedures for offsite disposal. Health risk assessment to identify pathways whereby contaminants may threaten the health of future site residents and the local environment. Identify the appropriate standard to be used for the cleanup, based on the results of a health risk assessment. Methods for validation of cleanup. Identify the site or sites to be used for disposal of removed wastes.

CONTENT		SCOPE OF WORK	
Factor	**Site specific factor**	**EPA objective**	**Work required for the environmental review**
Groundwater quality	Contaminated groundwater beneath the site in Guildford formation and Leederville aquifer; Groundwater down gradient of the site.	Maintain or improve the quality of groundwater to ensure that existing and potential uses, including ecosystem maintenance are protected, consistent with the draft WA Guidelines for Fresh and Marine Waters (EPA, 1993).	Identification of existing groundwater quality and location of contaminant plumes and proposed remediation of contaminated groundwater both inside and outside the proposed containment wall. Proposed cleanup standard for groundwater based on health risk assessment. Identification of proposed measures to prevent further groundwater contamination due to cleanup activities. Validation of remediation.
Air emissions	Particles and dust	Ensure that the dust levels generated by the proposal do not cause health problems, or adversely impact upon welfare and amenity, by meeting statutory requirements and acceptable standards.	Identify potential dust sources, including contaminated material, on site. Propose methods for the control of dust to minimise potential impacts on health or amenity of nearby residents and users of the adjacent bowling club. Provide details of monitoring of offsite dust impacts. Outline contingency plan in the event that contaminated dust is detected offsite to ensure that the health and wellbeing of local residents and landusers is safeguarded.
	Odour	Odours emanating from the proposed development should not adversely affect the health, welfare and amenity of surrounding land users.	Identify sources of odour and measures to be employed to minimise odour generation during remediation of the site, including methods of dealing with removal of the HDPE liner. Outline contingency plan in the event that unacceptable odour is detected offsite.

CONTENT		SCOPE OF WORK	
Factor	**Site specific factor**	**EPA objective**	**Work required for the environmental review**
	Volatile gases and other airborne gases and odour		Identify whether, toxic gases and other airborne contaminants, including HCl and H_2SO_4, are likely to be released during the site cleanup. Detail the proposed measures to minimise impact of gases on residents and users of the adjacent bowling club and commercial operators. Provide details of monitoring to detect gases offsite. Outline contingency plan in the event that unacceptable levels of gases are detected offsite to ensure the health and wellbeing of local residents and landusers.
Noise and vibration	Impacts on residents and users of adjacent bowling club	Protect the amenity of nearby residents from noise and vibration impacts resulting from activities associated with the proposal by ensuring that noise and vibration levels meet statutory requirements and acceptable standards.	Provide details of the numbers and type of equipment to be used on site, heavy vehicles used for transport of waste off site, and the hours of operation. Demonstrate that assigned noise levels will be met at the boundary of the premises. Provide details of any equipment or methods to be used on site which may result in ground vibration, the steps to be taken to minimise impacts and steps to be taken in the event that vibration impacts are felt off site.

CONTENT		SCOPE OF WORK	
Factor	**Site specific factor**	**EPA objective**	**Work required for the environmental review**
SOCIAL SURROUNDINGS			
Transport of waste	Transport and disposal of contaminated material		Undertake a risk assessment of various methods considered for transport for contaminated material from the site. Detail proposed methods for off-site disposal and transport of contaminated material. Identification of suitable landfill site(s) and transport routes. Detail the packaging or containment to be used for transport of contaminated waste to ensure that no leakage or dust lift off occurs during transport. Prepare a contingency plan to deal with spillage of waste in the event of a road accident during transport of contaminated waste.
	Road traffic safety	Ensure that roads are maintained or improved and road traffic managed to meet an adequate standard of safety.	Proposed methods for the management of increased vehicular movements associated with the remediation process to minimise impacts.

In discussing the environmental factors identified above, the CER should include the following additional specific issues:

- information on previous investigations on the geology, hydrology and hydrogeology of the site as it relates to environmental impacts form past, existing and proposed activities at the site;
- sequence of remediation of the site;
- suitability of remediation proposed for future land use;
- outline of rehabilitation proposals for disturbed areas including stabilisation, landscaping, types of native vegetation cover and the management of future drainage from the area; and

These factors should be addressed within the environmental review document for the public to consider and make comment to the EPA. The EPA expects to address these factors in its report to the Minister for the Environment.

The EPA expects the proponent to take due care in ensuring any other relevant environmental factors which may be of interest to the public are addressed.

Figures and Diagrams

The following figures and diagrams should be included in the CER document for inclusion in the EPA's assessment report to the Minister for the Environment:

- Site description figure showing:
  - existing facilities;
  - environmental features;
  - distribution of contamination;
- Sources of contamination:
  - a contaminant pathway diagram linking contamination and pollutant sources with the potential for off-site impact;
  - mass balance for the project;
- Regional environment:
  - site area surrounds showing adjacent land uses and environmentally sensitive areas and receiving environments for off-site discharges.

3. Availability of the environmental review

3.1 Copies for distribution free of charge

Supplied to DEP:

	• Library/Information Centre 9
	• EPA members 6
	• Officers of the DEP (Perth) 6

Distributed by the proponent to:

Government departments	• Department of Environmental Protection, Part V 1
	• Health Department 1
	• Water and Rivers Commission 2
	• WorkSafe WA 1
	• Main Roads WA 1
	• Ministry for Planning 1
Local government authorities	• Shire of Swan 2
Libraries	• J S Battye Library 3
	• The Environment Centre 2
	• Midland Library .... 2 (at least)
	• Guildford Library .... 2 (at least)
Other	• Conservation Council of WA 1
	• Bellevue Action Group 2
	• Other members of Omex Site Remediation Implementation Consultative Committee not already listed .... 1 each

3.2 Available for public viewing

- J S Battye Library;
- Midland Library;
- Guildford Library;
- Department of Environmental Protection Library.

Part B: Generic Guidelines for the preparation of an environmental review document

1. Overview

All environmental reviews have the objective of protecting the environment. Environmental impact assessment is deliberately a public process in order to obtain broad ranging advice. The review requires the proponent to describe:

- the proposal;
- receiving environment;
- potential impacts of the proposal on factors of the environment; and
- proposed management strategies to ensure those environmental factors are appropriately protected.

Throughout the assessment process it is the objective of the Environmental Protection Authority (EPA) to help the proponent to improve the proposal so the environment is protected. The DEP will co-ordinate, on behalf of the EPA, relevant government agencies and the public in providing advice about environmental matters during the assessment of the environmental review for this proposal.

The primary purpose of the environmental review is to provide information on the proposal within the local and regional framework to the EPA, with the aim of emphasising how the proposal may impact the relevant environmental factors and how those impacts may be mitigated and managed.

The language used in the body of the environmental review should be kept simple and concise, considering the audience includes non-technical people, and any extensive, technical detail should either be referenced or appended to the environmental review. It should be noted that the environmental review will form the legal basis of the Minister for the Environment's approval of the proposal and therefore the environmental review should include a description of all the main and ancillary components of the proposal, including options where relevant.

Information used to reach conclusions should be properly referenced, including personal communications. Assessments of the significance of an impact should be soundly based rather than unsubstantiated opinion, and each assessment should lead to a discussion of the management of the environmental factor.

2. Objectives of the environmental review

The objectives of the environmental review are to:

- place this proposal in the context of the local and regional environment;
- adequately describe all components of the proposal, so that the Minister for the Environment can consider approval of a well-defined project;
- provide the basis of the proponent's environmental management program, which shows that the environmental impacts resulting from the proposal, including cumulative impact, can be acceptably managed; and
- communicate clearly with the public (including government agencies), so that the EPA can obtain informed public comment to assist in providing advice to government.

3. Environmental management

The EPA expects the proponent to develop and implement an Environmental Management System (EMS) appropriate to the proposal consistent with the principles outlined in the AS/NZS ISO 14000 series, including provisions for performance review and a commitment to continuous improvement.

The key components which should be included in environmental review documentation, depending on the scale of the proposal, are environmental management:

- policy;
- environmental management program;
- structure and responsibility (resources);
- training program;
- monitoring and measurement program;
- corrective and preventative action;
- EMS audit; and
- management review (with feedback).

Documentation on the relevant components should be proportional with the scale of the proposal and the potential environmental impacts. If appropriate, the documentation can be incorporated into a formal environmental management system and provision made for periodic performance review. Public accountability should be incorporated into the approach on environmental management.

The environmental management program (EMP) is the key document that should be appropriately defined in an environmental review document. The EMP should provide plans to manage the relevant environmental factors, define the performance objectives, outline the operational procedures and outline the monitoring and reporting procedures which would demonstrate the achievement of the objectives.

4. Format of the environmental review document

The environmental review should be provided to the DEP officer for comment. At this stage the document should have all figures produced in the final format and colours.

Following approval to release the review for public comment, the final document should also be provided to the DEP in an electronic format.

The proponent is requested to supply the project officer with an electronic copy of the environmental review document for use on Macintosh, Microsoft Word Version 6, and any scanned figures. Where possible, figures should be reproducible in a black and white format.

5. Contents of the environmental review document

The contents of the environmental review should include an executive summary, introduction and at least the following:

5.1 The proposal

A comprehensive description of the proposal including its location (address and certificate of title details where relevant) is required.

Justification and alternatives

- justification and objectives for the proposed development;
- the legal framework, including existing zoning and environmental approvals, and decision making authorities and involved agencies; and
- consideration of alternative options.

Key characteristics

The Minister's statement will bind the proponent to implementing the proposal in accordance with any technical specifications and key characteristics[1] in the environmental review document. It is important therefore, that the level of technical detail in the environmental review, while sufficient for environmental assessment, does not bind the proponent in areas where the project is likely to change in ways that have no environmental significance.

Include a description of the components of the proposal, including the nature and extent of works proposed. This information must be summarised in the form of a table as follows:

[1] Changes to the key characteristics of the proposal following final approval, would require assessment of the change and can be treated as non-substantial and approved by the Minister, if the environmental impacts are not significant. If the change is significant, it would require assessment under section 38 or section 46. Changes to other aspects of the proposal are generally inconsequential and can be implemented without further assessment. It is prudent to consult with the Department of Environmental Protection about changes to the proposal.

Table 1: Key characteristics (example only)

Element	Description
Life of project (mine production)	< 5yrs (continual operation)
Size of ore body	682 000 tonnes (upper limit)
Area of disturbance (including access)	100 hectares
List of major components • pit • waste dump • infrastructure (water supply, roads, etc)	refer plans, specifications, charts section immediately below for details of map requirements
Ore mining rate • maximum	 • 200 000 tonnes per year
Solid waste materials • maximum	 • 800,000 tonnes per year
Water supply • source • maximum hourly requirement • maximum annual requirement	 • XYZ borefield, ABC aquifer • 180 cubic metres • 1 000 000 cubic metres
Fuel storage capacity and quantity used	litres; litres per year
Heavy mineral concentrate transport • truck movements (maximum)	 • 75 return truck loads per week

Plans, Specifications, Charts

Adequately dimensioned plans showing clearly the location and elements of the proposal which are significant from the point of view of environmental protection, should be included. The location and dimensions (for progressive stages of development, if relevant) of plant, amenities buildings, accessways, stockpile areas, dredge areas, waste product disposal and treatment areas, all dams and water storage areas, mining areas, storage areas including fuel storage, landscaped areas etc.

Only those elements of plans, specifications and charts that are significant from the point of view of environmental protection are of relevance here.

Figures that should always be included are:

- a map showing the proposal in the local context - an overlay of the proposal on a base map of the main environmental constraints;
- a map showing the proposal in the regional context; and, if appropriate,
- a process chart / mass balance diagram showing inputs, outputs and waste streams.

The plan/s should include contours, a north arrow, a scale bar, a legend, grid co-ordinates, the source of the data, and a title. If the data is overlaid on an aerial photo then the date of the aerial photo should be shown.

Other logistics

- timing and staging of project; and
- ownership and liability for waste during transport, disposal operations and long-term disposal (where appropriate to the proposal).

5.2 Environmental factors

The environmental review should focus on the relevant environmental factors for the proposal, and these should be agreed in consultation with the EPA and DEP and relevant public and government agencies. Preliminary environmental factors identified for the proposal are shown in Part A of these guidelines.

Further environmental factors may be identified during the preparation of the environmental review, therefore on-going consultation with the EPA, DEP and other relevant agencies is recommended. The DEP can advise the proponent on the recommended EPA objective for any new environmental factors raised. Minor matters which can be readily managed as part of normal operations for the existing operations or similar projects may be briefly described.

Items that should be discussed under each environmental factor are:

- a clear definition of the area of assessment for this factor;
- the EPA objective for this factor;
- a description of what is being affected - why this factor is relevant to the proposal;
- a description of how this factor is being affected by the proposal - the predicted extent of impact;
- a description of where this factor fits into the broader environmental / ecological context (only if relevant - this may not be applicable to all factors);
- a straightforward description or explanation of any relevant standards / regulations / policy;
- environmental evaluation - does the proposal meet the EPA's objective as defined above;
- if not, environmental management proposed to ensure the EPA's objective is met;
- predicted outcome.

The proponent should provide a summary table of the above information for all environmental factors, under the three categories of biophysical, pollution management and social surroundings:

Table 2: Environmental factors and management (example only)

Environmental Factor	EPA Objective	Existing environment	Potential impact	Environmental management	Predicted outcome
BIOPHYSICAL					
vegetation community types 3b and 20b	Maintain the abundance, species diversity, geographic distribution and productivity of vegetation community types 3b and 20b	Reserve 34587 contains 45 ha of community type 20b and 34 ha of community type 3b	Proposal avoids all areas of community types 20b and 3b	Surrounding area will be fully rehabilitated following construction	Community types 20b and 3b will remain untouched Area surrounding will be revegetated with seed stock of 20b and 3b community types
POLLUTION MANAGEMENT					
Dust	Ensure that the dust levels generated by the proposal do not adversely impact upon welfare and amenity or cause health problems by meeting statutory requirements and acceptable standards	Light industrial area - three other dust producing industries in close vicinity Nearest residential area is 800 metres	Proposal may generate dust on two days of each working week.	Dust Control Plan will be implemented	Dust can be managed to meet EPA's objective
SOCIAL SURROUNDINGS					
Visual amenity	Visual amenity of the area adjacent to the project should not be unduly affected by the proposal	Area already built-up	This proposal will contribute negligibly to the overall visual amenity of the area	Main building will be in 'forest colours' and screening trees will be planted on road	Proposal will blend well with existing visual amenity and the EPA's objective can be met

5.3 Environmental management commitments

The implementation of the key characteristics of the proposal and the consolidated environmental management commitments made by the proponent become legally enforceable under the conditions of environmental approval issued in the statement by the Minister for the Environment. All the key environmental management commitments should be consolidated in the public review document in a list (usually in an Appendix). This list is attached to the Minister's statement and becomes part of the conditions of approval.

The proponent's compliance with the consolidated environmental management commitments will be audited by the DEP, so they must be expressed in a way which enables them to be audited.

A commitment needs to contain most of the following elements to be auditable:

- who (eg. the proponent)

- will do what (eg. prepare a plan, take action)
- why (to meet an environmental objective)
- where/how (detail the action and where it applies)
- when (in which phase, eg. before construction starts)
- to what standard (recognised standard or agency to be satisfied)
- on advice from (agency to be consulted).

The proponent may make other 'commitments', which address less significant or non-environmental matters, to show an intention to good general management of the project. Such 'commitments' would not be included in the consolidated list of environmental management commitments appended to the statement.

Continuous improvement during the implementation of the consolidated commitments may necessitate changes, which can be made in updates to the environmental management plan, whilst ensuring the environmental objective is still achieved. Additional proponent commitments arising from the fulfilment of environmental conditions will be audited by the DEP.

Once the proposal is approved, changes to the consolidated commitments constitute a change to the proposal and should be referred to the EPA.

Examples of the preferred format for typical commitments are shown in the following table:

Table 3: Summary of proponent's commitments (example only)

Commitment (Who/What)	Objective (Why)	Action (How/Where)	Timing (When)	Whose advice	Measurement/ Compliance criteria
1. XYZ Mining will develop a rehabilitation plan	to protect the abundance, species diversity, geographic distribution and productivity of the vegetation community types 3b and 20b	by limiting construction to a small area (10 ha) of Reserve 34587 and rehabilitating the area	before construction	CALM, NPNCA	fences built; species distribution and density consistent with vegetation community types 3b and 20b
2. XYZ Mining will minimise dust generation	to maintain the amenity of nearby land owners	by preparing and implementing a Dust Control Plan which meets EPA Dust Control criteria	before the start of construction phase	preparation: DEP; implementation: Shire	Letter from Shire submitted with Performance and Compliance Report.

Commitments should be written in tabular form, preferably with some specification of ways in which the commitment can be measured, or how compliance can be demonstrated.

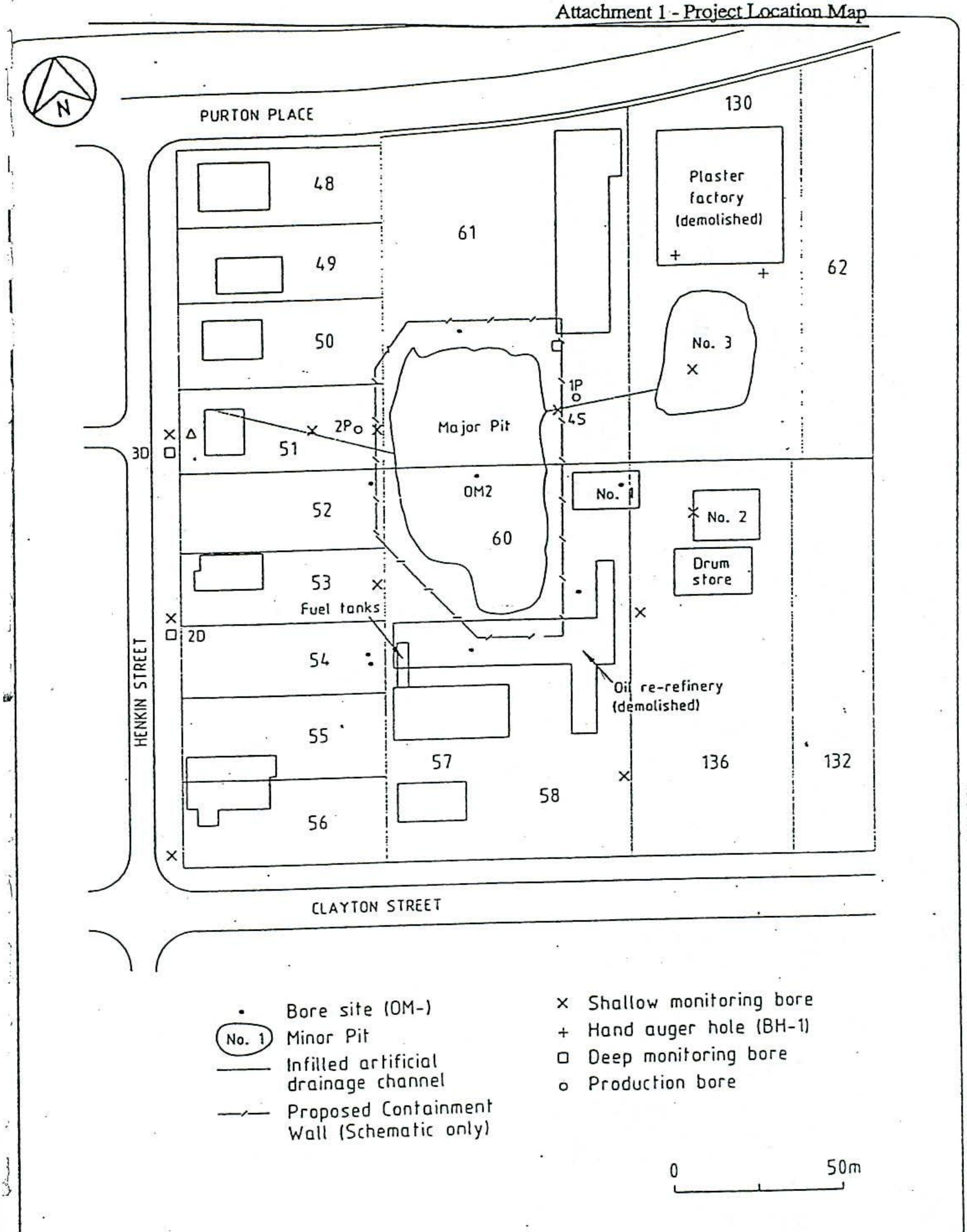
Draft commitments which are not in a format that can be audited will not be accepted by project officers for public review documentation. Proponents will be assisted to revise inadequate commitments.

5.4 Public consultation

A description should be provided of the public participation and consultation activities undertaken by the proponent in preparing the environmental review. It should describe the activities undertaken, the dates, the groups/individuals involved and the objectives of the activities. Cross reference should be made with the description of environmental management of the factors which should clearly indicate how community concerns have been addressed. Those concerns which are dealt with outside the EPA process can be noted and referenced.

5.5 Other information

Additional detail and description of the proposal, if provided, should go in a separate section.

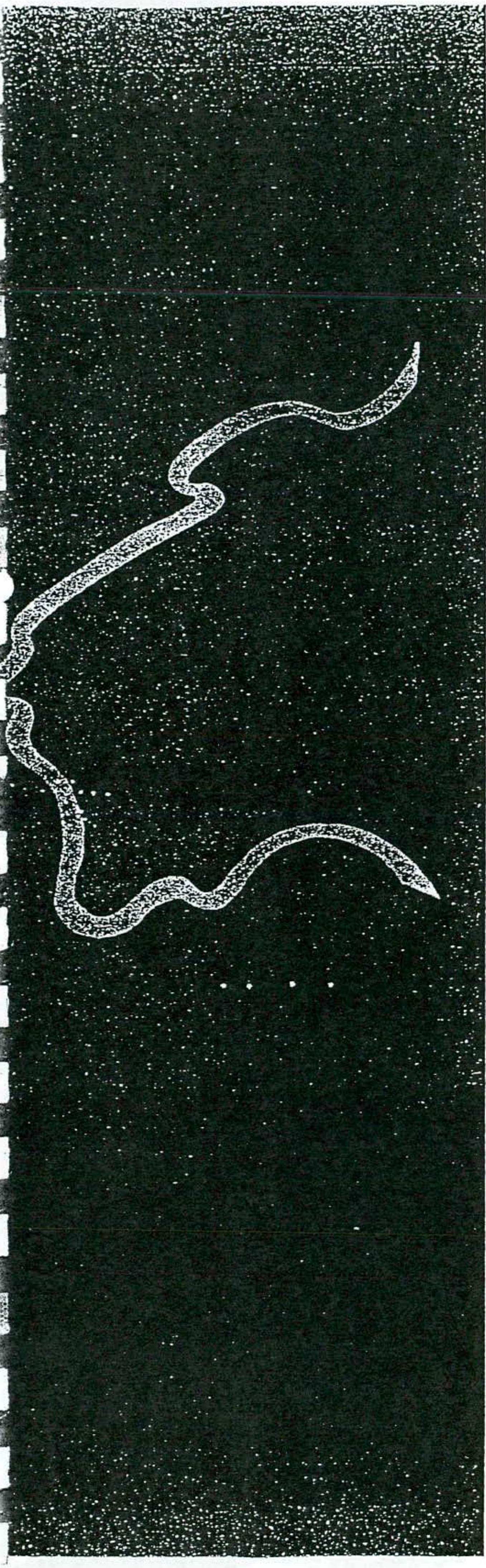


OMEX REHABILITATION PROJECT

FIGURE 1 : SITE PLAN

CMPS&F

Environmental Protection Authority



Policies, Guidelines and Criteria for Environmental Impact Assessment

A Site Remediation Hierarchy for Contaminated Sites

No. 17

Interim Policy

July 1997

Western Australia

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EPA Policy for EIA No 17

A Site Remediation Hierarchy for Contaminated Sites

Keywords: **contamination, remediation, hierarchy, contaminated sites**

1 Purpose

The purpose of this policy is to put in place a hierarchy of remediation and treatment options. This hierarchy is based upon the approach proposed in the Discussion Paper (August 1995) and draft Position Paper on 'The Assessment and Management of Contaminated Land and Groundwater in Western Australia'. It is also consistent with the approach taken in the ANZECC/NHMRC Guidelines for the Assessment and Management of Contaminated Sites (1992).

2 Objective

The objective of this policy is:

(a) to protect the environment as defined by the *Environmental Protection Act* 1986 (EP Act 1986) with focus on human health and the environment;

(b) to address the factor of uncertainty of outcome of the EIA process as raised in 1992 during the review of the EP Act 1986;

(c) to address the factor of a remediation hierarchy for Contaminated sites as a major environmental pressure on Western Australia; and

(b) to present to developers, proponents who have proposals subject to environmental impact assessment (EIA) and the general public, the Environmental Protection Authority's (EPA) position on 'a hierarchy for the remediation of contaminated sites' to ensure consistency and transparency in decision-making on these matters.

3 Introduction

Contaminated sites may pose a threat to human health and the environment. They may have significant planning, economic and legal implications. Many government agencies — including the DEP, the Health Department of Western Australia, the Western Australian Planning Commission and Ministry for Planning, the Water and Rivers Commission and the Department of Land Administration — have important responsibilities in this field. It is crucial that agencies communicate effectively. Government action and decision making needs to be developed in a co-ordinate way.

Over the past decade there has been an increasing recognition of the problems associated with contaminated sites. The problem is of special importance in Western Australia because of our great reliance on groundwater and the threat posed by land contamination to groundwater quality.

It is difficult to estimate the exact number of contaminated sites in Western Australia. In many instances adequate information on former landuse activities was not collected, has not been retained or is not readily available. In other cases land may be contaminated to some extent but is still suitable for its existing use and is not posing a risk to people or the environment.

The management of contaminated soil and groundwater is becoming more important and more closely scrutinised as the public awareness of the issue increases. One of the major policy areas that needs to be resolved is the selection of remedial actions used in the management of contaminated sites.

As a result of the experience gained in remediating and managing contamination at a site in Mosman Park, the EPA prefers proponents to seek other alternatives to site remediation options involving either removing contaminated soil and disposing of it at an approved landfill, or consolidating and isolating the contaminated soil with purpose designed barriers.

4 Policy

4.1 The environmental objective

It is an objective of the EPA to prevent, control and abate pollution. To achieve this objective for this policy the EPA applies two complementary tests when assessing emissions of waste:

(a) all reasonable and practicable measures should be taken to minimise the discharge of waste into the environment, irrespective of the magnitude of the environmental impact; and

(b) cumulative discharges of waste must not cause cumulative impacts beyond environmentally acceptable limits/standards/criteria.

For the purposes of this policy, the general objective outlined above can be redefined thus:

The objective of the EPA is to prevent, control and abate pollution on contaminated sites. The EPA believes that this objective can be best achieved by facilitating the treatment of contaminated material, to reduce the total chemical load on the environment, rather than by adopting 'cap-and-contain' approaches. The EPA further believes that it is important to minimise the amount of treatable waste going to landfills, and that encouraging options which involve the treatment of waste will assist in achieving that aim.

4.2 Guidelines for new proposals in policy area

For the purposes of implementing the above objective, the following guidelines will be used by the EPA during the assessment of any proposal relating to the remediation of a contaminated site:

- contaminated soil will preferably be either treated on site and the contaminants reduced to acceptable levels or be treated off-site and returned for reuse after the contaminants have been reduced to acceptable levels;
- the EPA prefers proponents to seek other options rather than either disposal to an approved landfill or the implementation of 'cap and contain' isolation measures. These options will only be considered if treatment of the contaminated material is not practicable, and will need to be undertaken in an environmentally acceptable manner; and
- remediation should be undertaken in accordance with the best advice about available techniques and options.

5 Management Actions, Plan And System

5.1 Implementation action and plan

The proponent should outline plans for the implementation of these actions in an Environmental Management Plan for the site.

5.2 Management system

The proponent should, where appropriate, establish and implement an Environmental Management System (consistent with the objectives of AS/NZS ISO 14001).

6 Application

6.1 Area

This policy applies to all contaminated sites in Western Australia.

6.2 Duration and review of the policy

The duration of this policy is for five years unless some unforseen circumstance requires it to be revised. Within five years the policy will be reviewed and updated, if necessary, following the procedures outlined in section P of the dossier for formulating policies for EIA.

7 Responsibilities

7.1 EPA responsibilities

The EPA will apply this policy in making decisions about whether or not to assess proposals for the remediation of contaminated sites and in any assessment of such proposals.

The EPA will recommend to the Minister the imposition of these requirements following its assessment of proposals for which it is a relevant factor.

7.2 DEP responsibilities

The Department of Environmental Protection will assist the EPA in applying this policy in environmental impact assessment and conduct its own functions under the *Environmental Protection Act 1986* in accord with the policy.

7.3 Proponent responsibilities

Where proponents demonstrate to the EPA that these policy requirements are accountably and enforceably incorporated into their proposals, the assessment of such proposals is likely to be assisted.

8 Definitions

contaminated site - a site at which hazardous substances occur in soil or groundwater at concentrations above background levels and where assessment indicates it poses, or has the potential to pose, an unacceptable risk to human health or the environment.

9 Limitations Clause

This policy, guidelines and criteria for environmental impact assessment document has been prepared by the Environmental Protection Authority to assist proponents and the public. While it represents the contemporary views of the Environmental Protection Authority, each proposal which comes before the Environmental Protection Authority for environmental impact assessment will be judged on its merits. Proponents who wish to deviate from the contents of this document should therefore provide justification for the proposed departure.

10 References

EPA (1995) Discussion Paper on The Assessment and Management of Contaminated Land and Groundwater in Western Australia

EPA (1992) Draft Position Paper on The Assessment and Management of Contaminated Land and Groundwater in Western Australia

ANZECC/NHMRC (1992) Australian and New Zealand Guidelines for the Assessment and Management of Contaminated Sites

Index	Draft Policy Preliminary Policy **Interim Policy** The Policy	**July 1997**
Status	Signed off by the EPA at this stage	
Citation	This Interim EPA policy can be cited at this time and is used by the EPA for the purposes on environmental impact assessment (EIA) with respect to this factor.	
Acknowledgements	None at this stage	
Contact Officer	Gavin Scally, DEP (08) 9265 7118	

Attachment 3

The first page of the proponent's environmental review document must be the following invitation to make a submission, with the parts in square brackets amended to apply to each specific proposal. Its purpose is to explain what submissions are used for and to detail why and how to make a submission.

Invitation to make a submission

The Environmental Protection Authority (EPA) invites people to make a submission on this proposal.

[the proponent] proposes [the rezoning of land and the development of a Marina Complex in the City of Bunbury]. In accordance with the Environmental Protection Act, a [PER] has been prepared which describes this proposal and its likely effects on the environment. The [PER] is available for a public review period of [8] weeks from **[date]** closing on **[date]**.

Comments from government agencies and from the public will help the EPA to prepare an assessment report in which it will make recommendations to government.

Why write a submission?

A submission is a way to provide information, express your opinion and put forward your suggested course of action - including any alternative approach. It is useful if you indicate any suggestions you have to improve the proposal.

All submissions received by the EPA will be acknowledged. Submissions will be treated as public documents unless provided and received in confidence subject to the requirements of the Freedom of Information Act, and may be quoted in full or in part in the EPA's report.

Why not join a group?

If you prefer not to write your own comments, it may be worthwhile joining with a group interested in making a submission on similar issues. Joint submissions may help to reduce the workload for an individual or group, as well as increase the pool of ideas and information. If you form a small group (up to 10 people) please indicate all the names of the participants. If your group is larger, please indicate how many people your submission represents.

Developing a submission

You may agree or disagree with, or comment on, the general issues discussed in the [PER] or the specific proposals. It helps if you give reasons for your conclusions, supported by relevant data. You may make an important contribution by suggesting ways to make the proposal more environmentally acceptable.

When making comments on specific elements of the [PER]:

- clearly state your point of view;
- indicate the source of your information or argument if this is applicable;
- suggest recommendations, safeguards or alternatives.

Points to keep in mind

By keeping the following points in mind, you will make it easier for your submission to be analysed:

- attempt to list points so that issues raised are clear. A summary of your submission is helpful;
- refer each point to the appropriate section, chapter or recommendation in the [PER];
- if you discuss different sections of the [PER], keep them distinct and separate, so there is no confusion as to which section you are considering;
- attach any factual information you may wish to provide and give details of the source. Make sure your information is accurate.

Remember to include:

- your name;
- address;
- date; and
- whether you want your submission to be confidential.

The closing date for submissions is: **[date]**

Submissions should be addressed to:

The Environmental Protection Authority
Westralia Square
141 St George's Terrace
PERTH WA 6000

Attention: **[Project Officer name]**

Attachment 4

Advertising the environmental review

The proponent is responsible for advertising the release and arranging the availability of the environmental review document in accordance with the following guidelines:

Format and content

The format and content of the advertisement should be approved by the DEP before appearing in the media. For joint State-Commonwealth assessments, the Commonwealth also has to approve the advertisement. The advertisement should be consistent with the attached example.

Note that the DEP officer's name should appear in the advertisement.

Size

The size of the advertisement should be two newspaper columns (about 10 cm) wide by about 14 cm long. Dimensions less than these would be difficult to read.

Location

The approved advertisement should, for CER's, appear in the news section of the main local newspaper and, for PER's and ERMP's, appear in the news section of the main daily paper's ("The West Australian") Saturday edition, and in the news section of the main local paper at the commencement of the public review period and again two weeks prior to the closure of the public review period.

Timing

Within the guidelines already given, it is the proponent's prerogative to set the time of release, although the DEP should be informed. The advertisement should not go out before the report is actually available, or the review period may need to be extended.

Example of the newspaper advertisement

SCM CHEMICALS LTD

Consultative Environmental Review

EXTENSION TO DALYELLUP RESIDUE DISPOSAL PROGRAM

(Public Review Period: **[date]** to **[date]**)

SCM Chemicals Ltd is planning to extend the company's existing residue disposal program at Dalyellup, south of Bunbury, from March 1992 to March 1993.

A Consultative Environmental Review (CER) has been prepared by the company to examine the environmental effects associated with the proposed development, in accordance with Western Australian Government procedures. The CER describes the proposal, examines the likely environmental effects and the proposed environmental management procedures.

SCM has prepared a project summary which is available free of charge from the company's office on Old Coast Road, Australind.

Copies of the CER may be purchased for $5 from:

SCM Chemicals Ltd
Old Coast Road
AUSTRALIND WA 6230
Telephone: (08) 9467 2356

Copies of the complete Consultative Environmental Review will be available for examination at:

- Environmental Protection Authority
  Library Information Centre
  8th Floor, Westralia Square
  38 Mounts Bay Road
  PERTH WA 6000
- Environmental Protection Authority
  65 Wittenoom Street
  BUNBURY WA 6230
- City of Bunbury public libraries
- Shire of Capel libraries
- Shire of Harvey library (Australind)
- Shire of Dardanup (Eaton)

Submissions on this proposal are invited by **[closing date]**. Please address your submission to:

Chairman
Environmental Protection Authority
8th Floor, Westralia Square
38 Mounts Bay Road
PERTH WA 6000
Attention: **[Project Officer name]**

If you have any questions on how to make a submission, please ring the project officer, **[Project Officer name]**, on (08) 9222 7xxx.

APPENDIX B

DOCUMENT NO:VW1100

REPORT FOR

HEALTH RISK ASSESSMENT

FOR

OMEX SITE, BELLEVUE

Client: **DEPARTMENT OF ENVIRONMENTAL PROTECTION**

Report: **FINAL REVISION**

Dated: **23 DECEMBER 1998**

Rev	Date	Revision Description	By CMPS&F	Checked CMPS&F	Approved for Issued
A	6 Aug 1998	Draft Report	PL	DER	
B	12 Dec 1998	Draft Report	PL	DER	
O	23 Dec 1998	Final Report	PL	DER	

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1. BACKGROUND TO THE HEALTH RISK ASSESSMENT ISSUE

The history of contaminating activities on the Omex site in Bellevue is addressed elsewhere in the CER and will not be repeated in detail in this background discussion to the health risk assessment (HRA) issue.

In summary, the principal feature of the Omex site is a large, filled clay-pit used historically for the uncontrolled disposal of wastes. Both liquid and solid wastes arising from the refining of used engine sump oils for reuse were placed in the pit. A major process chemical used to treat the oils was concentrated sulphuric acid and this is a component of the wastes now present in the pit. Other components of the process wastes include hydrocarbon compounds and heavy metals. The wastes in the pit were poorly managed and liquids overflowing the pit onto adjoining properties and fires have been recorded.

The WA government is committed to the remediation of the Omex site and recognises the need for careful management of contaminated materials to avoid both adverse effects on human health and the environment.

It is the objective of this HRA to consider and assess any risks to:

- members of the public who will be located off site during the removal of contaminated materials;
- future residents on the remediated Omex site.

Because groundwater in the immediate vicinity of the Omex site is not currently used and future access can be denied by regulation, the issue of contaminated groundwater and an assessment of hypothetical risks to health will not be considered. Regulatory acceptance and correspondence on this conclusion is provided in Appendix 2.

It is also noted that the protection of the health of workers engaged in the removal of contaminated materials from the Omex site will be addressed by the remediation contractor at a later date as part of their occupational health and safety management plan.

2. THE HEALTH RISK ASSESSMENT PROCESS

General

Determining the level of risk of an adverse effect on human health uses a structured and well-recognised process (ANZECC/NHMRC 1992). The principal components of this process are:

- hazard identification;
- exposure assessment;
- toxicity evaluation;
- risk characterisation

and their relationship is illustrated in Figure 1.

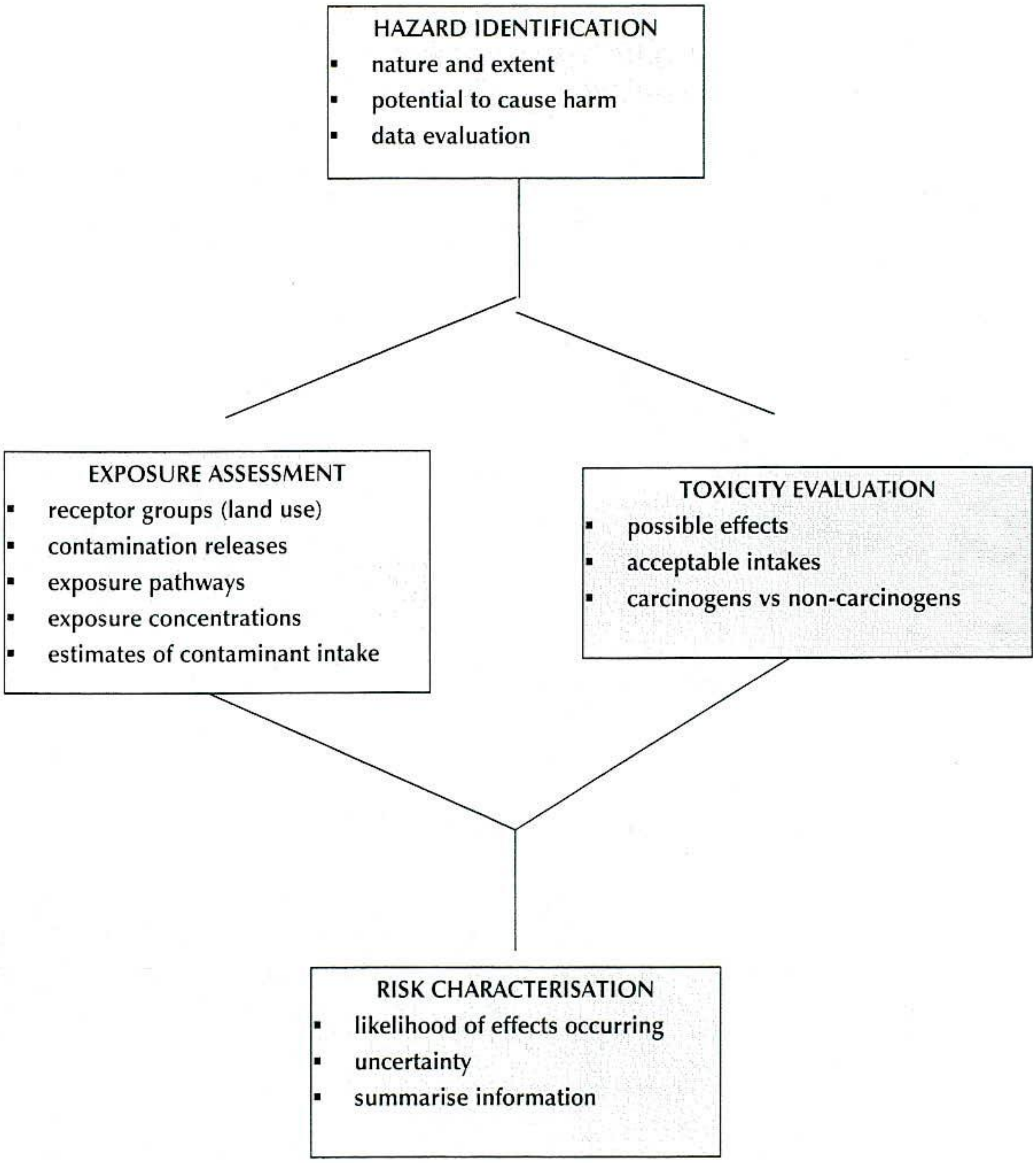
An important tenet of health risk assessment is that the underlying objective is to effectively protect the most sensitive individuals in the exposed population (for example children or the elderly). In protecting the more sensitive receptor groups in the population it is assumed that the general population is hence sufficiently protected. This objective is evidenced in the commonly adopted levels of acceptable incremental risk of cancer used in decision making; usually in the range 1 in 1,000,000 (1×10^{-6}) to 1 in 10,000 (1×10^{-4}) per lifetime, i.e. one additional case of cancer per 10,000 to 1,000,000 people per lifetime.

Health risk assessment seeks to determine the intake of a chemical by an individual and how this level compares to a nominal dose that is considered acceptable. With respect to soil contamination, exposure may be estimated via a range of routes, including ingestion of soil, inhalation of volatiles or particulates, dermal absorption and food chain exposure.

In assessing possible adverse effects on human health, consideration is given to a range of carcinogenic and non-carcinogenic effects. It is often the carcinogenic effects that are limiting in terms of possible adverse effects.

The manner in which risk is *managed* is a separate issue to assessing risk. Since the proposed remediation of the Omex site is to be undertaken for the public good, a number of considerations (for example aesthetic, political, social, economic and human health) will need to be balanced by the community in order to determine the optimum public good. Risk management is not considered further in this assessment.

Figure 1 Health Risk Assessment Process



2.1 HAZARD IDENTIFICATION

The objective of undertaking this stage of the HRA process is to identify all chemical substances that are present on a site and which have the potential to cause harm to human health.

Hazardous substances are usually identified by considering which materials may have been used or stored on a site or arrived through dumping or site filling.

It is noted that neither biologically or physically hazardous materials are an issue on the Omex site and hazard identified will concentrate solely on chemical toxicants.

2.2 EXPOSURE ASSESSMENT

Exposure assessment involves the:

- identification of receptor groups, both on site and off site
- identification of complete exposure pathways
- estimation of concentrations in media to which humans may be exposed (e.g. air)
- estimation of the exposure likely to be experienced by human receptors.

2.3 TOXICITY ASSESSMENT

Having identified the potential adverse effects that may be associated with exposure to a chemical or mixture of chemicals, the level of exposure associated with the onset of adverse effects is evaluated. The level of exposure at which an adverse effect may occur is characterised using a dose-response factor. This information is chemical specific, not site specific.

In considering possible adverse effects on human health, information may be drawn from epidemiological studies (i.e. studies of human populations occupationally or environmentally exposed), animal bioassays (conducted in the laboratory) and a range of cellular tests, e.g. genotoxicity assays.

2.4 RISK CHARACTERISATION

The results of the exposure and toxicity assessments are combined to provide an estimate of the risk of adverse effect to human health. As part of the risk characterisation component, consideration should be given to both:

- presenting the uncertainty associated with the risk estimates
- communication of risk estimates to relevant decision makers.

3. THE APPROACH TAKEN TO ASSESSING RISK FOR THE OMEX SITE

General

The following approach to assessing health risk was taken:

- If appropriate, an existing standard, goal or guidance level was used.
- If a number of criteria appeared appropriate, acceptability was determined from the following hierarchy:
  - ~ a locally developed criterion was most acceptable;
  - ~ a national criterion was the next most acceptable;
  - ~ an international (e.g. World Health Organisation) or overseas criterion (e.g. the RIVM, the Dutch Ministry for Public Health and Environmental Protection) was the least acceptable.
- If no appropriate criterion has been developed, one was developed from first principles using the four-part process outlined in Section 2.

It is important to note that the best available science should dictate any decision regarding the adoption of a criterion.

3.1 Contaminant Levels in Air

As noted in Section 1, the receptor of concern has been identified as a member of the public located off-site during the proposed removal of contaminated materials from the Omex site. Nearby sedentary residents are anticipated to have the longest and highest exposure to any hazardous substance released during remediation. It is noted that a child at Bellevue Primary School is also a potential receptor but the distance of the school from the Omex site (>300 m) would ensure a lesser exposure.

Hazard Identification

Six studies related to air quality have been performed since 1994 (refer Table 1), and which have varying relevance to the manner of release anticipated, that is the bulk excavation of pit materials.

[redacted]

TABLE 1
OMEX SITE: AIR QUALITY STUDIES, 1994-8

Activity Undertaken	Date	Investigation Performed by	Wind Direction	Study Conclusions	
				Organic Substances	Inorganic Substances
Hand digging.	January 1994	CCWA	NW	No 'significant' compounds detected (charcoal tube collector).	Sulphate level slightly elevated (0.34 v 0.15 mg/m^3) Chloride level slightly elevated (9.7 v 8 mg/m^3)
No activity, monitoring of pit with sand cover only.	May 1995	CCWA	E	Some PAHs detected. (2-me naphthalene, phenanthrene and b(ghi) perylene). Possibly some organo-sulphur compounds present.	Negligible elevation in levels of heavy metals (Cd, Cr, Co, Cu, Fe, Mn, Ni and Zn). Similarly for lead. Chloride level possibly elevated (0.06-0.1 mg/m^3).
Soil drilling	October 1996	CCWA	NR	Hexane, benzene and PAH not detected.	Zinc and lead levels frequently elevated. Sulphate level probably elevated.
No activity, monitoring of pit with HDPE liner.	April 1998	CMPS&F / CCWA	NR	No phenols, BTEX, hexane or low mass PAHs detected.	Picture not clear; suggest levels of nitrate, chloride and sulphate elevated.
No activity, headspace monitoring of bores installed within the pit.	May 1998	CMPS&F / CCWA	NR	False detection of acetic acid reported due to interference from sulphur dioxide.	Sulphur dioxide detected; no sulphuric, hydrochloric or nitric acid detected.
Laboratory simulation	June 1998	CMPS&F / ARL	NA	No organic substances detected in the heated head-space gas above either of two samples of pit materials. Maximum head-space gas temperature:100 C. Analytical techniques: GC-MS and detector tubes.	Sulphur dioxide only detected in heated head-space gas above both samples of pit materials. Maximum head-space gas temperature:100 C Analytical techniques: GC-MS and detector tubes.

Notes: NR= not recorded. NA= not applicable.

A recent simulation of vapour generated from the waste on a hot day was undertaken in the laboratory. The study used two soil/sludge samples recovered from the pit which were considered to represent the worst contamination. The material was heated to 100°C in an enclosed environment, gas or a headspace sample was withdrawn for analyses. Testing indicated sulphur dioxide only, no other substances including acid gases or organic materials, were released at measurable levels from either of the two soil samples. These results are presented as the laboratory test certificate (ARL Report No. 11623-24) which is included in Appendix 2.

Dust from disturbed pit and surface soils near the proposed excavation may carry lead and hydrocarbons (aliphatic, long chain and PAHs). As a precautionary approach, lead, polycyclic aromatic hydrocarbon compounds and dust are also nominated in this study as potentially important toxicants to be considered.

Exposure Assessment

Whilst a number of hazardous substances have been identified from investigations on contaminated materials recovered from the Omex site, it is difficult at this time to *predict* the exposure that a receptor will receive during remediation. For example, the level of sulphur dioxide gas released at source will depend on the amount of soil disturbance occurring during excavation, wind speed and ambient temperature. It is planned that the details of the manner in which contaminated soil materials are to be excavated will be provided by remediation contractors prior to selection for this work.

In the absence of exposure information, the objective has been to determine a level of exposure corresponding to an acceptable risk (refer Tables 2).

Table 2
Average Levels in Air Protective of Public Health

Time	Sulphur dioxide[A] ppm	Lead[AB] µg/ m³	Fine Particulates[AC] µg/ m³	PAHs[D] µg/ m³
1 hour	**0.20**	-	-	-
1 day	0.08	-	50	-
1 year	0.02	0.50	-	0.30

Notes

A, National Environmental Protection Measure for Ambient Air Quality, 1998

B, reported as a fraction of total suspended particulate material.

C, measured as PM_{10} material. PM_{10} is fine particulate material with an aerodynamic diameter of 10 µm or less. Particles of this size can be harmful as they are capable of penetrating deeply into the lung.

D, measured as the sum of the levels of benzo(b)fluoranthene, benzo(k)fluoranthene and benzo(a)pyrene. The level nominated corresponds to an estimated incremental lifetime risk of cancer of 1 in 10^{-5}. Data adapted from Integrated Risk Information System, United States Environmental Protection Agency. Refer Appendix 1

Note for sulphur dioxide, compliance with the one hour average level of 0.20 ppm should ensure compliance with the one day and one year levels is also achieved.

In order to ensure that a resident experiences acceptable risk, consideration needs to be given to how releases to air during site rehabilitation will be managed.

Toxicity Evaluation

A toxicity evaluation for each of the hazardous substances of concern was undertaken during the development of the National Environment Protection Measure for Ambient Air Quality and a summary is presented in Table 3.

The exception to this was a toxicity evaluation for the polycyclic aromatic hydrocarbons of interest which was undertaken by the US Environmental Protection Agency.

Table 3 Toxicity Evaluation: National Environment Protection Measure

Substance	Adverse Health Effect	Protection Provided by the NEPM Standard
Sulphur dioxide	Bronchospasm	Lung function protected in asthmatics and similarly sensitive people.
Inorganic lead	Decreased IQ value is linked with a higher blood-lead level in children. More generally, there are adverse effects on kidneys, reproduction, cardiovascular and central nervous systems.	Nominates a maximum blood-lead level of 10μg/dL in all members of the population.
Fine particulates, PM_{10}.	Increased medical assistance required with respiratory conditions (including asthma) & conditions of the cardiovascular system Increased mortality from respiratory or cardiovascular disease. Small decrease in the lung function of healthy children.	Fewer adverse health effects such as acute respiratory symptoms and reduced lung function

Risk Characterisation

An assessment of risk will be undertaken when ambient levels in air of the substances of concern become known by measurement. As the levels in air nominated in Table 2 correspond to acceptable risks, actual risk can be simply inferred from the measured level of toxicant in air.

If measurements were performed, having regard for wind direction, on the boundary of the Omex site, the risk would be 'worst case' since no allowance for dilution prior to reaching a nominated receptor would have been made.

Since the lowest odour threshold level for sulphur dioxide reported in a review of odour thresholds and irritation levels (Ruth 1986) was ≈0.41 ppm, the absence of an odour can still represent a risk from this gas.

3.2 Contaminant Levels in Soils

The receptor group of concern identified in Section 1 as future residents living on the remediated Omex site. Since young children of about 2 years old (toddlers) are known to have the largest incidental ingestion of soil, this subgroup of future residents has been identified as the one requiring greatest protection.

Hazard Identification

The following hazardous substances in soils were found to be present at the Omex site (Golder Associates 1997):

- lead and other heavy metals
- hydrocarbons:
  - ~ benzene, toluene, ethylbenzene and xylenes (BTEX)
  - ~ polycyclic aromatic compounds
  - ~ others
- phenols
- acidity (pH value).

As a precautionary measure, arsenic is nominated for inclusion with the known hazardous substances.

If, as seems likely, soils from an off-site source are imported onto the Omex site following the removal of unacceptably contaminated site soils, a second hazard identification process will be necessary. This will ensure imported soils are suitable for residential use as it is not unknown for virgin soil materials to naturally contain unacceptably high levels of toxicants.

Exposure Assessment

The rate of incidental ingestion of soil by toddlers has been conservatively estimated at 100 mg/day (ANZECC/NHMRC, 1992) which is approximately four times higher than the adult rate. With their lower body weight and higher daily incidental ingestion of soil, it is clear young children will be at greater risk from soil contaminants than adults.

To nominate protective levels in soils, the exposure to residual soil contaminants by future site users is assumed to be controlled such that:

- a minority (<10%) of vegetables consumed by the receptor will be grown on the site;
- no back-yard poultry products will be eaten.

This exposure setting is referred to as 'A' standard residential and includes day care centres, preschools and primary schools (NEHF, 1996).

On the basis of the above assumptions, protective exposure levels have been developed which correspond to negligible risk for a future child resident. Table 4 summarises protective levels used for screening the contaminants of concern identified at the Omex site.

Table 4 Average Levels in Soils to Protect Health of Resident Child

Contaminant of Concern	Response Level mg/kg		
	NEHF[(a)] Residential 'A'	**NSW EPA[(b)]**	**SAHC[(c)]**
Heavy Metals			
inorganic lead	300	-	-
cadmium	20		
chromium	12%		
copper	1000		
nickel	600		
zinc	7000		
Hydrocarbons:			
BTEX	-	benzene 1 toluene 130 ethylbenzene 50 xylenes 25	-
PAHs	20, benzo(a)pyrene not to exceed 5%		-
Others		TPH C_c-C_9, 65 TPH >C_9, 1,000	
Phenol	8,500	-	-
pH value	-	-	Not less than 5 and not greater than 9

(a) Health-based Soil Investigation Levels; National Environmental Health Forum 1996.
(b) Guidelines for Assessing Service Station Sites; NSW EPA 1994.
(c) A Practical Guide to the Health Risk Assessment and Management of Contaminated Sites in SA; SA Health Commission 1993.

It is recommended that these health levels are applied to all soils down to a depth of 3.5 metres on a residential site. Soils affected by contaminants at concentrations above the health levels may be allowed to remain at greater depth as these are unlikely to be brought to the surface on land used for residential purposes. For high concentrations of volatile contaminants left below 3.5 metres, it would be necessary to demonstrate that these concentrations could be left without ill effect. Results to date indicate no elevated levels of volatile compounds in the contaminated soil at the Omex site, however it should be noted that semi volatile compounds are found.

Toxicity Evaluation

A toxicity evaluation for each of the hazardous substances of concern present in soils at the Omex site is necessary in order to develop acceptable levels protective of human health. Generally the Tolerable Daily Intake (or an equivalent) determined by the National Health and Medical Research Council or the World Health Organisation was the toxicological basis for levels sourced from the NEHF. The Tolerable Daily Intake over a lifetime of exposure is designed to ensure negligible risk.

Risk Characterisation

Risk to future child residents at the remediated Omex site can simply be assessed via the conservative health levels for soils provided in Table 4.

It is prudent that these levels are used as a response or clean-up criteria and be provided to the remediation contractor to ensure negligible risk is achieved.

3.3 Synergism in Risk Assessment

The concept of "synergism" is considered in several ways in human health risk assessment. Synergism occurs when exposure to one chemical enhances, or significantly increases, the toxicity of another chemical. This effect has been observed experimentally in controlled animal studies for a limited number of chemicals but has been poorly documented in "real world" settings. Synergism is primarily of concern only when chemicals exert their toxic effect on the same target organ or through a similar mechanism of action. Synergistic effects for the chemicals of interest (sulphur dioxide, lead, and polycyclic aromatic hydrocarbons are unlikely to occur for several reasons:

- the toxic effects on which the risk-based exposure limits are set and the mechanisms through which the effects occur are quite different for the chemicals of interest (irritation of respiratory system in susceptible individuals for sulphur dioxide, intellectual impairment in children for lead, and cancer of the forestomach in rats for PAHs). In addition, the general toxicological profile of these chemicals is quite different for each other. Sulphur dioxide is a common air pollutant that is an irritant and can cause pulmonary inflammation at high enough concentrations. Lead is associated with hypertension in adults and neurological deficits in children. Heavy metals generally tend to be associated with kidney and liver damage at high exposure levels. PAHs have been shown to be carcinogenic to experimental animals and are considered to be probable carcinogens in humans. Because these chemicals have different mechanisms by which they exert their toxic effects as well as affect different target organs, it is unlikely that combined exposure to them will result in a synergistic effect;

- synergism between these chemicals of interest have not been observed even though the chemicals are common environmental contaminants and have been well studied;

- the exposure of local residents will be limited to inhalation of either volatile chemicals or windborne particulate compounds. There is no direct contact with chemicals in the pit. Inhalation of ambient air typically does not pose a significant health threat because of the relatively small amounts of chemicals that get into the ambient air and the large amount of atmospheric dilution that occurs before the air gets to a receptor;

- the toxicity criteria used to evaluate human health effects associated with chemical exposure are designed to be highly conservative (ie. health protective). Toxicity criteria are typically based on an exposure level shown to cause no adverse effects when administered to laboratory animals over an extended period, usually the entire lifespan of the animal. These "no effects" levels are then reduced by a factor of 100 to 1,000 to derive an acceptable exposure level for humans. The large margin of safety incorporated into toxicity criteria (the no effects level reduced by 100 to 1,000-fold) is designed to provide a safety margin against adverse effects that may occur but haven't been documented (such as synergism). In this way the possibility of synergism is accounted for during the development of the toxicity criteria.

For these reasons it is not expected that the chemicals of interest will cause any synergistic effects which will adversely affect human health.

References

ANZECC/NHMRC 1992	*Australian and New Zealand Guidelines for the Assessment and Management of Contaminated Sites*. Australian and New Zealand Environment and Conservation Council/National Health and Medical Research Council.
Golder Associates 1997	*Extent of contamination and options for remediation: Omex Petroleum site (Clayton Street, Bellevue)*
NEHF 1996	*Health – Based Soil Investigation Levels.* National Environmental Health Forum Monographs. Soil Series No. 1.
NEPC 1998	*National Environment Protection Measure for Ambient Air Quality.* National Environment Protection Council.
NSW EPA 1994	*Guidelines for Assessing Service Station Sites.*
Owen 1990	*Literature derived absorption coefficients for 39 chemicals via the oral and inhalational routes of exposure*. Reg. Tox & Pharm 11, 237-252.
Ruth 1986	*Odour thresholds and irritation levels for several chemical substances: a review.* Am. Ind. Hyg Assoc J, (4), 1986.
SA Health Com. 1993	*A Practical Guide to the Health Risk Assessment and Management of Contaminated Sites in SA.* South Australian Health Commission.
US EPA 1998	*Integrated Risk Information System (IRIS).*

APPENDIX 1

CALCULATION OF A RISK-BASE LEVEL IN AIR PROTECTIVE OF PUBLIC HEALTH FOR SELECTED PAHs

APPENDIX 1

CALCULATION OF A RISK-BASE LEVEL IN AIR PROTECTIVE OF PUBLIC HEALTH FOR SELECTED PAHs

A1.1 FACT AND ASSUMPTIONS

Fact or assumption	Comment	Source of Information
Fact 1	benzo(b)fluoranthene, benzo(k)fluoranthene and benzo(a)pyrene are all classified by weight of evidence as probable human carcinogens	IRIS, USEPA 1998
Fact 2	benzo(a)pyrene has an oral slope factor of 7.3/(mg kg^{-1} day^{-1})	IRIS, USEPA 1998
Fact 3	There is no quantitative estimate available of carcinogenic risk from inhalation for benzo(b)fluoranthene, benzo(k)fluoranthene and benzo(a)pyrene	IRIS, USEPA 1998
Fact 4	The oral slope factor is estimated from a 70 year exposure duration	USEPA
Fact 5	The adult male inhalational volume is 23 m^3/d	ICRP 1975
Fact 6	The adult male body mass is 70 kg	
Assumption 1	The oral slope factor is applicable to the inhalation route of exposure for benzo(a)pyrene This is a conservative assumption as the oral absorption coefficient, 0.5, is larger than the coefficient for inhalation (0.29).	OWEN 1990
Assumption 2	benzo(b)fluoranthene, benzo(k)fluoranthene and benzo(a)pyrene are equally potent human carcinogens by the inhalational route	-
Assumption 3	The duration of exposure of residents to benzo(a)pyrene from the proposed remediation work is not greater than 1 year	CER
Assumption	An incremental lifetime risk of 1 x 10^{-5} of developing cancer due to PAH exposure during remediation is acceptable	-

A1.2 CALCULATION

The inhalation dose:

$$= \frac{V \times C}{M}$$

Where:

V	=	adult male inhalational volume (in m^3/d)
C	=	risk-based limiting total concentration of benzo(b)fluoranthene, benzo(k)fluoranthene and benzo(a)pyrene (in $\mu g/m^3$)
M	=	adult male body mass (in kg)

Therefore:

Incremental lifetime risk of cancer per year of exposure to benzo(b)fluoranthene, benzo(k)fluoranthene and benzo(a)pyrene

$$= \frac{V \times C \times S \times 10^{-3}}{M \times 70}$$

Where S is the oral slope factor.

For a 1 year exposure period and an acceptable incremental lifetime risk of cancer of 1×10^{-5}:

$$C = \frac{1 \times 10^{-5} \times M \times 70}{V \times S \times 10^{-3}} = \frac{1 \times 10^{-5} \times 70 \times 70}{23 \times 7.3 \times 10^{-3}}$$

$$= 0.3\ \mu g/m^3$$

APPENDIX 2

RELEVANT CORRESPONDENCE AND TEST RESULTS

WATER AND RIVERS
COMMISSION

FACSIMILE TRANSMISSION

To:	CMPS&F	Date:	27 July, 1998
Attention:	Barry Robbins	Fax No:	9325 9897
From:	S. Appleyard	Phone No:	9278 0517
Total pages:		Direct Fax No:	9278 0586
Subject:	Management of groundwater contamination risk, OMEX site		

Message:

Barry,

Thank you for your facsimile of 23 July 1998 about the proposed strategy of managing groundwater risk associated with the site. The Water and Rivers Commission agrees with the strategy, and will not allocate new groundwater licenses near the OMEX site.

Regards

Steve Appleyard
Supervising Hydrogeologist
Groundwater Contmination Investigations Section

Western Australia

Health Department of Western Australia

Environmental Health Service

6291/98

RECEIVED
3 AUG 1998

Mr Barry Robbins
Environmental
CMPS&F Pty Ltd
PO Box 6311
EAST PERTH WA 6892

Dear Mr Robbins

I refer to your facsimile of 24 July 1998 regarding the necessity to perform a risk analysis for domestic use of ground water in the vicinity of the Omex site in Bellevue.

In your facsimile you list five factors which are used to assess the need for a risk analysis, with factor five citing Sulphur Dioxide as the contaminant of concern following a head space analysis of Omex waste samples. Previous results from ground water sampling indicate that contaminants other than sulphur dioxide have leached into the Leederville aquifer. Moreover, the limit of detection for a number of contaminants was higher than for the drinking water guidelines.

Whilst I confer with the recommendation to prevent the construction of any additional bores in the vicinity of the Omex site impacted area, the current sampling program at existing irrigation bores should continue to monitor for all potential contaminants. Chemicals of concern to public health from contaminated ground water include, but are not restricted to, substances which may be volatilised when brought to the surface.

A health risk analysis for groundwater may not need to be undertaken provided the Water and Rivers Commission do not grant any licences to construct new bores in the potentially impacted area and the existing sampling and testing program for current bores continues.

Yours sincerely

Peter N Di Marco PhD
PRINCIPAL TOXICOLOGIST

29 July 1998
(8729fm2a)

CMPS & F PERTH

DATE	REC'D	DOC. No.
3.8.98	CME	IVW 3443

DIST	ACTION	INIT	DATE
BMR			5/8/98
SAB	I		3/8/98.

PROJECT No.	FILE No.
	VW/1.00/100/001.

ANALYTICAL REFERENCE LABORATORY (W.A.) PTY. LTD.

26 JUN 1998

LABORATORY REPORT

ARL LAB No: 11623-24
DATE: 23 June 1998

CLIENT: CMPS&F Pty Ltd
PO Box 6311
EAST PERTH WA 6892

ATTENTION: Mr Barry Robbins

SAMPLE DESCRIPTION: Two sludge samples as received for analysis of gases.

JOB NO: VW 1100/300

DATE RECEIVED: 18 June 1998

LOCATION: Omex Vapour Study

RESULTS:

Lab No	Sample Marks
11623	CMA - 14
11624	CMB - 15

The headspace gases above the two samples were analysed by GC-MS and with detector tubes.

Both techniques identified sulphur dioxide in the headspace above the two samples (concentrations greater than 10 ppm). No other volatile compounds were detected.

David Williams
Manager

Page 1 of 1

CMPS & F PERTH			
DATE 26/6/98	REC'D ST	DOC. No. 1100/300	
DIST BMR	ACTION	INITIAL	DATE
PROJECT No.		FILE No. VW1100/300 ST	

ANALYTICAL REFERENCE LABORATORY (W.A.) PTY. LTD.
A.C.N. 050 159 898
55 Wittenoom Street, East Perth, Western Australia 6004
Telephone: (08) 9221 1415. Facsimile: (08) 9325 2398
NATA Registration No. 2377

APPENDIX C

A GROUPE EGIS COMPANY

CMPS&F PTY LIMITED

ENVIRONMENTAL PLANNING & ASSESSMENT
ACN 000 912 630
SYDNEY OFFICE

17 September 1998

ATTENTION: Dr Peter Thorpe
Principal Hydrogeologist
CMPS&F
PERTH WA 6000

SUBJECT: OMEX GROUNDWATER MODEL

Dear Peter

1. INTRODUCTION

1.1 General

CMPS&F Environmental have completed a groundwater model of the OMEX site located on the corner of Clayton Street and Henkin Street, Bellevue.

The site consists of a 7m deep former clay pit used for the disposal of used oil re-refining waste which includes sulphuric acid, waste oil and grease, Fullers Earth and engine deposits. The waste liquid filled pit was backfilled with builders rubble (clay, sand, brick and concrete), plaster wastes and steel scrap to give a volume of about 13,000m^3. The wastes are largely submerged below the watertable and leachate from the pit has contaminated the upper level of a deep confined aquifer to the west of the site (Leederville Formation).

The waste is considered to be relatively homogenous throughout the pit considering the mode of placement.

In order to provide an initial assessment of existing and potential migration of the contaminated plume, a numerical solute model was developed. This report details the design of the conceptual and numerical model and the use of the model in predicting solute concentrations.

1.2 Scope of Works

The scope of works for development of the solute model was to:

- develop a simple model of the fate and transport of Total Petroleum Hydrocarbons (TPH), total phenols and heavy metals (nickel and zinc only) in leachate from the waste pit;
- simulate the effect of installing a cut-off wall on the fate and transport of the leachate contaminants.

67 Albert Avenue Chatswood NSW 2067 Australia PO Box 201 Chatswood 2057 Tel: (02) 9412 9546 Fax: (02) 9412 9876

1.3 Methodology

The area studied is approximately 91Ha in size and includes the OMEX site and the land between the site and the Helena River. Site specific data has been made available from 14 monitoring wells installed in an area within 140m of the site. Consequently an area of 26Ha around the site has been examined in more detail with a finer grid size in the model. This smaller area constitutes the selected modelling domain whereby good calibration of the model has been achieved.

A three layer, steady-state model has been selected for this work. The model includes 2 numerical processing codes called Visual Modflow[1] and MT3D[2].

The applications are coupled and both are considered to be appropriate tools for the first estimate of contaminant behaviour in the groundwater at the site. The models are well documented, public domain codes that have not been modified for this study.

The principal tasks were to:

- develop a groundwater model that replicates groundwater depth and flow in the 3 geological layers;
- identify and simulate the existing groundwater contaminant source and plume;
- simulate the contaminant plume after the contaminant source has been isolated by a cut-off wall;

The overall approach used to accomplish the modelling objectives is given below.

1. Define Purpose
2. Conceptual Model
3. Code Selection
4. Model Design
5. Calibration
6. Verification
7. Prediction
8. Presentation of Results

[1] Visual modflow is the standard modelling software package for the USGS's MODFLOW code. Visual Modflow vs. 2.71 (for Windows 95/NT) is produced by Waterloo Hydrogeolic Inc.

[2] MT3D[96] vs. 2.0 is produced by S.S. Papadopolous & Associates Inc.

1.4 Previous Work

Previous work referred to in the preparation of the model included:

- OMEX SITE (WASTE INFORMATION KIT) MAY 1998, prepared FOR THE Department of Environmental Protection by CMPS&F Environmental.
- OMEX SITE CONTAINMENT WALL CONSTRUCTION SPECIFICATION, CMPS&F 1998.
- Report on testing of "Hazard Characterisation and Samples for Golder Associates, October 1996, Chemistry Centre.
- Analytical Results for Stage 1 and Stage 2 Site Assessment, 1998 CMPS&F.

1.5 Use of the Model

The groundwater model that has been developed in this work has the objective of assisting in the initial assessment of the extent and significance of groundwater contamination at the Omex site. The preparation of the model has drawn upon a body of groundwater contamination information available for the site; however, this information is limited, and the model must be regarded as providing only an indicative picture of the extent and movement of groundwater contamination at the Omex site. Notwithstanding these limitations, the model is considered to provide a useful tool for evaluating the current and potential behaviour of the identified dissolved phase plume.

2. SITE CHARACTERISATION

2.1 Setting and Topography

The site, located in the eastern suburbs of Perth, is set on low relief plains, typical of the topography to the east of Perth. The site is within a mixed commercial/industrial/residential precinct.

The site slopes gently to the south-west. The elevation is consistent at 18 mAHD. The Helena River passes through the southern portion of the site, and flows towards the south and south west. The creek is a strongly defined, incised feature with steep banking and a fall in elevation of over 10 m at some points along the creek channel.

2.2 Geology and Hydrogeology

The site is underlain by interbedded clays and clayey sands of the Guildford Clay to 16m depth and in turn by the Leederville Formation (sand and clay beds). The Guildford Clay contains minor laterally discontinuous sand aquifers of low to variable transmissivity. The Leederville Formation forms a major confined aquifer beneath the Guildford clay, which at the site consists of a highly transmissive sand bed underlain by a laterally continuous black clay/silt bed at about 25m depth. Current work (CMPS&F 1998) has assessed the extent of off-site groundwater contamination in the Leederville Formation.

It is anticipated that any removal of solid and liquid wastes will require control of groundwater inflow to ensure pit wall stability during excavation and to minimise the volume of grossly contaminated water to be disposed of during excavation of the solid wastes.

It has therefore been proposed that a cut-off wall is installed around the pit. One of the primary objectives of this work is to predict and assess the change in groundwater quality that may result from the installation of the wall.

3. HYDROGEOLOGICAL FRAMEWORK FOR MODELLING

For hydrogeological modelling purposes the stratigraphy has been simplified using the following assumptions:

- Three layers have been established in the model corresponding to an upper clayey sand/sandy clay unit (15m thick), a combined coarse and aquifer (10m thick) and a basal marine clay silt bed (>2m thick).
- The layers have been modelled as horizontal and of constant thickness.

3.1 Boundaries and Distribution

The boundaries of the model have been selected to encompass the site area of interest and have taken the hydrogeological features of the site into consideration. The following boundary conditions have been assumed:

- North - north flow cell.
- East - constant head boundary set at 13.8 - 14.6 mAHD (22.8 - 23.6m above the base of the model);
- South - normal flow cell.
- West - constant head boundary set at 9.5 mAHD (18.5m above the base of the model);

The model grid has been set up to allow maximum interpretation of the problem domain whilst still covering all the area of interest on and all the site. Figure 1 shows the model grid.

The X boundary of the model is 1281m and the Y boundary is 713m. The smallest model grid spacing is 20m in the area of the problem domain (Omex Site - Roe Highway).

Model spacing increase in size by expansion of 1.5 to a maximum of 35m.

The grid has been orientated in a north west - south east orientation so that the model boundaries and grid lines are aligned with the anticipated groundwater flow direction and the contaminant plume.

3.2 Hydraulic Parameters

The hydraulic parameters of the aquifer material are important inputs into the model. The hydraulic conductivity and aquifer type for each layer in the model is listed below:

- Layer 1 - upper sandy clay, 8×10^{-6} m/sec, unconfined.
- Layer 2 - Coarse sand layers, 1.2×10^{-4} m/sec, confined.
- Layer 3 - clay and silts, 1.2×10^{-11} m/sec, confined.

The estimated hydraulic conductivity[3] values have been applied uniformly across each layer in the site, as no trend in heterogeneity was observed and the groundwater contours are relatively uniform. A cross-section of the model layers is shown in Figure 2.

A steady state water movement model was run to provide the hydraulic conditions for contaminant transport. The steady state model did not require storage characteristics for water movement, however porosity values are required for the contaminant transport simulation. These have been applied as follows:

Effective Porosity - 30%
Total Porosity - 35%

Porosity values have been taken from published sources.[4]

[3] Hydraulic conductivities have been determined from tests carried out by CMPS&F 1998.
[4] Groundwater, Freeze RA and Cherry JA 1979, published by Prentice Hall.

4. GROUNDWATER CONTAMINATION

The disposal of waste oil in the Omex Site has led to soil and groundwater contamination by a variety of organic and inorganic parameters. Groundwater sampling has indicated that some areas both within and outside of the site boundaries have elevated concentrations of dissolved metals and organic compounds. To date 2 rounds of sampling have been undertaken.

The following parameters and terms have been used in this modelling exercise:

- Source term: the source term for the model has been taken from the analytical results of testing performed on a aqueous phase liquid collected from the area of the tarpit. Representative concentrations of contaminants in this sample are listed in Table 1.
- Background water quality has been assessed by examination of the water quality of groundwater samples taken from 2 bores located upgradient of the pit, see Table 1 and Figure 2.
- Contaminated groundwater samples were collected from 4 bores located downgradient of the pit, see Table 1 and Figure 2.
- Uncontaminated groundwater samples were collected from a further 8 boreholes located downgradient of the pit and are judged to be beyond the zone of impact of a groundwater plume emanating from the site.
- In this modelling exercise only a selected number of parameters have been simulated, these are; one organic parameter based on Total Petroleum Hydrocarbons (TPH) and one inorganic parameter based on dissolved nickel. The monitoring results indicate that the major sources of contamination are located within the area of the pit. It is believed that waste oils and by-products have been placed in the pit for a period of 40 years.

5. NUMERICAL MODELLING

5.1 Introduction

The behaviour of existing and potential groundwater contaminant plumes at the site is important, particularly with regard to the protection of groundwater resources in the Leederville aquifer.

Previous work has assessed the distribution of contamination in groundwater downgradient of the pit and the composition of the material within the pit that is sourcing the contamination.

5.2 Parameter Estimation

The data that characterises the hydrogeological conditions of the site were input into a Visual Modflow data file and used in the simulation of water movement. The parameters and the selected data values are listed below:

Hydraulic Conductivity:	Layer 1	$8\text{-}10^{-6}$ m/sec
	Layer 2	1.2×10^{-4} m/sec
	Layer 3	1.2×10^{-11} m/sec

Storage Coefficients: Infinite storage in constant head boundaries

Storage Coefficient	=	0.1
Effective Porosity	=	0.3
Total porosity	=	0.35

Piezometry: Water table map used for calibration and initial condition taken from monitoring well gauging results undertaken by CMPS&F 7/8/98.

Computation: Convergence was achieved using the WHS (Bi-Combugate Gradient Method) with default values used for number of iterations and the maximum error.

Calibration of the model was achieved by comparing the simulated heads against the observed heads. Input parameters were adjusted on a trial and error basis until a good match between simulated results and field measurements was achieved.

Having demonstrated that the calibrated water movement model provides a realistic simulation of the groundwater flow process at the site, the model was then used to predict the behaviour of groundwater contaminant plume. Source term calls were nominated in the model such that groundwater flow through these cells was contaminated by a set concentration. The source cells were located in the Omex site within Layer 2 (Leederville aquifer). For transport computation, the following parameters were used:

Dispersion: numerical dispersion is through to have been significantly minimised in this model by the grid orientation. Longitudinal dispersion was set at 5.0 m and the ratio between longitudinal and transverse dispersion was set of 0.1. These parameters have been set according to a conventional approach whereby, in the absence of site specific information, the longitudinal dispersion is set at one tenth the length of the anticipated flow path. It is also necessary to keep the dispersion below the size of the smallest computational cell used in the model grid in order to avoid problems associated with numerical dispersion (viz Peclet Number[5].) Another assumption often used in modelling, and substantiated by tracer tests, is that longitudinal dispersivity is an order of magnitude larger than the transverse[6].

Source Concentration: The source concentration for TPH was set between 5.6 to 0.2 mg/L, in a distribution based on the observed groundwater conditions. The source concentration for nickel was set between 5.0 to 0.04 mg/L, in a distribution based on the observed groundwater conditions.

Retardation: Retardation factors have been taken from published material and have been refined on a trial and error basis so that the resultant simulated chemical concentrations matched the observed concentration, the retardation rates are described below. Distribution coefficients range from values near zero to over 1000ml/g, if coefficients are orders of magnitude above 1 then the contaminant is essentially immobile. TPH is expected to be both sorbed onto mineral grains and to undergo degradation as a result of microbial activity, both mechanisms are included in the simulation and are listed below[7].

---

5 Applied Groundwater Modelling, Anderson M.P and Woessner W.W. Academic Press, 1992.

6 A Groundwater tracer test with deuterated compounds for monitoring in-situ biodegradation and retardation of aromatic hydrocarbons. Thierrin, J., Davis, G. B. and Barber, C. 1995. Ground water, 33, 469-475.

7 Technologies for enhanced remediation of contaminated soils and aquifers: overview, analysis and case studies. Rao P.S.C., Davis G.B. and Johnstone C.D. Contaminants and the soil environment in the Australasia- Pacific Region. 1996 Kluwer Academic Publishers.

Sorption coefficient (linear): 0.00012 m^3/Kg

Degradation rate (1st order rate) : 0.000063 day^{-1}

Studies[8] have indicated that the sorption capacity of nickel in sand with minor quantities of fines and organic matter, is reached at about 256mg/Kg for nickel, the isotherms tend to display Langmuirian characteristics. Competitive sorption between heavy metals causes a reduction in their removal from solution, when compared to individual elements. However , these features are strongly site specific, and in the absence of information for the Omex site a simplified approach has been adopted:

Sorption coefficient (linear): 0.00012 m^3/Kg

5.3 Results

Organic Plume

The analytical results for TPH in groundwater from monitoring wells in the environs or the Omex site is presented in Table 1.

TPH was simulated as a release from a source in model grid cells in the position labelled OMEX site (see figure 1). The source was released from layer 2 only. The contaminant plume was calibrated so as to match the observed concentrations and the overall distribution or the contaminants is representative of the existing conditions, ie there is a reasonable match between the simulated plume and the field measurements, see TPH results, Time = O years (Figure 4a and 4b).

The source of the contaminants was then stopped in the simulation and the contaminant plume was simulated for a further 100 years. This was done in an attempt to replicate the installation or a cut-off wall around the pit. During this period the simulated plume recedes and moves away from the source. The results are shown in the attached figures which show the plume distribution at 5 years (Figure 5a and 5b), 25 years (Figure 6a and 6b), 50 years (Figure 7), 75 years (Figure 8) and 100 years (Figure 9). The concentration contour which relates to the drinking water standard (Dutch B guideline level for TPH = 0.2 mg/l) is included in the plots.

Inorganic Plume

The analytical results for Nickel in groundwater from monitoring wells in the environs or the Omex site is presented in Table 1.

Nickel was simulated as a release from model grid cells in the position labelled OMEX site (see figure 1). The source was released from layer 2 only. The contaminant plume was calibrated so as to match the observed concentrations and the overall distribution or the

[8] Adsorption tests of heavy metals on three sand soils from the Botany Sands aquifer, Sydney, Australia: Implications for estimation of contaminant transport. Beck P.H. and Jankowski J. International Groundwater Conference 1998; Sustainable Solutions.

contaminants is representative of the existing conditions, ie there is a reasonable match between the simulated plume and the field measurements, see Nickel results, Time = O years (Figure 10a and 10b).

The source of the contaminants was then stopped completely and the contaminants plume was simulated for a further 100 years. This was done in an attempt to replicate the installation or a cut-off well around the pit. During this period the simulated plume recedes and moves away from the source The results are shown in the attached figures which show the plume distribution at 5 years (Figure 11a and 11b), 25 years (Figure 12a and 12b), 50 years (Figure 13), 75 years (Figure 14) and 100 years (Figure15). The concentration contour which relates to the drinking water standard (NHMRC guideline level for Nickel = 0.02 mg/l) is included in the plots.

6. CONCLUSIONS AND RECOMMENDATIONS

A 3 dimensional steady state ground model has been established which simulates the transport of organic and inorganic parameters across the environs surrounding the OMEX site. The modelling results indicate:

- The estimated hydraulic conductivity values appear to be appropriate and result in water movement across the study area that is reasonable and matches the observed groundwater lead distribution;

- Contaminants have been modelled by introducing a source and generating a plume. The extent of the plume is known as an initial condition and the model was then terminated and the plume allowed to dissipate and recede.

- The model results appear to be sensitive to retardation and these have been established in the model based on published references, wherever possible selecting retardation factors from sites with similar settings. Retardation for the organic parameter (TPH) includes a linear sorption coefficient and a degradation term. Retardation for the inorganic parameter (Nickel) includes only a linear sorption coefficient. The model code allows for more sophisticated retardation terms, however, in the absence of site-specific information these have not been applied.

- It was found that the behaviour of Nickel and TPH was similar (the effect of the degradation term is not considered to be large) and overall indicated that the extent of the plume continued to enlarge for a period of approximately 50 years after the source was stopped. After this time the plume appears to dilute and disperse away.

- The model has used concentration contours which relate to the drinking water standard (0.2 mg/L TPH and 0.02 mg/L Nickel).

  The results indicate that for TPH the plume concentrations are higher than the drinking water standard for a period of 25 years at locations down gradient of the OMEX tip. After this period, the model predicts that the overall areal extent of the plume may continue to enlarge but the predicted concentrations are likely to be less than the drinking water standard.

  The results indicate that the nickel plume concentrations are higher than the drinking water standard for a period of at least 100 years at locations down gradient of the OMEX tip. The plume extent reaches a maximum after a period of 75 years after which the model results indicate that it begins to recede in size.

  In both TPH and nickel plumes, the existing condition (ie as measured during investigations) is one where the contaminants are distributed in a wide area around the source, indicating that transverse dispersion coefficients are quite significant. As the plume migrates away from the source, the model predicts the plume will became extremely elongated (ie longitudinal dispersion will dominate), these results are consistent with current hydrogeological understanding of plume behaviour[9].

- Overall the groundwater plumes are shown to move relatively slowly and consistently through the aquifer. Additionally the contaminants appear to be relatively persistent. The slow movement of the plume is attributed to the low hydraulic gradient in the Leederville aquifer. The persistence of the contaminants is due, in part, to the retardation factors that have been incorporated. These have been determined from published sources and it is not possible to determine how accurate they are. It is possible that the retardation factors that have been used in the model are an over-simplification and in reality the retardation is more complex than the simple linear sorption isotherm that has been assumed.

****

[9] A Groundwater tracer test with deuterated compounds for monitoring in-situ biodegradation and retardation of aromatic hydrocarbons. Thierrin, J., Davis, G. B. and Barber, C. 1995. Ground water, 33, 469-475.

Should you wish to discuss any aspects of this work please do not hesitate to contact the undersigned on (94129698)

Yours faithfully,

Philip Burris
Hydrogeologist

Attachments: Table 1 - Summary of Contaminant Concentration in OMEX Source and Monitoring Wells.

Figure 1 - Model grid
Figure 2 - Model cross-section
Figure 3 - Groundwater contours and velocities
Figure 4a - TPH plume (0 years), plan view
Figure 4b - TPH plume (0 years), section view
Figure 5a - TPH plume (5 years), plan view
Figure 5b - TPH plume (5 years), section view
Figure 6a - TPH plume (25 years), plan view
Figure 6b - TPH plume (25 years), section view
Figure 7 - TPH plume (50 years), plan view
Figure 8 - TPH plume (75 years), plan view
Figure 9 - TPH plume (100 years), plan view
Figure 10a - Nickel plume (0 years), plan view
Figure 10b - Nickel plume (0 years), section view
Figure 11a - Nickel plume (5 years), plan view
Figure 11b - Nickel plume (5 years), section view
Figure 12a - Nickel plume (25 years), plan view
Figure 12b - Nickel plume (25 years), section view
Figure 13 - Nickel plume (50 years), plan view
Figure 14 - Nickel plume (75 years), plan view
Figure 15 - Nickel plume (100 years), plan view

Table 1 : Summary of Contaminant Concentrations in Omex Source and Monitoring Wells

Parameter	Background		Source[1]	Contaminated				Uncontaminated								Drinking Water Guidelines[2]
	MB1D	WA2	OM2B/2	WA6	WA8	MB2D	MB3D	1	2	3	4	5	7	8	9	
TPH C_6-C_9	**ND**	**ND**	-	0.78	1.2	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	
TPH C_{10}-C_{14}	**ND**	**ND**	-	0.74	0.64	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	
TPH C_{15}-C_{28}	**ND**	**ND**	-	0.46	0.31	ND	ND	ND	ND	ND	ND	ND	ND	0.09	0.15	
TPH C_{29}-C_{36}	**ND**	**ND**	-	ND	ND	2.2	ND	ND	ND	ND	ND	ND	ND	0.07	0.25	
TPH C_6-C_{36}	**ND**	**ND**	**5.56**	**1.98**	**2.15**	**2.2**	ND	ND	ND	ND	ND	ND	ND	0.16	**0.4**	0.2
Total Phenols	0.007	**ND**	5.2	ND	ND	ND	0.02	ND	ND	ND	ND	ND	ND	ND	ND	
Nickel	**ND**	**ND**	**5**	**0.17**	**0.41**	**0.16**	**0.03**	ND	ND	ND	ND	ND	ND	**0.04**	**0.06**	0.02
Zinc	0.01	0.03	**440**	0.28	1.2	0.52	0.18	0.11	0.03	0.01	ND	0.04	0.02	0.02	0.12	3

Note : Units are mg/L

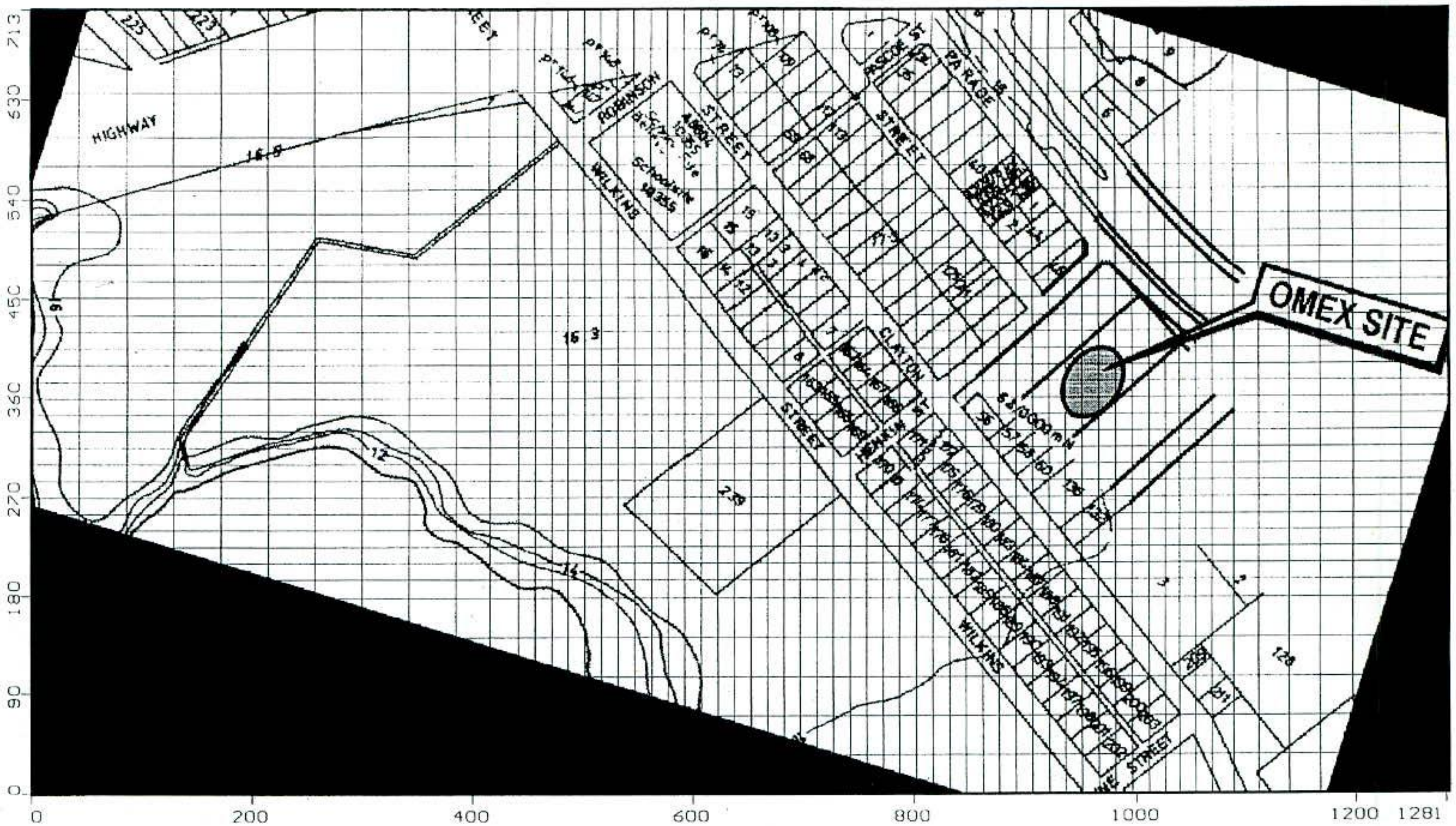
Bold = value greater than guideline.

[1]Taken from sample OM2B/2 as reported in the testing of Hazard Characterisation Samples for Golder Associates. Report No 96EH0123r by the Chemistry Centre (WA).

[2]National Health and Medical Research Council (NHMRC) / Agricultural and Resource Management Council for Australia and New Zealand (ARMCANZ).

GROUNDWATER MODEL

OMEX



CMPS&F Project: OMEX Description: Model Domain and Grid Modeller: P. Burris 28 Aug 98	Visual MODFLOW v.2.7.1, (C) 1995–1997 Waterloo Hydrogeologic, Inc. NC: 60 NR: 34 NL: 3 Current Layer: 2

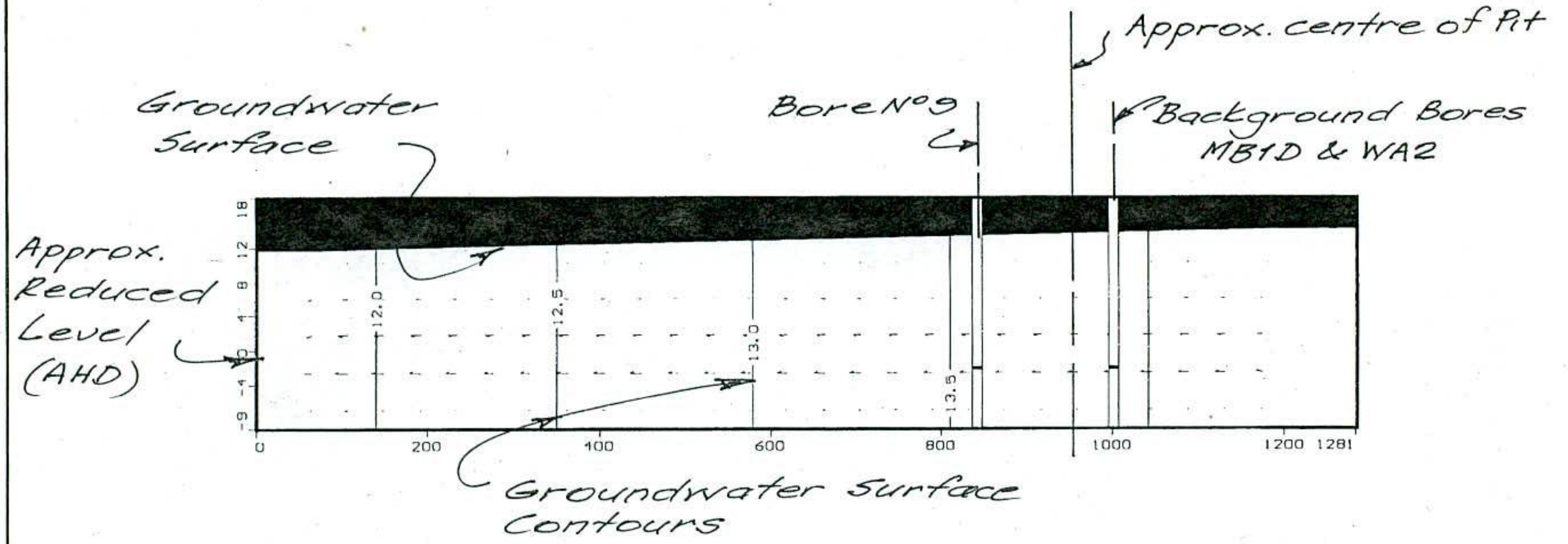
Date : 31 August 1998

Source: CMPS&F

File Name : G:\DATA\VW\1100\VW110001.CDR

GROUPE aegis CMPS&F

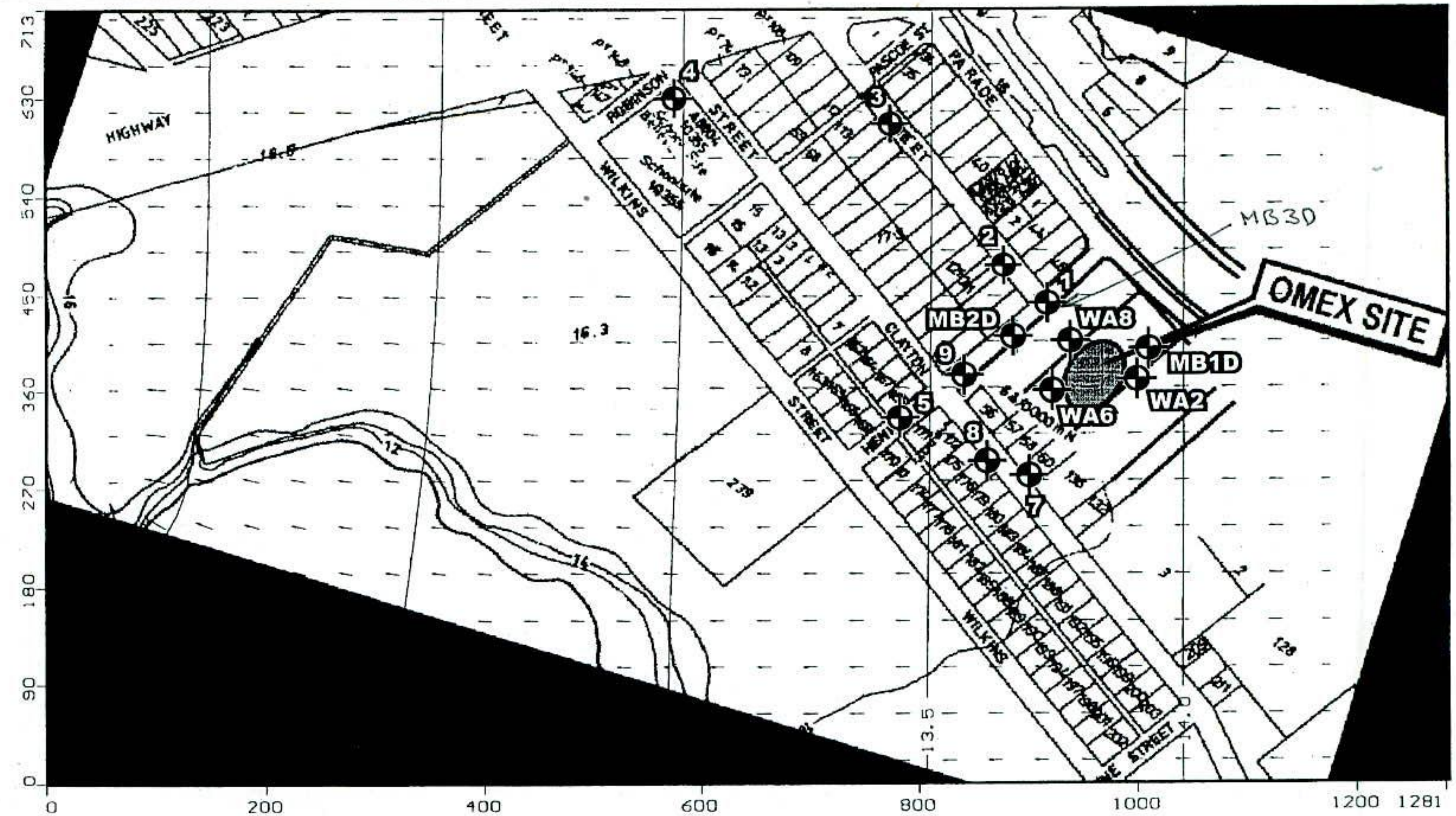
Figure 1



CMPS&F Project: OMEX Description: GW Contours Modeller: P. Burris 28 Aug 98	Visual MODFLOW v.2.7.1, (C) 1995–1997 Waterloo Hydrogeologic, Inc. NC: 60 NR: 34 NL: 3 Current Row: 17

GROUNDWATER MODEL

OMEX



CMPS&F Project: OMEX Description: GW Contours – Velocities Modeller: P. Burris	Visual MODFLOW v.2.7.1, (C) 1995–1997 Waterloo Hydrogeologic, Inc. NC: 60 NR: 34 NL: 3 Current Layer: 2

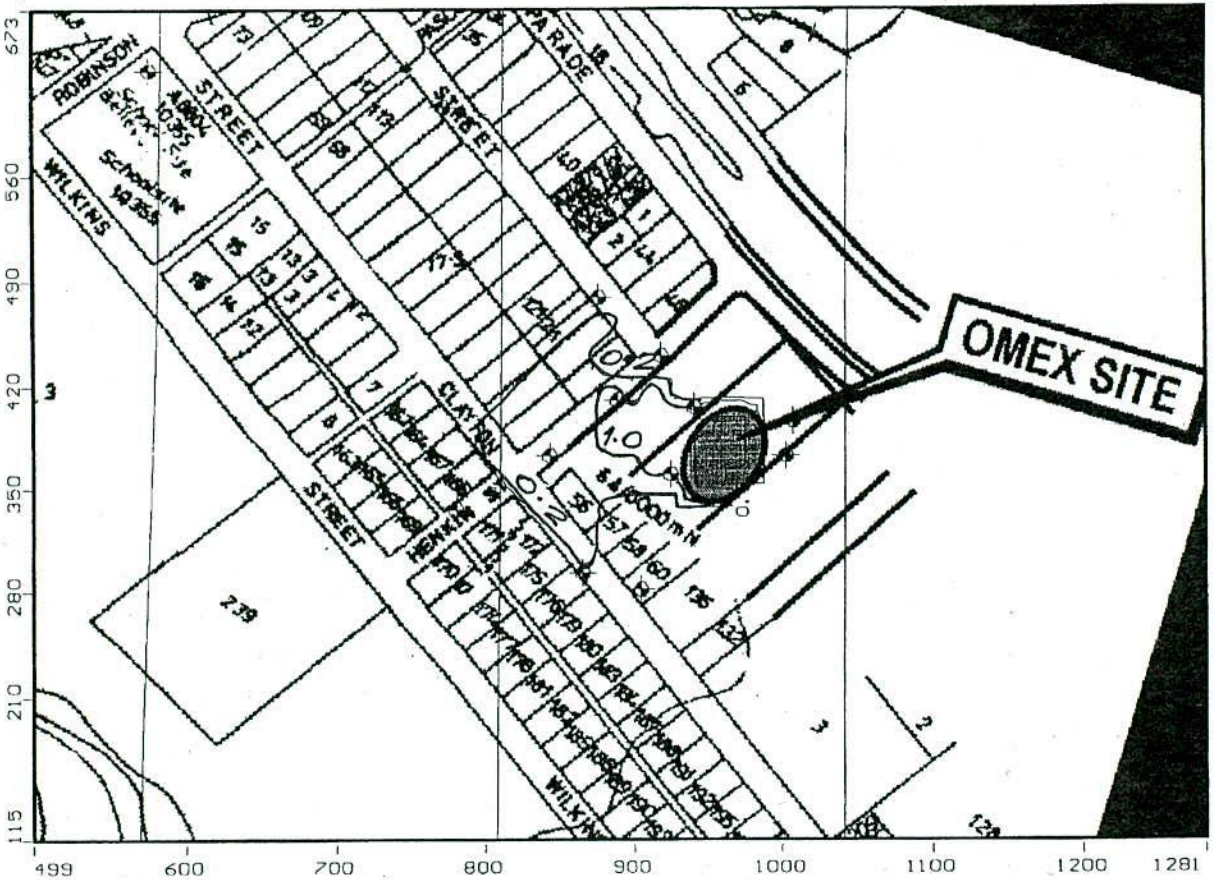
Date : 1 September 1998

Source: CMPS&F

File Name : G:\DATA\VW\1100\VW110003.CDR

Figure 3

OMEX

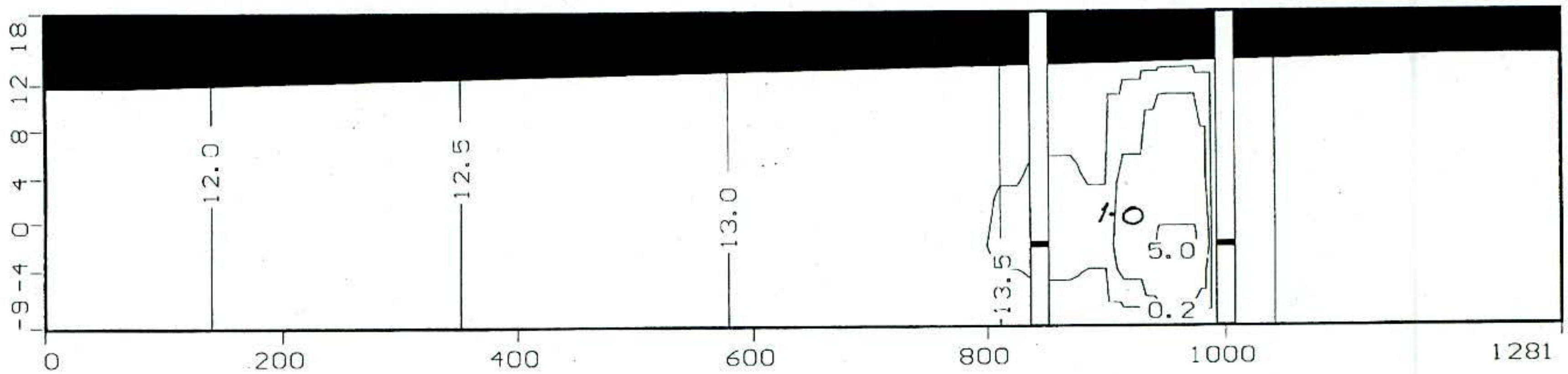


CMPS&F
Project: OMEX
Description: TPH (0 Years), mg/L
Modeller: P. Burris
28 Aug 98

Visual MODFLOW v.2.7.1, (C) 1995–1997
Waterloo Hydrogeologic, Inc.
NC: 60 NR: 34 NL: 3
Current Layer: 2

GROUNDWATER MODEL

OMEX



CMPS&F
Project: OMEX
Description: TPH (0 Years), mg/L
Modeller: P. Burris
28 Aug 98

Visual MODFLOW v.2.7.1, (C) 1995-1997
Waterloo Hydrogeologic, Inc.
NC: 60 NR: 34 NL: 3
Current Row: 17

Date : 1 September 1998

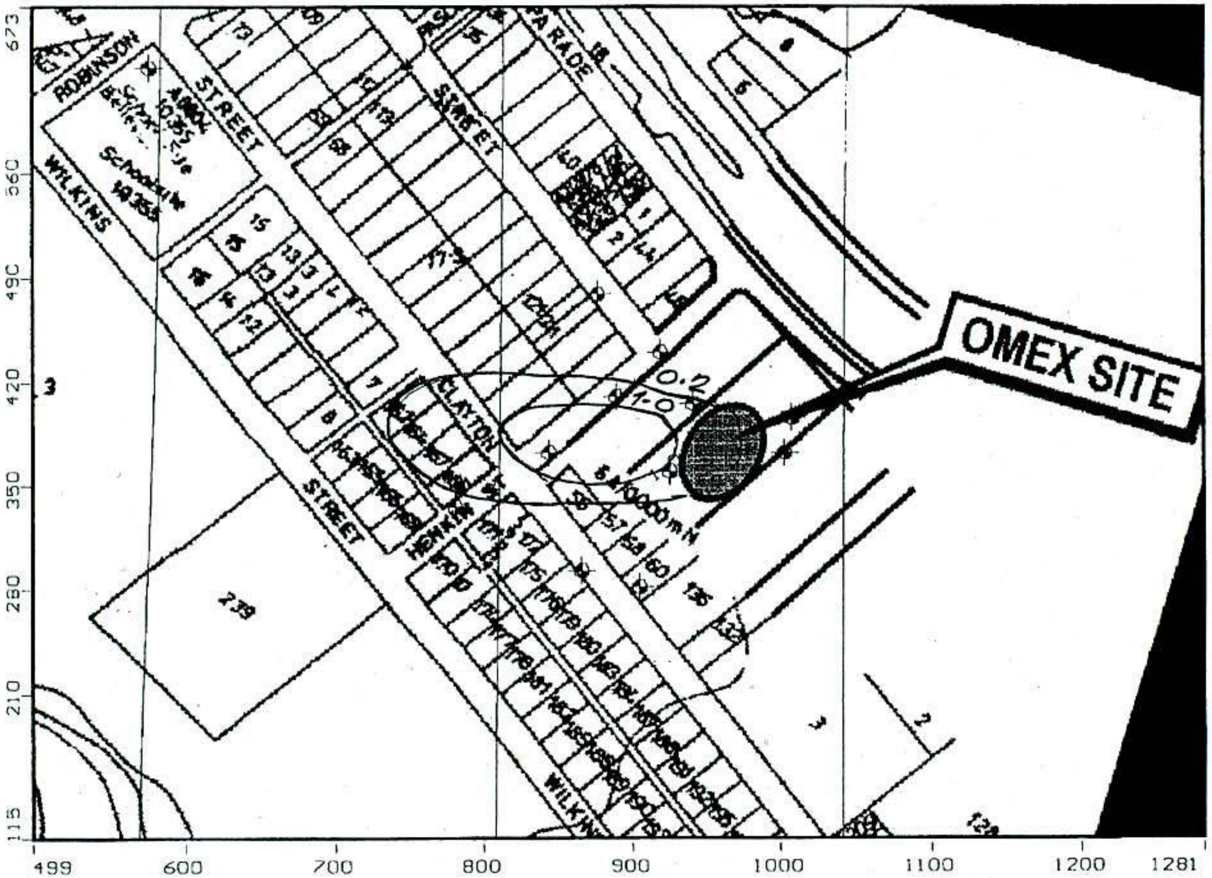
File Name : G:\DATA\VW\1100\VW110005.CDR

Source: CMPS&F

Figure 4B

GROUNDWATER MODEL

OMEX



CMPS&F
Project: OMEX
Description: TPH (5 Years) , mg/L
Modeller: P. Burris
28 Aug 98

Visual MODFLOW v.2.7.1, (C) 1995–1997
Waterloo Hydrogeologic, Inc.
NC: 60 NR: 34 NL: 3
Current Layer: 2

Date : 1 September 1998

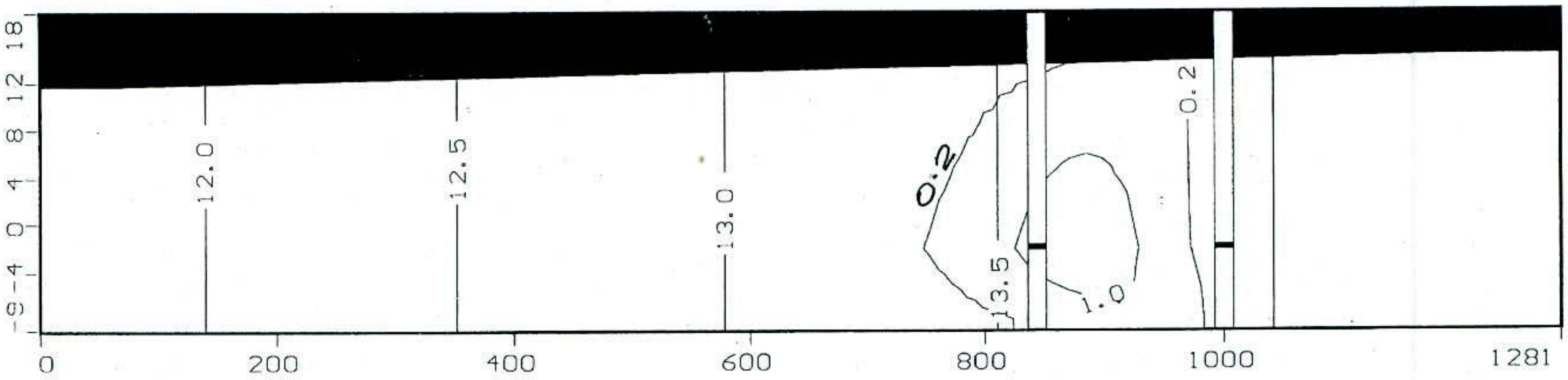
Source: CMPS&F

File Name : G:\DATA\VW\1100\VW110006.CDR

Groupe Aegis CMPS&F

Figure 5A

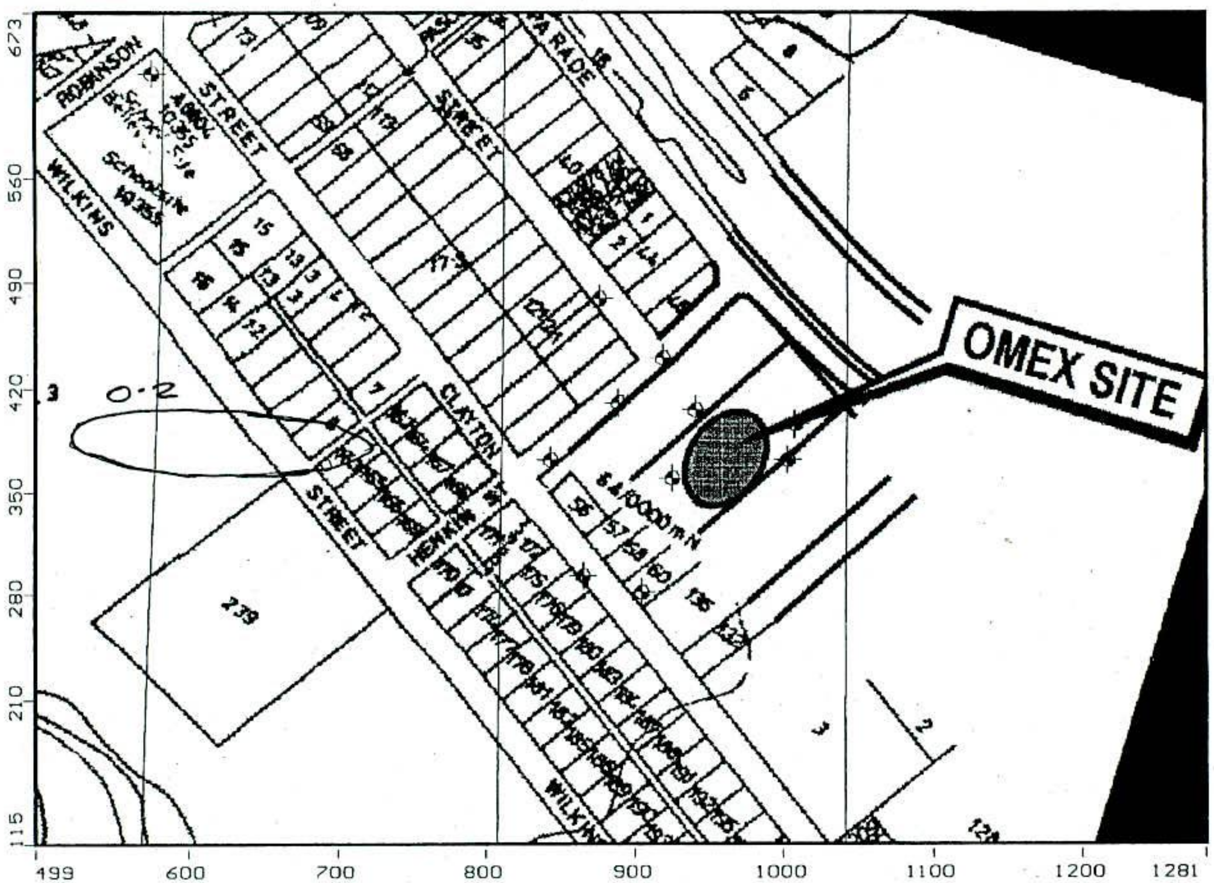
OMEX



CMPS&F
Project: OMEX
Description: TPH (5 Years), mg/L
Modeller: P. Burris
28 Aug 98

Visual MODFLOW v.2.7.1, (C) 1995–1997
Waterloo Hydrogeologic, Inc.
NC: 60 NR: 34 NL: 3
Current Row: 17

OMEX



CMPS&F Project: OMEX Description: TPH (25 Years), mg/L Modeller: P. Burris 28 Aug 98	Visual MODFLOW v.2.7.1, (C) 1995–1997 Waterloo Hydrogeologic, Inc. NC: 60 NR: 34 NL: 3 Current Layer: 2

GROUPE egis CMPS&F

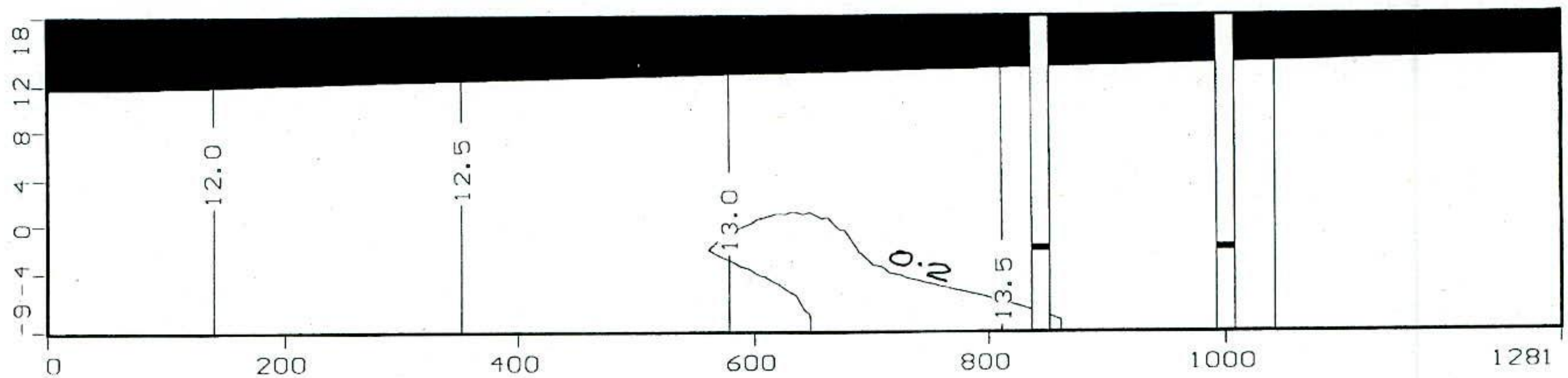
Date : 1 September 1998

File Name : G:\DATA\VW\1100\VW110008.CDR

Source: CMPS&F

Figure 6A

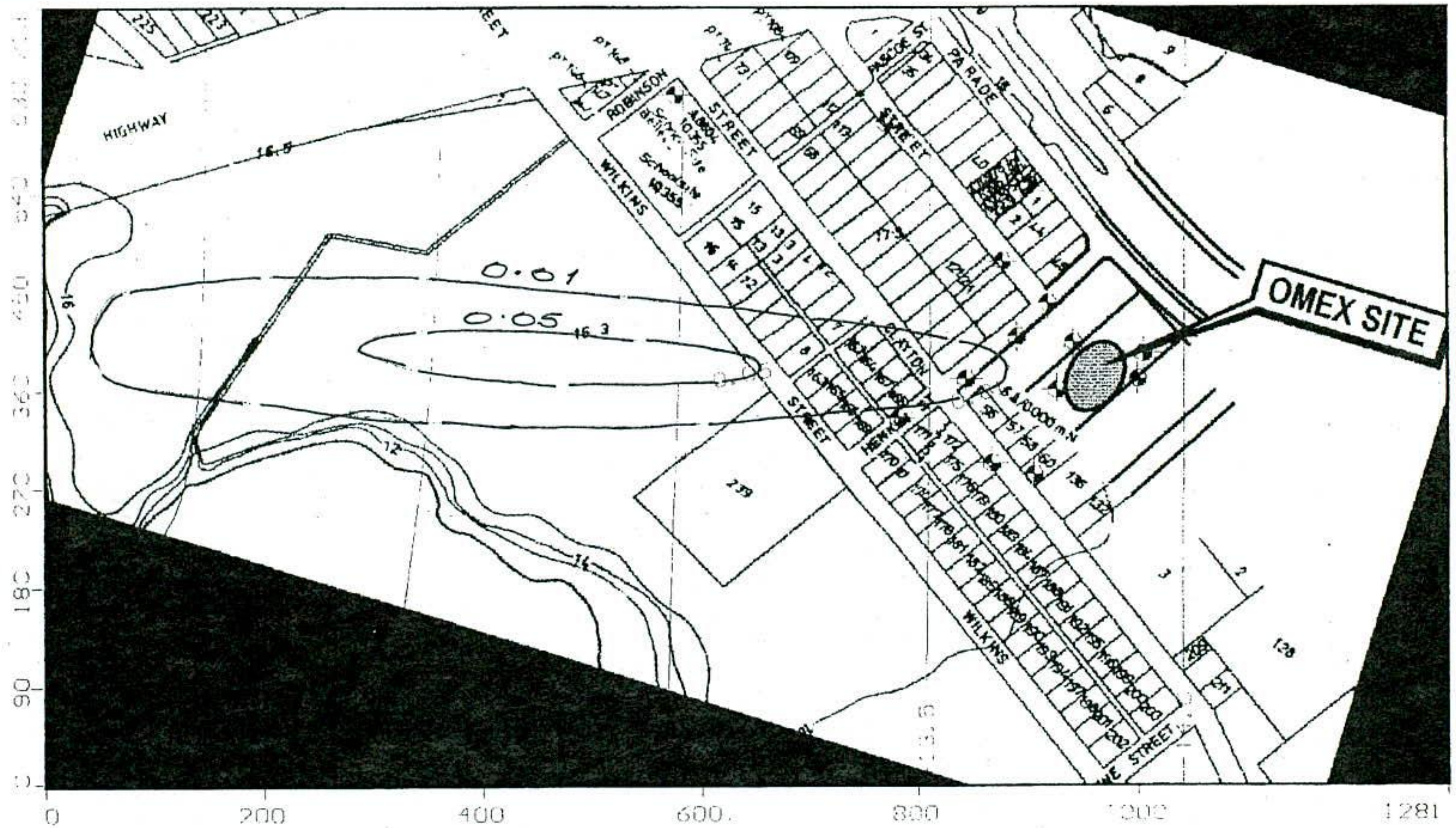
OMEX



CMPS&F
Project: OMEX
Description: TPH (25 Years), mg/L
Modeller: P. Burris
28 Aug 98

Visual MODFLOW v.2.7.1, (C) 1995–1997
Waterloo Hydrogeologic, Inc.
NC: 60 NR: 34 NL: 3
Current Row: 17

OMEX

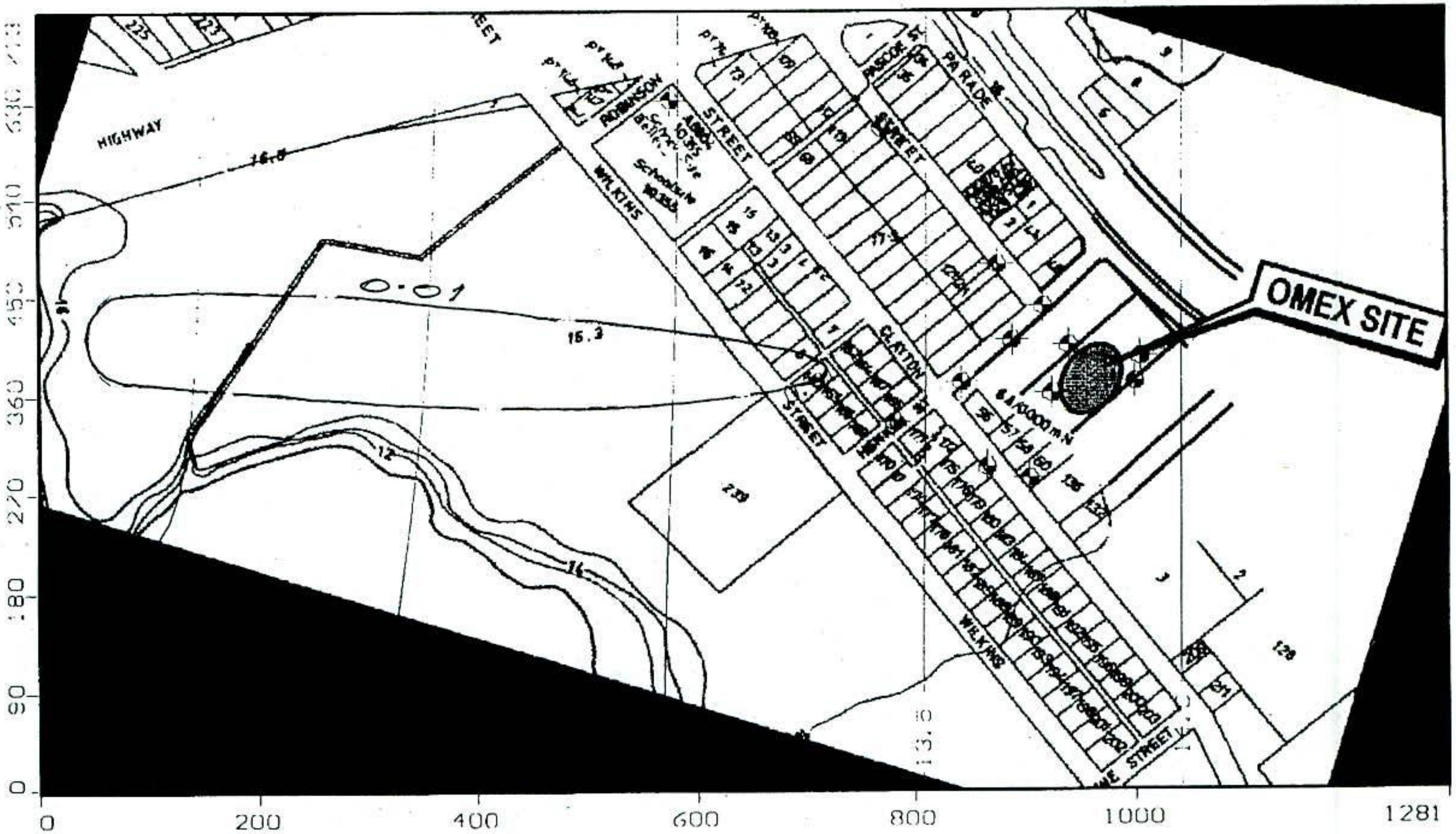


CMPS&F
Project: OMEX
Description: TPH (50 Years), mg/L
Modeller: P. Burris
28 Aug 98

Visual MODFLOW v.2.7.1, (C) 1995–1997
Waterloo Hydrogeologic, Inc.
NC: 60 NR: 34 NL: 3
Current Layer: 2

GROUNDWATER MODEL

OMEX



CMPS&F Project: OMEX Description: TPH (75 Years), mg/L Modeller: P. Burris 28 Aug 98	Visual MODFLOW v.2.7.1, (C) 1995–1997 Waterloo Hydrogeologic, Inc. NC: 60 NR: 34 NL: 3 Current Layer: 2

Date : 1 September 1998

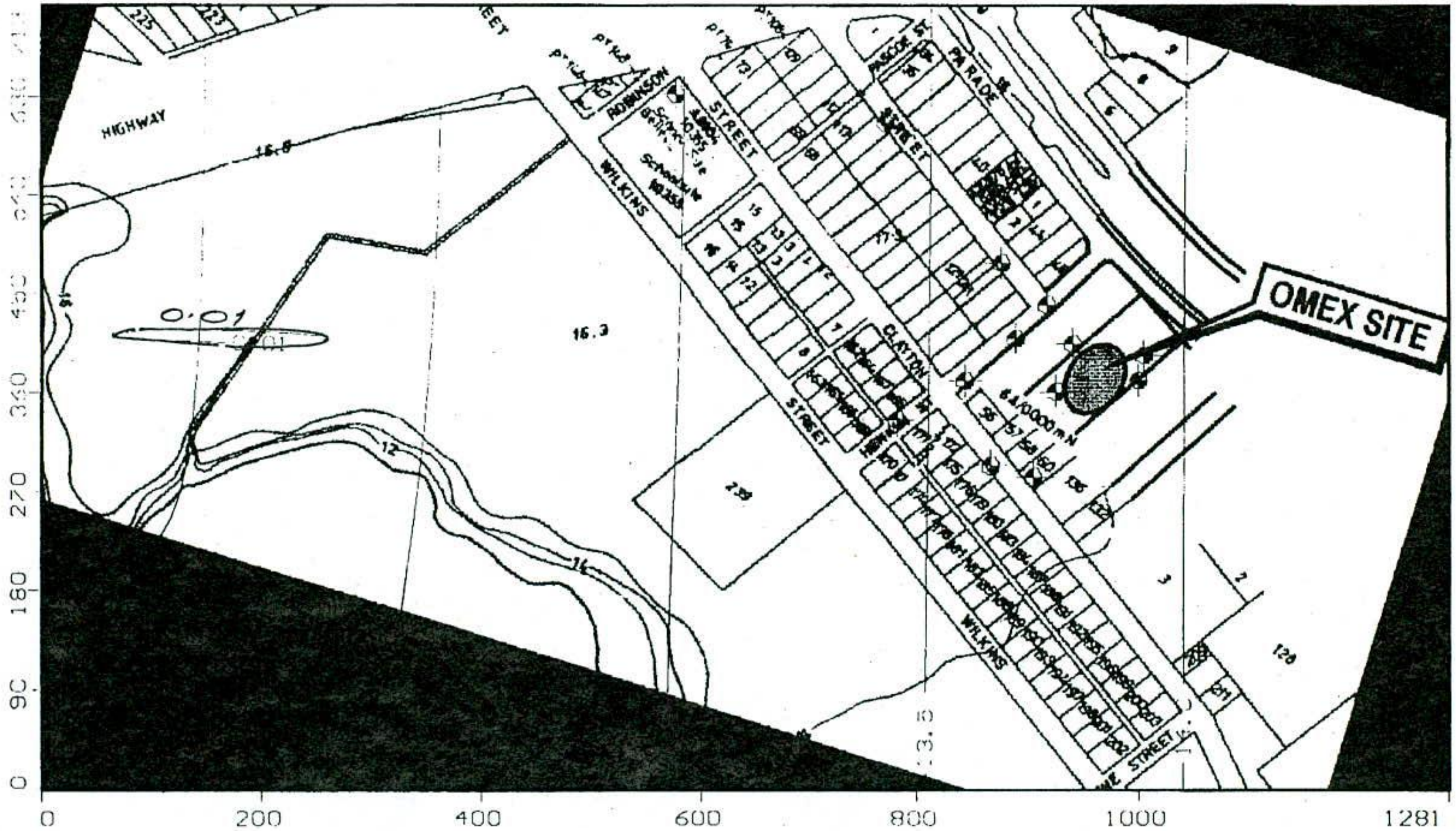
Source: CMPS&F

File Name : G:\DATA\VW\1100\VW110011.CDR

GROUPE Aegis CMPS&F

Figure 8

OMEX



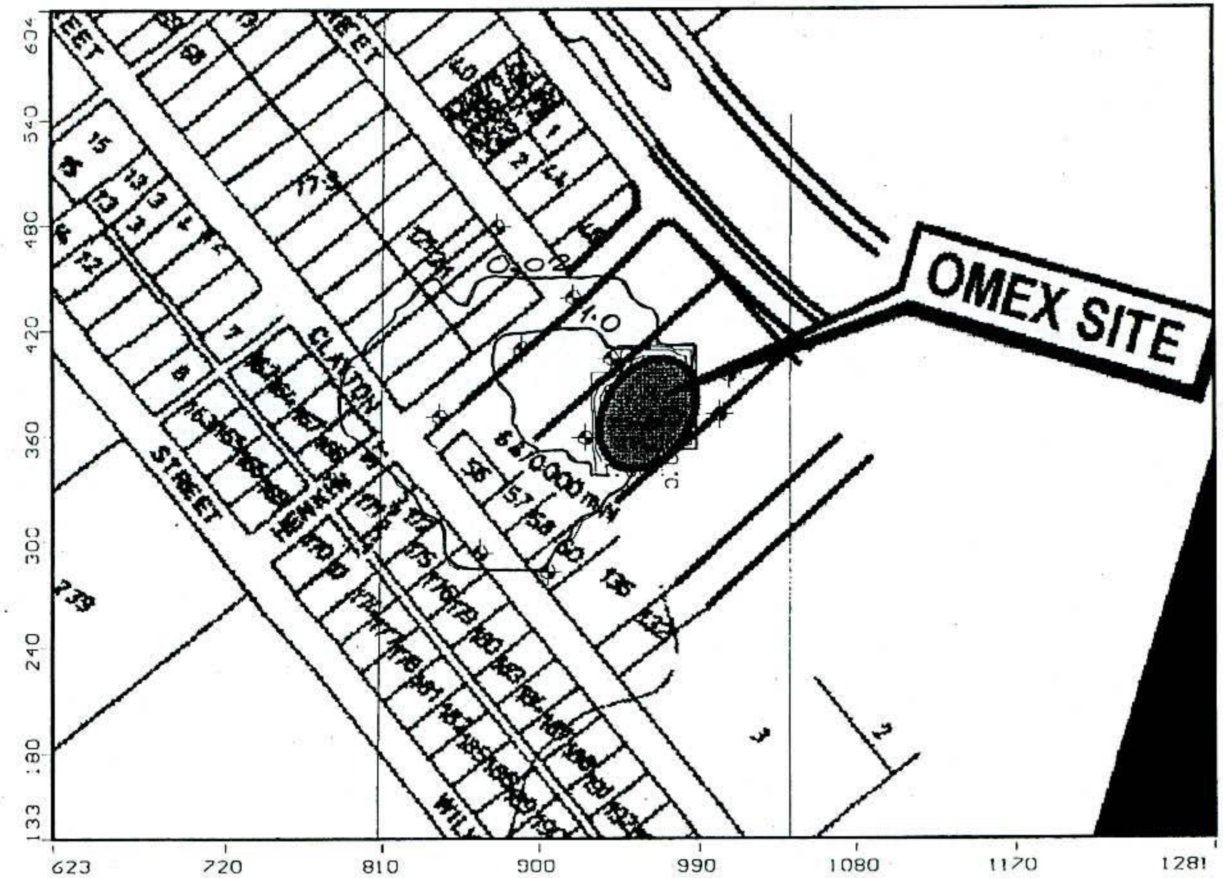
CMPS&F Project: OMEX Description: TPH (100 Years), mg/L Modeller: P. Burris 28 Aug 98	Visual MODFLOW v.2.7.1. (C) 1995-1997 Waterloo Hydrogeologic. Inc. NC: 60 NR: 34 NL: 3 Current Layer: 2

Date : 1 September 1998

Source: CMPS&F

File Name : G:\DATA\VW\1100\VW110012.CDR

Figure 9

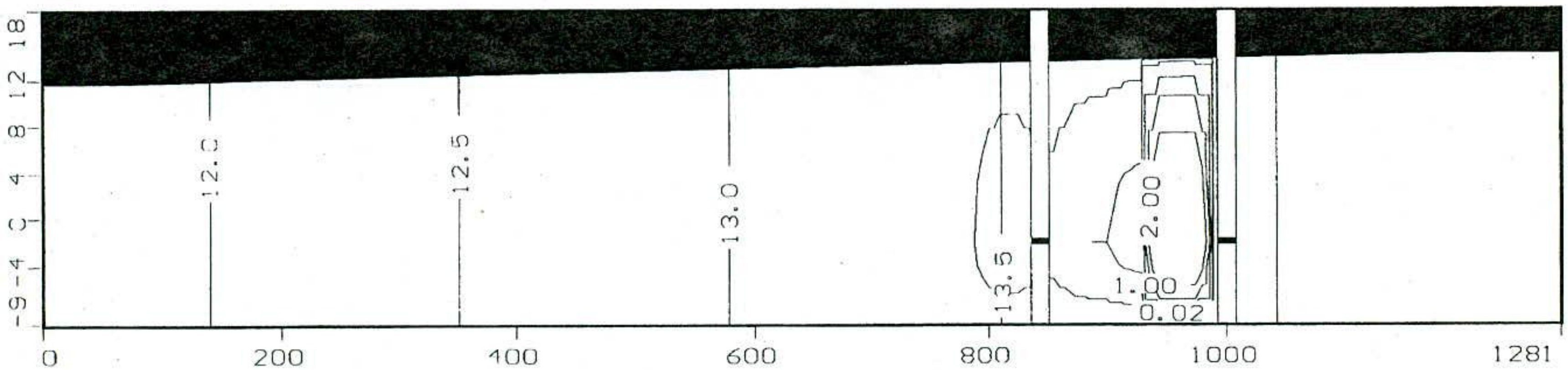


CMPS&F
Project: OMEX
Description: Nickel (0 Years), mg/L
Modeller: P. Burris
28 Aug 98

Visual MODFLOW v.2.7.1, (C) 1995–1997
Waterloo Hydrogeologic, Inc.
NC: 60 NR: 34 NL: 3
Current Layer: 2

GROUNDWATER MODEL

OMEX



CMPS&F Project: OMEX Description: Nickel (0 Years), mg/L Modeller: P. Burris 28 Aug 98	Visual MODFLOW v.2.7.1, (C) 1995–1997 Waterloo Hydrogeologic, Inc. NC: 60 NR: 34 NL: 3 Current Row: 17

Date : 1 September 1998

Source: CMPS&F

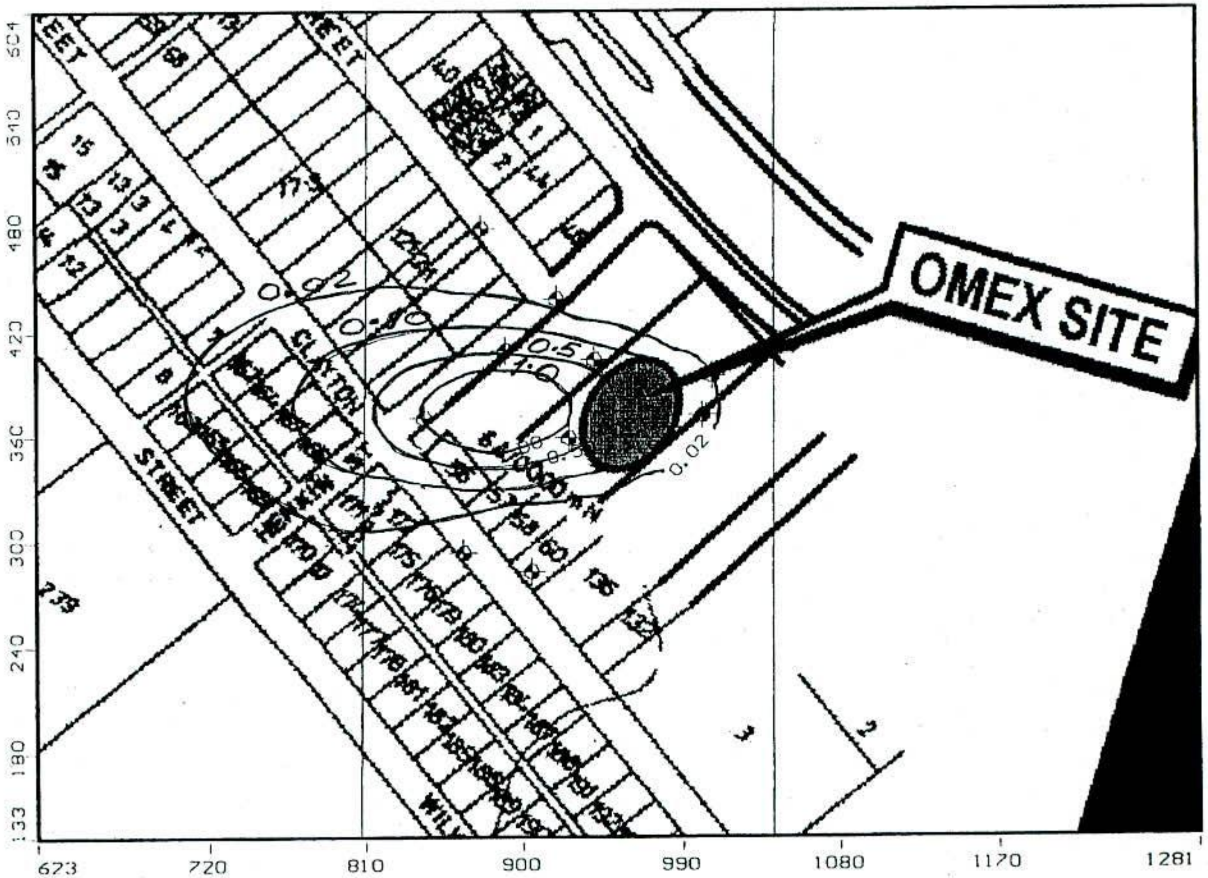
File Name : G:\DATA\VW\1100\VW110014.CDR

Groupe egis CMPS&F

Figure 10B

GROUNDWATER MODEL

OMEX



CMPS&F Project: OMEX Description: Nickel (5 Years), mg/L Modeller: P. Burris 28 Aug 98	Visual MODFLOW v.2.7.1, (C) 1995–1997 Waterloo Hydrogeologic, Inc. NC: 60 NR: 34 NL: 3 Current Layer: 2

Date : 1 September 1998

Source: CMPS&F

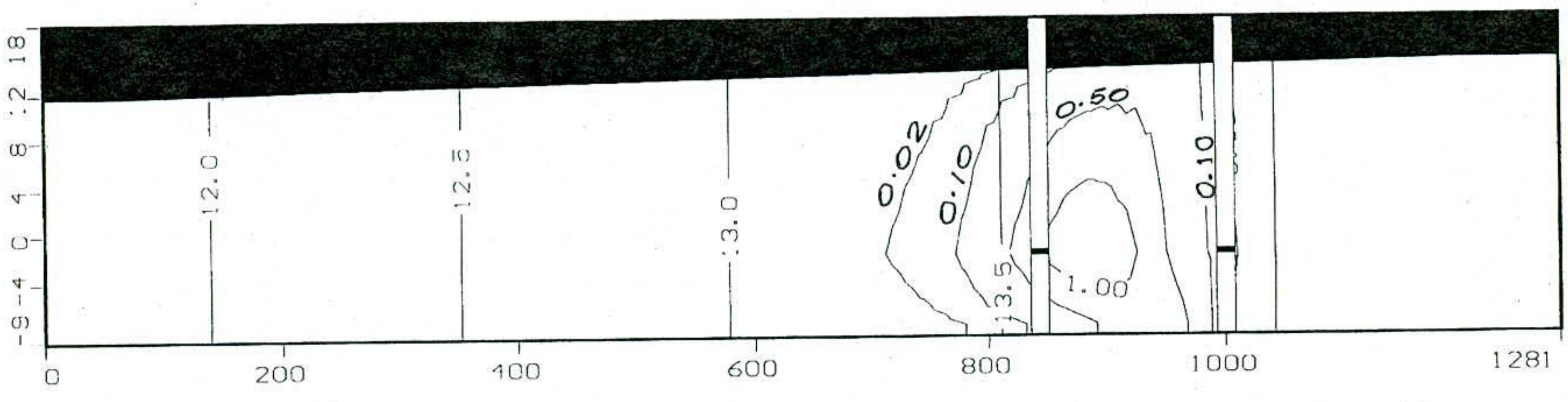
File Name : G:\DATA\VW\1100\VW110015.CDR

GROUPE aegis CMPS&F

Figure 11A

GROUNDWATER MODEL

OMEX



CMPS&F
Project: OMEX
Description: Nickel (5 Years), mg/L
Modeller: P. Burris
28 Aug 98

Visual MODFLOW v.2.7.1, (C) 1995-1997
Waterloo Hydrogeologic, Inc.
NC: 60 NR: 34 NL: 3
Current Row: 17

Date : 1 September 1998

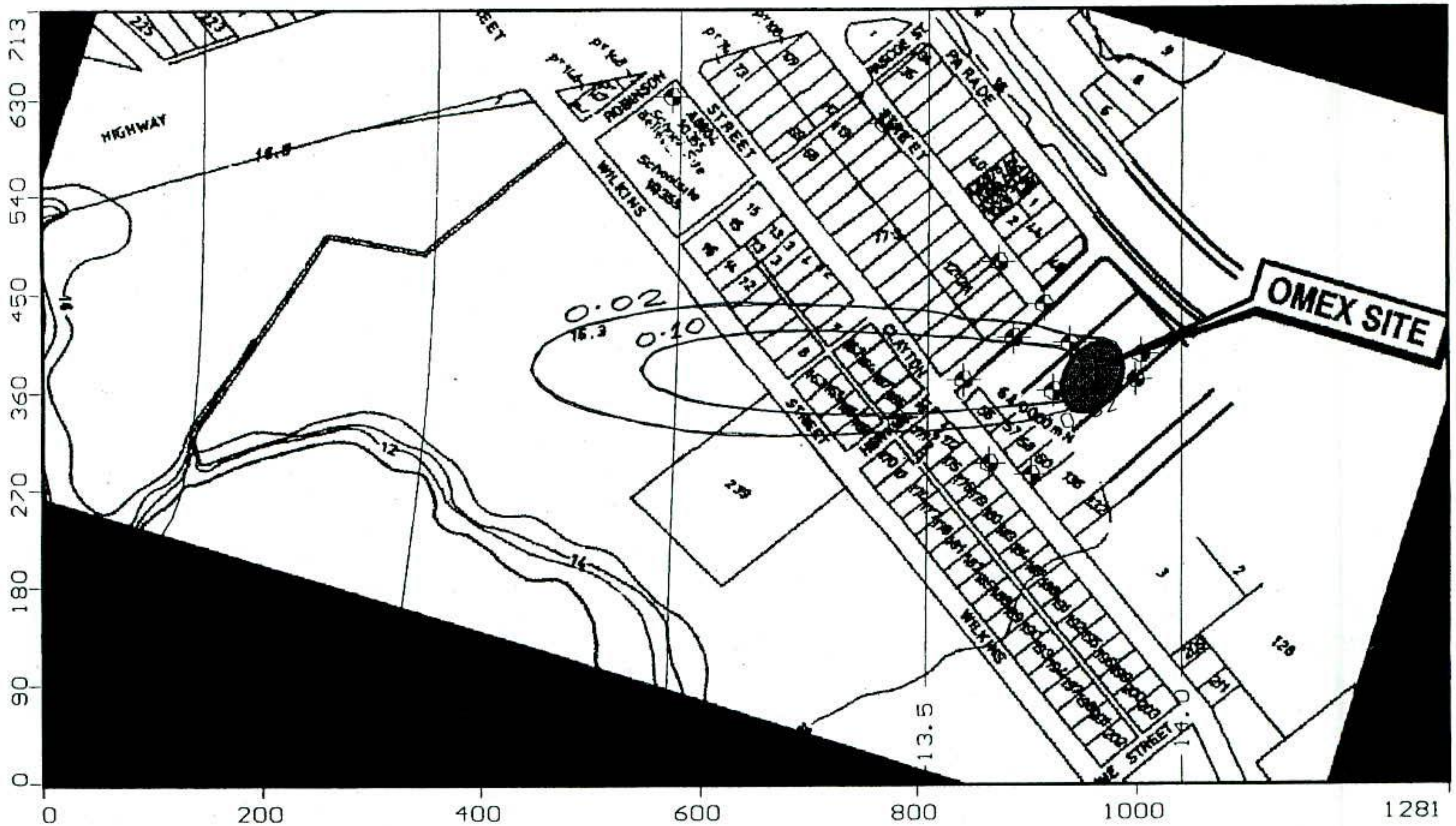
Source: CMPS&F

File Name : G:\DATA\VW\1100\VW110016.CDR

Figure 11B

GROUNDWATER MODEL

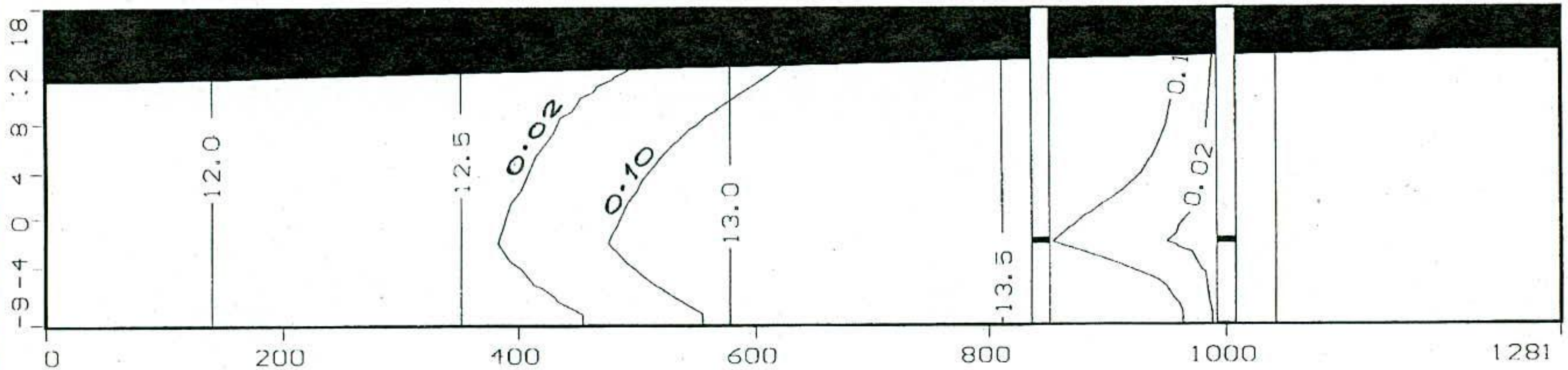
OMEX



CMPS&F Project: OMEX Description: Nickel (25 Years), mg/L Modeller: P. Burris 28 Aug 98	Visual MODFLOW v.2.7.1, (C) 1995–1997 Waterloo Hydrogeologic, Inc. NC: 60 NR: 34 NL: 3 Current Layer: 3

GROUNDWATER MODEL

OMEX



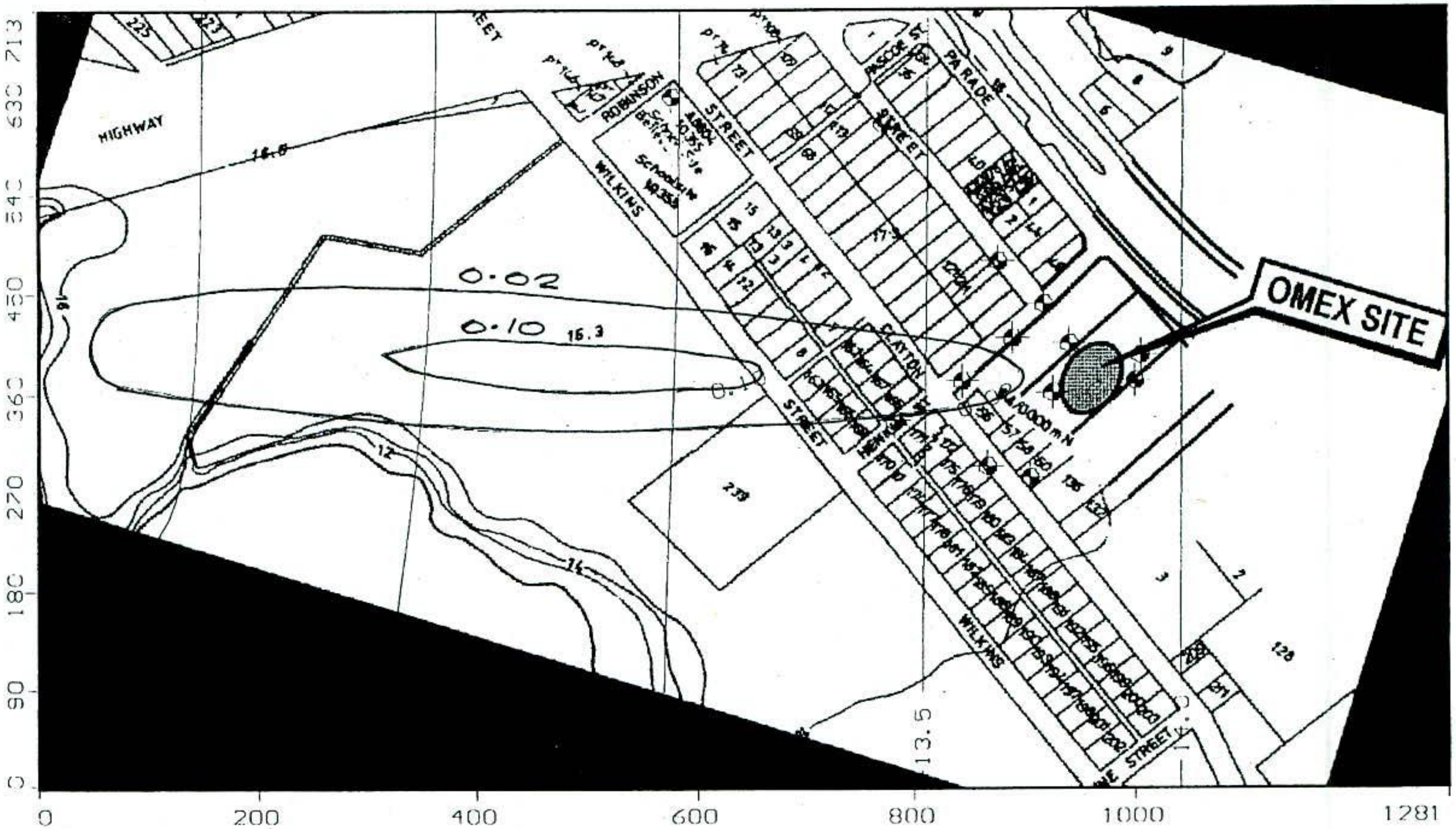
CMPS&F Project: OMEX Description: Nickel (25 Years), mg/L Modeller: P. Burris 28 Aug 98	Visual MODFLOW v.2.7.1, (C) 1995–1997 Waterloo Hydrogeologic, Inc. NC: 60 NR: 34 NL: 3 Current Row: 17

Date : 1 September 1998

Source: CMPS&F

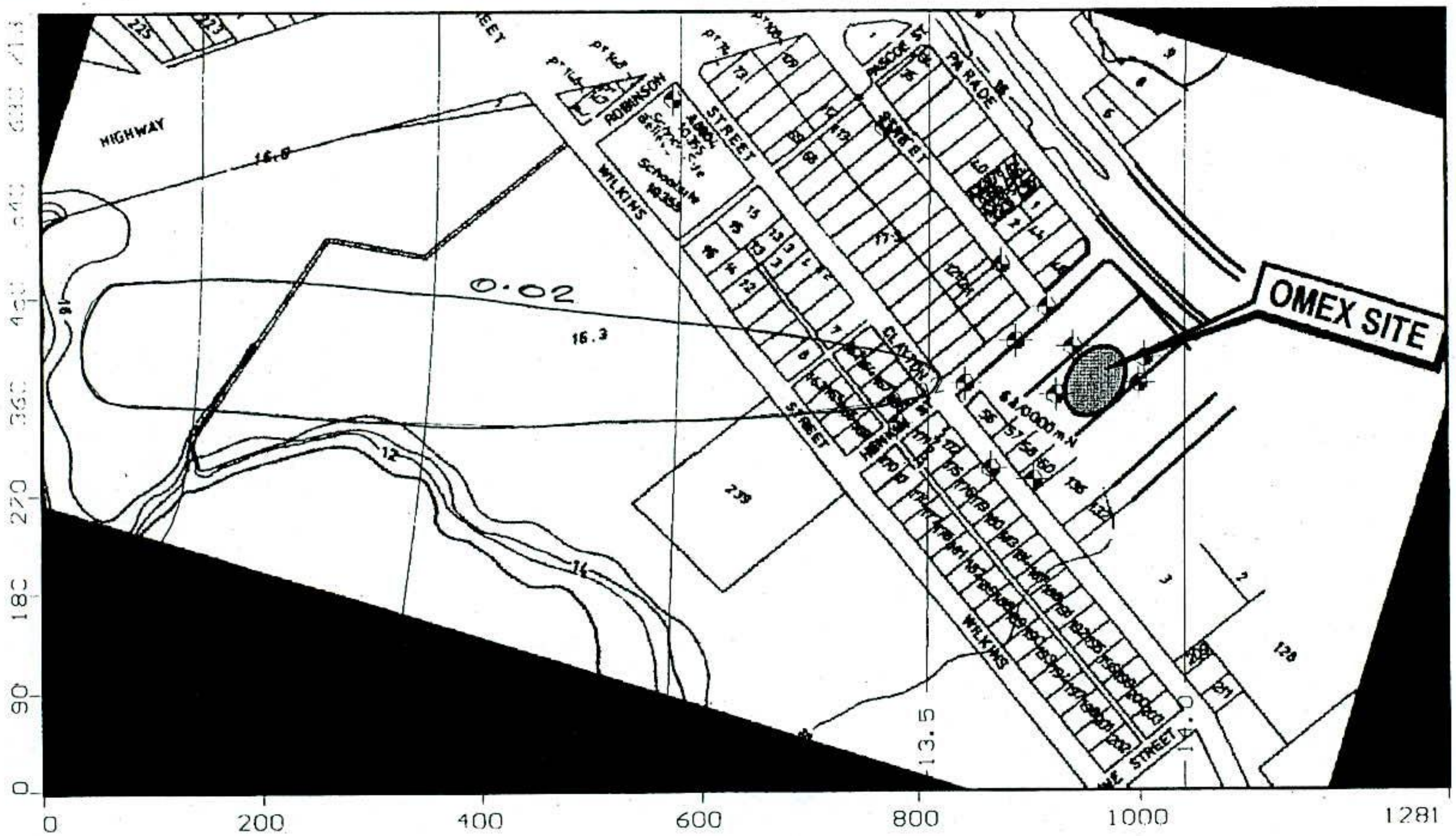
File Name : G:\DATA\VW\1100\VW110018.CDR

Figure 12B

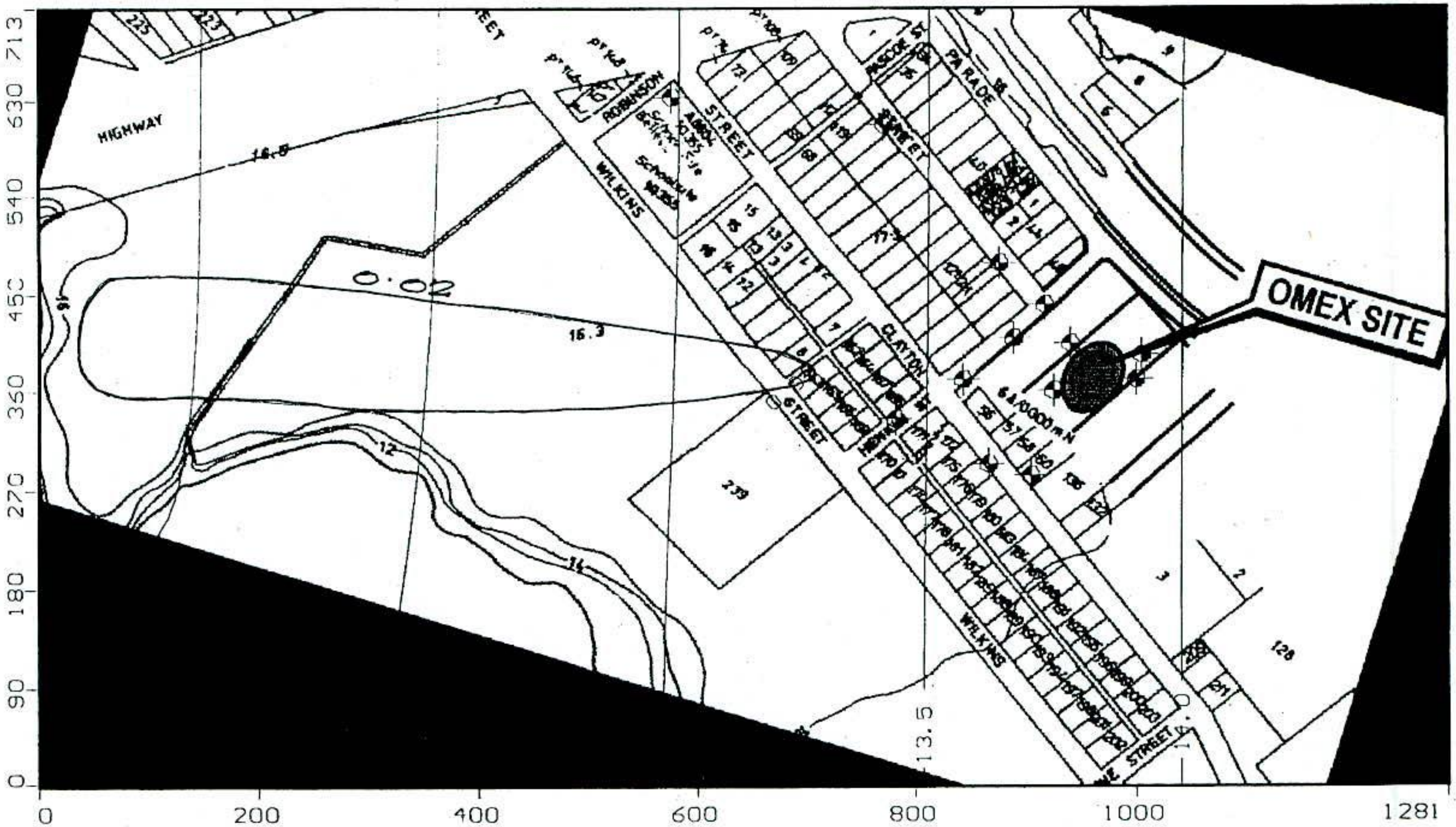


CMPS&F
Project: OMEX
Description: Nickel (50 Years), mg/L
Modeller: P. Burris
28 Aug 98

Visual MODFLOW v.2.7.1, (C) 1995–1997
Waterloo Hydrogeologic, Inc.
NC: 60 NR: 34 NL: 3
Current Layer: 2



CMPS&F Project: OMEX Description: Nickel (75 Years), mg/L Modeller: P. Burris 28 Aug 98	Visual MODFLOW v.2.7.1, (C) 1995–1997 Waterloo Hydrogeologic, Inc. NC: 60 NR: 34 NL: 3 Current Layer: 2



CMPS&F Project: OMEX Description: Nickel (100 Years), mg/L Modeller: P. Burris 28 Aug 98	Visual MODFLOW v.2.7.1, (C) 1995–1997 Waterloo Hydrogeologic, Inc. NC: 60 NR: 34 NL: 3 Current Layer: 2

GROUNDWATER CONTAMINATION ASSESSMENT CRITERIA

All levels expressed as micrograms per litre.

CONTAMINANT	AWQ/DRAFT WAWQ RAW WATER GUIDELINES	DUTCH B CRITERIA
	MAXIMUM LEVEL	
HEAVY METALS		
Arsenic (As)	50	30
Cadmium (Cd)	5	2.5
Chromium (Cr)	50	50
Copper (Cu)	1000	50
Lead (Pb)	50	50
Nickel (Ni)	100/20[2]	50
Zinc (Zn)	5000	200
HYDROCARBONS		
Total (TPH)	NC	600[1]
Volatile (C_6-C_9)	NC	40
Semi-volatile (C_{10}+)	NC	200
Benzene	10	1
Ethylbenzene	300[2]	20
Toluene	800[2]	15
Xylenes	600[2]	20
Total PAH	NC	10
Benzo(a)pyrene	0.01	0.2
Total Phenols	2	15
OTHERS		
PCB	0.1	0.2
Sulphate (SO_4)	400000	NC
pH	6.5-8.5	NC

Notes 1 Dutch Intervention Criteria

2 NHMRC/ARMCANZ Australian Drinking Water Guidelines

APPENDIX D

APPENDIX D
QUALITY ASSURANCE PROGRAM

Environmental sampling requires specific sampling techniques and a high level of quality control. Sampling protocols ensure that the samples submitted for laboratory analysis have been sampled in the appropriate manner and are truly representative of the conditions. Quality control includes laboratory reanalysis of a number of samples and decontamination procedures for sampling equipment to ensure there has been no cross contamination between sample locations.

Soil and groundwater samples were taken in accordance with an appropriate quality assurance plan which details the methods of sampling, handling and transport of samples and decontamination or cleaning procedures for sampling equipment.

All samples were analysed at quality controlled NATA (National Association of Testing Authorities) registered laboratories. Samples were transported in cooled, insulated containers and were analysed within their appropriate holding times.

The quality assurance procedures involved with the three major investigations (GSWA 1995, Golder 1997 & CMPS&F 1998 a,b,c) which are used to characterise the nature and extent of contamination are outlined as follows:

- *GSWA, 1995*: all equipment used for sampling of water or soil were decontaminated before and after use with a pressure cleaner using a detergent solution and clean water rinse. During the groundwater pumping programme, samples of the final rinse water were tested to check the decontamination procedure between individual bores.

- *Golder, 1997*: all equipment used for sampling of water or soil were decontaminated before and after use with a pressure cleaner using a detergent solution and clean water rinse. Duplicate samples of soil and groundwater were independently tested at a second laboratory.

- *CMPS&F, 1998a,b,c*: all equipment used for sampling of water or soil were decontaminated before and after use with a pressure cleaner using a detergent solution and clean water rinse. Duplicate samples of soil and groundwater were performed including secondary laboratory checks.

Laboratory inconsistencies with regard to results reported in the CER are noted as following:

- *GSWA, 1995*: high levels of arsenic reported in the solid wastes and groundwater were proven incorrect and due to an analytical error. Metals concentrations in the groundwater were overestimated as unfiltered samples were inadvertently tested by the laboratory. Levels of Polycyclic Aromatic Hydrocarbons in groundwater were possibly overestimated as several samples contained very high sediment loads.

- *Golder, 1997*: results of the independent testing of duplicate samples of soil and groundwater together with testing of reference samples showed that Total Petroleum Hydrocarbon concentrations in groundwater were underestimated. This anomaly is of a result of the method adopted by the primary laboratory.

APPENDIX E

APPENDIX E
EXCAVATION STRATEGIES

Strategy A

A summary of the scope of work for this strategy: *excavate and treat solid wastes followed by disposal to landfill, treat liquids in-situ, remove and dispose.*

Major Pit

1. Roll back HDPE cover.
2. Assess, excavate, load, haul and dispose of sand cover to appropriate class of landfill.
3. Excavate rubble and any adhered oil/water/soil matrix using an excavator with a ditch cleaning bucket.
4. Load into lined trucks onto a 300mm layer of limestone. Cover waste with an additional layer of limestone.
5. Cover trucks and transport to appropriate class of landfill.
6. Adjust pH of remaining liquid/slurry waste in the pit. Mixing achieved using an excavator.
7. Install sump.
8. Pump liquid waste, separate oil and water, and transport for recycling or disposal.
9. Excavate remaining oil/water/soil matrix.
10. Load into Mixing Trommel and mix with limestone to neutral pH and a spadeable consistency.
11. Load into lined trucks.
12. Cover trucks and transport to appropriate class of landfill.
13. Trim faces of pit.
14. Load into trucks, cover and haul to appropriate class of landfill.
15. Validation sampling and analysis of excavations prior to backfill with certified clean fill.

Minor Pit

1. Excavate oil/water/soil matrix.
2. Load into Mixing Trommel and mix with limestone to neutral pH and a spadeable consistency.
3. Load into trucks.
4. Cover trucks and transport to appropriate class of landfill.
5. Trim faces of pit.
6. Load into trucks, cover and haul to appropriate class of landfill.
7. Validation sampling and analysis of excavations prior to backfill with certified clean fill.

Soil Contamination

1. Excavate, load, and haul material to appropriate class of landfill.
2. Validation sampling and analysis of excavations prior to backfill with certified clean fill.

Advantages and disadvantages associated with this option are:

Advantages

- Major pit left as an in-situ "mixing bowl" following removal of rubble.
- Liquid/slurry waste can be treated (pH adjustment or such) within the confines of the major pit.
- Reduces the need to install a storage facility for liquid treatment phase.

Disadvantages

- Excavated material will be saturated with oil/water solution.
- Increased risk of free liquid generation during transport of the solid waste.
- Requires complete removal of the HDPE cover.
- Likely increase in odour production, particularly during the mixing phase, resulting in a perceived health risk by local residents.
- *Heavy metals precipitated during pH adjustment would be mixed throughout the solids.*

Strategy B

A summary of the scope of work for this strategy: *excavate and treat solid wastes followed by disposal to landfill, remove and treat liquids followed by disposal.*

The scope of works is identical with that of Strategy A with the exception that the liquid waste is pumped from the pit before it is adjusted for pH.

With Strategy B, the major pit would not be used for in-situ treatment of the liquid component, therefore the advantages of excavating first are now somewhat diminished. The disadvantages of the sequence described in Strategy A would still apply in addition to the disadvantages listed in Strategy C, but with none of the advantages. Therefore it can be concluded that de-watering the pit of the liquids first would appear to be the best practical approach.

Strategy C

A summary of the scope of work for this strategy: *remove and treat liquid wastes followed by disposal, remove and treat solids followed by disposal to landfill.*

Major Pit

1. Roll back HDPE cover.
2. Assess, excavate, load, haul and dispose of part of sand cover to appropriate class of landfill to facilitate removal of liquids.
3. Install sump.
4. Pump liquid to storage tank.
5. Adjust pH of liquid.
6. Separate oil and water.
7. Transport oil and water for recycling or disposal.
8. Excavate, load, haul and dispose of balance of sand cover to landfill.
9. Excavate solid waste.
10. Load into Mixing Trommel and mix with limestone to neutral pH and a spadeable consistency.
11. Load into trucks.
12. Cover trucks and transport to appropriate class of landfill.
13. Trim faces of pit.
14. Load into trucks, cover and haul to appropriate class of landfill.
15. Validation sampling and analysis of excavations prior to backfill with certified clean fill.

Minor Pit

1. Excavate oil/water/soil matrix.
2. Load into Mixing Trommel and mix with limestone to neutral pH and a spadeable consistency.
3. Load into trucks.
4. Cover trucks and transport to appropriate class of landfill.
5. Trim faces of pit.
6. Load into trucks, cover and haul to appropriate class of landfill.
7. Validation sampling and analysis of excavations prior to backfill with certified clean fill.

Soil Contamination

1. Excavate, load, and haul material to appropriate class of landfill.
2. Validation sampling and analysis of excavations prior to backfill with certified clean fill.

Advantages and disadvantages associated with this option are:

Advantages

- Pumping would remove large amounts of the free oil/water solution from the pit.
- Excavated solids would be less likely to produce free water during transport.
- The HDPE liner could remain virtually in place during dewatering thus reducing nuisance odour emissions.
- The HDPE liner could then be gradually removed during excavation.
- Odour production would be reduced resulting in a lower perceived heath risk by local residents.
- Rubble can be reduced to manageable sizes during excavation within the confines of the de-watered pit.
- Heavy metals would precipitate after pH adjustment of the liquid and be isolated at the liquid treatment facility.
- The concentrated heavy metal sludge could possibly be recycled.

Disadvantages

- Additional storage required for pumped liquid.
- De-watering may prove difficult and/or slow.

Strategy D

A summary of the scope of work for this strategy: *remove and treat liquid wastes followed by disposal, treat solids in-situ followed by removal and disposal to landfill.*

The scope of works is identical to that of Strategy C (5.4.3) with the exception that the solids are treated in-situ. Advantages and disadvantages would be as per Strategy C and in addition would involve significant logistic difficulties in achieving:

- a uniform homogenous mixture of the solid waste material with treatment additives; and.
- control and evaluation of the treatment process as a whole.

Important factors which make Strategy D problematic are the irregular shape and depth of the pit, the 'stiffer' nature of the solid waste material once dewatered and the variation of the nature of the waste material throughout the pit including the presence of rubble.