LANDBANK

PROPOSED DEVELOPMENT AT McCABE STREET

MOSMAN PARK

PUBLIC ENVIRONMENTAL REPORT

MAUNSELL & PARTNERS PTY. LTD.

NOVEMBER 1987

VOLUME I

PROPOSAL FOR THE DEVELOPMENT OF THE LANDBANK SITE AT McCABE STREET MOSMAN PARK IN WESTERN AUSTRALIA

PUBLIC ENVIRONMENTAL REPORT

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

The Public Environmental Report (PER) for the development of the LANDBANK site at McCabe Street, Mosman Park has been prepared on behalf of LANDBANK in accordance with Western Australian Government procedures. The PER will be available for comment for ten weeks, beginning on 23 November 1987 and finishing on 29 January 1988.

Comments from Government agencies and from the public will assist the EPA in preparing an Assessment Report, in which it will make a recommendation 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 will be acknowledged.

DEVELOPING A SUBMISSION

You may agree or disagree, or comment on, the general issues discussed in the PER or with 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 PER:

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

POINTS TO KEEP IN MIND

It will be easier to analyse your submission if you keep in mind the following points:

- 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 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 factual information you wish to provide and give details of the source. Make sure your information is accurate.
- Please indicate whether your submission can be quoted, in part or in full, by the EPA in its Assessment Report.

Copies of Volume I of the PER can be obtained from LANDBANK at a cost of $5 plus packaging and postage. Volume II (Technical Reports) can also be obtained from LANDBANK for $5 plus packaging and postage.

Remember to include:

NAME

ADDRESS

DATE

The closing date for submission is 29th January, 1988.

Submissions should be addressed to:

The Chairman,
Environmental Protection Authority
1 Mount Street
Perth WA 6000

Attention Dr V. Talbot.

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SUMMARY

SUMMARY

This Public Environmental Report (PER) presents details of a proposal by LANDBANK to develop land adjacent to McCabe Street, Mosman Park for residential and parkland purposes. The document describes the site, its past use, the present level and distribution of contaminants, proposed remedial works to safeguard public health and the development concept.

The objectives of the PER are to provide a full account of the proposal to the Environmental Protection Authority (EPA) for assessment, and to provide a means for other interested parties, including members of the public, to be informed of the proposal and to participate in its assessment.

The McCabe Street site was used between 1910 and 1969 for the production of superphosphate. This process involved the roasting of pyrites which contained heavy metals and the production of sulphuric acid in lead chambers. In the latter stages of industrial use, the pyrites were also treated with cyanide to remove gold. As a result of these activities various parts of the site are now contaminated with heavy metals and chemical by-products.

The principal areas of contamination are three large pyrites dumps (the western cinder dump, the pyrites slurry dump and the embankment cinders dump) and the area around the former building which contained the lead chambers. However, discrete pockets of topsoil contamination occur on various parts of the site and particularly around former buildings.

Heavy metals are capable of causing health problems if ingested and exposure typically occurs either through the breathing of contaminated airborne dust or by drinking contaminated water supplies. Air samples collected on and near the McCabe Street site indicate that, in its present condition, no significant transport of dust by wind is occurring. There is also no possibility of contamination of water supplies. Finally, no significant contamination of groundwater has been found.

Therefore, the contaminants on the McCabe Street pose no immediate health risk. However, a potential health risk is present and the condition of the site is environmentally unacceptable.

The LANDBANK proposal seeks to eliminate the potential health risk and to convert the site to parkland and residential use. In essence the proposal involves:

- Removal of topsoil from the northern part of the site to the western cinder dump and the slurry dump.
- Removal of the embankment cinder dump to the western cinder dump.
- Removal of the lead contaminated soils to an approved toxic waste landfill.
- Removal of the old site drainage system which is causing surface leaching of heavy metals to the Swan River.
- Covering of the slurry dump with a PVC membrane to prevent leaching.
- Covering the entire site with 1m of clean soil fill.
- Scheduling of site works when soil moisture levels are high and use of spray tankers to ensure that no hazardous dust is generated.
- Development of a residential subdivision on the northern part of the site.
- Development of the remainder of the site (about 70% of the total area) including all land adjacent to the Swan River, as parkland.
- Follow up monitoring to ensure the effectiveness of the site treatments.

This development plan has been formulated after considerable research into the nature and distribution of heavy metals in the site. It is considered that it will provide a comprehensive and effective treatment which will make the area safe and environmentally acceptable.

SECTION 1

INTRODUCTION

1.1 PURPOSE

This Public Environmental Report (PER) presents details of a proposal by LANDBANK to develop land adjacent to McCabe Street, Mosman Park (see Figure 1.1) for residential and parkland purposes. The PER describes the site, its past use, the present level and distribution of contaminants, proposed remedial works to safeguard public health and the development concept.

The objectives of the PER are to provide a full account of the proposal to the Environmental Protection Authority (EPA) for assessment, and to provide a means for other interested parties, including members of the public, to be informed of the proposal and to participate in its assessment.

Public review is an integral part of the EPA assessment process and comments from interested persons and groups in the form of written submissions are sought. A guide to the preparation of submissions is provided at the beginning of this PER.

1.2 BACKGROUND

A fertiliser plant operated on the McCabe Street site in the past and, as a result, some parts of the site are contaminated, to varying degrees, with chemical by-products and heavy metals. Site investigations have shown that the following metals are present in certain areas on the site in unusually high concentrations:

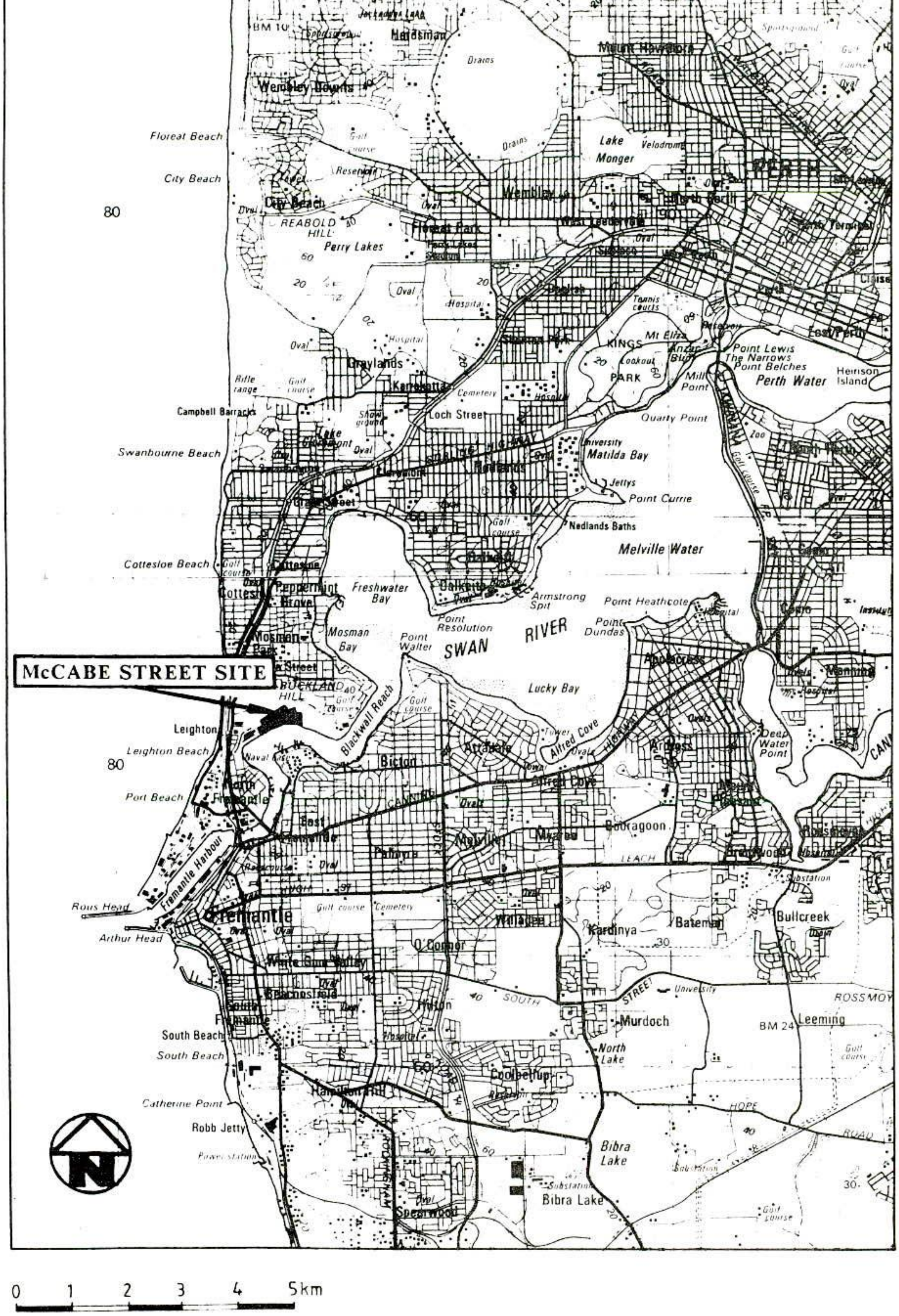
- cadmium (Cd)
- mercury (Hg)
- iron (Fe)
- zinc (Zn)
- lead (Pb)
- copper (Cu)

Other contaminants which have also been encountered on the site are:

- arsenic (As)
- sulphur compounds (SO_4^{2-})
- nitrogen compounds (NO_3^-)
- cyanide (CN^-)
- bismuth (Bi)

The McCabe Street industrial area was established in 1910 but is now surrounded by residential suburbs. The site is alongside the Swan River and is close to the city centre. Consequently the site has access to an existing urban infrastructure of roads, electricity, gas, sewer and water.

Neighbouring land includes the State Engineering Works and Buckland Hill which also have the potential for development as residential land.



LOCATION OF DEVELOPMENT SITE FIGURE 1.1

Development of the McCabe Street site for residential and parkland purposes is therefore consistent with local land use planning. Detailed planning for the development will proceed once the proposal has been approved in principle.

1.3 THE ENVIRONMENTAL ASSESSMENT PROCESS

The environmental assessment process in Western Australia is enabled by the Environmental Protection Act, 1986 and is described by the Environmental Protection Authority (1987) in a specific publication (see Reference List). It is illustrated in Figure 1.2 and is summarised below.

The EPA can require a report for any development proposal in Western Australia. That report will be required to provide information on the environmental implications of the proposal and the procedures for environmental management and monitoring nominated by the proponent.

The report may be in the form of a Notice of Intent (NoI), Public Environmental Report (PER), or Environmental Review & Management Programme (ERMP). The last two of these are specifically intended for public distribution for the purpose of review and comment. They are generally required for all development proposals considered to be significant due to scale, location, perceived public interest or other factors determined to be of importance.

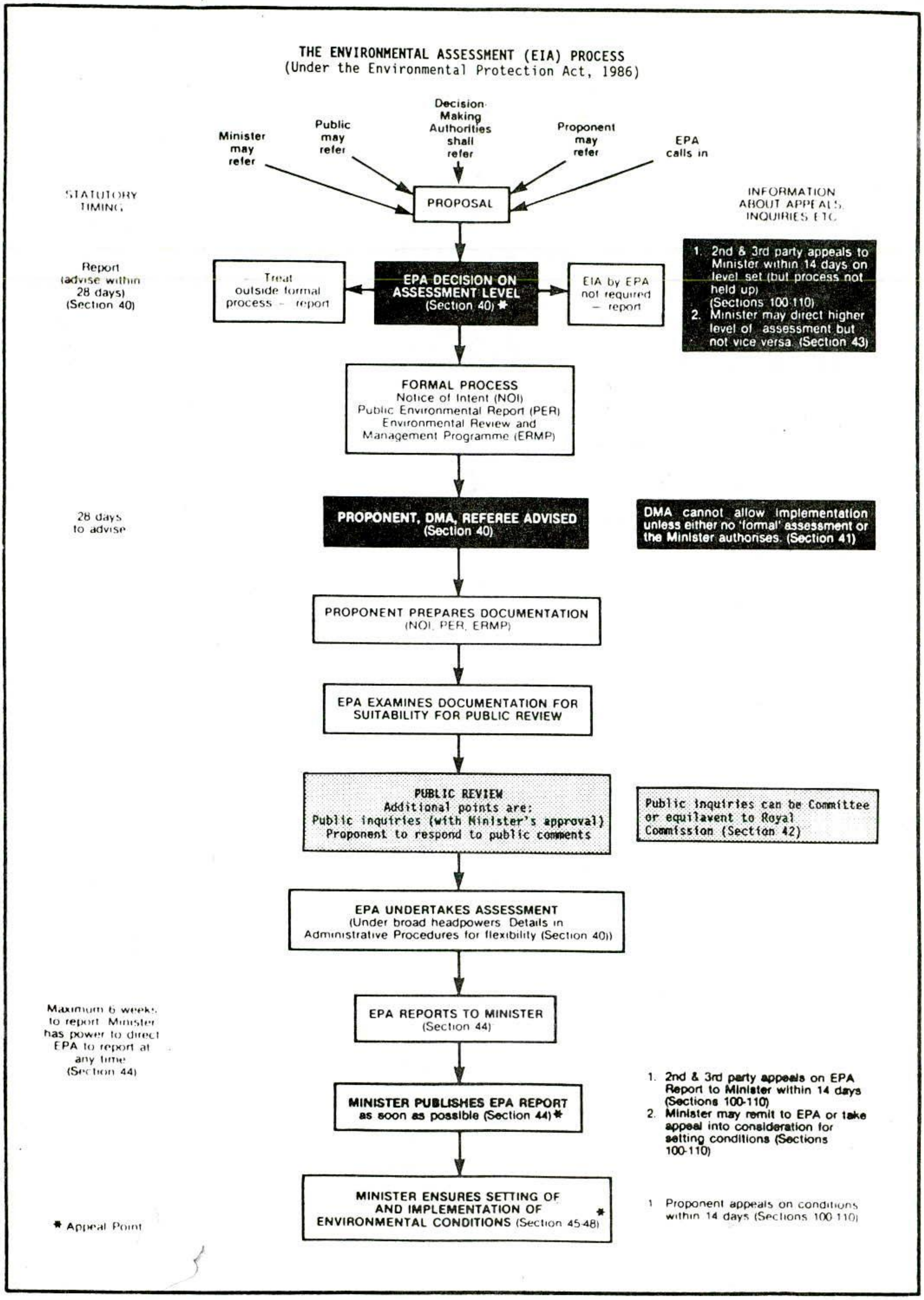
A detailed NoI for the McCabe Street proposal was prepared and submitted for EPA consideration. The EPA has required that a PER be prepared, because of potential public interest.

After the public review period of the PER the EPA will prepare an Assessment Report for the Minister for Environment. That Assessment Report will take into account public submissions and the proponents' response to those submissions. The document will make recommendations to the Minister as to whether the proposal should be allowed to proceed, and if allowed, under what environmental conditions. The Assessment Report will be published and any interested party may appeal to the Minister against it within 14 days of its publication.

The final decision on the proposal will be made by the Government of Western Australia after consideration by Cabinet of the recommendations put forward by the Minister for Environment.

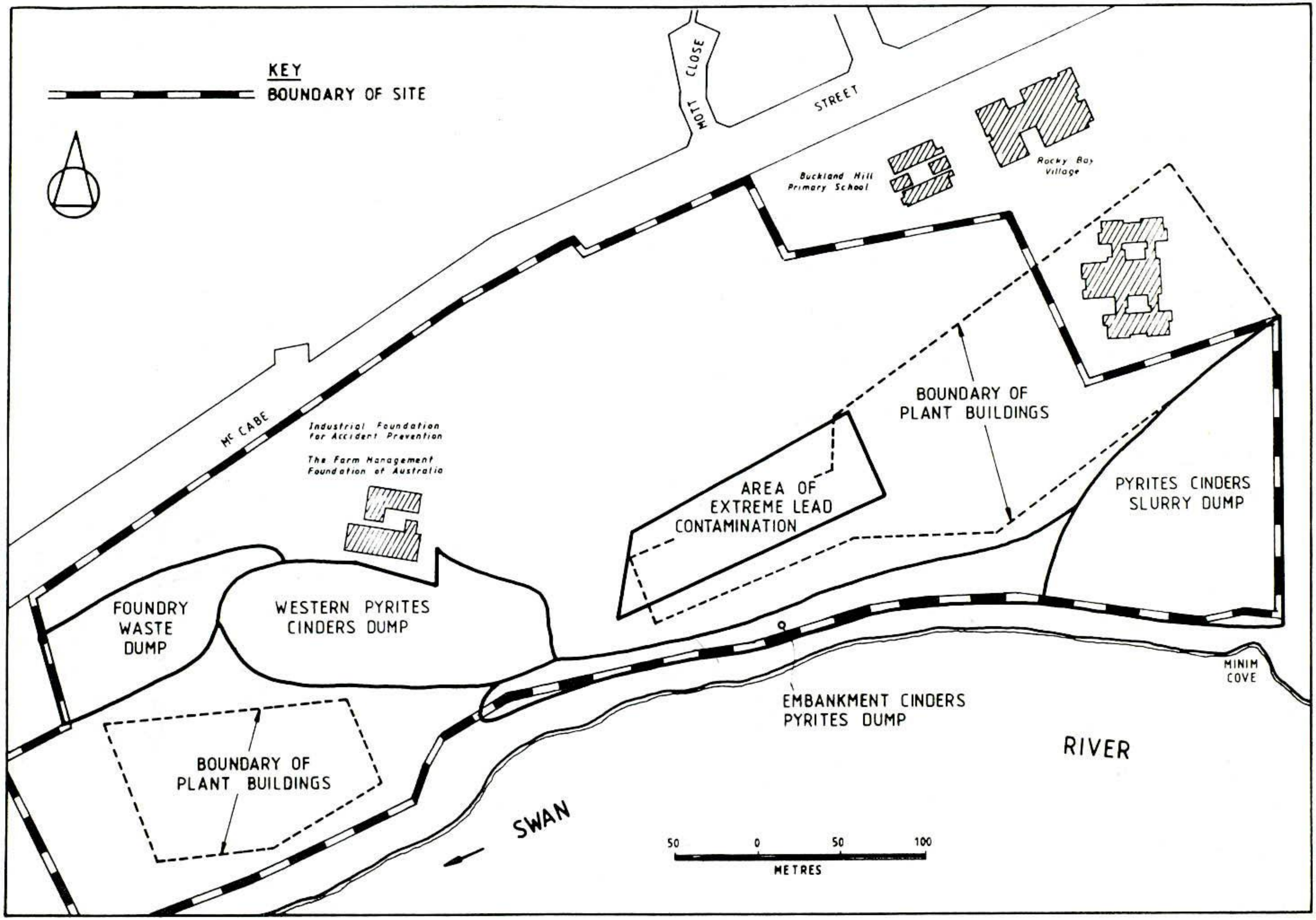
1.4 SITE LOCATION AND OWNERSHIP

The site is bounded to the north by McCabe Street and the Buckland Hill Primary School and the Rocky Bay Village. To the south of the site is the Swan River and to the east and west by recreational land and the State Engineering Works respectively (see Figure 1.3).



WESTERN AUSTRALIAN ENVIRONMENTAL ASSESSMENT PROCESS

FIGURE 1.2



FORMER PLANT AND WASTE DISPOSAL AREAS FIGURE 1.3

The majority of the site is presently owned by the University of Western Australia. Details of the present cadastral boundaries within and adjoining the site are shown in Figure 1.3 and discussed in detail in Section 2.1. It should be noted that the boundaries of the site include part of a Reserve that at present is vested in the Education Department, and is used for the Buckland Hill Primary School. However, negotiations to excise that part of the reserve shown as part of the site, are at an advanced stage.

The school and village to the north are not part of the LANDBANK proposal. However, these locations have been involved in previous site sampling programmes, the results of which are described in Section 3 and in the reports included in Volume 2 of this PER.

Photographs of the site showing its present appearance are given in Figures 1.4 and 1.5.

1.5 THE PROPONENT

At present the McCabe Street site comprises titles with various ownerships but it is intended that LANDBANK will acquire and develop the area, if the development concept presented here is approved. LANDBANK (formerly the Western Australian Urban Lands Council) is a Government agency established to acquire, develop and market residential land in the Perth Metropolitan Area to ensure the availability of supply at a reasonable price, in a range of locations.

1.6 THE PROPOSAL

The LANDBANK proposal is detailed in Section 4 of this PER. In essence it involves:

- excavation and transfer of all site top-soil to two restricted locations which were formerly used as pyrites cinders or pyrites slurry dumps,
- covering the site with one metre of clean fill,
- sealing of the pyrites slurry dump, with a PVC impermeable membrane,
- rezoning to enable residential development of a section closest to McCabe Street where contaminant levels are low, and landscaping for parkland of the remainder,
- controlled access to the steep slopes of the pyrites cinders dumps,
- follow-up monitoring studies to ensure the effectiveness of remedial works.

1.7 NEED FOR THE PROPOSAL

In 1979 the University of Western Australia (UWA) acquired the central portion of land on the site which is the subject of this PER. The UWA intended to develop the site but became aware of its previous use for industrial purposes and therefore commissioned studies of the groundwater by Rockwater Pty. Ltd., and Analabs Pty. Ltd., for surface soils. These studies were completed in June 1980 and November 1981 respectively (see Volume 2 of this PER).

Further investigations were carried out in 1984, by a Technical Assessment Group (TAG) which called on expertise from many Government Authorities as well as utilising that information generated in the two previous studies. The background of research work on the site was further expanded in March 1986, when Maunsell and Partners Pty. Ltd. were employed jointly by the University and the Lands and Surveys Department. This study addressed the appropriateness of developing the site for residential and/or recreational usage and undertook additional sampling.

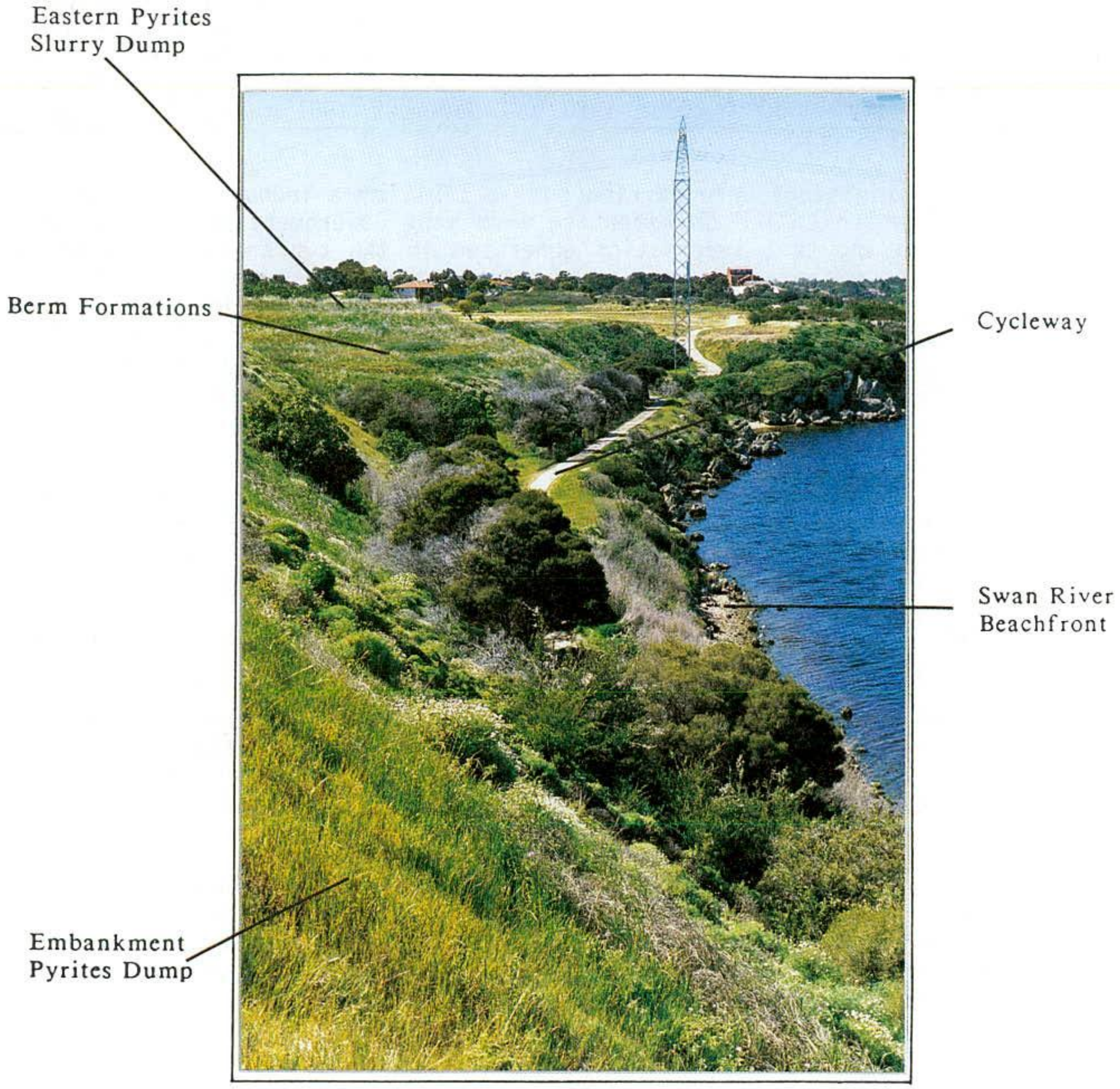
Collectively these studies have established that:

- the McCabe Street site is presently contaminated with various heavy metals and other substances as a result of previous industrial activities. The substances have not been disposed of in ways consistent with modern environmental protection requirements,

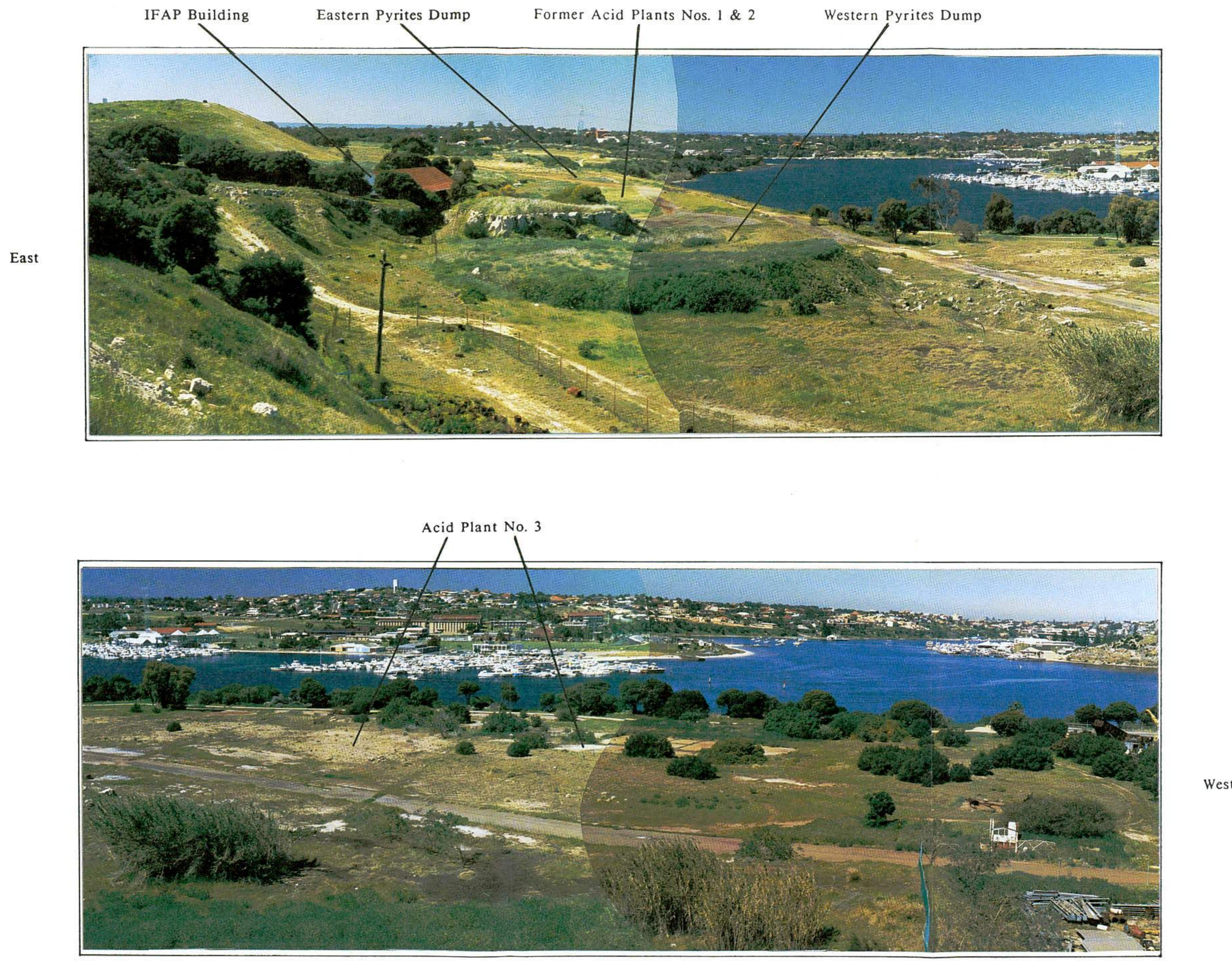
- the site presents a potential public health risk and restoration is desirable in order to remove any possibility of risk.

An alternative to site restoration would be to exclude usage altogether. However, the nature of the contamination and the potential for site treatment suggests that such precautions are not necessary. This option would not allow the full potential of the land in terms of parkland and residential usage to be realised.

There is therefore a need to clean up and manage the site such that it is safe for public use whilst at the same time the site's residential and recreational amenity may be realised. The LANDBANK proposal seeks to achieve this by various site treatments, by appropriate planning and by continued management and monitoring.



McCABE STREET SITE FEATURES FIGURE 1.4



PANORAMIC VIEW OF McCABE STREET SITE FROM THE NORTH-EAST FIGURE 1.5

SECTION 2

HISTORY OF THE SITE

2.1 HISTORY OF LAND ACQUISITION

The McCabe Street site has a long and complex history of industrial usage which is described in the TAG Report (1984), included in Volume 2 of this PER. The major usages have been:

- 1895-1909, limestone quarry,
- 1910-1964, original acid plants,
- 1930-1969, additional acid plant,
- 1953-1969, flash furnace,
- 1955-1969, small fluidised bed furnace,
- 1956-1969, larger fluidised bed furnace,
- 1971, lease expired,
- 1973, site returned to government.

Details of the previous land tenure are presented in Figure 2.1 in terms of:

- lease number,
- year of lot number issue, and
- area of the individual lots.

Figure 2.2 shows the location of the individual Lots mentioned in the following discussions.

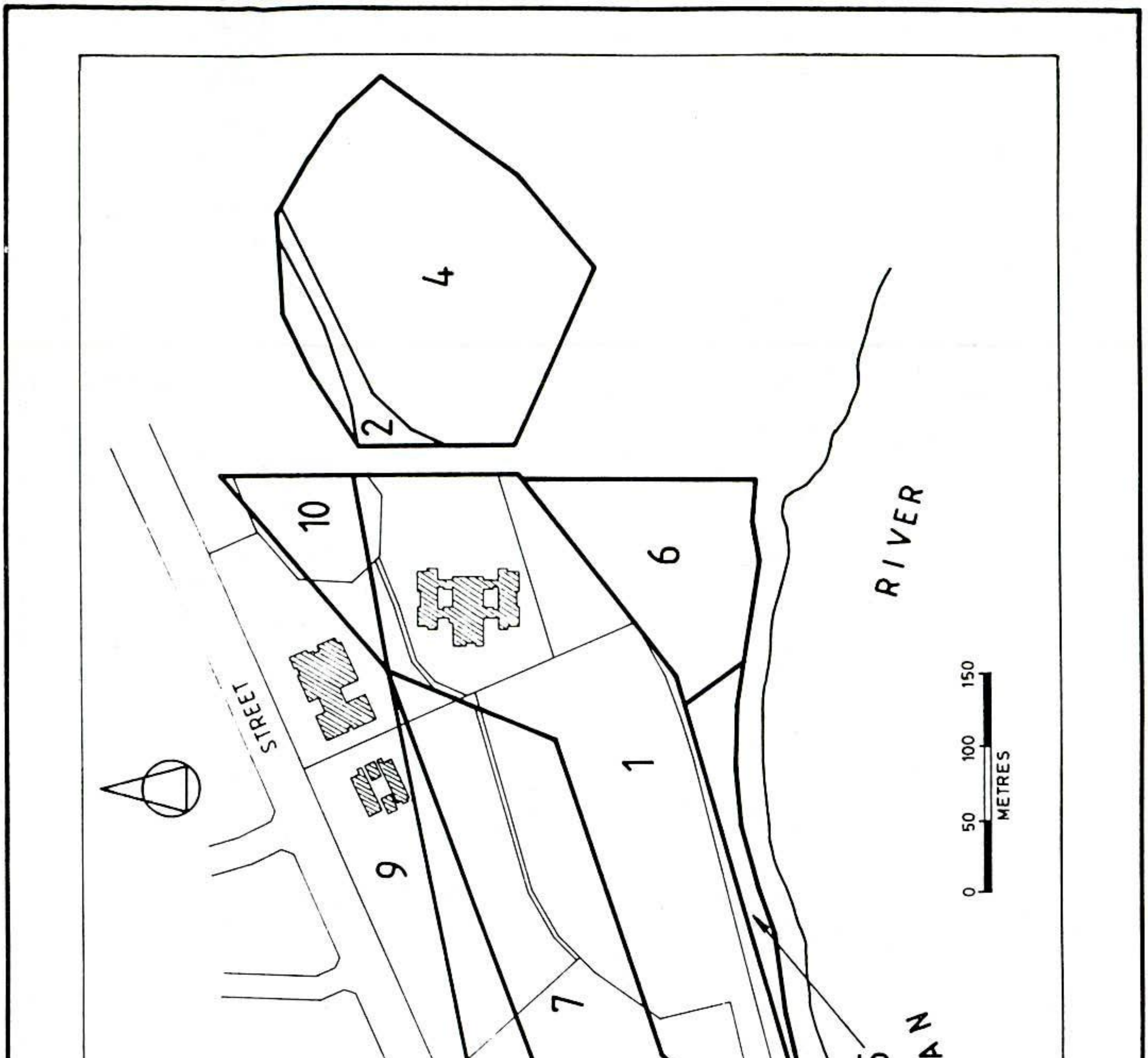
A detailed history of the site is presented below.

Around 1895 the Public Works Department quarried limestone on the site to obtain rock to build the north and south moles at Fremantle. This quarry was serviced by a railway, and the route of the lower railway line is still present today as a cycleway along the river embankment.

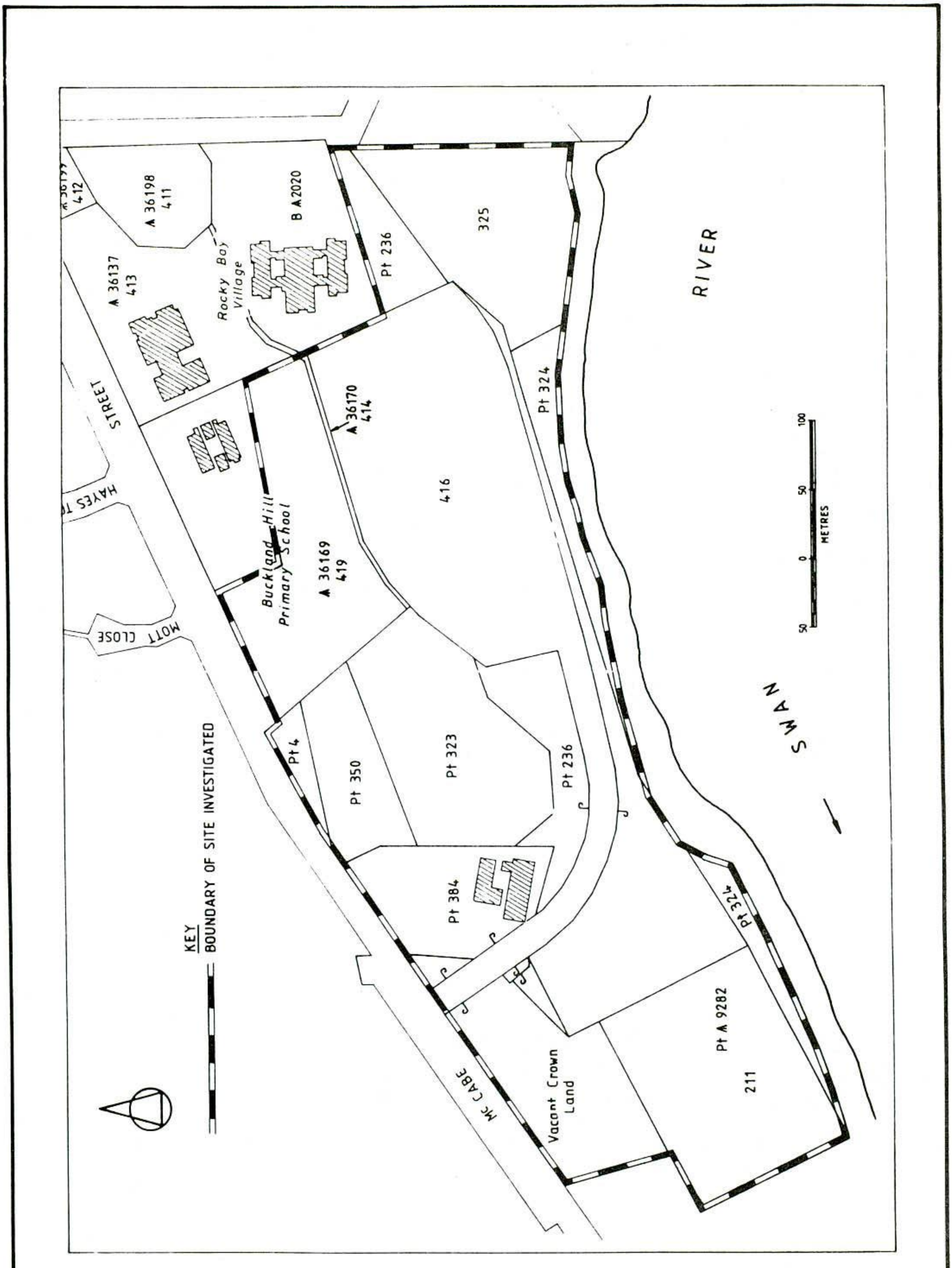
The original lease of approximately 7ha was issued in 1909 by the Minister for Works to the Mt. Lyell Mining and Railway Company Ltd., shown as lease area 1 on Figure 2.1. This was for the establishment of works for the production of sulphuric acid used to manufacture agricultural fertiliser (superphosphate). It covered a portion of Reserve later surveyed as North Fremantle Lot 236 (see Figure 2.2).

In 1916 the company sought additional land, this time for extension of its works railway siding and the area shown as lease area 2 in Figure 2.1 was issued. The company sought further land to the south-west in 1924. This was held under sub lease from the Minister for Works by Westralia Iron Works Co. Ltd. Westralia agreed to subdivide its holding which was then transferred to the Mt. Lyell Mining and Railway Company as North Fremantle Lot 211 (lease area 3 in Figure 2.1).

In 1929 the Mt. Lyell Company was restructured as Cuming Smith Mt. Lyell Farmers Fertilisers.



BREAKDOWN OF LEASE AREAS FIGURE 2.1



McCABE STREET EXISTING BOUNDARIES FIGURE 2.2

In 1951 permission was granted for pyrites cinders to be deposited on:

(i) Lease area 4 on Figure 2.1.

(ii) Portions of Reserve No. B2020 distinguished as North Fremantle Lots 324 and 325 (lease areas 5 and 6 on Figure 2.1).

In 1953 formal leases were issued over these sites for the purpose of disposal of pyrites cinders on a year to year tenancy. Deposits were to be placed in existing borrow pits with a view to the eventual restoration of ground levels. A lease over North Fremantle Lot 323 (refer to Figure 2.2) was granted to the company in 1957 for the manufacture of acids, superphosphate and other agricultural fertilisers (part of lease area 7 on Figure 2.1).

Further land was leased by the company in 1961. This was identified as North Fremantle Lot 350 (lease area 8 on Figure 2.1) and was used to rationalise the boundaries of the works, and for the provision of internal road, offices, superphosphate storage and staff amenities.

In 1966 Cuming Smith and Mount Lyell Farmers Fertilisers Ltd. became CSBP Farmers Ltd. The company ceased operations on this site in 1969 and terminated the leases in July 1973. The Government of the day was satisfied that the conditions of the leases with respect to the restoration of the site had been complied with by the company.

In June 1979 the University of Western Australia exchanged the land now occupied by the Rocky Bay Village for a portion of land in the middle of the site, now designated Location 416 (refer to Figure 2.2).

LANDBANK became responsible for the management and development of the site in 1986. The site now under the control of LANDBANK includes the area between the existing State Engineering Works to the west; an oval to the east, McCabe Street; the Buckland Hill Primary School and the WA Society for Crippled Children (Rocky Bay Village) to the north; and the Swan River to the south. However, the former industrial use extended beyond the LANDBANK property boundary as shown in Figure 1.3.

2.2 THE FERTILISER WORKS

The fertiliser works which operated between 1901 and 1969 are the source of present contamination of the McCabe Street site. The administration and laboratory buildings of the fertiliser works are still standing and are used by the Industrial Foundation for Accident Prevention (IFAP) and the Farm Management Foundation of Australia (FMFA).

Reference should be made back to Figure 1.3 to visualise the sites of the fertiliser work's buildings and waste dumps.

Figures 2.3, 2.4 and 2.5, when viewed concurrently, give details of; the companies involved in the fertiliser works, the various processes and waste products, and the layout of the plant. Figure 2.5 is a 1984 aerial photograph of the site and has superimposed the positions of the various plant buildings and storage areas associated with the fertiliser works from a 1967 aerial photograph.

Initially the fertiliser works consisted of two sulphuric acid plants (Nos. 1 and 2), each were supplied with sulphur dioxide from a group of six roasters (for detail see TAG Report, Volume 2 of this PER). The acid was combined with crushed phosphate rock to produce superphosphate to which trace elements were finally added. The processes and the wastes generated are illustrated in Figure 2.3. A more detailed description of the processes is given below.

The roasters burnt various pyrites depending on the availability and cost of the raw product, as follows:

- iron pyrites (FeS_2) from Norseman
- chalcopyrite ($CuFeS_2$) from Tasmania
- Spanish pyrites (FeS_2 possibly with cinnabar HgS)
- Norseman pyrites concentrate
- pyritic flotation concentrate from Gold Mines of Kalgoorlie

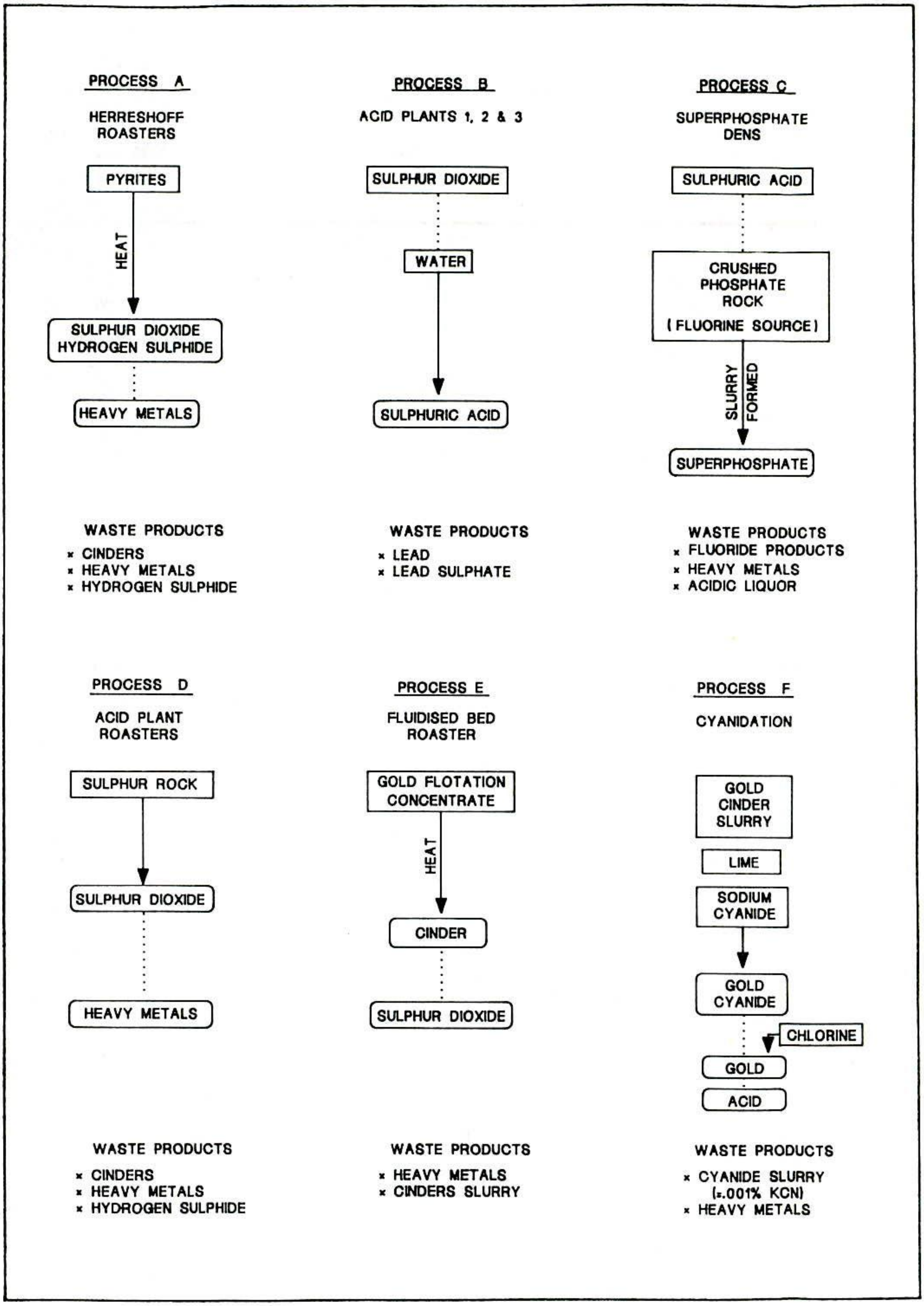
Apart from the major constituents of sulphur and iron, the pyrites contained small amounts of many other minerals as shown on Table 2.1.

The residue from the roasters comprised pyritic cinders containing residual sulphur and low levels of metals. These cinders were dumped at various locations on the site and occasionally used as road base material. Some were also exported to Japan.

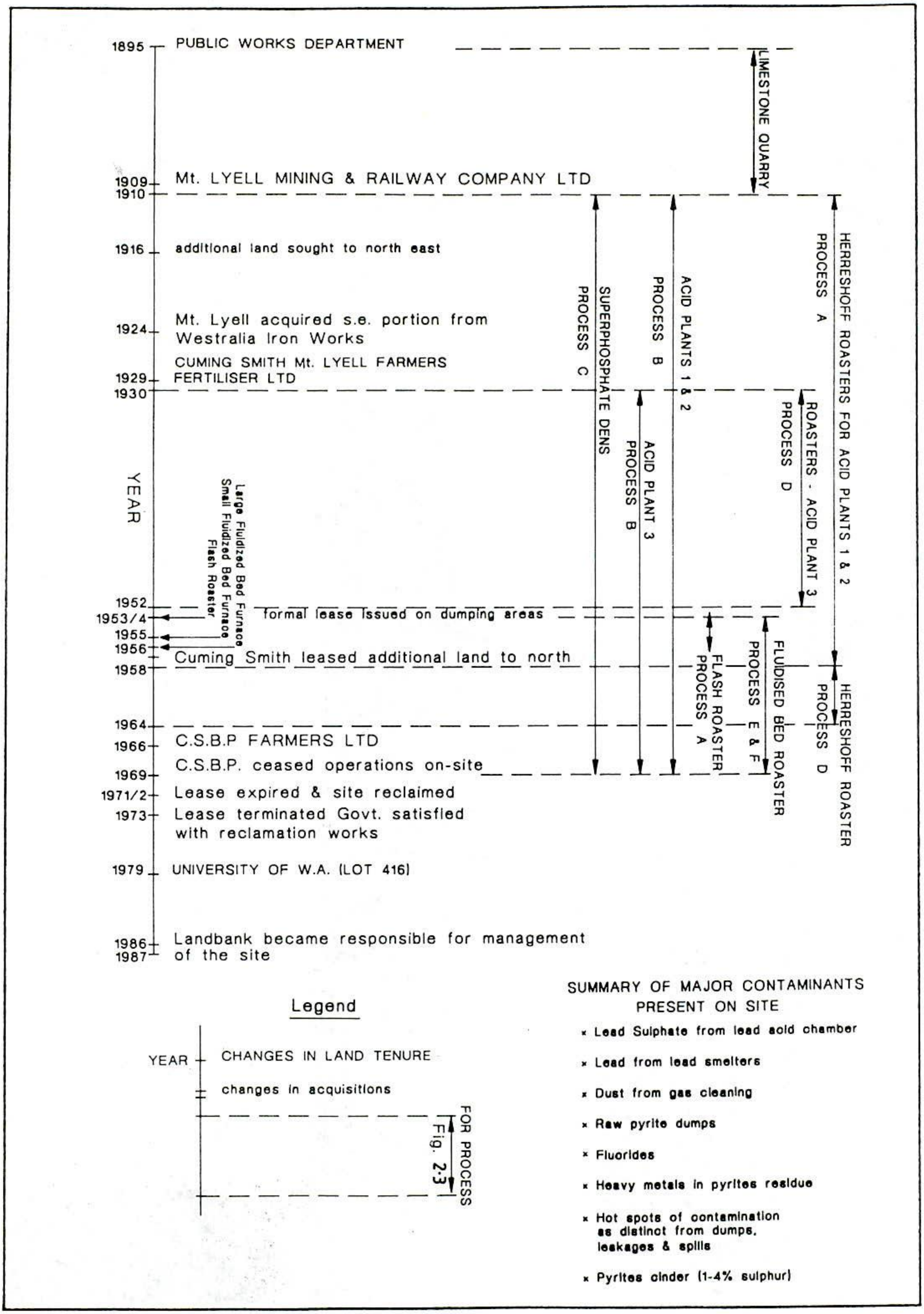
The sulphur dioxide gas from the roasters was passed through a series of cyclones to remove dust. The dust collected is thought to have contained a high concentration of a large number of metal oxides including arsenic, copper, lead, mercury, selenium and zinc. It is thought that the dust was either sold or dumped at various locations around the site, particularly on the northern edge of Lot 325 (see Figure 2.2). Although the sulphur dioxide gas was cleaned by cyclones the process removed little of the heavy metals and most were entrained in the sulphur dioxide and passed on to the superphosphate and exported from the site.

The sulphuric acid was produced in acid plants which included a series of lead chambers. Over time, the inside of the chambers corroded and became coated with a lead sulphate scale, which was periodically cleaned and dumped on-site. Eventually the chambers had to be replaced and old chambers were melted down on-site and the recovered lead was used to manufacture new chambers or was sold as scrap. The process of disposing of the lead sulphate on-site and the melting down of old lead chambers was the source of the majority of lead contaminant on the site. This part of the activities of the fertiliser works is referred to as lead melting and foundry activities.

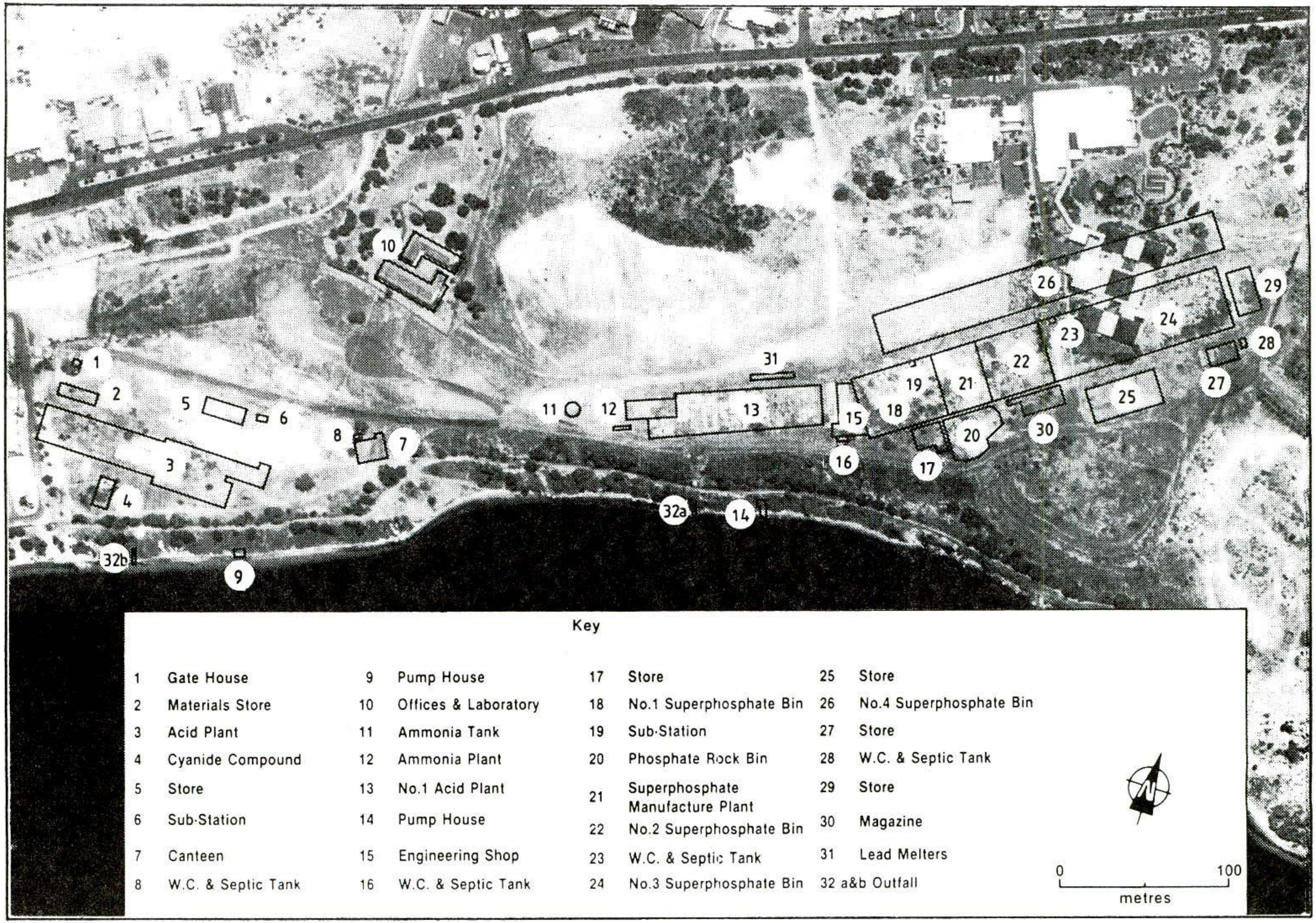
The combination of acid and crushed phosphate rock produced a slurry which was fed into concrete boxes known as dens and allowed to sit until superphosphate formed by reaction.



FERTILISER WORKS PROCESSES AND WASTES FIGURE 2.3



INDUSTRIAL PROCESSES AND LAND TENURE FIGURE 2.4



INDUSTRIAL WORKS LAYOUT, 1984 FIGURE 2.5

TABLE 2.1
ANALYSIS OF A KALGOORLIE PYRITIC CONCENTRATE

Major constituents		**Per Cent**
Sulphur (as sulphide)	S	27.09
Iron (as pyrite)	Fe	32.31
Minor and trace constituents (as below)	-	0.40
Other (silicates, carbonates etc.)	-	40.20
		100.00

Trace element constituents		**Parts per million**
Arsenic	As	1280
Copper	Cu	1120
Zinc	Zn	622
Nickel	Ni	301
Cobalt	Co	202
Tellurium	Te	132
Gold	Au	103
Antimony	Sb	40
Silver	Ag	25
Mercury	Hg	22
Lead	Pb	20
Germanium	Ge	19
Bismuth	Bi	18
Selenium	Se	13
Platinum	Pt	<0.1

In the later years of operation the dens were equipped with scrubbers to control the release of hydrogen fluoride and other fluoride compounds to the atmosphere. The scrubbers also removed mercury compounds. Initially the liquor from these scrubbers was allowed to flow onto the site in the vicinity of the dens but was later discharged into the pyrites cinders slurry dump. This scrubber residue was highly acidic.

Once the sulphuric acid had sufficiently reacted with the phosphate rock in the dens, the superphosphate was removed and placed in the superphosphate storage sheds to cure. Superphosphate Store No. 1 (see Figure 2.5) had a large depression in the floor from which the superphosphate was extracted for packaging and sale. This depression is still present today. Other sheds had tunnels with conveyors to allow superphosphate removal.

Trace elements were mixed in with the superphosphate, some of them being the heavy metal by-products of the pyrites roasting and sulphuric acid production reactions, such as copper (as copper or copper sulphate), manganese and zinc.

In 1958, the roasters in acid plant Nos. 1 and 2 burnt sulphur instead of pyrites to yield sulphur dioxide. Acid plant No. 3, which was built in 1930 near the south-west corner of the site, also burnt sulphur from 1930 to 1952. The sulphur to feed all three acid plants was stored near plant No. 3 (refer to Figure 2.5).

In 1953/54, a flash roaster was used to burn Norseman pyrites concentrate in plant No. 3. In 1955 a small fluidised bed furnace was also built. The fluidised bed furnaces utilised gold flotation concentrates from the Western Mining Company's Kalgoorlie mines. The concentrates were stockpiled alongside the plant while the furnace was constructed. Following the successful operation of this unit, a much larger version was constructed in 1956.

The gas passing out of the fluidised bed furnaces was treated in a similar manner to that employed in the Nos. 1 and 2 acid plants, except that electrostatic precipitation was used to collect the waste-products. The acid was then used to make superphosphate. Wastes from the process were discharged into dumps at various locations around the site, particularly Lot 325.

The use of fluidised bed furnaces and mining concentrates enabled the sulphide minerals and gold compounds in the concentrate to be broken down so that the gold could be extracted by cyanidation. Unlike the Herreshoff roasters of acid plants 1 and 2, which produced a granular cinder residue, the furnaces produced a very finely divided powder residue, from the electrostatic precipitators. This was slurried with water for transportation from the furnaces to the limestone bunds on Lot 325.

Before dumping to the bunds the slurry was limed, to make it alkaline, and then reacted with cyanide (mostly in the form of sodium cyanide), for a period of 24 hours. It was then filtered and the filter cake washed with water. The gold was removed from the cyanide filtrate and wash water and the gold free water returned to the process. Some of this water was bled off the return process water stream, and then mixed with the filter cake to form a 50% slurry. Following this, the slurry was oxidised with chlorine to destroy the cyanide (cyanide may be broken down into the elements of carbon and nitrogen) until it had a free cyanide content equivalent of 0.001% potassium cyanide. This slurry was then pumped to limestone bunds on Lot 325. Over time, this pond would fill up and a new pond would be constructed above it. Eventually, when the works were closed, several ponds had been constructed and filled in this way (see Figure 4.3).

Apart from a certain amount of copper oxide incorporated in the superphosphate, all the residues of the materials burnt in the fluidised bed furnaces ended up in the dump of Lot 325. The dump of Lot 325 contains approximately 70,000m3 of pyritic cinder residue, contained within progressively higher limestone bunds, and has a total residue thickness of 9-10m.

When burning pyrites the operating conditions of the fluidised bed furnace produced a residue containing higher levels of metals than in the residue from the Herreshoff roasters associated with Acid Plants 1 and 2. This is now reflected in the fact that the cinders associated with later fluidised bed furnace processes contain higher levels of heavy metals.

In the roasters in acid plant Nos. 1 and 2, most of the heavy metals were entrained in the sulphur dioxide gas and transferred to the superphosphate in which they left the site. In contrast, the sulphur dioxide gas from the fluidised bed roasters passed through electrostatic precipitators which collected all of the heavy metal dust which was them slurried and ultimately disposed of on-site.

SECTION 3

EXTENT AND NATURE OF SITE CONTAMINATION

3.1 INTRODUCTION

Various studies of the levels of heavy metal and other chemical contamination at the McCabe Street site have been carried out since 1981. These have indicated that for all practical purposes the entire site must be considered to be in need of remedial treatment to remove the potential health risk posed by heavy metal contamination. However, certain parts of the site, such as the various main waste dumps and areas adjacent to parts of former buildings, have particularly high levels of contamination and require special attention. These include a section of the embankment along the Swan River, where there is also some evidence of heavy metal leachate, and beach contamination, and possibly of contaminant transfer to food chains.

The principal contaminant is lead, but copper and zinc also occur in places at concentrations above those generally allowed for agricultural soils, as do arsenic and mercury. Cadmium has also been recorded at high levels in some sampling trenches and amosite (a form of asbestos fibre) has been located in one area. The potential health affects of these substances are discussed in Appendix 2.

The extent of groundwater contamination beneath the site is not known but the Rockwater Report (1980) indicates that above ground contamination has leached to the groundwater table in two of four sample sites.

3.2 SITE INVESTIGATION

Four consecutive studies have investigated the extent of industrial contamination at the McCabe Street site with particular emphasis on the areas occupied by former buildings and waste dumps. These have been:

- a groundwater assessment by Rockwater Pty. Ltd. in 1980,
- a study of surface soils by Analabs Pty. Ltd. in 1981,
- air and soil sampling by a Technical Assessment Group in 1984,
- additional soil sampling and development of a zoning plan by Maunsell & Partners Pty. Ltd. in 1986.

These reports are included in Volume 2 of this PER.

The Rockwater report identified a very small groundwater gradient towards the Swan River with potential contamination of groundwater on the southern and south-eastern edges of the site. In particular nitrate, phosphate and mercury levels were found to be in excess of levels recommended for potable water supplies. Groundwater to the north of the site was found to be uncontaminated and of potable quality.

The Analabs study established that the shallow surface soils within Lot 416 (see Figure 2.2) were contaminated to varying degrees by a number of heavy metals.

Following submission of the Rockwater and Analabs reports, the University and the Lands & Survey Department (now Department of Lands Administration) undertook further investigations in an effort to determine the full extent and degree of contamination over the entire area of the former CSBP & Farmers leases. Particular attention was paid to evaluation of any risks that may be associated with the location of the Rocky Bay Village and the Buckland Hill Primary School, which are adjacent to the study area (see Figure 1.3).

These further investigations were carried out by a Government appointed Technical Assessment Group (TAG) consisting of senior members of several relevant Government Authorities. The report of these investigations (TAG, October, 1984) concluded that:

- the "majority of the site is contaminated to varying degrees by a variety of substances",

- the most significant contaminant in the surface soils was identified as lead but high levels of copper, zinc and cadmium were also found particularly in areas close to the former buildings, and

- groundwater beneath the site was not contaminated and there was no significant contamination of the atmosphere due to windblown dust. The TAG report (1984), emphasised that the results of air pollution monitoring from two high volume air samplers did not record any adverse effects on the sites of the Rocky Bay Village or the grounds of the IFAP offices due to their proximity to the industrial site.

There was some evidence to indicate that stormwater outfalls from the site were acting to concentrate heavy metal accumulations in the river sediments but in general contamination of these sediments was not high.

The text of the TAG report was reviewed by the Health Department of Western Australia. As a result of this review the Department stated in correspondence, to the Working Group Co-ordinator, Department of Conservation and Environment (November, 1984) that the site could be used for residential development provided that at least one metre of clean fill was added to all areas affected by contamination and that use of groundwater from beneath the site be prohibited (see Volume 2 of PER).

Consequently, agreement was reached between the UWA and the Lands & Survey Department to rationalise site boundaries and to investigate the possible development of all land bounded by McCabe Street, the Rocky Bay Village, the Swan River and the State Engineering Works.

Maunsell & Partners was commissioned to carry out this investigation in 1986. This final study included results of further site investigations of soils, and suggested a strategy for remedial works and a development proposal (see Volume 2).

3.3 CONTAMINATION CRITERIA

A range of values of normal, or "background" levels of heavy metal concentrations in soils and also "allowable" concentrations for various land uses are listed in Tables 3.1 and 3.2.

The information presented in Table 3.2 indicates that:

- internationally there is some variation in the level of heavy metal concentrations considered to be acceptable, and

- acceptable concentrations for agricultural land are much lower than for residential and open space land use because human intake of heavy metals (either through meat or crop produce) is more likely.

The values listed in Table 3.2 give some indication as to the safe levels of heavy metal for soils found in different locations. Soils with contaminant levels equal to or greater than those listed in 3a) and 3b) of Table 3.2 would have to be covered with a minimum of 500mm of clean soil because, even though the levels may be safe for human contact, zinc and copper are phytotoxic and at the levels quoted would inhibit growth of covering vegetation. The 500mm depth would seem adequate for root penetration as long as the area did not have water table fluctuation within 500mm of the surface.

3.4 RESULTS OF SOIL AND RELATED ANALYSES

Various field investigations have been carried out on samples of existing top-soils and soils from just above the limestone bedrock. The preparation and analysis of the samples was similar for each set of tests and therefore comparisons can be made between the various studies (see Volume 2 of PER). The samples were air dried, pulverised and sieved to separate particles less than 2mm in size. Heavy metal concentrations were then determined by digestion of a one gram sub-sample with perchloric acid followed by atomic absorption spectrophotometry.

The lead contamination results of the 1981 and 1984 studies are shown in Figures 3.1 and 3.2 for top-soil and bedrock samples respectively. Comparison of the lead concentrations for top-soil on the site with normal background levels given in Table 3.1. (9 to 500ppm) indicates that, for certain land use categories, a significant proportion of the area investigated contains an unacceptably high level of heavy metal surface contamination.

Similarly, comparison of the plotted values with the allowable lead concentration for agricultural soils of 56-100ppm (Table 3.2) illustrates their general unsuitability for the production of food.

The recommended level of lead for public open space and playing fields is 2000ppm (SPCC, 1987), which is greater than that encountered on the site except for some restricted locations.

TABLE 3.1

NORMAL BACKGROUND HEAVY METAL CONCENTRATIONS IN SOIL (ppm)

Source	Fe	Cu	Zn	As	Cd	Hg	Pb	Bi
1. Content of Carbonate Rocks (Analabs, 1981)	-	4	20	1	0.035	0.04	9	-
2. Accumulation of copper, lead and arsenic in some Aust. Orchard Soils (Merry et al, 1983) Background levels in								
(a) S.E. Australia	-	16	-	4	-	-	20	-
(b) N. America	-	22	-	6.5	-	-	20	-
(c) Ontario	-	25	-	6.3	-	-	14	-
3. Data from NSW State Pollution Control Commission uncontaminated, normal range	-	0-100	0-250	0-30	0-1	0-1	0-500	-

Key to heavy metals:

As Arsenic
Bi Bismuth
Cd Cadmium
Cu Copper
Fe Iron
Hg Mercury
Pb Lead
Zn Zinc

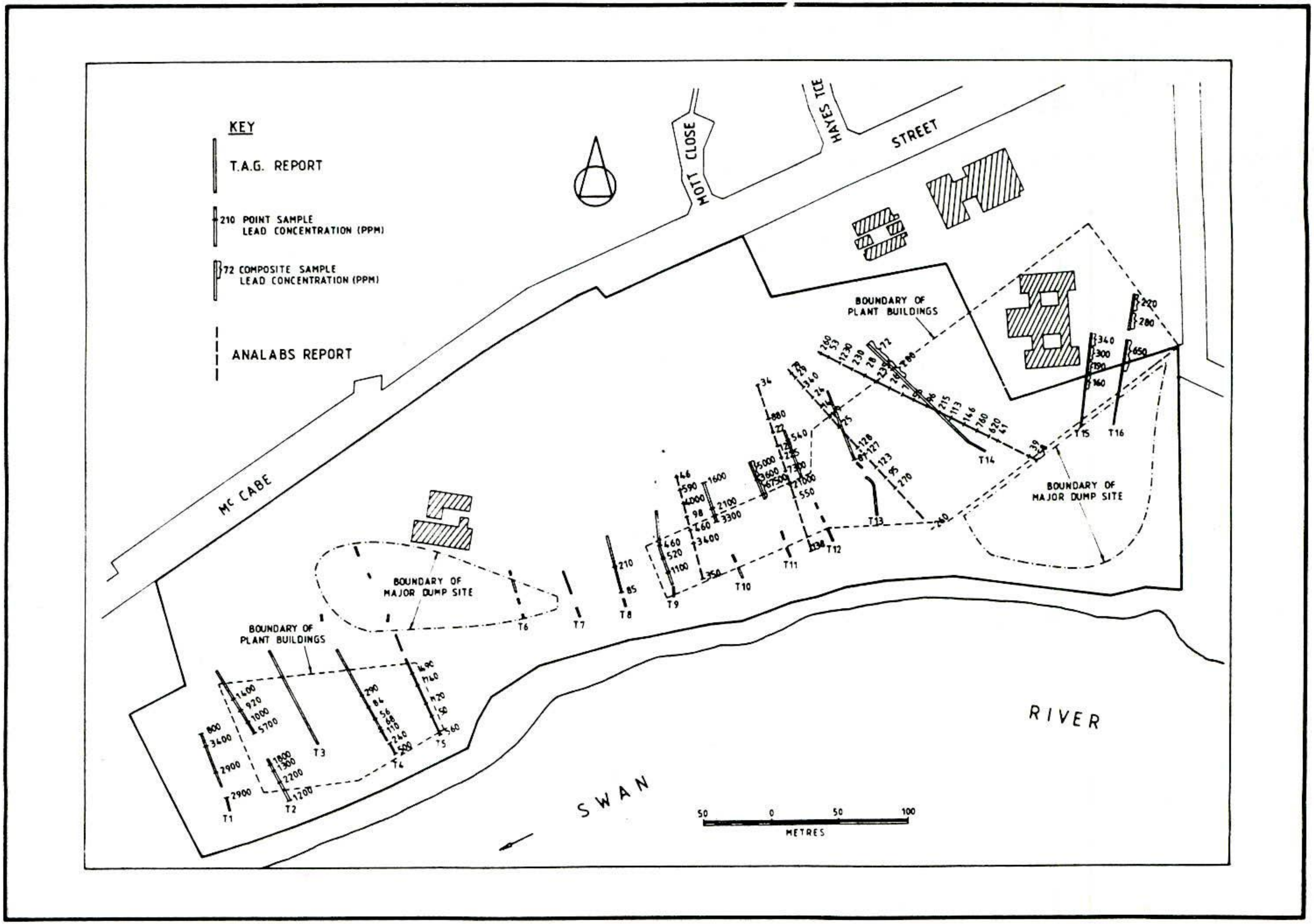
TABLE 3.2

RECOMMENDED HEAVY METAL CONCENTRATIONS IN SOIL BY LAND USE (ppm)

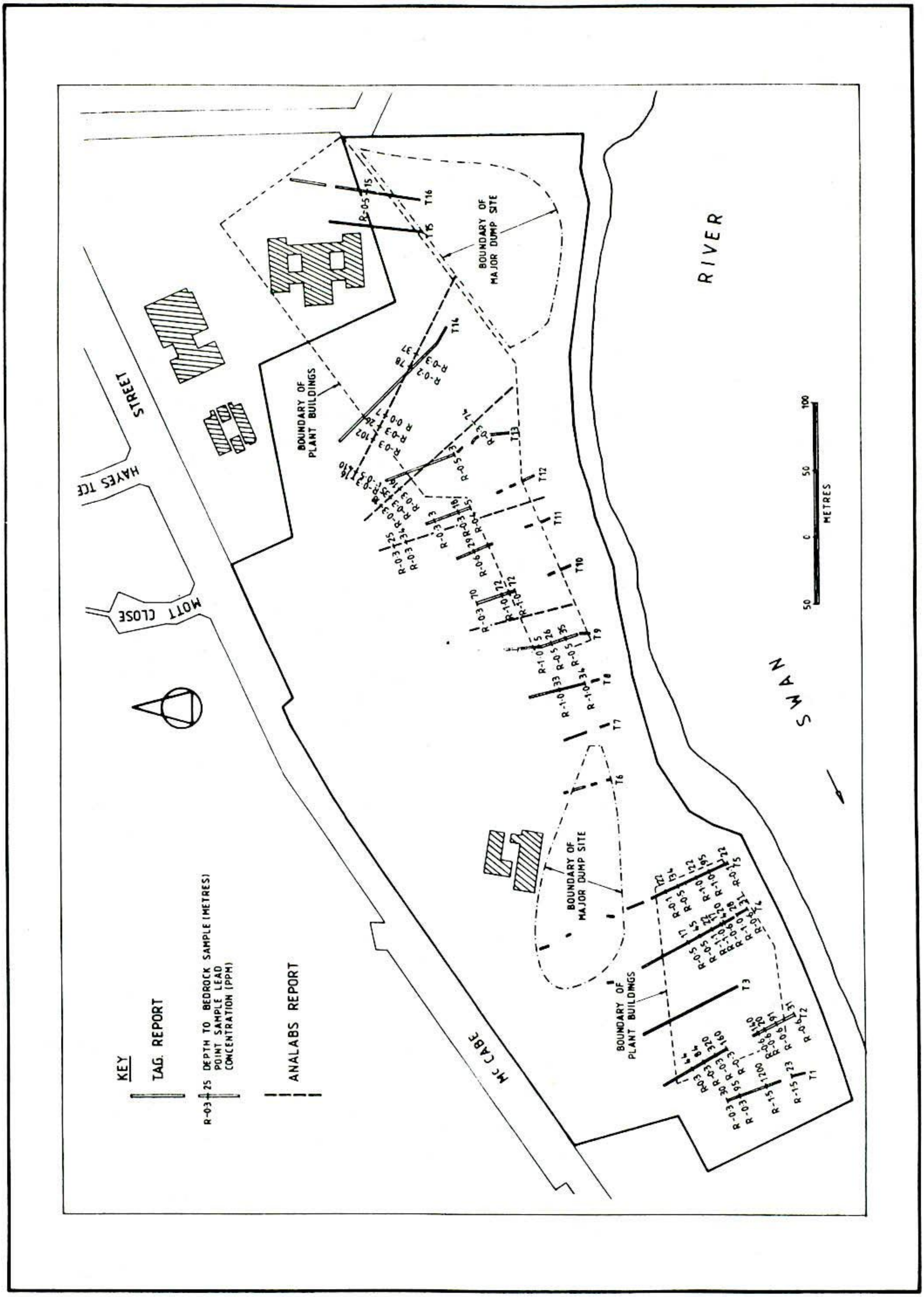
Source	Fe	Cu	Zn	As	Cd	Hg	Pb	Bi
1. Max. allowable in Agricultural Soils, Ontario (TEC, 1986)	-	100	216	13	1.4	0.5	56	-
2. Re-Use of Sludges and Treated Waste Water in Agriculture, Germany (Kloke, 1986) Guidelines for Tolerable Limits in Arable Land	-	100	300	20	3	2	100	-
3. Recommended soil levels from NSW State Pollution Control Commission (SPCC, 1987)								
a. Public Open Space, Formal Playing Fields	-	1000	-	40	15	20	2000	-
b. Amenities playing fields, parks, play-grounds, small children - adopted for use in NSW	-	1000	130	40	12	4	1500	-

Keys to heavy metals:

AS Arsenic
Bi Bismuth
Cd Cadmium
Cu Copper
Fe Iron
Hg Mercury
Pb Lead
Zn Zinc



TOP-SOIL LEAD CONTAMINATION 1981 & 1984 STUDIES FIGURE 3.1



BEDROCK LEAD CONTAMINATION 1981 & 1984 STUDIES FIGURE 3.2

Comparisons of allowable lead concentrations with lead levels for bedrock samples, as shown in Figure 3.2, indicate that in only a few isolated areas the bedrock is contaminated to unacceptably high levels for agricultural use. Contaminant levels in deep soils and bedrock are not as applicable to development of the site as are the top-soils, but they provide an indication of the mobility of the contaminants, as discussed in Section 3.6.

Heavy metals are generally defined as stable in an alkaline environment but in an acidic environment some, such as lead and cadmium, form soluble compounds that are highly mobile and highly toxic. It is considered that the alkaline nature of the soils and underlying bedrock at the McCabe Street site has resulted in the general confinement of the majority of heavy metal contamination to the surface and near-surface soils.

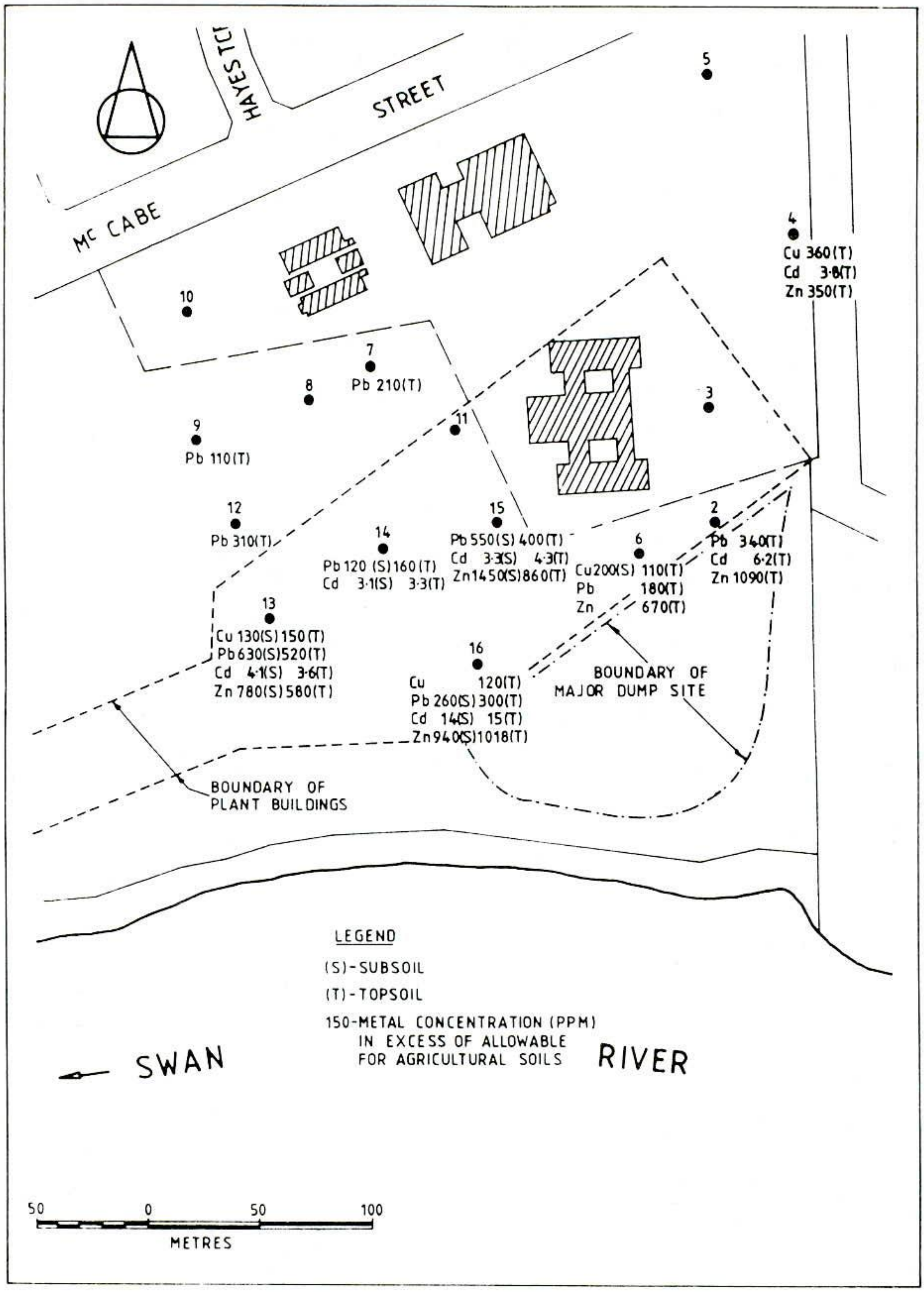
The TAG Report includes a series of point samples sited on a 100m grid at the eastern end of the site. A summary of results from this analysis programme together with sampling point locations are plotted in Figure 3.3. The data shown are for bulk top-soil and subsoil samples where levels exceed the highest allowable concentrations listed in Table 3.2 for agricultural soils. It can be seen that although lead has been identified as a principal contaminant, concentrations of other heavy metals are also above that allowable for agricultural use. These areas include those in close proximity to the original plant buildings and associated facilities. These results are also confirmed by sample analyses from the Analabs report.

Samples of the pyrites cinders residue have also been analysed and found to contain levels of copper and zinc in excess of those allowable for agricultural soils.

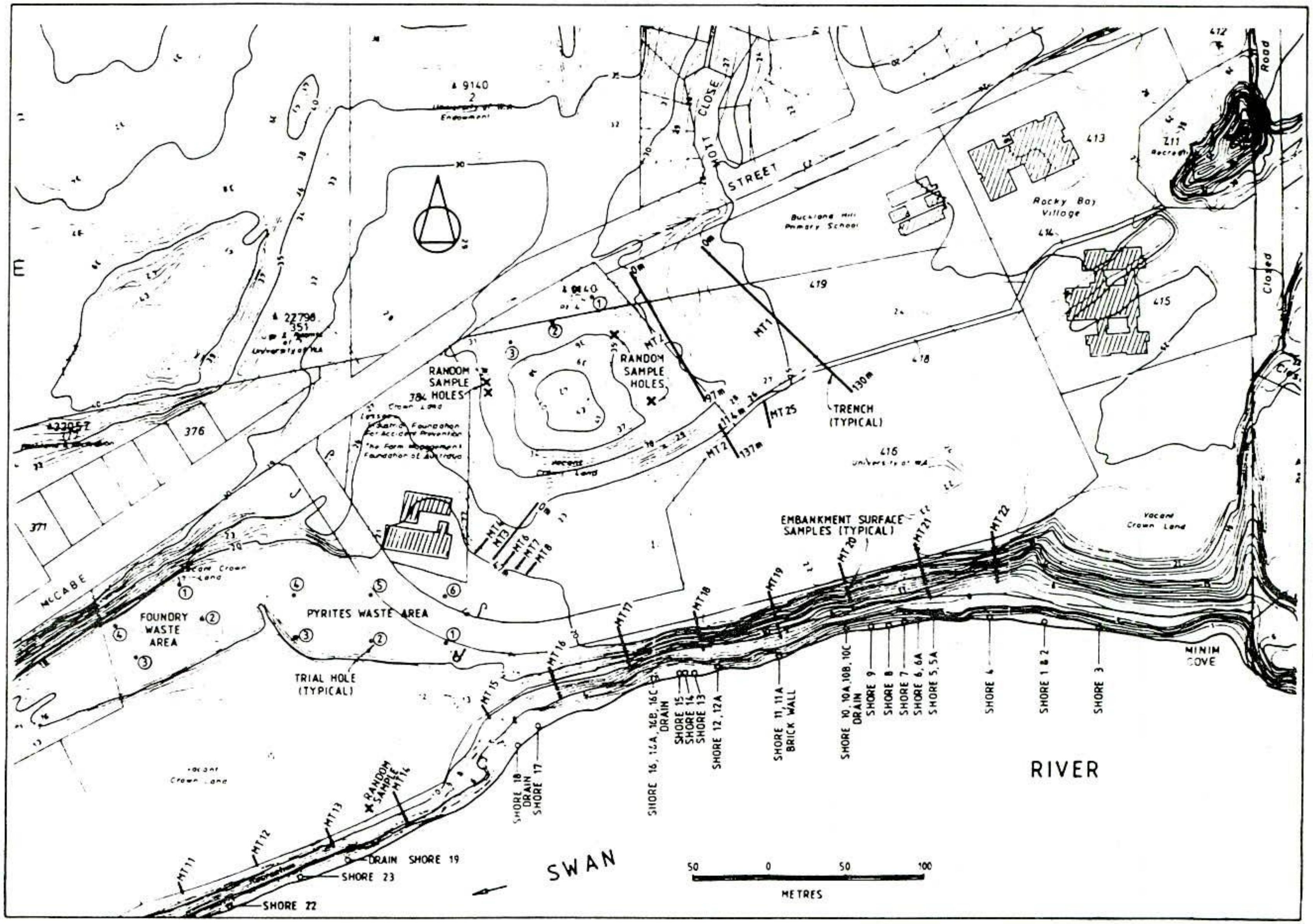
The location of additional sampling sites in the 1986 study by Maunsell & Partners is shown in Figure 3.4. Sampling along trenches MT1 and MT2 revealed surface lead, copper and arsenic concentrations in places in excess of levels recommended for agricultural lands and levels of zinc in excess of those recommended for playing fields and public recreation land usage. For detailed information on testing of samples from all trenches refer to Volume 2 of this PER.

Samples collected in the area covered by trenches MT3 and MT4-8 intercepted a small pyrites cinders dump with excessive levels of lead, zinc, copper and arsenic and also a small area of amosite (a form of asbestos). The prime purpose of trenches MT11-15 was to establish the depth of any pyrites waste in the western part of the river embankment. As no deep deposits of such material were located, extensive sampling was not carried out.

Trenches MT16-22 intercepted the pyrites dump along the river embankment which in places was covered with limestone rubble. Results of analyses of pyrites cinder samples from these trenches are listed in Table 3.3.



HEAVY METAL CONCENTRATIONS 1984 STUDY FIGURE 3.3



SITE INVESTIGATIONS 1986 FIGURE 3.4

TABLE 3.3

HEAVY METAL LEVELS RECORDED IN THE 1986 SAMPLING PROGRAMME EMBANKMENT SAMPLES

	Metal Concentrations (ppm)						
Sample	Fe	Cu	Zn	As	Cd	Hg	Pb
MT15 Gen Sample	352,000	230	365	260	2.0	0.1	120
MT15 7/2.1	10,000	500	1,800	2	3.3	x	x
MT16 Gen Sample	484,000	260	230	200	2.1	0.145	950
MT17 4/1.0	459,000	850	950	1,100	6.1	8.8	2,250
MT17 6/0.45	152,000	900	1,100	110	4.5	0.54	775
MT18 7/0.4*	19,000	34,000	60,000	110	240	0.26	105
Arithmetic Mean (MT18 7/0.4 omitted)	291,400	548	889	334	3.6	1.9	819
Allowable in Agricultural Soils - Ontario	-	100	216	13	1.4	0.5	56
Playground small children - NSW	-	1,000	130	40	12	4	1,500
Public Open Space	-	1,000	-	40	15	20	2,000

(Allowable values from Table 3.2)

Key to sample description: (refer to Figure 3.4)

MT15 Trench 15
7 Distance of sample location from reference point
2.1 Depth below ground level of sample location
* Sample from thin blue vein of material located immediately beneath pyrites cinders waste
x no discernable quantity

The sample identified as MT18-7-0.4 however, was taken from a thin vein of blue coloured material located immediately beneath the pyrites cinders. The concentrations of the various metals listed for the remaining samples are well above acceptable levels even if the MT18 sample is omitted. It is possible that the bright blue material is ferric ferrocyanide or "Prussian Blue", a product of the reaction of cyanides (perhaps from the gold extraction wastes in the pyrites cinders slurry dump) and iron. The metal concentrations and, in particular, the level of cadmium given for this sample (240 ppm) are extremely high and potentially toxic if ingested.

Soil samples collected along the foreshore and beach below the embankment also showed elevated levels of heavy metals especially in the area covered by samples Shore 9 to 18 (Figure 3.4). The results for this section are shown in Tables 3.4 and 3.5.

Sampling in the shore area was extended to include a small number of edible molluscs (*Venus chemnitzii*), one of which had a mercury level of 1.7ppm (wet weight), which is three times the allowable Food & Drug Regulation level. The earlier TAG study recorded a mollusc sample with a lead concentration of 19ppm (wet weight), which is seven times the allowable level. Ingestion of six of the mercury contaminated molluscs and 6-27 of the lead containing individuals would exceed safe ingestion levels (N.S.W. Dept. of Industrial Relations, Occupational Health Division, 1986).

The results from random sampling holes in the pyrites cinder dump area are given in Table 3.6. Comparison of the arithmetic mean values, for heavy metals, with allowable levels for agricultural use indicates that arsenic and zinc levels are in excess of those recommended, and to a lesser degree copper and lead levels are higher than those acceptable for agricultural land use.

The results of tests in the cinders dumps indicate that the arithmetic mean values of iron, copper, cadmium, mercury and lead are within limits set for playgrounds for small children (SPCC, N.S.W.), but that zinc and arsenic are in excessive concentrations. Arithmetic mean values of contaminant concentration should not necessarily be taken as indicative of the dump's contamination levels as there are concentrations within the dump which are well above all safe levels.

The presence of both iron and arsenic within the pyrites dumps is due to their relatively high concentrations in the raw product ores. Table 2.1 shows that arsenic (0.0001%) is the main trace element constituent and iron (30%) is the major constituent.

Finally, samples taken from holes in the foundry waste area indicate elevated levels of copper and zinc, in particular, with levels of cadmium and lead slightly higher than acceptable. The samples tested also contained a large proportion of metal turnings and pieces of scrap metal.

TABLE 3.4

HEAVY METAL LEVELS RECORDED IN THE 1986 SAMPLING PROGRAMME

FORESHORE SAMPLES

Sample		Fe	Metal Concentrations (ppm) Cu	Zn	As	Cd	Hg	Pb
Fshore 1	0.15m	151,000	40	35	100	0.5	0.06	30
Fshore 1	0.3m A	4,000	5	10	3	0.4	x	5
Fshore 1	0.3m B	162,000	45	35	120	0.6	0.10	110
Fshore 1	0.8m	3,000	5	10	2	0.5	x	x
Fshore 1	200mm above drain	59,000	45	20	79	0.4	0.05	20
Fshore 1	in pipe	163,000	35	15	100	0.3	0.05	10
Fshore 1	250-300mm below dr	20,000	55	75	5	0.9	x	5
Fshore 1	below drain	150,000	90	20	100	0.6	0.04	x
Fshore 1	rock below drain	780,000	80	30	16	0.6	0.32	x
Fshore 1A	0.5m	49,000	50	65	20	0.6	0.04	10
Fshore 1A	1m	5,000	x	5	2	0.4	0.01	x
Fshore 1A	0.4m	4,000	x	5	6	0.5	0.04	x
Fshore 2	0.05m	17,000	10	85	5	0.8	0.1	20
Fshore 2	0.15m	49,000	10	25	5	0.4	x	10
Fshore 2	1.5m	5,000	x	5	3	x	x	x
Arithmetic Mean		67,930	31	29	38	0.5	0.05	15
Allowable in Agricultural Soils - Ontario		-	100	216	13	1.4	0.5	56
Playground small children - NSW		-	1,000	130	40	12	4	1,500
Public Open Space		-	1,000	-	40	15	20	2,000

(refer to Figure 3.4)

x no discernable quantity

TABLE 3.5

HEAVY METAL LEVELS RECORDED IN THE 1986 SAMPLING PROGRAMME

RIVER BEACH SAMPLES

Sample	Location	Fe	Cu	Zn	As	Cd	Hg	Pb	pH
				Metal Concentrations (ppm)					
09	beach	204,000	530	1,050	150	2.0	0.43	2,650	
10B	mid-height	160,000	1,100	270	200	6.3	0.75	2,300	
10C	toe of beach	176,000	3,300	3,100	850	5.1	0.80	3,100	
13	beach	53,000	5,850	7,400	1,400	28.0	0.08	25	7.4
15	beach	66,000	6,650	11,000	540	35.0	0.62	45	8.2
16C	toe of beach	60,000	26,500	40,000	780	95.0	0.78	190	8.0
17	beach	66,000	1,050	1,950	95	7.3	1.8	1,100	
18	beach	43,000	780	950	25	3.2	0.03	95	
Arithmetic Mean		103,500	5,270	8,215	505	22.7	0.66	1,188	
TAG Report River Sediment - Sample No.6		-	2,600	2,400	310	7.1	1.40	1,900	
Allowable in Agricultural Soils - Ontario		-	100	216	13	1.4	0.5	56	
Playground small children - NSW		-	1,000	130	40	12	4	1,500	
Public Open Space		-	1,000	-	40	15	20	2,000	

(refer to Figure 3.4)

x no discernable quantity

TABLE 3.6

HEAVY METAL LEVELS RECORDED IN THE 1986 SAMPLING PROGRAMME

WESTERN PYRITES CINDERS DUMP SAMPLES

			Metal Concentrations (ppm)						
Sample	**Description**	**Fe**	**Cu**	**Zn**	**As**	**Cd**	**Hg**	**Pb**	**pH**
PH1 0.7m	Pyrites Cinders	476,000	400	405	420	2.3	0.96	1,100	
PH1 1.0m	Limestone rubble	10,000	170	540	42	2.4	0.08	45	
PH1 2.0m	Foundry waste	27,000	35	25	3	0.6	0.10	15	
PH2 1.0m	Pyrites Cinders	468,000	180	115	240	1.0	x	15	8.8
PH2 2.0m	Pyrites Cinders	420,000	165	80	350	1.3	x	25	4.3
PH2 3.0m	Pyrites Cinders	429,000	105	60	490	1.2	x	x	7.9
PH3 1.0m	Pyrites Cinders	484,000	275	150	220	1.1	x	x	
PH3 2.0m	Pyrites Cinders	469,000	55	105	280	1.1	x	x	
PH3 3.0m	Pyrites Cinders	450,000	80	105	240	0.8	x	x	
PH4 2.0m	Pyrites Cinders	470,000	130	155	210	0.8	x	x	
PH4 3.0m	Pyrites Cinders	504,000	105	135	240	1.0	x	x	
PH6 0.15m	Topsoil	9,000	20	20	5	0.5	0.04	x	
PH6 0.4m	Pyrites Cinders and limestone	86,000	120	1,950	63	4.7	0.25	315	
Arithmetic Mean		349,620	142	296	216	1.4	0.11	115	
Allowable in Agricultural Soils - Ontario		-	100	216	13	1.4	0.5	56	
Playgrounds small children NSW		-	1,000	130	40	12	4	1,500	
Public Open Space		-	1,000	-	40	15	20	2,000	

Key to sample description: PH1 - pyrites cinder stockpile hole No.1
0.7m - depth below ground level of sample location

x no discernable quantity

3.5 ONGOING CHEMICAL ACTIVITY AND LEACHING

The study by Maunsell & Partners, 1986 (see Volume 2 this PER) includes a mineralogical study of the pyrites cinders dump. This concludes as follows:

(a) The mineralogical composition of the material is:

- dominant: haematite
- subordinate: quartz, gypsum
- minor: barite, potassium feldspar
- trace: magnetite, calcite, plumbojarosite.

(b) Detected heavy metal minerals are:

- zincian brochantite
- azurite
- plumbojarosite
- cerussite
- hydrated hydroxysulphates of iron and aluminium with small content of copper and zinc.

(c) No sulphides were detected in the investigated samples, but the presence of ephemeral iron sulphates indicates that oxidation of sulphides to sulphuric acid and SO_4^{2-} is still taking place in the dump material.

(d) Copper, zinc and lead appear to be well contained within the dump material by the neutralising action of the limestone under low water flow conditions but copper and zinc could escape into the wider environment under conditions of increased water flow.

The mobility of leachate from the dumps is a complex mechanism and is dependent on the solubility of the contaminants. According to the Analabs Report (1981), mobility of the leachate is dependent on acidity, that is, the contaminants are more soluble in acid. Present indications on leaching to and dilution within the adjacent river, of contaminants, are that the aquatic environment could continue to assimilate the limited quantity of leachate presently expected without adverse effects.

However, the leachate does not necessarily enter the river to be diluted. As the leachate approaches the river, the pH of the leachate is affected by the river's pH buffering ability. As the acidic leachate becomes alkaline the calcium carbonate precipitates out of solution and carries the heavy metals with it. This mechanism was confirmed in the Analabs Report. Continual monitoring at the river, as well as throughout the site, should be undertaken to confirm and observe the mechanism of heavy metal movement.

3.6 GROUNDWATER QUALITY

The Rockwater report, 1981 (see Volume 2 of this PER) concluded that the groundwater beneath the southern and south-eastern ends of Lot 416 is contaminated with nitrate and phosphate together with mercury. Samples were obtained at intervals during approximately 4 days of continuous pumping with precautions taken to avoid re-circulation of pumped water. The bores extended 8-10m below the groundwater level.

With reference to groundwater quality beneath the slurry dump the TAG report concludes that "apart from the occasional raised iron value all heavy metal levels are well below the maximum allowable". However, in an earlier reference to the bore the comment is made that "this bore had not been properly developed and the sample taken may not be representative of the state of the groundwater below the dump". It is also noted that all groundwater samples from bores within the site were obtained by bailing and that prolonged pumping with sampling at intervals was not undertaken. On this basis the results may not be reliable.

The TAG Report, 1984 (see Volume 2 of this PER) notes that the Geological Survey of WA suggests that the bore, from which the samples were taken, should extend to the base of the aquifer (i.e. 28-30m below groundwater level). At this depth it is believed that an appropriate indication of possible downward migration of metal contaminants would have been obtained. Heavy metal contamination at this level is unlikely to restrict the usage of domestic bores. However, LANDBANK intends to carry out further groundwater studies to determine if there needs to be any restrictions on domestic bore usage.

As noted in the previous sections there is potential for the development of soluble heavy metal compounds, particularly within the pyrites cinders dumps. There is also evidence to support the fact that these compounds are mobile within an acidic environment. Surface staining and sample analyses again provide evidence that heavy metals are being carried down to accumulate on the beach below the site either by direct leaching or by mechanical means associated with stormwater run-off. The apparent continued leaching of jarosite indicates an acidic environment and, as discussed in Section 3.5, is therefore a further indication of the downward and lateral movement of leachate.

Downward migration of heavy metals within the slurry dump is also apparent because of the recorded significantly higher concentrations of heavy metal near the base.

The Rockwater Study (1980) determined that the groundwater gradients are uniform under the study area with a 1 in 100 gradient towards the south-south-west. Thus any leachate reaching the water table would move toward the Swan River and this means that groundwater in the northern areas of the site would not be contaminated by leachate from the site. However, the TAG Report, 1984 (Volume 2 of PER) states that elevated levels of organic contaminant were encountered and that these organic contaminants are from sources outside the fertiliser works site.

SECTION 4

THE DEVELOPMENT PROPOSAL

4.1 CONSTRAINTS TO SITE DEVELOPMENT

Various options have been considered for the treatment and development of all or parts of the McCabe Street site. The earthworks and subsequent landscaping proposed for the site have been conceptualised so as to:

- instigate measures to immediately ameliorate the possibility of human contact with the areas on the site determined to be highly contaminated,

- permanently develop the site to minimise exposure of people to the contaminated soils on the site, and

- develop a passive recreation facility for residents and the general public.

The initial reports and evaluations suggested that a cover of at least one metre of clean fill be placed over the site prior to development as recommended by the Health Department. However, it is considered that this treatment would not sufficiently reduce the potential for residents to be exposed to contaminated soils. Potential exposure, with one metre of fill covering the site, could result from any of the following scenarios:

- Consumption through uptake in fruit trees, or the uprooting of trees or telegraph poles in storms.

- Extraction of polluted groundwater. Although it is recognised that a caveat or licence system can control bore installation such restrictions could be viewed as undesirable by potential land buyers.

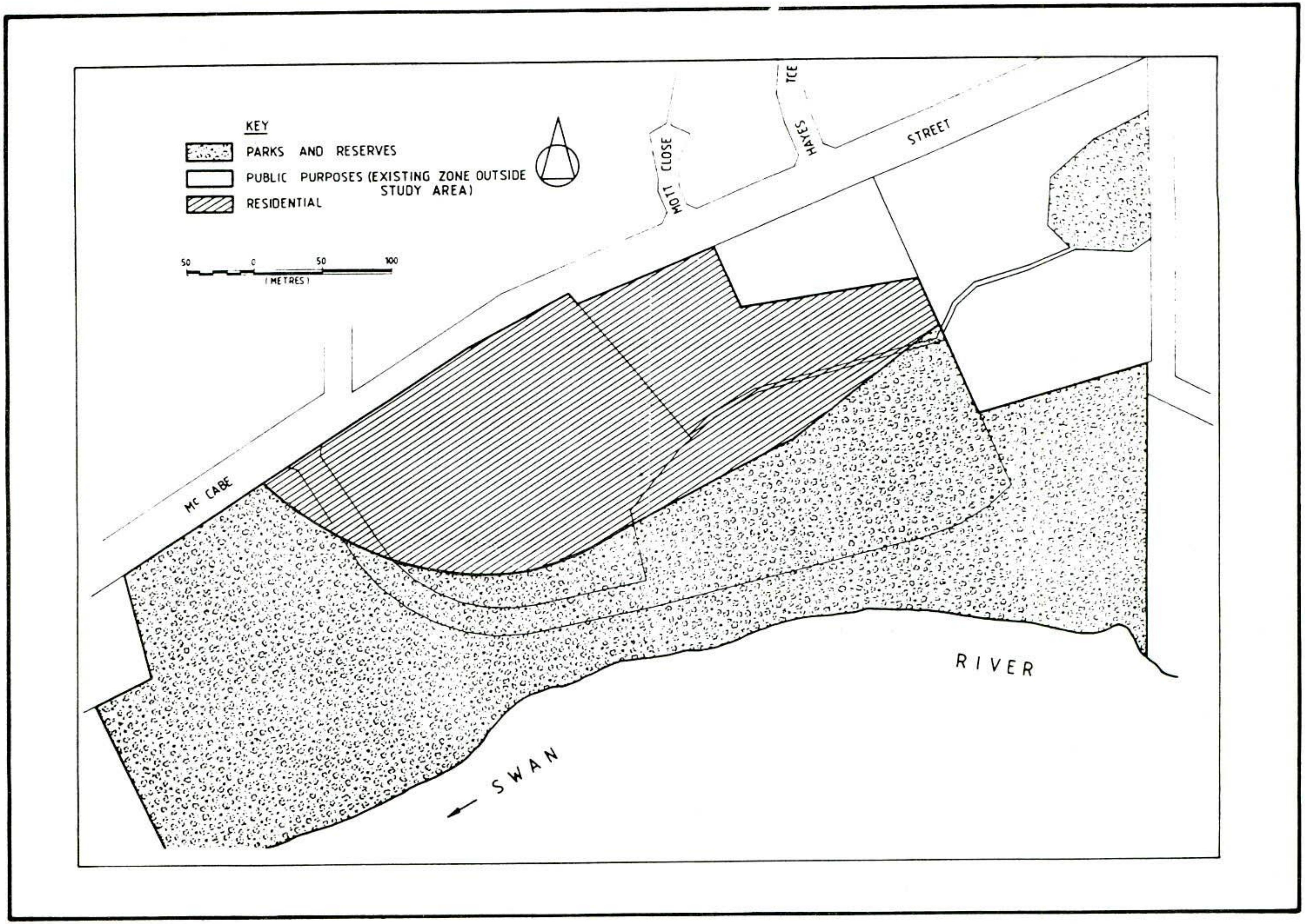
- Installation of swimming pools, landscaping, cellars, soak-wells etc.

- Installation and maintenance of deep services such as sewerage and drainage.

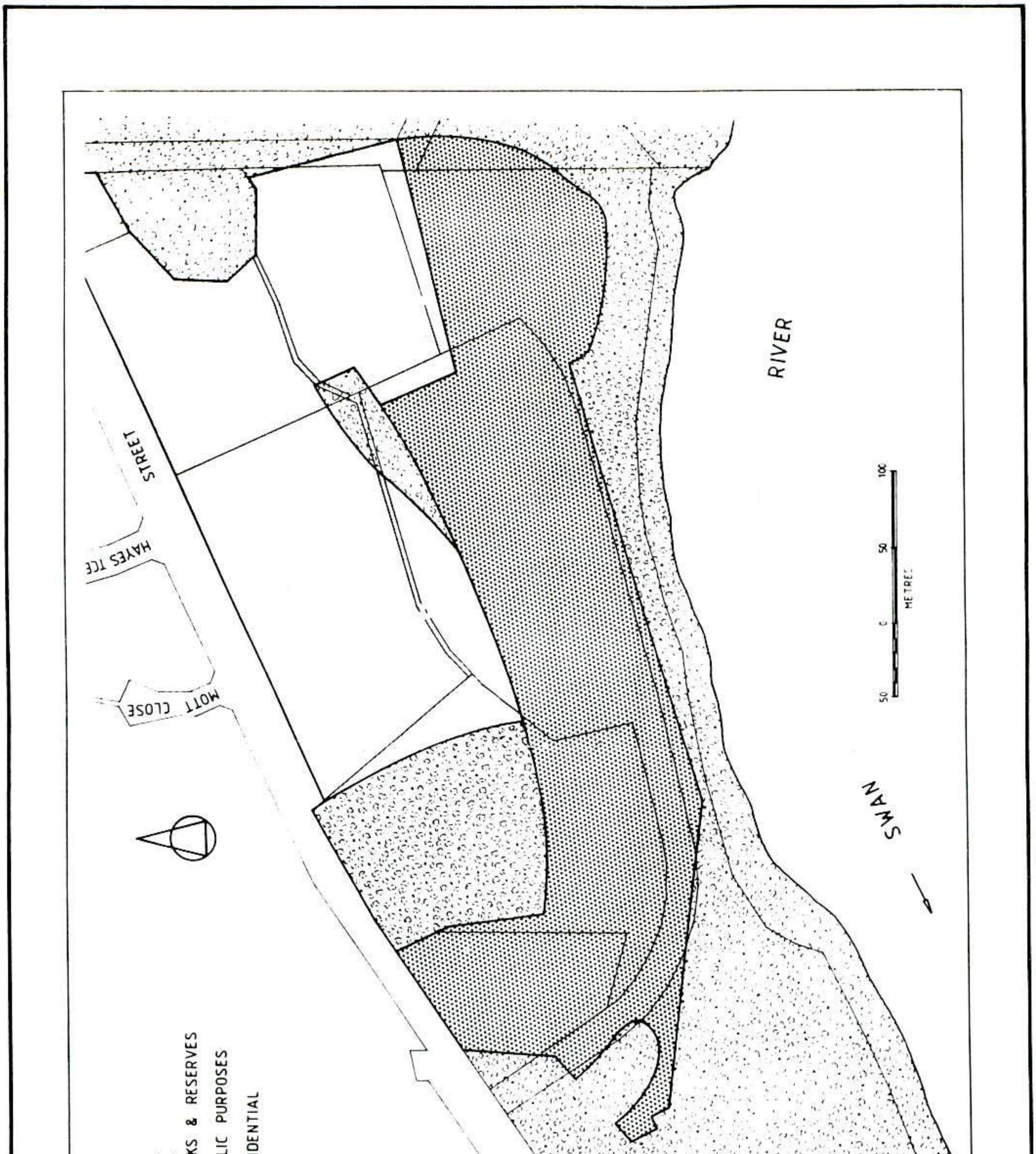
In view of these hazards, the establishment of residential properties on areas with high levels of contamination is considered to be unacceptable. These areas include the:

- pyrites cinders slurry dump - Lot 325
- western pyrites cinders dump - Lot 211
- embankment pyrites cinders dump - Lot 324
- smaller isolated areas

In addition, protection of the public by fencing off contaminated areas is regarded as unacceptable because it is considered desirable that access be provided to as much of the site as possible for public use and because fences will not necessarily maintain definite isolation of the site.



McCABE STREET PROPOSED ZONING FIGURE 4.1



McCABE STREET EXISTING ZONING   FIGURE 4.2

4.2 PROPOSED ZONING

The proposed zoning of the site is shown in Figure 4.1. Proposed residential land is confined to the northern portion of the site adjacent to McCabe Street where direct access to the estate can be provided. The field studies indicate that the level of contamination in this area is relatively low but some remedial treatment will still be necessary. Normal residential development will then be possible.

The remainder of the site, including all of the present areas of high contamination, is zoned for development as parks and reserves after extensive earthworks and landscaping.

4.3 ALTERATION TO CURRENT ZONING

The current zoning of the site is shown in Figure 4.2. Comparison with the proposed zoning (Figure 4.1) indicates that the area currently zoned for residential purposes is proposed to be substantially modified and reduced. Conversely, it is proposed to greatly expand the area zoned for parks and reserves with significant additions along the frontage to the Swan River.

4.4 SITE TREATMENT

Prior to development most of the site will be treated with remedial works to effectively remove any hazard to the public and residents. The bitumen and concrete surfaces remaining from the fertiliser work's buildings will remain and have fill placed over them. These impervious surfaces will be advantageous to site rehabilitation as they will limit, if only to a modest extent, surface water ingress and leaching.

In the residential zone soil to a depth of not less than 300mm will be removed, unless solid bedrock is found at lesser depth. The depth of 300mm has been selected as appropriate to make certain that most of the top-soil is removed. The work will be supervised and programmed for winter with strict requirements related to watering for dust control purposes. Inspection by a qualified chemist and supplementary soils testing will be employed to ensure removal of all contaminated ground. The area for development will then be covered with a minimum of one metre of clean fill.

This stripped top-soil material will be placed on top of the cinder and slurry dumps. The anticipated minimal degree of contamination in this soil is such that various stabilisation-solidification and chemical fixation technologies available for heavily contaminated materials are not believed to be warranted. However, random assessment of the "uncontaminated" material for total and mobile contaminant concentrations will be carried out.

Pyrites cinders from the river embankment area will also be added to the surface of the western pyrites cinders dump. Deposits of foreign material will be identified, from previous site work, and either treated similarly to the pyrites cinders or, if judged to be inappropriate for this type of disposal, removed from site to an approved landfill site (eg amosite found in trench MT4).

In the parkland zone the following treatments will be applied:

Pyrites Slurry Dump

This dump received the waste product from the furnaces, and as discussed in Section 2.2 contains a higher level of heavy metal contamination because the furnace process removed these metals from the sulphur dioxide product. It is therefore recommended that this dump receive a slightly different treatment from that of the dumps in the western area of the site.

Although there is no clear evidence to suggest that leakage of hazardous material (eg soluble heavy metal compounds, cyanides etc) from this dump is occurring. It is considered unlikely that the permeable limestone will have sealed the dump entirely. Therefore the surface will be covered with an impermeable PVC membrane (Canvacon 16SS or similar) on a 150mm thick layer of clean sand. Figure 4.3 shows a cross-section of the dump and details of the proposed treatment.

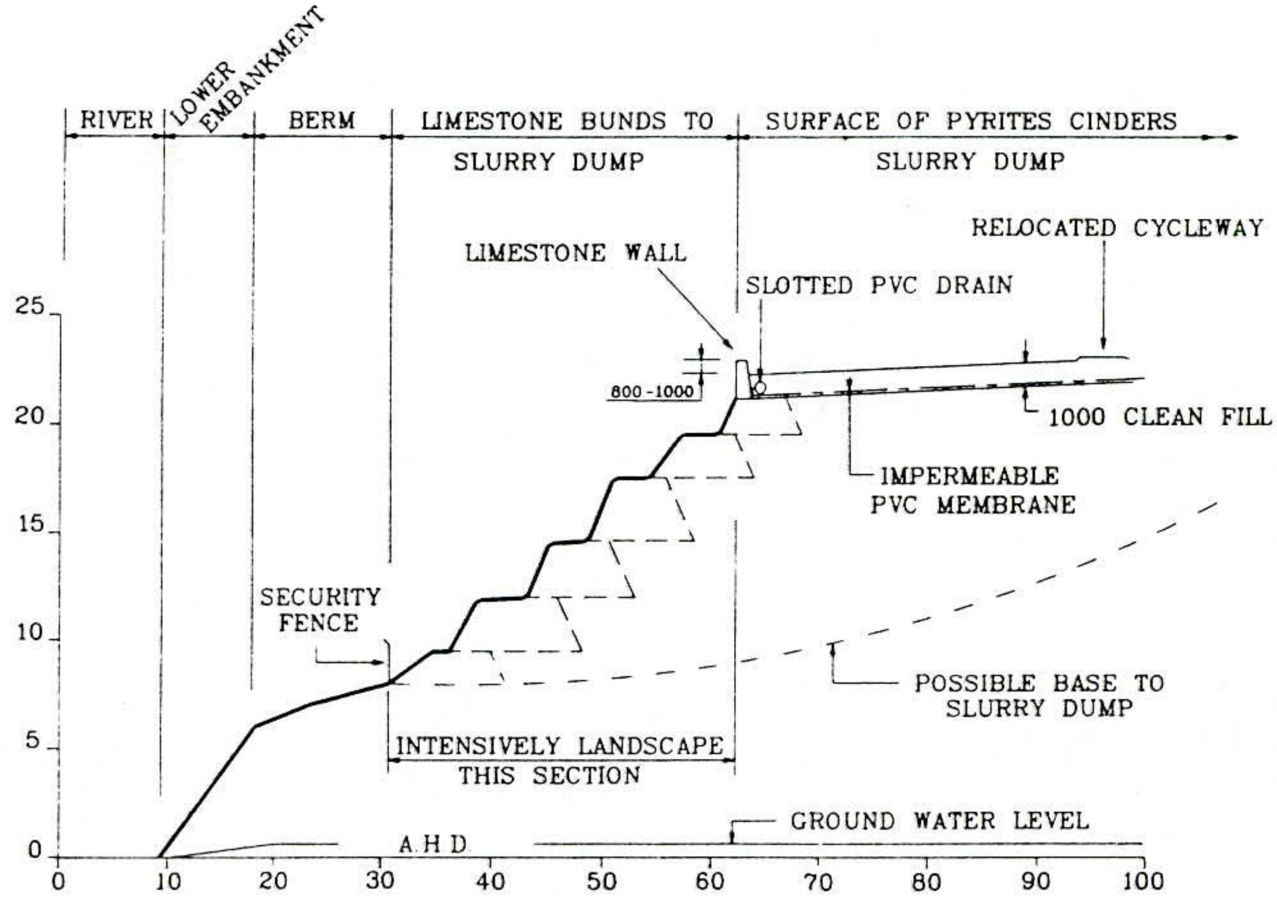
Impermeable PVC membranes are in widespread use as a mechanical form of leachate control. They are used for caustic waste disposal ponds associated with the alumina industry, emergency oil spillage containment bunds and landfill disposal site linings.

The dump will be then be topped with some of the top-soil from the proposed residential area of the site as well as one metre of clean fill. The membrane will prevent the ingress of water and in the absence of water the material should remain chemically stable. All possible care and supervision will be undertaken during placement of the membrane to ensure that tears do not occur.

Restriction of public access to the front slopes of the dump will, unfortunately, be necessary to avoid disturbance and consequent erosion of the steep faces. This will be achieved by the construction of a low (800-1000mm) limestone wall along the top edge of the face of the dump. This wall will retain the one metre of clean fill over the dump and will create a 1.8 to 2.0m drop to the steeply sloping bunds on the river side of the wall. It should therefore effectively discourage public access.

The bottom of the bund wall slope will be security fenced and returned as necessary to meet the limestone wall to isolate the slope area. The slopes will then be intensively landscaped to further dissuade public access. It will be necessary to install an agricultural drain immediately behind the limestone wall to intercept and remove seepage above the membrane and to carry it to a suitable sump, this water will be uncontaminated.

DETAIL OF PROPOSED SITE TREATMENT FIGURE 4.3



SECTION APPROX 50m WEST OF MINIM COVE

PYRITES SLURRY DUMP

The advantage of treating the pyrites cinders slurry dump in this way is that it will form a high point along this stretch of the Swan River and this will possibly be developed as a viewing area. The pyrites cinders dump on the western side of the site can be landscaped to also form a viewing area. The relative amounts of earth allocated from areas of the site to either of the dumps will be determined in the final landscaping designs.

Riverbank and Beaches

The section of the lower river bank and adjacent beachline that has been identified as being particularly contaminated, between sampling points Shore 9 and Shore 18 (see Figure 3.4). Clean up action for this area will include the following:

- Excavation and removal of beach sand together with loose rock and soil from the lower embankment. The initial extent of such excavation will be guided by visual inspection but will be finally determined by further sampling and testing.

- Placement of contaminated material removed from the beach in a discrete stockpile not exceeding 1.5m in height adjacent to the toe of the western pyrites cinders dump and covering of this stockpile with crushed limestone to a depth of not less than 0.5m.

- Re-establishment of the bank profile and beachline with crushed limestone filling, including replanting on the lower embankment slopes and placement of limestone rip-rap to prevent scour of the rebuilt slopes (see Figure 4.4).

A strategy for reducing the public health risk due to contaminated mussels will also be implemented after further sampling. This may require collection and destruction of all molluscs along the entire stretch of beachline adjacent to the site. Sampling of molluscs along the shore have indicated that high levels of contamination are associated with the areas immediately adjacent to drainage pipe outfalls.

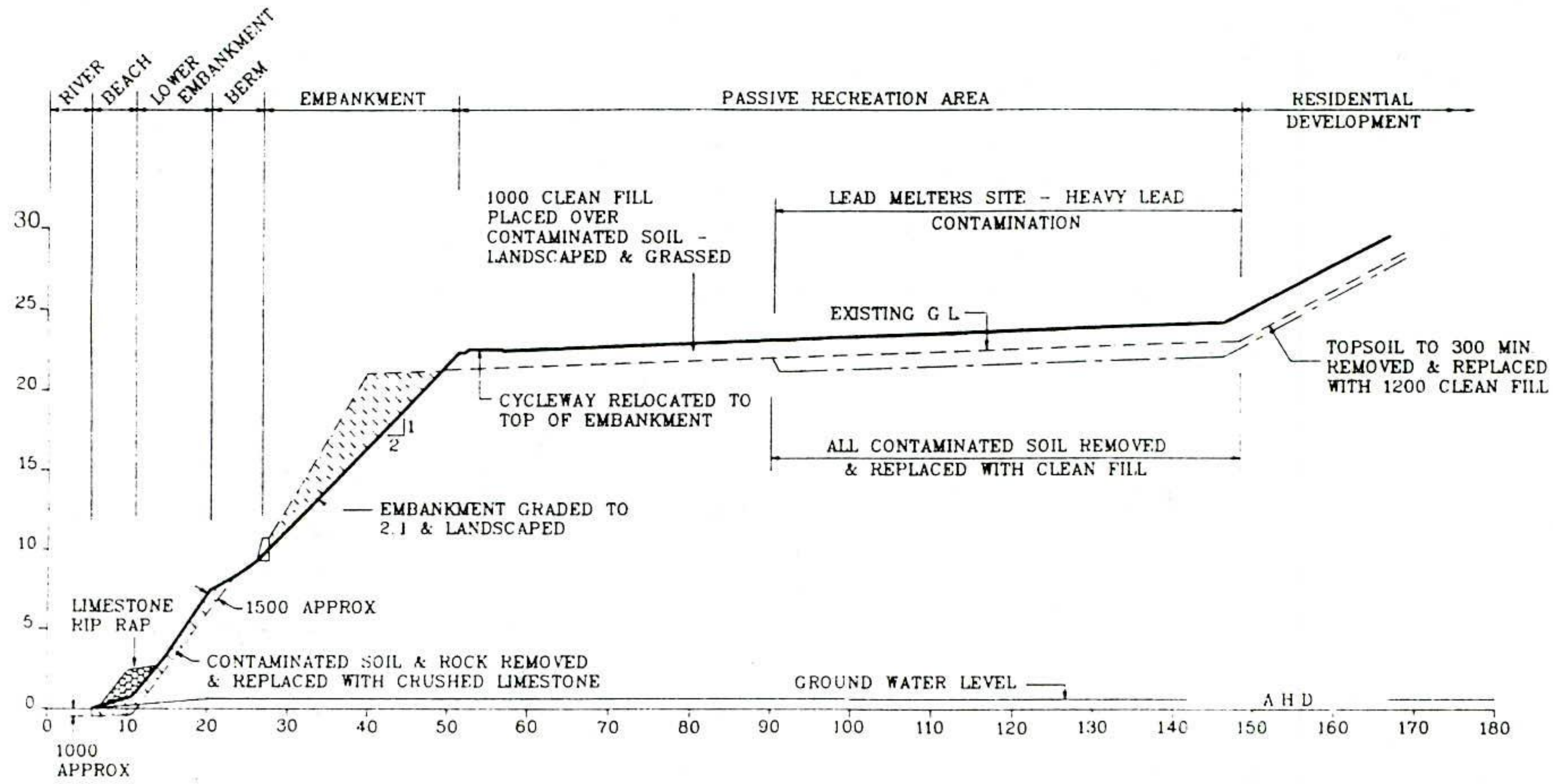
Stormwater Collection Systems and Outfalls

All existing stormwater collection systems and outfalls on the site will be excavated and removed. Rubble and other debris will be disposed of in an approved landfill site because of the possibility that some pipes may contain contaminated silts. All trench excavations required for removal of the outfalls in the embankment will be backfilled with at least two impermeable barriers across each trenchline to prevent continued drainage.

Site Drainage

As much of the surface drainage of the site as possible, allowing for grade restriction, will be concentrated to exit from the site at one point. At that one point a gross pollutant trap will be installed to collect floating rubbish and sediment transported from the site in the surface, and to a lesser extent the sub-surface waters. This trap will then serve as a way of monitoring for contaminant content in the sediments flowing from the site.

DETAIL OF PROPOSED SITE TREATMENT FIGURE 4.4



SECTION APPROX 310m WEST OF MINIM COVE

CENTRE OF EMBANKMENT

Cycleway

In order to complete the embankment works described above it will be necessary to remove the existing cycleway at least in the area adjacent to the embankment pyrites cinders dump. Therefore, the cycleway will be relocated to the top of the embankment. Figures 4.3 and 4.4 show the proposed location of the cycleway.

Embankment Pyrites Cinders Dump

To achieve an acceptable level of protection for future users of the site and, in particular, of the river foreshore and embankment area, it will be necessary to remove the pyrites cinders material from the river embankment. An assessment has been made of alternative treatments such as covering and sealing the dump but the costs associated with such treatments are prohibitive. Partial treatment with a covering of crushed limestone and sand would offset the cost of sealing but would not eliminate the possibility of future leaching with consequent recontamination of the beaches and biota. Further, indicative costs of such partial treatment are similar to the estimated costs for removal of the material due to the need for retaining structures. Therefore little advantage is seen in pursuing these alternative courses of action.

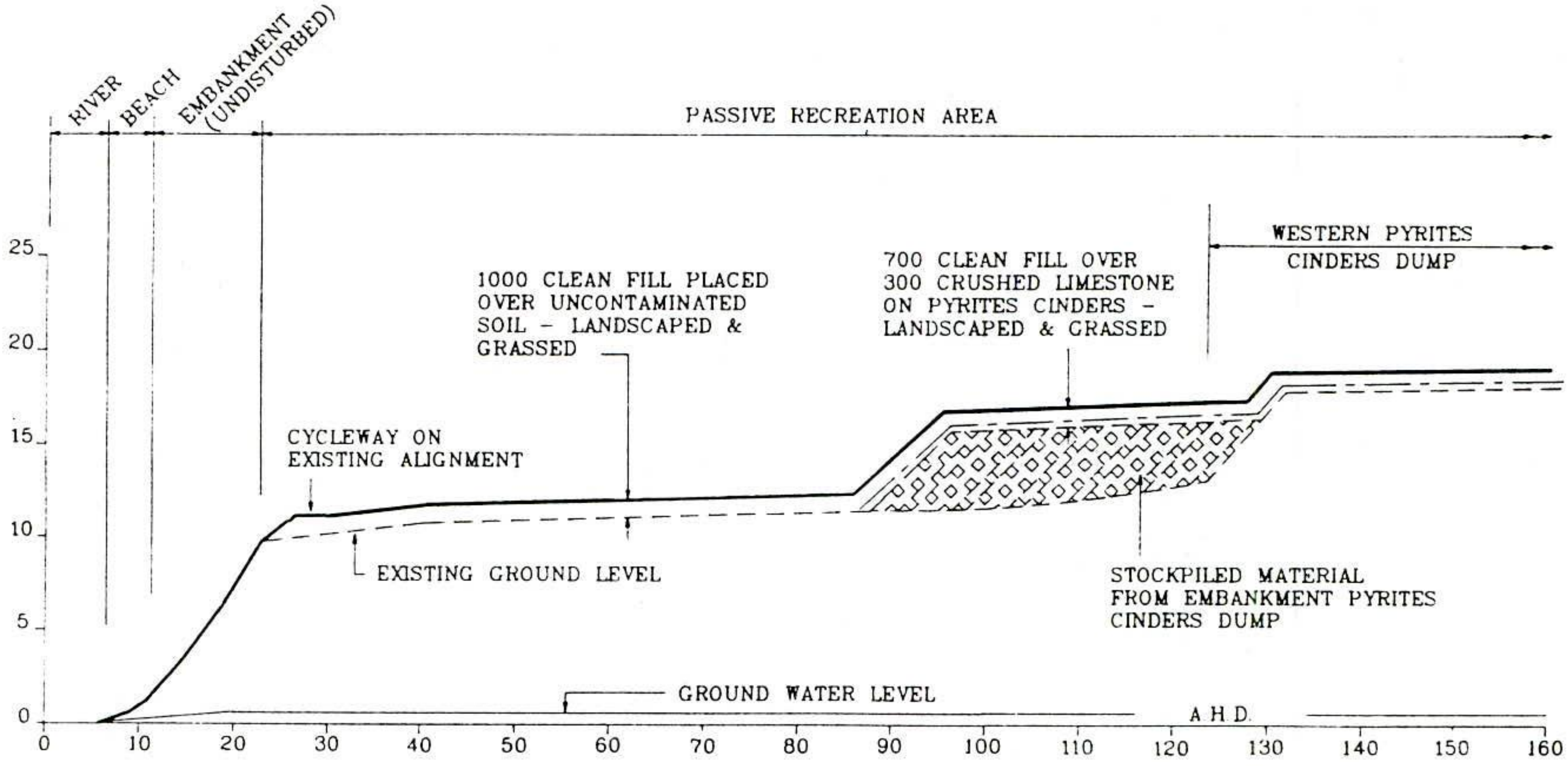
It is considered practicable to excavate the material with a large hydraulic excavator loading into dump trucks although scope exists for alternative methods of excavation. Again, dust control will be of paramount importance so the work will be programmed for the winter months and water sprays will be used if necessary. The excavated material will be relocated on-site to form either an extension of the western pyrites cinders dump or the eastern slurry dump.

Following removal of all the pyrites cinders and any other foreign materials encountered, the embankment slope above the existing berm will be flattened to a slope not exceeding 26 degrees (approximately 1:2). The slope will then be covered with one metre of clean fill and intensively landscaped with discrete paths provided at selected locations to facilitate public access to the river (see Figure 4.4).

Former Lead Melting Site

The levels of lead contamination in this small area are well above even the 2,000ppm level recommended by the NSW State Pollution Control Commission for use beneath clean fill on recreational areas. It is therefore considered inappropriate to allow this material to remain at the site even under a clean soil covering. Accordingly, all soil within this heavily contaminated area will be excavated, removed and buried in an approved landfill site.

DETAIL OF PROPOSED SITE TREATMENT FIGURE 4.5



SECTION APPROX 550m WEST OF MINIM COVE

WESTERN CINDERS DUMP

Western Pyrites Cinders Dump

This dump will be left undisturbed. However, in order to minimise the chances of leaching, particularly of soluble heavy metal compounds, the surface will be covered with 300mm of crushed limestone topped with 700mm of clean fill. This treatment will also apply to the stockpiled pyrites cinders from the embankment dump.

Passive Recreation Area

All other areas of the site identified as being suitable for passive open space recreation will be covered with a minimum of one metre of clean fill and vegetated as described below.

Future Constraints

All relevant Local and State Government authorities will be made aware of the features of the site and development constraints will be sought to ensure that no future uncontrolled excavations or development is allowed to take place.

Aspects of the proposed treatment of the site are illustrated in Figures 4.3 to 4.5. A potential layout for residential, open space and roadway easements for the site is shown in Figure 4.6. (Note, this is an illustration only and is not the final plan.)

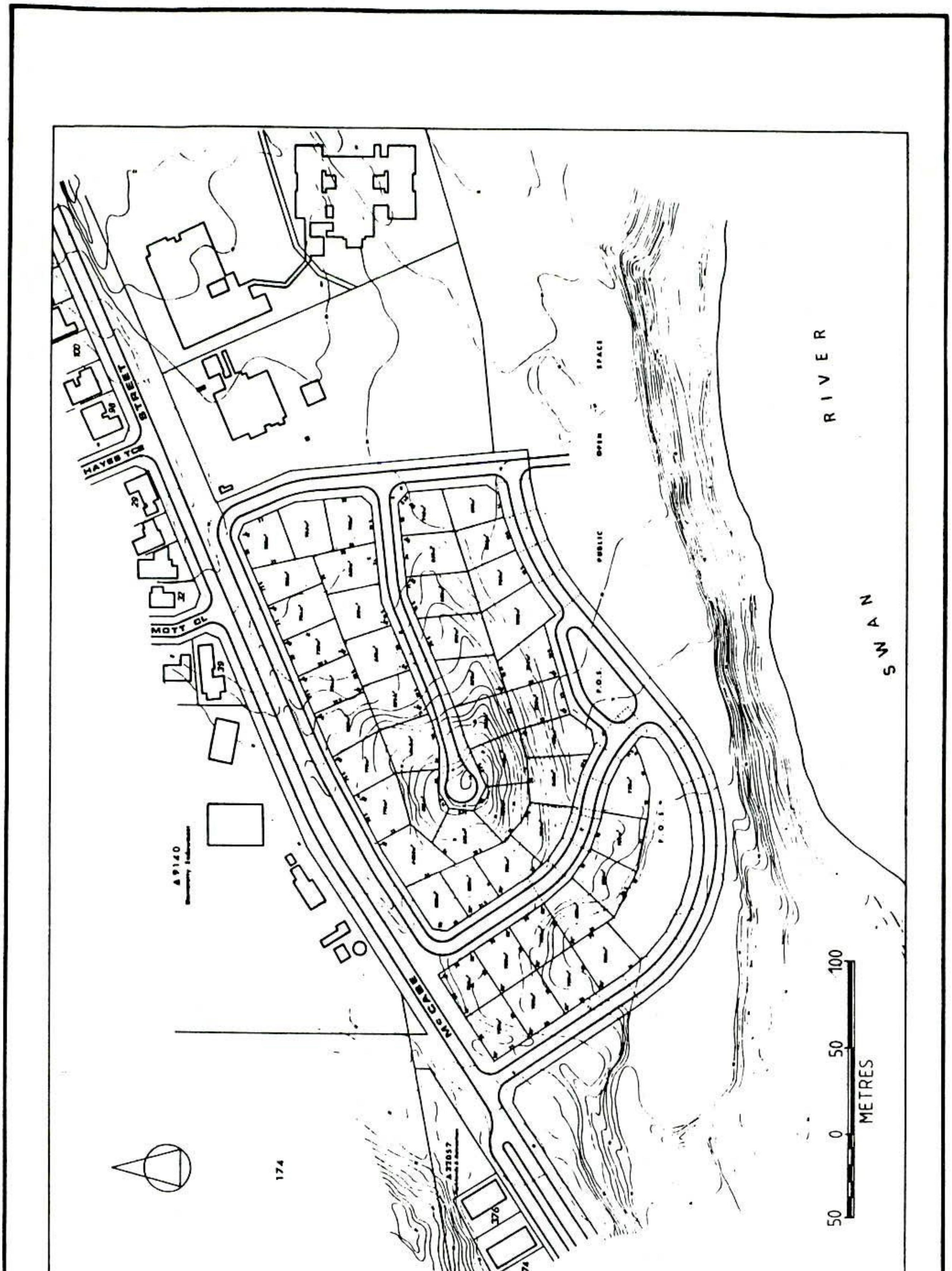
4.5 MONITORING

A proposed monitoring programme is shown on Table 4.1.

Additional sampling and analyses of surface soils will be carried out following the site treatments described in Section 4.4.

After site development, the following monitoring programme will apply:

- The restored river beachline and adjacent embankment will be inspected for scour and erosion initially at six month intervals for two years. Inspection may be reduced to yearly intervals thereafter subject to satisfactory stability being achieved in the first two years. Any damage noted in these inspections will be repaired promptly.



POTENTIAL LAYOUT FOR RESIDENTIAL BLOCKS AND PUBLIC OPEN SPACE **FIGURE 4.6**

TABLE 4.1
PROPOSED MONITORING PROGRAMME

Sampling Area	Monitoring Parameter	Frequency & Duration
Beachline & Embankment	scour & erosion	6 monthly for 2 years
Beachline & Embankment	leachate	after heavy rain or twice/year for 5 years
Gross Pollutant Trap	sediments	after heavy rain or twice/year for 2 years
Beachline & Embankment (Slotted PVC Pipes)	groundwater	annually
Bores	groundwater	6 monthly for 2 years
Soil Samples	soil	6 monthly for 3 years
River Biota	mussels	6 monthly for 3 years

- Inspections will be carried out at least twice during each winter period and immediately after heavy rainfall events to identify and analyse any leaching. The extent and frequency of such inspections will be varied according to results and experience gained over an initial five year period.

- The gross pollutant trap installed on the surface drainage outlet to the river will be maintained and cleaned out on a regular basis. The frequency required for cleaning will be determined by the size of the trap and the frequency with which it fills, which depends on the site condition and the stability of the top-soils. The N.S.W. SPCC is presently reviewing comments received on their Draft Urban Runoff Pollution Management document, which contains guidelines for sizing of gross pollutant traps. These guidelines will be used at the outfall of drainage from the McCabe Street site.

  Each time the trap is cleaned a sample of sediment will be taken and processed to determine if there is any contaminant leaving the site in surface water.

- During the earthworks stage of the development there will be a number of runoff water sediment capture devices installed and maintained for the time required for the site to evolve a stable plant surface cover.

- A network of slotted PVC groundwater monitoring bores will be installed either along the upper beachline or on the embankment berm. The bores will be used to monitor the quality of the shallow groundwater at yearly intervals. The bores will penetrate to different levels in the aquifer up to approximately 3m depth. Each bore will be designed to sample from a small depth range (300mm) of the aquifer by selective slotting. Samples will only be taken after at least three volumes of each bore's contents have been pumped and discarded. Analyses will test for heavy metals and also pH (measured on-site) since a drop in pH will indicate the possible presence of soluble heavy metal compounds.

- All permanent bores on the site and particularly those close to or along the river embankment will be sampled and analysed at six monthly intervals for two years and at yearly intervals thereafter. Sampling frequency after the first five years may be varied depending on the results of previous analyses.

  Samples will be taken from water pumped at a set rate to the surface and at time intervals as recommended by a qualified Groundwater Consultant.

- Soil samples will be taken and analysed at preselected locations along the foreshore adjacent to the entire site at six monthly intervals for a period of three years. Particular attention will be applied to the area identified as being heavily contaminated (ie location Shore 9 to location Shore 18). After the initial period, sampling frequency will be reduced if the results show no signs of contamination.

- Collection and analysis of mussels from locations adjacent to the site where heavy metal concentrations have been identified and from a control area nearby. Sampling will occur in winter and summer for a period of three years at which time the need for continuation of the programme will be reviewed.

4.6 POTENTIAL FOR GOLD EXTRACTION

As described in Section 1.3.2, the pyrites treated in the roasters included flotation concentrate from Kalgoorlie which contained on average 103ppm of gold. The various waste dumps on the McCabe Street site therefore potentially contain gold in sufficient quantities to warrant extraction. Prospecting licences are currently being sought over the area as a result of this potential.

If gold extraction proves to be commercially viable, the proposed site treatment could alter considerably. In this case, the pyritic wastes would presumably be excavated and removed from the site to a gold treatment plant. The site could then be covered with at least one metre of clean soil and landscaped. Restrictions on-site development and monitoring would still apply but could be reduced because it is probable that only residual traces of heavy metals would remain. Monitoring of groundwater in particular would continue to be necessary in recognition of the fact that heavy metal leachates are likely to be present for some time in the limestone and aquifer underlying the site.

SECTION 5

CONCLUSIONS

5. CONCLUSIONS

The proposed development of the McCabe Street site will provide a means for the restoration and rehabilitation of an important area adjacent to the Swan River. The development will provide a significant amount of parkland and foreshore suitable for recreational use by the general public and of visual appeal to river users. It will also enable the consolidation of heavy metals on the site which at present constitute an ongoing potential hazard to public health.

The development plan has been formulated after considerable research into the nature and distribution of heavy metals on the site. Residential blocks will be located only on areas of relatively low heavy metal concentrations which will be extensively treated to remove any credible hazard. The strategy of including residential development in the site plan provides a means of funding the intensive treatments required to make the rest of the site suitable for public use. Finally, an extensive monitoring programme will be implemented to ensure the continued effectiveness of site treatments.

SECTION 6

REFERENCES

6. REFERENCES

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SECTION 7

GLOSSARY

7. GLOSSARY

Acid plants:	Plant used for the production of sulphuric acid which is used in the manufacture of superphosphate.
Amosite:	An asbestos mineral.
Atomic absorption spectrophotometry:	A method for the analysis and identification of heavy metals.
Bedrock:	The hardened layer of material on which superficial sediments lie, and is in this case limestone.
Berms:	Gradually built up mounds to contain liquids.
Borrow pits:	Quarry areas where material has been removed.
Buffering ability:	Ability to resist change in pH.
Bunds:	Embankments for containing liquids.
Dens:	Reaction chambers in which superphosphate is produced.
Flash furnace:	A furnace which heats the pyrites or sulphur ores rapidly to release sulphur dioxide (SO_2).
Fluidised bed furnace:	A vessel used for heating in a high temperature liquid sand, pyrites or sulphur ores to high temperatures to oxidise them to sulphur dioxide gas (SO_2).
Fluorine rock:	Rock containing the mineral fluorite (CaF_2).
Food chains:	A food relationship in which energy is transferred from plants through a series of organisms by each stage feeding on the preceding stage and providing food for the succeeding one.
Gross Pollutant Trap:	A structure placed at the end of a drainage line which collects sediments and trash from water flowing through the drianage system.
Herreshoff roaster:	A vessel in which pyrites ores are heated with excess oxygen to oxidise sulphur to sulphur dioxide gas (SO_2).
Jarosite:	A yellow-brown weathering product of iron-rich minerals and rocks

Leachate: The liquid produced by water passing through dumps.

Limed: Mixed with calcium oxide to make alkaline.

Liquor: Liquid part of a product of operation.

Molluscs: Invertebrate animals including snails and mussels, commonly inhabiting shallow waters.

pH: A measure of the concentration of hydrogen ions in a solution to determine acidity/alkalinity.

Phytotoxic: Poisonous to plant life.

Potable water: Drinkable water.

Pyrites cinders: Large particle residue of pyrites combustion after roasting.

Rip-rap: Large rock for stabilising earthworks.

Scavenger: Species that readily combines with other species to form new intermediates or molecules.

Scrubbers: Devices for the removal of particulates from gas exhausts.

Slurry dumps: Sites where liquid material from the electrostatic precipitators, associated with fluidised bed furnaces, were dumped.

APPENDIX 1

GUIDELINES FOR THE PUBLIC ENVIRONMENT REPORT

GUIDELINES FOR THE PUBLIC ENVIRONMENTAL REPORT ON THE PROPOSED DEVELOPMENT OF FORMER INDUSTRIAL LAND AT McCABE STREET, MOSMAN PARK, FOR RESIDENTIAL PURPOSES

The guidelines identify issues that should be addressed within the Public Environmental Report (PER). They are not intended to be exhaustive and the proponent may consider that other issues should also be included in the document.

The PER is intended to be a brief document; its purpose should be explained, and the contents should be concise and accurate as well as being readily understood by interested members of the public. Specialist information and technical description should be included where it assists in the understanding of the proposal. It may be appropriate to include ancilliary or lengthy information in technical appendicies.

1. SUMMARY

The PER should contain a brief summary of:

- salient features of the proposal;
- alternatives considered;
- the history of the proposed site and associated problems;
- description of receiving environment (including contaminants) and analysis of potential impacts and their significance;
- environmental monitoring and management programmes, safeguards and commitments; and
- conclusions.

2. INTRODUCTION

The PER should include an explanation of the following:

- identification of proponent and responsible authorities;
- background and objectives of the proposal;
- brief details of, and timing of the proposal;
- relevant statutory requirements and approvals; and
- scope, purpose and structure of the PER.

3. NEED FOR THE PROPOSAL

The PER should discuss the need for the development of the proposed site for residential purposes (as compared with other land uses). Broad costs and benefits of the proposal at local level could be discussed.

4. EVALUATION OF ALTERNATIVE

A discussion of alternative uses for this site should be provided. This discussion should explain the rationale of choosing the preferred option of residential development.

5. DESCRIPTION OF SITE

The proposed location should be described, including:

- former land uses;
- adjacent land use, including urban;
- location of structures to be built on the site;
- provision of services, including drainage; and
- discharge point of drainage water.

6. REHABILITATION OF SITE PRIOR TO DEVELOPMENT

Proposed rehabilitation techniques should briefly describe and quantify:

- how contaminants are to be immobilised and/or removed;
- how rehabilitation will improve the site for future users; and
- the possibility of future users being impacted upon.

7. ENVIRONMENTAL IMPACT AND MANAGEMENT

Having described rehabilitation of the proposed site, it is important to identify likely impacts of contaminants on the receiving environment including implications to surrounding land users, and to indicate approaches that will be adopted to ameleorate and manage the identified impacts. Issues that should be addressed include:

- impact of contaminated seepage, groundwater and drainage water on the receiving environment eg Swan River;
- beneficial uses identified for the receiving aquatic environment (including harvesting of aquatic life, passage of aquatic life) and the expected implications of contaminant seepage water on them;
- how present impacts on the receiving environment will be managed;
- use of contaminated borewater;
- uptake of contaminants by edible plants;
- consumption of contaminated plants by animals;
- impacts of contaminated air-borne dust on residents and other land users; and

- procedures to be use, if further rehabilitation is required, to either avoid contaminants entering the receiving environment or impacting on residents.

8. MONITORING

Leakage of contaminants from the site will need to be monitored. The receiving environment will require monitoring to ensure environmental impacts are maintained to an acceptable level. The specifications of a monitoring system including reporting of results should be given, responsibility for the operation of that system should be assigned, and commitments made for its implementation.

9. CONCLUSION

Guidelines

A copy of these guidelines should be included in the document.

References

All references should be listed.

Appendices (including previous reports on site contamination generated by present and past managers of this site).

List of commitments on environmental matters made by the proponent.

APPENDIX 2

POTENTIAL HEALTH EFFECTS FROM HEAVY METALS

Much of the information presented in this Appendix is derived from an Environmental Quality Standards Reference Manual compiled by J.G. Bastias of the Department of Mines & Energy, Northern Territory (1987).

Arsenic (As)

Arsenic has a wide occurrence naturally and is used extensively in medicine and agriculture. It is probably essential in small quantities for human nutrition. However, chronic arsenic poisoning is known to cause skin abnormalities, amnesia, and liver, heart and nervous disorders. Chronic consumption has also been associated with lung and skin cancer. Large single doses of arsenic trioxide are likely to be fatal.

Bismuth (Bi)

Bismuth is not essential for human nutrition. Poisoning can occur from the ingestion of water soluble bismuth compounds though all accounts of bismuth poisoning are from compounds used in therapeutics. Principal organs affected are the kidneys and liver.

Cadmium (Cd)

Cadmium occurs naturally only in trace amounts, except in various ores. Absorbed cadmium is toxic to all body organs as it damages cells and the enzyme system. It also accumulates in the body such that continued low level dosages can lead to chronic toxicity.

Acute cadmium poisoning can occur after consumption of 15-20mg but acute fatal poisoning is rare as ingestion of large doses induces vomiting.

Copper (Cu)

Copper is an essential and beneficial element in human metabolism, and the adult daily requirement is about 2mg. However, continued exposure to large doses of copper in water can cause liver damage. Single doses of 7ppm in liquids may be fatal to infants, and 175-250mg of copper sulphate can cause death in adults. The symptoms of acute toxicity include cramps, vomiting and diarrhoea.

Iron (Fe)

Iron is essential for human nutrition and is widespread in nature. However doses in excess of 100mg per kg of body weight can cause damage to the liver and digestive system, hypertension, prostration and peripheral cardiac failure. Ingestion of 40 to 590mg/kg quantities of iron sulphate have been known to be fatal. This would correspond to an intake of 2.8g to 41.3g of iron sulphate for a person weighing 70kg.

Lead (Pb)

Lead is not essential for human nutrition. The amount of lead associated with toxicity is not known and symptoms are generally related to blood levels. A level of 3.3 parts per million (ppm) in blood has been associated with acute brain pathology and death in children. Levels of 0.8ppm and larger have been associated with a range of effects on the nervous system, kidneys and other organs including blindness and paralysis. Continual exposure to low levels in water can produce lead poisoning.

Mercury (Hg)

Mercury is not essential for human nutrition. Chronic poisoning can occur from prolonged exposure to low levels (eg 0.3mg/day) and induce nervous system disorders including impairment of speech, hearing, vision and locomotion. Damage to the blood cells, enzyme systems, kidneys and digestive tract can also occur. A fatal dose level of 158mg has been recorded.

Zinc (Zn)

Zinc is a nutritional trace element. Ingestion of more than 22mg per person per day may cause nausea, vomiting, purging, and pains in muscles and joints. This is followed by the development of a fever and shaking chills.

APPENDIX 3

COMMITMENTS

COMMITMENTS

The proponent makes the following commitments.

Any activity undertaken on the McCabe Street site shall:

- in no way jeopardise the health of either workers or residents.
- not compromise the present residential or recreational amenity of the site or its environs.
- not incur on behalf of the people of Western Australia any financial or environmental burden in the long term.
- not cause any degradation to the terrestrial or aquatic environment of the surrounding area or the Swan River.

To implement the general commitments above the proponent shall develop the site in the following way:

- Prior to development most of the site will be treated with remedial works to effectively remove any hazard to the public and residents. The bitumen and concrete surfaces remaining from the fertiliser work's buildings will remain and have fill placed over them.
- In the residential zone soil to a depth of not less than 300mm will be removed, unless solid bedrock is found at lesser depth. This stripped top-soil material will be placed on top of the cinder and slurry dumps. The work will be supervised and programmed for winter with strict requirements related to watering for dust control purposes. Inspection by a qualified chemist and supplementary soils testing will be employed to ensure removal of all contaminated ground. The area for development will then be covered with a minimum of one metre of clean fill.
- Pyrites cinders from the river embankment area will also be added to the western pyrites cinders dump. Deposits of foreign material will be identified, from previous site work, and either treated similarly to the pyrites cinders or, if judged to be inappropriate for this type of disposal, removed from the site to an approved landfill site.

In the parkland zone the following treatments will be applied to each of the distinct and unique features associated with the site:

Pyrites Slurry Dump

The surface will be covered with an impermeable PVC membrane (Canvacon 16SS or similar) on a 150mm thick layer of clean sand. The dump will then be topped with some of the top-soil from the proposed residential area of the site as well as one metre of clean fill. All possible care and supervision will be undertaken during placement of the membrane to ensure that tears do not occur.

The face of the slurry dump will be treated in the following way:

- A low (800-1,000mm) limestone wall will be built along the top edge of the face of the dump.
- The bottom of the bund wall slope will be security fenced and returned as necessary to meet the limestone wall to isolate the slope area. The slopes will then be intensively landscaped.
- A leach drain will be installed immediately behind the limestone wall to intercept and remove groundwater seepage above the membrane and to carry it to a suitable sump.

Riverbank Beaches

Action is this area of the site will include the following:

- Excavation and removal of beach sand together with loose rock and soil from the lower embankment. The initial extent of such excavation will be guided by visual inspection but will be finally determined by further sampling and testing.
- Re-establishment of the bank profile and beachline with crushed limestone filling, including replanting on the lower embankment slopes and placement of limestone rip-rap to prevent scour of the rebuilt slopes.
- Placement of contaminated material removed from the beach in a discrete stockpile not exceeding 1.5m in height adjacent to the toe of the western pyrites cinders dump and covering of this stockpile with crushed limestone to a depth of not less than 0.5m.

Cycleway

Removal of the existing cycleway at least in the area adjacent to the embankment pyrites cinders dump. The cycleway will then be relocated to the top of the treated embankment.

Embankment Pyrites Cinders Dump

Removal of the pyrites cinders material from the river embankment. Partial treatment with a covering of crushed limestone and sand.

Dust control will be of paramount importance so the work will be programmed for the winter months and water sprays will be used if necessary. The excavated material will be relocated on-site to form either an extension of the western pyrites cinders dump or the eastern slurry dump.

Following removal of all the pyrites cinders and any other foreign materials encountered, the embankment slope above the existing berm will be flattened to a slope not exceeding 26 degrees (approximately 1:2). The slope will then be covered with one metre of clean fill and intensively landscaped with discrete paths provided at selected locations to facilitate public access to the river.

Former Lead Melting Site

All soil within this heavily contaminated area will be excavated, removed and buried in an approved toxic waste landfill site.

Western Pyrites Cinders Dump

This dump will be left undisturbed except for covering with 300mm of crushed limestone topped with 700mm of clean fill. This treatment will also apply to the stockpiled pyrites cinders from the embankment dump.

Passive Recreation Area

All other areas of the site identified as being suitable for passive open space recreation will be covered with a minimum of one metre of clean fill and vegetated.

Stormwater Collection Systems and Outfalls

All existing stormwater collection systems and outfalls on the site will be excavated and removed. Rubble and other debris will be disposed of in an approved toxic waste landfill site. All trench excavations required for removal of the outfalls in the embankment will be backfilled with at least two impermeable barriers across each trenchline to prevent continued drainage.

Groundwater

The present level of investigation of groundwater in the northern area of the site indicates that there need be no restrictions on the use of groundwater. However, a further study will be undertaken of the quality of groundwater under the northern area of the site to absolutely determine whether there is any need to limit usage.

Monitoring

After site development, the following monitoring programme will apply:

- The restored river beachline and adjacent embankment will be inspected for scour and erosion.
- Inspections will be carried out to identify and analyse any leaching.

- The gross pollutant trap installed on the surface drainage outlet to the river will be maintained and cleaned out on a regular basis. Each time the trap is cleaned a sample of sediment will be taken and processed to determine if it contains any contaminant.

- Slotted PVC groundwater monitoring bores, along the upper beachline or on the embankment berm, will monitor the quality of the shallow groundwater.

- Permanent bores on the site and particularly those close to or along the river embankment will be sampled and analysed.

- Soil samples will be taken and analysed at pre-selected locations along the foreshore adjacent to the entire site.

- Samples of mussels from locations adjacent to the site where heavy metal concentrations have been identified and from a control area nearby will be collected and analysed.