New Munster Pump Station and Bibra Lake Main Sewer Extension

Public Environmental Review

FINAL REPORT

December 1998

WATER CORPORATION

Invitation to make a submission

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

The Water Corporation proposes to expand its sewage pumping capacity at Munster by constructing another pump station (No.3) and the extension of the Bibra Lake main sewer. In accordance with the Environmental Protection Act, a PER has been prepared which describes this proposal and its likely effects on the environment. The PER is available for a public review period of 8 weeks from 4th January 1999 closing on 1st March 1999.

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

Why write a submission?

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

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

Why not join a group?

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

Developing a submission

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

When making comments on specific elements of the PER:

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

Points to keep in mind

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

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

Remember to include:

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

The closing date for submissions is : 1st March 1999

Submissions should be addressed to:

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141 St George's Terrace
PERTH WA 6000

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Acknowledgments

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Dr Howard Gill, Murdoch University

1. Executive Summary

Water Corporation is proposing to upgrade its sewerage system at Munster in order to accommodate ultimate capacity from the Perth South catchment. In order to do this Water Corporation need to increase sewer and pumping capacity. An initial option to construct a further pump station on Mayor Road and increase pressure main capacity along a pre-existing causeway was rejected because of the social consequences and because it offered no environmental advantage.

A gravity main leading to a new pump station on the West Side of Lake Coogee was considered the most viable alternative and this option was referred to the Environmental Protection Authority to determine a level of assessment. This was set as a Public Environmental Review and a number of objectives for the protection of environmental values were made by the EPA.

A series of options for placing a gravity sewer from the existing pump station to a new pump station on the West side of Lake Coogee were considered and it was concluded that a gravity main leading to a low bridge across the North end of Lake Coogee and then to the new pump station site offered the best solution when environment, social impact, engineering and aboriginal issues were considered. This option is shown in Figure ES1 at the end of this section. The plan and elevations of the preferred option is shown as Figure ES2 at the end of this section.

The proposed gravity main will be approximately 3 metres in diameter and will be capable of transmitting the ultimate capacity for this catchment.

The proposal offers significant improvements to the sewerage system in this area providing redundancy and duplication in the system that does not currently exist. This is important because a failure in the existing system would lead to rapid overflow and releases of raw wastewater (sewage) to the environment. This will be significantly less likely with the proposed system.

A number of environmental investigations were undertaken in order to meet the EPA's requirements.

Approximately 0.9 hectares of Tuart Tall Open Woodland in Poor condition and 0.26 hectares of *Melaleuca cuticularis* Low Woodland in poor to good condition will be cleared as part of this proposal. The majority of the *M. cuticularis* woodland will be replaced once construction has been completed and a significantly greater area of Tuart Tall Open Woodland will be replaced after construction. In addition the existing causeway will be replanted and the fringing vegetation around the wetland will be increased. These issues are the subject of an environmental management plan committed to at the design stage of the proposal. There are no declared rare and priority flora in the area of the construction.

Due to the careful selection of route alignment options the impacts on Beeliar Park have been minimised. The conservation impacts have been minimised and the proposed revegetation program replaces more vegetation than currently exists, protecting the long term integrity of the fringing vegetation and restoring the visual amenity of the Park by tree screening with vegetation that would have originally grown in this area. The recreational aspects of the park will be enhanced by the provision of a walkway across the North end of Lake Coogee, giving better access for people to view the lake and hopefully in future to a walkway surrounding the lake.

A wide range of fauna uses Lake Coogee and its fringing vegetation. The proposed alignment will have impacts during construction, but rehabilitation measures will restore existing habitats and increase habitat types in this location. No specially protected fauna will be affected by this proposal.

Significantly more is now understood in relation to Lake Coogee than had been previously documented. Lake Coogee is a unique wetland for this area and as such is worthy of

preservation. The option selected for this proposal was chosen because it reduced the requirements for clearing, dewatering and impacts on the lake sediments. It also allowed for significant rehabilitation of cleared areas to be undertaken, minimising the area of permanently cleared land. The hydraulic connectivity of the wetland will be preserved. It is believed that the integrity of the wetland will maintained and that the amount of fringing vegetation will be increased as rehabilitation works are undertaken.

Dewatering through the wetland areas will be eliminated by selecting a low bridge option. This also reduces impacts on hydraulic conductivity in these areas. It is believed that dewatering at the pump station can be minimised by placing a grout curtain from ground level to a low permeability layer and isolating the construction zone. It is intended that as much water as reasonably practicable will be re-injected into the ground to reduce impacts on vegetation. Alternative options for disposal of any excess water remain to be investigated, with the final approval for disposal to be at the discretion of the DEP..

The groundwater quality in the vicinity of the proposed pipeline and pump station is reasonably good except that levels of nitrate exceed ANZECC guidelines. There were no pesticides or heavy metals of note in the groundwater. Leakage from this pipeline is not expected to occur because the pipe is plasti-lined providing effective double containment. Leakages in existing un-pressurised pipelines of this type is known to be minor because groundwater infiltration does not contribute significantly to sewer flows from the many thousands of kilometres of this type of sewer present in the Perth metropolitan area. A review of existing research indicates that, if a leak was to occur, most pollutants would never reach the groundwater and that the impact would be very difficult to detect. Water Corporation have committed to inspecting this pipe internally every 5-7 years, a step which recognises the size and strategic importance of this sewer.

The surface water of Lake Coogee is eutrophic (nutrient enriched), but probably protected from the effects of this by the high salinity encountered during the summer. There are few contaminants present apart from nutrients. Construction impacts could arise due to siltation and loss of oils from vehicles etc. It is proposed to contain surface run-off in constructed ponds to allow time for settlement and capture of any other contaminants. Most construction activities close to the wetland will take place in summer. The probability of leaks from the aerial portion of the pipeline are extremely low and egress to the wetland would be slowed further by the trough girder on which the pipe will rest. Visual inspection of the bridge section of pipeline will be undertaken on a regular basis.

Levels of lead and pesticides in excess of levels where further investigation is required were found in some test pits made into uncontrolled fill on the south side of Mayor Road. It is proposed to carry out further investigations prior to construction and dispose of any contaminated material.

Due to the selection of a low bridge visual impacts have been minimised along the line of the proposed pipeline. There will be significant visual impacts due to the pump station, but these can be resolved to some extent by reshaping the landforms to more closely match the existing topography. Tree screening with appropriate local native vegetation will enhance some vistas.

The European heritage of this area is extensive and fascinating. It is not believed that there will be any impacts on known sites although one site will be close and landscaping has been proposed to ameliorate the impacts of the proximity to the pump station. It is recognised that some unmarked graves exist in the area and caution will be taken during excavating activities.

The proposal in its entirety does not appear to compromise the natural heritage values of this area because the impact on well conserved areas is limited and the proposal intends to re-instate significantly more vegetation than that removed during the construction of the proposal.

No aboriginal sites have been identified within the proposed construction zone for this phase. Athough care will be take to align the sewer away from registered site S2968 and ensure that it is

not disturbed during construction. All requirements of the traditional landowners in relation to land disturbance have been accommodated.

Following these investigations Water Corporation has made a number of commitments as follows:

1. Develop and EMS for this proposal in line with Water Corporation's EMS, but covering contractual requirements of the proposed construction alliance (Section 11.1)

2.1 Develop a de-watering plan.

(Section 11.2)

2.2 Implement de-watering plan and report.

3. Design the sewer in a manner that reduces the potential for leaks

(Section 11.3)

3.2. Inspect pipeline prior to commissioning (Section 11.3)

3.3. Inspect pipeline on a routine basis (Section 11.3)

4. Develop an emergency action plan in case of catastrophic failure

5.1 Detain Stormwater from the construction site.

(Section 11.4)

5.2 Detain stormwater at the pump station site (Section 11.4)

6. Implement dust control plan.

(Section 11.5)

7. Meet Requirements of Environmental Protection (noise) Regulations (1997).

(Section 11.7)

8. Vibration to be included in noise communication strategy if needed. (Section 11.7)

9.1 Quantify contamination issues along alignment.

(Section 11.8)

9.2 Ensure final alignment is clean of contamination (Section 11.8)

10.1 Prepare an environmental management plan.

(Section 12.1)

10.2 Implement environmental management plan during construction.

10.3 Implement rehabilitation requirements of environmental management plan

11. Ensure vegetation is not subject to undue stress during summer months.

(Section 12.1)

12. Ensure that Lake Coogee is not impacted by dewatering, beyond seasonal norms

(Section 12.2)

13.1 Align sewer to minimise impacts on Tuarts

(Section 12.2)

13.2 Ensure tuarts close to sewer alignment are not impacted by excavations

14.1 Undertake timely preparation for rehabilitation of *M.cuticularis* woodland.

(Section 12.2)

14.2 Ensure temporary causeway is constructed of local material suitable for rehabilitation of *M. cuticularis* woodland

15. Ensure that run-off or temporary inundation during construction does not impact water quality in Lake Coogee

(Section 12.3)

16.1 Develop a landscape plan.

(Section 12.6)

16.2 Modify landforms to reduce visual impact

16.3 Undertake plantings to screen constructed items and accentuate visual quality

17.1. Turn the low bridge into a walkway with connections as stipulated by BPMC

(Section 12.7)

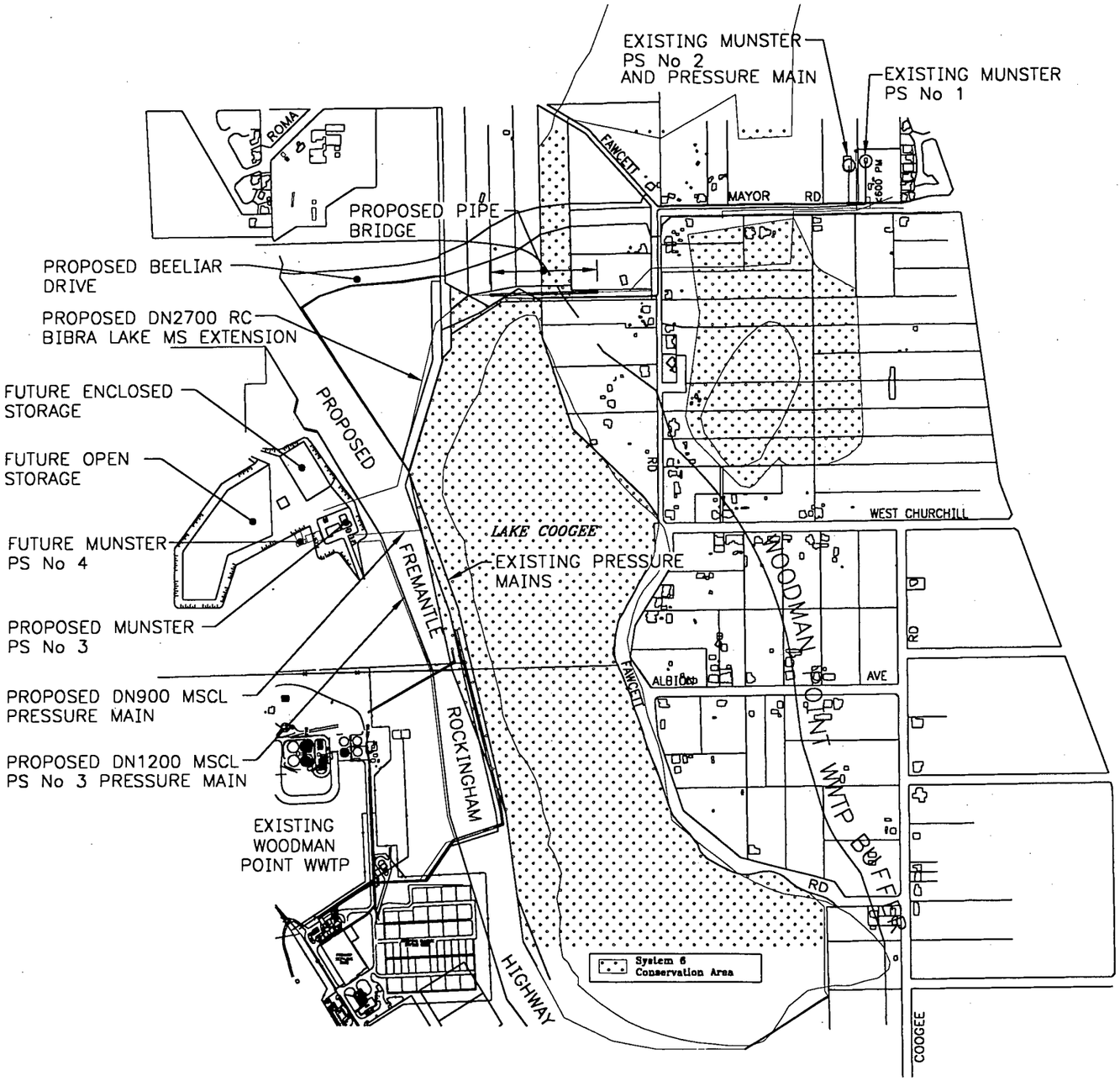
17.2 Investigate opportunities for increasing hydrological connectivity through existing causeway

18. Protect heritage sites close to construction area.

(Section 12.8)

19 Undertake a grave search along the proposed route (Section 12.8/12.9)

Full details of the actions associated with these commitments are reviewed in section 13.



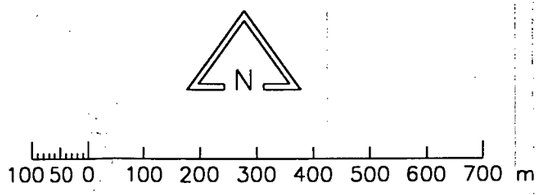


FIGURE ES1

LOCALITY PLAN

METROPOLITAN WASTEWATER
MUNSTER PUMPING STATION NO. 3 AND
BIBRA LAKE MAIN SEWER SECTION 8

WATER CORPORATION

SOURCE:WATER_CORPORATION

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JOB NO 60095800
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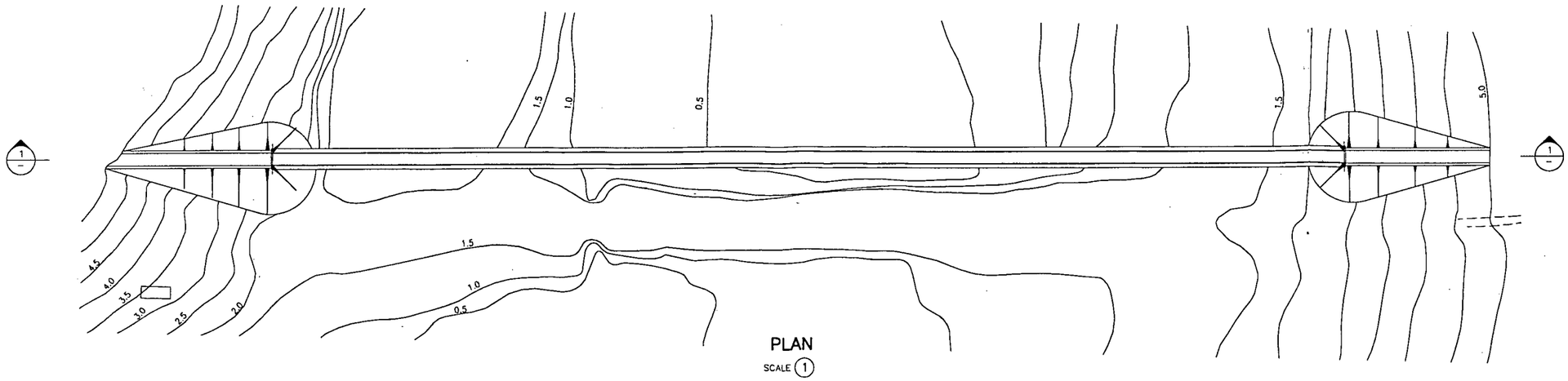

PLAN
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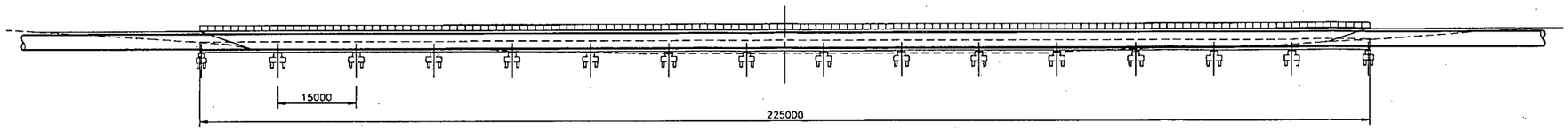
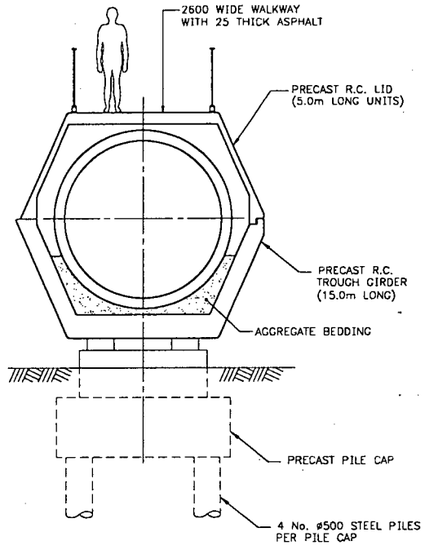
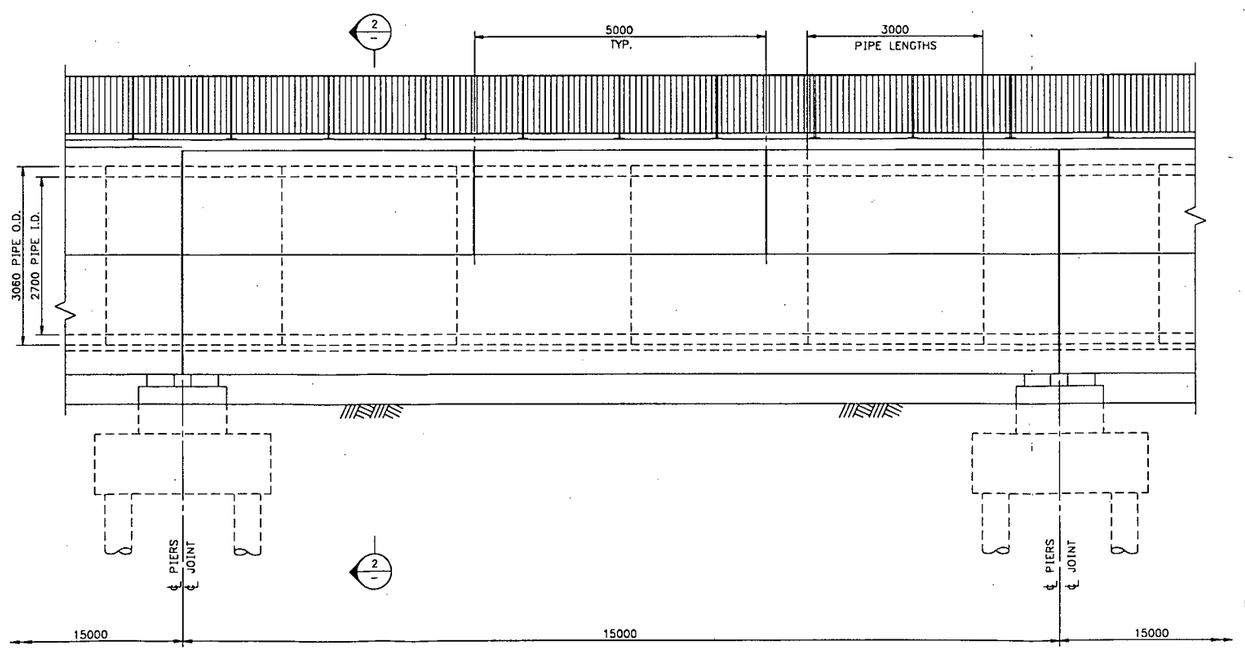


SECTION 1/–
SCALE (1)



SECTION 2/–
SCALE (2)



ELEVATION
SCALE (2)

(1) 5 0 5 10 15 20 25 30 35 m (1:500)

(2) 1000 500 0 1000 2000 3000 mm (1:50).

ISSUE	DATE	DRD	REVISION	DRN	REC	APPD
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SURVEY BOOKS

DATUM AHD

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DES CALC S.ERASITO
DES CHD T.KINLEY
DRN J.THOMPSON
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NORTH POINT

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DRAWING PATH 60095800\cad\FIG ES2.DWG

RECOMMENDED
JOB MANAGER
APPROVED
PROJECT DIRECTOR

WATER CORPORATION

METROPOLITAN WASTEWATER
BIBRA LAKE MAIN SEWER SECTION 8 (CONCEPTUAL DESIGN)
PLAN AND ELEVATIONS
OPTION 1

FILE | PROJECT | PLAN | CAD | ISSUE

FIGURE ES2

ISSUE A

ORIGINAL SHEET SIZE A1

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60095800\cad\FIG ES2.DWG 30 November 1998 – 2:07PM 0366 c3

2. Background and Proposal Justification

It is recognised that this proposal requires a background capable of justifying the impacts foreseen in subsequent sections. The Water Corporation has not arrived at the need for this proposal lightly. It follows a significant amount of research and public consultation identifying the need firstly, for ocean disposal of treated wastewater effluent, secondly the need for large wastewater treatment plants such as Woodman Point, Subiaco and Beenyup and thirdly the need for additional capacity to meet the wastewater demand in the Perth South area, which discharges to the Woodman Point Wastewater Treatment Plant (WWTP).

2.1 The Need for Ocean Disposal.

The need and feasibility of ocean disposal was highlighted by two studies undertaken by the Water Corporation (then the Water Authority) at the request of the Environmental Protection Authority. These studies were; The Study of Alternative Effluent Disposal Options (SAEDO) and The Perth Coastal Waters Study (PCWS) and were the result of conditions set by the Environmental Protection Authority for the second ocean outlet of the Beenyup WWTP.

The Environmental Protection Authority and interested parties are referred to these documents for a full account of these studies. A summary of the findings of these two studies, taken from a third document (Wastewater 2040 Strategy - for the Perth Region) is given below.

"The Perth Coastal Waters Study.

The Perth Coastal Waters Study was undertaken in conjunction with the Department of Environment (DEP) and was officially launched by the Minister for the Environment and the Minister for Water Resources in April 1991.

The DEP's effort concentrated on a study of the coastal waters from Fremantle south to Pt Kennedy and was designated the Southern Metropolitan Coastal Waters Study (SMCWS). This study was aimed at four specific coastal areas - Cockburn Sound, Gage Roads, Warnbro Sound and the Sepia Depression. Reporting on the SMCWS is being undertaken by the Department of Environmental Protection.

The PCWS examined the offshore waters of Perth on a regional basis from Alkimos in the north to Mandurah in the south, covering an area 200 kilometers along the coast and 50 kilometers offshore. The underlying objective was to assess the capacity of these coastal waters for accepting treated wastewater from the Authority's facilities without causing unacceptable change to the ecology up to the year 2040. In addition, the study concentrated on the areas of the existing three ocean outlet sites. The work was undertaken by the scientific community of Perth, and the reports on this study were finalised in December 1994.

Perth Coastal Waters Study indicates that current discharges are not causing unacceptable changes to the marine environment.

On the basis of the PCWS it is concluded that the existing ocean disposal systems are performing well and are not endangering the ecological processes in the marine environment. However, as wastewater flows for the Perth region could treble over the next fifty years, only ongoing monitoring will provide indications to what extent these future increased loads could be similarly sustained, assuming the unlikely scenario, that current treatment practices and ocean disposal continue unchanged in the long term future.

It was further established that nutrients, principally nitrogen, are of major concern for these coastal waters. The structure of the coastal areas varies from embayment zones (eg Cockburn Sound) to open areas (eg offshore at Swanbourne) such that the exchange of waters with the open ocean (ie flushing) is very variable. As a result of this, and with the complexity of

the ecological processes, it has not been possible to define a finite limit on mass discharge of nutrients which these water could accept without detrimental effects. Ongoing monitoring will be necessary to establish early warning signs of any impending unacceptable change, supplemented by the in-situ measurement and laboratory studies already conducted. Unacceptable change will be defined by the agreed set of environmental values for a particular locality.

The Study of Alternative (land based) Effluent Disposal Options

The second study, SAEDO, examined the technical feasibility and requirements for land disposal options and effluent reuse opportunities suitable for the Perth-Mandurah-Bunbury region. This work was undertaken for the Authority by Gutteridge Haskins & Davey, Consulting Engineers, who utilised their resources Australia wide based on similar studies, the most recent of which being for Geelong in Victoria. Their report was submitted to the Authority in December 1994.

The report has shown that land disposal options and reuse opportunities exist for the Perth-Mandurah region. Generally, any specific alternative provides only partial utilisation of the total flow at any time and combinations of options may have to be considered.

Alternatives to ocean disposal provide only a partial solution.

Options which warrant further examination are:

- *industrial reuse,*
- *groundwater recharge using borehole injection,*
- *irrigation of woodlots,*
- *irrigation of golf courses, urban parklands, etc and*
- *irrigation of horticultural crops.*

A research and development program is being established to assess these in more detail as current knowledge and experience indicate that they do not provide the most economic source of water or the cheapest method of safe disposal.

Options not considered appropriate at present are:

- *potable water reuse,*
- *dual water supplies,*
- *irrigation or groundwater recharge in the Authority's Underground Water Pollution Control Areas,*
- *disposal to wetlands or water courses, and*
- *pumping effluent to the east of the Darling Escarpment for irrigation purposes.*

However, the Authority will continue to monitor progress and development of these systems in other parts of Australia and the world, and periodically review them."

In order to develop a strategy for the future "Wastewater 2040" was developed. Wastewater 2040 took the findings of the PCWS and SAEDO and in conjunction with a community consultation program identified appropriate growth strategies into the future. The community consultation program was extensive and the process and findings area summarized in "Wastewater 2040"as follows;

"The Community Involvement Program

These two studies were integrated with a parallel community involvement program to ensure that the concerns and issues of the community are taken into account by the Authority in the preparation of the strategy. This program was managed for the Authority by the Australian Research Centre for Water in Society, a group of the CSIRO Division of Water Resources.

The community involvement program involved a number of steps -

- *initial community workshops where people had the opportunity to raise their concerns and issues with regard to wastewater, including disposal and reuse, the findings from these workshops were documented by the CSIRO,*
- *a response to these issues by the Authority in a Discussion Paper, and*
- *further follow-up workshops with the community.*

The report on the community involvement program was prepared by the CSIRO in December 1994.

The community involvement program revealed that wastewater should be treated as a resource, which, in our relatively dry region with its limited water resources, should be recycled/reused as much as possible. There was also concern that the current strategy of regional treatment plants limited the scope of land disposal and reuse opportunities, which could be better provided by smaller localised facilities (neighborhood plants). This is not necessarily the case as is demonstrated by the Albany agroforestry scheme which reuses the total municipal effluent from the town treated at one regional treatment plant.

Criteria for selecting Options

With input from the community, the Authority developed the wide ranging criteria to be met by any effluent disposal or reuse system, and these relate to the following:

**community health;*
**environmental implications*
**social implications*
**technical viability*
**financial considerations*

With these criteria and on the basis of the studies and community input, the Strategy was developed. It has to be realized that the Strategy provides detailed actions for the short term only (up to five years), and these are unlikely to change. For the medium term (five to ten years) the Strategy will depend on additional investigations and research and monitoring undertaken in the short term, and for the long term, it can only provide a general direction."

Whilst the title of "Wastewater 2040" points fifty years into the future the authors concluded that knowledge was insufficient at that time to plan with any certainty beyond five years and at most ten years. The significant long term strategy was that as much treated wastewater flow as possible and practicable should go to land or be reused for community benefit.

2.2 The need for large Wastewater Treatment Plants

Wastewater 2040 undertook a comparison of the small community wastewater treatment plant proposed by many and large centralized treatment plants. There is a clear cost saving to the community made in increasing the size of plants as demonstrated in Figure 1 on the following page.

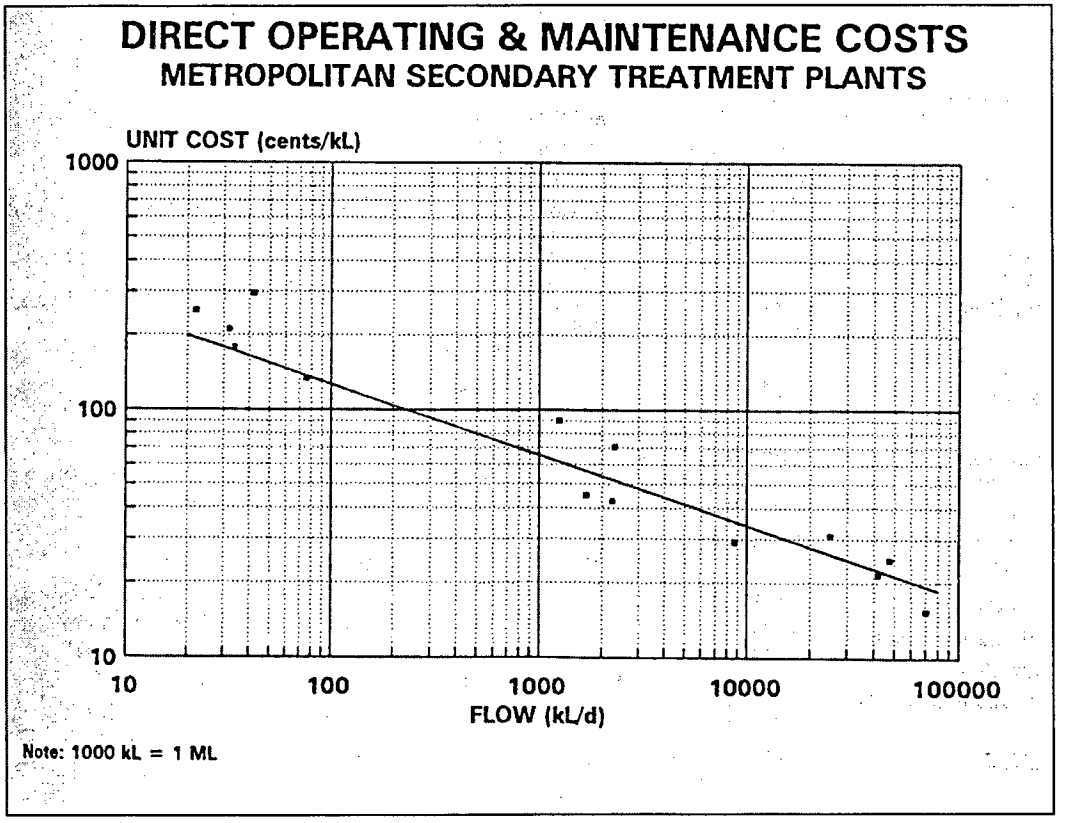
- small community plants require more total land than large centralized plants,
- odour issues are far more difficult to control and
- there are insufficient local repositories for the treated wastewater, be they woodlots, parks or industry. This would therefore require collection of all of the treated wastewater and subsequent disposal to the ocean.
- Sludge disposal from numerous community plants would be very difficult

Small community wastewater treatment plants not an option.

The cost savings obtained from using large centralized plants have allowed the Water Corporation to install advanced secondary treatment at all Metropolitan plants except Woodman Point where it is planned in the near future. In addition, cost savings made in wastewater treatment allow the Water Corporation to apply additional funds elsewhere in the sewerage system. Thus two demonstrated environmental gains (secondary treatment and expanded sewerage) outweigh the undemonstrated and doubtful environmental gains associated with small community plants.

Wastewater 2040 makes it clear that these gains are predicated on the basis of a significant amount of treated wastewater effluent disposal to ocean outfall accompanied with reuse and land disposal where feasible. The report notes that this approach is underpinned by the ongoing ocean monitoring and research program and that water quality at ocean outfalls will be maintained at agreed criteria designed to protect environmental values

FIGURE 1 - Cost saving of increased plant sizes, from Wastewater 2040



2.3 The need for additional wastewater pumping capacity at Munster

Additions to Woodman Point were heralded in Wastewater 2040, although it was not explicit that additional sewerage capacity would be required.

Woodman Point Wastewater Treatment Plant (WWTP) is served entirely through Munster Pump Station No.2. The strategic importance of this pump station cannot be stressed enough. Figure 2 at the end of this section indicates the area that this pump station and Woodman Point serve. There is some opportunity for load swapping at the northern end between this reticulation system and that serving Beenyup WWTP, but this is relatively minor and could not ease a significant amount of the burden placed on this location.

The review of future requirements for the existing Munster Pump Station facility located on Mayor road was the culmination of studies undertaken by the Water Corporation's Infrastructure Planning Branch in association with key stakeholders.

These studies addressed the following items -

- Examine past and current flows and determine the adequacy of the existing pump station
- Determine future flow
- Allow for the following operational and maintenance requirements
    - Enclosed Storage within the system to accommodate flow for 2 hours at peak flow in case of a pump station failure.
    - Enclosed Storage within the system to accommodate flow for 10 hours at low flow during the summer to allow for planned maintenance.
    - Open Storage capable of storing up to 8 hours of flow at extraordinary peak flows almost eliminating the possibility of overflows to the environment.
- Examine options for siting of future pump station facilities.
- Determine appropriate emergency overflow routes from the pump station to the environment.
- Produce a planning report addressing the following -
    - results of the investigations
    - agreed plan for new assets
    - identification of triggers for the commencement of the process
    - recommendations for monitoring
- recommendations for the inclusion of works on the Capital Investment Program (CIP).

Current system nearing capacity

The report indicated that the current pumping station has the capability to pump 2800 litres per second, which under average flow conditions would be adequate, but peak flows are 2.5 times the average flow. At the present time peak flows are not sufficient to lead to an overflow but, extraordinary peak flows during the winter have been recorded which have led to the system being overloaded and discharges to the environment occurring. In addition there is limited capacity in the system to manage a pump failure.

In February 1992 there was a major storm which led to extraordinary peak flows. The report calculated that the system would have required 23.47 ML of enclosed storage capacity and additional open capacity to take the total capacity to 74.3 ML in order to cope with this event. By comparison the current storage is 25 ML and a significant discharge took place.

The report concludes that the "do nothing" scenario would mean that flow to the existing Munster pump station would eventually exceed capacity of the pump station and cause wastewater overflows which will present health risks to humans, pollution of the environment and odours in the vicinity of the existing residential areas.

A series of options were examined by the study team and stakeholder consultation was undertaken.

The result of this study indicated that the preferred option was an extension of the Bibra Lake main sewer from the existing pump station to a new pump station to be located on the western side of Lake Coogee. At this location a closed and open storage area would be made available once flow capacity necessitates their construction.

The main sewer extension would be a 2.7m internal diameter gravity sewer capable of carrying a maximum of 9200 litres per second. This is the ultimate capacity required for the Perth South Catchment meaning that there should not be a requirement for a further pipe in the future. The new pump station together with the existing pump station will provide sufficient capacity for in excess of 50 years. The pumping capacity of new pump station will be 4600 l/s. Once the new pump station is operational the existing pump station will be shutdown, overhauled, then recommissioned to be used as a secondary pump station. At the appropriate juncture another pump station of similar capacity will be located adjacent to the new pump station taking the system to capacity. At this point the existing pump station on Mayor Road is likely to be mothballed.

Future capacity requirements indicate that no further pipes will be needed.

Whilst this option provides considerable advantages over the other alternatives and has met with agreement by key stakeholders there are a number of issues required action in order for the proposal to proceed. In particular these include;

- Managing the impacts of the main sewer extension construction across the System 6 wetland.
- Managing the longer term impacts of the main sewer extension including; visual impacts, potential severance of the wetland and potential for leaks.
- Managing the construction impacts of the new pump station and storage area including; visual impacts, dewatering, Aboriginal and post settlement heritage and flora and fauna impacts.
- Gaining broad community and stakeholder support for the decision making process.

In July 1998 Water Corporation commissioned GHD Pty Ltd to assist them in undertaking these investigations. At this time two options for the extension of the Bibra Lake main sewer were to be investigated. These were;

1. Trenching along Mayor Road, across private land to Fawcett Road and a high bridge across the wetlands at the Northern end of Lake Coogee to the new pump station. The height of the bridge (7.5m to the top of the pipe) would be such that there would be significant visual intrusion, but the long term impact on the wetland would be confined to piling for the supports which would be sited approximately 15m apart.

2. Similar to Option 1, but, allowing the pipe to be laid in a trench across the wetland. This option has much lower visual impacts but potentially significant long term impacts.

A meeting with the Department of Environmental Protection on the 29th August 1998 discussed options for progressing this proposal (see attached minutes - Appendix C). The meeting concluded that the planning report written by the Water Corporation's Infrastructure Planning Branch should be modified and referred to the Environmental Protection Authority so that a level of assessment could be determined for both options.

On 4th August this proposal was referred to the EPA and on 28th August a letter was received from the Department of Environmental Protection stating that the level of assessment had been set as Public Environmental Review (PER). There were no appeals.


PERTH CITY
Munster PS
Woodman Point WWTP
Munster Pumping Station Catchment
STIRLING
MORLEY
MIDLAND
PERTH
CANNINGTON
ARMADALE
KALAMUNDA NATIONAL PARK
Swan River
Cockburn Sound
Mangles Bay
DARLING

FIGURE 2

3. Options for extending the Perth South Reticulation Sewerage System.

The Water Corporation's Infrastructure Planning Branch undertook a limited survey of options for conveying wastewater from the Perth south Metropolitan area from the existing pump station on Mayor Road to Woodman Point WWTP . This has been supplemented by further investigation and assessment in the project definition phase. A summary of all alignments considered and the reasons for accepting or rejecting them are given in the following section.

3.1 Alignments Avoiding the System 6 Areas

Options to eliminate impacts on Beeliar Regional Park and associated wetlands and sumplands are limited if they exist at all. One option relating to aligning the main sewer extension along the east side of Lake Coogee and divert around the South end of the lake to Woodman Point WWTP was considered briefly but rejected for the following reasons

No alternative alignments exist that can avoid the System 6 areas and are reasonably practicable.

1. It would not be possible to run a main sewer extension to a location where there was no existing or proposed residential development, requiring the construction of a new pump station in a subdivision on the eastern side of Lake Coogee.

2. The capital costs are prohibitive due to the distances involved (an additional 1800m).

3. The operating costs and energy usage associated with pumping the additional distance would also add significantly to the overall financial impact.

4. There would be significant disturbance to residential areas already established in the area and impact on Russell Road.

3.2 Additional Pumping capacity on Mayor Road with Pressure Main across the Wetland.

Very early in the investigations it became clear that any proposal to increase pumping capacity at the existing pump station on Mayor Road would be met with stern opposition from local residents. The main reasons for this were;

Increasing pump capacity at the existing site rejected because it offers no environmental advantage and has several social impacts.

1. Odour - many of the newly arrived residents in neighbouring subdivisions had been misled as to the nature of the pump station over their back fence. Only after they had built and moved in did they become aware of the odours emanating from the pump station. Whilst the principle of *caveat emptor* (buyer beware) applies to property acquisition Water Corporation could see no significant reason for increasing their burden, when another, equally viable alternative location existed.

2. Constraint on future development - many of the existing landholders to the South of Mayor Road have resided in the area for over thirty years. Plans to subdivide their properties have been hindered by the presence of the Woodman Point WWTP declared odour buffer. A new pump station on Mayor Road would necessitate a new odour buffer around this critical infrastructure and further impact on subdivision plans. Again Water Corporation could see little benefit to pursuing an option that offered little environmental benefit whilst imposing a social cost.

It should be noted in this regard that increasing pump capacity at the existing pump station on Mayor Road would require additional pressurized sewers in the vicinity of the existing pressure mains which already cross the wetlands at the proposed location. Ultimately there would be 6 pressure mains across the wetlands increasing the risk of accidental rupture of the pipelines. Therefore there is no environmental advantage since a piped crossing of the wetland would be required whichever option was chosen.

3.3 Aligning the Extension to the Main Sewer along the Proposed Beeliar Drive Extension

At first glance this seems to be a way of consolidating impacts into a single corridor and there is one feasible option from an engineering point of view that can accommodate most environmental considerations.

This option would involve; piling the bed of the wetland and placing box culverts on the piles. A minimum of 1m of sand fill would be required to be placed on top of the culverts to reduce the risk of point loading the pipes which would lead to a pipe fracture. The MAIN SEWER extension would be constructed within the proposed fill for the Beeliar Dr. extension, but this would still require elevating the proposed Beeliar Drive extension by 2m. Whilst this does not seem much it is noted that the slope on the edge of the fill cannot be more than 1 in 3, meaning that an additional 12 metres of wetland would be lost permanently using this option. It is this last consideration that makes this proposal unacceptable from an environmental point of view.

Aligning the main sewer extension along the proposed Beeliar Drive Extension would increase environmental impacts.

Other options were considered including;

1. High and low bridges - too dangerous and risky (ie a crash could lead to fracture of the pipe), with massive visual impacts.

2. Below ground - leads to restriction below the ground (the MAIN SEWER extension) and a restriction above ground (the road) resulting in the through natural flow of the water within the wetland being severely restricted. This option would also require dewatering in the wetland.

Perhaps the most telling reason for rejecting this option is that the Beeliar Drive Extension does not yet have an environmental clearance and is based on the need to connect to the Fremantle to Rockingham control access highway which is also in the process of gaining environmental acceptance. In order for this option to provide any benefit the proposed Beeliar Drive Extension would have to be a certainty, which would require Water Corporation and City of Cockburn becoming co-proponents in obtaining that approval. Given the time constraints associated with the lack of pumping capacity at the existing pump station, this would be too unpredictable and politically sensitive and would delay the construction of the pump station.

3.4 Options Leading to a Wetland Crossing North of Lake Coogee

It should be explained why it is not possible to place the proposed sewer on or above the existing Water Corporation causeway: The pipe line in this proposal is exceedingly heavy - each 1m section weighs in the region of 4 tonnes with the wastewater adding up to a further 5.7 tonnes per metre depending on how full the sewer is at the time. Placing this sort of pipe directly onto the causeway would cause subsidence of the causeway and damage to the three pressure mains inside it. Damage to these pressure mains could potentially lead to major leakage and loss of the only connection between the pump station on Mayor Road and Woodman Point Wastewater Treatment Plant. Essentially the risks and impacts associated with getting too close to the pressure mains in the existing causeway are too high.

Placing the new sewer on or near the existing causeway would present a very major risk to the security of the pressure mains.

In the planning phases the Department of Environmental protection asked if it would be possible to remove the existing causeway and place the pressure mains onto the bridge. Water Corporation took this request seriously, however, it soon became clear that the additional mass loading onto an already heavy structure would add significantly to the engineering requirements of the proposal. It is important to bear in mind that the existing pressure mains could not be moved until the flow was diverted to the new sewer. At that time the existing pipes would have to be evacuated because they are full of wastewater at this point even when not being pumped. Placing the pressure mains onto the bridge would add a further 3 tonnes per metre because, once used, they would again be surcharged with wastewater.

Assuming that the existing causeway cannot be used, from a technical point of view there are at least five broad options, totaling twelve sub-options for crossing the System 6 area to the North of Lake Coogee. These broad options are reviewed in the following sections and a typical sub-option is shown as figures and long sections following this section.

1. A **High Bridge** - A high bridge would involve putting the 3m pipe on piers 15m apart. The top of the walkway would be 9m above the wetland at its lowest point and the bridge would span 330m. Any alignment between the existing and new pump stations would be possible, but the most likely alignment would be along Mayor Road requiring 3.5m of fill and the demolition of 1 house. See Figure 3.

   A high bridge is visually intrusive and requires Mayor Road to be raised by 3.5m, but minimises impacts on the wetland.

   The **advantages** of this option are that it provides for a shallow, steady grading of the main sewer extension whilst minimising long term environmental impacts.

   The **disadvantages** are that it will be visually very intrusive, it requires significant infilling on Mayor Road, a causeway will need to be constructed to allow lifting of the bridge sections and it requires the demolition of a residence.

2. A **Low Bridge** - A low bridge would require a much deeper main sewer extension which would probably be aligned by heading directly across Mayor Road and in to the System 6 area of Market Garden Swamp No. 3. The reason for this is that the existing pressure mains are aligned along Mayor Road and it would be too dangerous to put a deep trench near to them (ie the trench might collapse and cause the pipes to fall in). Although this alignment would enter the System 6 area it would not enter the zone of critical influence for the swamp but turn west to align with the proposed crossing point. This area of the System 6 area has been previously quarried and filled with an unknown quantity of material that appears to be of very low grade. The main sewer extension would need to be below current ground level but would not need to be below the pre-existing land surface. The main sewer extension would exit the ground at a much lower point prior to crossing the wetland and be placed on similarly spaced, but much lower piers. At the lowest point the top of the main sewer extension would be 5m above the surface allowing for easier landscaped screening. See Figure 4.

   A low bridge might require a southern alignment of the main sewer extension through the System 6 area of Market Garden Swamp No.3, but minimises impacts on the wetlands.

   The **advantages** of this option are that it provides for a steadily graded main sewer extension whilst minimising long term environmental impacts and it is relatively simple to construct.

   The **disadvantages** are that the alignment is constrained, does not allow rehabilitation under the bridge except with sedges, it requires the construction of a temporary causeway in order to lift the bridge sections and the new pump station will be 4m deeper into the limestone.

3. **Below Ground** - The below ground alignment requires even deeper trenching throughout the entire length of the main sewer extension. As with the low bridge option it would probably have to follow the Southern alignment, but in this case the trench would be so deep that it would enter the pre-existing land formation (ie the original land surface before the area was filled. The trench through the wetland would be 4m deep and 15m wide. As with the bridge option a working area would be required alongside. See Figure 5.

The **advantages** of this option is that it does not require a bridge structure and is visually less intrusive.

The **disadvantages** are that it requires significant disturbance of the wetland sediments, does not allow rehabilitation of the covered area and a safety margin except with sedges, requires the new pump station to be very deep into the limestone, and has been objected to by one Aboriginal group.

4. **Boring a Tunnel** - This approach would be to enter a drop section at Pump Station No.2 and then travel along the southern alignment until Fawcett Road. At that point a further drop section would be employed to get the sewer below the ground level at Lake Coogee. Tunnels would then be bored to carry the sewer pipes. The method and cost estimate for construction of the sewer by underground boring has been provided by SMEC Australia. See Figure 6.

A tunnel could not go deep enough to avoid the root zone of the trees and requires significant dewatering

Two options for boring were considered.
Option A - Underground Boring from the wetland (B1) to the proposed pump station N° 3.
The length of construction is 960m from the wetland to pump station N° 3.
Option B - Underground Boring a siphon under Lake Coogee.
This involves construction of three sewer pipes (DN2250, DN1800, DN1200) under the wetland only then continuing with conventional open cut excavation to pump station N° 3.
The method of tunnel construction for *Option B* is with an Earth Pressure Balance Machine (EPBM) and pipe jacking. This option has not been considered further due to the high cost associated with jacking three pipes under the wetland.
Option A is constructed with an EPBM and precast segmental lining. Precast segmental tunnel lining was chosen because it was a much lower cost than using pipe jacking. This method requires a liner to be installed inside the tunnel after tunnel construction. A GRP liner has been assumed. Dewatering becomes a major issue with the construction of shafts at approximately 4.0m below the water table.

The major **advantages** of this option are no visual impact, reduced vegetation impact and some support by local residents.

The **disadvantages** are that it requires significant dewatering to construct the shaft and would have to be cut through the root zone of thevegetation , has been objected to by one aboriginal group and is the most costly option for crossing the wetland at this point.

5. **Inversed Siphon** - The principle of an inversed siphon is that it is technically possible to go deeper from a shallow starting point and then use the flow of the wastewater to lift it back up the other side. This allows both the low bridge and the below ground option to be unconstrained on their alignment between Mayor Road and Fawcett Road and the new pump station to be constructed at a shallower depth. One significant issue is that the siphon would need to be split into three pipes to maintain velocity so that material did not settle out and a small drainage pump station would be required to de-sludge the siphon on occasions. In general the advantages and disadvantages of options 2 and 3 are the same but with additional advantages and disadvantages. See Figures 7 and 8.

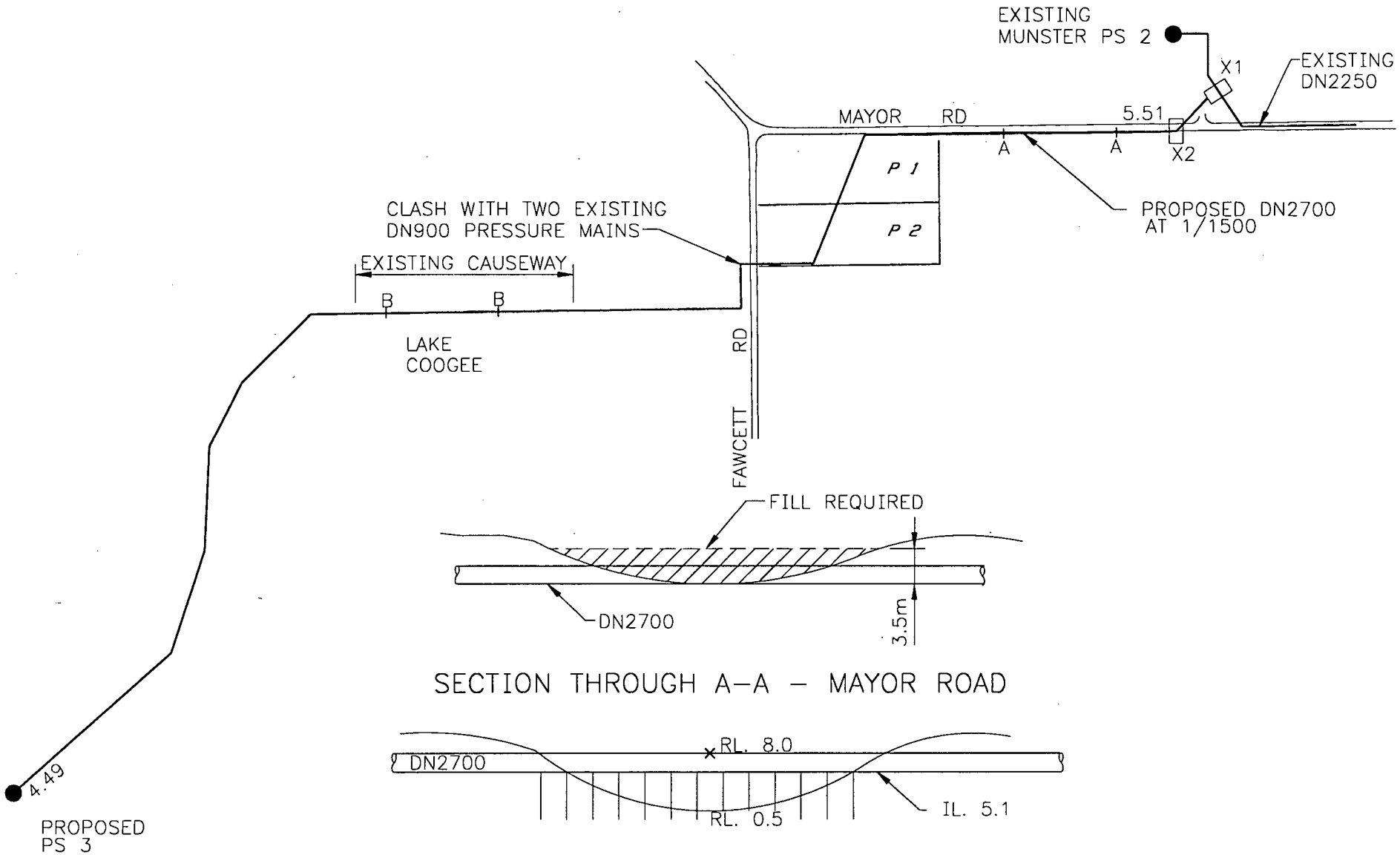
Inversed siphon reduces constraints on alignments, but requires an additional pump station and has a wider zone of permanent impact.

The **advantages** of an inversed siphon are that it reduces constraints on the alignment and allows the new pump station to be constructed at a shallower depth.

The **disadvantages** are that the inversed siphon is split into three pipes , widening the width of impact and an additional drainage pump station would be required. In addition the inversed siphon will be under a small amount of pressure.

The importance of the depth of the new pump station

Throughout the preceding section the depth of the new pump station has been mentioned on several occasions. The depth of the new pump station is important because it determines how far it must be excavated into the groundwater table. The greater the depth into the groundwater the greater will be the dewatering impact. The depth of the main sewer extension dictates the depth of the new pump station because the wastewater must always be flowing down hill. The inverse siphon removes this constraint, but imposes other problems. The issue of dewatering will be discussed in more detail later in this document.



SECTION THROUGH A–A – MAYOR ROAD

SECTION THROUGH B–B – LAKE COOGEE

GHD
NS /MI 1/10/98
60095800 ORG. OPTION 1
CAD. 58CF03.DWG

FIGURE 3 – SHALLOW ON MAYOR RD
(DN2700 ON HIGH BRIDGE)

3.5 Selection of the Preferred Option

Throughout the preceding section it is clear that once the choice of alignment was constrained to the wetlands just North of Lake Coogee, there were numerous options and combinations relating to trench depths of the main sewer extension , its alignment between Mayor Roads and Fawcett Road and the potential depth of the new pump station. Attempts were made to develop a clearly preferred option on the basis of cost, but most options except the boring option produced similar whole of life costs (The whole of life cost was calculated using a net present value to take into account the cost of building the system and its operating costs for 50 years).

3.5.1 Engineering Risk Assessment Workshop

On Wednesday 16th July an Engineering Risk Assessment Workshop was undertaken to determine if any of the options presented unacceptable risks. The key outcomes of this were that all options were viable from an engineering perspective except those that required deep trenching next to the existing pressure mains. The risk of a collapse to the closure of the Perth South sewerage reticulation system was considered too great. Details of the Risk Assessment Workshop are given in Appendix B.

Engineering risks eliminate those options where a deep trench is located next to existing pressure mains.

3.5.2 Community Meetings

On Wednesday 16th July and Thursday 17th July community meetings were held with people from within the area. The Wednesday meeting was generally with residents from the new subdivisions located near to the existing pump station. The major concern of these people was not to have a new pump station located on Mayor Road. They were also concerned to ensure that progress was maintained because they are living daily with the impact of odour and the possibility of release of wastewater into an uncovered storage area on the existing pump station site.

The community wants action to take the smell away and is concerned over the visual impact and the impacts on the wetlands.

The Thursday meeting was intended for groups with a broader interest. There were few new attendees. Concern was expressed that all options had not been examined and that Woodman Point WWTP was not the right location for a wastewater treatment plant. This was responded to in the light of the Perth Coastal Waters Study, the Study of Alternative Effluent Disposal Options and Wastewater 2040. Water Corporation is of the opinion that all options have been considered and that their general direction has been endorsed by the then Minister for the Environment, Mr Peter Foss. Concern was also expressed as to the visual impact of the high bridge and wetland impacts of the below ground option. Details of these meetings are given in Appendix A.

3.6 Community Feedback

Community, equally split on options.

Two thousand brochures were distributed to residents living in the immediate area, an advertorial was placed in the Cockburn Gazette (Issue : 11 September 1998) and a display was presented in the Cockburn City Library. Approximately 60 responses were received, of those that addressed environmental issues the responses were equally split between concern on the visual impact and concern on the wetland impact. Full details of the Consultation Program and Community Response are given in Appendix A.

3.7 Environmental Risk Assessment Workshop

On Friday 18th September an Environmental Risk Assessment Workshop was undertaken. Attendees included; CALM, DEP, City of Cockburn, Spearwood Residents Association, Water Corporation and representatives of GHD, Golder Associates and ECOSCAPE. Apologies were received from the local member Mr Bill Thomas MLA and all members of the Beeliar Park Management Committee.

The workshop was briefed on the current findings of the environmental and hydrological investigations and on the engineering options. The major factors identified in this workshop were;

- Vegetation
- Beeliar Park
- Declared Rare Flora
- Terrestrial Fauna
- Wetlands
- Groundwater
- Dewatering
- Leaks
- Visual Impacts
- Aboriginal issues

Once again, it was not possible to determine a preferred option because all of the options have benefits and impacts. Nevertheless, it became clear that the major issues of concern that varied between the options were;

1. The visual impact of the high bridge and the knock on impact on the plans for Beeliar Park were unacceptable.

2. The dewatering, major construction impacts, unacceptability to the Aboriginal community and permanent sediment impacts of a below ground option rendered these options unacceptable.

This left the only options available as a low bridge and the disbenefits of the siphon option made the selection of a graded low bridge inevitable.

The low bridge has the significant advantage that it can be reasonably well disguised as a walkway allowing public access for viewing of Lake Coogee and Market Garden Swamp No.2.

3.8 The Preferred Option

3.8.1 Sewer alignment

The preferred option is therefore the low bridge option across the North end of Lake Coogee. This option is seen as the most suitable compromise option between a range of extremes. It does not eliminate impacts on vegetation and visual amenity, but significantly reduces them both from the extremes. It eliminates the need for dewatering through the North end of the wetland, maintains hydraulic conductivity and meets the requirements of all aboriginal groups. The low bridge can easily be turned into a walkway/cycleway, significantly enhancing the recreational use of the North end of the lake. This option is shown diagrammatically in the following Figures 9 and 10.

The main features of this option are construction of the sewer in privately owned lots (Lot 505 Mayor Rd and Lot Pt 2 Fawcett Rd) through uncontrolled fill and the crossing of the wetland to the North of Lake Coogee on a low bridge.

Dropping the sewer 3.3m avoids the need to apply fill on Mayor Rd and therefore eliminates the requirement of demolishing the house on Lot 50. It also avoids the major fill requirements within private properties and retaining walls to the existing pump station N° 2 site.

The sewer does however enter the System 6 area of Market Garden Swamp N°. 3 in Lot 505 Mayor Rd and Lot Pt 2 Fawcett Rd. Although the sewer enters the System 6, the alignment of the sewer is within an area that contains uncontrolled fill and will therefore not affect the existing zone of critical influence for the swamp. The existing swamp has not been influenced by fill. Excavation contours dated 1975 showed that much of the route had been cut to about 2m AHD. The area had then been filled with significant rubble. The filling was completed by 1994. The fill has a thickness of in excess of 5m over a large area.

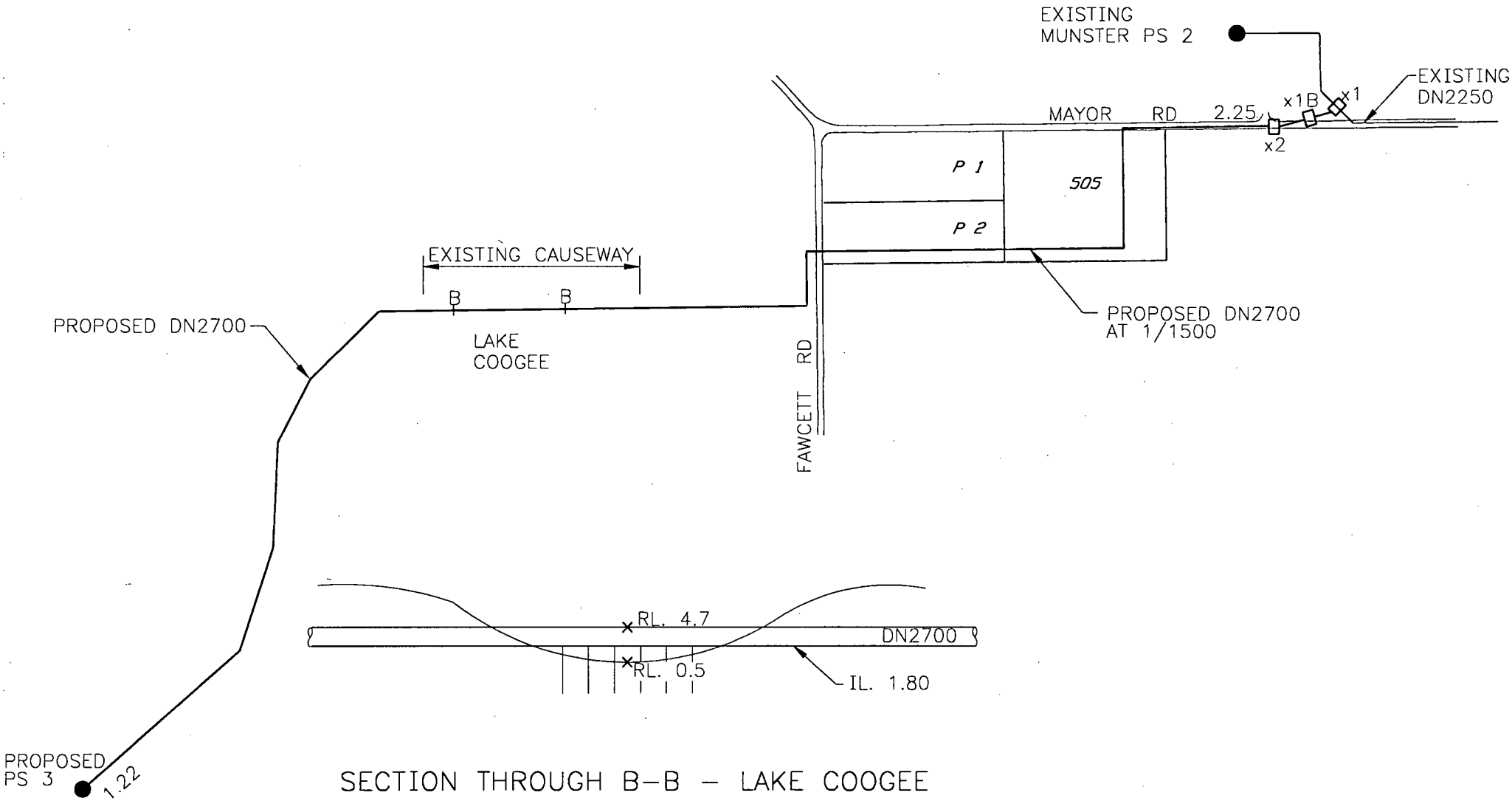
The sewer passes under the existing pressure mains on Fawcett Rd and into Lot 703 Fawcett Rd. Land along Lot 703 would need to be acquired. The alignment along the causeway is very close to the house on Lot 703.

It would be preferable to purchase the entire lot to enable ease of construction and allow the sewer to angle across the lot from the Fawcett Rd crossing to the start of the low bridge. This would shorten the length of sewer by approx. 25m. There are several owners of Lot 703. Discussions with some of the owners indicate their preference for the Water Corporation to purchase the entire lot provided a reasonable price was offered.

The sewer is to be constructed on a Iow bridge across Lake Coogee. The bridge is approximately 230m in length. The height from the natural surface of the wetland to the top of the sewer pipe is 4.5m at the midpoint of the bridge. The height is reduced by 3.0m compared to the high bridge option and the length shortened by 100m. Key Characteristics of the preferred option are given in Table 1 below.

TABLE 1 - Key Characteristics of Preferred Option

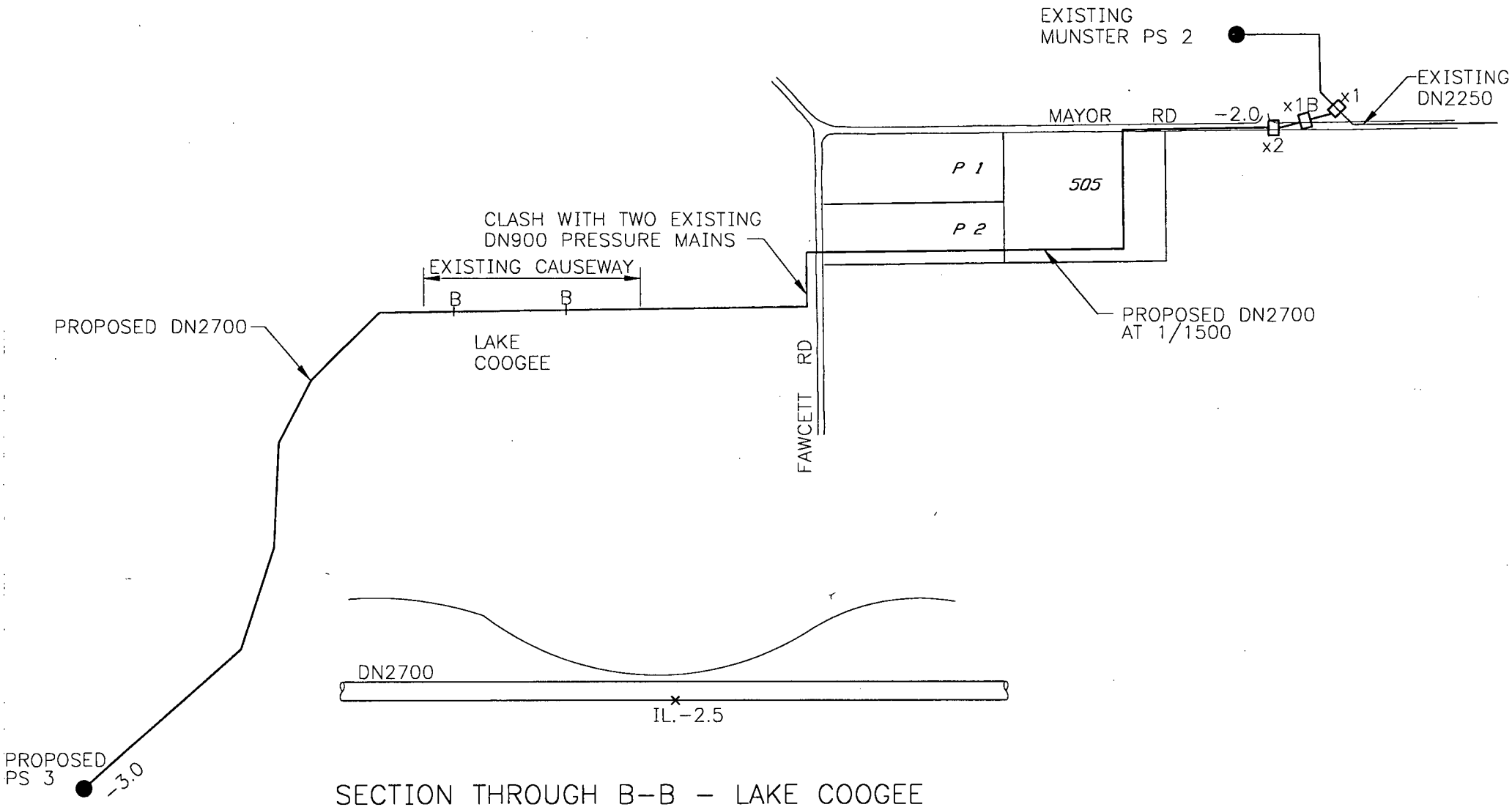
Item	Characteristic
Total Length of Sewer	1572m
Internal Diameter of Sewer	2700mm
External Diameter of Sewer	approx 3060mm
Maximum Flow Capacity of Sewer	9200 l/s
Maximum Flow Capacity of New Pump Station	4600 l/s
Storage Capacities (hours) at Peak Flow	Enclosed = 2 hours at peak Enclosed = 10 hours at summer low flow Open = 8 hours at extraordinary peak
Max height of Bridge to top of walkway	6.5m
Nature of Footings	Piles
Minimum Distance Between Piers	15m



SECTION THROUGH B–B – LAKE COOGEE

NS /MI 1/10/98
60095800 DRG. OPTION 8
CAD. 58CF10.DWG

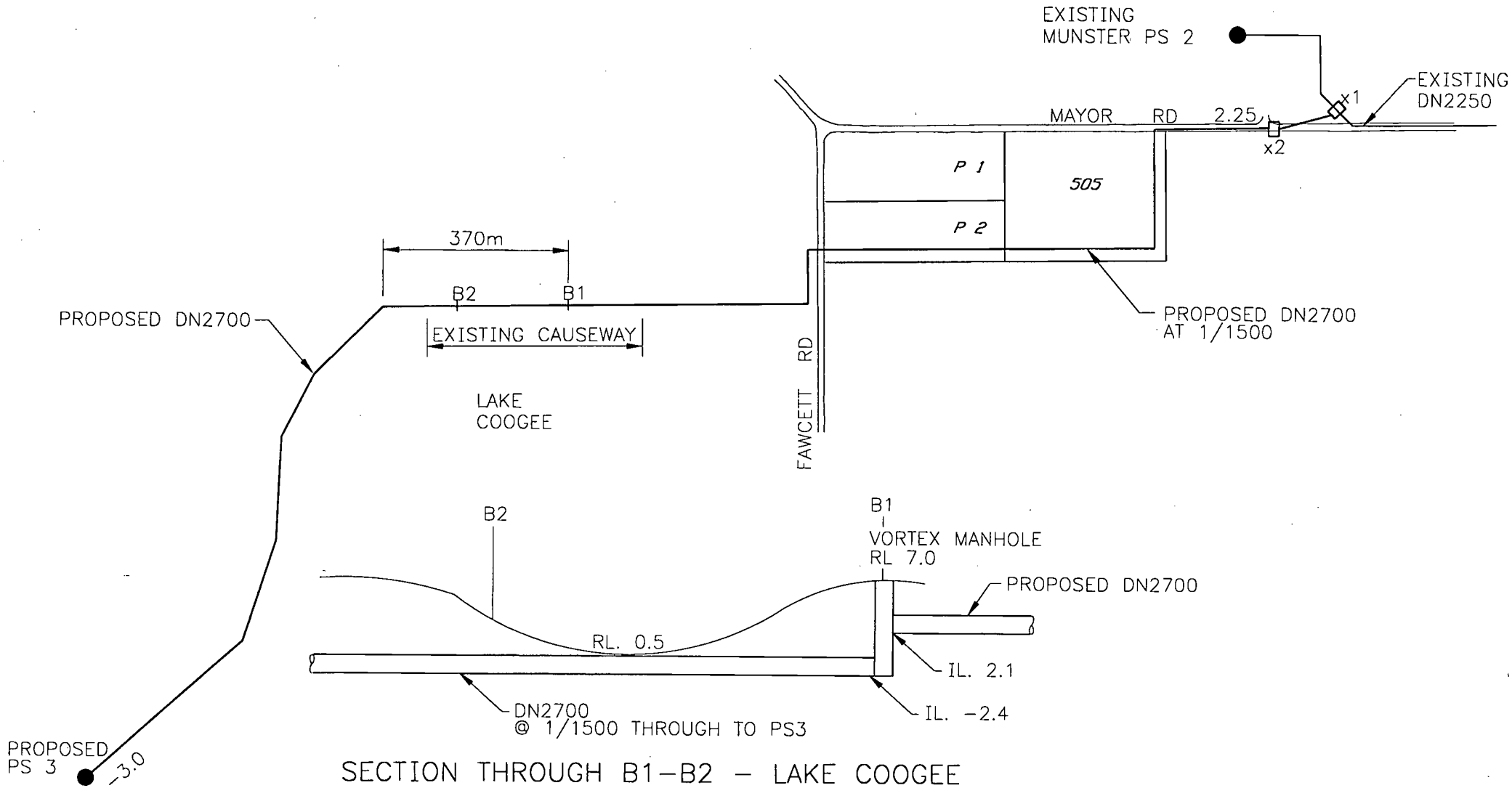
FIGURE 4 – DEEP THROUGH SUBDIVISION
(DN2700 ON LOW BRIDGE)



SECTION THROUGH B-B - LAKE COOGEE

NS /MI 1/10/98
60095800 DRG. OPTION 10
CAD. 58CF12.DWG

FIGURE 5 - VERY DEEP THROUGH SUBDIVISION
(DN2700 UNDER LAKE)



SECTION THROUGH B1–B2 – LAKE COOGEE

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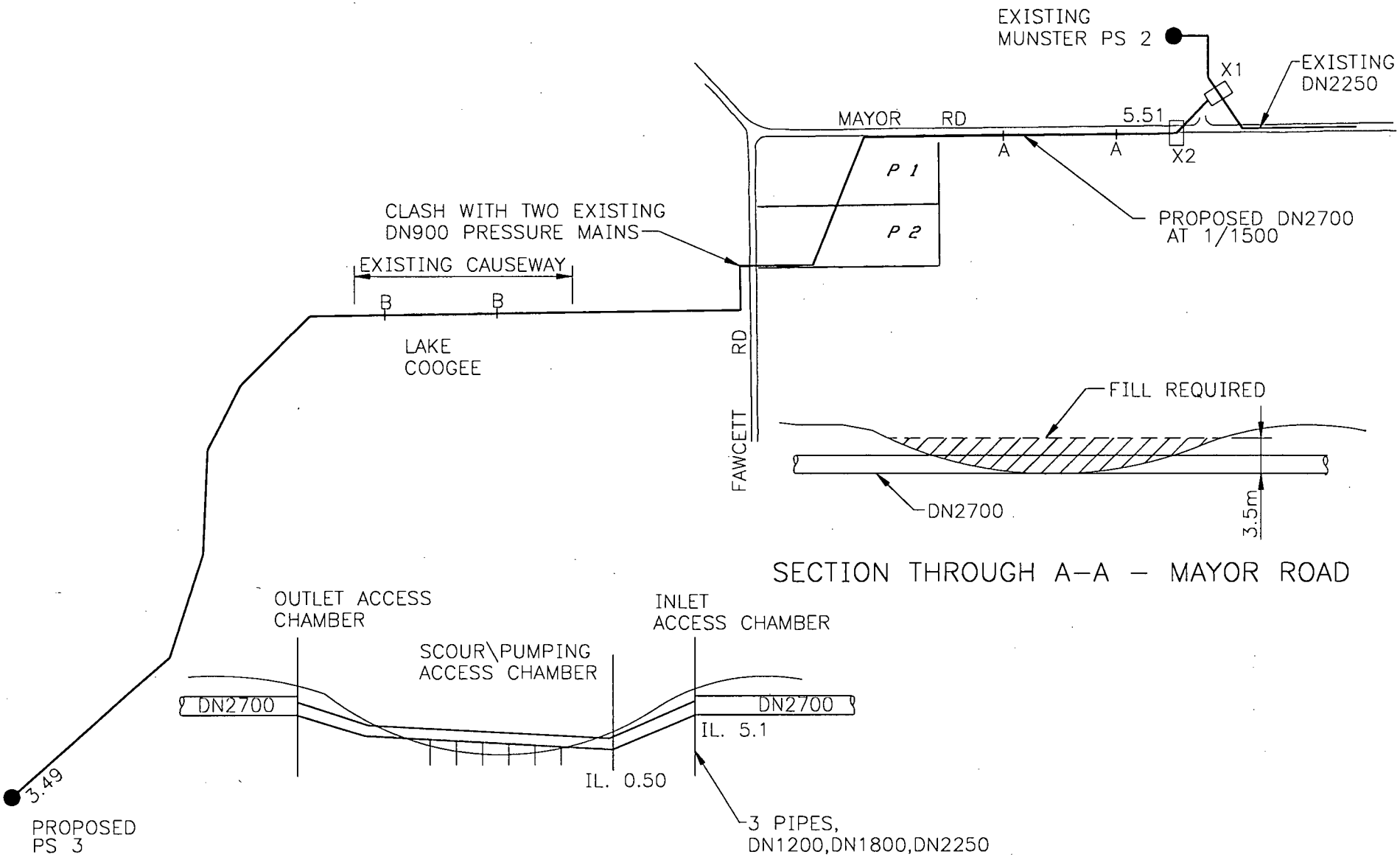
60095800 DRG. OPTION 12
CAD. 58CF14.DWG

FIGURE 6 – UNDERGROUND BORING



NS /MI 1/10/98
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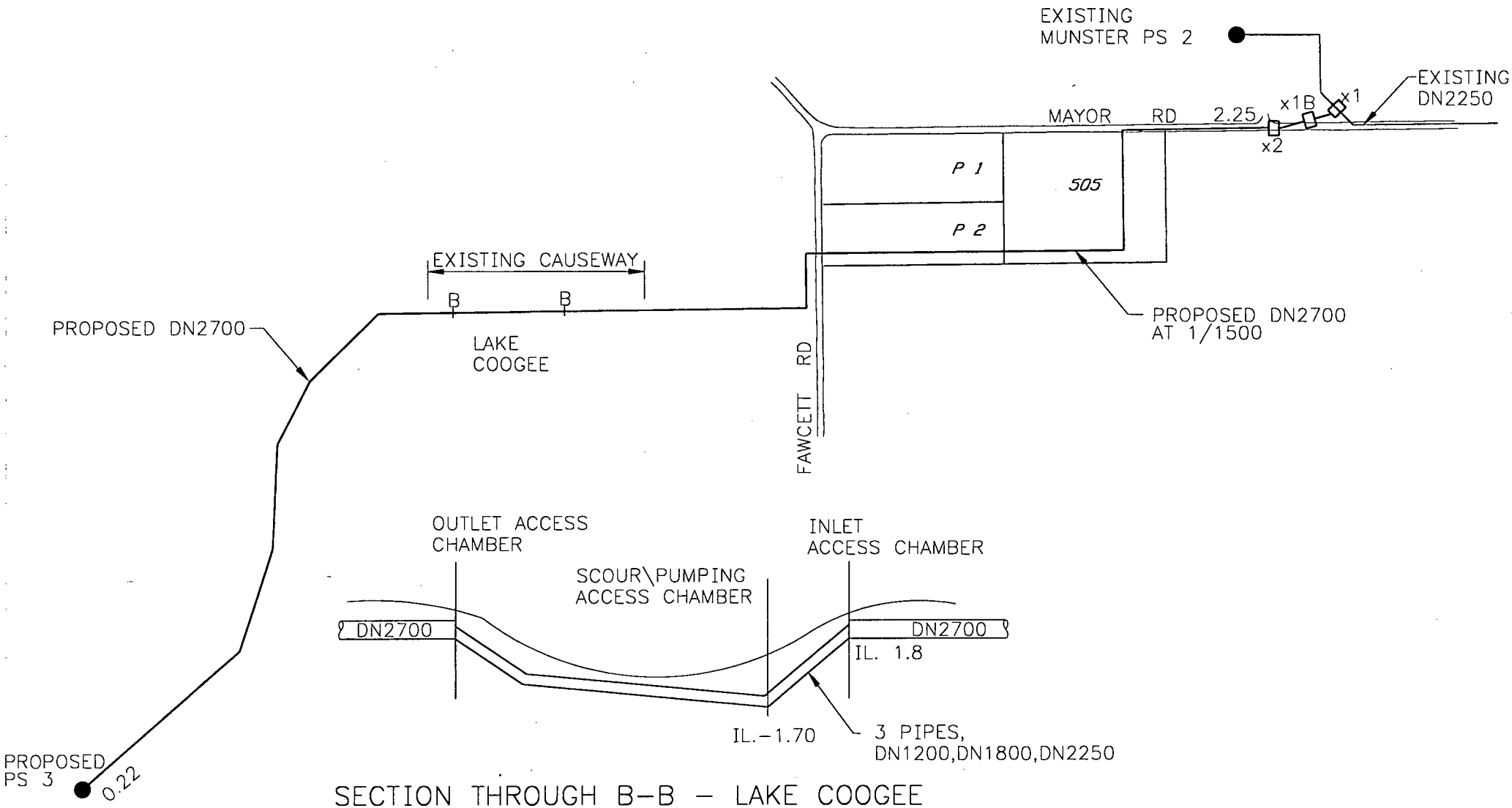
FIGURE 7 – SHALLOW ON MAYOR RD
(SIPHON ON LOW BRIDGE)

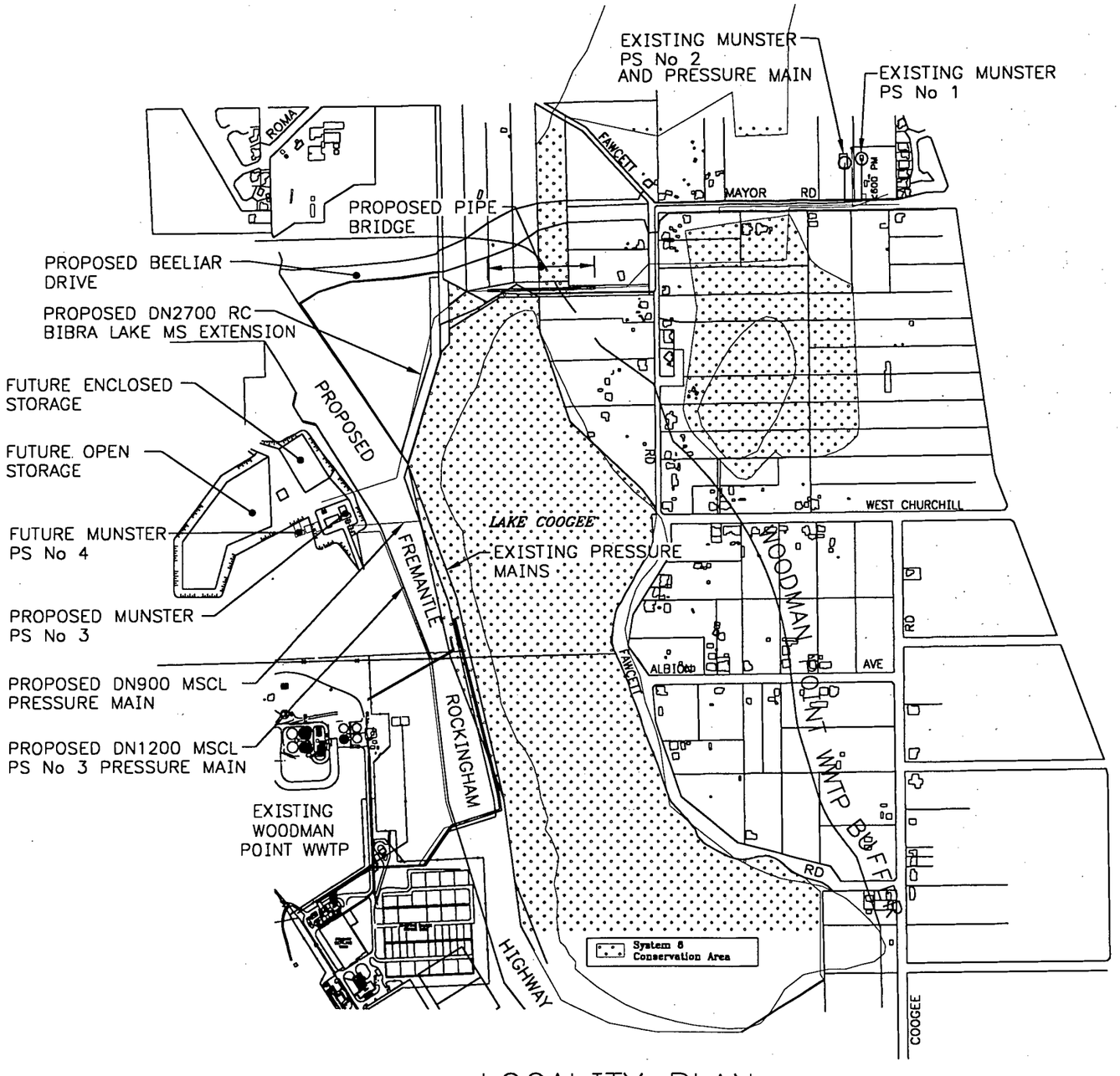


SECTION THROUGH B-B - LAKE COOGEE

GHD

NS /MI 1/10/98
60095800 DRG. OPTION 9
CAD. 58CF11.DWG

FIGURE 8 - DEEP THROUGH SUBDIVISION
(SIPHON UNDER LAKE)



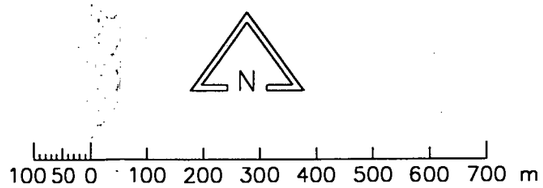


FIGURE 9

LOCALITY PLAN

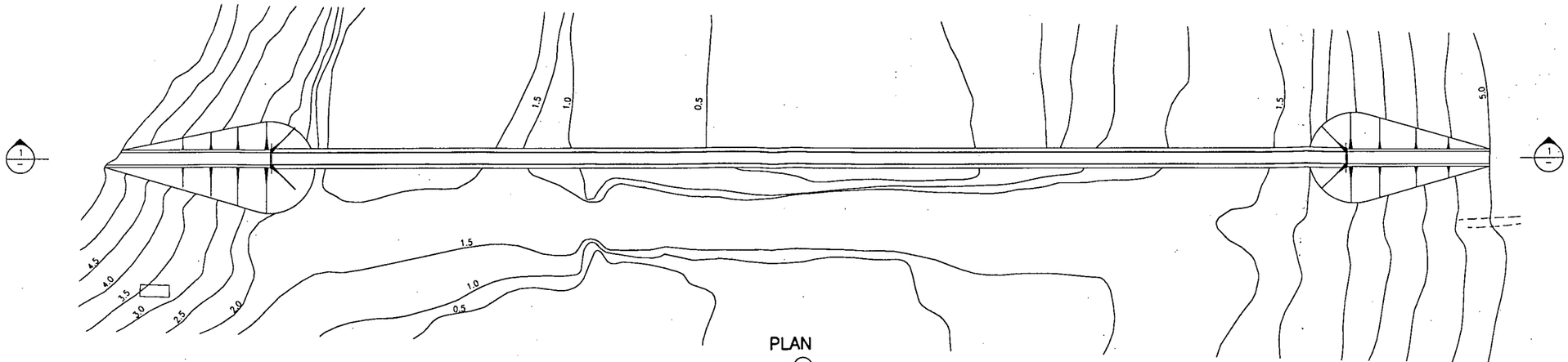
METROPOLITAN WASTEWATER
MUNSTER PUMPING STATION NO. 3 AND
BIBRA LAKE MAIN SEWER SECTION 8

WATER CORPORATION

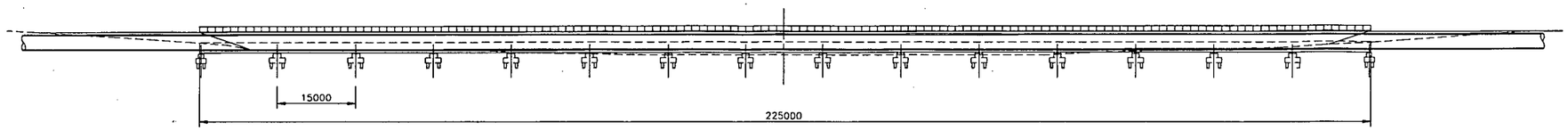
SOURCE:WATER_CORPORATION

Gutteridge Haskins & Davey Pty Ltd
CONSULTING ENGINEERS • ENVIRONMENTAL SCIENTISTS & PLANNERS • PROJECT MANAGERS
ACN 008 488 373
PERTH • BUNBURY • GERALDTON • KALGOORLIE

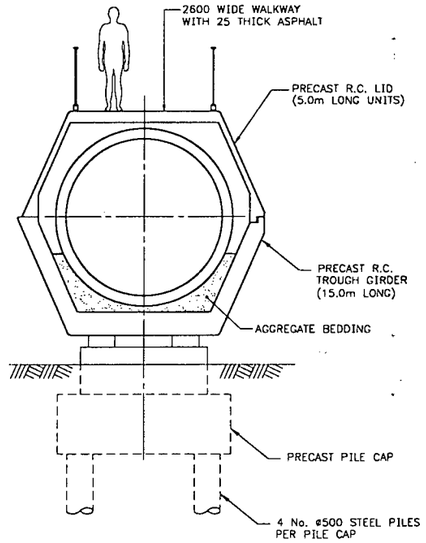
JOB NO 60095800
DRAWING PATH 60095800\CAD\GLB\F9.DWG



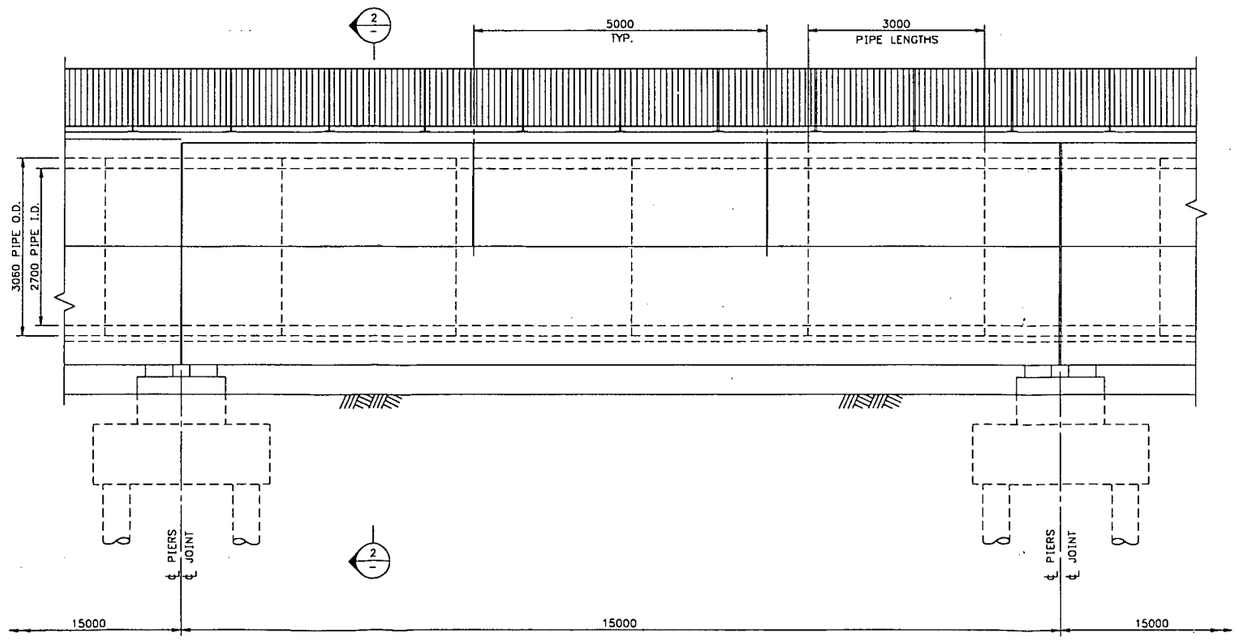
PLAN
SCALE (1)



SECTION 1
SCALE (1)



SECTION 2
SCALE (2)



ELEVATION
SCALE (2)

(1) 5 0 5 10 15 20 25 30 35 m (1:500)
(2) 1000 500 0 1000 2000 3000 mm (1:50)

ISSUE	DATE	CRTD	REVISION	DRN	REC	APPD

SURVEY BOOKS

DATUM AHD
DES REF

DES CALC S.ERASITO
DES CHD T.KINLEY
DRN J.THOMPSON
CHECKED

NORTH POINT

Gutteridge Haskins & Davey Pty Ltd
CONSULTING ENGINEERS + ENVIRONMENTAL SCIENTISTS & PLANNERS + PROJECT MANAGERS
ACN 008 488 373
PERTH • BUNBURY • GERALDTON • KALGOORLIE
JOB NO 60095800
DRAWING PATH 60095800\cad\FIGURE10.DWG

RECOMMENDED
JOB MANAGER
APPROVED
PROJECT DIRECTOR

WATER CORPORATION

METROPOLITAN WASTEWATER
BIBRA LAKE MAIN SEWER SECTION 8 (CONCEPTUAL DESIGN)
PLAN AND ELEVATIONS
OPTION 1

FILE | PROJECT | PLAN | CAD | ISSUE
FIGURE 10 | A

ORIGINAL SHEET SIZE A1

566 810

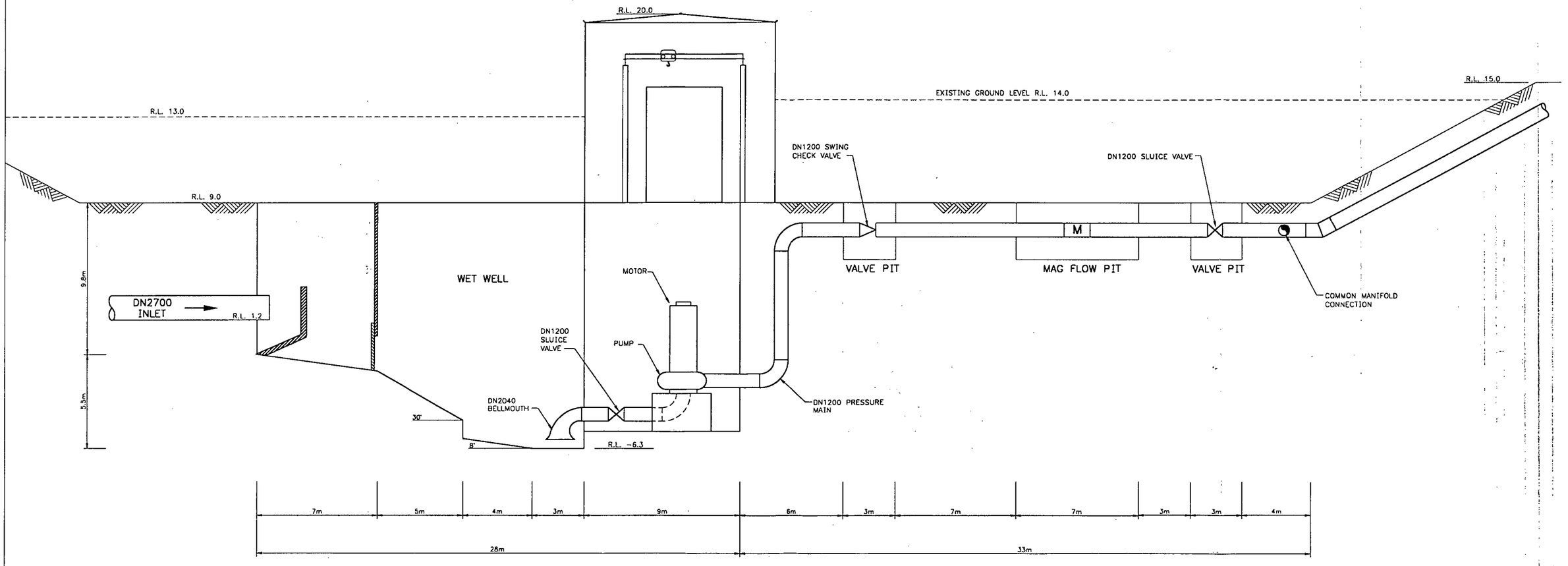
60095800\cad\FIGURE10.DWG 30 November 1998 – 2:09PM 0366 c3

3.8.2 Pump Station Layout

The plan and cross section of the pump station is shown in Figure 11 following and is based on:

- A central location within Water Corporation land. This provides more than adequate buffer of approximately 600m to the nearest property on eastern side of Lake Coogee, 600m to the nearest property north of pump station and 400m to Cockburn Road.
- Minimising the length of the gravity sewer.
- Minimising depth of sewer construction.
- Minimising depth of pump station construction.
- Siting adjacent the proposed Fremantle - Rockingham Highway.
- Fencing of the entire site for security and safety purposes.
- Limiting the visual impact of the proposed and future buildings.
- Provision of sufficient separation for the future pump station N°. 4.
- Provision for future open and enclosed storage areas.
- The wet well and dry well shall be constructed from reinforced concrete and the wet well will be protected against attack from hydrogen sulphide. The pump station superstructure and electrical building shall be constructed from brickwork/blockwork depending on aesthetic requirements.

Both the pump station and electrical building will require special ventilation requirements.
The pump station will require acoustic treatment to reduce sound transmission.
Generally access to the site shall be from the Woodman Pt WWTP site.



SECTION A-A
N.T.S.

ASM/PGS 4/11/98
JOB NUMBER 60095800
DRAWING PATH :\60095800\CAD\MUNSTER No.3 CROSS_SECTION.DWG

FIGURE 11
MUNSTER PS No.3
PUMP STATION SITE CROSS SECTION

3.8.3 Overflow from the Pump Station

The existing Munster sewerage system has limited storage capacity of approximately ½ hour before wastewater enters the existing open overflow basin which is located adjacent to pump station N° 2 on the western side, based on complete failure of the system including emergency power. The overflow basin has a storage capacity of approximately 25 ML which gives about 3 hours of time. Upon filling the basin, flow is directed into the disused limestone quarry which connects into the wetlands.

To minimise the possibility of overflow of wastewater to the environment and community during a system failure, including emergency power failure, the following design criteria for overflow storage will be implemented at the new pump station. These criteria are based on the requirements outlined in the Infrastructure Planning Report:

- Enclosed storage within the system shall be designed to accommodate flow for 2 hours at peak flow in case of a pump station failure. It may take up to 2 hours for an operator to travel to the pump station site, make minor repairs and activate the pump station.
- Enclosed storage within the system shall also be designed to accommodate flow for 10 hours at low flow during summer, to allow for the switching of a pump station off for planned maintenance work on the pump station. This will enable a crew to work up to a full shift to carry out planned maintenance work.
- Open storage in the system shall be designed so that the system can store flow for 8 hours from the 1 in 100 year storm (assumed to be the flows encountered in February 1992, scaled up to the ultimate capacity of the wastewater reticulation system). This will almost eliminate the possibility of overflows to the environment (it will take up to 8 hours for workers to travel to site, make repairs and activate the pump station).

Construction of pump station N° 3 will provide the capability to use the alternate pumping station as enclosed storage in case of failure. If pump station N° 3 fails, flow will be diverted to pump station N° 2. Alternatively if N° 2 fails, flow is diverted to N° 3. This will reduce the risk of an overflow significantly.

3.8.4 Enclosed Storage

Additional enclosed storage is not required until 2015 and therefore approval for this section of the system is not being sought under this PER. However, since it is an integral part of the design, it is important that the EPA and the general public are aware of these plans.

The storage volume that the system will be designed for is determined by the nominally accepted requirement of 10 hours of storage at low flow. The enclosed storage requirement is to include storage within the gravity sewer, storage in the wet well and pumping by the alternate pump station.

The additional enclosed storage volume that is required to be constructed to satisfy ultimate conditions is 33.7 ML. This additional enclosed storage tank is not required until 2015. It is proposed to construct the storage tank with reinforced concrete base, walls and roof. Staged construction is recommended with initial construction of 50% of the ultimate storage requirement.

The indicative location of the proposed additional enclosed storage tank is shown in the preceding Figure 9. The size shown satisfies ultimate conditions. The base of the storage area is designed to be above the water table eliminating the requirement for dewatering.

3.8.5 Open Storage

Additional open storage is not required until 2011 and therefore approval for this section of the system is not being sought under this PER. However, since it is an integral part of the design, it is important that the EPA and the general public are aware of these plans.

The storage volume that the system will be designed for is determined by calculating 8 hours at the extraordinary peak flow of February 1992. This storage requirement includes all of the enclosed storage described previously and an additional open storage area of 134.9 ML.

This additional open storage tank is not required until 2011. It is proposed to construct the storage tank with reinforced concrete base and walls. Staged construction is recommended with 1/3 sections built as required. An indicative location of the proposed additional open storage tank is shown in Figure 9, in the previous section. The size shown satisfies ultimate conditions and is designed to be entirely above the watertable.

3.8.6 Emergency Overflow

No matter how well designed and all encompassing an emergency overflow system is, there is ultimately the risk that all efforts to contain the wastewater could be overwhelmed and the wastewater would be discharged to the environment. In order to reduce the impact arising from such an event, Water Corporation designs for this situation even though it might never happen.

It is important to remember that overflow to the environment has happened in the past on at least one occasion and the new system is designed to accommodate even those extraordinary peak flow conditions. Therefore there have never been conditions in the history of pump station number 2 where this overflow would be required. By developing the proposal for pump station number 3 Water Corporation are significantly reducing the risks of another release to the environment, but it is not possible to entirely eliminate this issue.

The new system significantly reduces the risk of an uncontrolled release to the environment.

Two options presented themselves for this overflow as follows;

1. Leave the overflow where it is - discharging ultimately to Market Garden Swamp No.2
2. Direct the overflow to Cockburn Sound.

Whilst it is difficult to countenance either of these options, no other options are sensible because they relate to allowing the overflow to flood roads and people's houses and this is obviously unacceptable.

It is therefore intended that the emergency overflow arrangement remain as it is. When all other capacity is used up overflow will enter the open basin next to pump station N° 2 and then spill over into the disused limestone quarry which connects into the wetlands. It is most unlikely that an overflow of the proposed system would occur with the proposed storage system in place.

It should be noted that the risks of an overflow to the environment have been significantly reduced as part of this proposal. This can be seen from a comparison of the two systems under the February 1992 flow conditions as seen in Table 2

TABLE 2 - Relative Risks of Overflow from Current and Proposed Systems

Scenario	Existing Pump Station	Proposed System	Assumed Probability
1.February 1992 Flows	System is overwhelmed and storage overflows in a matter of hours.	Pump Station Number 3 operates under full capacity and Pump Station 2 comes on line to accommodate excess capacity. No overflow	1 in 100 years
2. February 1992 Flows and Single Pump Station Failure	Storage is rapidly overwhelmed and greater overflow to the environment occurs	If pump station 3 fails, pump station 2 moves to maximum output and storage backs up giving 8 hours for repairs to be undertaken. If pump station 2 fails, pump station 3 continues to run at maximum capacity and system backs up giving greater than 8 hours for repairs to be undertaken	Greater than 1 in 100 years
3. February 1992 Flows and Double Pump Station Failure	Not applicable	Storage overflows in a matter of hours	Significantly greater than 1 in 100

It can be seen from the above Table 2 that this proposal significantly reduces the risk of an overflow to the environment.

4. EPA Guidelines

Following referral of the proposal by Water Corporation to the Environmental Protection Authority a level of assessment was set as PER. There were no appeals and the EPA issued its guidelines for the development of the PER document. Specific environmental factors and EPA objectives for these factors were stated. Water Corporation was advised to address these factors and an outline of the work required was given. A copy of these factors is shown in Table 3 (overleaf).

Environmental factors relevant to this proposal

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

TABLE 3 - Environmental Factors

CONTENT		SCOPE OF WORK	
Factor	**Site Specific Factor**	**EPA Objective**	**Work required for the environmental review**
Flora and Fauna			
Terrestrial Flora	Vegetation communities	Maintain the abundance, species diversity, geographic distribution and productivity of vegetation communities	Assess and document the existing vegetation communities, the likely impacts (eg. clearing) from the proposal and the proposed management measures (if any) which will be planned and implemented to ensure the EPA's objective is met, including 'no net loss'.
	Beeliar Regional Park/System 6 M92	Ensure that the conversation values of System 6 recommended areas are not compromised and regionally significant flora and vegetation communities in System 6 are adequately protected.	Assess the document and the likely impacts from the proposals on the Beeliar Regional Park and the proposed management measures (if any) which will be planned and implemented to ensure the EPA's objective is met, including 'no net loss'.
	Declared Rare and Priority Flora	Protect Declared Rare and Priority Flora, consistent with the provisions of the Wildlife Conservation Act 1950.	Assess and document the presence of declared Rare and Priority flora species and proposed management measures (if any) which will be planned and implemented to ensure the EPA's objective is met.
Terrestrial Fauna	Terrestrial Fauna	Maintain the abundance, species diversity and geographical distribution of terrestrial fauna.	Assess and document the presence of terrestrial fauna, the likely impacts and proposed management measures (if any) which will be planned and implemented to ensure the EPA's objective is met.
	Specially Protected (Threatened) Fauna	Protect Threatened Fauna and Priority Fauna species and their habitats, consistent with the provisions of the Wildlife Conservation Act 1950.	Assess and document the presence of Declared Rare and Priority fauna species and proposed management measures (if any) which will be planned and implemented to ensure the EPA's objective is met.
Wetlands	Wetlands	Maintain the integrity, functions and environmental values of wetlands.	Assess and document the environmental values of wetlands, the likely construction and post construction impacts and proposed management measures (if any) which will be planned and implemented to ensure the EPA's objective is met.

CONTENT		SCOPE OF WORK	
Factor	**Site Specific Factor**	**EPA Objective**	**Work required for the environmental review**
	Groundwater	Maintain the quantity of groundwater so that existing and potential uses, including ecosystem maintenance, are protected.	Assess and document groundwater hydrology, the likely construction and post construction impacts (eg. dewatering and hydraulic barriers) and proposed management measures (if any) which will be planned and implemented to ensure the EPA's objective is met.
Pollution Management			
Air	Particulates/Dust	Ensure that the dust levels generated by the proposal do not adversely impact upon welfare and amenity or cause health problems by meeting statutory requirements and acceptable standards.	Assess and document the likely construction impacts (eg. dust levels) and proposed management measures (if any) which will be planned and implemented to ensure the EPA's objective is met.
Water	Groundwater Quality	Maintain or improve the quality of groundwater to ensure that existing and potential uses, including ecosystem maintenance are protected, consistent with the draft WA Guidelines for Fresh and Marine Waters (EPA, 1993).	Assess and document the existing ground water quality, the likely construction and post construction impacts (eg. below ground pipeline failure and leakage and dewatering disposal-groundwater injection).
	Surface Water Quality	Maintain or improve the quality of surface water to ensure that existing and potential uses, including ecosystem maintenance are protected, consistent with the draft WA Guidelines for Fresh and Marine Waters (EPA, 1993).	Assess and document the existing surface water quality, the likely construction and post construction impacts (eg. fuel and chemical storage, pipeline failure and leakage, sewage overflows, dewatering disposal and changes to causeway)
Land	Soil Contamination	Ensure the rehabilitation of the site to an acceptable standard that is compatible with the intended land use, consistent with appropriate criteria. Contaminated material should be treated on-site or disposed of off-site at an appropriate land fill facility. Where this is not feasible, contaminated material should be managed on-site to prevent groundwater contamination or risk to public health.	Assess and document the nature and extent of suspected contaminated fill in the proposal area in accordance with NHMRC and NSW EPA guidelines. Document proposed management measures (if any) to ensure contamination which exceeds accepted EPA/DEP criteria is managed to meet the EPA's objective. (For more information contact Harvey Johnson 9222 7161).
Non-Chemical Emissions	Noise	Protect the amenity of nearby residents from noise impacts resulting from activities associated with the proposal by ensuring that noise levels meet statutory requirements and	Assess and document the likely construction impacts and proposed management measures (if any) which will be planned and implemented to ensure the EPA's objective is met. (For more information contact

CONTENT		SCOPE OF WORK	
Factor	**Site Specific Factor**	**EPA Objective**	**Work required for the environmental review**
		acceptable standards.	Dick Langford 9222 7110).
	Vibration	Protect the amenity of nearby residents from vibration impacts resulting from activities associated with the proposal by ensuring that vibration levels meet statutory requirements and acceptable standards.	Assess and document the likely levels/duration of vibration during construction, the likely impacts on residents and building and proposed management measures (if any) which will be planned and implemented to ensure the EPA's objective is met.
Social Surroundings			
Aesthetic	Visual Amenity	Visual amenity of the area adjacent to the proposal should not be unduly affected by the proposal.	Assess and document the current level of visual amenity, the proposed impacts and management measures (if any), with particular reference to the Beeliar Regional Park. Outline management measures (if any) which will ensure the EPA's objective is met.
Culture and Heritage	Heritage	Comply with statutory requirements in relation to areas of cultural or historical significance/.	Assess and document the existence of any sites of non Aboriginal heritage, the likely impacts and proposed management measures which will ensure the EPA's objective is met. The site is listed with the Australian Heritage Commission on the National Register. Document these values and what (if any) management measures are proposed to ensure these values are protected.
	Aboriginal Culture and Heritage	Ensure that the proposal complies with the requirements of the Aboriginal Heritage Act 1972; and Ensure that changes to the biological and physical environment resulting from the project do not adversely affect cultural associations with the area.	Assess and document the existence of significant Aboriginal sites, the likely impacts and proposed management measures (if any) which will ensure the EPA's objectives are met.

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

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

5. Existing Environment

5.1 Physico-chemical Environment

The physico - chemical environment is the non-living environment and comprises the meteorology, topography, geology, hydrogeology, hydrology, aquatic chemistry and atmospheric chemistry of the environment in the area of the proposal.

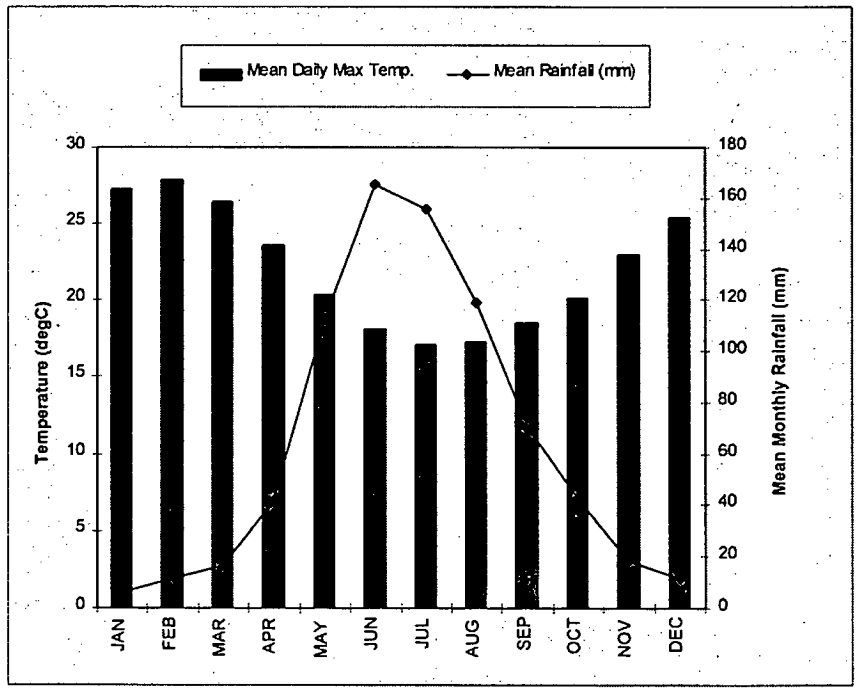
The physico - chemical environment is an important factor in determining the type of living organisms that can exist in the area, but this interaction is by no means one way and many organisms alter the physico-chemical environment on a local scale to better suit their requirements or simply as a result of their presence.

In the course of defining this proposal Water Corporation has taken every step to quantify the ecology of this area and determine the expected short term and long term impacts.

5.1.1 Meteorology

The meteorology of this location is coastal Mediterranean. Early sea breezes during the summer months keep the maximum temperatures down, whilst the average rainfall is a little lower than that of Perth. Figure 12 below, indicates the annual variation in temperature and rainfall at Fremantle (the nearest meteorological station). The most important elements of this weather pattern are that evaporation easily exceeds rainfall during the summer months and that over 70% of the annual rainfall occurs in just four months during the cooler winter period.

FIGURE 12 - Meteorology of Fremantle



5.1.2 Topography

Lake Coogee and Market Garden Swamp No. 2 are situated in a valley approximately one kilometre from the coast. Grades in the area are a maximum of 1 in 11 from Fawcett Road to Lake Coogee, which is not particularly steep, but it is this landform that contributes significantly to the visual quality of the area. The North -South valley affords excellent views from Coogee Heights.

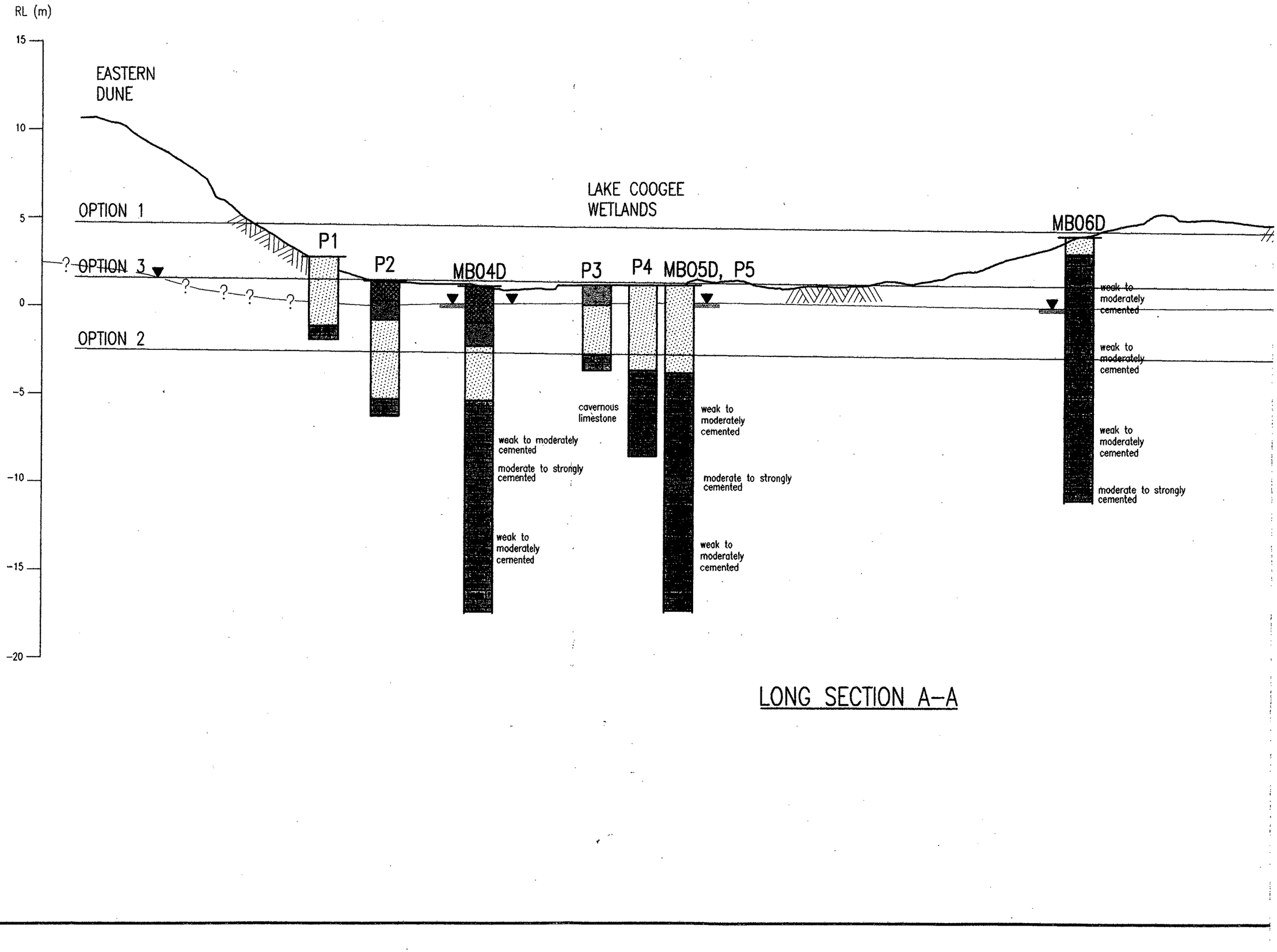
In order to achieve the preferred option, the main sewer extension will have to slope steadily downwards from the existing pump station on Mayor Road. A vortex drop will be built near the point of connection into the existing Bibra Lake main sewer to ensure sufficient depth is achieved for the low bridge (a gradual slope without the drop section would result in the high bridge). The topographic map indicates where the sewer will be above ground and a what depth it will be when underground.

5.1.3 Geology

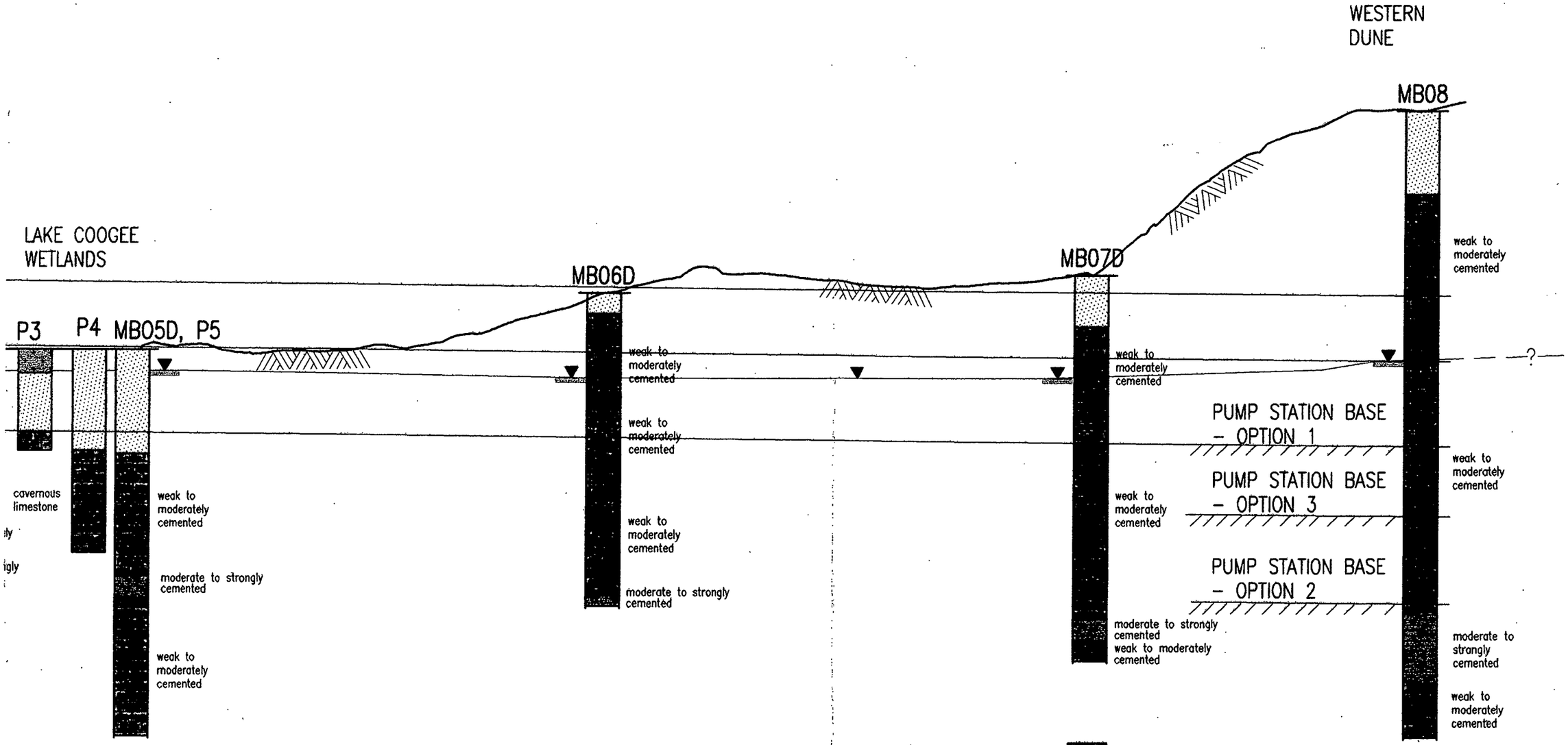
Geological, geotechnical and hydrogeological assessment was undertaken by Golder Associates. The following sections of this report using *this alternative font* are verbatim copies of the pertinent sections.

The study area lies on the Swan Coastal Plain and is underlain by a variable sequence of Quaternary and Tertiary age deposits to a maximum thickness of about 70 m. These are underlain by Cretaceous age siltstone, sandstone sand shale. The superficial strata (to a nominal depth of about 50 m) will exert the greatest influence on the construction of the sewer trench and pumping station. The general stratigraphy in the project area comprises loose to moderately dense, orange-brown, fine to medium grained quartz sand over limestone (Tamala limestone). The base of the inter-dunal depression is covered with several metres of weak unconsolidated materials including up to 2 m of sand and limestone rubble fill, very loose to loose silty sand or peaty sand, and very soft to soft compressible peat.

Figure 13 following shows a long section along the sewer route, starting at Fawcett Road. The depth to limestone varies along the alignment, and is greatest in the area of the Lake Coogee wetlands.



LONG SECTION A-A



LONG SECTION A–A

Golder Associates

Drawn: LMB	Date: 07-10-98	MUNSTER SEWER AND P/S No. 3 LAKE COOGEE BOREHOLE PROFILE DIAGRAM	
Checked: SMW	Date: Oct 98		
Revision:	Date:		
Scale: H 1 : 2000 V 1 : 200	A3+	Project No.: 98640233.	FIGURE 13

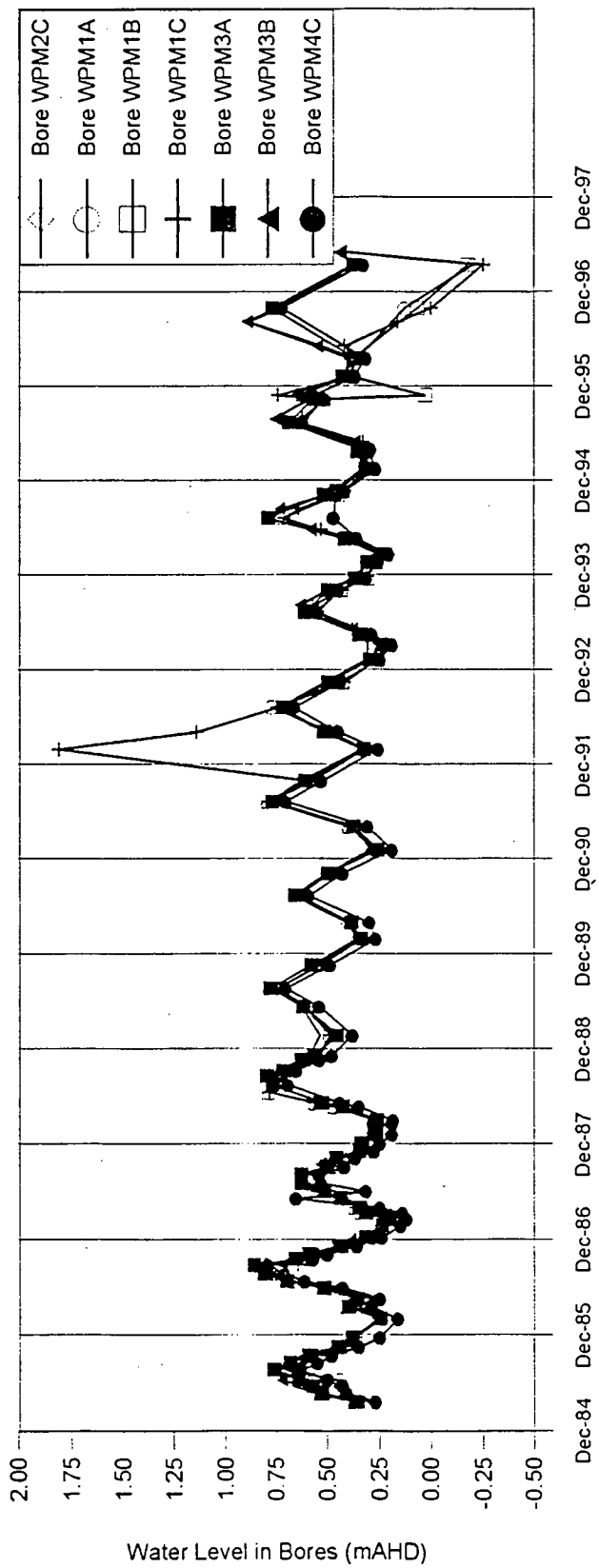
5.1.4 Groundwater Flow Systems

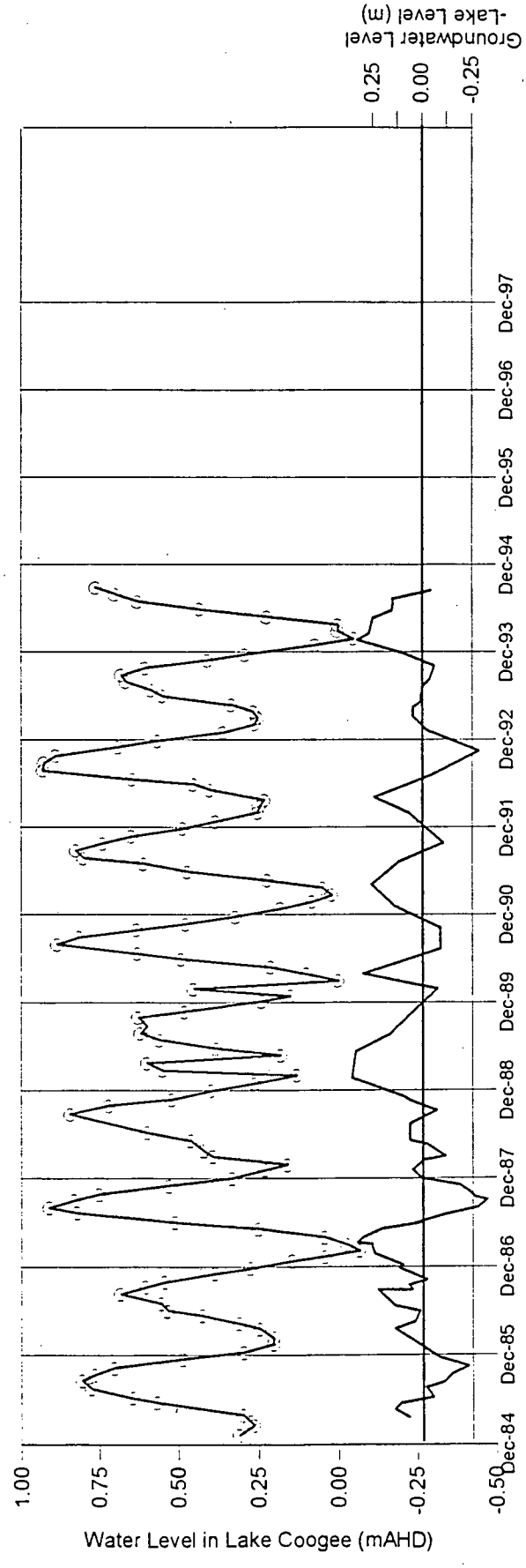
Groundwater flow within the Tamala Limestone occurs in two unconfined flow systems: the Jandakot Mound (Allen, 1976; Davidson, 1981) and the Woodman Mound. Lake Coogee itself is located at a low point in the water table between these two mounds (Hirschberg, 1984). The Jandakot Mound is a major flow system centred east of the lake area, with flow towards the lake from the centre of the mound. The Woodman Mound is a minor, seasonally variable flow system centred beneath the dune belt to the west of the lake, with flow eastwards towards the lake and westwards towards the sea. Recharge to the unconfined flow systems is estimated to be approximately 20% of incident rainfall (Davidson, 1981).

Groundwater flow changes direction, depending on the time of year

Groundwater extraction takes place from over 100 private wells in the area to the east of Lake Coogee, for irrigation of market gardens. Total groundwater extraction has been estimated at $3.1x10^6$ kilolitres/year, with up to 50% of this volume returned to the groundwater system due to enhanced recharge in the irrigated areas (Hirschberg, 1989). A depression of up to 0.75 m in the water table is evident at times in the area of pumping (Hirschberg, 1984). However, monitoring of water levels in a network of monitoring bores around Lake Coogee throughout the 1980's Hirschberg (1989) indicated that the flow systems were relatively stable over this period of time, suggesting that the groundwater flow system is in a state of relative equilibrium with groundwater extraction in the area.

The water table elevation in the project area varies seasonally by approximately 0.5 m, around an average elevation of approximately 0.5m AHD. Part of this fluctuation is possibly due to increased pumping from irrigation wells during the dry season. The variations in water level in seven bores in the vicinity of the Woodman Point Waste Water Treatment Plant are illustrated in Figure 14, for a period of approximately 13 years. The locations of the bores is illustrated in Figure 15. Installation and monitoring of these bores were undertaken by the Water and Rivers Commission. The depths and/or screened intervals of the bores is not known, however some of the bores are apparently installed in close proximity to each other in multi-level "nests." The similarity of response at all the bores indicates that horizontal and vertical gradients are minimal, as would be expected in an environment with a high hydraulic conductivity.





Golder Associates	CLIENT: Water Corporation		PROJECT: Munster Sewer and P/S No 3
	DRAWN: SRF	DATE: Oct 1998	TITLE: Variations in Lake Coogee Water Levels and Groundwater Levels
	CHECKED: SMW	DATE: Oct 98	
	SCALE: As shown	A4	PROJECT No: 98640233
			FIGURE 14

98640233/84233g02 grf/wlevels.csv

N

P5 P4 P3 P2 P1

MB05S,D

MB04S,D

A

MB06S,D

Lake Coogee

MB07S,D

MB08

A

MB02

MB03

LEGEND

MB08 - MONITORING BORES

P1 - ELECTRIC-FRICTION CONE PENETROMETER TEST LOCATION.

1:3000 0 30 60 90 120 150 m

Golder Associates	CLIENT: Water Corporation		PROJECT: Munster Sewer and P/S No. 3
	DRAWN: T. Pollock	DATE: Sept. 1998	TITLE: Site Plan
	CHECKED: LC	DATE: 16.10.98	
	SCALE: 1:3000	A3	PROJECT No: 98640233 FIGURE 15

C:\JOBS98\98640233\drawings\84233f02.dwg

5.1.5 Salt Water/Fresh Water Interface

An interface between fresh water and salt water exists in coastal regions. Fresh water flowing towards the coast is underlain by a wedge of denser saline water which extends inland from the coast. Depending on various factors such as flow velocities, the change from fresh water to saline water may occur at a relatively abrupt interface, or may occur over a wider "mixing zone." As an approximation, in steady state situations the depth of the interface between fresh water and the salt water is commonly taken to be equal to forty times the height of the water table above sea level. Since the water table fluctuates seasonally, the depth of the interface will also vary seasonally, moving inland and upwards during summer, and seaward and downwards during winter. The position of the interface would also change with changes in extraction from the irrigation bores to the east of Lake Coogee.

Saltwater, similar to seawater underlies the fresh groundwater at Munster. There is a small risk that some of this could be pulled towards the surface during de-watering.

Profiles of salinity vs. depth at two locations in the vicinity of Munster No. 2 Pumping Station were reported by Bestow and Hirschberg (1982). The profiles indicated that in this area, water with a salinity similar to that of seawater was present below a depth of 30 m, with a relatively wide mixing zone of brackish water present to within a few metres of the surface. These profiles were measured after the period of dewatering at the Pumping Station (PSZ), and it is possible that saline water was drawn upwards by the dewatering, resulting in the thick zone of brackish water.

Monitoring results for five multi-level bores on the eastern shore of Lake Coogee are reported in Hirschberg (1989), for the period 1981-1987. These results indicate that in this area, the location of the salt water/fresh water interface fluctuates by up to several metres from one season to the next.

5.1.6 Regional and Local Water Quality

Groundwater in the Lake Coogee area is widely exploited for irrigation purposes. Results of water testing carried out on irrigation bores in the general vicinity of the project area are available from the Water and Rivers Commission ("WRC"). The WRC was also able to provide groundwater monitoring results from a number of bores at Woodman Point and results of tests carried out on water taken from Lake Coogee. These water chemistry data were reviewed by Golder Associates and are summarised in Tables 4, 5 and 6 following.

Groundwater in the are has been affected by man made sources from Market Gardens and Industry.

The chemical data summarised in Tables 4 through 6 illustrate some of the main attributes of water in the project area. Water in the unconfined aquifer of the coastal plain is dominantly of a sodium chloride type. In the market garden areas around Lake Coogee, shallow groundwater tends to show a narrower sulphate:chloride ratio than is common elsewhere on the coastal plain. (That is, the ratio of sulphate to chloride in shallow groundwater near Lake Coogee is commonly 0.25 or higher, whereas shallow groundwater elsewhere in the coastal plain would typically have sulphate to chloride ratios of 0.15 or less). The ratio of sulphate to chloride in seawater is typically about 0.02 to 1.

The increase in sulphur in shallow groundwater around Lake Coogee has been attributed to the influence of heavy use of phosphate fertilisers Hirschberg, 1989), although a minor component of the sulphur in groundwater may be associated with atmospheric deposition of sulphur from heavy industry in the Kwinana area. Levels of oxygen demand (BOD5) reported for water samples taken from Lake Coogee during the period 1970 to 1984 were exceptionally high, with a minimum reported BOD5 of 60 mg/L for the twenty-eight readings taken during that period. Unfortunately, no BOD results are available for irrigation bores or monitoring bores in the area, so it is difficult to explain the high levels of oxygen demand measured in the lake water.

TABLE 4 - Summary of Water Chemistry - Lake Coogee Region Irrigation and Monitoring Bores

Parameter	Average	Maximum	Minimum	Median	No of Results
pH	Not calculated	7.9	6.8	7.5	58
TDS	3361	21,200	620	1120	19
Sodium	1170	6330	68	195	40
Calcium	200	494	66	143	40
Magnesium	152	799	6	28	40
Potassium	40	188	3	14	40
Chloride	2128	11500	112	334	40
Sulphate	404	2080	35	130	40
Bicarbonate	308	721	146	282	40
Carbonate	9.6	40	5	5	40

Units are Mg/L

TABLE 5 - Summary of Water Chemistry - Woodman Point Monitoring Results

Parameter	Average	Maximum	Minimum	No. of Results
pH	Not calculated	8	6.9	12
Electrical Conductivity, µS/m	47,836	93,200	30,400	25
Chloride	57	106	15	5
Sulphate	24	24	24	1
Kjeldahl N	0.203	1.065	0.074	20
$NO_3 + NO_2$	0.799	3.02	0.15	21
Total N	0.966	3.283	0.311	19
Reactive P	0.004	0.01	0.002	4
Total P	0.014	0.19	0.002	21

Units are mg/L

The influence of anthropogenic inputs is also reflected in the relatively high levels of nutrients in lake water and in monitoring bores at Woodman Point. Lake chemistry results from the late 1970s and early to mid-1980s recorded relatively high average concentrations of a number of metals, including cadmium, copper and lead. The occurrence of elevated levels of these metals in lake water is likely to be associated with agricultural inputs, althougn minor contributions from the Woodman Point WWTP and from atmospheric deposition may also be a factor.

The salinity of groundwater at shallow depths (within a few metres of the water table) is typically in the range 600 mg/L to about 1200 mg/L. Lake water salinities vary through the year from less than 5000 mg/L to over 25,000 mg/L, reflecting the influence of evaporative concentration of lake water through the year. Water from greater depths in the unconfined aquifer (in the order of 20 m to 30 m deep, or greater) is typically characterised by relatively high salinity, approaching the concentration and ion composition of seawater.

TABLE 6 - Summary of Water Chemistry - Lake Coogee Monitoring Results

Parameter	Average	Maximum	Minimum	No. of Results
pH (lab)	Not calculated	9.6	8	32
TDS	19,329	45012	1560	27
Chloride	8991	23263	1759	32
Suspended solids	91	482	2	26
Dissolved Oxygen	8.3	10.7	6.9	3
BOD5	778	6600	60	28
Kjeldahl N	4.4	10.3	0.7	11
NO3 + NO2	0.36	0.36	0.36	1
Total N	5.1	15.5	0.3	30
Total P	0.18	1	0.01	43
Cadmium (F)	0.024	0.09	0.01	14
Chromium (F)	0.026	0.06	0.02	17
Copper (F)	0.046	0.13	0.01	14
Lead (F)	0.094	0.46	0.04	17
Mercury (F)	0	0	0	14
Zinc (F)	0.024	0.05	0.01	17
Iron	0.115	0.3	0	23

Note : Results in Table 6 include data for the period April 1970 to august 1998. Metals values are for the period to September 1984. Units are in mg/L, except for pH, which is expressed in pH units. The letter "F" indicates the sample was filtered.

5.1.7 *Groundwater/Surface Water Interactions*

The variation in water level in Lake Coogee with respect to water levels in nearby bores is illustrated in the preceding Figure 14, for a period of approximately 10 years. It can be seen that lake water level highs and low correspond temporarily to groundwater level highs and lows. However, a direct comparison of the levels indicates that the hydraulic gradient between the lake and its surrounds fluctuates throughout the year, with flow towards the lake occurring in summer and flow away from the lake during winter.

Lake Coogee is a low point in the system, to which everything tends to flow at certain times of the year.

Overall, however, gradients appear to be towards the lake more often than away from the lake, which indicates that the lake normally acts as a "discharge lake" . (That is, both surface water runoff and groundwater discharges concurrently feed into the lake, from where a substantial amount of the inflow is then "discharged" as evaporation.) The fact that the salinity in the lake is not continuously increasing over time indicates flushing of the lake occurs, either during times of high hydraulic gradient away from the lake, or due to lateral surface flow to the north or south.

5.1.8 *Chemical Analyses*

The chemical testing programme for this investigation was designed to provide information on the general chemical character of groundwater likely to be intercepted during construction of the trench and pump station and to provide a preliminary assessment of the contamination status of both the groundwater and surface waters in

the project area. This information is required as input to Water Corporation's considerations of options for disposal of water during construction dewatering.

Eleven water samples were collected for testing. Samples were collected from boreholes by means of a Grundfos MP1 pump, which was flushed with clean water in between sampling events. Samples of lake water were taken by partially submerging a clean sampling bottle below the surface of the lake, and allowing water to flow into the bottle. All sample bottles were provided by the testing laboratory.

Readings of water electrical conductivity and pH were taken in the field immediately after sampling. Samples were not filtered in the field or in the laboratory, in order to better represent the "worst case" condition of water which might be discharged during construction[1]. Samples were stores in a chilled "Esky" during the interval between sampling and transport to the laboratory. All water samples were delivered to the testing laboratory within 24 hours of sample recovery.

Samples were prepared and analysed by Australian Environmental Laboratories, who are NATA accredited for the analyses included in the testing programme. A copy of the AEL laboratory report is presented in Appendix D. A summary of the results of chemical testing of water samples is provided in Table 7 following.

5.1.9 Chemical Analysis Results

Results of chemical analysis carried out on samples of groundwater and lake water are summarised in Table 7. A copy of the analytical laboratory report prepared by AEL is provided in Appendix D. The results in Table 7 include two samples of lake water (LCN, from a position north of the causeway, and LCS from a position south of the causeway) and nine groundwater samples. The main findings of the water testing programme carried out during this preliminary investigation are:

- *groundwater salinity was in the range 600 mg/L TDS to 1600 mg/L TDS, which is typical of water quality in the region*
- *water recovered from the lake was much more saline than the water recovered from groundwater bores, and water from the open body of water south of the causeway was about twice as saline as water from the wetland area to the north of the causeway; the salinity of water in the lake was higher than is usual in winter months, which is likely to be a reflection of the relatively dry winter experienced in Perth in 1998*
- *the ionic character of lake water differed from the ionic composition of groundwater sampled during the field investigation; the composition of the lake water reflected the influence of rainfall inputs to the lake during the field investigation period*
- *all water samples had levels of inorganic nitrogen which may contribute to excessive algal growth and to eutrophication of surface waters*
- *levels of total phosphorus in five of the nine groundwater samples tested were in the range that might be expected to contribute to excessive algal growth and to eutrophication of surface waters*
- *both of the lake water samples tested showed levels of phosphorus well above the ANZECC recommended criteria for protection of aquatic ecosystems, although not all*

Nutrient levels in all samples were in excess of ANZECC guidelines.

[1] Water samples tested for "soluble iron" were filtered by the testing laboratory. Other metals are reported as total metals and were unfiltered.

of the phosphorus present may exist in biologically available forms (such as orthophosphate)

- *lake water showed higher levels of oxygen demand than did samples of either deep or shallow groundwater; BOD levels were similar in lake water samples taken either side of the causeway*

- *levels of heavy metals in both lake water samples and all groundwater samples satisfied EPA criteria for toxicants in water used for ecosystem support; this finding is in contrast to historical monitoring results for Lake Coogee, which showed contamination by cadmium, copper and lead (all of which have been used in the past in pesticide formulations).*

- *levels of organochlorine and organophosphate pesticides in water were below the analytical detection for every analyte in every sample; there is no evidence of lake water or ground water contamination by organic pesticides*

Heavy metal and pesticide levels were either suitable for ecosystem maintenance or below detection limits

In general, the results of the field testing programme show that the lake is affected by excessive nutrient levels, particularly of nitrogen. The level of readily available (inorganic) nitrogen in groundwater which may be intercepted during construction of the trench and pumping station is similar to the level currently existing in the lake. In contrast to past monitoring results, the recent results do not indicate heavy metal contamination of the lake water. Levels of metals in groundwater were similar to, or lower than, the levels measured in the lake. All metals levels measured during Golder Associates' recent field investigation were below the maximum values recommended by ANZECC in water used for support of aquatic ecosystems.

Certain water constituents were present in lake water (and possibly in deeper groundwater) at levels which might limit the use of the water for irrigation of sensitive crops. These potentially limiting constituents include boron and chloride.

TABLE 7 - Summary of Water Analyses

Analyte	LCN	LCS	04S	04D	05S	05D	06S	06D	07S	07D	08	EPA Criteria	WRC Guidelines	Drinking Water Criteria
pH	7.8	7.8	7.3	7.5	7.6	7.6	7.8	7.5	7.3	7.5	7.5	6.5-9.0	BG±0.2	6.5-8.5
EC, µS/cm	10,000	20,000	1500	1300	2500	1600	1200	2000	2300	1900	1800	-		-
TDS, mg/L	5500	11,000	780	770	1600	870	600	1200	1400	1000	1000	BG±5%	BG±10%	500
TSS, mg/L	<5	130	30	230	80	95	<5	25	10	<5	<5	BG±10%	BG±10%	-
Inorganic N, mg/L	1.1	0.8	4.1	8.4	0.8	0.4	1.6	0.2	0.2	3.8	4.4	0.1-0.5		50 (NO3)
Total P, mg/L	0.25	0.30	0.05	<0.05	0.05	0.1	<0.05	<0.05	0.05	0.05	<0.05	0.005-0.05		
Ortho-P, mg/L	0.1	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	-		
BOD5, mg/L	10	10	<5	<5	<5	<5	<5	<5	<5	<5	<5	-		
Pesticides, ug/L	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	(various)		
Arsenic*, mg/L	0.002	0.001	0.005	<0.001	0.006	0.003	<0.001	0.010	0.017	0.003	<0.001	0.05		0.007
Boron, mg/L	0.6	1.1	0.1	<0.1	0.1	0.1	<0.1	0.1	0.1	0.1	0.1	-		0.3
Cadmium, mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.002	BG	0.002
Chromium, mg/L	0.015	0.035	0.010	0.015	0.030	0.010	0.005	0.015	0.010	0.010	0.010	0.05	BG	0.05 (CrVI)
Copper, mg/L	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	0.005	BG	2(1)
Iron (soluble), mg/L	0.15	1.1	0.20	0.15	0.25	0.20	<0.05	<0.05	0.10	0.10	0.15	-		(0.3)
Lead, mg/L	0.010	<0.005	<0.005	0.01	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	0.005	BG	0.01
Mercury, mg/L	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	0.0001	BG	0.001
Zinc*, mg/L	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.02	BG	(3)

EPA criteria are those recommended for support of marine ecosystems. WRC guidelines for construction site dewatering stipulate that any nutrient discharges in water should not result in excessive or nuisance algal growth in the receiving water. Drinking water criteria in parentheses are criteria derived on the basis of aesthetic considerations. The letters "ND" mean that no pesticide was detected.

5.2 Contaminated Site Assessment

During the course of determining the appropriate alignment it became clear that the area of land immediately to the North of Market Garden Swamp No.3 had been filled with material of an uncontrolled nature.

Uncontrolled fill to the South of Mayor Roads appears to contain demolition rubble from residential and industrial origin.

During the geotechnical investigation of this section 5 test pits were excavated using a backhoe. The approximate locations of these test pits are shown in Figure 16, following. The test pits were between 4 and 5 metres deep and photographs of the material excavated from the pits are shown in Figures 17 to 24, below. This material is clearly of demolition origin, with the majority of the material being residential in origin. However a section of concrete footing excavated from test pit 1 was approximately 500mm thick which exceeds the requirement for residential construction and suggests that some of the material is of industrial origin. In addition there were occasional small fragments of asbestos sheeting. There was no evidence of putrescible waste that might lead to methane generation.

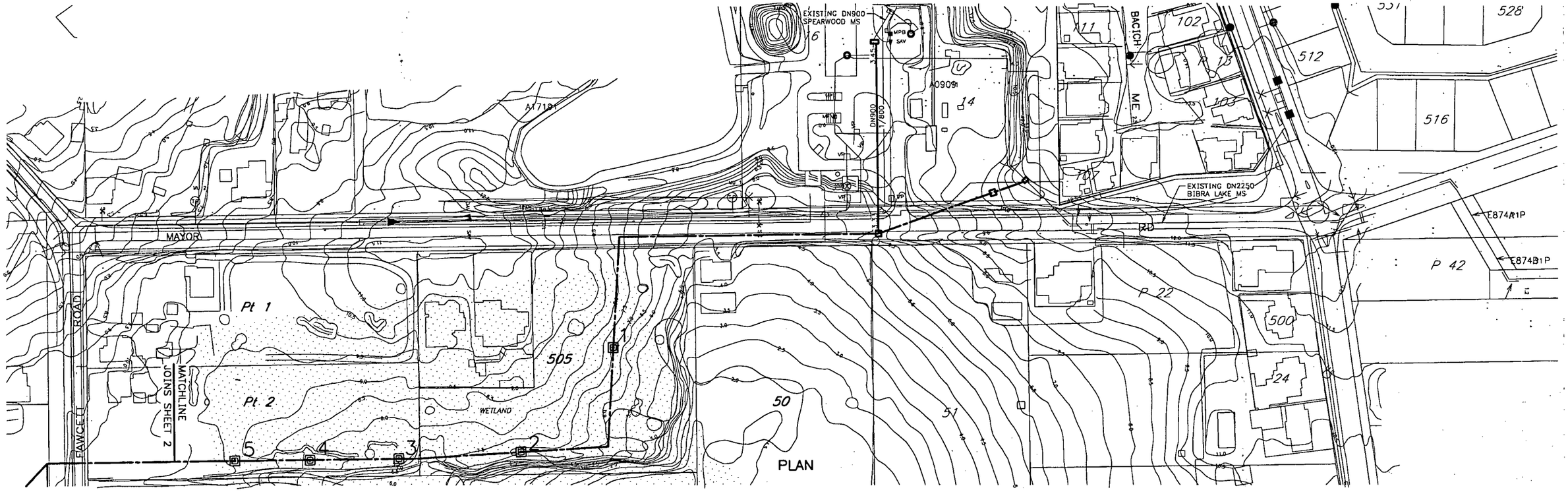


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FIGURE 16
APPROXIMATE LOCATIONS OF
CONTAMINATED SOIL TEST PITS

FIGURE 17 - Test Pit 1

FIGURE 18 - Material Excavated From Test Pit 1.

FIGURE 19 - Material Excavated from Test Pit 2

FIGURE 20 - Material Excavated from Test Pit 2

FIGURE 21 - Material Excavated from Test Pit 3

FIGURE 22 - Test Pit 3

FIGURE 23 - Material Excavated from Test Pit 4

FIGURE 24 - Material Excavated from Test Pit 5

Two samples were taken from each test pit and sent for analysis with Australian Environmental Laboratories. The samples were tested for; organo-chlorine pesticides, heavy metals, total petroleum hydrocarbons, pH and sulphate. The latter items are not particularly of concern from a contamination perspective, but are important in indicating the potential for corrosion of concrete.

Some contaminants were found in concentrations higher than that which would be suitable for residential development - this warrants further investigation.

It should be noted that the sampling regime used in this program is not statistically sufficient to definitively eliminate the possibility of contamination, however given the consistency of the findings it would suggest that the material is not grossly contaminated. It is recommended that if the nature of the fill material varies from demolition material then a further investigation is undertaken.

The results of the analyses are shown in detail in Appendix E. Regrettably during the analysis stage one of the samples was lost. Three areas of concern were found in the analyses as follows;

1. A lead level from test pit 1 was in excess of the environmental investigation level and would not be suitable for use in areas where access to the material could be obtained. Thus it would be suitable for material under a sealed road, but would not be suitable for back yards or other recreational areas.

   Due to the loss of sample it is not certain that the pit is heavily contaminated or that this was just a hotspot. Further sampling along the line of the proposed trench will be required from the start of the uncontrolled fill to Test Pit No.2. Sampling frequency will be dependent on proposed final land use.

2. Pesticides (Dieldrin and p,p'-DDE) were found in Test Pit 4. The origin of this material is uncertain at such depths and suggest that, rather than being introduced by the Market Gardeners in the course of their activities, it was an integral part of the fill. Further sampling between Test Pit 3 and Test Pit 5 will be required to delineate this contamination. Sampling Frequency will be dependent on final land use.

3. Sulphate levels were elevated in some pits. This contamination pertains to the potential for corrosion of the concrete and will need to be considered when selecting fill material to be replaced into the trench.

Some mercury was found in some of the samples, but only one sample was at the environmental investigation level. The rest were significantly lower and therefore this does not appear to be a significant issue.

5.3 Biological Environment

Assessment of the Biological Environment was undertaken by ECOSCAPE (Aust) Pty Ltd. The following sections using the alternative font are verbatim copies of the original report.

5.3.1 Vegetation

The Wetland vegetation appears to be unusual in its makeup and is probably vulnerable from a conservation point of view.

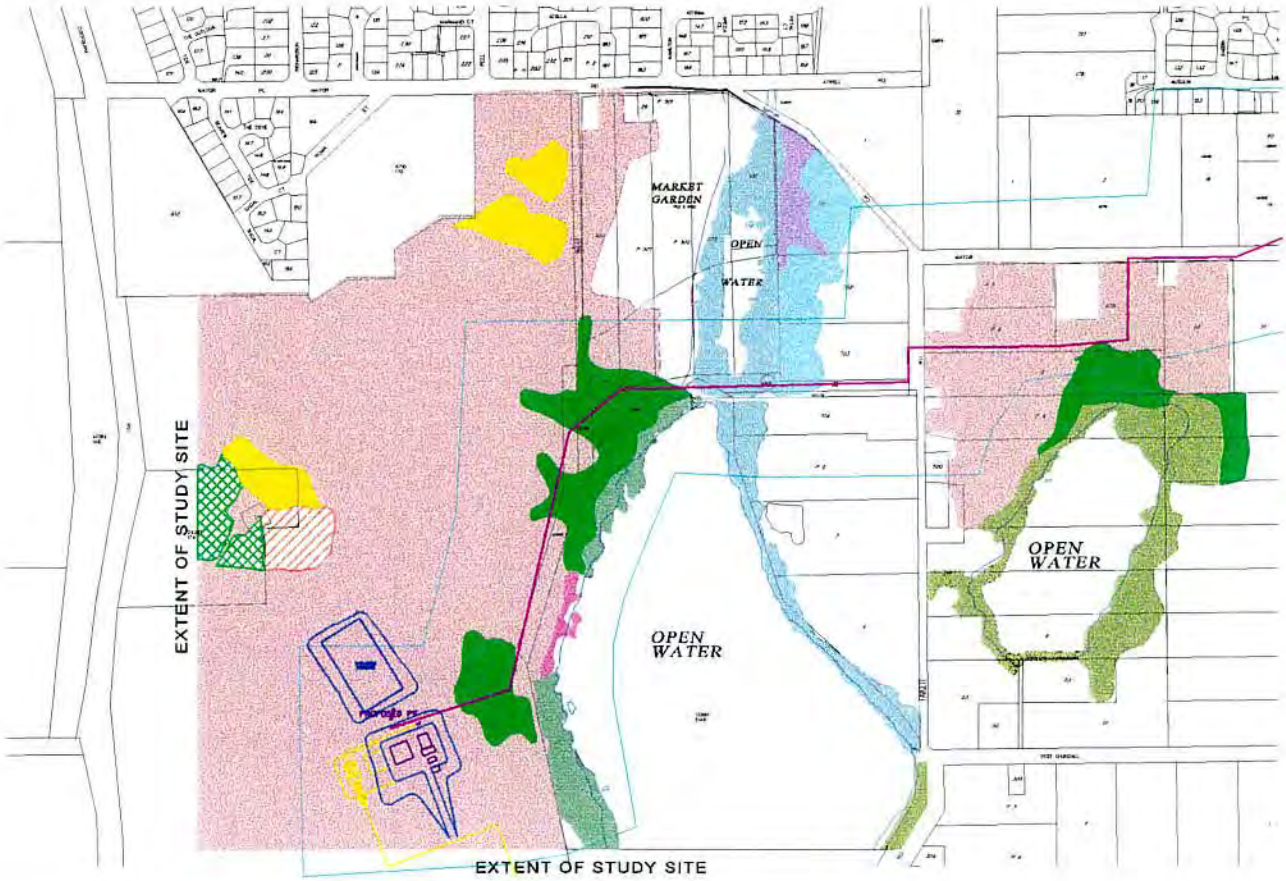
A vegetation map of Lake Coogee is shown in Figure 25, at the end of this section. Much of the non-emergent fringing and upland vegetation surrounding the northern end of Lake Coogee was cleared over 100 years ago. Several mature Tuarts remain, on the slopes between the lake and the limestone ridge to the west, creating a small area of Tuart Tall Open Woodland but little else has been retained. The upland area consists mainly of introduced pasture grasses and annual weeds. A thin band of emergent vegetation remains, possibly because the saline nature of the wetland discouraged landholders from clearing low lying land for horticultural activities.

The fringing vegetation is dominated by Low Woodlands and Low Forest of the Saltwater Paperbark, *Melaleuca cuticularis*, though some specimens of *M rhaphiophylla* were intermixed with *M cuticularis* in some areas. The fringing vegetation association does not

fit in any of the community types identified in the Flora of the Swan Coastal Plain (Gibson *et al*, 1994), therefore a floristic survey was carried out of this community, as detailed below.

Both young and mature Tuarts were present within the narrow band of fringing vegetation on the north-western and western margins of the lake.

A small stand of *Dryandra sessilis* is present on part of the limestone ridge where the track leads from Mayor Rd to the western margin of the lake. This area also supports remnant individuals of *Banksia attenuata*, *Xanthorrhoea preissii* and *Macrozamia reidlii*. The specimens present are mature individuals whose presence probably predates the 1870s settlement of this area. No sign of regrowth of these species was observed. However, several sites had seedling or sapling eucalypts, probably Tuarts, present.



LEGEND

- Tuart Open Woodland
- Melaleuca rhaphiophylla
- Tuart over Melaleuca cuticularis
- Melaleuca cuticularis Low Woodland
- Sedgeland A
- Sedgeland B
- Fennel
- Cleared land
- Dryandra sessilis Shrubland
- Xanthorhea Heathland
- Melaleuca and Spyridium

0 600m

SCALE: 1:10 000

DIGITAL DATA INFORMATION		
DIGITAL INFORMATION	SOURCE	DATA CAPTURE
Bushland Condition	Ecoscape 1998	1:10000 aerial photo, field study
Cadastral	DOLA	unknown

FIGURE 25

Vegetation Map - Lake Coogee

Date: 16/10/98

File: veg0511-2d.dgn

• E C O S C A P E •
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5.3.2 Floristic Survey

In October, 1998, Ecoscape established two 10 m x 10 m quadrats in the area north of the existing causeway. A floristic survey of these quadrats was carried out using the methodology of the Floristic Survey of the Swan Coastal Plain (Keighery, 1994). The quadrats will be resurveyed, probably during December 1998, as required by the methodology. The data from the floristic survey is provided in Appendix F. The data from the two surveys will be forwarded to CALM for analysis and inclusion into the floristic survey database.

The results show that structurally, the community consists of Low Woodlands of *Melaleuca cuticularis*, intermixed at some locations with *M rhaphiophylla*. Common understorey components include the samphires *Suaeda australis* and *Sarcocornia quinqueflora*. The composition of the sedge component differed between the two quadrats. *Baumea juncea* and *Juncus pallidus* were present in the first quadrat, *Bolboshoenus caldwellii* and *Gahnia trifida* were present in the second. Both *J pallidus* and *B caldwellii* are known to favour disturbed ground. Both quadrats were well-stocked with exotic species, notably the major weed species:

- Wild Oats, *Avena fatua*
- Great Brome, *Bromus diandrus*
- Couch, *Cynodon dactylon*
- Fennel, *Foeniculum vulgare*
- Hares' Tail Grass, *Lagurus ovatus*
- Rose Pelargonium, *Pelargonium capitatum*

The presence of *M rhaphiophylla* in one of the quadrats, associated with the presence of Gahnia trifida indicates that the community present may be a variant of Community Type 17 of the Floristic Survey of the Swan Coastal Plain (Gibson *et al*, 1994), *Melaleuca rhaphiophylla – Gahnia trifida* seasonal wetlands. Although this community type is listed as well-reserved and at low risk in the survey, M Trudgen has indicated that the community type is currently considered to be vulnerable and is assessed as such by State Government agencies (M Trudgen, pers comm). Thus, for the purposes of this assessment, it is immaterial whether the community present is a variant of community type 17 or a new and previously undescribed community as in either case the community is best described as vulnerable and treated accordingly. However, once the floristic survey has been completed, and the assessment carried out by CALM (this is likely to be in early 1999), in order to inform the preparation of an environmental management plan for this project.

Although the community type identification has not been completed yet, a preliminary literature search has been carried out of vegetation surveys of relevant components of the Swan Coastal Plain in order to ascertain whether *Melaleuca cuticularis*, with or without *M rhaphiophylla*, and with the range of sedges and samphires recorded at Lake Coogee is known from other areas of the Swan Coastal Plain. This provides a preliminary placement of the vegetation into a regional context.

Although *M cuticularis* communities are found at several points along the Swan-Canning estuary, the community differs from that at Lake Coogee in the make-up of the understorey sedges, with *Juncus kraussii* being a dominant understorey species. *Melaleuca cuticularis* is also found on saline clay flats east of Forrestdale Lake. Keighery and Trudgen (1992) identified several areas of remnant *M cuticularis* vegetation on the alluvial soils of the eastern side of the Swan Coastal Plain. However, the understorey composition was dissimilar to that found at Lake Coogee.

Although further details are required, preliminary assessment based on the literature indicate that comparable communities may be found on the Yoongarillup Plain geomorphic unit, particularly on the Leschenault Peninsula and around Lake Clifton and

adjacent wetlands. M cuticularis communities are also found around Lake Cooloongup and the Peel Harvey Estuary, though further details are required to establish their comparability.

More comparable vegetation associations are identified in coastal areas of the Swan Coastal Plain. These are summarised in Table 8 below.

TABLE 8 - Swan Coastal Plain Comparable Vegetation Associations

Area and Geomorphology	Description	Distribution	Source of information
Leschenault Peninsula Yoongarillup Plain	*M cuticularis* Low Open Forest. With *Sarcocornia quinqueflora* as main understorey element	Only observed as a thin belt at one location in the study area	Trudgen 1984
Lake Clifton Yoongarillup Plain	*M cuticularis* Low Woodland to Low Closed Forest over *Gahnia trifida* Open Tussock Sedgeland to Tussock Sedgeland	Narrow band around Lake Clifton. Also around 4 seasonal wetlands west of Lake Clifton	Trudgen, 1991 CALM & NPNCA, 1995
Lake Clifton Yoongarillup Plain	*M rhaphiophylla, M cuticularis* Low Woodland to Low Closed Forest over *Gahnia trifida* Open Tussock Sedgeland to Tussock Sedgeland	Narrow band around part of Lake Clifton, also stand of 25 ha on western bank of L Clifton	Trudgen, 1991
Lake Clifton Yoongarillup Plain	*M cuticularis* Closed Scrub to Low Forest over *Baumea juncea* Open Sedgeland to Sedgeland	Small scattered stands	Trudgen, 1991
Duck Pond (west of Lake Clifton) Yoongarillup Plain	*Eucalyptus gomphocephela* Open Woodland over *M cuticularis* Low Open Woodland over *Acacia saligna, Logania vaginalis* High Shrubland over *Gahnia trifida* Tussock Sedgeland	Small stand (1 ha)	Trudgen 1991
Pelican Point			Pen, 1983
Mount Henry, Bull Creek, Salter Point Lagoon, Clontarf, Waterford and Shelley Basin,	Band of *M cuticularis* with occasional *M rhaphiophylla* and *Casuarina obesa* present. Main sedge species *Juncus kraussii. Sarcocornia quinqueflora* and *Suada australis* commonly found.	Thin band on foreshore and as emergents in seasonal lagoons.	Pen, 1983, Brooker *et al*, 1994

5.3.3 Flora

Searches of the Rare and Priority Flora databases held by CALM indicated there are no records of any DRF or Priority Flora species in the Lake Coogee area, nor were any Priority species noted during vegetation and floristics surveys carried out as a part of this project.

The species richness of the northern Lake Coogee area is low and is dominated by introduced species. Native species of note include:

Melaleuca cuticularis Saltwater Paperbark	Although not a priority species, the Saltwater Paperbark is not a common species in the Metropolitan area and the Swan Estuary represents the northern limit of its distribution.
E. gomphocephala Tuart	This species is a common upland tree species on Quindalup and Spearwood Dune systems. However, on the margins of Lake Coogee, it is found within 5 m of the wetland margins, growing within the band of Saltwater Paperbarks.

Introduced species present within and adjacent to the study area include several highly invasive species that have the potential to further replace and degrade the remaining native vegetation. These are listed in Table 9 below. In addition to the species listed were other annual grasses and herbs.

TABLE 9 - Notable Weed Species in the Northern Lake Coogee Area

Common Name	Species Name	Priority
Couch	*Cynodon dactylon*	1
Veldt grass	*Erharta calycina*	1
Fennel	*Foeniculum vulgare*	2
Bridal Creeper	*Myrsiphyllum asparagoides*	1
Pelargonium	*Pelargonium australis*	1
Victorian Ti-tree	*Leptospermum laevigatum*	1
Onion Weed	*Asphodelus fistulosus*	1
Wild Oats	*Avena fatua*	1
Pampas	*Cortadera selloana*	1
Kikuyu	*Pennisetum clandestinum*	1
Prickly Lettuce	*Lactuca serriola*	3
Wild Radish	*Raphanus raphanistrum*	3
Prickly Pear	*Opuntia sp.*	
Pie Melon	*Citrullus lanatus*	3
Petty Spurge	*Euphorbia peplus*	3
Castor Oil Plant	*Ricinus communis*	3
White-flowered Fumitory	*Fumaria capreolata capreolata*	2
Plantain	*Plantago*	3
Geraldton Wax	*Chamelaucium uncinatum*	2
Mulberry		
Blowfly Grass	*Briza maxima*	2
Fig	*Ficus sp.*	
Fountain Grass	*Pennisetum setaceum*	3

5.3.4 Bushland Condition

Bushland Condition was assessed and mapped using a standard Bushland Condition Index (Kaesehagen, 1995). The scale is defined as follows:

TABLE 10 - Bushland Condition Scale

Bushland Condition Scale	
Very Good - Excellent	*Poor*
• 80 - 100% Native Flora composition. • Vegetation structure intact or nearly so. • Cover/abundance of weeds less than 5% • Minor signs of disturbance (tracks, rubbish dumping).	• 20 - 50% Native Flora composition. • Vegetation structure completely modified. • Cover/abundance of weeds 20 - 60%. • Disturbance incidence high.
Fair - Good	*Very Poor*
• 50 - 80% Native Flora composition. • Vegetation structure modified or nearly so. • Cover/abundance of weeds 5 - 20%. • Disturbance influence moderate.	• 0 - 20% Native Flora composition. • Vegetation structure disappeared. • Cover/abundance of weeds 60 - 100%. • Disturbance incidence very high.

From Kaesehagen (1995)

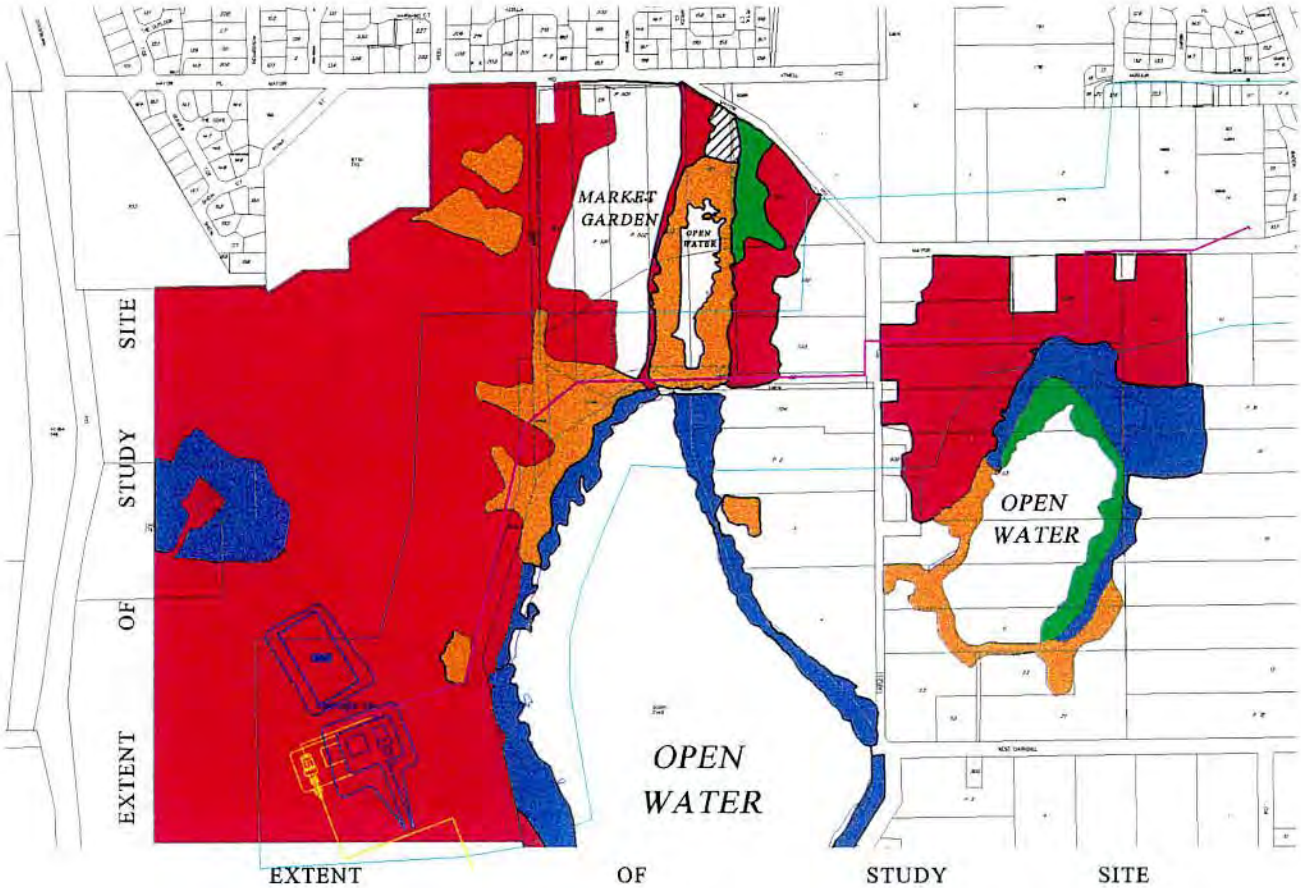
Bushland condition around Lake Coogee is highly variable and reflects its long history of settlement. Vegetation close to the lake on waterlogged soils or seasonally inundated is in good to excellent condition. Around much of the lake, this equates to a very narrow band. However, in the waterlogged and seasonally inundated soils between Lake Coogee and Market Garden Swamp No 2, this forms an area of approximately 2.5 ha. Some of this area has been burnt recently and therefore the bushland condition cannot be determined during the fire recovery period. A number of invasive weeds are present in and around this area which have the potential to reduce the integrity of the fringing vegetation still further.

Most of the vegetation in this area is disturbed to some extent, due to the long history of settlement.

Almost all vegetation outside this band has been cleared or severely disturbed and therefore is in poor to very poor condition, though some stands of limestone heath on the ridgeline are in fair condition.

The use of fuels that were high in Sulphur by industries in the Kwinana industrial belt led to high emission levels of SO_2 that affected vegetation in the area, particularly Tuarts, many of which became staghorned (J. Day, pers. comm.). Emission levels have since reduced.

A diagrammatical indication of the Bushland Condition of the area surrounding Lake Coogee is on the following page. (Figure 26)



BUSHLAND CONDITION SCALE

Very Good - Excellent
80 -100% Native Flora composition
Cover/abundance of weeds less than 5%
Minor signs of disturbance

Fair - Good
50-80% Native Flora composition
Vegetation structure modified or nearly so.
Disturbance influence moderate.
Cover/abundance of weeds 5-20%

Poor
20-50% Native Flora composition.
Vegetation structure completely modified.
Disturbance incidence high.
Cover/abundance of weeds 20-60%

Very Poor
0-20% Native Flora composition.
Vegetation structure disappeared.
Disturbance incidence very high.
Cover/abundance of weeds 60-100% cover

Recently Burnt

0 600m

SCALE

DIGITAL DATA INFORMATION		
DIGITAL INFORMATION	SOURCE	DATA CAPTURE
Bushland Condition	Ecoscape 1998	1:20000 aerial photo, field study
Cadastral	DOLA	unknown

FIGURE 26
Bushland Condition - Lake Coogee

SCALE: 1:10000

Date: 16/10/98

File: bc0511-2d.dgn

• E C O S C A P E •
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5.3.5 *Fauna and Habitats*

5.3.5.1 *Habitats*

Although much of the upland vegetation around Lake Coogee has been substantially modified over time, the existing fringing and emergent vegetation, areas of shallow and deeper water, as well as the upland mosaic of grasslands, open Tuart Woodland and remnant coastal limestone heathlands provides a diverse range of habitats in a relatively small area. Unfortunately most of the habitats are relatively small in area and linkages between them are relatively poor. Tables 11 and 12 on the following page list the habitats and their integrity, then briefly summarises their values for fauna. Please note that aquatic habitats, other than for bird species, are discussed in a separate section on wetland ecology.

TABLE 11 - Habitats And Habitat Integrity for the Lake Coogee Area

Habitats Present	Habitat Integrity
• Mature Tuarts & Tuart woodlands	Poor – Fair
• Fringing woodlands *of M. cuticularis*, with some *M rhaphiophylla*	Good
• Stands of emergent *M. cuticularis*	Poor – Fair
• Fringing and emergent wet sedgelands	Good – Excellent
• Bare shorelines & mudflats with shallow margins	Good
• Open shallow expanses of water	Good
• Grassland	N/A *

TABLE 12 - Habitat Values for Habitats Present at Lake Coogee.

Habitat	Values*
Pasture	This area will support open ground insectivores such as the Magpie Lark and Australian Magpie. Carnivores (ie, Kookaburra) and raptors (ie, Nankeen Kestrel) will be present feeding on house mice and small reptiles. Dugites also favour this type of habitat
Seasonally waterlogged areas	These areas may support populations of amphibians such as the Pobblebonk, *Lymnodynastes dorsalis*. Reptile species may include the Tiger Snake, *Notechis scutatis*, and the Crowned Snake, *Drysdalia coronata*.
Mature Tuarts	Tuarts contain hollows that provide nesting sites for species such as Striated Pardalotes, Ring-necked Parrots, Kestrels, Brushtail Possums and Falsistrelle bats. The fibrous bark of the Tuarts provides a resource for bark foraging species such as Sittellas. However, the lack of other remnant vegetation in proximity to the Tuarts may mean that these resources are not fully utilised.
Acacia shrublands	Both the Acacias and the Tuarts provide food for seed eating species such as Ring-necked Parrots, Silvereyes and Red Wattlebirds.
Fringing woodlands of *M rhaphiophylla* and *M. cuticularis*	Waterbird species nest in trees in wetland fringing vegetation. These include herons, egrets, spoonbills, darters, cormorants and ibis. Brush-tailed possums may also nest in hollows in mature *Melaleucas*. Bats may make use of flaking bark as shelter during the winter months (Hosken, 1996)
Fringing and emergent wet sedgelands and reedbeds of Cyperaceae and Restionaceae species with pockets of Myrtaceae and Mimosaceae shrublands.	The sedge and rush beds provide nesting sites for rails, crakes, waterhens, warblers and grassbirds. Storey *et al* (1993) note that sightings of birds that utilise this habitat have declined over the last 50 years, suggesting that abundance of these species have declined over this period.
Bare shorelines and mudflats with very shallow margins.	Mudflats and shallowly inundated areas provide feeding sites for migratory waders, rails, crakes and waterhens as well as herons, egrets, spoonbills and ibis (Thurlow *et al*, 1986).

* Please note that specific fauna species noted here are representative only, and do not imply, unless supported elsewhere in the text, that the species mentioned is present at Lake Coogee.

Woodlands of *Melaleuca cuticularis* in permanently inundated swamps.	Several waterbird species nest in trees fringing wetlands, these include herons, egrets, spoonbills, darters, cormorants and ibis.
Open, shallow expanses of water.	Shallow water also provides feeding sites for the larger waders.
Open, deep expanses of water.	Darters, larger grebes, pelicans, cormorants and terns may feed on fish in deeper water. Ducks may also use the deeper water for feeding and loafing. Permanent water is an important waterbird refuge during summer, particularly for species such as Grey Teal (Gentilli & Beckle, 1983) and the Clamorous Reed Warbler (Blakers *et al*, 1984).
Water meadows	Water meadows provide feeding sites for herons, egrets, spoonbills and ibis which eat invertebrates, frogs and snakes.

5.3.5.2 Fish and Aquatic Invertebrates

These species are discussed in section 5.5.2, Wetland Biota.

5.3.5.3 Amphibians and Reptiles

No records were found in the literature of species lists from direct observations at Lake Coogee of amphibians or reptiles. Nor have any unpublished data been located. Observations made during field reconnaissance trips to the area and data from the Market Garden Swamps area (Ecoscape, 1995) have been the primary data sources. Frog species within the general area include Green Tree Frogs, *Litoria* sp, and possibly the Bull Frog and the Pobblebonk, *Limnodynastes dorsalis*. The value of the wetland as breeding habitat is limited as many frogs require freshwater rather than saline or brackish water for breeding.

The linear burrowing trail of a Blind Snake was observed approximately 100 m from the edge of Lake Coogee. The species was most likely to be either the Southern Blind Snake, *Ramphotyphlops australis*, or the Fat Blind Snake, *Ramphotyphlops pinguis*. Reptiles recorded from the Market Garden Swamps area include:

- Tiger Snake, *Notatis scutatis*
- Dugite, *Pseudonaja affinis*
- Fence Skink, *Cryptoblepharus plagiocephalus*
- Yellow-bellied Skink or Two-toed Earless Skink, *Hemiergis quadrilineata*
- Southern Pale-flecked Morethia, *Morethia obscura*
- Gecko (species unknown)

It should be noted that it is likely that the reptile fauna is more diverse than recorded to date, though most species will utilise the upland areas and only the Tiger Snake is likely to be common in the fringing vegetation.

How & Dell (1994) surveyed the reptile fauna of 17 areas of remnant bushland, including four sites on the Spearwood Dune System. The four Spearwood sites had identical Skink assemblages and it is reasonable to assume that most if not all of these species may be present in the Lake Coogee area. These species are:

- Fence Skink, *Cryptoblepharus plagiocephalus* (noted above)
- West Coast Ctenotus, *Ctenotus fallens*
- Western Limestone Ctenotus, *Ctenotus lesueurii*
- Western Slender Bluetongue, *Cyclodomorphus branchialis*
- Two-toed Earless Skink, *Hemiergis quadrilineata* (noted above)
- West Coast Four-toed Lerista, *Lerista elegans*
- West Coast Line-spotted Lerista, *Lerista lineopunctulata*
- Western Worm Lerista, *Lerista praepedita*
- Common Dwarf Skink, *Menetia greyii*
- Western Pale-flecked Morethia, *Morethia lineoocellata*
- Southern Pale-flecked Morethia, *Morethia obscura* (noted above)

- Bobtail, *Tiliqua rugosa*

5.3.5.4 Birds

The avian fauna of Lake Coogee has been recorded by Crossley (1995) who recorded species seen during 42 field visits to Lake Coogee between 1993 and 1995. An additional three species were recorded during the Cockburn Wetlands Study (Newman *et al*, 1979). Thus a total of 110 avian species have been recorded at Lake Coogee and in the area of grassland and woodland between the Lake and the limestone ridge to the west. Approximately 55% of the bird species recorded are upland species, with good representation of the following feeding guilds:

- honeyeaters
- canopy insectivores
- open ground insectivores
- carnivores
- large seed eaters

One species of note in the records is the Short-billed Black Cockatoo, *Calyptorhynchus latirostris*. This species is listed on Schedule 1 of the Wildlife Conservation Act. However, the record is of a winter sighting. This species normally migrates to the Wheatbelt during winter and spring, returning to coastal areas to feed in the Banksia woodlands in summer and autumn. It is likely that the record for Lake Coogee represents an isolated incidental sighting and does not represent regular usage of the area as food resources are very limited

The remaining 45% of bird species were waterbirds, waders and shore birds.

5.3.5.5 Mammals

The native mammalian fauna is highly depauperate in the Lake Coogee area. It is possible that the area is used by individuals of the Echidna, *Tachyglossus aculeata*, the Brush-tailed Possum, *Trichosaurus vulpecula*, and possibly the Southern Brown Bandicoot, *Isoodon obesulus*. Apart from a clear imprint of an echidna on a sandtrack west of the lake, no signs of these species have been observed during field reconnaissance, though their presence cannot be discounted. It is also possible that some bat species may make use of exfoliating bark from the *Melaleuca rhaphiophylla* present around the lake as shelter.

There are very few native mammals still living in this area.

The majority of mammals present within the Lake Coogee area are introduced species including:

- Cat, *Felis catus* (feral and domestic)
- Fox, *Vulpes vulpes*
- Dog, *Canis domesticus*
- Rabbit, *Orctolagus cunniculus*
- Black Rat, *Rattus rattus*
- House Mouse, *Mus musculus*

5.3.6 Lake Coogee

Lake Coogee is the eponymous wetland of the Coogee Suite of Wetlands described by Hill *et al*, 1996a). It is a true lake, a permanent waterbody. It occurs in an inter-dunal ridge depression on the Spearwood Dune System and is an irregular, elongated wetland lying in a chain of smaller sumplands along the same north-south axis.

Its stratigraphy is of carbonate muds overlying limestone, though core sampling by researchers at the southern end of Lake Coogee and other wetlands in this suite indicates the presence of dolomitic muds.

Through Bulletins 374 and 686, the Department of Environmental Protection has sought to categorise wetlands of the Swan Coastal Plain according to appropriate management objectives. The Wetland Atlas (Hill *et al*, 1996a & b) builds on the methodology of Bulletin 686 and essentially updates and replaces it. Under Bulletin 374/686, Lake Coogee was allocated to the Resource Enhancement Management Category (R). Wetlands in this category were modified by land uses, but have moderate degrees of naturalness. The main management objective for wetlands in this category was to maintain and enhance the existing ecological functions. However, in the Wetland Atlas, Lake Coogee is reclassified as being in the Conservation Management Category based on:

- First tier assessment incorporates recognition of the fact that Lake Coogee is noted in the WAWRC Perth-Bunbury study as a wetland of regional importance.
- The Wetland Atlas, in identifying the percentage of native vegetation remaining in the 50 m and 200 m buffer zones, erroneously records that 98% of the 50 m buffer and 75% of the 200 m retain their original vegetation cover.

5.3.6.1 Wetland Ecology

The wetland ecology of Lake Coogee has not been studied, as far as can be determined, by any government department or university, or even by amateur naturalists. This is surprising, given that it has a number of unusual features that make it quiet distinctive. These features include:

Lake Coogee is seasonally very saline and is assumed to provide a habitat for salt tolerant species. However little if any work has been done on this lake.

- The wetlands of the Coogee suite have a base of shallow muds and muddy sands, comprising both peat and carbonate muds, underlain by quartz sand and limestone (Semenuik, 1997). The carbonate muds of the suite are of both calcitic and dolomitic origins (Semeniuk, 1997). This is, as far as is known, unique amongst Swan Coastal Plain wetlands.
- Lake Coogee is the most saline wetland occurring on the Spearwood Dune System. Lake Mt Brown and the Brownman Swamps, also part of the Coogee Suite, are brackish rather than saline.
- The occurrence of both freshwater and saltwater paperbark species around the lake suggest that the water chemistry may be of interest.
- The forty wetland study found only a small group of wetlands that had a halophilic fauna; these included Lake Mt Brown and the Brownman Swamps (Davis *et al*, 1993).
- Although phosphorous levels within Lake Coogee are relatively high, there are no records of problematic algal blooms in the Lake,

In the absence of actual data for the lake, the following sections draw on what information is available.

5.3.6.2 Wetland Biota

A search of the published literature and discussions with relevant academics from local tertiary institutions has not uncovered any previous work carried out on the wetland biota of Lake Coogee. Some inferences can be made from macro-invertebrate studies of comparable wetlands from the same suite. O'Brien (1993) notes that a native fish, *Glossogobius suppositus*, was present in the lake, though the source of his information is not given. This species has since been renamed *Afurcagobius suppositus*. It is likely

that *Pseudogobius alorum*, the most common goby in the Swan Coastal Plain wetlands, is also present (H Gill, pers comm)

There is a high degree of variability in the limnological characteristics of the wetlands on the Swan Coastal Plain. Davis et al (1993) correlated various characteristics with the invertebrate species composition of wetlands. Their research showed that the main factors affecting the invertebrate fauna of individuals wetlands were salinity, the degree of eutrophication, colour and seasonality. Therefore, the suite of species at a particular wetland will depend on the physico-chemical properties of that wetland.

Two of the saline wetlands studied by Davis *et al* (1993), that is Lake Mt Brown and Brownman Swamps, are a part of the same wetland suite as Lake Coogee. The species recorded by Davis and her co-workers include representatives from the following groups:

- A halophilic group present in moderately to slightly saline waters (approx. 6000 to 60,000 mg L^{-1}),
- A group of salt tolerant, freshwater forms found at salinities from less than 1000 to approx. 20,000 mg L^{-1},
- A freshwater group without tolerances to salt found only at salinities less than 1000 mg L^{-1}.

(Davis *et al*, 1993, includes descriptions of genus and species found in each group)

Ordination of the of the wetland species data by Davis *et al* (1993) showed that the species assemblage for these two wetlands and Lake Cooloongup, also a saline wetland, were quite distinct from the fauna of the other 37 wetlands assessed. She identified four diagnostic species present in all of these wetlands but not in any others: *Coxiella striatula*, Gastropoda, *Mytilocypris ambiguosa*, Ostracoda, *M. tasmanicus chapmani*, Ostracoda, and *Diacypris spinosa*, Ostracoda. Other species identified as typical of these wetlands by Davis and her co-workers are listed in Table 13 below.

TABLE 13 - Species and Taxa Typical of the Macroinvertebrate Fauna of Lake Mount Brown and the Brownman Swamps, as Identified as by Davis *Et Al* (1993).

Coxiella striatula	*Anisops thienemanni*
Mytilocypris ambiguosa	Haliplidae sp. 2
M. tasmanica chapmani	*Berosus* sp. 1 larvae
Diacypris spinosa	*Procladius* sp. 1
Harpaticoid copepods	*Nilobezzia* sp. 2
Austrochiltonia subtenuis	Stratiomyidae
Austrolestes annulosus	Tabanidae
Austrolestes io	Lepidoptera

Both salinity and eutrophication are important determinants in faunal composition of wetlands. The salinity of Lake Coogee varies seasonally, ranging from brackish in winter/spring to saline in late summer. Davies and her co-workers found that higher

salinities were associated with lower diversity of species, however, this appears to be a natural occurrence rather than a sign of wetland degradation.

Increases in nutrient status results in the increase of wetland productivity Initially this produces increases in the herbivorous macro-invertebrate species, however, if high productivity is maintained, the food web shifts to a detritivore dominated system, sustained by the high biomass of decaying algae. In severe cases anoxia can cause the loss of species, therefore, reducing biodiversity and interrupting the food web of the wetland system.

5.3.6.3 Wetland Vegetation

Work undertaken by Froend *et al*, (1993) shows that wetlands on the Swan Coastal Plain have a zonation of species along the littoral gradient ranging from peripheral wetland tree species, such as *Melaleuca rhaphiophylla, Eucalyptus rudis* and *Banksia littoralis*, to emergent macrophytes at lower elevations. Emergent macrophytes include sedges such as *Baumea juncea*, *Juncus pallidus* and *Gahnia trifida*. Wetland species are adapted to the Mediterranean climate of the region, tolerating periods of flooding and short periods of drought. Levels of tolerance varies however as species have adapted to particular niches on the continuum between upland dune slopes and permanently inundated zones.

Much of the fringing vegetation around the lakes has been lost, to be replaced by weeds that have escaped from the Market Gardens.

At Lake Coogee, adjacent land uses have alienated much of the zone that would normally be occupied by the fringing vegetation zones. Zonation is currently only apparent at the northern end of Lake Coogee, where linear zonation is evident in the seasonally inundated wetland area linking Lake Coogee with Market Garden Swamp No 2. This zone is comprised of seasonally inundated open water surrounded by a band of *Melaleuca cuticularis* Low Woodland, as identified in the floristic survey. This zone ranges between 20 and 80 m in width. To the northwest an additional zone of open sedgeland is present. This area is best viewed from Mayor Rd. It is probable that this band originally extended down both sides of this part of the wetland, but has now been replaced by market gardens or expanses of weeds, notably Fennel (*Foeniculum vulgare*). Assessment of the topography suggests that wetland fringing vegetation zones would have been widest on the northern, eastern and southern shores of Lake Coogee and narrowest on the western shores where the slopes of the ridgeline constrain the width of the bands. The growth of Tuarts within 5 m of the western shores of Lake Coogee provide an indication of this foreshortening.

5.4 Hydrological Connectivity

Until recently, human perceptions of what a wetland was and how its boundaries were defined used the surface water expression of the wetland, particularly the delineation of permanent surface water. It is now recognised that many wetlands have a number of zones which also include permanently inundated, seasonally inundated and seasonally waterlogged areas (Hill *et al*, 1996a&b), and that the extent of wetland vegetation provides a good guide to the boundary of the wetland.

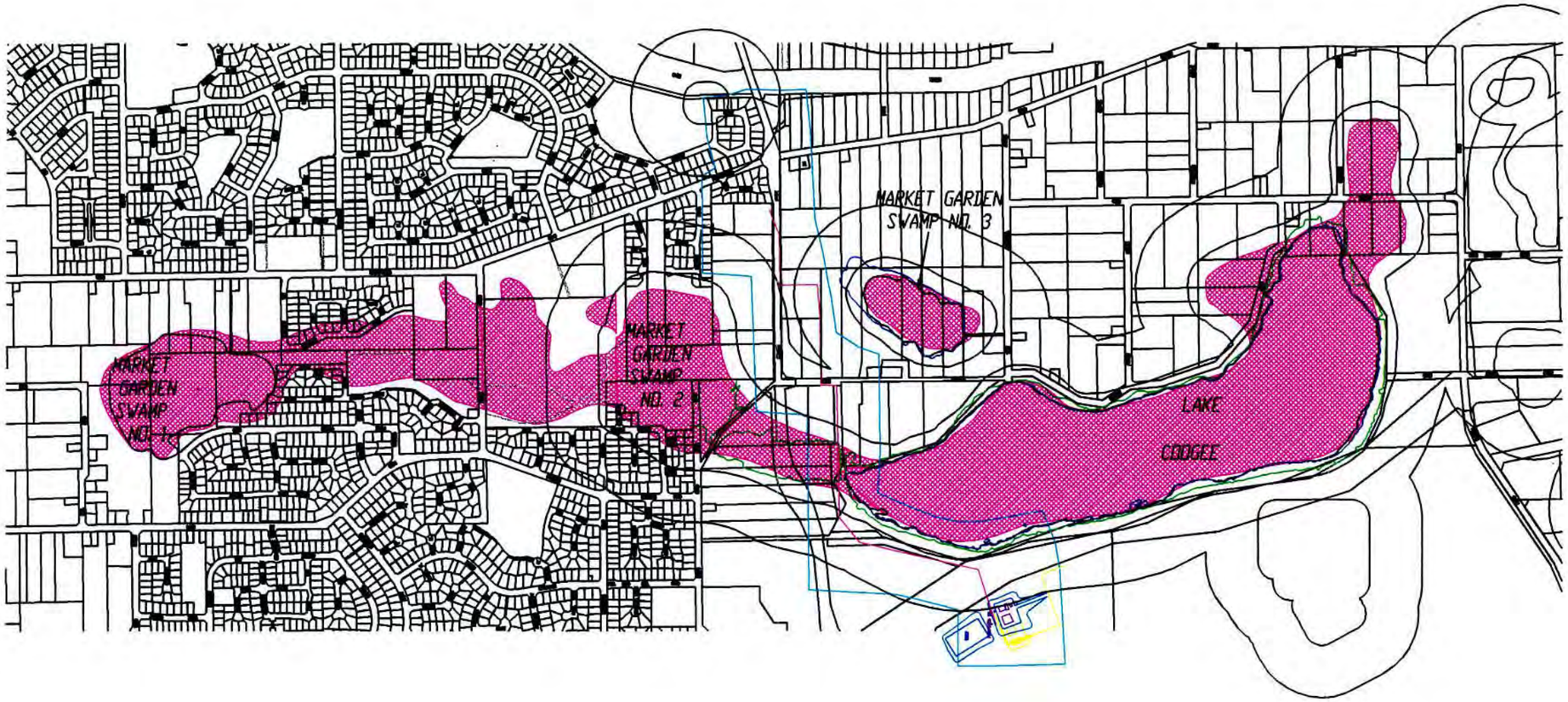
Lake Coogee has traditionally been defined by the area of open surface water. However vegetated, seasonally inundated areas exist both to the north and the southeast of the main waterbody. The area to the south-east has been fragmented by clearing and agricultural activities. The area to the north remains largely intact, apart from the Mayor Rd corridor. This vegetated area of sumpland is named Market Garden Swamp Nº 2. This sumpland has two basins, one north and one south of the Cables Water Ski area. During winter there is a continuous surface connection between the two Market Garden Swamp basins and Lake Coogee, thus they effectively form a single wetland with multiple zonations of waterlogged areas and seasonally inundated basins and a single large permanently inundated basin. This area has been mapped from topography and

Lake Coogee is much larger in extent than the surface water area would suggest.

remnant vegetation and is presented in Figure 27, Connectivity Between Wetlands following this section.

It should be noted that two artificial barriers exist to surface connectivity. These are Mayor Road and the existing services causeway. Each of these barriers includes a single culvert to provide limited interchange between the subdivided areas. The Cables Water Ski development could be considered a third barrier.

The surface flow is generally in a north-south direction. However, the seasonal appearance of the Woodman Point Groundwater Mound west of Lake Coogee means that during summer, groundwater flows north from Lake Coogee into Market Garden Swamp № 2.



NOTE:
Due to placement of fill in some of the perimeter areas the outline of the geomorphic basin may not reflect on ground conditions in some areas. Eg. Cable Waters Ski and properties on Coogee Road

DIGITAL DATA INFORMATION		
DIGITAL INFORMATION	SOURCE	DATA CAPTURE
Geomorphic Basin and Buffer Zones	Water and Rivers Commission	Unknown
Wetland Outline	AAM Survey	1:2000

LEGEND
- GEOMORPHIC BASIN
- WETLAND OUTLINE
- 1m CONTOUR
- 50m BUFFER ZONE
- 200m BUFFER ZONE

PROJECT:
BIBRA LAKE MAIN SEWER AND MUNSTER PUMP STATION 2

CLIENT:
GHD &
WATER CORPORATION

FIGURE 27
CONNECTIVITY BETWEEN WETLANDS

ECOSCAPE
ECOSCAPE (AUSTRALIA) PTY LTD ACN 070 128 675
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SCALE: 1:15000
DATE: 13/10/98
DRAWING No:
ORIGINAL DRAWING SIZE A3
N

6. Natural Heritage

Beeliar Park, including Lake Coogee and the Market Garden Swamps is on the interim listing of the National Heritage database. This database identifies the key natural, heritage and recreational uses of locations. The following text was taken from the database and highlights the natural values of Beeliar Park and the context of Lake Coogee within the park.

6.1 Statement of Significance:

Lake Coogee and the Market Garden Swamps are part of Beeliar Park. This park comprises two chains of wetlands that run in a North-South direction in the Southern Metropolitan area.

The Beeliar Regional Park and Adjacent Areas is an important remnant of ecosystems which were previously more widespread. It has been estimated that, by 1964, 75% of the Swan Coastal Plain wetlands had been drained or filled. The Beeliar wetlands are considered to form one of the most important systems of lakes and wetlands remaining in the Perth metropolitan region. The place supports a number of plants and animals of conservation significance, including Hackett's hopbush (*Dodonea hackettiana*) and *Hibbertia spicata* ssp *leptotheca* which are Conservation and Land Management (CALM) priority species; the rare southern brown bandicoot; nationally vulnerable freckled duck and the lined skink, a CALM priority species.

The wetlands show remarkable diversity in form, degree of permanence, water chemistry and vegetation cover. This diversity of habitat is very important to wildlife utilising the wetlands. The wetlands and surrounding areas are an important nesting and feeding habitat and, because of their high biological productivity, directly or indirectly support most of the wildlife of the surrounding region.

Because the wetlands of the Swan Coastal Plain are the only extensive varied wetland habitat and permanent summer fresh water in Western Australia (WA,) south of the Kimberley, the Beeliar Wetlands are of considerable importance to migratory waterbirds, including a number of species such as the greenshank, wood sandpiper, long toed stint and Oriental pratincole which are listed under the Japan Australia Migratory Birds Agreement (JAMBA). The Spectacles support a significant nankeen night heron rookery; such rookeries are restricted in the south-west of WA.

The Beeliar Regional Park and adjacent areas also has the best developed vegetated limestone cliff remaining in the metropolitan region and large, good examples of *M. rhaphiophylla*, *M. cuticularis* and *M. teretifolia* communities. A number of plant taxa and floristic community types are at the limits of their range in the place, including a number of taxa found on the coastal limestone cliffs which have not been located in other coastal areas.

In addition, the Beeliar Regional Park and adjacent areas makes a significant contribution to the amenity of the region, providing visual and topographic variety in the landscape. The place is also important for scientific research and teaching purposes.

The Beeliar Regional Park and adjacent areas also has significance for its Aboriginal values. It is known that North Lake and Bibra Lake are important to Aboriginal people because it is believed that a dreaming being, the Waugal, inhabits the lakes and maintains the flow of springs that feed them. Significant Indigenous values are known to exist in this area. The Commission is currently consulting with relevant Indigenous communities about the amount of information to be placed on public record. It is possible that non-indigenous cultural values of National Estate significance may exist in this place. As yet, the Australian Heritage Commission has not identified, documented nor assessed these values.

6.2 Description of Beeliar wetlands

The Beeliar Regional Park and Adjacent Areas is an area of remnant bushland and wetlands in the south of Perth. The Beeliar wetland system consists of two chains of lakes running roughly parallel to the coast for a distance of 25km south of the Swan River. The western chain is within 5km of the coast and is mostly saline. The eastern chain lies 5km further inland along the boundary of the Spearwood and Bassendean dune systems and contains several large perennial freshwater lakes.

The wetlands form a complex of swamps and swampy waterways which are permanent or ephemeral, saline or fresh and contain sedges and rushes or are open. They are surrounded by forest, woodland, scrub and herblands and have differing geomorphology, history, soils, vegetation and water character.

Together, these wetlands and surrounding areas form an ecosystem which supports a wide variety of native flora and fauna. Many of the waterbirds and waders that use the wetlands migrate from inland and from abroad, with the great egret, wood sandpiper, white winged tern and greenshank being species recognised under JAMBA. The range of wetland habitats is important for the species utilising them and waterbirds may use several wetlands at different times as conditions become favourable. A species may feed, rest and breed at different wetlands according to food availability, shelter and freedom from disturbance.

The abundance of invertebrates found in the wetlands is believed to be related to the cycle of lakes drying and filling and is important in maintaining the bird populations of the wetlands. The surrounding forest, woodland and scrub support breeding populations of a number of bush birds, mammals and reptiles. Bird species include the western warbler, rufous whistler, sacred kingfisher, grey fantail and Port Lincoln parrot.

The black gloved wallaby (*Macropus irma*), grey kangaroo (*M. fuliginosis*)), brush tailed possum (*Trichosurus vulpecula*), as well as the potentially vulnerable southern brown bandicoot (*Isoodon obesulus*) and endangered lined skink *(Lerista lineata*) are found around the wetlands.

6.3 Western chain areas

Lake Coogee: formed at the end of the last ice age (10,000 years bp) and is a shallow highly saline lake. Little native vegetation remains around the lake except for a strip of salt water paperbark (*M. cuticularis*) which is uncommon in the metropolitan area and has an under storey of sedge and samphire. Although degraded by agricultural activities, the lake is an important sea-bird habitat.

Market Garden Swamps: the three are small, saline, seasonal and eutrophic. Swamp 1 has a good stand of fringing *Melaleuca*. The smaller southern lobe of Swamp 2 is a good example of a salt water wetland containing impressive stands of salt water paperbark and is good bird habitat. The northern lobe of the swamp is a cable waterski park. Swamp 3 is degraded but still of importance to migratory birds. The swamps are in the Spearwood dune system. In the north *M. rhaphiophylla* (swamp paperbark) is dominant, to the south there is a transition to salt water paperbark (*M. cuticularis*) with a sedgeland understorey and samphire. The upland vegetation has been entirely removed apart from a few remnant tuarts. These swamps, along with Lake Coogee, contribute a great deal to the amenity of the coastal landscape.

6.4 Condition and Integrity

Several of the lakes are well managed and are in good condition. Some lakes and several swamps are suffering pollution from industrial developments, agricultural activities, horse riding and offroad vehicles. Generally, wetlands in the western chain are more degraded than those of the eastern chain. Groundwater extraction may affect water levels of the wetlands and some are kept full by artificial means.

Location : About 2700ha, comprising the Beeliar Regional Park as amended and gazetted in the Government Gazette of WA on 17 January 1995, but excluding the following areas of the Park: 1) the drain extending from Frankland Avenue (approximate AMG point Fremantle 50HLK 90703960) to Hope Valley Road: 2) the drain that extends from AMG northing 6438000mN (approximate AMG point 89403800)in the north to Hope Valley Road in the south; 3) the drain extending from Thomas Road to Bertram Road.

7. Aboriginal Heritage

An aboriginal heritage survey was undertaken as part of the assessment. This is a requirement of the Aboriginal Heritage Act (1972).

The Assessment was undertaken by Macintyre Dobson and Associates Pty Ltd and S. O'Reilly and T. O'Reilly and completed in August 1998. A copy of this report has been sent to the Aboriginal Cultural Materials Committee.

The data gathering survey involved four separate phases:

- an examination of the Aboriginal Sites Register at the Aboriginal Affairs Department, Heritage and Culture Division.
- consultation and discussion with relevant Aboriginal groups and spokespersons who have an interest in the Lake Coogee, Munster area under survey,
- several on-site meetings with senior Aboriginal consultants with an interest in the area,
- consultations with other senior Aboriginal spokespersons

7.1 Previously Recorded Sites of Significance

According to the Aboriginal Sites Register there are no previously recorded ethnographic sites in the project area.

7.2 On Site Meetings

A series of meeting were undertaken with Aboriginal groups and consultants. In order to ensure that groups reviewing this document can be certain that there views were considered the issues raised are listed as below, not all issues were raised by all groups;

- An archaeological site in the direction of the lighthouse
- Previously recorded site S2968 was visited
- Minimise impacts on native trees especially Tuart and grass trees
- Concern over the possible presence of Aboriginal remains and a request that this is carefully monitored
- Area should be rehabilitated with native vegetation
- No new sites of Aboriginal ethnographic significance within the boundaries of the proposal
- destruction of native vegetation and a strong spiritual affiliation with vegetation
- pipe leakage and contamination of the lake and water
- the need to increase flow through the existing causeway
- the lake used to be a hunting ground
- a preference for an alignment nearer Beeliar road, but if this was not feasible a requirement that the pipeline be constructed above ground.
- Please employ Aboriginal people in the rehabilitation and landscaping.

8. Post-Settlement Heritage Assessment

Post Settlement Heritage Assessment was undertaken by ECOSCAPE (Aust) Pty Ltd. The following sections using the alternative font are verbatim copies of the original report.

8.1 Post Settlement History

Lake Coogee and the Market Garden Swamps have been subject to three waves of European settlement and was one of the earliest areas of settlement in the colony.

Lake Coogee was originally named Lake Munster after Prince William, the Earl of Munster (crowned King William the IV the following year). The name *Kou-gee* was first recorded in 1841. Since then the name has also been spelt *Koojee*, *Koodjee Coojee* and *Coogee* (Drake & Kenneally, 1995). The lake has been a part of three waves of settlement in the area. The majority of the following summary of the history of the area is taken from Berson (1978) and all statements of fact, unless attributed to other sources, should be attributed to Berson.

Lake Coogee was part of the earliest land grants in the Swan River Colony, granted to Thomas Peel in December, 1829. Peel, an early entrepreneur, proposed that a township to be known as Clarence be established at Woodman Point. He brought 490 settlers with him from England on the *Gilmore* in order to establish his new colony. Due to a series of disasters and mis-timings, the settlement was abandoned within three years, leaving approximately sixty graves behind in the sand dunes between Woodman Point and Lake Coogee. The exact location of these graves is not known.

In the 1860s the area was a part of a large pastoral and timber lease held by Lucius Manning. However the 1870s saw the beginnings of the subdivision of the area into small holdings. In September, 1872, ticket-of-leave man Abraham Hake took up 20 acres on the southern bank of Lake Coogee. He built a house of local stone and cultivated an orchard and market garden. Although suspected of occasional sheep thefts, no charges were ever laid. Two years earlier, a pensioner guard, John Gilbride took up 40 acres north of Lake Coogee, in the area around the Market Garden Swamps. Gilbride also established a limestone cottage, market garden and orchard.

Gilbride was followed in the late 1870s and 1880s by a number of pensioner guards who took up small holdings on the western and northern shores of the lake. The pensioner guards were predominantly Irishmen who had served at least 20 years in the British Army, men who had fought in the Crimea, survivors of the Charge of the Light Brigade, the Indian Mutiny and the North West Frontier. These men had taken posts as prison guards on the convict transport ships and in the new Colony and brought their families with them to settle on the shores of Lake Coogee. The remains of the cottage built by Barney McGrath in 1881-1884 are still visible set back from the south-west bank of the lake, with the remains of a smaller building between the house and the lake. The remains of a second cottage from this era are also present in a saddle in the limestone ridge. These ruins are in poor condition.

Unfortunately, the pensioner settlement was abandoned as the pensioners aged and died. Few of their widows and children stayed past the turn of the century and in the early 1900s, the focus for settlement shifted to market gardens, orchards and vineyards in the South Coogee area. New settlers began to take up the abandoned allotments of the pensioner guards at the northern end of Lake Coogee and this area became the focus for a number of flourishing vineyards, no sign of which remain.

In 1911, the Federal Government proposed to establish a major naval base, to be known as the Henderson Naval Base, at Woodman Point and the old Clarence Townsite. The base was to support half of the Australian Fleet with a complement of 7,500 men. Work began in 1913 with a workforce of 300 labourers and a proposed completion date of 1933. This triggered a land development boom, with prices much inflated by

speculators. Pearce's Koojee Lake Estate was one of the estates proposed. However, the resumption of land for the naval base by the Government wiped out many of the proposed estates. In 1915, despite the expenditure of over one million pounds, the plans were abandoned.

This ended the three main waves of early settlement in the area. In an oral history of the Beeliar Wetlands, Wally Hagan, a long time resident of the area, noted that Aboriginal people did not go near Lake Coogee (Drake & Kenneally, 1995), though Aboriginal use of the other Beeliar wetlands is well documented (O'Connor, 1989; Hallam, 1975). The history of Lake Coogee is a story of abandonment.

Lake Coogee is now a part of the Beeliar Regional Park, under the management of the Department of Conservation and Land Management (CALM). Although to date there have been little if any on-ground environmental management works, CALM has initiated the preparation of a management plan for the Beeliar Regional Park, due to be completed by the end of 1999. Early reports indicate that Lake Coogee will be managed to enhance its conservation values (V Semeniuk, pers. comm.).

8.2 Heritage Sites and their Values

Lake Coogee has been on the interim list of the Register of the National Estate since 1994 as a part of the Beeliar Wetlands. The City of Cockburn Municipal Heritage Inventory also lists a number of places of heritage value in the general vicinity, including several of particular importance for this study (Table 14).

TABLE 14 - Heritage Sites Within the Mayor Road – Lake Coogee Area

Site	Location	Heritage Value	Comments
Lake Coogee		Possibly National	These three wetlands, although modified by post-settlement land uses, have value as a part of the Beeliar Regional Park, thus giving the whole a value greater than the sum of its parts.
Market Garden Swamp No 2		Possibly National	
Market Garden Swamp No 3		Possibly National	
Tuart Trees, Lake Coogee		Local, Management Category B	
Lime Kilns,	Lot 2 Mayor Rd, Munster	Local, Management Category A	
Lake Coogee Ruins	Pt Lot 1 Mayor Rd Lot 9 Cockburn Rd	Local, Management Category B	

Other heritage places within the general vicinity but not affected by the proposed works include the Coogee Lighthouse and Lighthouse Keepers Cottages, the Channel Marker Obelisk and the South Coogee Primary School Buildings.

9. Visual Resource Assessment

Visual resource assessment was undertaken by ECOSCAPE Pty Ltd and the following sections in the alternative font are verbatim copies of their report.

The development of the pipeline and pump station in the northern Lake Coogee area will result in a combination of short-term and long-term impacts on the visual character of the area. The extent of the impacts will vary, depending on the final mode of construction. Therefore, this section defines the landscape character types and the visual character types for the Lake Coogee area. It also presents the results of a scenic quality assessment of the landscape and identifies major viewsheds. This section provides the basis for identifying the potential impacts on the visual character of the area, and for mitigation and management of visual impacts, which will be addressed in subsequent sections.

9.1 Methodology

In order to define the existing visual resources and determine the magnitude and extent of any short-term or long-term changes, a standard assessment methodology is required. For this purpose, the Visual Resource Management System (VRMS) has been used, however, its methodology has been modified to exclude the development of management zones, as this is not appropriate for this project. VRMS is a technique used by the USA Forests Department, the Forests Commission of Victoria, the Department of CALM. This methodology has also been used for a visual resource assessment of the Darling Range sub-region by the Department of Planning and Urban Development (Stuart-Street and Kirkpatrick, 1993). Subsequently, the methodology has been adapted by Main Roads (WA) as a part of its Visual Quality Management Process and by CALM (CALM, 1997).

This area offers some excellent views, especially from the Coogee Heights location, but clearing has lowered the visual appeal.

The Visual Resource Assessment of the Darling Range Sub-Region (Stuart-Street and Kirkpatrick, 1993) utilises scenic quality assessment as a process for identifying landscape features. In particular, scenic quality classification was used which provides descriptive frames of reference that assume qualitative attributes can be assessed according to a set of criteria which includes naturalness, topographic relief, vegetative diversity and mixture. Frames of reference used for comparison of the Swan Coastal Plain Landscape Character Type provide a useful basis for analysis. The frames of reference for the study area were assessed from roadways and where necessary traversing sites on foot.

9.2 Results

Based on the frames of reference the following results were achieved. These results are based on visual analysis undertaken in September 1998.

9.2.1 Landscape Character Type

Stuart-Street and Kirkpatrick (1990) provide an overview of Landscape Character Type for the Swan Coastal Plain. As a part of the visual assessment for the Bibra Lake Main Sewer, the visual characteristics of Lake Coogee, as they pertain to the overall Swan Coastal Plain Landscape Character have been described in Table 15 on the following page.

TABLE 15 - Visual Characteristics of the Lake Coogee Area.

Landform	Form:	Steep limestone ridge to the west, low lying land to the east
	Line:	Strong horizontal form.
	Colour:	Soft yellows and pale greys.
	Texture	Coarse, rough limestone, dusty sands.
	Scale	Long open views to the north and south. The ridge truncates views to the west, but also provides views to the east.
Vegetation	Form	Tall Tuarts, singly or in stands, swathes of grassland, clusters of low green shrubs, bands of paperbarks and sedges,
	Line	Vertical Tuart Trunks, dense horizontal lines of paperbarks, low plains of grasses. Sedges provide a vertical line.
	Colour	Yellow swathes of grass in summer, replaced by green fresh growth in late winter, olive green Tuart foliage, deep green and grey green of paperbarks with white slabs of bark. Soft pink of Geraldton Wax in spring.
	Texture	Rough textured grasses, fibrous trunks of Tuarts, broad ribbons of paperbark, sharp, spiky Parrot bush and soft mounds of Acacias.
	Scale	Vegetation largely cleared, extensive views provided by landform.
Waterform	Form	Sheets of quiet lake water.
	Line	Elongated, linear
	Colour	Shimmering blue, pinkish tinge, pale shallows, brown muds exposed in summer.
	Texture	Smooth, glassy, ruffled, baked fissures in dried mud at the margins in summer
Land Use	Form	Uneven, unused, rectangular market gardens and ploughed bare earth, domes and geometrical industrial shapes, dense garden landscaping, rectangular and triangular houses and rooflines
	Line	Geometrical domestic architecture rising on the northern ridgeline, strong horizontal lines in the WWTP bunds, regular, parallel rows of vegetables.
	Colour	Whites and metallics in the industrial shapes, lush greens and earthy browns of market gardens, pale and medium contrasting tones of bricks and render, reds of tiles and silver of corrugated iron roofs.

9.2.2 Scenic Quality Assessment

The scenic quality assessment frames of reference used here are those developed by Stuart-Street & Kirpatrick (1990) for the Swan Coastal Plain Character Type. Their frames of reference provide a standardised comparison base upon which scenic quality can be assessed as high, medium or low for each of the categories of landform, vegetation, waterform and land use. The results of this comparison are provided below. It should be noted that the frames of reference are based the assumption that scenic quality increases with greater degrees of:

- Naturalness and lesser degrees of man-made alterations
- Relative topographic relief and ruggedness
- Vegetative diversity and crop patchwork effects in agricultural landscapes
- Vegetative diversity and edge diversity of vegetated areas

(DPUD, 1993)

TABLE 16 - Scenic Quality Assessment

Landform	High scenic quality
Vegetation	High (on bund),
	Medium (stands of Tuarts, remnant vegetation around Lake), Low (highly modified or cleared areas)
Waterform	Medium scenic quality
Agricultural Landscape:	
Pattern	Medium (market gardens area)
	Low (cleared slopes of western ridge)
Transition	Medium scenic quality
Structure	Medium scenic quality
Roadside	Not applicable

The results show that overall scenic quality is medium, with low scenic quality where there are extensive areas of cleared vegetation, and that the landform itself and the larger areas of remnant vegetation have a high scenic quality. This is due to its setting in the interdunal swale of the Spearwood system, its distinctive and dramatic vegetation patterns, and the presence of open water surrounded by vegetation. Examples of low, moderate and high scenic quality within the study area are shown in Figure 28 on the following page.

Panorama of Low Bridge Site

1

2 Panorama of Pump Station Site
Note residents on ridge in background

3

Panorama of stand of Tuarts
adjacent to pipeline

4

Panorama of stand of Tuart trees,
(Listed of the City of Cockburns Municipal Heritage Inventory).

FIGURE 29.	PROJECT:	CLIENT:		◦ E C O S C A P E ◦	SCALE: 30 000	DATE: 13/10/98
PANORAMAS OF MAJOR VIEWSHEDS WITHIN THE STUDY AREA	BIBRA LAKE MAIN SEWER & MUNSTER PUMP STATION	GHD Pty Ltd and The Water Corporation		ECOSCAPE (AUSTRALIA) PTY LTD ACN 070 128 675 LANDSCAPE ECOLOGISTS ENVIRONMENTAL CONSULTANTS 21A Pakenham Street Fremantle Western Australia, 6160 Telephone (08) 9430 8955 ◦ Facsimile (08) 9430 8977 email: ecoscape@wantree.com.au	DRAWING No:	N
					ORIGINAL DRAWING SIZE A3	

9.2.3 Seen Area Assessment

Seen area assessment is based on a public's eye view from travel routes and accessible vantage points into the viewshed. The assessment is based on landform screening and excludes vegetation screening as vegetation cover may change over time. Seen Area Viewsheds are divided into three distances:

- Foreground – 0 to 500 m from viewer
- Midground – 500 m to approximately 6.5 km from viewer
- Background – 6.5 km to approximately 16 km from viewer

In the Lake Coogee area, viewsheds are generally restricted by landform to foreground and midground, though views from the Coogee Heights area along the length of the lake may include all three.

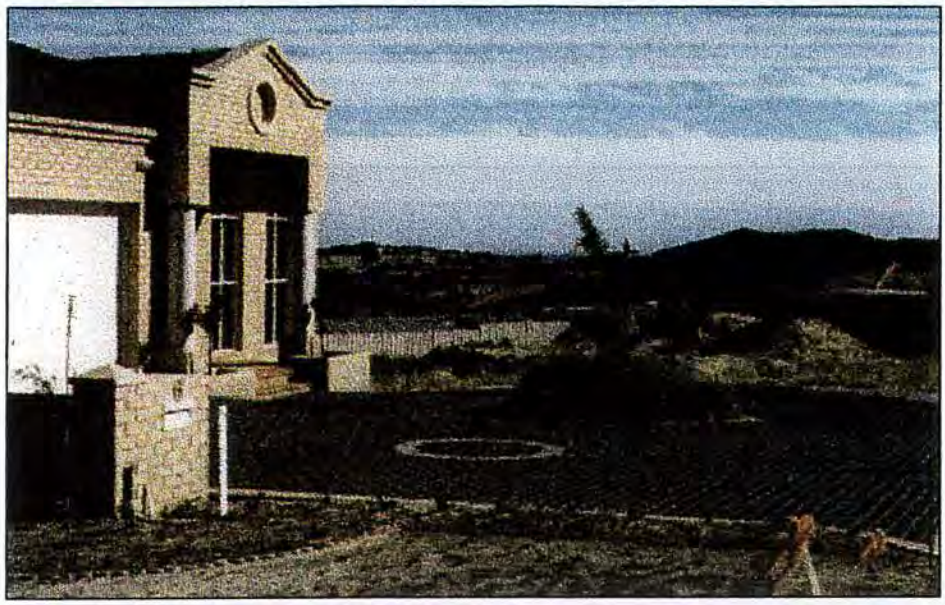
The main vantage points into the area affected by the pipeline and associated infrastructure are as follows:

- from the residential area on the ridgeline northwest of Lake Coogee;
- from Fawcett Road;
- from bush tracks west of Lake Coogee and
- the Dual Use Path around the southern end of the Lake.

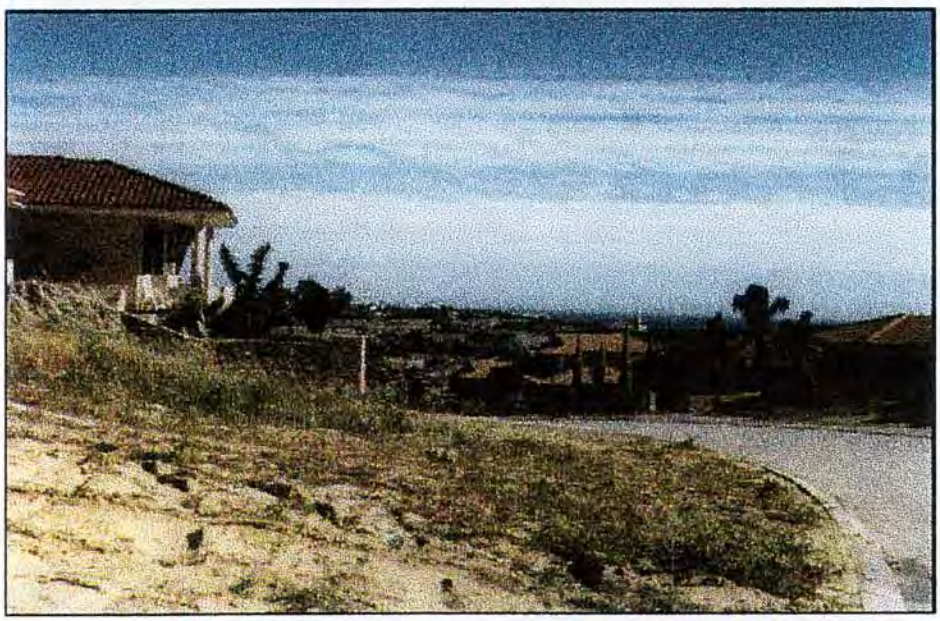
It should be noted that in future additional vantage points may be developed with the construction of the Controlled Access Highway (CAH) and Beeliar Drive. Future urban development, should it occur on the eastern shores of Lake Coogee, may also provide some additional vantage points, depending on the location of developments. The potential for urban development is constrained by the Munster Pump Station buffer zone, which affects lots 702, 703, 704, 2 and 3.

Figure 29 provides an indication of the views into and from the site using panoramas taken from a number of vantage points. In addition, views of the general area from Coogee Heights are shown in Figure 30 on the following page.

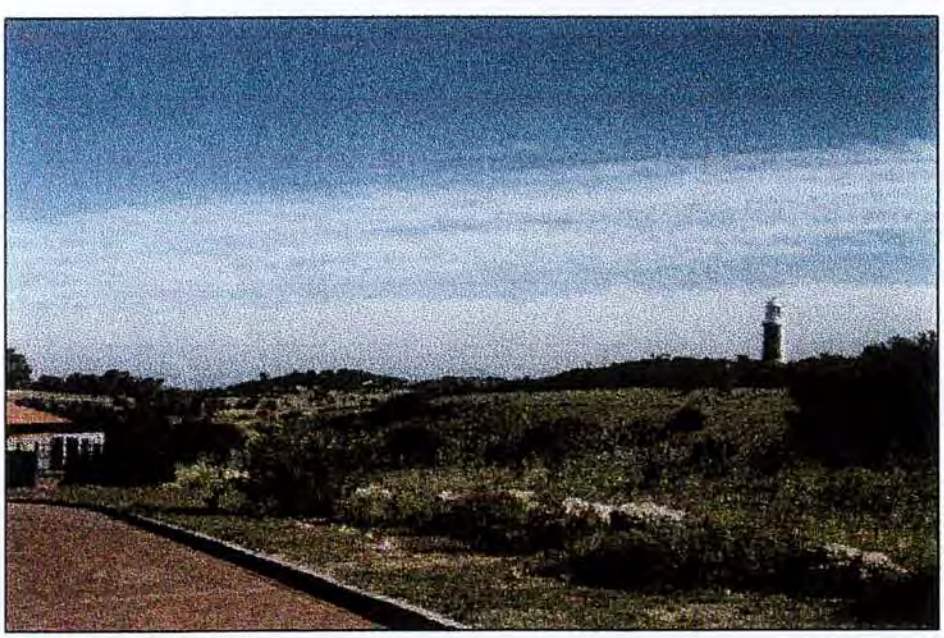
1



2



3



GURE 30
iews from vantage points in Coogee Heights indicating
ews into the area of the low bridge and pump station site

File: 0511cooa-hts.dgn

ECOSCAPE
ECOSCAPE (AUSTRALIA) PTY LTD ACN 070 12
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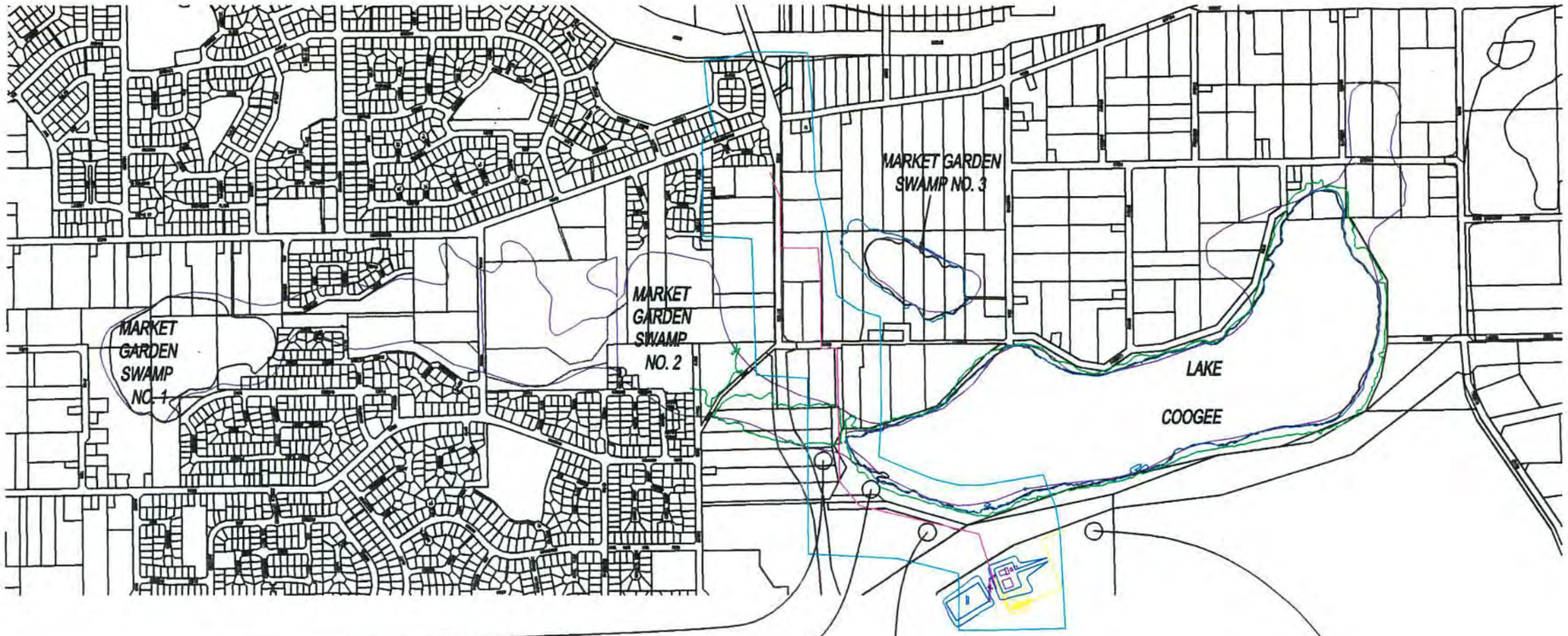
email: ecoscape@wantree.com



1 Moderate Scenic Quality - Agricultural Landscape

2 Moderate Scenic Quality - Natural Landscape

3 High Scenic Quality - Natural Landscape

4 Low Scenic Quality - Natural Landscape

FIGURE 28.	PROJECT:	CLIENT:		◦ E C O S C A P E ◦	SCALE: 15 000	DATE: 13/10/98
EXAMPLES OF SCENIC QUALITY CLASSES FOR NATURAL AND AGRICULTURAL LANDSCAPES WITHIN THE STUDY AREA	BIBREA LAKE MAIN SEWER & MUNSTER PUMP STSTION	GHD Pty Ltd and The Water Corporation		ECOSCAPE (AUSTRALIA) PTY LTD ACN 070 128 675 LANDSCAPE ECOLOGISTS ENVIRONMENTAL CONSULTANTS 21A Pakenham Street Fremantle Western Australia, 6160 Telephone (08) 9430 8955 ◦ Facsimile (08) 9430 8977 email: ecoscape@wantree.com.au	DRAWING No:	N
					ORIGINAL DRAWING SIZE A3	

9.2.4 Public Sensitivity Levels

Using established criteria (CALM, 1997), public sensitivity is currently highest in the viewshed accessed from the Coogee Heights residential area. This provides the most panoramic views of the affected area. The views contribute to high property values and are reflected in the orientation of houses and incorporation of large windows to take advantage of the views. Table 17 summarises the public sensitivity levels for all vantage points.

TABLE 17 - Public Sensitivity Levels for Current Potential Future Vantage Points Into the Area Affected by the Proposed Development of the Sewer Pipe and Associated Infrastructure at the Northern End Of Lake Coogee.

Vantage point	Sensitivity Level
Existing Vantage Points	
Coogee Heights residential area	High (see Figure 30, views from Coogee Heights)
Fawcett Road	Low
Dual Use Path, southern end of Lake	Low
Bush Tracks west of Lake	Very Low
Potential Future Vantage Points	
CAH	High
Beeliar Drive	Moderate (very low, if screened by vegetation)
Future urban development	Not possible to predict.

Both the pipeline and the pump station will be visible from the CAH, the pump station from the western carriageway and the pipeline from the eastern carriageway. As viewed from the western carriageway, the pump station will form an extension of the Woodman Point Wastewater Treatment Plant. Although the public sensitivity level for this area is high, the existing visual character has only low aesthetic value. The area retains very little original vegetation and is largely covered with invasive grassy weeds. The pipeline will intrude into views of Lake Coogee, though the viewshed is very narrow and the potential exists to further reduce visual impacts with appropriate landscaping.

10. Community Consultation

10.1 Consultation to Date

In order to ensure that the views of the residents and interested stakeholder groups have been adequately represented, several Community Consultation strategies have been undertaken for this project.

Gutteridge Haskins and Davey Pty Ltd (GHD) were commissioned to coordinate the Community Consultation on behalf of the Water Corporation.

The methodology employed by GHD involved a phased approach to inform the residents and other interested parties of the proposal and to obtain their views and comments.

Extensive consultation has now been undertaken. Most residents affected by the odours from the existing station want the proposal to proceed rapidly, although others are concerned about the environmental and visual impacts.

10.2 Brochure Number 1

A brochure was distributed to eight hundred properties in the immediate vicinity of the potential affected area to inform them of the proposal and to outline the preferred option of a new pump station on the West side of Lake Coogee. The brochure also introduced the alternate options of the pipes crossing the wetlands as being either underground or bridged across the wetlands. As part of this brochure, residents were invited to send their comments to GHD using a prepaid envelope supplied. Additionally, a dedicated GHD staff member was made available to answer telephone queries and coordinate the responses.

There were a total of sixteen residents who raised specific queries following receipt of brochure #1, and several others who did not provide their address details. In summary, the comments indicated an equally split preference to the pipework being underground or bridged across the wetlands. Concerns were also raised regarding the impact of potential leaks and the method of monitoring for leaks to ensure minimal impact upon the wetlands. Other residents expressed questions relating to the odour implications of the new pump station.

Following the residents questions after the receipt of brochure 1, GHD considered that the overall understanding of the proposal was low, leading to the decision to undertake more extensive consultation.

10.3 Brochure Number 2

A second brochure was sent to residents, this brochure being sent to an extended area with a total of 1300 being distributed. A copy of the brochure was also provided to the Coogee Primary School to be copied and attached to their School Newsletter, delivered to all parents of children at the school.

This brochure provided a more detailed background to the proposal and invited residents to contact GHD to obtain the details of two public meetings which were being arranged. Provision was made, as with the first brochure, for comments to be forwarded with the use of a prepaid envelope which was supplied with the brochure.

Responses with specific queries were received from a further eighteen residents. Numerous other residents telephoned to request details of the meeting without indicating having any immediate concerns. In summary, the comments received were largely resulting from the confusion of the residents, who were unaware of the issues relating to the extension of the existing Bibra Lake main sewer and location of a new pump station. After discussions with the GHD Community Consultation Coordinator however, the residents obtained a better understanding of the proposal.

10.4 Information Fact Sheet

An Information Fact Sheet was prepared by GHD to explain the proposal in more detail. The Fact Sheet discussed topics under the following headings:

- the background to the proposal,
- the proposal in detail,
- the new pump station,
- odour issues, and
- the Community Consultation process.

A copy of the Fact Sheet was sent to all residents who had contacted GHD with queries regarding the proposed project, either after receipt of the first or the second brochure.

10.5 Advertorial

An Advertorial was placed in the Cockburn Gazette on Friday 11th September. The advertorial outlined the project and the Community Consultation process that was in place. The distribution of the Gazette ensured an information dissemination to all residents in the City of Cockburn.

10.6 Library Display

A display was set up in the Spearwood Public Library for a two week period from the 14th September until 28th September. The display included a board with a copy of the two brochures, information fact sheet and a map detailing the proposed approximate location of the new pipework. Additional copies of these were made available to accompany the display to be taken away. The Spearwood Public Library is the main public library in the area and serves residents over a considerable distance.

10.7 Public Consultation Meetings

Two public meetings were held in the local Coogee Primary School in the evenings to accommodate the majority of the residents' schedules.

The first meeting was on Wednesday 16th September and was for the specific purpose of addressing community concerns and to answer residents' questions. The meeting was attended by staff from GHD, the Water Corporation and the Department of Environmental Protection. Invitations were also sent to the Cockburn City Council and the Beeliar Regional Park Community Advisory Committee, however they did not attend.

The second meeting was on Thursday 17th September, for the purpose of addressing environmental issues and technical issues relating to the new pump station and pipework. The meeting was attended by staff from GHD and the Water Corporation. Invitations were also sent to the Cockburn City Council and the Beeliar Regional Park Community Advisory Committee, however they did not attend.

Both meetings were well attended. A record of residents who attended was taken and minutes from the meetings forwarded to all attendees and other residents who had previously expressed and interest in the project.

10.8 Environmental Risk Workshop

An Environmental Risk Workshop was held on Friday 18th September. The workshop was attended by representatives from GHD, the Water Corporation, CALM, the Department of Environmental Protection, the Cockburn City Council, Golder Associates (the Geological/Hydrological consultants), Ecoscape (the Biological/Heritage/Visual Quality consultants), and the Spearwood Residents Association.

The environmental risk workshop was important in identifying risk issues and making a preliminary assessment of how important they were.

11. Environmental Impacts and Mitigation Measures Relating to Physico-Chemical Factors

11.1 Proponent's commitment to an environmental management system

Having fully quantified the existing environment and other issues associated with this proposal an assessment of the environmental impact can be undertaken. Proposed mitigation measures will be outlined as each impact is identified. In order to address the impacts of this proposal Water Corporation has made a number of commitments with associated actions. In order to ensure that these commitments are met fully during the design and construction phases of this proposal the Water Corporation makes the following commitment.

Commitment 1. Develop an EMS for this proposal in line with Water Corporation's EMS, but covering contractual requirements of the proposed construction alliance.

The following actions are proposed;

- Roles and responsibilities will be identified
- Programs of work will be developed in order to meet each commitment
- Timings and compliance targets will be identified
- Communication protocols including document control will be established
- Review and audit procedures will be identified

11.2 Dewatering

Dewatering was identified as a potentially major issue owing to the expected high hydraulic conductivity of the surficial deposits and rock. Golder Associates undertook an assessment of the dewatering impacts of the proposal.

In their report Golder Associates indicated that attempts to place the pipe underground through the wetland would require significant dewatering unless a cut-off was placed all the way to the calcrete layer (Figure 13 previously). The cut-off would take the form of sheet piling, but Golder Associates indicated that it might not be possible to drive the sheet piling all the way to the calcrete layer and a cut-off would therefore be difficult to establish.. This impact was deemed to be unacceptable and was one of the guiding factors in determining the preferred option.

The following sections do not therefore cover the dewatering impacts that would accrue with an underground alignment through the wetland, because this option has been rejected. Sections employing the *alternative font* are verbatim copies of the Golder Associates report.

11.2.1 Dewatering requirements for Pump Station Construction

Dewatering requirements are large unless the construction site can be cut-of from the groundwater. A cut-off wall would be dug down into the ground and encircle the construction site, isolating it from the groundwater.

Dewatering requirements for the pumping station excavation have been estimated for the following cases:

- *no cut-off and no re-injection*
- *cut-off wall*
- *no cut-off wall but re-injection*

The estimated dewatering requirements for the pumping station excavation are summarised in Tables 18 and 19. It can be seen that re-injection of water significantly increases the required pumping rate above that which would be required with no re-injection. However, re-injection limits the effects of dewatering so that drawdown of the water table is effectively limited to the area between the excavation and the ring of re-injection wells.

The results presented for the cases with a cut-off wall do not allow for re-injection of water, however re-injection would have very little impact on dewatering rates for these cases.

TABLE 18 - Pump Station Dewatering Requirements With Cut-Off Wall.

	Depth of Dewatering	Flow Rate (kL/day)	Water Table Drawdown at 100m from excavation (m)
K = 100 m/day	RL-7m*	700	0.08
K = 500 m/day	RL-7m	3600	0.08

* = expected depth of pump station

TABLE 19 - Pump Station Dewatering Requirements With No Cut-Off Wall.

	Depth of Dewatering	Distance to Re-injection Wells (m)	Flow Rate (kL/day)
K=100 m/day	RL-7m	30	19,000
		50	16,000
		75	9,900
		No re-injection	3,900
K = 500 m/day	RL-7m	30	85,000
		50	65,000
		75	44,000
		No re-injection	16,000

Please note that K relates to the permeability of the limestone - the higher the K value the higher the flow of water through the limestone.

11.2.2 Impacts of Dewatering

11.2.2.1 Drawdown

Because the sediments are highly permeable the maximum zone of influence from drawdown will be reached in a few days.

Dewatering will cause a reduction in level of the water table in the areas surrounding the various dewatering operations. Calculated values of drawdown for the various cases are reported in Tables 18 through 19 above, for points at a distance of 100 m from the dewatered excavations. Since the hydraulic conductivity of the system is relatively high,

the system will reach steady state quickly (that is, within days of the commencement of pumping).

The estimated values of drawdown reported above do not allow for the likely presence of preferential flow paths. The high hydraulic conductivity and potentially large lateral extent of such features can cause drawdowns at significant distances from the dewatered excavation. There is no means of positively identifying such features in advance, and therefore allowance should be made for measures such as targeted re-injection of water or provision of an alternative water supply for cases where large drawdowns adversely affect existing wells.

11.2.2.2 Migration of Salt Water/Fresh Water Interface

As discussed above, a dense wedge of saltwater extends inland from the coast, and possibly outwards from beneath Lake Coogee[2]. The extraction of water for the dewatering operations could cause the salt water/fresh water interfaces to migrate upwards towards the point(s) of extraction. Flow velocities derived from the computer modelling discussed above indicate that "upconing" of the salt water/fresh water interfaces could occur during dewatering operations that extend for period in excess of a few weeks in any one location. "Upconing" refers to the case in which the salt water/fresh water interface does not reach a stable configuration in equilibrium with the hydraulic regime imposed by the pumping. In the worst case, the interface could migrate to the point of pumping so that salty water is extracted.

The saltwater interface could migrate to some extent, but this should be limited by re-injection and cut-off walls.

The predicted lateral extent of upwards migration of the saltwater interface varies significantly depending on whether cut-offs are provided, or whether water is reinjected. For the pumping station, upward migration of the interface would probably be limited to within the ring of re-injection wells, or if cut-off walls are provided, to within about 50m of the excavation.

11.2.3 Impacts of Water Disposal

The quantities of water requiring disposal will be strongly dependent upon the depth of the pipe invert or pumping station base, the area of excavation requiring dewatering, and whether or not an effective cutoff to a low permeability stratum (eg. calcrete) can be achieved. On the basis of this preliminary investigation, there appear to be five main options for managing groundwater pumped from excavations during construction. These are:

- *reinject the water*
- *use the water for irrigation*
- *disposal of water at Woodman Point WWTP*
- *dispose of the water to Lake Coogee*
- *dispose of the water to the ocean*

The following subsections discuss the environmental issues associated with each of these options.

11.2.3.1 Water Injection

Water disposal could be effected via a series of wells. This method of disposal would have relatively low environmental impact, if properly designed and executed. The two key environmental risks associated with this disposal method include:

Re-injection poses a low environmental risk is undertaken carefully.

[2]The salt water plume extending outwards from Lake Coogee is associated with the highly saline water mass that develops as a result of evaporative concentration of water in the lake. 'This dense brine flows downwards from the lake bed towards the bare of the aquifer (Hirschberg, 1989).

- *temporarily altering (increasing) the salinity of shallow groundwater*
- *temporary mounding of groundwater in the vicinity of the recharge well field.*

The number of bores required and the area required cannot be determined on the basis of the limited testing carried out in connection with this investigation. As a general rule, the number of wells and the distribution of the well network would need to be at least as great as (and most likely, somewhat greater than) the number of wells used for dewatering and the perimeter defined by the pumping station dewatering bore network.

11.2.3.2 Use of Water for Irrigation

There are a number of existing users of groundwater in the project area. Annual demand for irrigation water from registered water bore users in the area has been estimated at about three million kilolitres per year, or about 8,200 kilolitres per day (averaged over the year). The estimated quantities for water associated with pumping station dewatering ranged from 4900 kilolitres per day to 450 kilolitres per day (with a cutoff) to 21,000 kilolitres per day to 2000 kilolitres per day (without a cutoff). It is conceivable that a proportion of the water generated during construction could be offered to local market gardeners, providing an effective distribution method could be devised. There is some minor risk that the water delivered from construction excavations would reach higher salinity levels than would be acceptable to local growers, due to upconing of deep saline water. The risk of serious damage resulting to vegetation if this were to occur would depend upon the type of vegetation, the method of water application, the soil type in the area being irrigated and a number of other meteorological and agronomic factors.

Water could be used for irrigation, but there is some risk from salinity and the Market Gardeners may not want the water.

11.2.3.3 Disposal of Water to the Woodman Point Wastewater Treatment Plant

The potential for using existing facilities at the Woodman Point WWTP has been investigated. Discussions with the Water Corporation revealed that the outflow capacity of the WWTP is limited. For peak sewerage flows the disposal pipeline capacity would not be sufficient to dispose of the anticipated groundwater volumes. Therefore the Water Corporation have indicated that disposal of groundwater via the WWTP is not viable.

Disposal to Woodman Point is not feasible.

11.2.3.4 Disposal of Water to Lake Coogee

There are a number of possible effects of disposing of water to Lake Coogee. The magnitude of the observed impact (if any) will depend upon the quantity of water disposed of to the lake.

On the basis of dewatering models Golder Associates concluded that between 450 and 21,000 kiloliters of discharge per day would occur depending on the scenario chosen. This would result in water level changes of between 1mm and 40mm per day. Whilst this is an indicative figure and does not take account of evaporation, Golder associates stated that: -

Disposal to Lake Coogee is possible, but has the potential to cause significant environmental change.

The chief impact of discharging water to Lake Coogee would be short term changes in the lake water chemistry. The general effect of dewatering discharges would be to make the lake more dilute (less saline) than would be usual if discharges occur in summer.

Under the highest dewatering scenario, the quantity of water discharged to the lake each day would be in the order of 4% of the total volume of the lake (assuming an average lake depth of about 1m). There is no doubt that this would result in measurable changes to the lake water chemistry during the discharge period. However, it is unlikely that the changes would fall outside the range of salinities or nutrient levels which might be experienced in the lake during typical annual changes associated with wet and dry

seasons. We are unable to comment on whether this temporary dilution effect would have a discernible impact (positive or negative) on biota in and around the lake.

At meetings with Water Corporation and others, the question was raised whether the discharge of water during construction would have the ultimate effect of increasing contaminant levels in the lake, due to increased mass loadings of metals and other species during the construction period. This concentration effect is unlikely, given the fact that the lake alternates between acting as a discharge lake and as a throughflow lake. That is, it is currently the case that for part of the year, groundwater similar to that likely to require disposal discharges into the lake. At the meeting, it had been suggested by some participants that the lake is chiefly fed by surface run-off and not by groundwater from the surrounding area. This is not the case.

To minimise disturbance to the aquatic environment of Lake Coogee, it is anticipated that some form of sprinkler discharge system would be required. The sprinklers would be arranged in such a way to disperse the volume of water over a greater area and reduce the potential for scouring and localised changes to the water chemistry within the lake.

11.2.3.5 Discharge to the Ocean

The project area is located about two kilometres east of the ocean. If the option selected for the sewer trench and pumping station involves a deep sewer line placement and limited cutoff, disposal of water via a temporary ocean outfall may be more cost effective than alternative disposal options. The chief environmental impacts associated with ocean disposal of water from the construction excavations would be those associated with discharge of relatively fresh, but potentially turbid, water to a marine environment. The nitrogen levels in the groundwater intercepted during construction are likely to exceed the levels that ANZECC recommend in coastal waters. Therefore, it may be difficult to obtain DEP approval for ocean based disposal, despite the fact that the discharge would be temporary and that mixing would reduce the impact of the discharge. It is important to remember that under normal flow conditions water from the western part of the project discharges to the ocean in any event.

Disposal to the Ocean is technically possible, but nutrient levels are too high for this to be considered as the total option.

11.2.4 Conclusions and Recommendations from Golder Associates.

On the basis of this preliminary hydrogeological and geotechnical investigation, it is concluded that :

1. Relates to trenching through the wetland, which is not considered a feasible option..

2. *Dewatering during construction of the pumping station will be required for each option. The deepest of the three options is predicted to have a dewatering requirement slightly greater than twice that of the shallowest option. The provision of an effective cut-off around the excavation would potentially reduce the amount of dewatering required by a factor of about four.*

3. *Use of re-injection wells may offer a feasible method of managing water from construction of the pumping station excavation, whilst also reducing the impacts of dewatering on the surrounding water table and reducing the potential for upward movement of the salt water interface. However, re-injection could increase the required rate of pumping by a factor of between 2.5 and 5 depending on the location of the re-injection site. The estimated range of the volume of water which will need to be removed during construction of the pumping station is described in Tables 18 and 19 previously. Additional investigations would be required to establish locations suitable for re-injection bores if this option were adopted.*

4. *Over most of the alignment, the most effective method of excavation dewatering would be to pump from a sump in the excavation, rather than from a series of bores*

or wellpoints. The probable presence of large scale preferential flow paths in the limestone of the Lake Coogee area indicates against the use of pumping wells.

5. *Under certain construction scenarios, it would be possible to create an extensive drawdown cone that could affect irrigation bores in the general vicinity of the site. It is unlikely that the lake water levels would be strongly affected by pumping draw-downs. It is recommended that nearby irrigation bores be monitored (Water levels) both before and during construction so that Water Corporation has direct knowledge of any effects on nearby groundwater users.*

6. *Options with a very high dewatering requirement have the potential to cause temporary up-coning of the deep saline groundwater in the limestone aquifer. This effect is likely to be more pronounced for longer periods of dewatering. The increased salinity that would result from up-coning of the deeper aquifer would not be a permanent effect, but has the potential to adversely affect the use of existing irrigation or domestic bores in the short term (weeks to months, i.e. potentially through an irrigation season)*

7. *High rates of pumping during construction dewatering may cause a significant shift in the position of the salt water/fresh water interface in the Lake Coogee area. The magnitude of the displacement of the salt water boundary could exceed that which normally occurs in the area as a result of seasonally high rates of water withdrawals from irrigation bores. The landward shift of the salt water wedge would be a temporary effect which would dissipate upon cessation of pumping. A number of regional salt water interface monitoring bores are located west of the investigation area. It is recommended that these bores be used to monitor the migration of the salt water interface during dewatering.*

8. *A number of options for disposal of water have been identified and discussed. None of the options considered is likely to result in permanent harmful impact to the environment. The options with the highest likelihood of causing significant change to the receiving environment are discharge to Lake Coogee and use of the water for irrigation. Options with a relatively low likelihood of causing discernible impact to the receiving environment included disposal to an ocean outfall and re-injection of water.*

9. *Water pumped during construction of the pumping station may be relatively higher in available nitrogen than water in the lake or elsewhere in the project area due to the influence of the Woodman Point WWTP. It is possible that statutory approvals would not be issued for disposal of water with high nitrate levels to the ocean or to Lake Coogee, despite the fact that this groundwater currently flows into both these water bodies under natural flow regimes.*

10. *Significant groundwater contamination by pesticides, metals or other toxicants (other than nutrients) was not evident from the testing undertaken during this investigation.*

11. *Preliminary geotechnical assessment of the project area indicates that excavation for all three options is likely to be achievable by conventional methods, although rock breaking may be required where excavations encounter strongly cemented limestone bands. Excavations deeper than about 5m will require ground support, either by means of anchored sheet piling or by passive support systems.*

12. *It is unlikely that it will be practicable to drive sheet piling below the proposed depth of excavation for the pumping station. Therefore other options for ground support, such as anchored secant pile walls or diaphragm walls will need to be considered for the construction of the pumping station.*

13. *The options which incorporate a bridge structure across the Lake Coogee wetlands will most likely require the use of driven pre-cast concrete or tubular steel piles.*

Spread footings are not considered an appropriate option for support of the pipeline bridge. It will be necessary to construct an embankment parallel to the existing causeway for the purpose of installing piled footings for the bridge structure. Further geotechnical investigation of the soft and compressible materials along the embankment alignment will be required.

14. To enable a 10 tonne capacity crane to operate effectively from the existing causeway, it will be necessary to place and compact a 500 mm layer of crushed limestone (or similar material) over the causeway.

Option 2 (construction of a buried pipeline and deep pumping station) will present a number of engineering difficulties which may not be readily overcome unless expensive solutions are used. Options 1 and 3 are preferable from both an engineering and environmental perspective, although we recognise that aesthetic considerations after construction may tend to favour Option 2.

Golder Associates then suggested that Water Corporation investigate the costs and feasibility of pumping station designs which incorporate the cut-off barrier as part of the final pumping station structure. Additional investigations would be required to allow the further development of dewatering strategies which rely on establishment of a cut-off, as the properties and continuity of the inferred low permeability calcrete layer had not been assessed in detail as part of their investigation.

In addition Golder Associates recommended that the issue of water disposal options be reviewed in greater detail after a preferred trench alignment and pumping station design level had been selected, as the environmental suitability of the various options is closely linked to the quantity of water requiring disposal.

Table 20 on the following page highlights the various options based on a comparison between estimated costs, aesthetic considerations, and environmental protection. Golder Associates suggested that Option 3 appears to be the best compromise based on these considerations with dewatering assisted by a cut-off wall surrounding the pumping station and disposal to Lake Coogee.

TABLE 20 - Options Evaluation

Increasing Environmental Protection →					
Options	No Cut-off wall Re-injection of water Method A	Cut-off wall No re-injection Disposal to Lake Coogee Method B	Cut-off wall No re-injection Disposal to Lake Coogee Method C	Cut-off wall Re-injection of water Method D	Increasing cost for de-watering ↓
1	$110,000	$830,000	$540,000	$770,000	
2	$160,000	$950,000	$610,000	$900,000	
3	$520,000	$1,000,000	$760,000	$1,500,000	

11.2.5 Conclusions and Proposed Intended Mitigation Measures

The following conclusions were reached during development of the Golder Associates Report and after its receipt;

1. A low bridge option should be selected to avoid the need to dewater in the wetland.
2. The requirement to dewater should be minimised, not only from an environmental point of view, but also from an engineering consideration.
3. Dewatering could feasibly be minimised by constructing a cut-off wall to the less permeable calcrete layer. However to be certain that this is feasible further investigations will be needed. These investigations should consider the integrity of the calcrete layer and the possibility of very high permeability areas within the limestone.
4. If dewatering can be minimised as described it should have little impact on groundwater levels and therefore recharge of the water is not vital, but is a feasible disposal option. If for any reason the dewatering requirement is much higher than expected then recharge may become necessary to maintain water levels.

The Water Corporation intends to use all engineering means to reduce dewatering requirements and groundwater recharge to dispose of dewatered groundwater. This will minimise all impacts on the environment.

In conclusions 8 and 9 of their report, Golder Associates make important qualifications in relation to the option to dispose of the dewatered groundwater indicating, that there is significant potential for environmental change associated with disposal to Lake Coogee. Golder Associates also indicate that this approach may encounter difficulty in obtaining approvals from regulatory authorities. Water Corporation has taken these comments into consideration and would prefer to find an alternative if it exists.

In an ideal situation the water could be disposed of by recharge to the ground, however if permeabilities around the construction site prove to be significantly higher than that expected there will be great difficulty in disposing of all of the water in this manner. One problem is that the final dewatering requirement cannot be fully quantified until construction, consider; high density drilling through the calcrete layer in the vicinity of the construction site will have the impact of rendering it useless as a low permeability layer. Certain other options for the disposal of water from this site exist, but each of them has inherent problems. These options are considered below;

I. Disposal through the treatment works and thence to the Sepia depression would be a useful solution, however the treatment works is unlikely to have sufficient capacity at peak periods and a temporary storage would have to be constructed. This option warrants further investigation to determine the likely quantity of water that could be disposed of during low flow periods.
2. To the West of the site is an old quarry that could feasibly be used as a recharge/storage area. A minor amount of construction would be required to allow acceptable volumes to be disposed of in this location. This option requires further investigation to ensure that seepage will not cause damage to infrastructure.
3. The facility exists to dispose of water via the emergency discharge from Woodman Point WWTP. However this discharges to Cockburn Sound and may not prove acceptable as a solution to various community groups. Nevertheless it should be considered that the groundwater removed from the construction site is discharging to Cockburn Sound, albeit in a diffuse manner, throughout the year. Any discharge via this route would have to be due to an emergency and as such would be temporary. The volume of any discharge would be recorded and the EPA notified.

11.2.6 Proponents Commitments on Dewatering

Commitment 2.1. Develop a de-watering plan.

In order to achieve this the following actions will be undertaken;

- Final expected quantities of water arising from dewatering will be quantified as fully as possible.
- The three potential options for disposal will be fully quantified prior to construction with the priority being to re-charge as much water as possible.
- An emergency discharge plan will be determined incorporating the need to limit discharges to environmentally sensitive areas and reporting requirements if the emergency plan is implemented.
- A groundwater and vegetation monitoring protocol will be established with actions to be taken if significant departures from seasonal norms are noted.
-

Commitment 3. Implement Dewatering Plan

- The de-watering plan will be implemented and the results of the monitoring program reported to the DEP.

11.3 Leakages from the Pipeline

The pipeline in this case will probably be a 3m diameter concrete pipe with rubber ring seals and plasti-lining. The pipe will not be under significant pressure during its operation and therefore the rate of any leakage will not be major unless there is catastrophic failure which will be noted quickly and remediated.

The sewer used in this proposal will be the same as standard large diameter pipelines used extensively in Perth.

Quantifying the likelihood of minor leak in low pressure sewer pipe is extremely difficult because little work has been undertaken in this field. One factor for this is that below ground sewer pipe with flexible couplings are an inevitable requirement of urban life - Perth has many thousands of kilometres of this type of sewer, although this is particularly large.

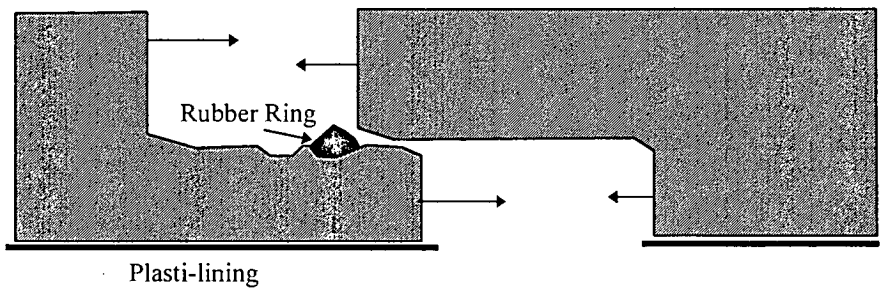
Another factor is that by their very nature sewer pipes are below ground and in many cases below the water table. In un-pressurised sewer below the water table, the usual concern is for groundwater inflow into the pipe rather than sewer leakage. It should be noted in this context that groundwater ingress is not adding significantly to Perth's wastewater volumes indicating that leaks around these joints are minor. In the case of this sewer it will be entirely above the water table and therefore any leaks, if they occur, will pass from the pipe to the surrounding sands.

Estimation of the probability of leaks is a difficult task, however, breakdown of the pipe itself is highly unlikely and this leaves the possibility of a leak associated with the rubber ring joint. A typical rubber ring joint cross section is shown in Figure 31, below. It can be seen that once the joint is fitted together the rubber ring acts as a compression seal, whilst the plasti-lining overlaps and is sealed to protect the joint. There is a small section of the plasti-lining that is not sealed at the bottom end of each joint. The reason that this is not sealed is because of the risk of water ingress leading to ballooning and potential rupturing of the lining. The potential for a leak from these joints is extremely low and at most would be drips. The basis of this assertion is that;

The likelihood of a leak from this sewer is extremely low and will be of small volume because the sewer is not pressurised.

1. The sewer is under only minor (hydrostatic) pressure during operation,
2. The vast majority of the pipe will be double contained (concrete and plasti-lining),
3. There is no evidence of significant ingress from sewers below the water table elsewhere on the Swan Coastal Plain, indicating that leaks, if they occur at all, are relatively minor.

FIGURE 31 - Diagram of Rubber Ring Joint



Prior to commissioning the pipe will be visually inspected to ensure that joints have been made properly and the plasti lining will be tested electrostatically. Any holes found in the plasti-lining will be repaired at this stage. The minimum pressure capability of this pipe is rated as 9m of hydrostatic pressure which is considerably greater than any pressure that could be applied to this pipe due to backing up of wastewater.

It can reasonably be concluded that leaks, if they occur at all, will be very minor. The following sections indicate the fate of any material that enters the environment from a leak.

11.3.1 Below Ground sections

When the pipeline is underground it will be in a quartz rich sands with a high permeability, the Quindalup sands to the West of Lake Coogee and the Spearwood sands to the East. The Quindalup sands are a lime rich sand, whilst the Spearwood sands have a moderate clay content (Whelan et al.).

A study was undertaken by Sinclair Knight Merz in August 1997 to investigate typical loadings of pollutants in wastewater. The results are outlined in Table 21.

TABLE 21 - Typical Pollutant Loadings in Wastewater Entering Woodman Point Wastewater Treatment Plant

Parameter	Raw Wastewater concentration (mg/L)	
	50%ile	90%ile
Suspended Solids	340	395
BOD	320	400
COD	600	798
TKN	56	65
Ammonia N	42	46
Total P	11.1	12.2
Alkalinity (as CaCO3)	270	290

Regrettably little work has been undertaken in relation to impacts of wastewater leakages into the Quindalup and Spearwood sands, however two reports undertaken by Rockwater Pty Ltd are important in understanding these impacts. These are as follows;

1. In their study "Hydrogeological Conditions along Gnangara Road and Possible Impacts of Accidental Leakage from Proposed Ellenbrook Sewer Main", Rockwater pointed out that Sharma et al. (1989) indicate that the sand overlying the Tamala Limestone retains phosphorous. In subsequent sections they point out that the bacterially active aerated sections of sand, found in the superficial deposits of the Swan Coastal Plain are remarkably good at denitrification, significantly reducing the impacts of nitrate plumes on groundwater.

   In relation to bacteria and viruses, Rockwater indicated that bacteria would not survive long in the aerated sections of the superficial sediments found on the Swan Coastal Plain (Appleyard, 1994; Whelan et al. 1979). Viruses may be adsorbed to sediments, but may also be desorbed if conditions change. They indicated that viruses would only last a limited time in groundwater with 90% being removed in 9 to 20 days depending on conditions.

   Rockwater noted that a paper by Gerritse et al., (1990) found that heavy metal concentrations in Perth's groundwater were significantly lower than would be expected by calculation of all of the inputs from recharge. They concluded that even the sandy soils of Perth's Coastal Plain are capable of adsorbing significant quantities of heavy metals.

   In relation to suspended particulates Rockwater noted the high filtering capability of the sand and suggested that initial trapping of silty material would increase filtering capability as a mat of material is formed.

2. In their study "Mandurah No.1 Wastewater Treatment Plant Investigation of Effects of Wastewater Infiltration to Groundwater", Rockwater investigated infiltration of large volumes of wastewater into the Tamala Limestone and overlying sands. Concentrations of nitrate and phosphate were lower than those expected in the wastewater passing through this sewer (10 mg/L), but the quantities of infiltration were many order of magnitude higher than that expected from a minor leak (6500 - 11,000 m^3/d).

   In this important study Rockwater found that 94% of the nitrate would be lost to atmosphere through denitrification and 99% of the phosphate would be adsorbed to the limestone.

The vast majority of pollutants in leaked wastewater will be trapped in the first few metres of sediments and will not reach the groundwater.

Whilst there is little evidence of heavy metal contamination in the wastewater to this plant it is important to understand that the majority of heavy metals will be in particulate form whilst being transported to the WWTP. Goldstone et al (1990a,b.c) investigated the phase distribution of heavy metal in wastewater. The results of their studies are shown in Table 22.

TABLE 22 Heavy Metal Phase Distributions in Wastewater

Heavy Metal	% Particulate
Copper	91
Lead	80
Nickel	29
Chromium	37
Zinc	65
Cadmium	30
Arsenic	86
Mercury	93

It is important to note that the United Kingdom has combined wastewater and stormwater sewers and this may have had an impact on the behaviour of lead, most of which would have come from road run-off. Additionally it is significant that the authors concluded, on the basis of the behaviour of the copper in the wastewater, that most of this metal arose from domestic sources, that is from the copper pipes used for plumbing. This high particulate association means that the majority of any heavy metals present in leaked wastewater would be filtered out by the sand within a few metres of the sewer.

It may therefore be concluded that the risk of a leak of any magnitude in a gravity sewer of this nature is extremely low and the quantity of any leak would be low unless there was a catastrophic failure (earthquake, force majeure etc). It may also be concluded that in the unlikely event of a leak, the vast majority of pollutants would never reach the groundwater.

11.3.2 Above Ground Sections

The only section of pipe above ground level will be on the low bridge passing over the Northern end of Lake Coogee. This section of pipe will be constructed in exactly the same fashion as the underground sections except that it will be laid on a Trough Girder (See Figure 10). The Trough Girder will slow egress of minor leaks if they occur, but regular inspection of this pipe will allow any leaks to be repaired rapidly.

In spite of the low probability of a leak it is recognised that the sensitivity of this location is such than an emergency action plan is developed - the following steps were developed in discussion with ECOSCAPE for action in case of a major spill at the wetland crossing.

1. Immediately close the hydrological connections between this area and the main waterbody of Lake Coogee.
2. Notify relevant authorities including the Water & Rivers Commission, the DEP, CALM and the City of Cockburn.
3. If the spill appears to be of a large magnitude, close off the hydrological connection beneath Mayor Road (as this is more than 300 m from the pipeline, this will only be required for major spillages).
4. Assess water quality and compare it with the average water quality, seasonally adjusted, for this part of the wetland.
5. If the water quality is within one standard deviation of the average for a range of parameters including nitrogen, phosphorous and chlorophyll a and others as required, then a watching brief should be maintained and water quality levels monitored at daily or weekly intervals until values return to average levels.
6. If the water quality is significantly adversely impacted then action should be taken to rectify the environmental harm. The action may include the removal of contaminated sediments using sediment suction machinery (noting that the usefulness may be constrained by the fact that this is a vegetated wetland); or reclamation of contaminants from the water column. This may temporarily remove the macro-invertebrate fauna from the area affected, however, due to the hydrological connectivity with both Lake Coogee and Market Garden Swamp No 2, this area will be readily recolonised once the situation has been stabilised.
7. Monitor both water quality and, if required, macro-invertebrates for a period of no less than one year.

11.3.3 Reduced potential for wastewater losses to the environment

Whilst considering the issue of leaks it is pertinent to consider the positive environmental benefits of the proposal. Under current circumstances the only storage in case of a pump failure is the open storage on Mayor Road. If the pump station on Mayor Road fails, or if there is an extraordinary peak flow, as there was in February 1992, this open storage area will overflow and the contents will pass into Market Garden Swamp No.2. Clearly this is an unacceptable situation and increases the requirement for a rapid solution.

Overall, risks of a leak will be reduced, because the majority of wastewater will be transported in un-pressurised sewer and the old pressure mains will only be used in emergencies.

It is important to note that this significant overflow in February 1992 had no lasting discernible impact on the lake system and was considerably greater than the impacts that could be expected from anything but a catastrophic failure of the system. It should be noted that this event was not monitored in detail and therefore dilution effects associated with the storm were not quantified.

A further benefit of this proposal is diversion of the flow from the existing pressure mains. The proposed sewer will be used for most of the time and only diverted to the pressure mains during maintenance operations. This reduces the risk of leaks leading to significant spills because it diverts the flow from a pressurised system to a non-pressurised system.

11.3.4 Proponents Commitments on Leaks

Commitment 3.1. Design the sewer in a manner that reduces the potential for leaks.
Commitment 3.2. Inspect pipeline prior to commissioning.
Commitment 3.3. Inspect pipeline on a routine basis.
Commitment 4. Develop and emergency action plan in case of catastrophic failure.

In order to achieve these the following actions will be undertaken;

- The pipe will be designed in such a fashion that the design specification of 9m of hydrostatic pressure cannot be exceeded.
- Prior to commissioning, the pipeline will be visually inspected to ensure all joints are properly made.
- During operation, routine inspections of the above ground section of the pipeline will be made to ensure integrity of the pipeline.
- Any evidence of problems with the operation of the sewer will be acted upon as soon as possible. (Operational problems, such as stripping of the plasti-lining would cause back pressures which would be noted at the splitter box).
- The sewer will be inspected internally every 5-7 years and any damage made good.
- An emergency action plan will be developed to cater for the unlikely event of a major spill at the wetland crossing.

11.4 Drainage

Drainage is an issue in relation to three components of this project:
stormwater drainage during construction
stormwater drainage at the pump station site
drainage from overflow of the storage areas

Although it is intended that the construction process will take place during summer, when average rainfall values are low, provision will be made for temporary stormwater detention basins along the route. Stormwater from any storm events associated with cyclonic features will be directed to these basins and away from wetland basins. The temporary basins will cater for storm events to a magnitude of a 1:10 year storm.

Stormwater run-off during construction will be contained.

Stormwater drainage for the operational phase of the pump station will be directed to a sump within the bunded area of the pump station. The final size of the sump will be agreed with the appropriate authorities at the design stage.

Overflow from the system has been addressed in a previous section. The existing overflow system will not be changed. The flow path is from the overflow basin at Munster pump station No 2 (the existing pump station on Mayor Rd) into a disused limestone quarry and from there into Market Garden Swamp. This flow path has been utilised once, during a 1 in 100 year storm during February 1992. However, as the capacity of the system will be increased significantly beyond the capacity required to cope with a 1 in 100 year storm event, it is considered that once the Munster Pump Station No 3 is operating at full capacity, the risk of the system overflowing into Market Garden Swamp will be significantly reduced.

11.4.1 Proponents Commitments on Drainage

Commitment 5.1. Detain Stormwater from the construction site.
Commitment 5.2. Detain stormawater at the pump station site.

In order to achieve this Water Corporation proposes the following actions;

- Temporary stormwater detention structures will be constructed at appropriate points along the route to direct stormwater from events up to a 1 in 10 year event away from wetland basins during construction.
- Stormwater will be directed to a sump within the pump station bund. This will be designed in consultation with the Water and Rivers Commission.

11.5 Dust

Dust will be a consideration during the construction of the pipeline. Dust has been considered in accordance with "Land Development Sites and Impacts on Air Quality", a DEP guideline on the prevention of dust from land development sites (1996). The Nature of the Site was classified as follows;

1. Nuisance potential of the soil when disturbed - the soil is a moderately coarse sand that will require significant winds to lift-off. However the see breeze is fairly regular and strong at this location. This scores 4.
2. Topography and protection provided by undisturbed vegetation - along the pipeline this should be fairly good, but at the pump station there is little screening. The pump site scores 12 whilst the pipeline scores 6.
3. Area of site disturbed by the works - this is less than 1 hectare. The score is 1.
4. Type of work being done is roads, drains sewers and partial earthworks. The score is 9

This gives a total score for the nature of the site as 20 for the pipeline and 26 for the pump station.

The Proximity of the site to other land uses is as follows;

1. Distance of other land uses from site - this is more than 1 km for the pump station but less than 100m at some sites along the pipeline. Scores are 1 for the pump station and 18 for the pipeline at the worst locations.
2. Effect of prevailing wind on other land uses - this is unimportant for the pump station, but there are some residences that will be affected by the sea breeze during construction of the pipeline and the splitter box at pump station No.2. Scores are 1 for the pump station and 9 for the pipeline at the worst locations.

This gives a total score of 27 for the pipeline and 2 for the pump station.

Multiplying these out gives final scores of 52 (negligible risk) for the pump station and 540 (medium risk) for the worst locations of the pipeline.

11.5.1 Proponents Commitments on Dust

Water Corporation commits itself to;

Commitment 6. Implement dust control plan.

The following actions are proposed in order to achieve this;

- All dirt access roads will be wetted during dry and windy conditions
- Stockpiles of material close to residential areas will be kept to a minimum and wetted during dry and windy conditions.
- Vehicles carrying potentially dust causing material offsite will be covered.
- Material carried offsite by on vehicle wheels will be cleaned up and returned to site.
- Nuisance dust associated with construction and rock-breaking near to residences will be subject to negotiation with residents with a view to minimising impacts, giving notice of times when dust-generating activities will take place and cleaning up impacts if they arise (e.g. window cleaning, etc).
- Construction sites near to residences will be fitted with wind fencing perpendicular to the sea breeze.

11.6 Odour

One of the positive environmental impacts of this proposal will be the reduction in odour events experienced by residents. The main reasons for this reduction will be;

Odour emissions should be reduced following expansion of the system.

1. The new pipe and pump station offer duplication of the existing system allowing for in-built redundancy in the system - this is important because if there is a failure under the current system there is no alternative and the system could overflow into the open storage close to residents on Muslin Rise. The odour implications of such an overflow are significant.

2. The new pump station, which will be carrying the vast majority of the flow is on Water Corporation land away from residences and so cannot be encroached upon by new developments.

3. The new proposal incorporates a significant amount of closed storage, reducing the likelihood of an odour event during routine maintenance.

11.7 Noise and Vibration

Construction noise can be expected over a fairly lengthy period of time because this proposal will take in the region of 12 months to complete. Once in service, however there will be minimal noise from the pump station. Noise is regulated under the Environment Protection Noise Regulations (1997) and the proposed actions comply with this.

11.7.1 Proponents Commitments on Noise

Commitment 7. Meet requirements of Environmental Protection (noise) Regulations (1997).

The following actions are proposed;

- Construction noise will be managed by confining noisy construction activities to between 7 a.m. and 7 p.m. Monday to Saturday, with significant noise generating activities to be limited further subject to negotiation with local residents.

- Any noise generating activities that must be undertaken outside of these hours will require a noise management plan to be approved by the DEP and be subject to negotiation with local residents.
- Mechanisms to receive noise complaints and react to them will be set up so that the local community can alert the contractor to unacceptable noise generating activities.
- In addition, the contractor will be expected to communicate to residents occasions when major noise generation is likely to occur.

Vibration was considered a potential issue because there was the potential for rock breaking activities within 100m of residences. In order to assess the potential impact a rock breaker was brought onto site and tested at distances of 40m and 70m. Measurements were taken in three mutually orthogonal directions on the foundation of the fencing adjacent to the house by Engineering Dynamics Consultants Pty Ltd. In order to undertake this work a Bruel and Kjaer Type 4371 accelerometer was used with Bruel and Kjaer Type 2635 Conditioners. The system was connected to a Diagnostic Instruments Model DI2200 Spectrum analyser.

Vibration levels from a rockbreaker were well below nuisance values.

The maximum peak particulate velocity recorded was 0.2mm/sec-peak. A small component of this velocity arose from the pump station itself.

Most standards for vibration have been set for transient vibration e.g AS 2187 (1983) and DIN Standard 4150 (1970). The minimum specified standard in these is 2mm/s and this is for buildings of great historical importance. Standards for structurally sound buildings have been set as 10mm/s.

The DIN standard mentioned previously recommends that the transient standard should be reduced by one third of the transient values giving a standard of 3mm/s for structurally sound buildings of 6.7 mm/sec. The measured values are approximately thirty times lower than this value.

In addition to structural damage there is the question of human sensitivity. Reiher and Meister (1931) found that velocities of 1mm/sec were perceptible by humans and that velocities of 2.5 mm/sec were annoying. A similar conclusion was reached by Soliman 1968.

Engineering dynamics concluded that "the measured vibration levels from ground transmission are well below the levels likely to cause any structural damage to houses greater than 40 meters from the rock breaker".

11.7.2 Proponents Commitments on Vibration

Commitment 8. Vibration to be included in noise communication strategy if needed.

In order to achieve this vibration will be part of the noise communication strategy, allowing residents to voice their concerns on this issue.

11.8 Soil Contamination

The preliminary site assessment undertaken during the geotechnical assessment of the uncontrolled fill to the South of Mayor Road indicated two areas where further investigation is required from an environmental and health perspective.

Soil contamination will be further assessed before construction.

Water Corporation proposes to sieve the material excavated from the trench in order to obtain fill material to backfill the trench once the pipe is laid. The larger cobbles, bricks and other material will be disposed of in an appropriate land fill.

11.8.1 Proponents Commitments on Soil Contamination

Commitment 9.1 Quantify contamination issues along alignment
Commitment 9.2 Ensure final alignment is clean of contamination

In order to achieve this Water Corporation will;

- Further assess potential lead levels around Test Pit 1 in accordance with the proposed final land use.
- Further assess pesticide levels around Test Pit 4 in accordance with the proposed final land use.
- Dispose of any contaminated material in accordance with Department of Environmental Protection requirements.
- Disposed of other material extracted from the trench, but unsuitable for backfilling, in an approved landfill.

12. Environmental Impacts and Mitigation Measures Relating to Biological Factors

Biological factors are discussed after the physico-chemical factors because many of the impacts on biota relate to changes in the physico-chemical environment. ECOSCAPE Pty Ltd assessed the impacts on biota and the following section in the alternate font are verbatim copies of their report.

The construction of the Munster No 3 pump station and the extension of the Bibra Lake Main Sewer to the pump station have the potential to impact on the functional ecology and biota of the area. The impacts can be summarised under the following categories:

- Impacts on Market Garden Swamp No 3
- Impacts upon Lake Coogee and its biota
- Impacts on the fringing vegetation of Lake Coogee
- Impacts on stands of Tuarts on the western side of Lake Coogee

Impacts arise primarily from clearing and construction works, and from dewatering. Other impacts considered include drainage, impacts on wetlands and leakage from the operational pipeline over Lake Coogee. The following sections identify the type and extent of potential impacts, as far as these are known, and address strategies that will avoid, mitigate or ameliorate the potential impacts. Finally the net impacts are identified and their significance discussed.

12.1 Dewatering impacts on vegetation

The common outcome of a dewatering programme is a lowering of the groundwater table within the drawdown cone. In this instance the grout curtain will limit the area of drawdowns to the area within the grout curtain, which is devoid of native vegetation.

Re-injection of the water in a zone approximately 100 m outside the grout curtain means that actual impact, in relation to movement of the groundwater table, is a temporary increase in the height of the surface of the saturated zone. It is not expected that this temporary phenomenon will adversely affect either the upland vegetation or the fringing vegetation around Lake Coogee. If anything, the physiological responses of deep rooted perennial vegetation to chronic summer drought will be alleviated to some extent for the duration of the dewatering programme. This is particularly relevant for the Heritage stand of Tuarts, some of which will be root pruned. Elevated groundwater levels will reduce water stress on these individuals and promote their survival.

Re-injection should eliminate most of the vegetation stress issues related to dewatering.

An additional side effect may be that the normal rate of curing of vegetation may be slowed. 'Curing' refers to the rate at which the moisture levels in vegetation reduce with the onset of hot dry weather. This is most obviously seen in the drying of grasses. This may or may not be sufficient to reduce the fire hazard in this area for the duration of works.

There is some potential for a minor increase in the salinity levels of the groundwater but this has not been quantified. However, both the groundwater and the lake water exhibit high seasonal and annual variation in salinity as well as relatively rapid changes in salinity (Table 23 (Lake water, see below) and Table 24 (Golders table of their water quality results)). Thus it is probable that both the fringing vegetation and the upland vegetation is adapted to seasonal changes in salinity, as long as the changes resulting from the dewatering programme are within the general range experienced in the area.

The groundwater salinity levels will need to be monitored between the re-injection wells and the stand of Tuarts listed on the Municipal Heritage Inventory, as well as between the wells and the native vegetation in the vicinity of the Lighthouse, depending on the location of the wells. If salinities substantially above historical levels are recorded, then remedial action may be required, in consultation with the Department of Environmental Protection, to avert adverse impacts on the vegetation. Monitoring and remedial action are not recommended in relation to fringing vegetation for the following reasons:

- The fringing vegetation is adapted to higher salinities than the upland vegetation
- No re-injection wells will be placed within the zone of critical influence (see following section for details).

In conclusion, there are no adverse impacts on either the upland vegetation or the fringing vegetation as a result of the dewatering programme.

12.1.1 Proponents Commitments on Dewatering Impacts on Vegetation

Commitment 10.1 Prepare and environmental management plan
Commitment 10.2 Implement environmental management plan during construction.
Commitment 10.3 Implement rehabilitation requirements of environmental management plan

The following actions are proposed in order to complete the management plan;

- Prior to final design identify and adjust the alignment of the pipeline to minimise the amount of mature trees impacted by the proposal.
- Develop a detailed revegetation and landscape plan to screen the pump station and pipeline using locally provenanced native vegetation.
- Identify reinjection locations to mitigate impacts of de-watering on vegetation.
- Quantify, as closely as possible, expected dewatering rates.
- Develop site induction and training plan.
- Environmental management plan to be available for public comment and final sign off by DEP.

Commitment 11. Ensure vegetation is not subject to undue stress during summer months

The following actions are proposed;

- Groundwater levels and water quality will be monitored at points between the re-injection wells and any stands of native vegetation down-gradient from the wells.
- Vegetation Stress levels will be monitored in the upland vegetation down-gradient of the re-injection wells and compared with seasonal norms.
- If significant changes in the groundwater quality or vegetation stress levels are identified that are not due to normal seasonal variation, then the DEP will be informed and consulted as to appropriate remedial action to either divert the groundwater flow or dilute the effect.

12.2 Dewatering impacts on Lake Coogee

As there will be no significant disposal to the Lake, there will be no direct impacts on Lake Coogee. However, there will be indirect impacts from the temporary mounding of groundwater. This is expected to result in a slight increase in Lake water levels. Golder Associates calculated the rises in Lake levels if the water was disposed of directly to the lake. The scenarios they examined for the dewatering with grout curtains installed indicated that rises in Lake levels would be in the order of 1 – 10 mm/day. As the water will be reinjected, there is likely to be some attenuation of the potential rises, though the nature of the limestone and the possible existence of preferential flow paths may affect the potential for attenuation.

If carefully managed, water levels in Lake Coogee should stay within seasonal norms.

The potential rises will be offset by evaporation from the lake surface, evapotranspiration of fringing vegetation and losses to groundwater. During the period of December to

March mean Pan A evaporation in the Perth Area varies between 239.6 mm (March) and 308.4 mm (January), based on data supplied by the WA Bureau of Meteorology, thus evaporation is substantially higher than potential rises in lake level. It is not expected that the range of wetland habitats normally present will be affected by the dewatering programme, except possibly in the event of an extreme summer rainfall event is recorded, in which case a temporary increase in lake water levels is likely.

In the case of significantly higher than average rainfall in the preceding winter season, which would result in a higher initial lake water level, the dewatering programme would be amended to place the re-injection wells further from the lake than currently anticipated. Under average conditions, re-injection wells will be placed on the ridge and on the eastern slopes of the ridge. No re-injection wells will be placed within the 50 m zone of critical influence for Lake Coogee.

It should be noted that the groundwater intercepted and transplaced by the dewatering programme will be a part of the seasonal Woodman Point Groundwater Mound, which discharges to Lake Coogee.

Golder Associates identify that there will be a slight (unquantified) increase in Lake salinity as a result of the dewatering programme. The Lake already undergoes high seasonal and annual variation in salinity, given that Lake Coogee has been recorded as fresh, brackish and saline at various times over the last two years (Table 23). The rate of change in salinity is also high. For example, Total Dissolved Solids rose from 1968 mg/l (9/12/97) to 3439 mg/l (30/1/98).

It has also been noted elsewhere in this report that no studies have been carried out to date on the wetland biota of Lake Coogee. However, from studies on other wetlands within the same consanguineous suite and other saline wetlands on the Swan Coastal Plain the following inferences can be made in relation to the dewatering programme:

- The biota is adapted to relatively high salinities (compared with other wetlands within the consanguineous suite).
- The biota are adapted to high seasonal and annual variation in salinity.

Thus it can be concluded that the risk is low of the dewatering programme alone resulting in any changes in level or chemical composition of the water that will affect the biota or the ecological functioning of the wetland. High evaporation is likely to offset any increased groundwater flow into the lake, thus the range of habitats normally present in the Lake during summer, including areas of wader habitat, is not likely to be affected beyond the normal range of seasonal variation.

12.2.1 Proponents Commitments on dewatering impacts on Lake Coogee

Commitment 12. Ensure that lake Coogee is not impacted by dewatering beyond seasonal norms.

In order to do this the following actions are proposed;

1. No re-injection wells to be placed within the 50 m zone of critical influence around Lake Coogee, as defined by the Water & Rivers Commission.
2. If water levels in Lake Coogee are higher than seasonally expected prior to the start of the dewatering programme, then the placement of re-injection wells will be reassessed and placed further from the Lake.
3. Temporary storage for disposal water to be supplied to an appropriate capacity in line with the Water & Rivers Commission's interim dewatering guidelines.
4. Lake water levels will be monitored during the dewatering programme. The monitoring programme will be developed as a part of the environmental management programme and

address monitoring of water levels in relation to areas of wader habitat and inundation of fringing vegetation.

5. Remedial action is only recommended if lake levels rise to the point where wader habitat or fringing vegetation is significantly compromised. As this scenario is likely only as an outcome of high rainfall in combination with the dewatering programme, the necessity for remedial action, such as pumping to lower lake water levels, will be determined in consultation with the relevant statutory authorities.

TABLE 23 - Water Quality Data, Lake Coogee 1995 – 1998. Data Source: Water and Rivers Commission.

Date	Chironomids per square meter	Visibility %	Total Dissolved Solids (micrograms per litre)	pH	Temperature °C	Australian Height Datum (meters)	Total – Phosphorus (micrograms per litre)	Nitrate – Nitrite	Total – Nitrogen (micrograms per litre)	TP : TN
16/08/95	64	100	1006	9.04	17.00	0.84	56	78	2916	52
27/09/95	3720	100	963	8.29	18.27	0.78	75	16	2228	30
01/11/95	5580	100	1020	8.17	16.47	0.64	25	15	2575	103
15/12/95	1707	100	1328	8.33	24.43	0.42	56	5	3302	59
11/01/96	1529	100	1538	8.59	21.93	0.36	57	6	3362	59
06/02/96	357	100	1902	8.27	23.87	0.26	73	4	5142	70
29/03/96	255	100	210	8.75	13.20	0.22	69	100	5757	83
07/05/96	1249	100	165	8.87	19.40	0.33	77	305	5420	70
04/07/96	764	100	1081	8.44	11.82	0.75	40	153	3418	85
24/09/96	10523	100	893	8.37	16.62	0.92	32	7	2138	67
24/10/96	14320	100	1189	8.11	17.90	0.78	23	8	2038	89
05/12/96	7975	100	1469	8.30	20.46	0.54	12	20	4812	401
06/03/97	178	100	2426	8.89	19.92	0.25	42	22	3150	75
10/07/97	1427	100	1125	8.47	10.80	0.63				
11/09/97	3210	100	1042	8.38	14.98	0.72	38	7	2452	65
02/10/97	7619	100	1102	8.22	16.60	0.61	17	5	2694	158
06/11/97	20945	100	1418	8.08	18.76	0.40	38	5	3753	99
09/12/97	13122	100	1968	8.32	23.18	0.23	46	7	5204	113
30/01/98	102	100	3439	8.13	22.06	-0.01	125	65	10768	86
12/03/98	102	100	3174	7.96	17.46	-0.05	170	381	13672	80

TABLE 24
TABLE OF WATER QUALITY RESULTS
SUMMARY OF WATER ANALYSES

Analyte	LCN	LCS	04S	04D	05S	05D	06S	06D	07S	07D	08	EPA Criteria	WRC Guidelines	Drinking Water Criteria
pH	7.8	7.8	7.3	7.5	7.6	7.6	7.8	7.5	7.3	7.5	7.5	6.5 - 9.0	BG± 0.2	6.5 -8.5
EC, uS/cm	10,000	20,000	1500	1300	2500	1600	1200	2000	2300	1900	1800	--		--
TDS, mg/L	5500	11,000	780	770	1600	870	600	1200	1400	1000	1000	BG ± 5%	BG± 10%	500
TSS, mg/L	<5	130	30	230	80	95	<5	25	10	<5	<5	BG ± 10%	BG± 10%	--
Inorganic N, mg/L	1.1	0.8	4.1	8.4	0.8	0.4	1.6	0.2	0.2	3.8	4.4	0.1 - 0.5		50 (NO3)
Total P, mg/L	0.25	0.30	0.05	<0.05	0.05	0.1	<0.05	<0.05	0.05	0.05	<0.05	0.005- 0.05		
Ortho-P, mg/L	0.1	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	--		
BOD5, mg/L	10	10	<5	<5	<5	<5	<5	<5	<5	<5	<5	--		
Pesticides, ug/L	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	(Various)		
Arsenic*, mg/L	0.002	0.001	0.005	<0.001	0.006	0.003	<0.001	0.010	0.017	0.003	<0.001	0.05		0.007
Boron, mg/L	0.6	1.1	0.1	<0.1	0.1	0.1	<0.1	0.1	0.1	0.1	0.1	--		0.3
Cadmium, mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.002	BG	0.002
Chromium, mg/L	0.015	0.035	0.010	0.015	0.030	0.010	0.005	0.015	0.010	0.010	0.010	0.05	BG	0.05 (CrVI)
Copper, mg/L	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	0.005	BG	2 (1)
Iron (soluble), mg/L	0.15	1.1	0.20	0.15	0.25	0.20	<0.05	<0.05	0.10	0.10	0.15	--		(0.3)
Lead, mg/L	0.010	<0.005	<0.005	0.01	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	0.005	BG	0.01
Mercury, mg/L	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	0.0001	BG	0.001
Zinc*, mg/L	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.02	BG	(3)

EPA criteria are those recommended for support of marine ecosystems. WRC guidelines for construction site dewatering stipulate that any nutrient discharges in water should not result in excessive or nuisance algal growth in the receiving water. Drinking water criteria in parentheses are criteria derived on the basis of aesthetic considerations. The letters "ND" mean that no pesticide was detected.

12.2.2 Vegetation Clearing

Vegetation clearing associated with the construction of the Bibra Lake Sewer Main has the potential to affect two components of the receiving environment. These are:

- Wetland vegetation of Lake Coogee
- Tuart Tall Open Woodland on the western shores of Lake Coogee

Table 25 indicates the total area affected for each of these components. As the pump station is to be placed in a site which has been cleared during historical times, the pump station construction will not result in the loss of any existing native vegetation.

TABLE 25 - Area of Vegetation Affected by the Construction of the Bibra Lake Sewer Main.

Vegetation type	Area to be cleared* (ha)	Bushland condition
Tuart Tall Open Woodland	0.865	Poor
M cuticularis Low Woodland	0.26	Poor to Good

*Assumes a 25 m construction corridor.

A small amount of vegetation will need to be cleared, but most will be replaced after construction. Less than 0.5% of the wetland vegetation will be permanently cleared and this can be replaced with other appropriate species.

The pipeline will also pass close to Market Garden Swamp No 3, however, the earthworks associated with the construction of the sewer line adjacent to the northern perimeter of the Market Garden Swamp No 3 will be restricted to the area of fill on former market garden land. The following points should be noted regarding construction works near Market Garden Swamp No 3:

- works will take place solely within previously cleared and filled land; and
- works will not require the removal of any existing fringing vegetation.

12.2.3 Minimisation of clearing impacts on Tuart Open Woodland

The Tuart Tall Open Woodland on the western shores of Lake Coogee, although in poor condition, is valued by the local community, as evidenced by the listing of one of the stands on the City of Cockburn Municipal Heritage Inventory. Thus the primary objectives for these stands are:

- to minimise the loss of mature Tuarts
- to reconstruct this community where ever possible and appropriate along this alignment in areas currently cleared of native vegetation.

The open nature of the Tuarts is beneficial in achieving this objective. An initial inspection of the Heritage stand identified that a gap exists on an appropriate alignment that would permit the construction of the pipeline with the loss of 1 – 2 of the smaller trunks. Final route selection should be based on achieving the objective stated for this component. Some root pruning would be required of other Tuarts adjacent to this route. With the use of arboricultural specialists to oversee this process, these Tuarts should survive and, after an initial setback, regain their vigour.

12.2.4 *Proponents Commitments on Mitigating impacts on Tuart open Woodland*

Commitment 13.1 Align sewer to minimise impacts of Tuarts
Commitment 13.2 Ensure tuarts close to sewer alignment are not impacted by excavations

The follow actions are proposed to achieve this;
1. Select the final route through this area to minimise loss of mature Tuarts.
2. Employ an arboricultural specialist with appropriate expertise to advise and supervise root-pruning of Tuarts adjacent to the route in order to minimise adverse setbacks and maximise survival.

12.2.5 *Mitigation of impacts on* Melaleuca cuticularis *Woodland*

It should be noted that all options that would redirect the pipeline and avoid impacts on this stand of *M cuticularis* have been assessed and found to be non-viable. These options and their outcomes are addressed in Section 2 of the PER.

The construction of the pipeline across the northern tip of Lake Coogee will affect 0.26 ha of the total of 5.81 ha of wetland vegetation between the existing bund and Mayor Road. This land includes the pipeline footprint and the construction of a temporary bund to provide access during the construction works. The existing bund cannot be used for heavy vehicle access without endangering the integrity of the existing pipes within the bund. However, the choice of the low bridge provides the option of rehabilitating all but 0.03 ha of the area cleared, as well as opportunities for weed control and restoration works on the existing causeway. It should be noted that although *M cuticularis*, and some *M rhaphiophylla*, will be re-established in the corridor cleared, the area immediately under the bridge will be rehabilitated with appropriate sedge species, based on the floristic survey carried out as a part of this study. This is due to the height restraints imposed by the presence of the bridge.

The Environmental Management Plan for this project will address the rehabilitation of this community in full. However the following points should be noted:
- In order to utilise stock of local provenance in the rehabilitation works, collection of seed from the Melaleucas should be carried out in April of 1999. This is likely to be in advance of the finalisation of the Environmental Management Plan and allowance should be made at an earlier stage for the seed collection to be carried out.
- Of the species present, one sedge species, *Gahnia trifida*, is known to be a difficult species to grow from either seed or greenstock. Nursery estimates suggest that effective tissue culture may be at least another 5 years away (K Meney, pers comm). If analysis of the floristic data shows that the community present is a variant of the *Melaleuca rhaphiophylla – Gahnia trifida* seasonal wetland community, then this species may be considered an essential component to re-establish.

Fortunately, during the 1998-1999 summer, an experiment will be carried out by the Town of Kwinana at Pickle Swamp to remove and replant large clumps (1m x 1m x 0.6m) of *Gahnia trifida*. The outcomes of this trial should be assessed in the light of the needs of the Lake Coogee project. The methodology used for the removal and re-establishment of *G trifida* is to either slash the surface biomass to a height no greater than 10 cm or use a controlled burn to remove most existing stems. Then approximately one week later, use earth-moving equipment to scoop out 1m x 1m clumps of *G trifida* to at least a depth of 600mm. These should be placed into

either permanent or temporary storage areas and watered to maintain saturation until new growth is established.

12.2.6 Proponents Commitments on preparing for and rehabilitating Melaleuca cuticularis woodland

Commitment 14.1 Undertake timely preparation for rehabilitation of *M.cuticularis* woodland.
Commitment 14.2 Ensure temporary causeway is constructed of local material suitable for rehabilitation of *M. cuticularis* woodland.

The following additional actions are proposed to achieve this

- Subject to environmental approval, seed collection to take place at appropriate times of the year, in advance of the finalisation of the environmental management plan.
- Investigation as a part of the environmental management plan, of methodologies to maximise the re-establishment of *Gahnia trifida*, if analysis of the floristic data indicates that this is necessary.
- The proposed construction causeway will be constructed of material excavated from the trench between the wetland and the new pump station, once the weedy topsoil has been removed.

12.3 Impacts of Construction on Wetlands

The proposed construction of the sewer main has the potential to impact upon Lake Coogee and Market Garden Swamp No 3 and their buffer zones. This section details the type and, where known, the magnitude of potential impacts and summarises pertinent information in relation to the receiving environment. The net environmental impacts are described and commitments made that will mitigate or minimise the potential impacts. It should be noted that impacts relating to vegetation clearance, dewatering and drainage/overflows are addressed more thoroughly in separate sections, though are summarised here where relevant. Although this involves some repetition of information, it does provide a clearer picture of the impacts in relation to site.

There are several impacts on the wetlands during construction, but these can be managed and rehabilitated afterwards. The net impact should be positive because the area will be actively managed.

12.3.1 Market Garden Swamp No 3

If the Low Bridge option is utilised, then

- construction works will be outside the zone of critical influence of the wetland buffer
- construction works will, however, occur within the zone of secondary influence of the wetland buffer.

Key issues for consideration are the protection of the wetland from stormwater runoff from the construction works, and the rehabilitation of the corridor once construction is complete. Provision will be made for directing any stormwater drainage during construction away from the wetland into temporary storage structures that will be removed and rehabilitated once construction of this section is completed.

Once works have been completed, recontouring of the fill over the pipeline should be carried out wherever possible to improve the aesthetics of the area in relation to the wetland. The corridor itself should be rehabilitated with appropriate species, though it is recognised that there may be constraints imposed by surrounding land uses. Priority should be given to the potential for re-establishing linkages between Market Garden Swamp No 3 and both Lake Coogee and Market Garden Swamp No 2.

Commitments made in relation to Market Garden Swamp No 3 have been made in the relevant sections and not repeated here.

12.3.2 Lake Coogee

Section 4 of the PER identifies the fact that virtually nothing is known of the aquatic flora and fauna of Lake Coogee. Inferences can be drawn from wetlands that share some pertinent characteristics with Lake Coogee, but detailed descriptions and quantifications of impacts cannot be determined at this stage. Direct impacts upon Lake Coogee should be avoided or minimised until more is known of the biology of this lake. Fortunately, options for development and construction exist that will allow impacts to be minimised or avoided. Impacts upon Lake Coogee may arise from the following components of the development:

- Construction of a low bridge across the northern end of the lake
- Dewatering and re-injection of groundwater at the pump station site.

The following points should be noted:

- Works will take place within the wetland, and within both components of the Lake Coogee wetland buffer zones
- Disturbance to wetland soils during construction will be limited to areas of seasonal inundation north of the causeway. Construction during summer will minimise the risk of mobilisation of soils in permanently inundated areas.
- Connectivity between Lake Coogee and Market Garden Swamp No 2 will not be further impeded, and provision may exist for the creation of additional culverts beneath the existing causeway to improve surface connectivity.

Drawing upon the above points, construction and decommissioning of the temporary causeway and construction of the low bridge will not result in adverse impacts upon wetland water quality within Lake Coogee itself. Even if stormwater runoff is generated during the construction phase thus resulting in temporary re-inundation of the seasonal wetland north of the existing causeway, the surface hydrological connection between this portion of the wetland and the main lake can be controlled. This can be used to limit or avoid the passage of turbid water into the main waterbody until the suspended particles have resettled. The vegetation will act as a filter to reduce or limit the passage of turbid water into the area of open water between Lake Coogee and Market Garden Swamp No 2.

Dewatering impacts and mitigation are addressed in section 10.1. However the following points should be noted

- It is likely that Impacts from dewatering of the pump station site will be limited to the area within the grout curtain thus there will be no drawdowns of water levels in Lake Coogee associated with dewatering. Golder Associates noted that without a grout curtain, drawdowns could be experienced at significant distances from the site, due to the existence of preferential flow paths through the vuggy limestone.
- Re-injection of the dewater into shallow wells in a 100 m radius of the grout curtain will result in temporary mounding of the groundwater and a temporary increase (quantity not specified) in groundwater salinity in the immediate area.

The construction of the pipeline across the northern tip of Lake Coogee will affect 0.26 ha of wetland vegetation of *Melaleuca cuticularis* Low Woodland. Approximately 90% of the area cleared as a part of construction will be available for reconstruction of the vegetation. The vegetation present may be a variant of *Melaleuca rhaphiophylla – Gahnia trifida* seasonal wetland vegetation, or it may be a new community type not previously recorded in the Floristic Survey of the Swan Coastal Plain (Gibson et al, 1994). Constraints imposed by the methodology and

by resource availability with CALM have meant this question cannot be resolved until January-February 1999. Analysis by CALM of the floristic survey data for this vegetation type will inform the detailed planning of the rehabilitation works, as a part of the environmental management plan, for this area. *Gahnia trifida* has been identified as a species that is difficult to replace using normal methods of replanting (ie, seed, green stock or tissue culture). Transplantation of large clumps is currently being trialled elsewhere in the Metropolitan Area and the results of these trials will inform the rehabilitation works for this project.

Many water bird species that utilise the range of wetland habitats found at Lake Coogee will make use of the fringing vegetation for perching, roosting and nesting. Some species such as the Purple Swamp Hen use the inundated vegetated area for feeding. The area affected by the works (0.26 ha) is 1.7 % of the total area of paperbark woodland around the perimeter of the Lake (15.4 ha). The net impact is considerably less, given that 90% of the area disturbed will be reconstructed. Thus it is considered that the net effect on waterbird habitat at Lake Coogee is negligible Neither stormwater nor overflows from the pump station system will be directed towards Lake Coogee.

12.3.3 Proponents Additional Commitments on Wetlands

Commitments in relation to vegetation clearing, dewatering and drainage are already made in the relevant sections.

Commitment 15. Ensure that run-off or temporary inundation during construction does not impact water quality in Lake Coogee

This will be achieved by;

- restraining any turbid run-off water from entering Lake Coogee until particulates have settled.
- Constructing the bridge across the causeway in summer.

12.3.4 Market Garden Swamp No 2

Although this wetland is not directly affected by any of the works associated with this project, a net environmental benefit for this wetland resulting from this project is worth noting here.

Currently any overflow from the existing Munster Pump Station No 2 is directed firstly into an overflow basin. The overflow basin itself overflows into a disused limestone quarry which overflows into Market Garden Swamp No 2. This overflow path has been used in its entirety only once, in February 1992, on the occasion of a 1 in 100 year storm event. The development of the Munster Pump Station No 3 will enable the system to cope with storm events of this magnitude, allowing sufficient time to effect repairs even if one of the pump station fails.

12.4 Visual Change

Visual change has been included in the biological impacts because many of the remediation options relate to improving the biological environment of the area. This section was developed by ECOSCAPE Pty Ltd. The following section in the alternate font are verbatim copies of their report.

Visual change refers to the impact of the proposed works in relation to the current landscape values. The level of acceptable visual change is based on an

The major visual impact will be the pump station, but this can be screened using Tuarts and other appropriate vegetation.

assessment of all of the information compiled to undertake the visual analysis. To understand the impacts of the development, further description of the extent of works and their visual impact is required.

12.4.1 Expected Visual Change and Visual Impacts

Ranking of the visual impact is based on the visual impact of the works on the scenic quality and visual character. Ranking of these impacts forms part of the basis for the recommendations for minimising visual impacts.

The following table identifies and ranks the visual impacts for the proposed works.

TABLE 26 - Identification and Ranking of Visual Impacts Associated with the Proposed Munster Pump Station No 3 and the Extension of the Bibra Lake Sewer Main.

Proposed Works	Visual Impact	Ranking
Construction of a 3 m diameter sewer pipe between the Munster Pump Station and Fawcett Rd, Coogee	The pipe will be placed below ground in this section. The primary visual intrusion will be from the construction works during the construction phase. As the area affected has been previously cleared for agriculture, but is currently fallow, there will be no perceived change of land use.	Low
Construction of a 3 m diameter sewer pipe between Fawcett Rd and the west bank of Lake Coogee.	The pipe will emerge from the ground on the east bank of the Lake and will cross the wetland north of the existing causeway suspended on a low bridge to a maximum height of 5 m above ground level. The pipe will re-enter the ground at an appropriate point in the topography. The major visual intrusion is from the low bridge, which will be set amongst the paperbark trees in the wetland channel, and from the exposed sections either side of the existing wetland vegetation.	Moderate to high
Construction of sewer between the northern end of Lake Coogee and the Munster No 3 Pump Station site.	The major visual intrusion will be during the period of construction. Careful choice of alignment for the pipeline will minimise the number of existing trees removed as a part of works. The majority of the route passes through previously cleared land.	Low
Construction of Munster Pump station No 3 and associated infrastructure.	The pump station will be located within a shallow saddle within the coastal ridgeline. This will minimise visual intrusion from viewpoints lower in the landscape, however the site is visible from homes on the ridgeline in the suburb of Cockburn.	High

12.4.2 Level of Acceptable Visual Change

The proposed sewer pipe is to be laid below ground level for the majority of the route. If the route can be selected to minimise the potential loss of existing mature trees, then the net visual impact will be neutral for these sections of the route. Permanent visual change is limited to two areas:

- The low bridge across the northern end of Lake Coogee
- The site of the pump station and its associated infrastructure.

In both cases, the sites form part of the viewscape from housing constructed to the North. The low bridge in particular may also be visible from a limited number of existing properties and from future residential and transport developments. The visual sensitivity of these sites is moderate to high.

It is considered that with appropriate management of the visual impacts, through landscaping and choice of appropriate building materials, as detailed in the objectives and recommendations in the following section, the level of visual intrusion can be minimised thus maintaining the existing visual resources and values.

12.5 Visual Quality Management Objectives

Specific objectives for the visual quality management have been developed from the visual analysis undertaken for this project. The visual management objectives are:

- Minimise impacts of the low bridge on viewscapes.
- Minimise impacts of the pump station and associated infrastructure on viewscapes
- Ensure background and foreground view types are maintained along viewsheds.
- Maintain landscape character.
- Re-establish vegetation where appropriate along the route of the pipeline and in the vicinity of the pump station.

12.6 Mitigation of Visual Impact

The following recommendations have been made taking into account the visual character, existing vantage points and viewsheds, features of visual significance, the type of viewers and their expectations and the expected visual impact that the proposed Munster pump station and pipeline will have. The recommendations cover landform, vegetation, waterform, and land use – each a component of the visual character.

EXISTING VIEWS	DESIRABLE OBJECTIVE	RECOMMENDED ACTIONS
Landform – Steep limestone ridge to the west, low-lying land to the east. – Long open views to the north and south.	• Maintain scenic quality of landform. • Minimise intrusive changes.	• Contour bunds for pump station area to mimic natural contours. • Minimise the use of cut and fill. • Contour the areas where the pipe emerges above ground to minimise intrusion.
Vegetation – Stands of Tuarts on the slopes of the ridge. – Mainly scattered groups of trees with pasture grasses under. – Open grassland with few scattered trees. – Dense stands of Melaleucas in low lying areas.	• Screen out undesirable views of the pipeline and pump station. • Improve scenic quality of cleared areas along pipeline route. • Minimise loss of existing mature indigenous trees along route.	• Use appropriate vegetation to screen low bridge across wetland • Select pipeline route to maximise use of existing cleared areas and minimise loss of mature trees. • Views into degraded land to be enhanced by clumps of indigenous vegetation. Trees grouped to promote views to ridge. • Linear plantings where total screening is necessary around pump station and low bridge. • Use indigenous trees and shrubs for all revegetation and rehabilitation works. • Use native species to landscape the areas between the existing wetland vegetation adjacent to the low bridge and the point at which the pipe re-enters the ground.
Waterform – Elongated, linear lake.	• Retain and accentuate views where possible. • Unify area.	• Accentuate planting along pipeline route along western shore where original vegetation has been lost and at bridge area using indigenous species.
Land Use – Urban on ridgeline. – Market gardens. – Major highway (potential future).	• Minimise views of pump station from homes on ridgeline.	• Use Acacias and Tuarts for rapid screening of pump station site. • Use *M cuticularis* and *M rhaphiophylla* in re-plantings adjacent to the low bridge.

In summary, the major areas of visual intrusion are from the location of the pump station and infrastructure, and from the low bridge across the northern end of Lake Coogee.

The pump station will be most visible to the homes overlooking this site from the Coogee heights area. Two strategies are proposed to ameliorate the visual impacts and retain or re-establish the overall scenic quality of the viewscape. These are:

- To contour the outer bund walls to reflect the natural contours of the landform; and
- To plant the bund walls and adjacent area with native species indigenous to the area, including fast growing acacias and Tuarts (*E gomphocephala)*, which are also noted for their rapid establishment and growth. Where possible within the pump station site, landscape planting of small stands of Tuarts and other species will also contribute to screening.

The low bridge will, initially, be visually intrusive, although it is low in the landscape, because of the need to clear the adjacent vegetation for the temporary causeway. Unlike the pump station site, it would be inappropriate to foster rapid screening through the use of rapid growing species as the overall objective for this site is to re-establish the original vegetation. The dominant tree species at this site is *Melaleuca cuticularis*, which is relatively slow growing, intermixed with *M rhaphiophylla*, which grows marginally faster and taller than *M cuticularis*. As a part of the environmental management plan, consideration will be given to maximising the effective growth of these two species to achieve screening as rapidly as possible without compromising the overall objective of revegetation.

12.6.1 Proponents commitments on Visual Impacts

Commitment 16.1 Develop a landscape plan.
Commitment 16.2 Modify landforms to reduce visual impact
Commitment 16.3 Undertake plantings to screen constructed items and accentuate visual quality.

The following action are proposed;

- A plan will be developed that will detail rehabilitation and landscape procedures, showing in detail locations of proposed plantings and monitoring
- Bunds for pump station area will be contoured to mimic natural contours
- Cut and fill will be minimised
- Areas where the pipe emerges above ground will be contoured to minimise intrusion
- Appropriate native vegetation will be used to screen the low bridge across wetland
- The pipeline route will be selected to maximise use of existing cleared areas and minimise loss of mature trees
- Views into degraded land will be enhanced by clumps of indigenous vegetation. Trees will be grouped to promote views to ridge
- Linear plantings will be undertaken where total screening is necessary around pump station and low bridge
- Locally provenanced indigenous trees and shrubs will be used for all revegetation and rehabilitation works
- Locally provenanced native species will be used to landscape the areas between the existing wetland vegetation adjacent to the low bridge and the point at which the pipe re-enters the ground
- Planting along the pipeline route along western shore where original vegetation has been lost and at bridge area using indigenous species will be accentuated
- Acacias and Tuarts will be used for rapid screening of pump station site
- *M cuticularis* and *M rhaphiophylla* will be used in re-plantings adjacent to the low bridge
- Full details of the Landscape plan will be included in the environmental management plan (Commitment 9)

12.7 Beeliar Park

Many of the issues in relation to Beeliar Park have been addressed as part of the preceding sections on biota and visual amenity and wetlands. Beeliar Park was established in recognition of the unique conservation value of the two chains of wetlands running North-South through the southwest section of Metropolitan Perth. The management responsibility for this park falls to the Beeliar Park Management Committee who were visited during the progress of this study. In addition members of the committee were invited to the risk assessment workshop, and in the event the CALM representatives from that committee were able to attend.

Many of the rehabilitation activities undertaken following construction will improve the long term sustainability of the park and make it more accessible.

Management of the Beeliar Park is a daunting task; development encroaches on many of the lakes alienating the wetlands and leading to nutrient enrichment.

Water Corporation recognises that it is yet another organisation seeking to impose development in this park. This development is not a matter of choice - this PER demonstrates that there are no easy options for disposing of the wastewater that all people in Perth produce. Water Corporation has put this proposal on hold whilst it investigated alternatives and concluded that none of them offer viable solutions at this stage.

Water Corporation considers that the time for investigation has now passed, without significant increases in capacity in a relatively short period of time, Munster pump station No.2 will be overwhelmed and the impacts on Market Garden Swamp No.2 and thence to Market Garden Swamp No.1 and Lake Coogee will be certain and regular.

In developing this proposal Water Corporation has been mindful of two major issues - the impact on the wetland (geology, hydrogeology, hydrology, water quality, biota) and the impact on recreational use (heritage, access, visual impacts). It is considered that the preferred option represents the best compromise in achieving all of these values.

Water Corporation have developed this proposal, considering that repeated intrusion into the wetland areas will lead to further degradation, and have designed for ultimate capacity of the Perth South Sewerage System. That is - based upon current usage patterns and expected housing densities in this area this pipeline is designed to carry the wastewater from the ultimate population in this catchment. There will be no further pipeline in the future.

In order to enhance the recreational values of the Park, Water Corporation are committing to developing a walkway from Fawcett Road along the full line of the above ground section of pipeline. Provision for connection to any extension to this path by other groups (eg Cockburn City Council) will be made.

In order to enhance the long term viability of the vegetation in this area, taking into account the potential road reserves, Water Corporation will replant vegetation removed during construction, provide for additional plantings of appropriate vegetation along the path of the pipeline, on either side of the wetland and at the Pump Station and undertake a two year monitoring program in the area of Tuart rehabilitation and a five year monitoring program in the wetland area to ensure that all vegetation is properly established and where necessary undertake supplementary plantings.

In order to enhance the integrity of the wetland, the existing causeway will be scalped to remove weedy topsoil and the batters planted with appropriate sedges and restriction to access will be investigated to allow for revegetation of the top of the causeway. These issues will be detailed in the environmental management plan.

12.7.1 Proponents commitments in relation to Beeliar Park

Commitment 17.1 Turn the low bridge into a walkway with connections as stipulated by the Beeliar Park Management Committee
Commitment 17.2 Investigate opportunities for increasing hydrological connectivity through existing causeway

12.8 Heritage

This report has identified that there are a number of heritage places and values within the vicinity of the proposed pipeline and pump station. These range in significance between local, regional and possibly national significance. The objectives in relation to heritage places are:

- To avoid or minimise impacts upon heritage sites
- To maintain heritage values

This section details the potential impacts of the proposed construction works on heritage places and details strategies to avoid or minimise those impacts in order to maintain heritage values.

None of the heritage sights are impacted by the proposal, but the pump station is close to one. This will be managed to ensure the development does not intrude on the sight.

12.8.1 Lake Coogee ruins

One of the ruined cottages lies immediately south of the bund around the proposed pump station. The site is in poor condition with many materials, such as sheets of tin and limestone rubble scattered around the remains of the cottage. The site will be fenced prior to the commencement of earthworks in order to avoid encroaching upon this site. Sympathetic landscaping of the bund walls in the vicinity of the ruins will soften the visual intrusion. Thus there will be no net impact upon the site itself or its heritage values.

12.8.2 Proponents Commitments on Lake Coogee Ruins

Commitment 18. Protect heritage sites close to construction area
This will be achieved by the following actions;

- A fence will be constructed approximately 10 m from the outer perimeter of the ruins located on the south side of the proposed pump station site to ensure that earthworks and other activities associated with the construction of the pump station will not impact upon the cottage.
- The bund walls close to the ruins should be landscaped, using native species of local provenance, to soften the visual intrusion of the bund.
- The alignment and the area of the pump station will be surveyed for graves and appropriate action taken.
- All workers will be alerted to the possibility of graves in this area. If any remains are found, work will cease and a qualified archaeologist will be called.

12.8.3 Lime kilns, Mayor Road

The proposed works are not in the vicinity of the lime kilns and therefore there will be no impacts upon the kilns or their heritage values from this project.

12.8.4 Tuart Trees at Lake Coogee

This stand of trees will be affected by vegetation clearing associated with pipeline construction and possibly by a temporary rise in the watertable associated with the dewatering programme. Opportunities exist to minimise the impacts on the Tuarts through judicious route selection and through the use of arboriculturalists advisers to maximise retention of trees adjacent to the route. The temporary rise in groundwater, which will occur during summer, will aid in the protection and recovery

of these trees following pipeline construction. These impacts and their mitigation are addressed in detail elsewhere in this report. No additional commitments are required.

In conclusion there will be a moderate impact upon the heritage values of the existing stand of Tuarts, which will be offset by a net gain in the area of Tuart woodland following rehabilitation of the pipeline.

12.8.5 Market Garden Swamp No 3

Although works will take place within the wetland buffer for this wetland, all works will be restricted to previously filled and disturbed areas. Existing and proposed land uses for the private land in the north west corner will limit the potential for revegetation of the corridor.

It is concluded that the net effect of this project on Market Garden Swamp No 3 and its heritage values will be neutral.

12.8.6 Market Garden Swamp No 2

The construction of the low bridge over the northern end of Lake Coogee is the only potential source of impacts on Market Garden Swamp No 2, through the hydrological connection between the two wetlands. As this site will be subject to rigorous environmental controls during construction and operation, as detailed elsewhere in this report, it is concluded that there will be no adverse impacts upon the heritage values of Market Garden Swamp No 2.

12.8.7 Lake Coogee

Lake Coogee will be affected by this project as detailed in the relevant sections of this report. The primary source of impacts upon the heritage values of the wetland will be the construction of the low bridge, which will be a permanent structure.

The primary heritage values present at Lake Coogee are natural heritage values relating to scientific and conservation value. The low bridge, while visually intrusive, will have a relatively low impact upon the functional ecology of the wetland. The physical disruption and vegetation loss during construction will be repaired and the vegetation community reinstated, with only a narrow footprint remaining alienated. The revegetation of the pipeline corridor on the western shores of the lake with Tuarts will reinstate vegetation lost over 100 years ago and will eventually provide a visual buffer between the lake and the proposed Controlled Access Highway.

The Lake is currently listed in the Interim List of the Register of the National Estate as part of the Beeliar Wetlands. Like several other wetlands within the chain, the Lake is in a modified condition, though it has potential for some restoration. The placement of the low bridge across a portion of the wetland will impact upon the Lake and therefore will impact upon a heritage place. However, the impact is not of a magnitude that would affect the status of Lake Coogee in the final determination regarding the placement of the Beeliar wetlands on the Register of the National Estate, or even on the Municipal Heritage Inventory for the City of Cockburn, thus the project will not diminish the overall heritage value of Lake Coogee.

A range of commitments are given elsewhere in the PER in relation to minimising and ameliorating the potential impacts upon Lake Coogee and its hinterland from this project and no further commitments are required here.

12.8.8 Clarence Townsite Graves

It was noted in the history section that the ill-fated settlement at Clarence in 1829-1831 resulted in the loss of 60 lives. These people were buried in a graveyard established on high ground behind the townsite. The location of these graves is unknown. As a precaution, the site of the pump station should be surveyed using appropriate technology in order to verify that it is not the site of these graves. No additional commitment is required, as a commitment to survey the site for graves is given in the section on Aboriginal Heritage.

12.9 Aboriginal Culture and Heritage

Due to the selection of a low bridge and the intention to minimise clearing impacts and revegetate with local native vegetation it is considered that the proponent has met all of the requirements of the traditional owners of this area.

Water Corporation have taken account of the views of traditional landowners and have accommodated their concerns.

Care will be taken to ensure that the proposed alignment avoids registered site S2968.

It is noted that there is the possibility of archaeological remains on site, contractors and workers will be alerted to the possibility and if any remains are found work will cease and a qualified archaeologist will be called.

12.9.1 Proponents Commitments on Aboriginal Heritage

Commitment 19 Undertake a Grave search along the proposed alignment

13. Detailed List of Proponent's Commitments

Commitment	Phase	Objective	Actions	Whose Advice	Compliance Criteria
1. Develop and EMS for this proposal in line with Water Corporation's EMS, but covering contractual requirements of the proposed construction alliance (Section 11.1)	Prior to commencement of detailed design	Ensure that requirements to minimise environmental impacts and mitigate them following construction are complied with by all parties and to establish a clear and formal path for the communication of environmental management actions.	1.1 Roles and responsibilities will be identified. 1.2 Programs of work will be developed in order to meet each commitment. 1.3 Timings and compliance targets will be identified. 1.4 Communication protocols including document control will be established 1.5 Review and audit procedures will be identified	DEP	EMS documentation will be given to DEP for review.
2.1 Develop a de-watering plan. (Section 11.2)	Prior to Construction	maintain ground and surface water levels/quality and reduce stress on vegetation.	2.1.1 Final expected quantities of water arising from dewatering will be quantified as fully as possible. 2.1.2 The three potential options for disposal will be fully quantified prior to construction with the priority being to re-charge as much water as possible. 2.1.3 An emergency discharge plan will be determined incorporating the need to limit discharges to environmentally sensitive areas and reporting requirements if the emergency plan is implemented. 2.1.4 A groundwater and vegetation monitoring protocol will be established with actions to be taken if significant departures from seasonal norms are noted.	DEP/ BPMC	Dewatering plan will form part of environmental management plan and will be available for review
2.2 Implement de-watering plan and report.	Construction		2.2.1 The de-watering plan will be implemented and the results of the monitoring program reported to the DEP.		Monitoring results will be given to DEP.
3. Design the sewer in a manner that reduces	Design	maintain ground and surface water	3.1.1 The pipe will be designed in such a fashion that the design specification of 9m of hydrostatic pressure cannot be exceeded (That is the lowest point in	DEP/WRC	Design drawing

Commitment	Phase	Objective	Actions	Whose Advice	Compliance Criteria
the potential for leaks (Section 11.3)		quality	the sewer is no more than 9m below the height of the overflow weir at the pump station on Mayor Road).		
3.2. Inspect pipeline prior to commissioning (Section 11.3)	Construction		3.2.1 The pipeline will be visually inspected to ensure all joints are properly made and the plastilining will be tested electrostatically..	DEP	Inspection reports indicate the pipe and lining are intact
3.3. Inspect pipeline on a routine basis (Section 11.3)	Operation		3.3.1 Routine inspections of the above ground section of the pipeline will be made to ensure integrity of the pipeline. Any evidence of problems with the operation of the sewer will be acted upon as soon as possible 3.3.2 The sewer will be inspected internally every 5-7 years and any evidence of damage made good.	DEP (licensing)	Inspection reports given to DEP licensing
4. Develop an emergency action plan in case of catastrophic failure	Design	Plan for the mitigation of major leaks	4.1 Identify scenarios where a catastrophic failure could occur. 4.2 Quantify expected flow rates of leaks. 4.3 Determine expected responses and mechanisms that do not lead to additional problem in other environmentally sensitive areas. 4.4 Estimate expected worse case leakages and impacts.	WRC/ CALM DEP	Design drawings have fail safe mechanisms where appropriate.
5.1 Detain Stormwater from the construction site. (Section 11.4)	Construction	Maintain surface water quality	5.1.1 Temporary stormwater detention structures will be constructed at appropriate points along the route to direct stormwater from events up to a 1 in 10 year event away from wetland basins.	DEP/WRC	Performance compliance report to DEP
5.2 Detain stormwater at the pump station site (Section 11.4)	Operation	Maintain surface water quality	5.2.1 Stormwater will be directed to a sump within the pump station bund.	DEP/WRC	Performance compliance report to DEP
6. Implement dust control plan. (Section 11.5)	Construction	minimise nuisance from dust on adjacent landholders	6.1 All dirt access roads will be wetted during dry and windy conditions. 6.2 Stockpiles of material close to residences will be kept to a minimum and wetted during dry and windy conditions. 6.3 Vehicles carrying dust generating material offsite will be covered. 6.4 Material carried offsite on vehicle wheels will be cleaned up and returned to site. 6.5 Nuisance dust associated with construction and rock-breaking near to residences will be subject to negotiation with residents with a view to minimising impacts, giving notice of times when dust-generating activities will take place and cleaning up impacts if they arise (e.g. window cleaning,	DEP	No visible dust will cross the boundaries of the construction site.

Commitment	Phase	Objective	Actions	Whose Advice	Compliance Criteria
			etc). 6.6 Construction sites near to residences will be fitted with wind fencing perpendicular to the sea breeze.		
7. Meet Requirements of Environmental Protection (noise) Regulations (1997). (Section 11.7)	Construction	Minimise nuisance to residents	7.1 Noisy construction activities to be confined between 7 a.m. and 7 p.m. Monday to Saturday, with significant noise generating activities to be limited further subject to negotiation with local residents. 7.2 Any noise generating activities that must be undertaken outside of these hours will be subject to the development of a noise management program and negotiation with local residents. 7.3 Mechanisms to receive noise complaints and react to them will be set up. 7.4 The contractor will communicate to residents occasions when major noise generation is likely to occur	DEP	Performance compliance report to DEP
8. Vibration to be included in noise communication strategy if needed. (Section 11.7)	Construction	Minimise nuisance to residents	8.1 Communication of vibration findings and issues relating to vibration (e.g. thresholds) to be undertaken as part of feedback to community. 8.2 Project manager to be available to discuss individual issues with local residents.	DEP	Copy of community feedback leaflet to be sent to DEP
9.1 Quantify contamination issues along alignment. (Section 11.8)	Design	Reduce health risk to community. Reduce environmental risks.	9.1.1 Further assessment of lead levels around Test Pit 1 will be undertaken once the final land use is decided. 9.1.2 Further assessment of pesticide levels around Test Pit 4 will be undertaken once the final land use is decided. .	DEP	Contamination levels identified in environmental management plan
9.2 Ensure final alignment is clean of contamination (Section 11.8)	Construct	Reduce health risk to community. Reduce environmental risks.	9.2.1 Disposal of any contaminated material will be undertaken in consultation with DEP. 9.2.2 Dispose of other material from the trench either by re-using it or disposing of in an appropriate landfill.	DEP	Verification report to DEP.
10.1 Prepare an environmental management plan. (Section 12.1)	Design	Ensure that vegetation and habitats are protected and enhanced as far as	10.1.1 Identify and adjust the alignment of the pipeline to minimise the amount of mature trees impacted by the proposal. 10.1.2 Develop a detailed revegetation and landscape plan to screen the pump station and pipeline using locally provenanced native vegetation. 10.1.3 Identify reinjection locations to mitigate impacts of de-watering on	DEP/ BPMC	Report available for public

Commitment	Phase	Objective	Actions	Whose Advice	Compliance Criteria
		possible and meet the EPA's requirement of "no net loss". Allow the EPA and public the ability to review and consider environmental actions at more finalised stage.	vegetation. 10.1.4 Develop site induction and training plan. 10.1.5 Environmental management plan to be available to be available for public comment and final sign off by DEP.		
10.2 Implement environmental management plan during construction.	Construction	Limit environmental impacts during construction phase	10.2.1 Ensure items 10.1.1, 10.1.3 and 10.1.4 are completed satisfactorily.	DEP/ BPMC	Photographic record/signature of those taking induction course.
10.3 Implement rehabilitation requirements of environmental management plan	Post Construction	Ensure vegetation is rehbilitated and enhanced following completion of construction work.	10.3.1 Ensure item 10.1.2 is carried out on the ground.	DEP/ BPMC	Photographic record
11. Ensure vegetation is not subject to undue stress during summer months. (Section 12.1)	Construction	Minimise the loss of vegetation due to construction and dewatering activities.	11.1 Groundwater levels and water quality will be monitored at points between the re-injection wells and any stands of native vegetation down-gradient from the wells. 11.2 Vegetation Stress levels will be monitored in the upland vegetation down-gradient of the re-injection wells and compared with seasonal norms. 11.3 If significant changes in the groundwater quality or vegetation stress levels are identified that are not due to normal seasonal variation, then the DEP will be informed and consulted as to appropriate remedial action to either divert the groundwater flow or dilute the effect	WRC/ CALM/ DEP	Bore monitoring records Photographic and botanist records
12. Ensure that Lake Coogee is not impacted by dewatering, beyond seasonal norms	Construction	Minimise and mitigate dewatering impacts on Lake Coogee	12.1 No re-injection wells to be placed within the 50 m zone of critical influence around Lake Coogee. 12.2 If water levels in Lake Coogee are higher than seasonally expected prior to the start of the dewatering programme, then the placement of re-injection wells will be reassessed and placed further from the Lake.	WRC/ DEP/ CALM	Water level and quality Monitoring reports submitted to DEP

Commitment	Phase	Objective	Actions	Whose Advice	Compliance Criteria
(Section 12.2)			12.3 Temporary storage for disposal water to be supplied to an appropriate capacity in line with the Water & Rivers Commission's interim dewatering guidelines. 12.4 Lake water levels will be monitored during the dewatering programme. The necessity for remedial action, such as pumping to lower lake water levels, will be determined in consultation with the relevant statutory authorities.		
13.1 Align sewer to minimise impacts on Tuarts (Section 12.2)	Design	Ensure long term sustainability of Tuart Open Woodland.	13.1.1 The final route will be selected to minimise loss of mature Tuarts.	DEP/ BPMC	Environmental management Plan will show alignment and existing trees.
13.2 Ensure tuarts close to sewer alignment are not impacted by excavations			13.2.1 An arboricultural specialist with appropriate expertise to advise and supervise root-pruning of Tuarts adjacent to the route in order to minimise adverse setbacks and maximise survival will be employed	CALM	Photographic record of trees will be given to DEP.
14.1 Undertake timely preparation for rehabilitation of *M.cuticularis* woodland. (Section 12.2)	April 1999 /Pre-design	Meet EPA requirement of "no net loss" of wetland fringing vegetation	14.1.1 Subject to environmental clearance seed will be collected from the Melaleucas. 14.2.1 Conservation of Gahnia trifida will be investigated.	DEP/ CALM/ BPMC	Environmental management plan.
14.2 Ensure temporary causeway is constructed of local material suitable for rehabilitation of *M. cuticularis* woodland	Construction		14.2.1 The proposed construction causeway will be constructed of material excavated from the trench between the wetland and the new pump station, once the weedy topsoil has been removed		photographic record.
15. Ensure that run-off or temporary inundation during construction does not impact water quality in	Construction	Mitigate construction impacts on the water quality of Lake Coogee	15.1 In the case of temporary inundation of the low bridge site during construction works from stormwater runoff, turbid water resulting from the construction works will be restrained from entering Lake Coogee until all particulate matter has settled. 15.2 Construct the bridge in summer.	DEP/WRC	Monitoring results submitted to DEP

Commitment	Phase	Objective	Actions	Whose Advice	Compliance Criteria
Lake Coogee (Section 12.3)					
16.1 Develop a landscape plan. (Section 12.6)	Design	Mitigate visual impact and enhance appropriate vegetation along the line of the proposal.	16.1.1 Landscape plan to be part of environmental management plan and available for public review. 16.1.2 The pipeline route will be selected to maximise use of existing cleared areas and minimise loss of mature trees.	DEP/ BPMC/ CALM	Items will be mapped in landscape plan and available for public review in the environmental management plan..
16.2 Modify landforms to reduce visual impact	Construct	Mitigate visual impact and enhance appropriate vegetation along the line of the proposal	16.2.1 Bunds for pump station area will be contoured to mimic natural contours. Cut and fill will be minimised. 16.2.2 Areas where the pipe emerges above ground will be contoured to minimise intrusion.		rehabilitation and landscaping will be subject to fixed point photographic record and independent botanical verification
16.3 Undertake plantings to screen constructed items and accentuate visual quality	Post Construct	Mitigate visual impact and enhance appropriate vegetation along the line of the proposal	16.3.1 Appropriate native vegetation will be used to screen the low bridge across wetland. 16.3.2 Views into degraded land will be enhanced by clumps of indigenous vegetation. 16.3.3 Trees will be grouped to promote views to ridge. 16.3.4 Linear plantings will be undertaken where total screening is necessary around pump station and low bridge. 16.3.5 Locally provenanced indigenous trees and shrubs will be used for all revegetation and rehabilitation works. 16.3.6 Where available locally provenanced native species will be used to landscape the areas between the existing wetland vegetation adjacent to the low bridge and the point at which the pipe re-enters the ground. 16.3.7 Planting along the pipeline route along western shore where original vegetation has been lost and at bridge area using indigenous species will be accentuated. 16.3.8 Acacias and Tuarts will be used for rapid screening of pump station site. 16.3.9 M cuticularis and M rhaphiophylla will be used in re-plantings adjacent		rehabilitation and landscaping will be subject to fixed point photographic record and independent botanical verification

Commitment	Phase	Objective	Actions	Whose Advice	Compliance Criteria
			to the low bridge. 16.3.10 A five year monitoring program and supplementary replanting program for wetland areas is to be undertaken. 16.3.11 A two year monitoring program and supplementary replanting program is to be undertaken in woodland rehabilitation areas. 16.3.12 The existing causeway to be revegetated as far as possible with appropriate native vegetation. Following construction an investigation into the feasibility of increasing connectivity through the existing causeway will be undertaken		
17.1. Turn the low bridge into a walkway with connections as stipulated by BPMC (Section 12.7)	Construct	Enhance recreational use of area	17.1.1 A walkway is to be established from Fawcett Road across the low bridge and connecting into whatever access is needed the other side.	DEP/ CALM/ BPMC	Design Drawings/ Photographic record
17.2 Investigate opportunities for increasing hydrological connectivity through existing causeway	post-construct	Improve hydrological connectivity between wetlands	17.2.1 Options for increasing hydrological connectivity will be investigated and implemented if they are shown to be practicable and significantly enhance connectivity between the wetlands.	WRC/ BPMC	Report on hydrological connectivity to be developed and given to DEP.
18. Protect heritage sites close to construction area. (Section 12.8)	Construct	Protect heritage in the area of Lake Coogee Ruins	18.1 A fence will be constructed approximately 10 m from the outer perimeter of the ruins located on the south side of the proposed pump station site. 18.2 The bund walls close to the ruins will be landscaped, using native species of local provenance.. 18.3 All workers will be alerted to the possibility of graves in this area. If any remains are found, work will cease and a qualified archaeologist will be called	DEP	Performance compliance report submitted to DEP.
19 Undertake a grave search along the proposed route (Section 12.8/12.9)	Pre-design	Reduce likelihood of unexpectedly encountering remains of heritage or aboriginal significance	19.1 The alignment and the area of the pump station will be surveyed for graves and appropriate action taken.	DEP/AAD	Search report to be available to DEP/AAD.

BPMC = Beeliar Park Management Committee, DEP = Department of Environmental Protection, CALM = Department of Conservation and Land Management, WRC = Water and Rivers Commission

14. Reconciliation with EPA Requirements

14.1 Vegetation communities

EPA Requirement
Assess and document the existing vegetation communities, the likely impacts (eg. clearing) from the proposal and the proposed management measures (if any) which will be planned and implemented to ensure the EPA's objective is met, including 'no net loss'
Response
Work undertaken as required
Summary
Approximately 0.9 hectares of Tuart Tall Open Woodland in Poor condition and 0.26 hectares of *M cuticularis* Low Woodland in Poor to Good Condition will be cleared as a part of this proposal. The majority of the *M cuticularis* woodland will be replaced once construction has been completed and a significantly greater area of Tuart Tall Open Woodland will be replaced after construction. In addition the existing causeway will be replanted and the fringing vegetation around the wetland will be increased. These issues are the subject of an environmental management plan committed too at the design stage of the proposal.

14.2 Beeliar Regional Park/System 6 M92

EPA Requirement
Assess and document the likely impacts from the proposals on the Beeliar Regional Park and the proposed management measures (if any) which will be planned and implemented to ensure the EPA's objective is met, including 'no net loss'.
Response
Work undertaken as part of Vegetation assessment, heritage assessment and visual quality assessment.
Summary
Due to decisions undertaken whilst selecting route alignment options the impacts on the Park have been minimised. The conservation impacts have been minimised and the proposed revegetation program replaces more vegetation than currently exists, protecting the long term integrity of the fringing vegetation and restoring the visual amenity of the Park by tree screening with vegetation that would have originally grown in this area. The recreational aspects of the park will be enhanced by the provision of a walkway across the North end of Lake Coogee, giving better access.

14.3 Declared Rare and Priority Flora

EPA Requirement
Assess and document the presence of declared Rare and Priority flora species and proposed management measures (if any) which will be planned and implemented to ensure the EPA's objective is met.
Response
CALM database search and ground survey undertaken.
Summary
There are no declared rare and priority flora in the area of the construction.

14.4 Terrestrial Fauna

EPA Requirements
Assess and document the presence of terrestrial fauna, the likely impacts and proposed management measures (if any) which will be planned and implemented to ensure the EPA's objective is met.
Response
Work has been undertaken
Summary
A wide range of fauna uses lake Coogee and its fringing vegetation. The proposed alignment will have impacts during construction, but rehabilitation measures will restore existing habitats and increase habitat types in this location.

14.5 Specially Protected (Threatened) Fauna

EPA Requirements
Assess and document the presence of Declared Rare and Priority fauna species and proposed management measures (if any) which will be planned and implemented to ensure the EPA's objective is met
Response
Work has been undertaken
Summary
No specially protected fauna will be affected by this proposal. The proposed rehabilitation measures will restore existing habitats and increase habitat types in this location.

14.6 Wetlands

EPA Requirements
Assess and document the environmental values of wetlands, the likely construction and post construction impacts and proposed management measures (if any) which will be planned and implemented to ensure the EPA's objective is met.
Response
Work has been undertaken
Summary
Significantly more is now understood in relation to Lake Coogee than had been previously documented. Lake Coogee is a unique wetland for this area and as such is worthy of preservation. The option selected for this proposal was chosen because it reduced; the requirements for clearing, dewatering and impacts on the lake sediments. It also allowed for significant rehabilitation of cleared areas to be undertaken, minimising the area of permanently cleared land. The hydraulic connectivity of the wetland has been preserved. It is believed that the integrity of the wetland has been maintained and that the amount of fringing vegetation will be increased as rehabilitation works are undertaken.

14.7 Groundwater

EPA Requirements
Assess and document groundwater hydrology, the likely construction and post construction impacts (eg. dewatering and hydraulic barriers) and proposed management measures (if any) which will be planned and implemented to ensure the EPA's objective is met.
Response
Work has been undertaken.

Summary
Dewatering through the Wetland areas has been eliminated by selecting a low bridge option. This also reduces impacts on hydraulic conductivity in these areas. If technically possible dewatering at the pump station will be minimised by placing a grout curtain to a low permeability layer and isolating the construction zone. Dewatering will take place and as much water as reasonably practicable will be re-injected in a manner that will maintain groundwater levels. The remainder will be disposed of according to options to be quantified in the environmental management plan.The grout curtain will remain in place after construction and will present a minor localised perturbation to groundwater flows.

14.8 Particulates/Dust

EPA Requirements
Assess and document the likely construction impacts (eg. dust levels) and proposed management measures (if any) which will be planned and implemented to ensure the EPA's objective is met
Response
A qualitative assessment has been undertaken
Summary
Dust impacts will be limited to the construction phase and managed by wetting down of access tracks, covering dust causing loads, limiting stockpiles and restricting the impacts of material carried of site by vehicle wheels etc.

14.9 Groundwater Quality

EPA Requirements
Assess and document the existing ground water quality, the likely construction and post construction impacts (eg. below ground pipeline failure and leakage and dewatering disposal-groundwater injection).
Response
Groundwater quality has been determined and the likelihood of leaks and subsequent impacts investigated.
Summary
The groundwater quality in the vicinity of the proposed pipeline and pump station is reasonably good except that levels of nitrate exceed ANZECC guidelines. There were no pesticides or heavy metals of note in the groundwater. Leakage from this pipeline is expected to be minimal because the pipe is plasti-lined providing effective double containment. Leakages in existing un-pressurised pipelines of this type is known to be minor because groundwater infiltration does not contribute significantly to sewer flows from the many thousands of kilometers of this type of sewer present in the Perth Metropolitan Area. A review of existing research indicates that, if a leak was to occur, most pollutants would never reach the groundwater and that the impact would be very difficult to detect. Water Corporation have committed to inspecting this pipe internally every 5-7 years, a step which recognises the size and strategic importance of this sewer.

14.10 Surface Water Quality

EPA Requirements
Assess and document the existing surface water quality, the likely construction and post construction impacts (eg. fuel and chemical storage, pipeline failure and leakage, sewage overflows, dewatering disposal and changes to causeway)
Response
Surface water quality has been assessed and potential impacts determined.

Summary
The surface water of Lake Coogee is eutrophic, but probably protected from the impacts of this by the high salinity encountered during the summer. There few contaminants present apart from nutrients. Construction impacts could arise due to siltation and loss of oils from vehicles etc. It is proposed to contain surface run-off in constructed ponds to allow time for settlement and capture of any other contaminants. Most construction activities close to the wetland will take place in summer. The probability of leaks from the pipeline are extremely low. Visual inspection of the bridge section of pipeline will be undertaken on a regular basis.

14.11 Soil Contamination

EPA Requirements
Assess and document the nature and extent of suspected contaminated fill in the proposal area in accordance with NHMRC and NSW EPA guidelines. Document proposed management measures (if any) to ensure contamination which exceeds accepted EPA/DEP criteria is managed to meet the EPA's objective.
Response
An area of uncontrolled fill was assessed for potential contamination.
Summary
Levels of Lead and Pesticides in excess of the environmental investigation levels were found in some test pits. It is proposed to carry out further investigations prior to construction.

14.12 Noise

EPA Requirements
Assess and document the likely construction impacts and proposed management measures (if any) which will be planned and implemented to ensure the EPA's objective is met
Response
Noise impacts of construction have been reviewed.
Summary
There will be noise impacts during the construction of this proposal. These will be restricted to between 7 a.m. and 7 p.m. or subject to negotiation with local residents. Excessively noisy activities will be further restricted subject to negotiation with local residents. A communication strategy will be developed between the contractor and the residents.

14.13 Vibration

EPA Requirements
Assess and document the likely levels/duration of vibration during construction, the likely impacts on residents and building and proposed management measures (if any) which will be planned and implemented to ensure the EPA's objective is met
Response
A vibration assessment was undertaken to determine potential impacts on local residents.
Summary
The assessment found that vibration levels from a rock breaker at the nearest residences to the proposed work were approximately 30 times lower than accepted standards for structural damage and 5 times lower than those found to be perceptible to humans.

14.14 Visual Amenity

EPA Requirements
Assess and document the current level of visual amenity, the proposed impacts and management measures (if any), with particular reference to the Beeliar Regional Park. Outline management measures (if any) which will ensure the EPA's objective is met
Response
A full visual impact assessment was undertaken
Summary
Due to the selection of a low bridge visual impacts have been minimised along the line of the proposed pipeline. There will be significant visual impacts due to the pump station, but these can be resolved to some extent by reshaping the landforms to more closely match the existing situation. Tree screening with appropriate local native vegetation will enhance some vistas.

14.15 Heritage

EPA requirements
Assess and document the existence of any sites of non Aboriginal heritage, the likely impacts and proposed management measures which will ensure the EPA's objective is met. The site is listed with the Australian Heritage Commission on the National Register. Document these values and what (if any) management measures are proposed to ensure these values are protected
Response
European heritage has been documented and impacts determined. Natural heritage values have been reviewed and are in line with those for Beeliar Park.
Summary
The European Heritage of this area is extensive and fascinating. It is not believed that there will be any impacts on known sites although one site will be close and landscaping has been propose to ameliorate the proximity. It is recognised that some unmarked graves exist in the area and caution will be taken during excavating activities.

The Proposal in its entirety does not appear to compromise the natural heritage values of this area because the impact on well conserved areas is limited and the proposal intends to re-instate significantly more vegetation than that removed.

14.16 Aboriginal Culture and Heritage

EPA Requirements
Assess and document the existence of significant Aboriginal sites, the likely impacts and proposed management measures (if any) which will ensure the EPA's objectives are met
Response
A full aboriginal heritage and consultation program sufficient to meet the requirements of the Aboriginal Heritage Act (1972) has been undertaken and the result referred separately to the Aboriginal Affairs Department.
Summary
No aboriginal sites have been identified within the proposed construction zone for this phase. A registered site has been noted in the vicinity of the proposed open storage area, but this will not require construction until 2011. This has therefore been deferred and will be subject to separate negotiation nearer to the time of implementation. It is not inevitable that this site will be disturbed. All requirements of the traditional landowners in relation to land disturbance have been accommodated.

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Appendix A

Community Consultation Information

The Water Corporation and GHD wishes to take this opportunity to thank all the members of the public for their input to the public consultation phase. It is not proposed to reproduce the minutes of all of the meetings and copies of the public consultation documentation in this report. However, in acknowledgment of the time taken in preparing responses to leaflets and attending consultation meetings Water Corporation and GHD wishes to publish the name of all people who attended public meetings or responded to leaflets. Your contribution was invaluable in helping us to assess public opinion and in arriving at the preferred solution which we believe is a meaningful response to the views expressed.

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Appendix B

Minutes of Risk Assessment Workshop

MINUTES OF MEETING

Munster Pump Station Risk Management Workshop

HELD ON: 18th September 1998
TIME: 9.00am
PLACE: GHD Projects Area

JOB NO: 611/600939/00

PURPOSE OF MEETING: Assess Environmental Risks

PRESENT:	John Kaub	CALM	Lisa Chandler	Golder Assoc –
	Theresa Gepp	CALM	Mary Separovich	Spearwood Residents' Assoc.
	Paddie Strano	City of Cockburn	Leigh Bollen	Water Corporation –
	Adrian Vlok	DEP	John Cox	Water Corporation
	Leslie Thomas	Ecoscape –	John Bond	Water Corporation
	Mark Goldstone	GHD –	Graham Currie	Water Corporation
	Des Boland	GHD –	Rob Korenhof	Water Corporation
	Marie Hauxby	GHD –	Nick Sarapunas	Water Corporation

Item	Subject	Discussion/Action Agreed
1.0	**Risk Issues** **Mark Goldstone**	• Societal Hazard - Traditional from of risk, can be quantified • Environmental Risk - Complex issues make quantifying difficult, but can be scaled (High, Medium, Low), magnitude needs to be weighted for the risk. • Perceptions of risk need to be modified to reality (James Bond mentality to risk) • Qualitative Risk assessment is structure commonsense.
2.0	**Background to the Proposal** **Mark Goldstone**	• Beenyup WWTP → Perth Coastal Water Study, looking at alternative effluent disposal methods, Land study of Alternative Effluent Disposal Options (SAEDO) • Wastewater 2040 → Alternatives of small community WWTP's looked at but deemed price prohibitive, poor effluent quality, still had effluent disposal problems. • Min of Environment, Peter Foss approved - Water Corp could now proceed with planning study for Munster. • Decision to expand Woodman Point and build a secondary treatment plant.
3.0	**Munster Pipe Options** **Nick Sarapunus**	Eleven Options to be addressed: Option 1 - Shallow along Mayor Road and High Bridge Option 2 - Shallow along Mayor Road and Siphon Option 3 - Shallow along Mayor Road and Siphon on Low Bridge Option 4 - Deep on Mayor Road and Low Bridge Option 5 - Deep through on Mayor Road and Siphon Option 6 - North of existing PS #2 and High Bridge Option 7 - North of existing PS#2 and Siphon Option 8 - Deep through Subdivision and Low Bridge Option 9 - Deep through Subdivision and Siphon Option 10 - Deep through Subdivision and Under Natural Surface Level Option 11 - Alignment along proposed Beeliar Road extension
4.0	**Hydrological Issues** **Lisa Chandler**	Described boreholes and estimated profile of subsoil strata Described construction issues re water table effects etc: ➢ Strength and compressibility of soil ➢ How much water needs to be pumped ➢ How to get rid of the water ➢ Effects on Lake levels and water quality

Item	Subject	Discussion/Action Agreed
		Results to date: • *Geotechnical* ➢ Sand over limestone primarily ➢ Variability of limestone depth and strength ➢ Compressable peat layer under Lake (1 metre thick) • *Hydrogeological* ➢ Will need to work below the water table, so dewatering will be necessary in both limestone and sand ➢ A lot of water, so necessary for engineering cut-off, not for trench, but for the PS ➢ Depth of new pumpstation will be the driver to the extent of dewatering required ➢ Dewatering options - into ocean, into lake, into bores (close or far) ➢ If reinjection, dewatering cut-off need to be much higher ➢ Still deciding if feasible to have below ground options • *Water Chemistry* Only 1 test result to date, but looking at historical data from bores Series of 5 monitoring bores at varying depths and 5 penetrometer test locations ➢ Acidity - no strong differences between shallow and deep bores ➢ Salinity - groundwater lower than the lake - south of causeway double salinity of north - all groundwater < 2000mg/l ➢ Metals - no high levels (samples not filtered to represent possible worst case scenario) ➢ Pesticides - none found ➢ Nitrogen - found in lake water, both north and south of causeway. 1mg/l inorganic nitrogen EPA guidelines are 0.1 to 0.5mg/l; Goundwater in deep bores ranging from 0.2 to 0.8mg/l ➢ Phosphorous - Only detected in deep bore. Lake levels are well above EPA recommended levels ➢ Peat - results if peat layer disturbed still being reviewed, probably float around and cause turbidity ➢ Lake probably connected to the groundwater, but currently still being determined
9.0	Environmental and Social Issues	• *Historical* ➢ Area settled by Peel originally as part of Town of Clarence in approx 1826, then abandoned after 2 years ➢ Approx 1870, 20 acre lots allocated, this is when much of the clearing took place. Area then abandoned in 1900 ➢ Idea that Woodman Point could be a location for a naval base, leading to a land rush in the area. Did not proceed so area again abandoned in 1915.
	Leslie Thomas	• *Heritage* ➢ Heritage sites of lime kilns (behind existing PS) and old cottages (near new PS) ➢ Lake is on the interim list for natural heritage ➢ Tuart trees in northwest are on the interim list for the local area register • *Vegetation* ➢ Dominant band of vegetation ➢ Saltwater paperbark - not a rare species but at northern end of range. In reasonable condition, some understorey ➢ Freshwater paperbark - some species, unusual mix with saltwater variety. ➢ Tuarts - Fair to poor condition, all understorey destroyed ➢ Melaluka - awaiting info re condition ➢ Poor vegetative condition in proposed site

Item	Subject	Discussion/Action Agreed
		➢ Cooch is the main weed near lake ➢ Some of the area cannot be assessed due to recent bushfire ➢ Flora - no rare flora (Geraldton Wax is a weed and not local to the area) ➢ Weeds - 9 are priority one species ➢ Fauna - varying values, seasonally waterlogged (useful for birds, amphibians and dugites), pasture provides some habitat, mature Tuarts (nesting birds, foraging animals), deeper water (summer refuge for birds, not nesting), no native mammals, biota of lake unknown ➢ Lake - will study other lakes in chain to determine fauna in lake ➢ Conclusion - Area has had long history of disturbance, removed lot of native vegetation and ability to support mammals ➢ Visual Assessment - Landform denuded in parts, variable. ➢ Medium visual quality - Tuarts ➢ Moderate visual quality - Wetlands ➢ Low visual quality - West bank
9.0	**Risk Analysis** **Mark Goldstone**	The group then conducted a risk analysis qualitative and quantitative assessment for the alternate options for the site. Data was entered into an access database to be used later as input for the Draft PER document to be produced by Mark Risk factors assessed as most important were: • visual intrusion • dewatering - water quality, hydraulics, drawdown, flooding • noise • vibration • vegetation loss • leaks • hydraulic connectivity • odour • soil/peat disturbance • sediment suspension - turbidity and suspension • fill - controlled and uncontrolled • dust • catastrophic events • risks to Beeliar Park • Aboriginal heritage Minor factors to consider were: • damage to existing infrastructure • vandalism / graffiti • energy • subsidence • amenity / access • public damage • heritage - natural and post-colonisation • safety

Distribution:

Attendees

Mr Darren Walsh	Director Environmental Services Cockburn City Council
Mr Alan Blood	Strategic Planner Cockburn City Council
Mr Steve Hillier	Director of Planning Cockburn City Council
Mr Rod Brown	CEO, Cockburn City Council
Mr Kevin Allen	President, Coogee Beach Progress Assoc.
Mr Bill Thomas	Local Member
Mr Tim Bowra	National Parks Coordinator (CALM) Re: Beeliar Regional Park Advisory Committee
Mr Jeffrey Spencer	Beeliar Regional Park Advisory Committee

Ms Diana Corbyn	Beeliar Regional Park Advisory Committee
Ms Dierdre Napier	Beeliar Regional Park Advisory Committee
Mr Clive Robartson	Beeliar Regional Park Advisory Committee
Ms Wilma Vincent	Beeliar Regional Park Advisory Committee
Mr Siddhartha Jha	Beeliar Regional Park Advisory Committee
Assoc. Professor Philip Jennings	Beeliar Regional Park Advisory Committee
Mr Mark Street	City of Melville Re: Beeliar Regional Park Advisory Committee
Councillor Carol Adams	Town of Kwinana Re: Beeliar Regional Park Advisory Committee
Mr Mark Armstrong	Beeliar Regional Park Advisory Committee

Appendix C

Minutes of DEP Meeting

Sent to Water Corp + Dep 4/8/98

Minutes of Meeting with DEP
Wednesday 29th July 1998

Subject: Munster Pump Station No. 3

Attendance:
Darryl Whitely - Water Corp
Rob Korenhof - Water Corp
Mark Goldstone - GHD
Kim Taylor - Director Evaluation Division - DEP
Garry Middle - Manager Evaluation - DEP

After brief introductions Darryl Whitely outlined the history and need for the proposal. The Woodman Point Wastewater Treatment Plant is to be enhanced to include advanced secondary treatment. Linked to this is a proposal to increase the capacity of the sewerage leading to the treatment works.

The increase in capacity is needed because the current Munster Pump Station No.2 is already being overloaded on a regular basis and there is increased concern of uncontrolled releases of waste water to the environment with associated health, odour and environmental impacts.

The proposal is a new gravity sewer leading from Pump Station Number 2 to a new Pump Station (No.3) located on the North West of Lake Coogee. The existing pressure Main which runs across the North end of Lake Coogee in a bank would remain in place.

In order to provide the gravity sewer a further crossing of the Cockburn Wetlands - Western Chain adjacent the alignment of the existing Water Corporation causeway is required. An option to extend the sewer along the line of the proposed Beliar Drive had been rejected early because it would require a massive above ground bank increasing the separation of the wetland chain.

2 options exist for the crossing; 1) a bridge 2) a below ground pipe.

Option 1) will retain connectivity between the wetlands and have reduced construction impacts, but will be unsightly.

Option 2) will have increased construction impacts including dewatering, but will have reduced long term impacts except for occasional maintenance.

Dewatering will also be an issue for the Pump Station.

Dr Goldstone indicated that Ecoscape had been appointed in order to quantify the environmental issues and that a public consultation phase had been planned. This would commence following this meeting. A risk assessment workshop was planned following the workshop and Kim Taylor and Garry Middle were invited to attend on behalf of the DEP.

The timelines for this proposal are quite tight because the planning study was delayed in order to accommodate some late issues.. Darryl Whitely indicated that this meant Water Corporation needed to have conditional approval by the end of December.

Garry Middle suggested that in order for this time line to be met a project definition study should be referred as soon as possible because the level of assessment could be set whilst more detailed study and public consultation was being undertaken. He indicated that the contents of the Infrastructure Planning Branch report dated April 1998 looked like a good start.

A cover letter clearly defining the proposal should come with the report and it should be addressed to the Chairman of the EPA, but for the attention of Garry Middle.

The proposal was most likely to be assessed as a CER and Garry Middle suggested that certain groups including The Conservation Council and Beliar Park Management Committee should be contacted as soon as possible in order to reduce the likelihood of an appeal.

At this point the meeting ended.

Actions

Minutes of the meeting - Mark Goldstone
Access to the Planning report and update - Rob Korenhof
Referral Letter - Mark Goldstone
Review of planning report content - Mark Goldstone

Appendix D

AEL Laboratory Report

Australian
Environmental
Laboratories

LABORATORY REPORT COVERSHEET

DATE:	22 September 1998
TO:	Golder Associates Pty Ltd
	441 Vincent Street West
	LEEDERVILLE WA 6007
ATTENTION:	Ms Lisa Chandler
YOUR REFERENCE:	98640233
OUR REFERENCE:	41522
SAMPLES RECEIVED:	9/9/98
SAMPLES/QUANTITY:	11 Waters

The above samples were received intact and analysed according to your accompanying chain of custody form which is returned with this report for your reference.
Unless otherwise stated, solid samples are reported on a dry weight basis and liquid samples as received.
OC Pesticides were analysed by our Sydney laboratory (method SEO-005), report No.9316 and Boron by our Melbourne laboratory, report No.24003.
Lead by ICP/MS was analysed by Analabs, Welshpool, report No.WM037704.

Steven Edmett
STEVEN EDMETT
Manager Client Liaison

PETER BAMFORD
Manager Laboratory Services

JANICE VENNING
Manager Operations

This report supercedes our preliminary results that were reported by facsimile.
This report must not be reproduced except in full.

(Analabs Pty. Ltd.) ACN 004 591 664
52 Murray Road Welshpool Western Australia 6106 Australia
Telephone: (08) 9458 7278 Facsimile: (08) 9451 3505

Australian Environmental Laboratories

CLIENT: Golder Associates Pty Ltd **OUR REFERENCE:** 41522
PROJECT: 98640233

LABORATORY REPORT

Your Reference	07 S	07 D	08	04 S	04 D
Our Reference	41522-1	41522-2	41522-3	41522-4	41522-5
Date Sampled	08/09/98	08/09/98	08/09/98	08/09/98	08/09/98
Type of sample	Water	Water	Water	Water	Water
Total Inorganic Nitrogen	0.2	3.8	4.4	4.1	8.4
Total Phosphorus, P	0.05	0.05	<0.05	0.05	<0.05
Ortho Phosphorus, PO4-P	<0.05	<0.05	<0.05	<0.05	<0.05
BOD 5 day	<5	<5	<5	<5	<5

Your Reference	05 S	05 D	06 S	06 D	LCN
Our Reference	41522-6	41522-7	41522-8	41522-9	41522-10
Date Sampled	08/09/98	08/09/98	08/09/98	08/09/98	08/09/98
Type of sample	Water	Water	Water	Water	Water
Total Inorganic Nitrogen	0.8	0.4	1.6	0.2	1.1
Total Phosphorus, P	0.05	0.10	<0.05	<0.05	0.25
Ortho Phosphorus, PO4-P	<0.05	<0.05	<0.05	<0.05	0.10
BOD 5 day	<5	<5	<5	<5	10

Your Reference	LCS
Our Reference	41522-11
Date Sampled	08/09/98
Type of sample	Water
Total Inorganic Nitrogen	0.8
Total Phosphorus, P	0.30
Ortho Phosphorus, PO4-P	<0.05
BOD 5 day	10

Australian Environmental Laboratories

CLIENT: Golder Associates Pty Ltd **OUR REFERENCE:** 41522
PROJECT: 98640233

LABORATORY REPORT

Your Reference	07 S	07 D	08	04 S	04 D
Our Reference	41522-1	41522-2	41522-3	41522-4	41522-5
Date Sampled	08/09/98	08/09/98	08/09/98	08/09/98	08/09/98
Type of sample	Water	Water	Water	Water	Water
Electrical Conductivity @ 25°C	2300	1900	1800	1500	1300
Total Dissolved Solids (grav)	1400	1000	1000	780	770
Total Suspended Solids @ 103°C	10	<5	<5	30	230
Sodium, Na	[NA]	[NA]	240	[NA]	[NA]
Potassium, K	[NA]	[NA]	16	[NA]	[NA]
Calcium, Ca	[NA]	[NA]	130	[NA]	[NA]
Magnesium, Mg	[NA]	[NA]	32	[NA]	[NA]
Chloride, Cl	[NA]	[NA]	370	[NA]	[NA]
Carbonate, CO3	[NA]	[NA]	<1	[NA]	[NA]
Bicarbonate, HCO3	[NA]	[NA]	290	[NA]	[NA]
Sulphate, SO4	[NA]	[NA]	180	[NA]	[NA]
Nitrate, NO3	[NA]	[NA]	17	[NA]	[NA]
Sum of ions	[NA]	[NA]	1275	[NA]	[NA]
Cations/Anions % difference	[NA]	[NA]	1.94	[NA]	[NA]

Your Reference	05 S	05 D	06 S	06 D	LCN
Our Reference	41522-6	41522-7	41522-8	41522-9	41522-10
Date Sampled	08/09/98	08/09/98	08/09/98	08/09/98	08/09/98
Type of sample	Water	Water	Water	Water	Water
Electrical Conductivity @ 25°C	2500	1600	1200	2000	10000
Total Dissolved Solids (grav)	1600	870	600	1200	5500
Total Suspended Solids @ 103°C	80	95	<5	25	<5
Sodium, Na	350	210	[NA]	[NA]	[NA]
Potassium, K	21	14	[NA]	[NA]	[NA]
Calcium, Ca	210	110	[NA]	[NA]	[NA]
Magnesium, Mg	54	23	[NA]	[NA]	[NA]
Chloride, Cl	450	260	[NA]	[NA]	[NA]
Carbonate, CO3	<1	<1	[NA]	[NA]	[NA]
Bicarbonate, HCO3	340	300	[NA]	[NA]	[NA]
Sulphate, SO4	520	180	[NA]	[NA]	[NA]
Nitrate, NO3	0.4	1.0	[NA]	[NA]	[NA]
Sum of ions	1945	1088	[NA]	[NA]	[NA]
Cations/Anions % difference	2.66	1.12	[NA]	[NA]	[NA]

Australian Environmental Laboratories

CLIENT: Golder Associates Pty Ltd **OUR REFERENCE:** 41522
PROJECT: 98640233

LABORATORY REPORT

Your Reference	LCS
Our Reference	41522-11
Date Sampled	08/09/98
Type of sample	Water
Electrical Conductivity @ 25°C	20000
Total Dissolved Solids (grav)	11000
Total Suspended Solids @ 103°C	130
Sodium, Na	3300
Potassium, K	180
Calcium, Ca	150
Magnesium, Mg	420
Chloride, Cl	5200
Carbonate, CO3	<1
Bicarbonate, HCO3	250
Sulphate, SO4	1400
Nitrate, NO3	<0.2
Sum of ions	10900
Cations/Anions % difference	2.76

CLIENT: Golder Associates Pty Ltd **OUR REFERENCE:** 41522
PROJECT: 98640233

LABORATORY REPORT

Your Reference Our Reference Date Sampled Type of sample	05 S 41522-6 08/09/98 Water	05 D 41522-7 08/09/98 Water	06 S 41522-8 08/09/98 Water	06 D 41522-9 08/09/98 Water	LCN 41522-10 08/09/98 Water
alpha-BHC	<0.1	<0.1	<0.1	<0.1	<0.1
Lindane	<0.1	<0.1	<0.1	<0.1	<0.1
Heptachlor	<0.1	<0.1	<0.1	<0.1	<0.1
Aldrin	<0.1	<0.1	<0.1	<0.1	<0.1
beta-BHC	<0.1	<0.1	<0.1	<0.1	<0.1
delta-BHC	<0.1	<0.1	<0.1	<0.1	<0.1
Heptachlor Epoxide	<0.1	<0.1	<0.1	<0.1	<0.1
alpha-Endosulfan	<0.1	<0.1	<0.1	<0.1	<0.1
gamma-Chlordane	<0.1	<0.1	<0.1	<0.1	<0.1
alpha-Chlordane	<0.1	<0.1	<0.1	<0.1	<0.1
p,p'-DDE	<0.1	<0.1	<0.1	<0.1	<0.1
Dieldrin	<0.1	<0.1	<0.1	<0.1	<0.1
Endrin	<0.1	<0.1	<0.1	<0.1	<0.1
p,p'-DDD	<0.1	<0.1	<0.1	<0.1	<0.1
beta-Endosulfan	<0.1	<0.1	<0.1	<0.1	<0.1
p,p'-DDT	<0.1	<0.1	<0.1	<0.1	<0.1
Methoxychlor	<0.1	<0.1	<0.1	<0.1	<0.1
Endosulfan Sulphate	<0.1	<0.1	<0.1	<0.1	<0.1
Endrin Ketone	<0.1	<0.1	<0.1	<0.1	<0.1
2,4,5,6-tetrachloro-m-xylene	30	60	70	60	20

Australian Environmental Laboratories

CLIENT: Golder Associates Pty Ltd **OUR REFERENCE:** 41522
PROJECT: 98640233

LABORATORY REPORT

Your Reference	07 S	07 D	08	04 S	04 D
Our Reference	41522-1	41522-2	41522-3	41522-4	41522-5
Date Sampled	08/09/98	08/09/98	08/09/98	08/09/98	08/09/98
Type of sample	Water	Water	Water	Water	Water
Chlorpyrifos	<0.1	<0.1	<0.1	<0.1	<0.1
Fenitrothion	<0.1	<0.1	<0.1	<0.1	<0.1
Bromofos Ethyl	<0.1	<0.1	<0.1	<0.1	<0.1
Ethion	<0.1	<0.1	<0.1	<0.1	<0.1

Your Reference	05 S	05 D	06 S	06 D	LCN
Our Reference	41522-6	41522-7	41522-8	41522-9	41522-10
Date Sampled	08/09/98	08/09/98	08/09/98	08/09/98	08/09/98
Type of sample	Water	Water	Water	Water	Water
Chlorpyrifos	<0.1	<0.1	<0.1	<0.1	<0.1
Fenitrothion	<0.1	<0.1	<0.1	<0.1	<0.1
Bromofos Ethyl	<0.1	<0.1	<0.1	<0.1	<0.1
Ethion	<0.1	<0.1	<0.1	<0.1	<0.1

Your Reference	LCS
Our Reference	41522-11
Date Sampled	08/09/98
Type of sample	Water
Chlorpyrifos	<0.1
Fenitrothion	<0.1
Bromofos Ethyl	<0.1
Ethion	<0.1

CLIENT: Golder Associates Pty Ltd **OUR REFERENCE:** 41522
PROJECT: 98640233

LABORATORY REPORT

Your Reference	07 S	07 D	08	04 S	04 D
Our Reference	41522-1	41522-2	41522-3	41522-4	41522-5
Date Sampled	08/09/98	08/09/98	08/09/98	08/09/98	08/09/98
Type of sample	Water	Water	Water	Water	Water
Arsenic, As	0.017	0.003	<0.001	0.005	<0.001
Boron, B	0.1	0.1	0.1	0.1	<0.1
Cadmium, Cd	<0.001	<0.001	<0.001	<0.001	<0.001
Chromium, Cr	0.010	0.010	0.010	0.010	0.005
Copper, Cu	<0.005	<0.005	<0.005	<0.005	<0.005
Iron, Fe (soluble)	0.10	0.10	0.15	0.20	0.15
Lead, Pb	<0.005	<0.005	<0.005	<0.005	<0.005
Zinc, Zn	<0.05	<0.05	<0.05	<0.05	<0.05
Mercury, Hg	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005

Your Reference	05 S	05 D	06 S	06 D	LCN
Our Reference	41522-6	41522-7	41522-8	41522-9	41522-10
Date Sampled	08/09/98	08/09/98	08/09/98	08/09/98	08/09/98
Type of sample	Water	Water	Water	Water	Water
Arsenic, As	0.006	0.003	<0.001	0.010	0.002
Boron, B	0.1	0.1	<0.1	0.1	0.6
Cadmium, Cd	<0.001	<0.001	<0.001	<0.001	<0.001
Chromium, Cr	0.030	0.010	0.005	0.015	0.015
Copper, Cu	<0.005	<0.005	<0.005	<0.005	<0.005
Iron, Fe (soluble)	0.25	0.20	<0.05	<0.05	0.15
Lead, Pb	<0.005	<0.005	<0.005	<0.005	0.010
Zinc, Zn	<0.05	<0.05	<0.05	<0.05	<0.05
Mercury, Hg	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005

Your Reference	LCS
Our Reference	41522-11
Date Sampled	08/09/98
Type of sample	Water
Arsenic, As	0.001
Boron, B	1.1
Cadmium, Cd	<0.001
Chromium, Cr	0.035
Copper, Cu	<0.005
Iron, Fe (soluble)	1.1
Lead, Pb	<0.005
Zinc, Zn	<0.05
Mercury, Hg	<0.0005

CLIENT: Golder Associates Pty Ltd **OUR REFERENCE:** 41522
PROJECT: 98640233

LABORATORY REPORT

TEST PARAMETERS	UNITS	LOR	METHOD
Total Inorganic Nitrogen	mg/L	0.1	PEI-012
Total Phosphorus, P	mg/L	0.05	PEI-014
Ortho Phosphorus, PO_4-P	mg/L	0.05	PEI-015
BOD 5 day	mg/L	5	PEI-018
Standard 2			
Electrical Conductivity @ 25°C	µS/cm	1	PEI-032
Total Dissolved Solids (grav)	mg/L	10	PEI-002
Total Suspended Solids @ 103°C	mg/L	5	PEI-003
Sodium, Na	mg/L	0.5	PEM-001
Potassium, K	mg/L	0.5	PEM-001
Calcium, Ca	mg/L	0.5	PEM-002
Magnesium, Mg	mg/L	0.5	PEM-002
Chloride, Cl	mg/L	1	PEI-020
Carbonate, CO_3	mg/L	1	PEI-006
Bicarbonate, HCO_3	mg/L	5	PEI-006
Sulphate, SO_4	mg/L	1	PEI-020
Nitrate, NO_3	mg/L	0.1	PEI-020
Sum of ions	mg/L		Calculation
Cations/Anions % difference			Calculation
OC Pesticides in Water			
alpha-BHC	µg/L	0.1	PEO-100
Lindane	µg/L	0.1	PEO-100
Heptachlor	µg/L	0.1	PEO-100
Aldrin	µg/L	0.1	PEO-100
beta-BHC	µg/L	0.1	PEO-100
delta-BHC	µg/L	0.1	PEO-100
Heptachlor Epoxide	µg/L	0.1	PEO-100
alpha-Endosulfan	µg/L	0.1	PEO-100
gamma-Chlordane	µg/L	0.1	PEO-100
alpha-Chlordane	µg/L	0.1	PEO-100
p,p'-DDE	µg/L	0.1	PEO-100
Dieldrin	µg/L	0.1	PEO-100
Endrin	µg/L	0.1	PEO-100

CLIENT: Golder Associates Pty Ltd **OUR REFERENCE:** 41522
PROJECT: 98640233

LABORATORY REPORT

TEST PARAMETERS	UNITS	LOR	METHOD
p,p'-DDD	µg/L	0.1	PEO-100
beta-Endosulfan	µg/L	0.1	PEO-100
p,p'-DDT	µg/L	0.1	PEO-100
Methoxychlor	µg/L	0.1	PEO-100
Endosulfan Sulphate	µg/L	0.1	PEO-100
Endrin Ketone	µg/L	0.1	PEO-100
2,4,5,6-tetrachloro-m-xylene	%		PEO-100
OP Pesticides in Water			
Chlorpyrifos	µg/l	0.1	PEO-100
Fenitrothion	µg/l	0.1	PEO-100
Bromofos Ethyl	µg/l	0.1	PEO-100
Ethion	µg/l	0.1	PEO-100
Metals in Water (low level)			
Arsenic, As	mg/L	0.001	PEM-004
Boron, B	mg/L	0.1	1530
Cadmium, Cd	mg/L	0.001	PEM-003
Chromium, Cr	mg/L	0.005	PEM-003
Copper, Cu	mg/L	0.005	PEM-003
Iron, Fe (soluble)	mg/L	0.05	PEM-001
Lead, Pb	mg/L	0.005	PEM-003
Zinc, Zn	mg/L	0.05	PEM-001
Mercury, Hg	mg/L	0.0005	PEM-005

Australian Environmental Laboratories

CLIENT: Golder Associates Pty Ltd **OUR REFERENCE:** 41522
PROJECT: 98640233

LABORATORY REPORT

QUALTY CONTROL	UNITS	Blank	Replicate Sm#	Replicate Sample||Replicate	Spike Sm#	Matrix Spike
Total Inorganic Nitrogen	mg/L	<0.1	Nil Replicate	Nil Replicate	Water	100%
Total Phosphorus, P	mg/L	<0.05	Nil Replicate	Nil Replicate	Water	94%
Ortho Phosphorus, PO_4-P	mg/L	<0.05	Nil Replicate	Nil Replicate	Water	99%
BOD 5 day	mg/L	<5	Nil Replicate	Nil Replicate	Water	-

QUALTY CONTROL	UNITS	Blank	Replicate Sm#	Replicate Sample||Replicate	Spike Sm#	Matrix Spike
Electrical Conductivity @ 25°C	µS/cm	-	Nil Replicate	Nil Replicate	Water	-
Total Dissolved Solids (grav)	mg/L	<10	Nil Replicate	Nil Replicate	Water	97%
Total Suspended Solids @ 103°C	mg/L	<5	Nil Replicate	Nil Replicate	Water	-
Sodium, Na	mg/L	<0.5	Nil Replicate	Nil Replicate	Water	106%
Potassium, K	mg/L	<0.5	Nil Replicate	Nil Replicate	Water	102%
Calcium, Ca	mg/L	<0.5	Nil Replicate	Nil Replicate	Water	92%
Magnesium, Mg	mg/L	<0.5	Nil Replicate	Nil Replicate	Water	98%
Chloride, Cl	mg/L	<1	Nil Replicate	Nil Replicate	Water	87%
Carbonate, CO_3	mg/L	<1	Nil Replicate	Nil Replicate	Water	-
Bicarbonate, HCO_3	mg/L	<5	Nil Replicate	Nil Replicate	Water	-
Sulphate, SO_4	mg/L	<1	Nil Replicate	Nil Replicate	Water	105%
Nitrate, NO_3	mg/L	<0.2	Nil Replicate	Nil Replicate	Water	-
Sum of ions	mg/L	-	Nil Replicate	Nil Replicate	Water	-
Cations/Anions % difference		-	Nil Replicate	Nil Replicate	Water	-

Australian Environmental Laboratories

CLIENT: Golder Associates Pty Ltd
PROJECT: 98640233

OUR REFERENCE: 41522

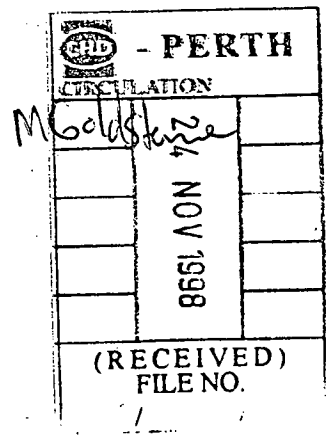
LABORATORY REPORT

QUALTY CONTROL	UNITS	Blank	Replicate Sm#	Replicate Sample||Replicate	Spike Sm#	Matrix Spike
alpha-BHC	µg/L	<0.1	Nil Replicate	Nil Replicate	Water	-
Lindane	µg/L	<0.1	Nil Replicate	Nil Replicate	Water	-
Heptachlor	µg/L	<0.1	Nil Replicate	Nil Replicate	Water	96%
Aldrin	µg/L	<0.1	Nil Replicate	Nil Replicate	Water	97%
beta-BHC	µg/L	<0.1	Nil Replicate	Nil Replicate	Water	-
delta-BHC	µg/L	<0.1	Nil Replicate	Nil Replicate	Water	-
Heptachlor Epoxide	µg/L	<0.1	Nil Replicate	Nil Replicate	Water	110%
alpha-Endosulfan	µg/L	<0.1	Nil Replicate	Nil Replicate	Water	-
gamma-Chlordane	µg/L	<0.1	Nil Replicate	Nil Replicate	Water	-
alpha-Chlordane	µg/L	<0.1	Nil Replicate	Nil Replicate	Water	-
p,p'-DDE	µg/L	<0.1	Nil Replicate	Nil Replicate	Water	-
Dieldrin	µg/L	<0.1	Nil Replicate	Nil Replicate	Water	120%
Endrin	µg/L	<0.1	Nil Replicate	Nil Replicate	Water	96%
p,p'-DDD	µg/L	<0.1	Nil Replicate	Nil Replicate	Water	-
beta-Endosulfan	µg/L	<0.1	Nil Replicate	Nil Replicate	Water	-
p,p'-DDT	µg/L	<0.1	Nil Replicate	Nil Replicate	Water	-
Methoxychlor	µg/L	<0.1	Nil Replicate	Nil Replicate	Water	88%
Endosulfan Sulphate	µg/L	<0.1	Nil Replicate	Nil Replicate	Water	-
Endrin Ketone	µg/L	<0.1	Nil Replicate	Nil Replicate	Water	-
2,4,5,6-tetrachloro-m-xylene	%	90	Nil Replicate	Nil Replicate	Water	100%

Appendix E

AEL Laboratory Report - Contaminated Site Analysis

Australian
Environmental
Laboratories



LABORATORY REPORT COVERSHEET

DATE: 23 November 1998

TO: Gutteridge Haskins & Davey Pty Ltd
GPO Box Y3106
PERTH WA 6000

ATTENTION: Dr Mark Goldstone

YOUR REFERENCE: 6009/39/00

OUR REFERENCE: 42488

SAMPLES RECEIVED: 7/11/98

SAMPLES/QUANTITY: 10 Soils

The above samples were received intact and analysed according to your accompanying chain of custody form which is returned with this report for your reference.
Unless otherwise stated, solid samples are reported on a dry weight basis and liquid samples as received.
Mercury was analysed by Analabs, Welshpool, report No.WM038984.

Steven Edmett
STEVEN EDMETT
Manager Client Liaison

PETER BAMFORD
Manager Laboratory Services

This report supercedes our preliminary results that were reported by E-Mail.
This report must not be reproduced except in full.

(Analabs Pty. Ltd.) ACN 004 591 664
52 Murray Road Welshpool Western Australia 6106 Australia
Telephone: (08) 9458 7278 Facsimile: (08) 9451 3505

Australian
Environmental
Laboratories

CLIENT: Gutteridge Haskins & Davey Pty Ltd **OUR REFERENCE:** 42488
PROJECT: 6009/39/00

LABORATORY REPORT

Your Reference	#1 Munster	#2 Munster	#3 Munster	#4 Munster	#5 Munster
Our Reference	42488-1	42488-2	42488-3	42488-4	42488-5
Date Sampled	05/11/98	05/11/98	05/11/98	05/11/98	05/11/98
Type of sample	Soil	Soil	Soil	Soil	Soil
TRH C6 - C9	<20	<20	<20(<20)	<20	<20
TRH C10 - C14	<20	<20	<20(<20)	<20	<20
TRH C15 - C28	150	<50	<50(<50)	<50	140
TRH C29 - C36	<100	<100	<100(<100)	<100	<100
TRH Surrogate (o-terphenyl)	113	101	120(102)	95	107

Your Reference	#6 Munster	#7 Munster	#8 Munster	#9 Munster	#10 Munster
Our Reference	42488-6	42488-7	42488-8	42488-9	42488-10
Date Sampled	05/11/98	05/11/98	05/11/98	05/11/98	05/11/98
Type of sample	Soil	Soil	Soil	Soil	Soil
TRH C6 - C9	<20	<20	<20	<20	<20
TRH C10 - C14	<20	<20	<20	<20	<20
TRH C15 - C28	<50	<50	<50	<50	<50
TRH C29 - C36	<100	<100	<100	<100	<100
TRH Surrogate (o-terphenyl)	114	102	113	108	110

Australian
Environmental
Laboratories

CLIENT: Gutteridge Haskins & Davey Pty Ltd **OUR REFERENCE:** 42488
PROJECT: 6009/39/00

LABORATORY REPORT

Your Reference	#1 Munster	#2 Munster	#3 Munster	#4 Munster	#5 Munster
Our Reference	42488-1	42488-2	42488-3	42488-4	42488-5
Date Sampled	05/11/98	05/11/98	05/11/98	05/11/98	05/11/98
Type of sample	Soil	Soil	Soil	Soil	Soil
pH (1:5)	8.7	I/S	8.4	8.9	8.7 (8.7)
Sulphate, SO4	600	930	650	1100	510

Your Reference	#6 Munster	#7 Munster	#8 Munster	#9 Munster	#10 Munster
Our Reference	42488-6	42488-7	42488-8	42488-9	42488-10
Date Sampled	05/11/98	05/11/98	05/11/98	05/11/98	05/11/98
Type of sample	Soil	Soil	Soil	Soil	Soil
pH (1:5)	8.0	8.6	8.7	8.7	8.1
Sulphate, SO4	17000	270	640(1100)	750	6800

Australian
Environmental
Laboratories

CLIENT: Gutteridge Haskins & Davey Pty Ltd **OUR REFERENCE:** 42488
PROJECT: 6009/39/00

LABORATORY REPORT

Your Reference	#1 Munster	#2 Munster	#3 Munster	#4 Munster	#5 Munster
Our Reference	42488-1	42488-2	42488-3	42488-4	42488-5
Date Sampled	05/11/98	05/11/98	05/11/98	05/11/98	05/11/98
Type of sample	Soil	Soil	Soil	Soil	Soil
Arsenic, As	1.1	I/S	1.4	1.0	0.8
Cadmium,Cd	<0.5	I/S	<0.5	<0.5	<0.5
Chromium, Cr	18	I/S	15	13	10
Copper, Cu	13	I/S	<5	5	7
Mercury, Hg	0.17	I/S	<0.05	0.07	0.05
Lead, Pb	700	I/S	19	56	40
Nickel, Ni	<5	I/S	<5	<5	<5
Zinc, Zn	69	I/S	56	110	85

Your Reference	#6 Munster	#7 Munster	#8 Munster	#9 Munster	#10 Munster
Our Reference	42488-6	42488-7	42488-8	42488-9	42488-10
Date Sampled	05/11/98	05/11/98	05/11/98	05/11/98	05/11/98
Type of sample	Soil	Soil	Soil	Soil	Soil
Arsenic, As	1.1	2.4	3.1	1.7	1.7
Cadmium,Cd	<0.5	<0.5	<0.5	<0.5	<0.5
Chromium, Cr	7	21	21	23	28
Copper, Cu	8	10	<5	6	15
Mercury, Hg	0.08	<0.05	<0.05	0.05	1.0
Lead, Pb	20	50	23	29	190
Nickel, Ni	<5	11	<5	<5	9
Zinc, Zn	86	94	28	36	300

Australian Environmental Laboratories

CLIENT: Gutteridge Haskins & Davey Pty Ltd **OUR REFERENCE:** 42488
PROJECT: 6009/39/00

LABORATORY REPORT

Your Reference	#1 Munster	#2 Munster	#3 Munster	#4 Munster	#5 Munster
Our Reference	42488-1	42488-2	42488-3	42488-4	42488-5
Date Sampled	05/11/98	05/11/98	05/11/98	05/11/98	05/11/98
Type of sample	Soil	Soil	Soil	Soil	Soil
alpha-BHC	<0.1(<0.1)	<0.1	<0.1	<0.1	<0.1
Lindane	<0.1(<0.1)	<0.1	<0.1	<0.1	<0.1
Heptachlor	<0.1(<0.1)	<0.1	<0.1	<0.1	<0.1
Aldrin	<0.1(<0.1)	<0.1	<0.1	<0.1	<0.1
beta BHC	<0.1(<0.1)	<0.1	<0.1	<0.1	<0.1
delta-BHC	<0.1(<0.1)	<0.1	<0.1	<0.1	<0.1
Heptachlor Epoxide	<0.1(<0.1)	<0.1	<0.1	<0.1	<0.1
alpha-Endosulfan	<0.1(<0.1)	<0.1	<0.1	<0.1	<0.1
gamma-Chlordane	<0.1(<0.1)	<0.1	<0.1	<0.1	<0.1
alpha-Chlordane	<0.1(<0.1)	<0.1	<0.1	<0.1	<0.1
p,p'-DDE	<0.1(<0.1)	<0.1	<0.1	<0.1	<0.1
Dieldrin	<0.1(<0.1)	<0.1	<0.1	<0.1	0.4
Endrin	<0.1(<0.1)	<0.1	<0.1	<0.1	<0.1
p,p'-DDD	<0.1(<0.1)	<0.1	<0.1	<0.1	<0.1
beta-Endosulfan	<0.1(<0.1)	<0.1	<0.1	<0.1	<0.1
p,p'-DDT	<0.1(<0.1)	<0.1	<0.1	<0.1	<0.1
Methoxychlor	<0.1(<0.1)	<0.1	<0.1	<0.1	<0.1
Endosulfan Sulphate	<0.1(<0.1)	<0.1	<0.1	<0.1	<0.1
Endrin Ketone	<0.1(<0.1)	<0.1	<0.1	<0.1	<0.1
2,4,5,6-tetrachloro-m-xylene	96(110)	108	104	95	107

Australian
Environmental
Laboratories

CLIENT: Gutteridge Haskins & Davey Pty Ltd **OUR REFERENCE:** 42488
PROJECT: 6009/39/00

LABORATORY REPORT

Your Reference	#6 Munster	#7 Munster	#8 Munster	#9 Munster	#10 Munster
Our Reference	42488-6	42488-7	42488-8	42488-9	42488-10
Date Sampled	05/11/98	05/11/98	05/11/98	05/11/98	05/11/98
Type of sample	Soil	Soil	Soil	Soil	Soil
alpha-BHC	<0.1	<0.1	<0.1	<0.1	<0.1
Lindane	<0.1	<0.1	<0.1	<0.1	<0.1
Heptachlor	<0.1	<0.1	<0.1	<0.1	<0.1
Aldrin	<0.1	<0.1	<0.1	<0.1	<0.1
beta BHC	<0.1	<0.1	<0.1	<0.1	<0.1
delta-BHC	<0.1	<0.1	<0.1	<0.1	<0.1
Heptachlor Epoxide	<0.1	<0.1	<0.1	<0.1	<0.1
alpha-Endosulfan	<0.1	<0.1	<0.1	<0.1	<0.1
gamma-Chlordane	<0.1	<0.1	<0.1	<0.1	<0.1
alpha-Chlordane	<0.1	<0.1	<0.1	<0.1	<0.1
p,p'-DDE	0.7	<0.1	<0.1	<0.1	<0.1
Dieldrin	<0.1	<0.1	<0.1	<0.1	<0.1
Endrin	<0.1	<0.1	<0.1	<0.1	<0.1
p,p'-DDD	<0.1	<0.1	<0.1	<0.1	<0.1
beta-Endosulfan	<0.1	<0.1	<0.1	<0.1	<0.1
p,p'-DDT	<0.1	<0.1	<0.1	<0.1	<0.1
Methoxychlor	<0.1	<0.1	<0.1	<0.1	<0.1
Endosulfan Sulphate	<0.1	<0.1	<0.1	<0.1	<0.1
Endrin Ketone	<0.1	<0.1	<0.1	<0.1	<0.1
2,4,5,6-tetrachloro-m-xylene	111	84	83	93	88

CLIENT: Gutteridge Haskins & Davey Pty Ltd **OUR REFERENCE:** 42488
PROJECT: 6009/39/00

LABORATORY REPORT

TEST PARAMETERS	UNITS	LOR	METHOD
Total Recoverable Hydrocarbons in Soil			
TRH C6 - C9	mg/kg	20	PEO-200
TRH C10 - C14	mg/kg	20	PEO-200
TRH C15 - C28	mg/kg	50	PEO-200
TRH C29 - C36	mg/kg	100	PEO-200
TRH Surrogate (o-terphenyl)	% Recovery		PEO-200
pH (1:5)	pH Units	0.1	PEI-300
Sulphate, SO4	mg/kg	100	AS1012.20
Metals in Soil			
Arsenic, As	mg/kg	0.5	PEM-004
Cadmium,Cd	mg/kg	0.5	PEM-001
Chromium, Cr	mg/kg	5	PEM-002
Copper, Cu	mg/kg	5	PEM-001
Mercury, Hg	mg/kg	0.05	PEM-005
Lead, Pb	mg/kg	5	PEM-001
Nickel, Ni	mg/kg	5	PEM-001
Zinc, Zn	mg/kg	5	PEM-001
OC Pesticides in Soil			
alpha-BHC	mg/kg	0.1	PEO-100
Lindane	mg/kg	0.1	PEO-100
Heptachlor	mg/kg	0.1	PEO-100
Aldrin	mg/kg	0.1	PEO-100
beta BHC	mg/kg	0.1	PEO-100
delta-BHC	mg/kg	0.1	PEO-100
Heptachlor Epoxide	mg/kg	0.1	PEO-100
alpha-Endosulfan	mg/kg	0.1	PEO-100
gamma-Chlordane	mg/kg	0.1	PEO-100
alpha-Chlordane	mg/kg	0.1	PEO-100
p,p'-DDE	mg/kg	0.1	PEO-100
Dieldrin	mg/kg	0.1	PEO-100
Endrin	mg/kg	0.1	PEO-100
p,p'-DDD	mg/kg	0.1	PEO-100
beta-Endosulfan	mg/kg	0.1	PEO-100

CLIENT: Gutteridge Haskins & Davey Pty Ltd **OUR REFERENCE:** 42488
PROJECT: 6009/39/00

LABORATORY REPORT

TEST PARAMETERS	UNITS	LOR	METHOD
p,p'-DDT	mg/kg	0.1	PEO-100
Methoxychlor	mg/kg	0.1	PEO-100
Endosulfan Sulphate	mg/kg	0.1	PEO-100
Endrin Ketone	mg/kg	0.1	PEO-100
2,4,5,6-tetrachloro-m-xylene	%		PEO-100

Australian Environmental Laboratories

CLIENT: Gutteridge Haskins & Davey Pty Ltd **OUR REFERENCE:** 42488
PROJECT: 6009/39/00

LABORATORY REPORT

QUALTY CONTROL	UNITS	Blank	Replicate Sm#	Replicate Sample||Replicate	Spike Sm#	Matrix Spike
TRH C6 - C9	mg/kg	<20	Nil Replicate	Nil Replicate	42488-2	83 || 87 || RPD: 5
TRH C10 - C14	mg/kg	<20	Nil Replicate	Nil Replicate	42488-2	102 || 104 || RPD: 2
TRH C15 - C28	mg/kg	<50	Nil Replicate	Nil Replicate	42488-2	101 || 105 || RPD: 4
TRH C29 - C36	mg/kg	<100	Nil Replicate	Nil Replicate	42488-2	99 || 100 || RPD: 1
TRH Surrogate (o-terphenyl)	% Recovery	-	Nil Replicate	Nil Replicate	42488-2	106 || 109 || RPD: 3

QUALTY CONTROL	UNITS	Blank	Replicate Sm#	Replicate Sample||Replicate	Spike Sm#	Matrix Spike
pH (1:5)	pH Units	-	Nil Replicate	Nil Replicate	42488-2	-
Sulphate, SO4	mg/kg	<100	Nil Replicate	Nil Replicate	42488-2	-

QUALTY CONTROL	UNITS	Blank	Replicate Sm#	Replicate Sample||Replicate	Spike Sm#	Matrix Spike
Arsenic, As	mg/kg	<0.5	Nil Replicate	Nil Replicate	42488-2	-
Cadmium,Cd	mg/kg	<0.5	Nil Replicate	Nil Replicate	42488-2	-
Chromium, Cr	mg/kg	<5	Nil Replicate	Nil Replicate	42488-2	89 || 61 || RPD: 37
Copper, Cu	mg/kg	<5	Nil Replicate	Nil Replicate	42488-2	61 || 52 || RPD: 16
Mercury, Hg	mg/kg	<0.05	Nil Replicate	Nil Replicate	42488-2	-
Lead, Pb	mg/kg	<5	Nil Replicate	Nil Replicate	42488-2	64 || 48 || RPD: 29
Nickel, Ni	mg/kg	<5	Nil Replicate	Nil Replicate	42488-2	66 || 52 || RPD: 24
Zinc, Zn	mg/kg	<5	Nil Replicate	Nil Replicate	42488-2	78 || 76 || RPD: 3

Australian
Environmental
Laboratories

CLIENT: Gutteridge Haskins & Davey Pty Ltd **OUR REFERENCE:** 42488
PROJECT: 6009/39/00

LABORATORY REPORT

QUALTY CONTROL	UNITS	Blank	Replicate Sm#	Replicate Sample||Replicate	Spike Sm#	Matrix Spike
alpha-BHC	mg/kg	<0.1	Nil Replicate	Nil Replicate	42488-2	-
Lindane	mg/kg	<0.1	Nil Replicate	Nil Replicate	42488-2	119 || 121 || RPD: 2
Heptachlor	mg/kg	<0.1	Nil Replicate	Nil Replicate	42488-2	128 || 132 || RPD: 3
Aldrin	mg/kg	<0.1	Nil Replicate	Nil Replicate	42488-2	126 || 130 || RPD: 3
beta BHC	mg/kg	<0.1	Nil Replicate	Nil Replicate	42488-2	-
delta-BHC	mg/kg	<0.1	Nil Replicate	Nil Replicate	42488-2	-
Heptachlor Epoxide	mg/kg	<0.1	Nil Replicate	Nil Replicate	42488-2	132 || 141 || RPD: 7
alpha-Endosulfan	mg/kg	<0.1	Nil Replicate	Nil Replicate	42488-2	-
gamma-Chlordane	mg/kg	<0.1	Nil Replicate	Nil Replicate	42488-2	-
alpha-Chlordane	mg/kg	<0.1	Nil Replicate	Nil Replicate	42488-2	-
p,p'-DDE	mg/kg	<0.1	Nil Replicate	Nil Replicate	42488-2	-
Dieldrin	mg/kg	<0.1	Nil Replicate	Nil Replicate	42488-2	137 || 134 || RPD: 2
Endrin	mg/kg	<0.1	Nil Replicate	Nil Replicate	42488-2	148 || 149 || RPD: 1
p,p'-DDD	mg/kg	<0.1	Nil Replicate	Nil Replicate	42488-2	-
beta-Endosulfan	mg/kg	<0.1	Nil Replicate	Nil Replicate	42488-2	-
p,p'-DDT	mg/kg	<0.1	Nil Replicate	Nil Replicate	42488-2	-
Methoxychlor	mg/kg	<0.1	Nil Replicate	Nil Replicate	42488-2	109 || 105 || RPD: 4
Endosulfan Sulphate	mg/kg	<0.1	Nil Replicate	Nil Replicate	42488-2	-
Endrin Ketone	mg/kg	<0.1	Nil Replicate	Nil Replicate	42488-2	-
2,4,5,6-tetrachloro-m-xylene	%	-	Nil Replicate	Nil Replicate	42488-2	127 || 116 || RPD: 9

NOTES:
LOR= Limit of Reporting.
I/S denotes insufficient sample.
pH was determined on a 1:5 as received sample to deionised water extract with result reported on that basis.
Bracketed results from duplicate analysis.

Appendix F

Flouristic Survey Data

2 facing MG N°2 Lake North

BUSHLAND PLANT SURVEY RECORDING SHEET 1- use pencil only

Photograph no. 1. facing Coogee

BUSHLAND AREA North end, Lake Coogee SITE NUMBER ONE

DATE TRIP 21/10/98 RECORDERS G. Bouma and Devon Cunningham

DATE TRIP _____ RECORDERS _____

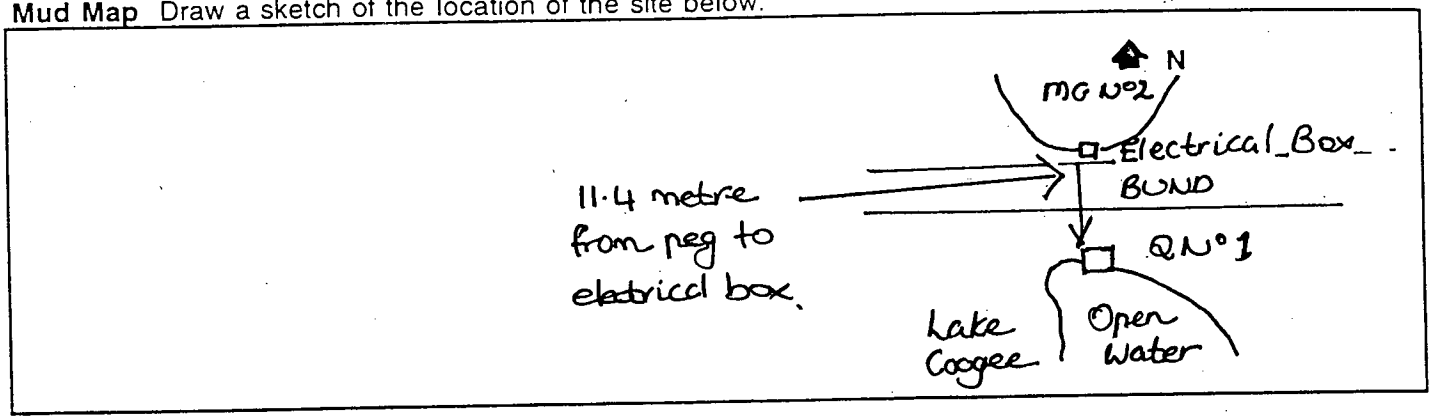
DATE TRIP _____ RECORDERS _____

BOTANIST G. Bouma

From '*Bushland Plant Survey*' written by B. Keighery (1994) and published by the Wildflower Society of WA (Inc.), PO Box 64 Nedlands WA 6008.

1. LOCATION of the QUADRAT

Mud Map Draw a sketch of the location of the site below.



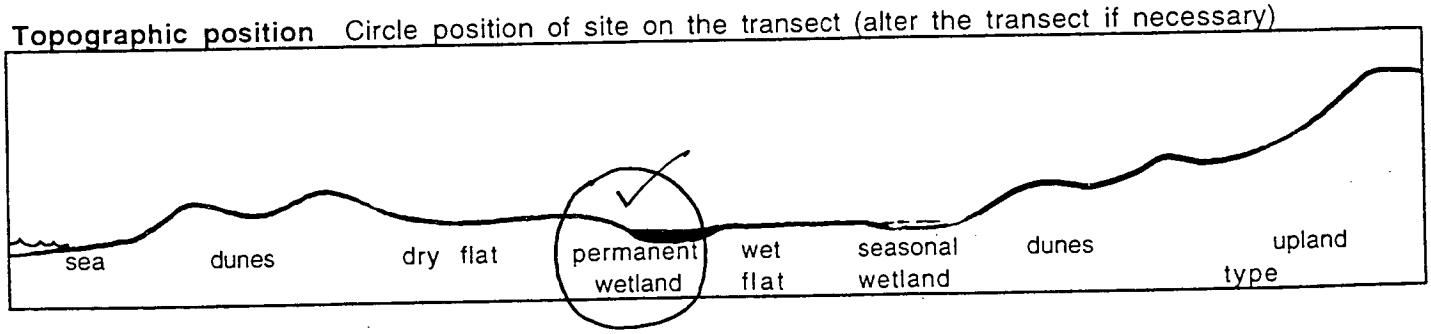
Road Location

Geographic Location Latitude S Longitude E Altitude

Reference Map

Photograph Photographer's Name GB Photo No 1 & 2

Topographic position Circle position of site on the transect (alter the transect if necessary)



2. SITE DATA Circle the correct response.

Slope flat (gentle) steep *Aspect* N NE E SE (S) SW W NW

Surface Soil Peaty sand *Colour* Grey/black

Exposed rock type — % surface —

Sub-surface Soil Peat/sand *Colour* blackish

Rock — type — depth to rock —

Drainage well mod poor depth water 200 cm *Wet* all year (winter/spring)

Litter Nil. Mainly weed cover: % cover

Depth cm

Bare Ground Nil %cover

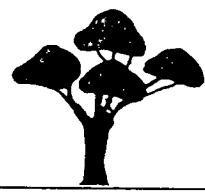
BUSHLAND PLANT SURVEY RECORDING SHEET 2 - use pencil only site One

From '*Bushland Plant Survey*' written by B. Keighery (1994) and published by the Wildflower Society of WA (Inc.), PO Box 64 Nedlands WA 6008.

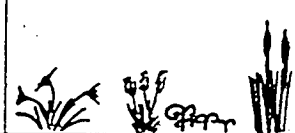
3. VEGETATION STRUCTURE AND COVER

For each layer **record** - appropriate **life form**, **cover class** (see below).and **dominant species** in each layer.

Cover Class	2-10%	10-30%	30 - 70%	over 70%

	TREES			MALLEES	
	over 30m	10 - 30m	under 10m	over 8m	under 8m
LIFE FORM					 30m 10m
COVER CLASS (%)			10-30%		
DOMINANT SPECIES			Melaleuca c cuticularis Low Woodland		

	SHRUBS		SHRUBS
	over 2m	2m - 1m	under 1m
LIFE FORM			 2m 1m
COVER CLASS (%)			2-10%
DOMINANT SPECIES			Rhagodia

	GRASSES	HERBS	SEDGES	OTHER
LIFE FORM			 1m	
COVER CLASS (%)	70%	0%	10-30%	10-30%
DOMINANT SPECIES	couch		Juncus pallidus Baumea	Samphire

4. VEGETATION CONDITION

1 'PRISTINE'	
2 EXCELLENT	
3 VERY GOOD	
4 GOOD	
5 DEGRADED	✓

COMMENTS

Bund and bank has introduced large numbers of weeds. Wetland area itself is in good condition.

BUSHLAND PLANT SURVEY RECORDING SHEET 3 - use pencil only

5. SPECIES PRESCENCE

SITE No One
Date 21/10/98

Label each plant with plants number, site code, date and plant's name or working name if required
Record on Sheet

- Column 1 plant name-
- Column 2 plant number
- Column 3 flowering time- TICK if species flowering
- Column 4 identification check

From '*Bushland Plant Survey*' written by B. Keighery (1994) and published by the Wildflower Society of WA (Inc.), PO Box 64 Nedlands WA 6008.

TREES	No	Fl	ID
Melaleuca cuticularis	5	✓	
MALLEES			
SHRUBS			
Rhagodia baccata	3		

SHRUBS (cont.)	No	Fl	ID
GRASSES			
Cynodon dactylon	100+	✓	
Lagurus ovata	3	✓	
Avena fatua	3	✓	
Lolium perenne	1	✓	✓
HERBS			
Sarcocornia quinqueflora	100+	✓	
Suada australis	50	✓	

HERBS (cont.)	No	Fl	ID
Fennel (Foeniculum vulgare)	6	✓	
Pelargonium capitatum	4	✓	
Lupinus mutabilis	2	✓	
Oxalis pes-caprae	100+	✓	
Carrot	1		✓
Euphorbia peplus	2	✓	
Bromus diandrus	100+	✓	
Vicia sativa	100+	✓	
Ornithogalum thyrsoides	10		✓
SEDGES			
Juncus pallidus	6	✓	
Baumea juncea	100+	✓	

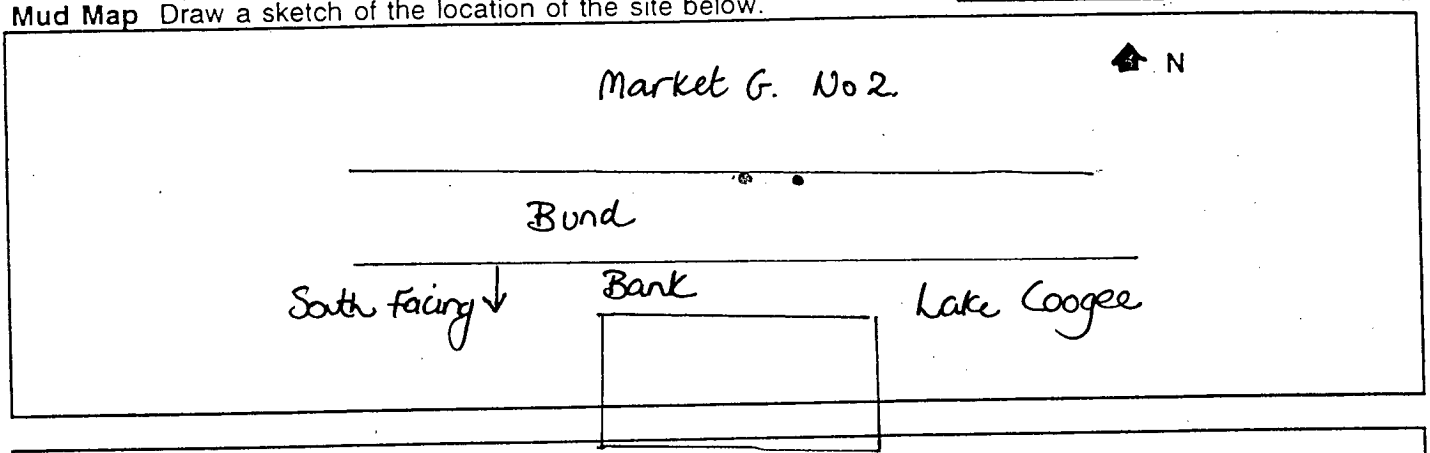
BUSHLAND PLANT SURVEY RECORDING SHEET 1- use pencil only

BUSHLAND AREA North End, Lake Coogee SITE NUMBER 2
DATE TRIP 21.10.98 RECORDERS G. Bouma & D. Cunningham
DATE TRIP _____ RECORDERS _____
DATE TRIP _____ RECORDERS _____
BOTANIST G Bouma

From '*Bushland Plant Survey*' written by B. Keighery (1994) and published by the Wildflower Society of WA (Inc.), PO Box 64 Nedlands WA 6008.

1. LOCATION of the QUADRAT

Mud Map Draw a sketch of the location of the site below.

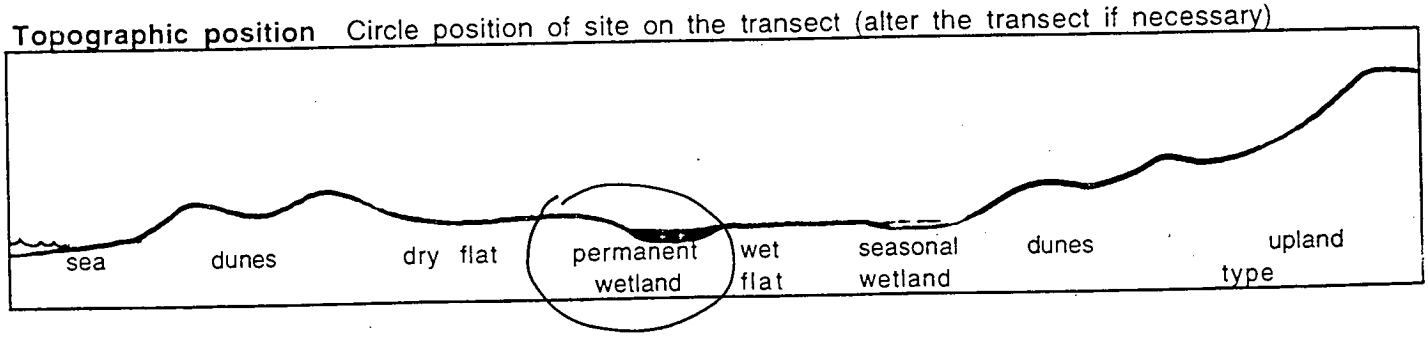


Road Location

Geographic Location Latitude S Longitude E Altitude
Reference Map

Photograph Photographer's Name GB Photo No 3 & 4

Topographic position Circle position of site on the transect (alter the transect if necessary)



2. SITE DATA Circle the correct response.

Slope flat (gentle) steep ***Aspect*** N NE E SE (S) SW W NW

Surface Soil Peaty sand ***Colour*** black
Exposed rock type % surface

Sub-surface Soil Peat/sand ***Colour*** black
Rock type – depth to rock

Drainage well mod poor depth water more muddy 250 cm ***Wet*** all year (winter/spring)

Litter NIL	% cover	***Bare Ground*** NIL	%cover
Depth	cm		

BUSHLAND PLANT SURVEY RECORDING SHEET 2 - use pencil only Site Two

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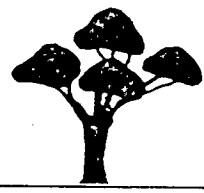
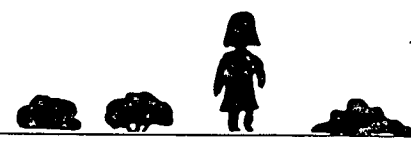
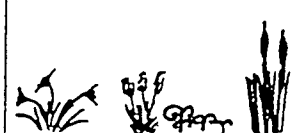
3. VEGETATION STRUCTURE AND COVER

For each layer **record** - appropriate **life form**, **cover class** (see below) and **dominant species** in each layer.

Cover Class	2-10%	10-30%	30 - 70%	over 70%

	TREES			MALLEES	
	over 30m	10 - 30m	under 10m	over 8m	under 8m
LIFE FORM					 30m 10m
COVER CLASS (%)			2-10%		
DOMINANT SPECIES			Melaleuca rhap Melaleuca cut. 10-30% Low woodland		

	SHRUBS over 2m	SHRUBS 2m - 1m	SHRUBS under 1m
LIFE FORM			 2m 1m
COVER CLASS (%)			
DOMINANT SPECIES			

	GRASSES	HERBS	SEDGES	OTHER
LIFE FORM				Samphire 1m
COVER CLASS (%)	On bank 2-10% couch		10-30%	70% species 2
DOMINANT SPECIES				

4. VEGETATION CONDITION

1 'PRISTINE'	
2 EXCELLENT	✓
3 VERY GOOD	
4 GOOD	
5 DEGRADED	

COMMENTS

Bund and banks have introduced weeds.
Water level has kept everything else native.

BUSHLAND PLANT SURVEY RECORDING SHEET 3 - use pencil only

5. SPECIES PRESCENCE

SITE No Two
Date 21/10/98

Label each plant with plants number, site code, date and plant's name or working name if required
Record on Sheet

- Column 1 plant name-
- Column 2 plant number
- Column 3 flowering time- TICK if species flowering
- Column 4 identification check

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TREES	No	Fl	ID
Melaleuca rhaphiophylla	2	✓	
Melaleuca cuticularis	4	✓	
MALLEES			
SHRUBS			
Rhagodia baccata	5	-	✓

SHRUBS (cont.)	No	Fl	ID
GRASSES			
Cynodon dactylon	1000+	✓	
HERBS			
Sarcocaia quinqueflora	100+	✓	
Suada australis	100+	✓	

HERBS (cont.)	No	Fl	ID
(Weeds)			
Oxalis pes-capre	10	✓	
Bromus diandrus	10	✓	
Carrot	1	✓	
SEDGES			
Juncus pallidus	100+	✓	✓
Baloskoenus cabwellii	100+		✓
Gahnia trifida	100+		✓