PUBLIC ENVIRONMENTAL REPORT

FOR LUDMILLA WASTEWATER TREATMENT PLANT

AND ASSOCIATED FACILITIES

OCTOBER 1998

CONSULTING ENVIRONMENTAL ENGINEERS

IN ASSOCIATION WITH

SINCLAIR KNIGHT MERZ

Contents

1. EXECUTIVE SUMMARY

1.1 Title of Proposal

The title of the proposal is:

Upgrade of Ludmilla Wastewater Treatment Plant and Associated Pipelines and Effluent Reuse Projects.

1.2 Name and Address of Proponent

The proponent is:

Power and Water Authority
Jape Plaza, 18 Cavenagh Street, Darwin NT 0801

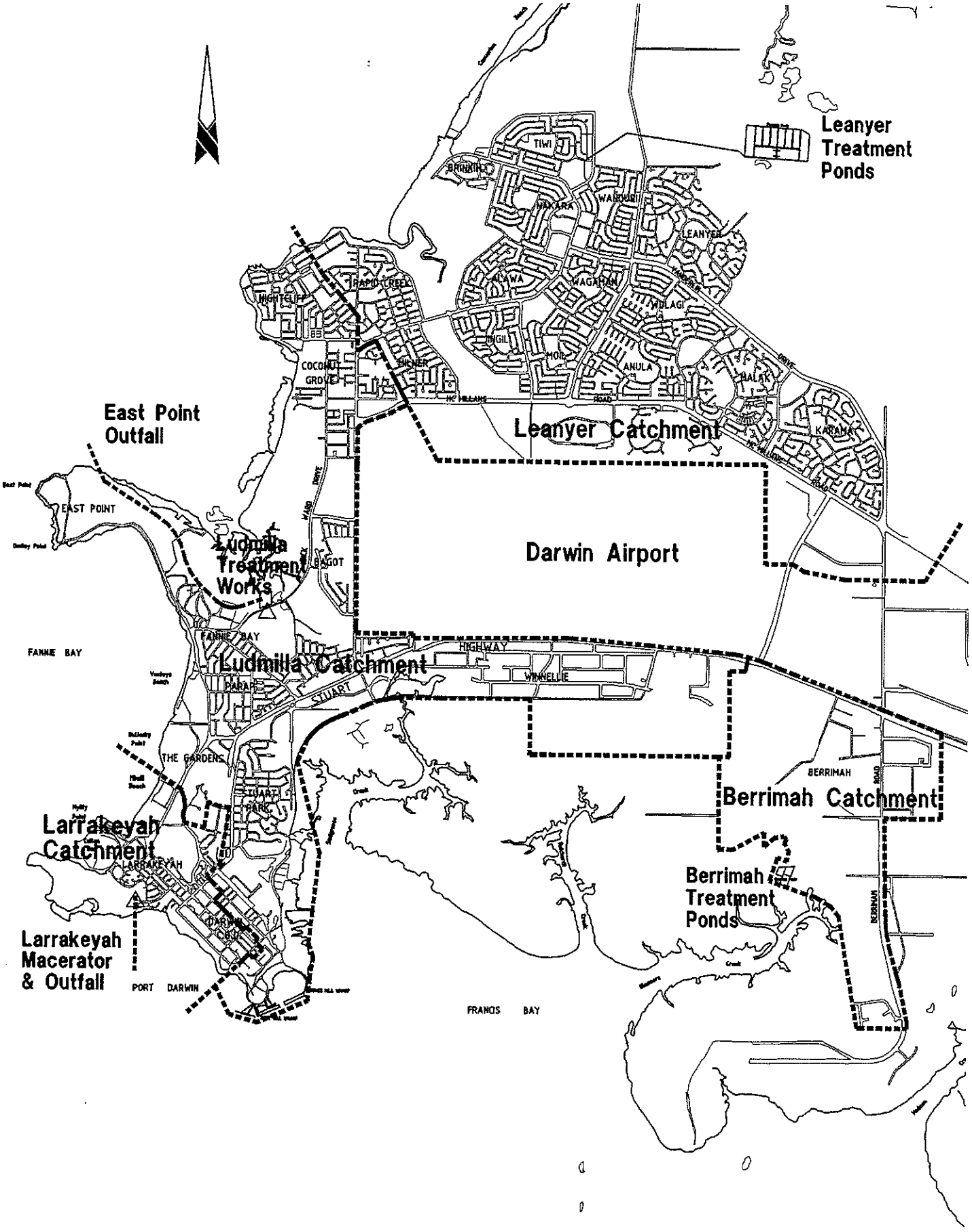
Contact: Mr D Day, Director, Infrastructure Management
Phone: 08 8924 7363 Fax: 08 8924 7161

1.3 Background to Proposal

The Power and Water Authority (PAWA) is responsible for sewerage services in Darwin and other urban areas of the Northern Territory. For Darwin, PAWA operates a sewerage system which collects wastewater from residences, commercial establishments and industry, and operates wastewater treatment plants (WWTPs) at: (1) Ludmilla; (2) Leanyer; and (3) Berrimah. Wastewater from the central business district (CBD) and adjacent suburbs, including the Larrakeyah military area, is macerated (the solids are ground into small pieces) and discharged to Darwin Harbour without further treatment through the Larrakeyah outfall.

The present arrangement of sewerage catchments and discharge points for Darwin is shown in Figure 1-1. No changes are proposed for the lagoons or effluent discharges at Leanyer and Berrimah.

It is proposed to transfer all the wastewater from the Larrakeyah catchment to the Ludmilla treatment plant for treatment there. The capacity of the Ludmilla plant will be increased to handle the transferred flows as well as higher flows due to population increases in the Larrakeyah and Ludmilla catchments. In addition, the level of treatment at the Ludmilla plant will be augmented for dry season and wet season flows.



PRESENT SEWERAGE CATCHMENTS IN DARWIN

Figure 1-1

Ludmilla Catchment

The catchment draining to the existing Ludmilla treatment plant comprises Frances Bay, Stuart Park, Winnellie, Mindil Beach, the Gardens, Fannie Bay, the CBD, Larrakeyah, the Narrows, RAAF Base, Ludmilla, Coconut Grove and Nightcliff. The population within this catchment is equivalent to 24,600 residents.

At the Ludmilla plant, the sewage is macerated, chemicals (lime and polymer) are added to assist in removal of organic solids, and the settleable solids are removed and incinerated.

East Point Outfall

The effluent from the Ludmilla WWTP is disinfected using chlorine and discharged to the ocean via the East Point outfall which comprises a pipeline extending for 3,040 m along East Point and then a buried pipeline extending 700 m northwest across the foreshore and intertidal mudflats. The East Point outfall discharges on the seabed at a depth of 2.2 m below mean sea level. This provides satisfactory submergence at high tides but not at low spring tide (which occurs about 10 per cent of the time) when the discharge point is exposed at (or above) sea level.

The discharged effluent is only slightly visible at high tide but more conspicuous at low tide. The present discharge does not cause a significant degradation in water quality (Moir, 1995; Parry and Munksgaard, 1997), but it is recognized that there is little immediate dilution of the effluent with seawater, particularly at low tide, and the odour produced by the discharge can be noticed in the picnic ground at times of low tide and north winds.

The East Point outfall has at present a hydraulic capacity of 22 ML/d (million litres per day).

Larrakeyah Catchment and Outfall

The catchment draining to the existing Larrakeyah outfall comprises the CBD, Larrakeyah, the Military Area and Cullen Bay. The population within this catchment is equivalent to 13,500 residents. The sewage is macerated (the solids are ground into small pieces) before being discharged to Darwin Harbour through the Larrakeyah outfall.

The Larrakeyah outfall is 850 m long, including a 66 m long diffuser, and discharges at a depth of 20 m through 11 ports each of 10 cm diameter. There is rapid dilution (typically 240:1) of the discharged wastewater with the tidal flows across the diffuser. The Larrakeyah outfall has a much better performance, in terms of dilution of effluent with seawater, than the performance of the East Point outfall, and does not cause any detectable effects on water quality (Moir, 1995; Parry and Munksgaard, 1997). The Larrakeyah outfall has a hydraulic capacity of 28 ML/d.

1.4 Need for Proposal

The proposal is required for the following reasons:

1. To ensure that the effluent discharged through the Larrakeyah outfall has received a suitable level of treatment;

2 To upgrade the Ludmilla treatment plant to provide secondary treatment, as provided at the other treatment facilities in Darwin;

3 To augment existing treatment facilities to provide capacity for future increases in wastewater flows from the area sewered;

4 To provide a volume of high quality effluent suitable for reuse on irrigating playing fields and open space;

5 To encourage the reuse of high quality effluent now and in the future on parks and landscaping in the Darwin urban area;

6. To develop backup facilities for handling the biosolids removed in treatment, and to encourage reuse of biosolids in the future; and

7. To minimise the effects of effluent discharges on ocean water quality.

1.5 Objectives of Proposal

The objectives of the proposal are:

1. To ensure effluent and biosolids from PAWA sewerage treatment facilities comply with discharge licence requirements, ANZECC guidelines and other statutory requirements;

2. To encourage reuse of effluent and biosolids, and to develop a market for these resources;

3. To implement a cost effective development strategy, which makes good use of existing facilities and sites, and which provides capacity for future increases in wastewater flows from the area sewered; and

4. To operate a sewerage system which has minimal odour and other impacts on neighbours near the treatment plants.

1.6 Major Components of Proposal

The proposal involves providing increased treatment capacity at the Ludmilla plant to handle present and future flows from the Larrakeyah and Ludmilla catchments, upgrading the level of treatment at the Ludmilla plant to biological secondary treatment (with a proportion of the flow receiving tertiary treatment), encouragement of effluent reuse and augmentation of the East Point outfall. The proposal is shown schematically in Figure 1-2.

The major components of the proposal are shown in the attached schematic diagram and are listed below:

1. New pumping station and pipelines to transfer wastewater from Larrakeyah and central city area to Ludmilla treatment plant;

2. Upgrade capacity of Ludmilla treatment plant in stages to handle additional flows and high flows in the wet season;

3. Screening, grit removal, additional wet weather treatment capacity and backup solids handling;

4. Additional odour and noise controls (for the new aeration equipment) at the Ludmilla treatment plant;

5. Tertiary filtration and disinfection arrangements to produce reclaimed effluent;

6. Arrangements to develop markets for reuse of effluent, including pipeline to reticulate reclaimed effluent to sites near the Ludmilla treatment plant;

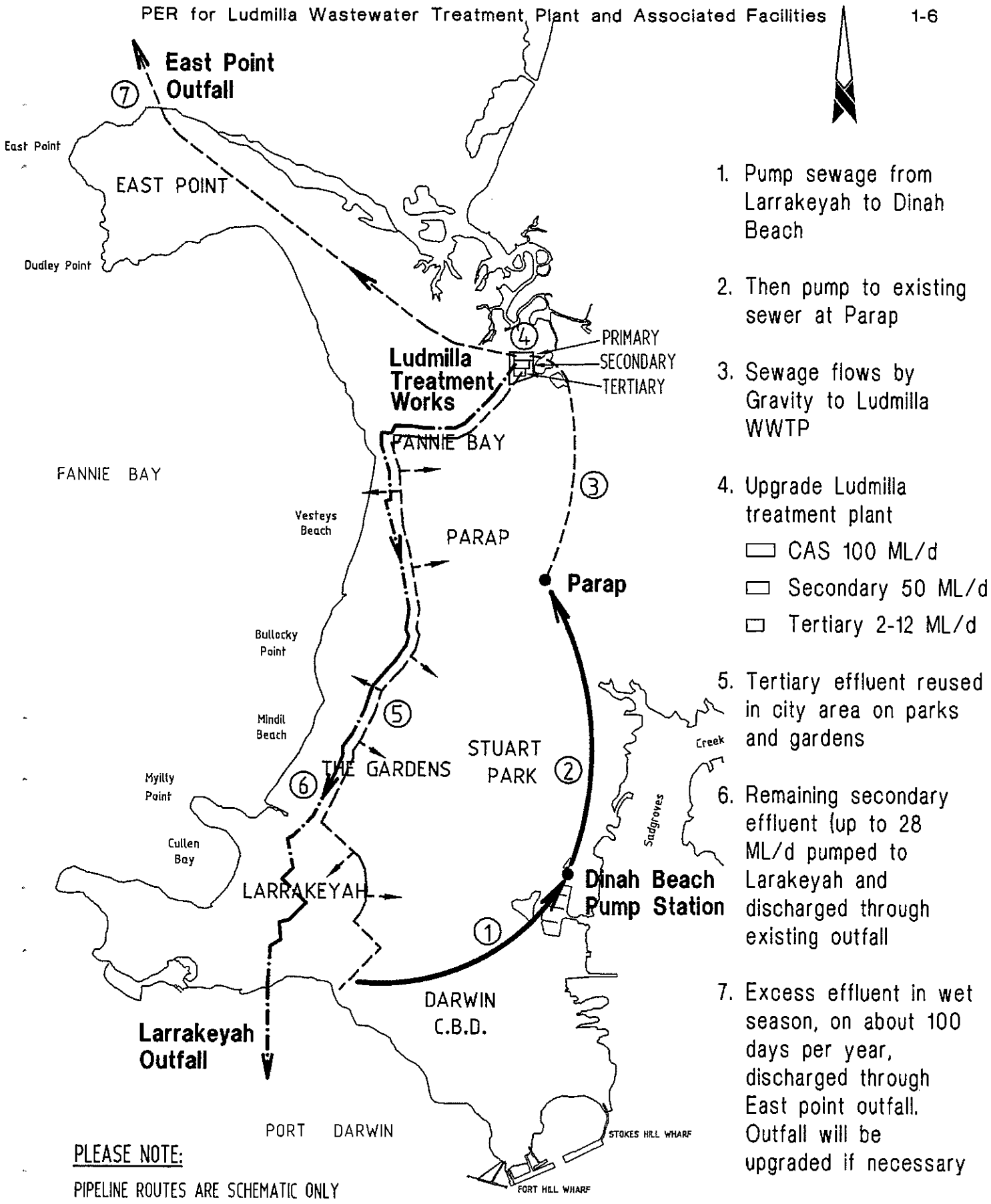
7. New effluent pumping station and pipeline to convey effluent in excess of reuse demand to the existing Larrakeyah outfall;

8. Special arrangements to handle mangrove mud and old sludge removed from Ludmilla site as part of construction;

9. Discharge of excess flows in wet weather through the existing East Point outfall, and possible extension of that outfall in future if monitoring shows that to be necessary;

10. Increase capacity of East Point outfall to 60 ML/d; and

11. Environmental Management Plan (EMP) to ensure construction and operations are conducted with minimal environmental impact.



1. Pump sewage from Larrakeyah to Dinah Beach
2. Then pump to existing sewer at Parap
3. Sewage flows by Gravity to Ludmilla WWTP
4. Upgrade Ludmilla treatment plant
   - CAS 100 ML/d
   - Secondary 50 ML/d
   - Tertiary 2-12 ML/d
5. Tertiary effluent reused in city area on parks and gardens
6. Remaining secondary effluent (up to 28 ML/d pumped to Larakeyah and discharged through existing outfall
7. Excess effluent in wet season, on about 100 days per year, discharged through East point outfall. Outfall will be upgraded if necessary

PLEASE NOTE:

PIPELINE ROUTES ARE SCHEMATIC ONLY
REFER TO FIGURES 4-3, 4-4 & 4-5 FOR ACTUAL ROUTES.

SCHEMATIC ILLUSTRATION OF PROPOSED UPGRADE TO SEWERAGE SYSTEM

Figure 1-2

1.7 Darwin Sewerage Strategy

The proposal is a key step in the implementation of the Darwin Sewerage Strategy (GHD/CEE, 1996). The goals of the sewerage strategy are to augment the Darwin sewerage system to handle future growth in residential, commercial and industrial flows, to upgrade the treatment and effluent outfall facilities to meet increasingly stringent environment requirements and to reuse an increasing proportion of effluent and biosolids in the future.

In developing the strategy, all present and likely future sites for treatment plants were reviewed. The review established that the preferred sites for wastewater treatment plants (WWTP) are Ludmilla, Leanyer, Berrimah and Hudson Creek. The Ludmilla site provides the best long term opportunity for reuse of effluent in the city parks and gardens, and also avoids the need to transport sewage long distances from the city for treatment, with consequent odour, corrosion and cost problems.

Ludmilla, unlike the other treatment sites, has limited available area, and hence must be developed as a mechanically operated plant; oxidation lagoons can be used at the other sites. Thus the proposal to augment and upgrade treatment at the Ludmilla WWTP is compatible with the long term sewerage strategy for Darwin.

1.8 Construction Aspects

The principal construction activities are as follows:

* New trunk sewers from Larrakeyah to Dinah Beach and then to Parap, and associated pumping stations;
* Augmentation of Ludmilla WWTP, including secondary and tertiary treatment processes;
* New effluent pipeline from Ludmilla to Larrakeyah;
* New pipelines to reticulate reclaimed water to users;
* Duplication of rising main to East Point; and
* Possible future extension of the East Point outfall.

The pipelines will be constructed mainly under roads, or under easements beside roads. Construction also will be carried out across the CBD. The pipeline routes are shown in Chapter 4, while management procedures to minimise impacts during construction are presented in Chapter 10.

It is recognized that the construction of the pipelines will lead to adverse local impacts during the period of construction, principally noise, dust, localised vibration, traffic congestion, restrictions to access and loss of a small number of trees and shrubs (to be replaced after construction).

However, the impacts are short term, have been minimized by careful route selection and will be controlled by proper construction management. The pipeline construction activities, and the consequent effects, are no different to other projects involving burial of pipelines and cables in urban areas (drains, water, gas, electricity, telephone, telecommunications) and there are well-established construction procedures and protocols to manage adverse effects. There will be full restitution and revegetation of construction trenches and sites.

Augmentation of Ludmilla WWTP

The augmentation of the Ludmilla WWTP will involve a staged development of the capacity of the plant, to handle an average daily flow of 12.4 ML/d in the year 2012 and an ultimate average daily flow of 16 ML/d. For comparison, the present average daily flow is 7 ML/d.

There is a diurnal variation in flow and during the dry season the peak flow is predicted to be 22 ML/d in the year 2012 and 28 ML/d ultimately.

Much higher flows occur at times of prolonged rainfall during the wet season, when the peak flow rate can reach 100 ML/d. Provision is being made to treat all flows during these flow peaks in wet weather.

The existing chemically-assisted primary tanks will be retained and can treat up to 40 ML/d. The secondary treatment tanks will be installed in modules, with a peak capacity of 8 ML/d in the year 2000, 32 ML/d in the year 2005 and ultimately 40 ML/d.

The tertiary plant and disinfection will be installed in modules beginning with 3 ML/d in the year 2000 and then increasing as the demand for reclaimed water grows progressively over time.

The ultimate peak daily flow in the dry season is predicted to be 28 ML/d. This is within the capacity of the secondary treatment processes and hence after 2005 all flow in the dry season will receive primary and biological secondary treatment.

Fine screens will be installed at the front of the plant to remove all coarse detritus greater than 3 mm in size. This material will be incinerated on the site or buried in either the Council landfill or a new burial site adjacent to the Leanyer lagoons. The screens will have a capacity of 100 ML/d and hence will handle all flows entering the WWTP.

Aerated grit tanks will be installed with a peak flow capacity of 40 ML/d, to match the ultimate capacity of the chemical primary tanks. The grit tanks will remove sand and gravel. The air used to agitate the grit tanks will be captured and conveyed through a soil bed filter to reduce odours. Hence the grit tanks will have an important role in reducing odour emissions from the Ludmilla WWTP.

The flow in the wet season which exceeds 40 ML/d (which is the ultimate capacity of the primary and secondary treatment tanks) will be conveyed (after fine screening) to a wet weather flow tank for storage and settling. The solids which settle in this tank will be transferred to the primary tanks. The wet weather tank will have a capacity of up to 60 ML/d. During the dry season, the wet weather tank may be used to store secondary effluent to reduce pumping costs (allowing pumping to occur mostly at night at a lower tariff).

The reclaimed water market and distribution system will be developed by PAWA progressively over the next decade or so in conjunction with consumer demand.

All these construction activities (apart from the reclaimed water distribution system) will occur within the existing PAWA treatment plant site. The first module of the secondary and tertiary treatment units will be constructed within the existing designated site.

Subsequent modules of secondary treatment units will be constructed to the north of the existing site, on land designated for sewage treatment purposes. This land is, however, the subject of two land claims by local Aboriginal groups, and construction will not commence unless and until the land claims have been settled and PAWA has a clear title to the land. If the event that PAWA does not obtain a title, the additional secondary treatment units could be constructed within the existing PAWA site, but this would involve the removal of a stand of mature mangroves. The decision of the final location of the secondary treatment modules does not have to be made until 2001.

Construction of the new facilities at the Ludmilla site will involve removal of previously installed gravel fill, mangrove mud and accumulated sludge from the site. The mud and sludge is potentially odourous after being disturbed and has the potential to produce acid leachate. To minimise the leachate problems, the mud and sludge will be transferred to the mudflats at Hudson Creek (to a site owned by PAWA), placed in a 1 m layer just below the high tide line and capped. However, there will be a short term odour problem around the Ludmilla WWTP during excavation. An odour masking system will be operated during excavation to reduce the odour nuisance.

Construction of the reclaimed effluent distribution lines will involve localised short term disturbances but no significant or long term adverse impacts.

Subsequent Construction Activities

After the year 2001, the additional components which will be constructed are as follows:

* Duplication of the pipeline for 3.04 km along East Point to augment outfall capacity;
* Extension of offshore outfall at East Point (provided that environmental monitoring shows that an extension is worthwhile);
* Additional secondary treatment modules at Ludmilla plant;

* Additional tertiary treatment modules, depending on demand for reclaimed water;
* Expansion of reclaimed water distribution system, in accordance with demand for reclaimed water.

The potential impacts arising from these activities are addressed in this PER as they form a part of the long term development envisaged in the proposal.

Duplication of the pipeline along East Point will involve the same impacts as for other pipeline construction except that the work will take place in the existing easement and generally in open land.

Construction of the East Point outfall extension will involve excavation of a trench across the mudflats using a floating dredge. The excavated material would be pumped to the mudflats about 200 m north of the working area and hence would cause a short term local increase in turbidity. The quantity of mud to be excavated is about 6000 m^3 each fortnight, which would correspond to a 0.3 m change in seabed level over about 2 ha. Similar changes in seabed level occur naturally on the mudflats in each major storm. Hence no large scale or long term detrimental effects on marine water quality or biological communities are expected.

The outfall extension would be installed in the trench and secured by piles to the underlying rock. The trench would then backfill naturally. A multiport diffuser at the offshore end of the extension would comprise a series of vertical discharge pipes projecting about 1 m above the seabed.

1.9 Operations Aspects

The operation of the Ludmilla treatment plant, the Larrakeyah outfall and the East Point outfall will be very similar to the present situation, with the following changes:

* Additional energy use at the Ludmilla treatment plant to achieve the higher level of treatment;

* Additional operating staff, as a consequence of the greater number of treatment operations;

* Better effluent quality, particularly for the discharge at Larrakeyah;

* Reclaimed effluent used to irrigate parks and open space near Ludmilla; and

* Discharge of a small quantity of disinfected secondary effluent through the East Point outfall each day, sufficient only to keep the outfall clear of sediment. Significant quantities of effluent, up to 60 ML/d, would be discharged during the wet season.

Screenings and grit will be removed at the plant. These will be either incinerated on the site or bagged and taken to the Darwin landfill or the Leanyer WWTP site for burial (the Leanyer site is discussed in Chapter 6).

Sludge will be removed from the primary sedimentation tanks. For the foreseeable future, the sludge will be incinerated on the site using the existing incinerator. The incinerator has adequate capacity to burn the additional sludge (this would increase the incineration operation from about 32 hours per week to 40 hours per week).

1.10 Existing Land Environment

The land environments which will be affected by the proposal are:

* Pipeline routes, as shown in Chapter 4;
* Ludmilla WWTP site, on which the augmented treatment facilities will be constructed;
* Pipeline route to East Point, as shown in Chapter 4;
* Offshore from the existing East Point outfall, where a future extension may be constructed; and
* All the parks and garden areas, possibly including the Fannie Bay Racecourse, Bicentennial Park, Gardens Park Golf Course, Botanic Gardens (part thereof) and potentially East Point, which may be irrigated with reclaimed water.

Potential long term environmental implications for the land environment are as follows:

* Odour emissions from the Ludmilla treatment plant will be reduced as a result of the aeration processes and additional odour control facilities;

* Noise emissions should not change significantly;

* Minor but acceptable increase in traffic (due to additional operations personnel plus waste transfer);

* The area occupied by treatment facilities will increase (the expansion will occur on land owned by PAWA); and

* Reclaimed effluent will be used to irrigate land near Ludmilla and, potentially, over most parks on the western side of the city.

These changes are not expected to cause significant adverse impacts on the land environment. The implications of the pipeline routes on heritage and Aboriginal sites has been checked and no known sites will be affected.

1.11 Existing Marine Environment

The marine environments potentially affected by the proposal are the regions near the Larrakeyah outfall, East Point outfall and Ludmilla Creek. All receive effluent at present, and as a result of the proposal will discharge higher quality effluent.

The rate of effluent discharge from the Larrakeyah outfall will increase. At the same time, there will be a significant improvement in the quality of the discharged effluent, so that the total solids load discharged to Darwin Harbour will decrease by about 25 per cent.

There will be minimal discharge of effluent from the East Point outfall in the dry season, but discharge of a mixture of primary and secondary effluent on about 100 days during the wet season. This will mean the quality of the effluent will be improved from the present quality on some days and the total annual solids load discharged at East Point will decrease. Water quality and biological conditions will be monitored and the outfall extended if found to be worthwhile.

All effluent, even in wet weather, will be screened and receive primary treatment (at least) before discharge. This will eliminate the present problem of floatables being discharged to the ocean and Ludmilla Creek.

1.12 Principal Environmental Impacts

The principal environmental impacts are as follows:

1. Short term impacts during pipeline construction, principally noise, dust, localised vibration, traffic congestion, restrictions to access and loss of a small number of trees and shrubs (to be replaced by new plantings;)

2. Increased energy use as a result of the higher level of treatment;

3. Production of about 1 t/day wastes (screenings and grit) as a result of increased removal of these materials by improved treatment;

4. Increased discharge of effluent (although of greatly improved quality) through the Larrakeyah outfall;

5. Minor increase in traffic (due to additional operations personnel plus waste transfer);

6. The area occupied by treatment facilities will increase; and

7. Reclaimed effluent will be used to irrigate land near Ludmilla and, potentially, over most parks on the western side of the city.

Potential Beneficial Impacts

Potentially beneficial changes are as follows:

* Remove present macerated sewage discharge at Larrakeyah;
* Reduce frequency of discharge through East Point outfall;
* Substantially reduce number of days of overflow, and improved treatment before discharge, to Ludmilla Creek;
* Reclaimed water available for reuse;
* Potential long term prospect for reuse of biosolids;
* Reduction in organic and nutrient loads discharged to Darwin Harbour; and
* Substantial reduction in organic and nutrient loads discharged at East Point during the dry season, and also a significant reduction over each year.

Minimal Change in Marine Conditions

Studies have found that the discharge of effluent through the Larrakeyah outfall has minimal impact on marine water quality or biological communities (Moir, 1995; Parry and Munksgaard, 1997). This has been attributed to the high dilution of the discharged effluent. The faecal coliform levels on the shore meet ANZECC guidelines. No change in these conditions is expected with a greater volume of higher quality effluent being discharged. Also, as noted above, the organic and nutrient loads discharged to Darwin Harbour and at East Point will be reduced as a result of the secondary treatment.

Studies have found that the discharge of effluent through the East Point outfall has a minor impact on marine water quality and minimal effect on biological communities (Moir, 1995; Parry and Munksgaard, 1997). At times when low tide coincides with onshore winds, there is an odour impact and elevated coliform levels in nearshore waters. These impacts are expected to be reduced as the outfall will be used in future mostly in the wet season, with only a small quantity of disinfected secondary effluent discharged in the dry season for maintenance purposes.

Studies have found that the overflows of wastewater to Ludmilla Creek have had very little impact on biological communities mainly because of the strong tidal flushing and because the creek in wet weather carries runoff from an urban area (Parry and Munksgaard, 1996). If anything, there should be an improvement in conditions as a result of the reduction in the frequency and volume of overflows, and the improvement in the quality of the discharge (it will be screened primary effluent instead of diluted sewage).

1.13 Proposed Environmental Management Measures

An Environmental Management Plan will be prepared for construction of the pipelines setting out policies and procedures to minimise impacts in the following areas:

* Noise
* Dust
* Contaminated runoff
* Vibration
* Protection (and reinstatement) of vegetation
* Traffic management
* Maintenance of access
* Protection of the public
* Risk minimisation
* Reuse and/or disposal of excavated material
* Storage of fuels and lubricants
* Limits on period of construction at any site
* Transport of waste materials.

A separate Environmental Management Plan will be prepared for construction of the Ludmilla plant augmentation setting out policies and procedures to minimise impacts in the areas listed above plus the following additional aspects:

* Acid sulphate soil management
* Transport of excavated material to Hudson Creek site
* Burial of mud at Hudson Creek site
* Protection of mangroves
* Maintenance of treatment operations

The EMP's will be prepared to the requirement of the Department of Lands, Planning and Environment.

1.14 Monitoring Procedures

The EMPs for construction include monitoring and auditing procedures to ensure that plans are fully implemented.

Water quality and marine biological monitoring programs have been formulated for the Larrakeyah and East Point outfalls, to ensure that future conditions are known and remedial action can be taken if warranted. The monitoring programs involve:

* Collection of water samples in and around the discharge location, and analysis to determine nutrient, NFR, faecal coliform and metal levels, as well as light attenuation.

* Collection of sediment samples near the discharge location and at a reference site, and analysis to determine organic carbon and metal levels, as well as infauna composition.

* Conduct of dye and other tracer dispersion tests to confirm initial dilution achieved by Larrakeyah outfall.

* Assessment of impacts of East Point discharge to establish need for extension of outfall.

* Regular monitoring of effluent quality and biosolids composition to confirm performance of treatment processes.

1.15 Studies and Consultations in Preparing PER

The following agencies have been formally consulted during the preparation of the PER:

* Lands, Planning and Environment
  Planning Division
  Heritage Conservation Branch
  Environment Protection Division
* Australian Heritage Commission
* Aboriginal Affairs Protection Authority
* Parks and Wildlife Commission
* Primary Industry and Fisheries
* Darwin City Council.

The following community groups reviewed and commented on the summary and outline for the PER:
* Total Environment Centre
* PLAN - Planning Action Network.

All points raised by the agencies and community groups have been addressed in this PER.

1.16 Structure and Scope of PER

The PER is divided into 11 chapters, including the executive summary, which forms Chapter 1. The other chapters may be divided into groups as follows:

Need for Proposal and Alternative Solutions
2. BACKGROUND AND NEED FOR PROPOSAL
3. EVALUATION OF ALTERNATIVES

Description of Proposal
4. DESCRIPTION OF PROPOSAL
5. CONSTRUCTION PHASE
6. OPERATIONS

Description of Existing Environment

7. TERRESTRIAL ENVIRONMENT
8. MARINE ENVIRONMENT
9. CULTURAL AND SOCIO-ECONOMIC ENVIRONMENT

Environmental Impacts

10. ENVIRONMENTAL IMPACTS AND MITIGATION MEASURES
11. CONCLUSIONS

2. BACKGROUND AND NEED FOR THE PROPOSAL

2.1 Current Situation

The sewerage catchments in Darwin are shown in Figure 1-1. The present arrangements for the Larrakeyah, Ludmilla, Leanyer and Berrimah sewerage catchments are summarised in Table 2-1. Note that the population in Table 2-1 refers to the equivalent residential population, which involves converting the wastewater flows from commercial and industrial sources to reflect the flows from an equivalent number of residents. This is the normal convention in planning new sewerage systems.

The oldest system is the Larrakeyah macerator and outfall which serves the CBD. The Ludmilla treatment works (primary sedimentation assisted by addition of lime and polymer to increase removal efficiency) was constructed to serve most of Darwin Peninsula and the suburbs south and west of the airport. The Leanyer lagoons serve the mainly residential suburbs north of the airport while the Berrimah lagoons serves the Berrimah area southeast of the airport. The Leanyer and Berrimah lagoons provide biological secondary treatment using solar power as the energy source.

Table 2-1 Summary of Present Sewerage Situation

Catchment	Population	Treatment	Discharge
Larrakeyah	13,500 EP	Maceration	Larrakeyah outfall to Darwin Harbour
Ludmilla	22,600 EP	Primary sedimentation	East Point outfall to (chemically-assisted) shallow coastal waters
Leanyer	48,600 EP	Oxidation lagoons	Buffalo Creek which flows to Hope Inlet
Berrimah	2,200 EP	Oxidation lagoons	Discharge at high tide to mangroves on Bleesers Ck

Larrakeyah Maceration Plant

The Larrakeyah plant is located on a small bench excavated into the cliff face between the road (Larrakeyah Terrace) and the Harbour. The bench is approximately 11 m above mean sea level and 5 m below the road level.

Sewage is prechlorinated (1 to 3 mg/L) and then macerated. No material is removed by the maceration process. The present effluent quality offers no potential for effluent reuse.

Larrakeyah Outfall

The outfall is 450 mm in diameter and 850 m long. The first 290 m length is constructed of UPVC (Class 4.5) while the remaining length is HDPE (Class 4.5). The diffuser is 66 m long, comprising 11 ports of 100 mm diameter at 6 m spacing on alternate sides of the pipe. The lowest initial dilution of effluent with seawater at slack water is 88:1 (CEE, 1996) at the present peak dry weather flow of 62 L/s, although the typical dilution through a tidal cycle is much greater at 240:1.

Ludmilla Primary Plant

The Ludmilla WWTP is the second largest sewage treatment plant in Darwin, handling flows from an equivalent population of 22,600 persons. A reasonable quality primary effluent is produced with the addition 60 mg/L of lime and 1 mg/L of polymer to the wastewater to settle organic solids.

The Ludmilla plant was designed for an equivalent population of 50,000 persons. The treatment processes include prechlorination, maceration, lime/ polymer addition, primary sedimentation and post-chlorination. The effluent is pumped to the existing outfall on the northern side of East Point. A high chlorine dose is added to the sewage entering the plant.

Sludge is removed from the primary tanks on four days per week and the lime dose is adjusted to allow storage of sludge in the sedimentation tanks. Solids are dewatered on vacuum filters and are incinerated in a single hearth furnace on the site. Earlier, sludge was stockpiled in an area to the north of the plant.

East Point Outfall

Effluent from the Ludmilla plant is discharged through an outfall extending to shallow water on the north side of East Point. At low tide, it is possible to walk along the crown of the exposed outfall pipe, and minor failure and leakage at one of the pipe joints is apparent. The discharge takes place from the upturned end of the pipe.

There does not appear to be a shoreline biological response to the effluent discharge, although there was a noticeable odour and a visually apparent effluent field (at low tide). The outfall is near a park and picnic area, so there is a risk of children coming in contact with the effluent. Water quality is monitored each year (Parry and Munksgaard, 1995, 1996, 1997).

Discharge to Ludmilla Creek

The Ludmilla plant experiences high inflows during wet weather, and during the wet season the capacity of the East Point outfall is exceeded so the additional effluent is discharged to Ludmilla Creek. Flow also is diverted to Ludmilla Creek during periods of plant maintenance and failure. Based on the frequency distribution of daily flows in the wet season, it was estimated that there is an overflow to Ludmilla Creek on about 100 days per year (CEE, 1998).

2.2 Reasons for the Proposal

As set out in Section 1-4, the proposal is required for the following reasons:

1. To ensure that the effluent discharged through the Larrakeyah outfall has received a suitable level of treatment (although the discharge of macerated sewage meets the present discharge licence it does not meet the new National Water Quality Guidelines or provide satisfactory protection against the discharge of floatables and detritus);

2. To upgrade the Ludmilla treatment plant to provide secondary treatment, as provided at the other treatment facilities in Darwin (this is to be achieved by adding secondary treatment units after the present primary treatment tanks);

3. To augment existing treatment facilities at the Ludmilla WWTP to provide capacity for future increases in wastewater flows from the area sewered (including both the Larrakeyah and Ludmilla catchments, as the Larrakeyah flows are to be transferred to the Ludmilla WWTP for treatment);

4. To provide a volume of high quality effluent suitable for reuse on irrigating playing fields and open space;

5. To encourage the reuse of high quality effluent now and in the future on parks and landscaping in the Darwin urban area;

6. To provide backup facilities for handling the biosolids removed in treatment, and to encourage potential reuse of biosolids in the future; and

7. To minimise the effects of effluent discharges on ocean water quality.

2.3 Capacity of Proposal to Meet Demand

The proposal provides secondary treatment capacity and effluent discharge to meet all projected flows in the dry season, and additional primary treatment capacity to handle peak flows during the wet season.

The present and projected dry weather flows at the Ludmilla WWTP during the dry season are set out in Table 2-2. The two measures of the dry season flows are the average dry weather flow (ADWF) and the peak dry weather flow (PDWF), which is the highest flow rate each day during dry weather.

Table 2-2 Present and Projected Dry Weather Flows at Ludmilla WWTP

Year	ADWF	PDWF	Contributing catchment
1996	7 ML/d	13 ML/d	Ludmilla catchment only
2012	12.4 ML/d	22 ML/d	Larrakeyah and Ludmilla
Ultimate	16 ML/d	28 ML/d	Larrakeyah and Ludmilla

The new effluent transfer pipeline from Ludmilla to Larrakeyah will have a peak capacity of 28 ML/d. Thus the ultimate PDWF could be discharged through the Larrakeyah outfall (even on a day when there was no reuse of effluent). Only a small and intermittent flow of disinfected secondary effluent will be discharged through the East Point outfall in the dry season (sufficient only to keep the pipeline clear of sediment).

The reuse of effluent during the dry season will reduce the quantity of effluent to be pumped to Larrakeyah and discharged to Darwin Harbour.

There may be a small discharge through the East Point outfall over a limited period each day or so to keep the outfall pipeline full of fresh water and hence minimise potential blockages due to sediment accumulating in the offshore pipeline. However, this is a very small proportion of the total, and the great majority of effluent (in the dry season) will either be reused or discharged through the Larrakeyah outfall.

Wet Season Flows

In the wet season, groundwater seeps into the pipes which comprise the sewerage system while stormwater enters at holes, low access pits and illegal yard drains. The result is that the flow in prolonged wet weather can be much higher than during the dry season, as much as 100 ML/d (this is about 8 times the ADWF in the year 2012).

There is expected to be very little demand for reclaimed effluent in the wet season. Hence in those months, almost all effluent from the Ludmilla plant will be discharged through the Larrakeyah outfall, up to its hydraulic capacity of 28 ML/d. Excess flows would be discharged through the East Point outfall or, in the event that the total flow exceeds the capacity of the East Point outfall, discharged to Ludmilla Creek.

Table 2-3 sets out the frequency distribution of peak daily flow projected for the year 2012. For about 240 days per year (throughout the dry season and for part of the wet season) the peak daily flow will be 22 ML/d. However during days of wet weather, the peak flow will exceed 25 ML/d on about 110 days, 50 ML/d on 50 days, 70 ML/d on 20 days and 85 ML/d on about 10 days per year. The peak day of flow in the wet season is expected to be 100 ML/d. For these estimates, it is assumed that the hydraulic capacity of the East Point outfall is increased to 60 ML/d.

Table 2-3 Wet Weather Flow Distribution; East Point Outfall of 60 ML/d

Days/year	1	10	20	30	40	50	60	70	80	90	100	110
Peak flow,ML	100	85	70	60	55	50	45	40	35	31	28	25
- Larrakeyah	- 28	- 28	- 28	- 28	- 28	- 28	- 28	- 28	- 28	- 28	- 28	- 25
- East Point	- 60	- 57	- 42	- 32	- 27	- 22	- 17	-12	- 7	- 3	0	0
= overflow	12	0	0	0	0	0	0	0	0	0	0	0

As shown in Table 2-3, using the full hydraulic capacity of Larrakeyah outfall is 28 ML/d and increasing the hydraulic capacity of East Point outfall to 60 ML/d, would reduce overflows to Ludmilla Creek to only about 8 days per year, with the peak overflow rate being 12 ML/d. Overflows of a small volume of screened primary effluent on the eight wettest days each year is considered to be acceptable in the environmental context of Ludmilla Creek, which drains an urban catchment and carries large volumes of urban runoff during the wet season.

If the East Point outfall was not used at all, there would be overflows to Ludmilla Creek on 100 days per year, with the peak overflow rate being 72 ML/d (100 ML/d less 28 ML/d to Larrakeyah).

If the hydraulic capacity of the East Point outfall was retained at the present limit of 22 ML/d, there would be overflows to Ludmilla Creek on 52 days per year, with the peak overflow rate being 50 ML/d. This is considered to be too many overflows per year to be acceptable, and underlines the need to augment the capacity of the East Point outfall pipeline.

2.4 Consequences of Not Proceeding

The consequences of not proceeding with the proposal are as follows:

1. Macerated sewage would continue to be discharged at Larrakeyah on 365 days/year;

2. Chemically-assisted primary effluent would continue to be discharged through the East Point outfall on 365 days/year;

3. Overflows to Ludmilla Creek would continue to occur on about 110 to 120 days/year (all during the wet season);

4. No reclaimed water would be produced, and hence all effluent would continue to be discharged to the Harbour or ocean waters. In addition, there would be no replacement of drinking water by reclaimed water in irrigation systems in Darwin.

5. Odour capture and biosolids backup systems at Ludmilla WWTP would not be installed.

6. On the other hand, there would be no disruption of traffic or other adverse local effects due to the installation of pipelines or new treatment facilities.

7. Energy consumption in the future would be lower as there would not be any biological secondary treatment at Ludmilla WWTP.

2.5 Current Status of Proposal

Concept designs and cost estimates have been developed for all aspects of the proposal to provide a firm basis for describing the impacts and benefits of the project (CEE, 1997; CEE/SKM, 1998; D&M, 1996; GHD/CEE, 1996; GHD, 1996; GHD, 1997; NTCA, 1998; SKM, 1997). Detailed design will commence only after the PER has been approved in accordance with the *Environmental Assessment Act 1982*.

PAWA has current licences to discharge effluent at the Larrakeyah outfall and the East Point outfall, and does not require any changes in the licences to upgrade the Ludmilla treatment plant or the East Point outfall. No change is proposed to the Larrakeyah outfall.

Environmental studies have been conducted into the potential impacts of existing and proposed discharges on marine water quality and biological communities and the findings are presented in subsequent chapters of this PER (Parry and Munksgaard, 1996, 1997, 1998; Padovan, 1997).

2.6 Timing

It is proposed to construct the project in the following sequence:
* Pipelines constructed in 1999
* First stage of Ludmilla plant upgrade in 1999
* Effluent reuse pipelines in 1999
* Commence operations in 2000
* Second stage of Ludmilla upgrade in 2003
* Expand effluent reuse in 2001-2005
* Possibly extend East Point outfall in 2002
* Augmentation of East Point pipeline (to 60 ML/d) in 2005.

2.7 Relevant Legislation and Policies

Legislation and Policies that are pertinent to the proposal are:
* *Environment Assessment Act 1982*
* *Water Act 1992*
* *Fisheries Act 1988*
* *Aboriginal Sacred Sites Act 1989*
* *Heritage Conservation Act 1991*
* *National Environment Protection Council (NT) Act 1994*
* Coastal Management Policy
* Waste Management and Pollution Control Strategy
* NT Water - Blueprint for Future Directions
* National Water Quality Management Strategy
* NT Greenhouse Challenge.

Environment Assessment Act 1982

This PER has been prepared and will reviewed and assessed in accordance with the requirements of the *Environment Assessment Act 1982*.

Water Act 1992

In June 1998, the Controller of Water Resources issued a discharge licence for the discharges through the existing East Point and Larrakeyah outfalls. The licences continue until 31 December 2000.

Under the licences, PAWA is required to monitor the daily discharge and the following effluent characteristics each month (conductivity, total phosphorus, total nitrogen, faecal coliforms, BOD, suspended solids, volatile suspended solids). In addition, PAWA are required to monitor the following water quality conditions at four sites near the East Point outfall each year (conductivity, turbidity, total phosphorus, total nitrogen, faecal coliforms, dissolved oxygen, chlorophyll-a, light attenuation). There are no limits on flow rate or effluent quality.

In discussions with the Office of Water Resources, they advised that limits on effluent quality and possibly constituent loads are likely to be set in the next licence (in the year 2000) based on the results of the monitoring surveys and ongoing studies of water quality in Darwin Harbour. The limits would depend in part on the location and dilution achieved by the proposed outfall diffuser.

Fisheries Act 1988

In January 1992, the East Point Aquatic Reserve was promulgated under the *Fisheries Act 1988*. This reserve is an extension of the former East Point Reef Marine Fish Reserve declared in April 1984. The Aquatic Reserve comprises all the sea within a 1250 m radius of trig station NTS220 on the western end of East Point (see Figure 2-1).

The Aquatic Reserve is considered by the Northern Territory Museum to contain one of the richest marine sponge habitats in the Northern Territory. The sponges are growing on rock and coral southwest of East Point at depths of 5 to 9 m below mean sea level. The purpose of the Aquatic Reserve is to protect the sponge and coral habitat, and also to prevent spearfishing, fishing and other activities which could adversely affect the marine habitat.

The existing East Point outfall ends about 400 m east of the boundary of the Aquatic Reserve (see Figure 2-1). However the discharged effluent is, during flood tides, carried into and through the Aquatic Reserve, although the effluent is considerably diluted by the time it reaches the more sensitive corals in the western section of the Reserve (see CEE/SKM, 1998 and discussion on measured dilutions in Chapter 8).

A series of possible outfall extensions have been investigated by PAWA. All extensions would be to the north of the Aquatic Reserve and would provide greater dilution than at present. The longer extension options would move the discharge point away from the Reserve (see discussion of discharge alternatives in Chapter 3).

Aboriginal Sacred Sites Act 1989

In accordance with the requirements of the *Aboriginal Sacred Sites Act 1989*, advice on the location of Registered Sacred Sites which may be affected by the proposal was obtained from the Aboriginal Affairs Protection Authority. The Authority advised on 26 June 1998 that there are no Registered or Recorded Sites within the areas of the pipeline routes or expansion of the Ludmilla WWTP.

Heritage Conservation Act 1991

In accordance with the requirements of the *Heritage Conservation Act 1991* advice on the location of heritage sites which may be affected by the proposal was obtained from Lands Planning and Environment. The Heritage Conservation Branch advised on 29 June 1998 that no sites are directly affected or will be impacted. The Australian Heritage Commission advised on

17 September 1998 that the sewer pipeline passes near the Palmerston Cemetery; however this site will not be impacted by the proposal.

Northern Territory Policies

The proposal is in accordance with the following Northern Territory Policies:
* Coastal Management Policy
* Waste Management and Pollution Control Strategy
* NT Water - Blueprint for Future Directions

National Water Quality Guidelines

The 1997 *National Water Quality Management Strategy - Australian Guidelines for Sewerage Systems - Effluent Management* propose the following typical levels of treatment for wastewater prior to discharge:

*Discharge to Coastal Waters via Extended Outfall - Primary Treatment

* Discharge to Coastal Waters with High Tidal Range - CAS (chemically assisted primary sedimentation) or Biological Treatment

* Discharge to Nearshore Coastal Waters - CAS or Biological Treatment

* Discharge to Bays and Estuaries - CAS or Biological Treatment

For discharge through the Larrakeyah and East Point outfalls, either CAS OR biological secondary treatment is required. A CAS effluent would involve at least 75 per cent removal of suspended solids. A biological secondary effluent would involve 90 per cent removal of suspended solids or an effluent suspended solids below 20 mg/L.

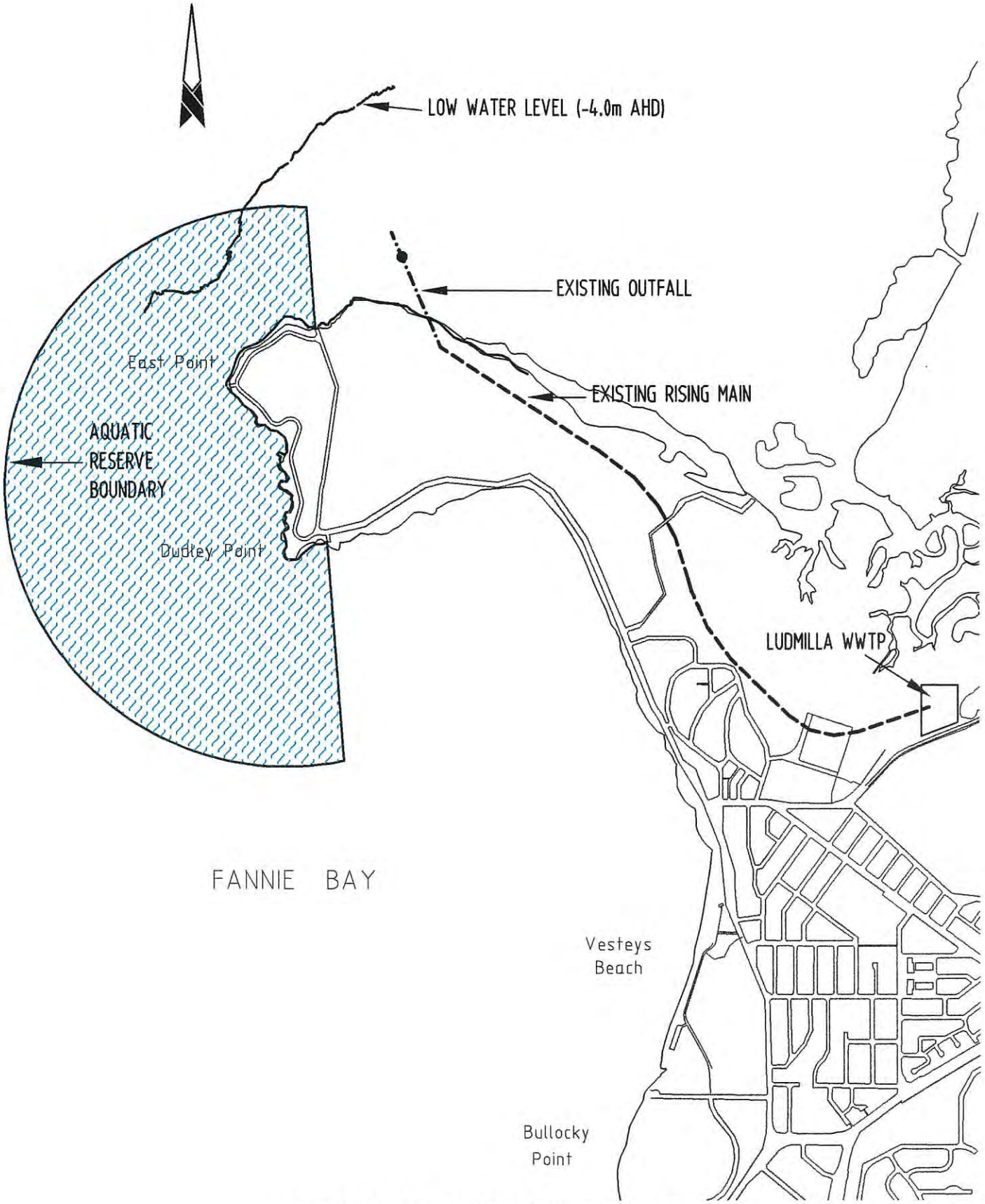
The proposal involves biological secondary treatment for the majority of the flow with CAS treatment for most of the excess flow during wet weather. Hence the proposal will comply with the national guidelines.

Guidelines for Reclaimed Water

The 1998 *National Water Quality Management Strategy - Australian Guidelines for Sewerage Systems - Reclaimed Water* recommend that reclaimed water used for irrigation of parks and gardens in urban areas should receive tertiary treatment with a pathogen reduction step. The reclaimed water produced at Ludmilla will involve tertiary filtration in a sand or dual media bed, followed by disinfection using chlorine. These processes will comply with the national guidelines.

NT Greenhouse Challenge

PAWA is part of a cooperative national effort to reduce Greenhouse gas emissions as far as is practical. This PER includes an assessment of the Greenhouse gas implications of the proposal. The direct effect is that the upgraded treatment will use additional electrical energy, which will increase Greenhouse gas emissions from the power station. The indirect effect is that the reduced organic discharge to marine waters will reduce microbiological decomposition of organic material and hence reduce Greenhouse gas emissions. Another indirect effect is that effluent reuse may stimulate plant growth and hence fix some carbon. The overall effect of the project is, unfortunately, an increase in greenhouse gas emissions.



LOCATION OF EAST POINT OUTFALL
AND LUDMILLA WASTEWATER TREATMENT PLANT
Figure 2-1

3. Evaluation of Alternatives

3.1 Consequences of 'Do Nothing' Option

The 'do nothing' option would mean that the existing sewerage arrangements would be continued for the foreseeable future. There is an expectation that improvements will be made, and they may be required in the discharge licence to be issued in the year 2000.

Until then, the situation would remain as at present:

1. Macerated sewage would continue to be discharged at Larrakeyah for 365 days/year;

2. Chemically-assisted primary effluent would continue to be discharged through the East Point outfall for 365 days/year;

3. Overflows to Ludmilla Creek would continue to occur on about 110 to 120 days/year (all during the wet season);

4. No reclaimed water would be produced, and hence all effluent would continue to be discharged to the Harbour or ocean waters. In addition, there would be no replacement of drinking water by reclaimed water in irrigation systems in Darwin.

5. Odour capture and biosolids backup systems at Ludmilla WWTP would not be installed.

6. On the other hand, there would be no disruption of traffic or other adverse local effects due to the installation of pipelines or new treatment facilities.

7. Energy consumption in the future would be lower as there would not be any biological secondary treatment at Ludmilla WWTP.

In practice, under the 'do nothing' option, treatment facilities at Ludmilla WWTP would be expanded as necessary to handle increases in population in the Ludmilla catchment, and minor improvements may be made to the treatment and associated processes. However the major improvements envisaged under the proposal would not be implemented.

3.2 Strategic Alternatives

GHD/CEE carried out a comprehensive study of strategic alternatives for Darwin sewerage, including the following major strategies:

1. Transfer Larrakeyah to an expanded Ludmilla WWTP (this proposal);

2. Construct a new compact treatment plant at Larrakeyah;

3. Transfer Larrakeyah and Ludmilla flows to Leanyer; and

4. Transfer Larrakeyah and Ludmilla flows to Berrimah.

Strategy 1 offered the best combination of benefits (less odour impact, best opportunity for reuse, least wastewater transfer, best use of existing facilities) and the lowest cost to ratepayers.

Strategy 2 was not followed because there is no space available at or near Larrakeyah for the construction of a new treatment plant.

Strategy 3 was not followed because a substantial increase in aerated lagoon capacity would be required at Leanyer to handle the increase in flow there, and there would be substantial costs in pumping, rising mains and odour control, so the overall result would be higher cost with fewer benefits. There was also the concern that a major increase in discharge to Buffalo Creek may not be acceptable.

Strategy 4 was not followed because a substantial increase in aerated lagoon capacity would be required at Berrimah to handle the increase in flow there, and there would be substantial costs in pumping, rising mains and odour control, so the overall result would be higher cost with fewer benefits. The discharge arrangement at Berrimah is not as good the Larrakeyah outfall.

In summary, strategy 1 offers the best opportunity to achieve the objectives of the proposal.

3.3 Site Alternatives

There are no realistic alternative treatment plant sites in the vicinity of the existing Ludmilla plant.

Three major alternatives for upgrading the Ludmilla WWTP were considered:
1. Option 1. CAS (chemically-assisted sedimentation);
2. Option 2. Extended Aeration (biological secondary treatment); and
3. Option 3. Aerated Lagoons (larger site but with lower energy use).

These three alternatives are described and compared below, together with other biological secondary processes which were assessed.

Option 1. CAS Treatment

The CAS process involves the addition of chemicals to enhance the removal of contaminants present in sewage. The present plant at Ludmilla was designed as a CAS plant but there were operating difficulties which were overcome by a significant reduction in the rate of chemical addition. As a result, the plant is now operated as a primary plant with sufficient chemical addition (lime of 60 mg/L and polymer of 0.2 mg/L) to control odours and facilitate storage, dewatering and incineration of the primary sludge. Records show that an average of 65 per cent of suspended solids are removed.

Re-introduction of the CAS process at Ludmilla would involve either:

* Return to the high lime process (e.g., about 400 mg/L of lime, according to page 45 of the 1985 GHD report). This option would revive the operational difficulties which prevented the plant being operated effectively for many years and is not considered feasible (CEE, 1998); or

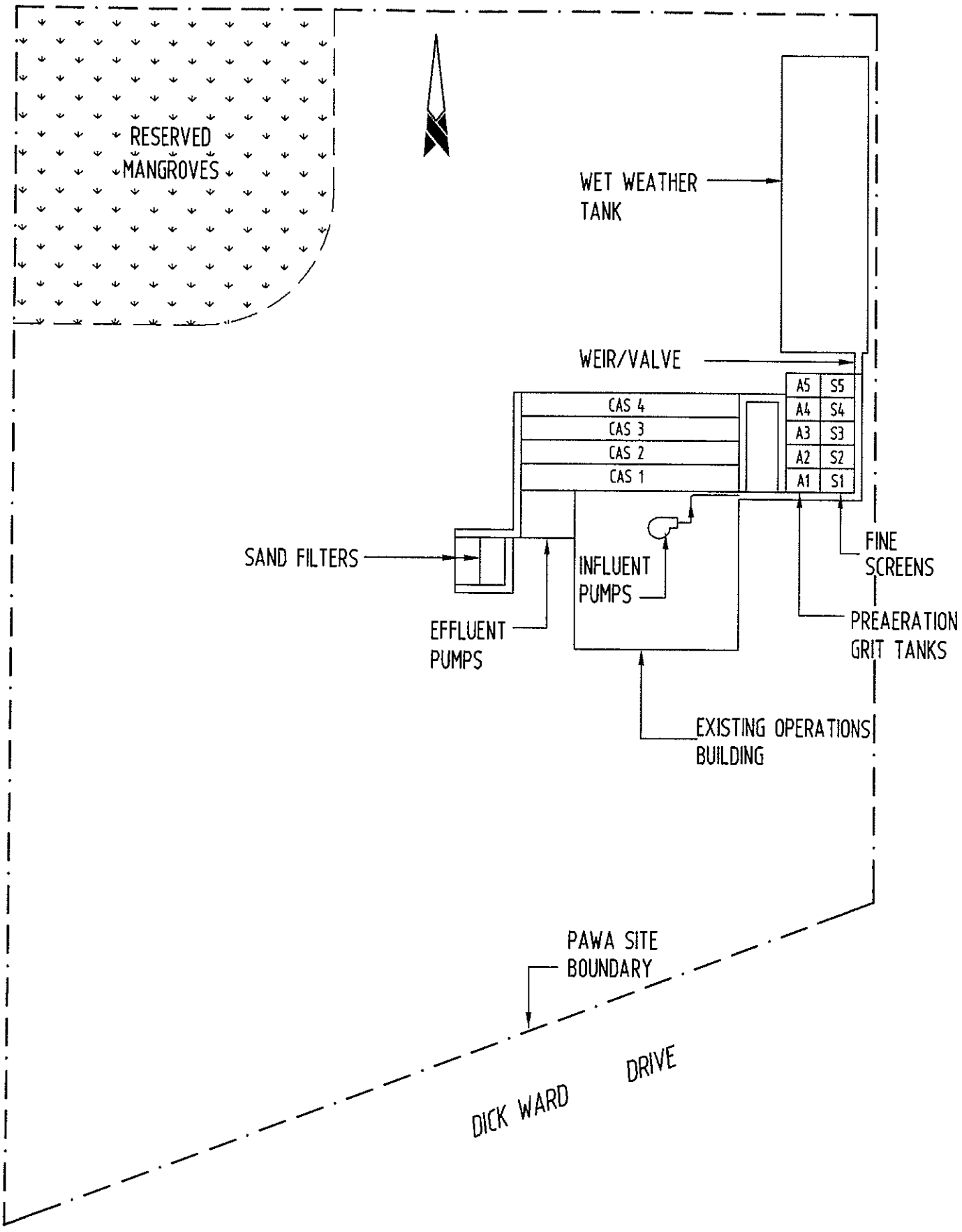
* Introduction of a ferric chloride CAS process (using 30 to 70 mg/L of ferric chloride). Jar tests carried out by PAWA at Ludmilla indicated that CAS would be successful and that possibly the lower chemical dose could be used. As a guide to the required dosage the results of CAS tests at Lower Molonglo Water Quality Control Centre (Canberra) and North Head WWTP (Sydney) were used. Cost estimates are based on a design dosage of 30 mg/L of iron salts and 60 mg/L of lime (the same lime dose as at present).

There are two CAS tanks at present and one additional tank would be needed to provide capacity to handle the year 2012 ADWF of 12.4 ML/d while two additional tanks would be needed to handle the ultimate ADWF of 16 ML/d. The proposed layout is shown in Figure 3-1.

The expected effluent quality from the CAS process is as follows:

Suspended solids	45 mg/L
BOD	80 mg/L
Total nitrogen	36 mg/L
Total phosphorus	5 mg/L.

A proportion of the CAS effluent could theoretically be polished by filtration for effluent reuse. The CAS process has the advantages of using existing facilities and a process familiar to the operators. However a high quality effluent will be difficult to produce consistently, and the residual dissolved organics and ammonia in the effluent would compromise effluent reuse.



LAYOUT FOR CAS TREATMENT OPTION

Figure 3-1

Option 2. Extended Aeration Plant

The proposed extended aeration plant layout for the Ludmilla WWTP is shown in Figure 3-2, based on the use of an intermittently decanted aeration plant (IDAL). The cycle of the sequential process involves 2.5 hours aeration, one hour settling and half hour withdrawal of effluent. By staggering the timing of the basins, there is continuous treatment of all flow. The effluent channel would be designed to operate as the flow balancing storage to make efficient use of effluent pumps and piping.

Four IDAL tanks would be needed to provide capacity to handle the year 2012 ADWF of 12.4 ML/d and five tanks to handle the ultimate ADWF of 16 ML/d. The tanks could either be constructed in a line on the clear land to the north of the existing CAS tanks (as shown in Figure 3-2) or fitted within the existing site (if mangroves are removed).

The existing primary sedimentation tanks would be retained as chemical primary (CP) tanks (with a lower chemical dose of lime and polymer than at present) to remove a significant proportion of the suspended solids. The flow through the primary tanks would be the same as through the IDAL tanks. This scenario offers lower energy use and some backup treatment capacity in the event of failure of the IDAL process, but with the additional cost of continuing to operate the primary tanks and associated sludge removal equipment.

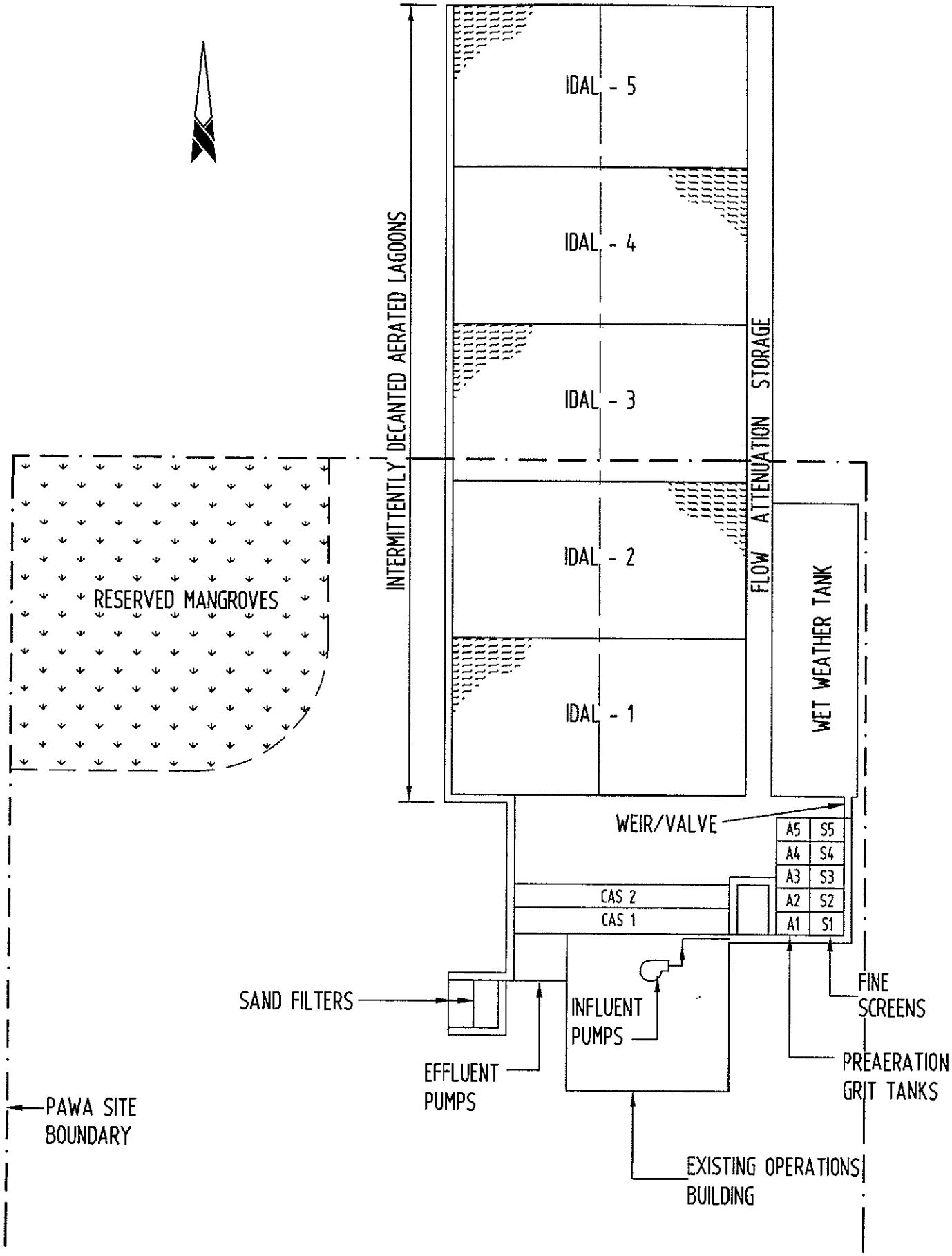
The aeration would be provided by blowers and submerged diffusers, rather than surface aerators, to minimise odour and noise impacts. Given the elevated wastewater temperature in Darwin, nitrification (conversion of ammonia to nitrate) will inevitably occur in the aeration process. This has the disadvantage of higher power demand, but the advantage of providing an effluent better suited for reuse.

The expected effluent quality from the CP + IDAL process is as follows:

Suspended solids	15 mg/L
BOD	10 mg/L
Total nitrogen	15 mg/L
Total phosphorus	4 mg/L.

The IDAL process provides a good quality biological secondary effluent which can be polished by filtration for effluent reuse. There are several commercial alternative variations of the IDAL process, which is used at many treatment plants throughout Australia. The process is known to be reliable and relatively easy to operate.

The major disadvantage is the high energy consumption, which average 260 kW at the ultimate dry season flow.



LAYOUT FOR IDAL TREATMENT OPTION

Figure 3-2

Option 3. Aerated Lagoons

A third treatment option is to adopt aerated lagoons. This option trades increased land area (and mangrove destruction) for reduced energy and chemical consumption. A substantial area of lagoons (11 ha) would be required, even though aerated lagoons are a more compact alternative than the traditional (non-aerated) oxidation lagoons as employed at Leanyer.

A possible aerated lagoon layout for the Ludmilla WWTP is shown in Figure 3-3. Three aerated basins would be needed for effective treatment. The first basin would be an aerated facultative lagoon with the surface layer aerated but with anaerobic process occurring in the deeper layer of settled sludge. The two subsequent lagoons would be fully mixed. The total retention time in the three lagoons would be 7.2 days in year 2012.

Sludge would be allowed to accumulate in the lagoons and be removed (for example, to the existing sludge drying area at Leanyer) at about 5 year intervals.

The expected effluent quality from the aerated lagoons is as follows:

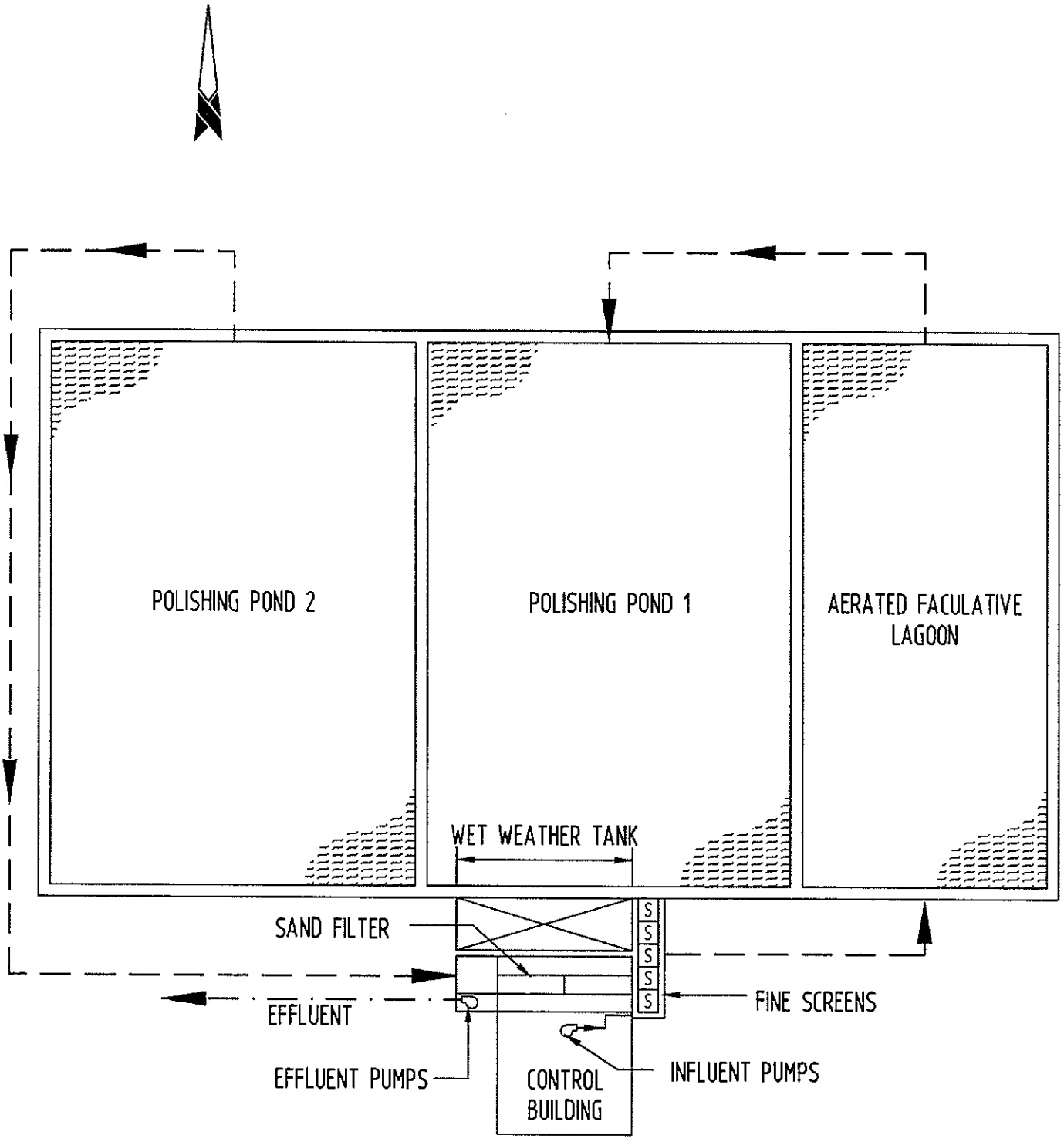
Suspended solids	30 mg/L
BOD	40 mg/L
Total nitrogen	17 mg/L
Total phosphorus	4 mg/L.

Aerated lagoons are simple to operate, particularly as the sludge need be removed only at intervals of about five years. The effluent quality from the lagoons is not as good, in terms of BOD and suspended solids, as from a more energy-intensive secondary process, but does offer improved removal of pathogens due to the long residence time (6 days).

The major disadvantage is the large area required, which would require removal of 11 ha of mangroves, and produce a large aerated lagoon area relatively close to a residential area. Also, a large volume of mud with acid sulphate potential would need to be moved to create the lagoons.

Alternative Site for Lagoons

Construction of aerated lagoons at the Ludmilla site would occupy a substantial area. Hence consideration was given to construction of the lagoons at another site. Based on the findings of the 1994/96 sewerage strategy report, the nearest alternative site to Ludmilla for 11 ha of aerated lagoons is at Leanyer. This would require a costly ($6 million) sewage transfer system (pumping stations and rising main), plus substantial odour control works (including oxygen injection) and require construction of aerated lagoons at essentially the same capital and operating cost as at Ludmilla.



LAYOUT FOR AERATED LAGOON TREATMENT

Figure 3-3

Opportunities for reuse of effluent would be less with the transfer option, as there is insufficient demand to use all the existing effluent from the Leanyer ponds. The additional effluent would have to be discharged to Buffalo Creek. There would not be any use of the Larrakeyah outfall if the Ludmilla effluent was pumped to Leanyer. Hence the transfer option involves additional cost and environmental risks (odour and effluent discharge) with no significant benefits.

Comparison of Three Treatment Options

The options were compared on the following basis:
* Effluent quality;
* Potential for effluent reuse;
* Use of existing facilities and skills;
* Capital and annual costs;
* Environmental implications; and
* Potential risks.

The IDAL process produces the best quality effluent. The aerated lagoons produce a reasonable quality secondary effluent and the CAS process produces an effluent with relatively high BOD and ammonia concentrations.

CAS effluent is not really suitable for reuse because it would require a two-stage filtration scheme which is not used anywhere at present. Even then, there would be a high level of ammonia and total nitrogen in the filtered CAS effluent. The secondary effluent produced by an IDAL system or aerated lagoons would be best suited to reuse. The IDAL effluent, with lower suspended solids and ammonia levels, would be more suitable for effluent reuse. All effluent would be filtered and disinfected before being supplied for reuse.

The CAS system involves an expansion of the existing treatment facilities and the process is an continuation of the existing treatment process, but with higher chemical doses. Hence CAS makes best use of existing facilities and operator skills. Aerated lagoons are relatively simple to operate and lagoon systems (non-aerated to date) are successfully operated elsewhere in Darwin. However the introduction of lagoons at Ludmilla would make little use of existing facilities. The CP-IDAL proposal for Ludmilla involves continued use of the existing primary tanks as the initial treatment stage and hence makes good use of existing facilities.

The estimated capital cost (CEE, 1998) for the ultimate flow of 16 ML/d, is:
* CAS $5.7 million
* IDAL $8.5 million
* Aerated lagoons $8.1 million.

As would be expected, the CAS option has the lowest capital cost at $5.7 million, while the IDAL and aerated lagoons have higher but very similar capital costs at $8.5 million and $8.1 million, respectively. The IDAL option has the highest operating cost, owing to the power consumption and the very high rate of 14 c/kWhr charged for power, while the CAS option has the next highest cost, owing to the cost of chemicals. The aerated lagoon option has significantly lower operating costs than the other two options.

Taking into account the present value of capital and annual costs, aerated lagoons are the least cost option, CAS is the middle option and CP-IDAL is the most costly option. Expressed another way, the results of the present value (PV) calculation show that the cost to the community (at 7 per cent discount rate) for two major choices is as follows:

* Plant using smaller land area (IDAL - aerated lagoon)
  = PV $6.0 million ($7.90/person/yr)

* Producing effluent for reuse (IDAL - CAS)
  = PV $4.9 million ($6.40/person/yr).

The three options produce an effluent quality which will meet current National Water Quality Guidelines for discharge to coastal waters or Darwin Harbour and anticipated future discharge licence requirements. The IDAL process produces the best effluent quality.

The effluent from the two biological treatment processes (IDAL and aerated lagoons) is suitable for reuse after being filtered and disinfected. This would produce a reclaimed effluent quality which will meet current National Water Quality Guidelines for reuse of effluent in areas with unrestricted public access, and anticipated licence requirements for effluent reuse.

There is some doubt that the effluent from the CAS process would be satisfactory for long term reuse, even after filtration, because of the higher concentrations of ammonia and fine organics. Hence the CAS option is not really compatible with the Darwin sewerage strategy, which envisages long term reuse of effluent produced by the Ludmilla WWTP.

The layout for the CAS option would fit within the existing PAWA site and would not require any mangrove areas to be destroyed. The layout for the IDAL option would extend beyond the existing site onto land designated in the Lands, Planning and Environment land use scheme for future sewage treatment purposes, and has been sited on the existing sludge stockpile in that land to avoid any further destruction of mangroves.

An alternative CAS layout has been prepared which would fit (just) on the existing site but would involve destruction of all the mangroves on that site.

The aerated lagoons would involve construction on a large area of about 11 ha of land presently occupied by mangroves.

The IDAL system requires about three times the electricity input as the other two options. However when account is taken of the power required to produce and transport the chemicals used in the CAS process, the total power input for both the CAS and the IDAL options are similar.

The aerated lagoon option requires the smallest electricity input. However a proportion of the carbon is discharged as methane rather than carbon monoxide, so the overall impact in terms of greenhouse gases of the aerated lagoons is similar to the other two options.

To provide a basis for assessment, the power input for the IDAL option corresponds to about 3 watts per person with the first IDAL tank and 8 watts per person with four IDAL tanks.

The land adjacent to the existing PAWA site is the subject of land claims by two Aboriginal groups. It is considered likely that these claims will be determined before any construction beyond the existing compound is undertaken. However construction of the aerated lagoon option is precluded at present.

Outcome

Overall, the IDAL treatment option is considered to offer the greatest benefits, at a higher cost to ratepayers. This option produces the highest quality effluent and has the greatest potential to develop a large future market for reuse of effluent (reclaimed water).

Effluent reuse offers the long term benefit that a future inland water supply for Darwin can be deferred if the reclaimed water is used for irrigation of sites presently (or proposed to be) irrigated with the normal drinking water supply.

3.4 Treatment Alternatives

There is a wide range of secondary treatment processes which could be used at Ludmilla. This PER is based on the IDAL process, recognizing that there are several variants of the IDAL process offered by different companies in Australia. In addition, a continuous activated sludge process would offer the same effluent quality and benefits as an intermittent process. The final selection of the actual secondary process will be made after tender prices are received from equipment suppliers.

The following additional treatment options also were considered before a biological secondary treatment process was adopted:

* activated sludge;
* enclosed biofilm systems (eg. Biocarbone);
* trickling filter/solids contact (TF/SC);
* membrane filtration; and
* vortex sedimentation.

All of these treatment options could be satisfactory; however the adopted treatment arrangement is considered to offer the highest cost/benefit ratio for the Ludmilla site, given the existing facilities.

3.5 Discharge Alternatives

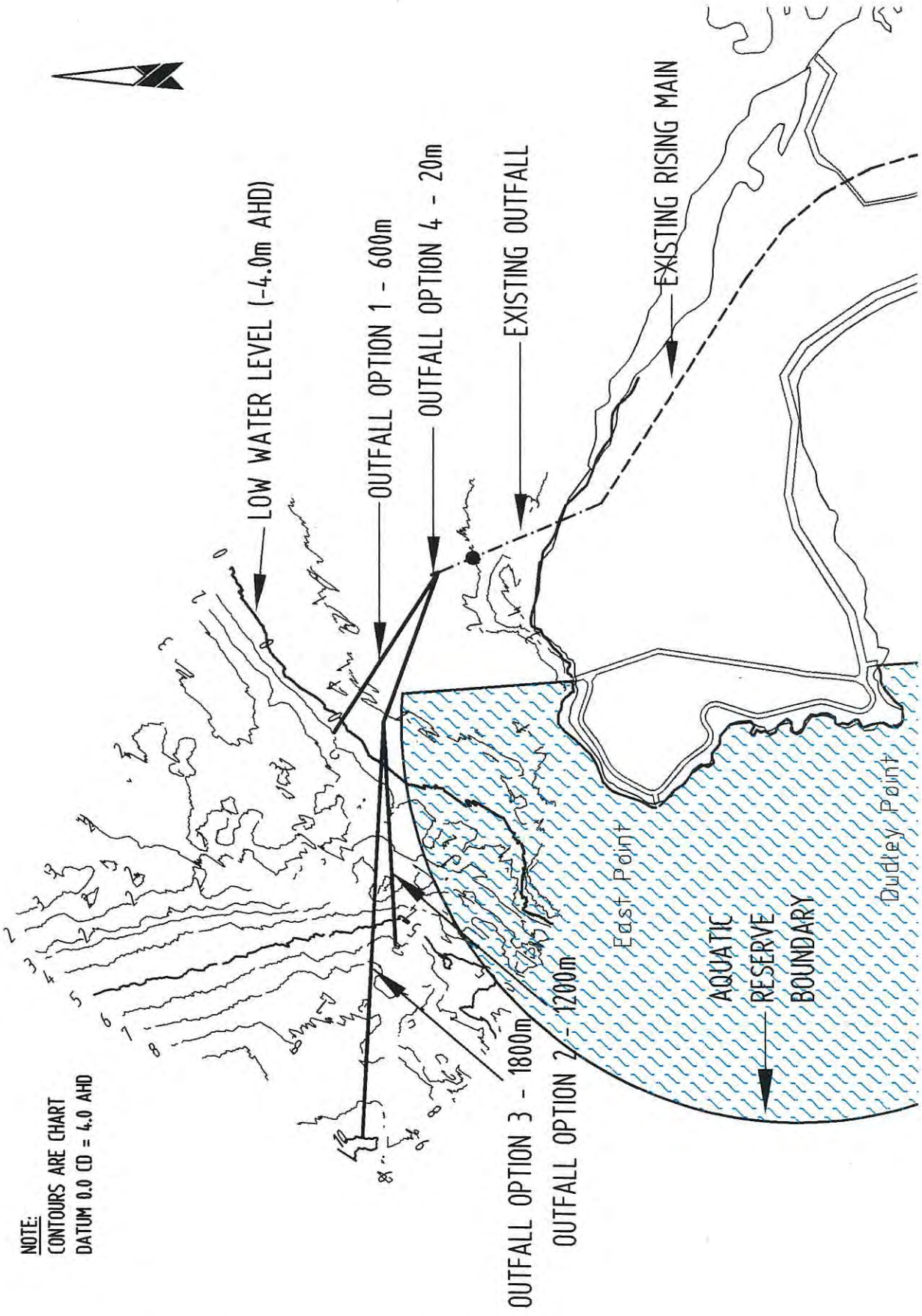
The discharge alternatives, for the effluent remaining after the reuse demand is satisfied, are (1) Larrakeyah outfall; (2) East Point outfall and (3) Ludmilla Creek. No new outfall options are considered feasible.

The Larrakeyah outfall provides good performance and there no need to extend or augment it. The peak hydraulic capacity is taken to be 28 ML/d.

The East Point outfall is in shallow water and the performance could be improved by extending it. A reconnaissance was made at low tide of the seabed near the existing East Point outfall to identify possible outfall alignments taking the following factors into account:

1. Near existing pipeline, to minimise additional connection piping;
2. Avoid Aquatic Reserve, about 400 m to the west; and
3. Reach deeper water with alignment perpendicular to depth contours.

Taking all these constraints into consideration, the preferred alignment for the extension of the East Point outfall is to continue to the northwest to beyond the Aquatic Reserve, and then to turn to the west to reach deeper water and areas with stronger tidal currents. Possible extensions along this general alignment were examined as shown in Figure 3-4.



POSSIBLE EXTENSIONS OF EAST POINT OUTFALL

Figure 3-4

The four extension options are as follows:

Option 1. 600 m extension to the northwest to the low water line;
This option is a 'minimal performance' option, but achieves a submerged effluent discharge at all tides with least length of pipe.
The cost would be $4.6 million, and effluent would be better diluted than at present, and kept away from the nearshore waters. Dilute effluent would be carried through the offshore part of the Aquatic Reserve, but with no detectable impact on marine life (CEE/SKM, 1998).

Option 2. 1200 m extension to the west to the 6 m depth contour;
This option provides a diffuser at 9 to 10 m depth below mean sea level (at least 7 m depth at low tide) and achieves a good performance in terms of initial dilution. The cost would be $7.6 million, and effluent would generally be outside the Aquatic Reserve, with no detectable impact on marine life (CEE/SKM, 1998).

Option 3. 1800 m extension to the west to the 10 m depth contour;
This option provides a diffuser at 13 to 14 m depth below mean sea level (at least 11 m depth at low tide), achieves a good performance in terms of initial dilution and keeps the diluted effluent field away from the Aquatic Reserve (CEE/SKM, 1998). The cost would be $10.6 million.

Option 4. 20 m extension to the northwest (ie, a new diffuser):
This option provides an improved discharge arrangement at the end of the existing pipe, plus renovation of the existing pipeline. The cost would be $0.9 million, would little environmental benefit.

As the number of days of discharge through the East Point outfall will be reduced from 365 to about 100/year, and the quality of the effluent will be improved, PAWA intends to monitor the existing discharge arrangement at East Point before making a decision on whether to adopt any extension. If an extension is adopted, it will be constructed in 2005. An Environmental Management Plan (EMP) for construction of the outfall extension would be prepared to the satisfaction of Lands, Planning and Environment.

Ludmilla Creek

The number of days with overflows to Ludmilla Creek will be reduced from about 100/year to about 8 per year. Studies have found that the overflows of wastewater to Ludmilla Creek have had very little impact on biological communities mainly because of the strong tidal flushing and because the creek in wet weather carries runoff from an urban area (Parry and Munksgaard, 1998). There should be an improvement in conditions as a result of the reduction in the frequency and volume of overflows, and the improvement in the quality of the discharge (it will be screened primary effluent instead of diluted sewage).

3.6 Effluent Reuse Options

The proposal involves a flexible approach to producing reclaimed water for reuse, starting with a small tertiary plant producing 3 ML/d of reclaimed water, and with flexibility to increase the production up to 12 ML/d.

As noted above, the reclaimed water quality will meet the requirements for use on urban parks and gardens with unrestricted access. Separate lines to distribute the reclaimed water will be installed alongside the effluent pipeline, allowing distribution to most parks on the western side of Darwin, as well as Bicentennial Park.

The growth in effluent reuse will be encouraged by PAWA but, ultimately, will be determined by users including Darwin City Council, the Botanic gardens and other agencies and companies responsible for landscape irrigation. It is expected that much more reclaimed water will be used in the dry season than in the wet season.

3.7 Sludge Management Options

The existing incinerator will be kept in operation for the foreseeable future and used to incinerate sludge, screenings and possibly grit.

An alternative disposal arrangement for screening and grit involving bagging and daily burial at an approved landfill site will be developed as a standby arrangement. The two landfill sites proposed are the Council landfill and a burial site adjacent to the Leanyer lagoons (see Chapter 6).

In the medium term, a lime stabilisation facility will be constructed at Ludmilla to provide an alternative to incineration. This facility will mechanically mix the sludge with an equal quantity of lime which will elevate the pH and temperature for a period sufficient to stabilise the biosolids and reduce pathogens to acceptable levels. After a short period of storage, the lime-stabilised biosolids would be ready for application to agricultural land. Lime is stored on the site now so the main equipment needed is a lime/sludge mixer and a storage area.

A longer term option is to develop a procedure to transport dewatered sludge from the site for co-composting with green wastes. This work will have to be carried out in cooperation with Darwin City Council. PAWA is developing a sludge management plan for all the WWTPs in Darwin, including lime stabilisation at Ludmilla. The management plan will be subject to review and approval by Territory Health Services and Lands, Planning and Environment.

3.8 Emergency Overflows

There is an existing wet weather overflow beside the Ludmilla WWTP which leads to Ludmilla Creek. Overflows occur on about 100 days per year at present but are predicted to occur on only 8 days per year after full implementation of the proposal. The existing overflow arrangement is a tidal channel which extends through the mangroves to the northern boundary of the plant. No alternative overflow arrangements were investigated.

4. Description of Proposal

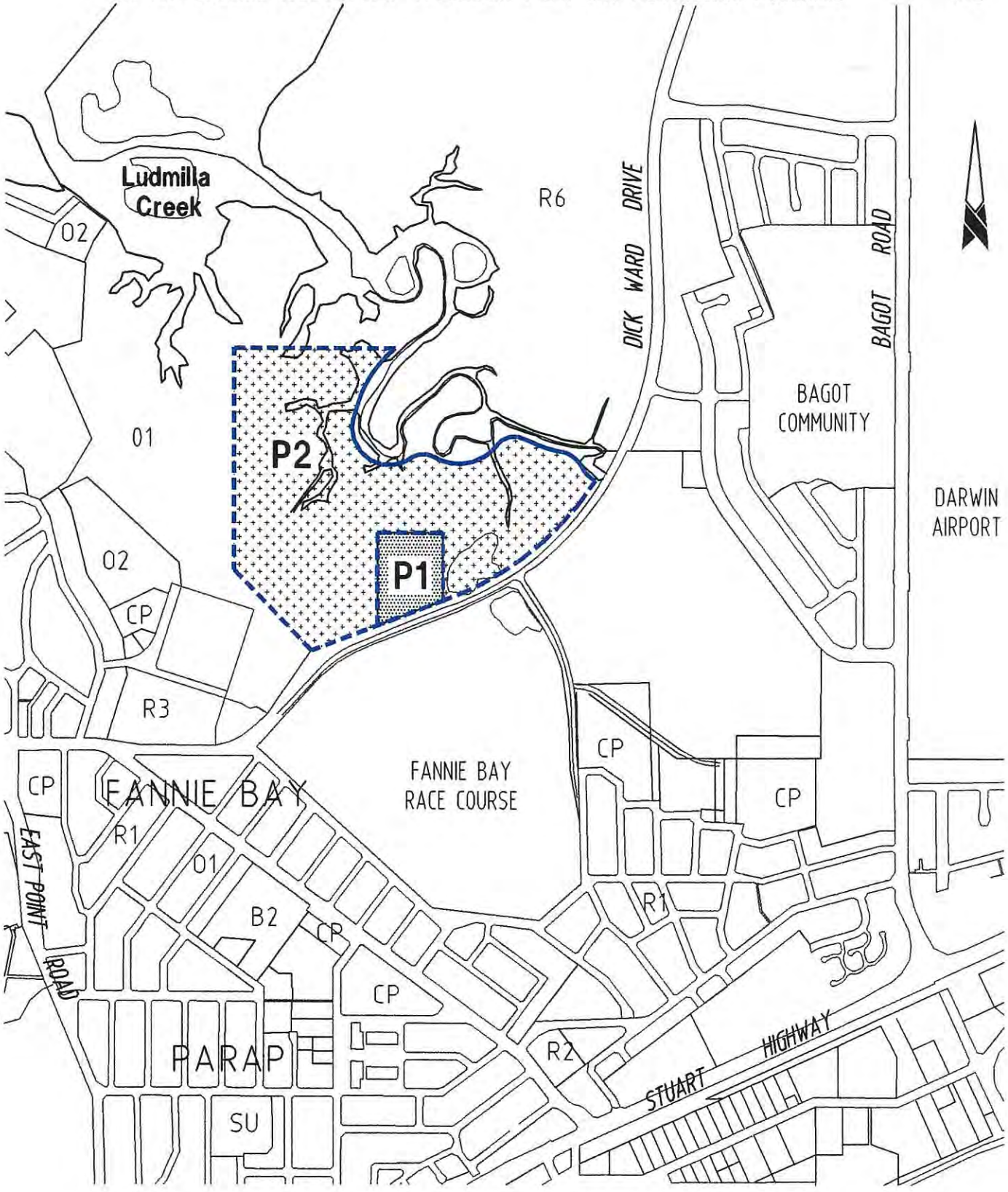
4.1 Scope and General Description

The proposal involves transferring all the wastewater from the Larrakeyah catchment to the Ludmilla treatment plant for treatment there, providing increased treatment capacity at the Ludmilla plant to handle present and future flows from the Larrakeyah and Ludmilla catchments, upgrading the level of treatment at the Ludmilla plant to biological secondary treatment (with a proportion of the flow receiving tertiary treatment), encouragement of effluent reuse and augmentation of the East Point outfall. The proposal is shown schematically in Figure 1-2 and is described in this chapter.

4.2 Location and Site

The sites of significant construction activity are as follows:

1. New pumping station at Larrakeyah;
2. New pipeline to transfer wastewater from Larrakeyah through central city area to Dinah Beach pumping station (see maps later in this chapter for precise route of pipeline);
3. New rising main from Dinah Beach pumping station to Parap (see maps later in this chapter for precise route of pipeline);
4. Upgrading capacity and providing additional treatment processes at Ludmilla treatment plant on land owned by PAWA or land designated for sewerage treatment purposes (see Figure 4-1);
5. New effluent pipeline from Ludmilla to Larrakeyah (see maps later in this chapter for precise route of pipeline);
6. New reclaimed water distribution pipeline from Ludmilla to Bicentennial Park;
7. Mud disposal at PAWA site at Hudson Creek;
8. New rising main beside existing rising main from Ludmilla to East Point; and
9. Possible extension of East Point outfall in future if monitoring shows that to be necessary.
10. Sites for burial of screenings and grit (Council landfill or Leanyer).



P1 Ludmilla WWTP Site

P2 Land zoned for future treatment plant works

LAND TENURE AT LUDMILLA PLANT

Figure 4-1

4.3 Ludmilla Upgrade

The augmentation of the Ludmilla WWTP will involve a staged development of the capacity of the plant, to a design average daily flow (in dry weather) of 12.4 ML/d and then to an ultimate average daily flow of 16 ML/d (for comparison, the present average daily flow is 7 ML/d).

The principal components which will be constructed are as follows:

* Fine screening with a peak flow capacity of 100 ML/d. A total of five in-channel screens of 1.3 m diameter with 3 mm apertures would be installed at the front of the plant;

* Grit removal with a peak flow capacity of 40 ML/d. A total of three aerated grit tanks 3 m deep and 67 m^2 in area would be installed after the fine screens;

* Scrubbing of air from grit tanks to reduce odours through a soil filter;

* Modify existing chemically-assisted primary tanks to enable treatment up to a peak flow capacity of 40 ML/d;

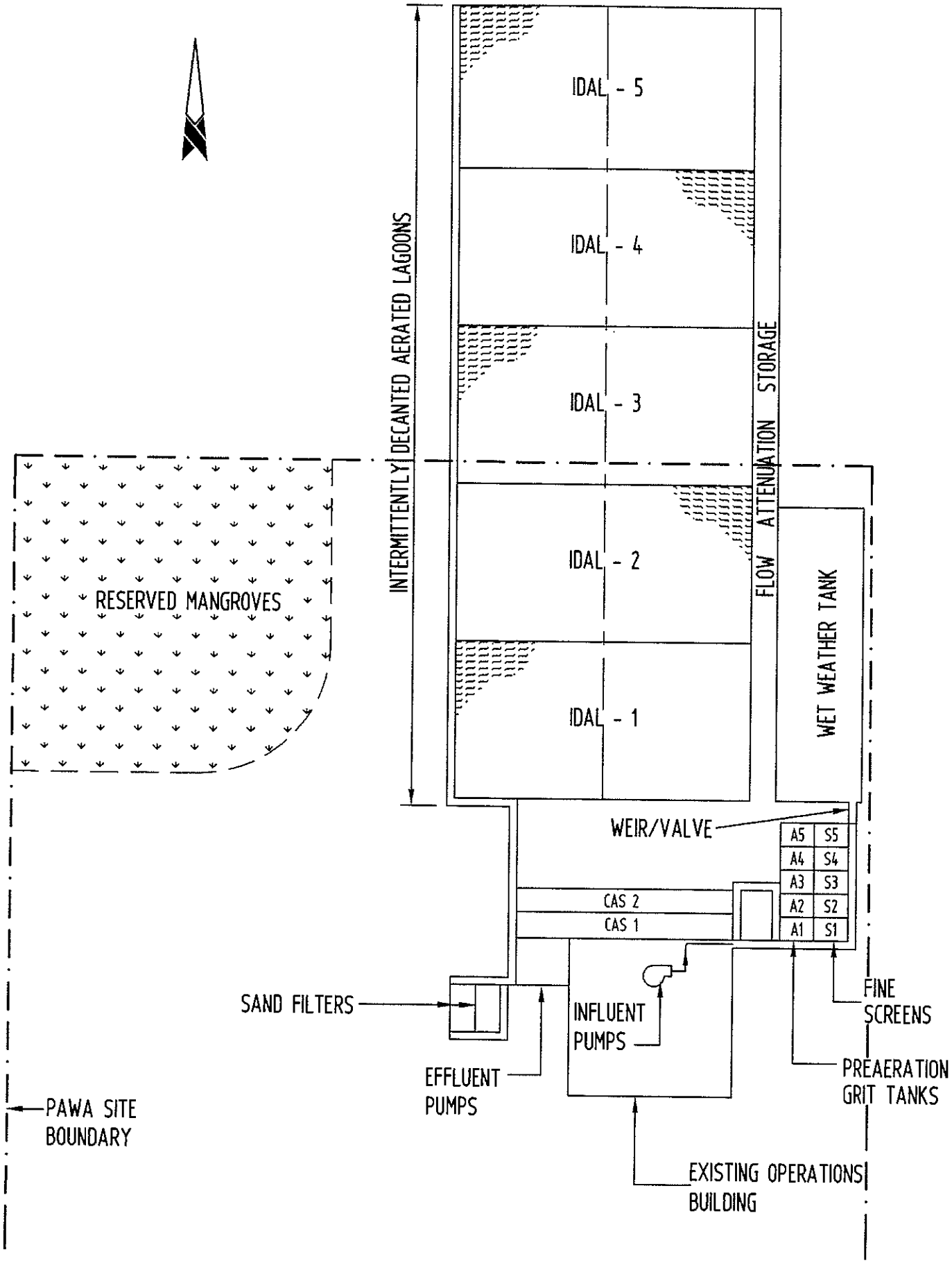
* Add secondary treatment capacity in modules to an eventual average flow capacity of 16 ML/d and peak flow capacity of 40 ML/d. The secondary system would use a typical BOD loading of 2,400 kg/d, a MLSS level of 3,000 mg/L and a sludge age of 20 days. A hydraulic retention time of approximately 24 hours would be provided;

* Add tertiary treatment capacity in modules, commencing with an initial module to produce 3 ML/d of reclaimed water. Two sand filters with an area of 42 m^2 would be installed; and

* Add tank to store and treat up to 60 ML/d of wet weather flows which exceed capacity of chemically-assisted primary sedimentation tanks. The tank would have a volume of approximately 2,000 m^3.

After completion of four secondary treatment modules, all flow in the dry season will receive primary and biological secondary treatment. Figure 4-2 shows the proposed Ludmilla plant layout.

All these construction activities (apart from the reclaimed water distribution system) will occur within the existing PAWA treatment plant site. The first module of the secondary and tertiary treatment units will be constructed within the existing designated site.



PROPOSED LAYOUT OF LUDMILLA WWTP

Figure 4-2

Subsequent modules of secondary treatment units will be constructed to the north of the existing site, on land designated for sewage treatment purposes. This land is, however, the subject of two or more land claims by local Aboriginal groups, and construction will not commence unless and until the land claims have been settled and PAWA has a clear title to the land.

If the event that PAWA does not obtain a title, the additional secondary treatment units could be constructed within the existing PAWA site, but this would involve the removal of a stand of mature mangroves. The decision on the final location of the secondary treatment modules does not have to be made until 2001.

4.4 Sewage Pipeline

The proposed alignment for the sewage pipeline to transfer wastewater from the Larrakeyah catchment to Ludmilla WWTP involves the following pipelines and pumping stations. There are three pipeline routes through the CBD (see Figure 4-3) and the final selection will be made after the location of all other services has been defined and the 'clearest' route established.

* An interception sewer will be constructed to divert the existing Mitchell Street and Cavenagh Street sewers to the head of the proposed tank farm trunk sewer and thence to the proposed new pumping station at Dinah Beach.

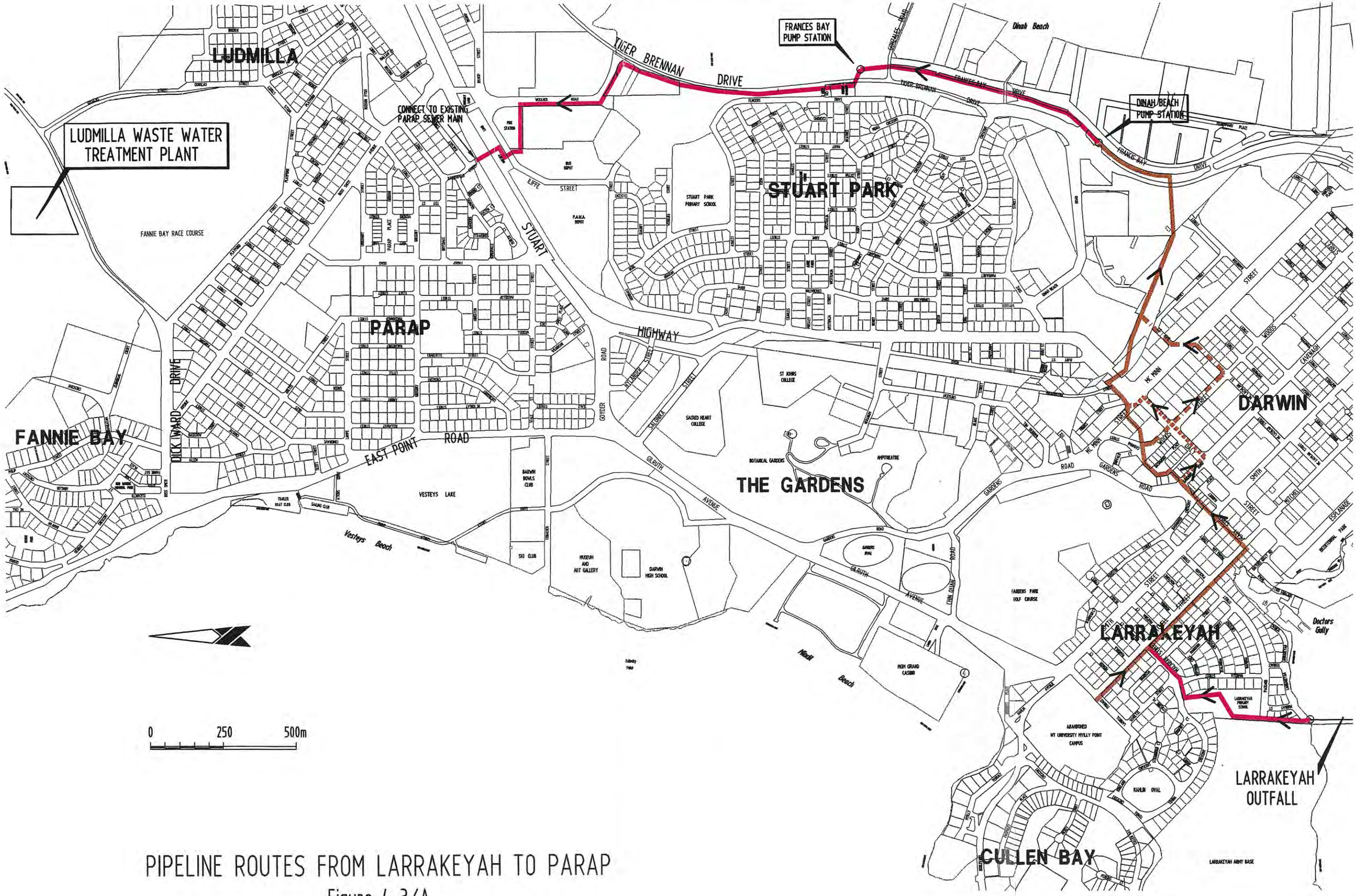
* A new gravity sewer would be constructed down Mitchell Street from Malabar Street to join the new interceptor sewer described above. The largest Cullen Bay marina pumping station would be diverted to discharge to this sewer.

* A new pumping station and rising main from Larrakeyah will be constructed to divert the flow to the interceptor sewer at Mitchell Street.

* The discharge from the Palmerston Park pumping station will be redirected from the Larrakeyah catchment to the Dinah Beach catchment.

* The Dinah Beach pumping station and rising main to the Parap trunk sewer will be constructed and augmented as necessary.

An alternative pipeline route was developed along the western side of the City, generally following the effluent pipeline described below (NTCA, 1998). Another western pipeline route was developed from Larrakeyah to Parap (GHD, 1998). The eastern route was preferred because it offers a clearer route (apart from the problem of sewer construction through the CBD) and slightly lower cost ($6.3 million compared to $6.9 million). However the eastern route does involve greater construction through the CBD and more impacts due to noise, restricted access and traffic disturbance.



PIPELINE ROUTES FROM LARRAKEYAH TO PARAP

Figure 4-3/A

4.5 Effluent Pipeline

The proposed alignment for the effluent pipeline to transfer secondary effluent from the Ludmilla WWTP to the Larrakeyah outfall involves the following pipelines and pumping stations (see Figure 4-4). The pipeline route was developed in cooperation with Darwin Council to ensure lowest possible impact on valuable trees and landscaping.

* A new effluent pumping station would be constructed at the Ludmilla WWTP to pump secondary effluent to Larrakeyah. The first section of the rising main would be along the northern side of Disk Ward Drive, beside the road.

* The main would continue around the Fannie Bay gaol and then along the service road on the east of East Point Road.

* The main would cross to the west side of East Point Road near that Sailing Club, and continue beneath vacant parkland to the Darwin Bowls Club. The main would be about 10 m west of the cycle path, and few trees would be affected.

* South of Conacher Street, the main would be constructed beneath the bike path. A temporary path would be provided during construction and the original path re-installed after installation of the main.

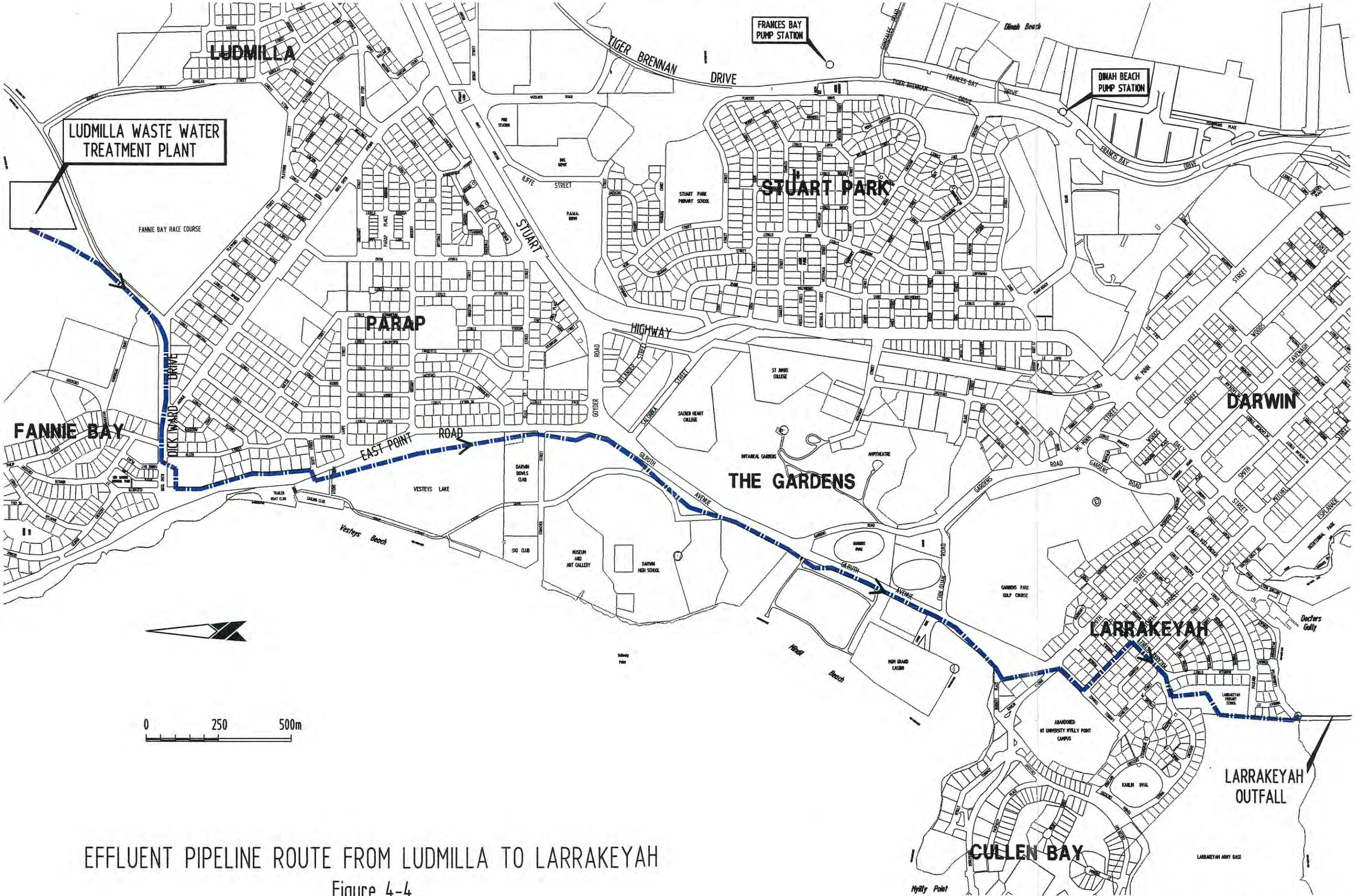
* Beside Atkins Drive, the main would be installed beside the power line.

* Along Gilruth Avenue at Mindal Beach, the main would be installed in the west shoulder of the roadway or on the verge beside the road. The existing landscaping in this area would be removed for construction and then replaced. There would be no impact on Mindal Beach market.

* The main would then pass through the grove of black wattles in Bennett Place, and continue south on Lambell Terrace, Schultze Street, and Temra Crescent to the Larrakeyah primary school. Construction in the school ground would be in a holiday period.

* The final section of the main would be adjacent to the fence of the Military area, and then for about 30 m along Larrakeyah Terrace to join the existing Larrakeyah outfall.

The whole of the effluent pipeline will be buried. As the flow being conveyed is secondary effluent there is no risk of odour concerns, and minimal maintenance of the pipeline should be required.



EFFLUENT PIPELINE ROUTE FROM LUDMILLA TO LARRAKEYAH

Figure 4-4

4.6 Reclaimed Water Pipelines

The reclaimed water quality will meet current National Water Quality Guidelines for reuse of effluent in areas with unrestricted public access, and anticipated licence requirements for effluent reuse.

As part of the proposal, PAWA proposes to construct a 'green line' system to reticulate reclaimed effluent to users. Negotiations are underway with potential users to establish the initial level of demand. The general principal is that PAWA will provide the large scale reticulation system along the west edge of the city, and that reclaimed water users will be responsible for local scale reticulation, distribution and sprinklers or drippers. The charge for reclaimed water will be set to recover running costs for the production and distribution of reclaimed water.

Initial users of reclaimed water are expected to include the Fannie Bay racecourse, Botanic Gardens, Darwin Council (parks and gardens), Darwin Museum and possibly the Gardens Park golf course. More users are expected to join over time, so that the use of reclaimed water is anticipated to grow from about 2 ML/d in the year 2000 to 6 ML/d in the year 2012.

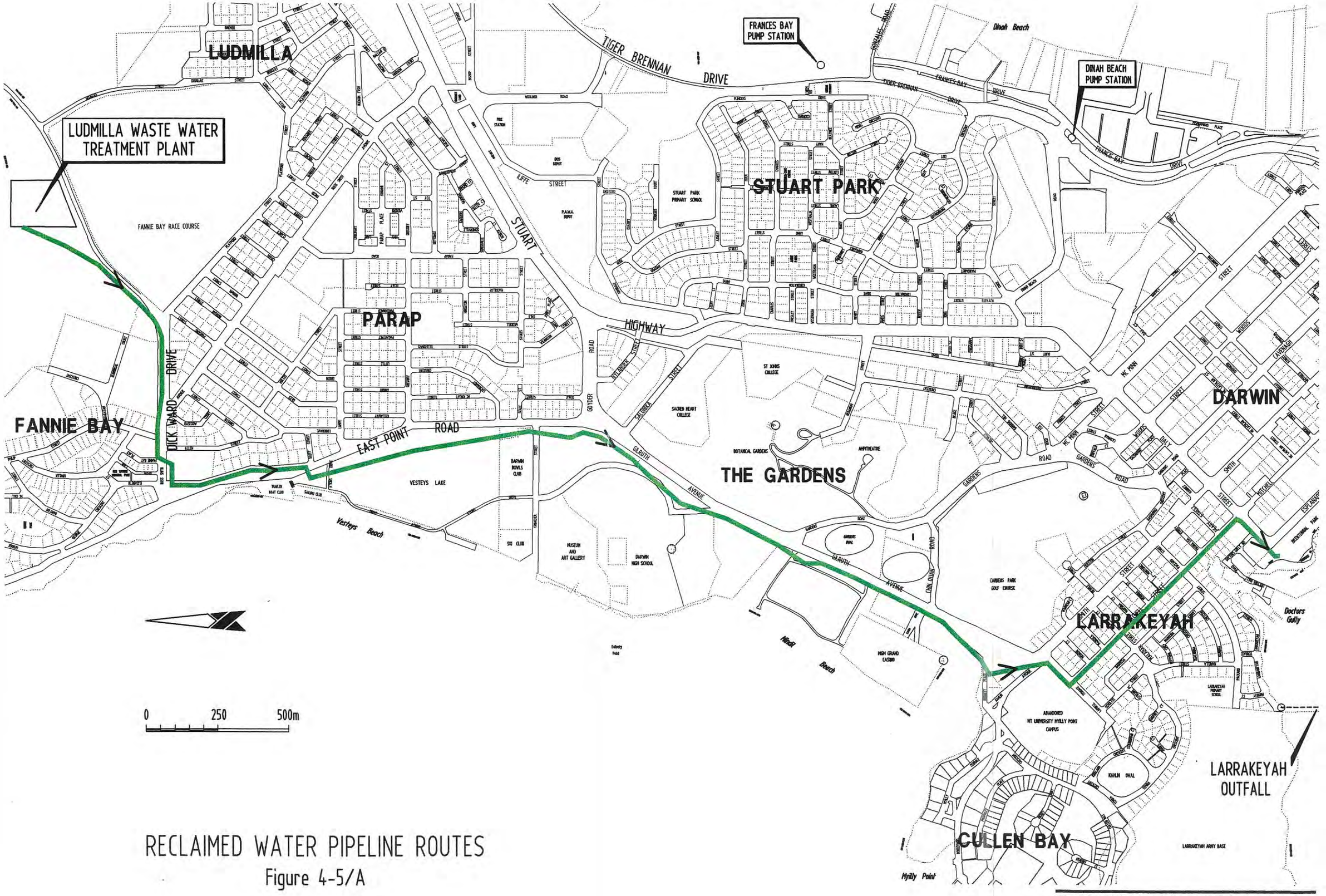
The routes of 'green lines' will correspond to the effluent pipeline route for part of the distance, with separate 'green lines' to the racecourse and Bicentennial Park. The routes are shown in Figure 4-5 and generally are as follows.

* A reclaimed water main (about 150 mm diameter) would be constructed across Dick Ward Drive from the Ludmilla WWTP to the racecourse.

* Another reclaimed water main would be constructed beside the effluent pipeline from Ludmilla WWTP along Dick Ward Drive, East Point Road and Gilruth Avenue to Mindal Beach.

* The reclaimed water main would cross to the east side of Gilruth Avenue and continue through Gardens Park golf course, up Dashwood Crescent and for short distances along Smith Street, Mauna Loa Street, and Doctors Gully Road to Bicentennial Park.

All the reclaimed water pipelines will be buried. As the flow being conveyed is reclaimed water (disinfected tertiary effluent) there is no risk of odour concerns, and minimal maintenance of the pipeline should be required. However new connections will be made to the pipeline from time to time, and it will be extended as new users emerge.



RECLAIMED WATER PIPELINE ROUTES

Figure 4-5/A

4.7 Larrakeyah Outfall

The Larrakeyah outfall will be used for the discharge of the secondary effluent which is not filtered and converted to reclaimed water. The average daily flow in the year 2012 will be 12.4 ML/d, and the expected reuse demand (in the dry season) could then be 4 to 6 ML/d. On that basis, the discharge through the Larrakeyah outfall will then be 6 to 8 ML/d. During the wet season, there is expected to be little reuse and virtually the whole of the effluent, up to 28 ML/d, will be discharged through the Larrakeyah outfall.

The suspended solids load discharged from the Larrakeyah outfall is:
Year 1998: 4 ML/d at 180 mg/L = 720 kg/d
Year 2012: 8 ML/d at 15 mg/L = 120 kg/d (average in dry season)
Year 2012: 28 ML/d at 20 mg/L = 560 kg/d (peak in wet season).

It is clear that there will be a substantial reduction in the solids load discharged to Darwin harbour through the outfall over a year, and throughout the dry season. There also will be a 25 per cent reduction in the ammonia and nitrogen loads discharged to the Harbour during the dry season, while the nitrogen loads in the wet season would remain about the same as now.

4.8 East Point Outfall

The East Point outfall will be used to discharge effluent from the Ludmilla WWTP which exceeds 28 ML/d. The present capacity of the East Point outfall is 22 ML/d but this will be increased to 60 ML/d by installing a duplicate 600 mm diameter pipeline for 3.04 km along East Point. This work is mostly in open ground.

Table 4-1 lists the flow through the East Point outfall based on the inflow to the Ludmilla WWTP in year 2012. For example, on 10 days per year, the peak inflow will be 85 ML/d. If there is little or no effluent reuse (as during the wet season, when high peak inflows occur) then 28 ML/d of effluent will be discharged through the Larrakeyah outfall and the balance of 57 ML/d will be discharged through the East Point outfall.

As shown in Table 4-1, the discharge through the East Point outfall will range from only 3 ML/d or more on 90 days per year to 57 ML/d on 10 or more days per year to a maximum of 60 ML/d on about 8 days per year (this being the capacity of the East Point outfall).

A periodic small discharge of disinfected secondary effluent will be made through the East Point outfall in the dry season (possibly every two days or so) to keep the pipeline clean of sediment and marine growths.

Table 4-1 Wet Weather Flow Distribution; East Point Outfall of 60 ML/d

Days/year	1	10	20	30	40	50	60	70	80	90	100	110
Peak flow, ML	100	85	70	60	55	50	45	40	35	31	28	25
- Larrakeyah	- 28	- 28	- 28	- 28	- 28	- 28	- 28	- 28	- 28	- 28	- 28	- 25
- overflow	12	0	0	0	0	0	0	0	0	0	0	0
= East Point	- 60	- 57	- 42	- 32	- 27	- 22	- 17	-12	- 7	- 3	0	0

The performance and impacts of the discharges from the East Point outfall will be monitored. If worthwhile, the East Point outfall may be extended 500 to 600 m offshore in about the year 2002.

The average daily suspended solids load discharged from the East Point outfall in the years 1998 and 2012 is:

Year 1998: 7 ML/d at 65 mg/L = 450 kg/d (dry season)
Year 1998: 17 ML/d at 50 mg/L = 850 kg/d (wet season, average)

Year 2012: 0.1 ML/d at 15 mg/L = 1 kg/d (dry season, cleaning flow)
Year 2012: 20 ML/d at 35 mg/L = 700 kg/d (wet season, average)

There will be a reduction in the solids load discharged in both the dry season and the wet season. There also will be a 20 per cent reduction in the nitrogen loads discharged through the East Point outfall over the year.

4.9 Wastes (Screenings and Grit)

The principal wastes created during the construction activities will be:
* clean fill, from excavations for pipelines and pumping stations; and
* mangrove mud/sludge, from excavations at the Ludmilla WWTP.

The clean fill will be transported to sites around Darwin being filled and thus reused. A plan has been developed for control of odours and leachate from the excavation of mangrove mud, as described in Section 4.12.

The principal wastes created during operation of the plant will be:
* screenings and grit removed from the wastewater; and
* sludge, from the treatment processes at the Ludmilla WWTP.

Screenings and grit are discussed below; sludge management in discussed in Section 4.10.

Screenings

Screenings comprise plastics, detritus, nappies, sanitary goods and other large solid objects which are removed on the screens at the head of the plant. These materials have no practical reuse applications and tend to be smelly and objectionable. They will be either incinerated at the Ludmilla plant or taken in sealed polyethylene bags to an approved landfill.

Grit

Grit comprises sand and gravel which is carried into the treatment system with the wastewater. The grit will be removed in aerated grit tanks and either incinerated at the Ludmilla plant or taken in sealed polyethylene bags to an approved landfill.

4.10 Sludge Management

The existing vacuum filters and incinerator at Ludmilla WWTP will continue to be used to handle sludge at the Ludmilla plant. The current procedure is to remove and dewater sludge from the primary tanks on four days per week. The sludge incinerator is kept 'warm' all the time. Foul air from odourous areas is ducted through the incinerator, to reduce odour emissions from the WWTP.

Continued operation of the vacuum filters and incinerator has the advantage that no offsite disposal of sludge is required and an `afterburner' is maintained at the plant to reduce odour emissions.

A dissolved air flotation (DAF) sludge dewatering system would be used to concentrate waste sludge from the IDAL tanks to avoid the need for secondary sludge to be returned to the primary tanks, with the consequent risk of odour release. A DAF unit is fully enclosed and can be operated to coincide with the incinerator operation.

Backup sludge handling systems are required in the event that the incinerator is not operating. At present there is a system allowing dewatered raw sludge to be carted from the site to another treatment plant site (Leanyer or Berrimah).

PAWA is developing a sludge management for the WWTPs in the Darwin region. For the Ludmilla WWTP, the possible future sludge handling options include lime stabilisation, composting and thermophilic digestion. Lime stabilisation has the advantage that it can handle the whole of the sludge in both the dry season and the wet season, and is relatively flexible, so that other disposal routes such as composting can operate in parallel.

A longer term option is to develop a procedure to transport dewatered sludge from the site for co-composting with green wastes. This work will have to be carried out in cooperation with Darwin City Council.

As stated in Chapter 3, PAWA is developing a sludge management plan for all the WWTPs in Darwin, with the goal of achieving reuse on land of all sludge in the long term. The management plan will be subject to review and approval by Territory Health Services and Lands, Planning and Environment.

As shown in Table 4-2, there would be a 50 per cent increase in the amount of sludge produced on the site, even though the reduction in chemical use and primary sludge production would to some extent counterbalance the secondary sludge production.

Table 4-2 Estimates of Sludge Production at Ludmilla WWTP (dry t/day)

Year	ADWF	Primary	Chemicals	Secondary	Total
1998	7.0 ML/d	820 kg/d	420 kg/d	nil	1240 kg/d
2012	2.4 ML/d	1120 kg/d	500 kg/d	180 kg/d	1800 kg/d

As noted above, sludge will be incinerated on the site using the existing incinerator. The incinerator has adequate capacity to burn the additional sludge (this would increase the incineration period from about 32 hours per week to 40 hours per week).

If sludge were to be dewatered and carted from the site, the quantity would be about 8 to 9 t/day, or about one truck load per day. Offsite transport and handling of sludge will be included in the forthcoming sludge management plan.

4.11 Removal of Materials - Ludmilla

Construction of the new facilities at the Ludmilla site will involve removal of mangrove mud and accumulated sludge from the site. This material is potentially odourous and likely to produce acid leachate. To minimise the leachate problems, the mud and sludge will be transported to a site owned by PAWA at Hudson Creek and buried on the intertidal mudflats there. The proposed procedure is described in Section 4.10. The procedure will minimise the exposure of the excavated material to the atmosphere and hence minimise the production of acid leachate.

There will be a release of odour during the period of excavation of the Ludmilla site, estimated to take up to 3 weeks. An odour masking system will be operated during the excavation to minimise the odour nuisance.

4.12 Acid Sulphate Control Measures

As noted above, the mud and sludge excavated from the Ludmilla WWTP site will be transported to Hudson Creek and buried on the intertidal mudflats there. Each secondary treatment module will require the removal of about 3000 m^3 of mud; this is equivalent to 200 truck loads and will take place in about a week. The material will be loaded into trucks and carted to Hudson Creek as soon as it is excavated. Covers will be used over the loads to minimize odour nuisance during cartage operations.

At Hudson Creek, a triangular area of land of approximately 0.5 ha has been designated for receival of the excavated mud and sludge. An access road will be constructed to the land, which is just below the high water line, and a clay bund installed across the lower side of the proposed fill area.

The excavated material will be placed in a 1 m deep layer from the trucks and capped. In this manner, the mud will be kept in an anaerobic state, and production of leachate will be minimised. The bund will restrict the movement of leachate from the filled area.

The composition of the old sludge at the Ludmilla site has been tested (SKM, 1998) and found to have low levels of metals. Hence there is not considered to be a leachate problem provided the mud and sludge are prevented from drying out and are quickly placed in a muddy zone just below the high tide line. Similar procedures have been used to move mud as part of the recent Cullen Bay and Port of Darwin developments.

Overall, an area of about 1 ha will be trenched and filled. This procedure will minimise the exposure of the excavated material to the atmosphere and hence minimise the production of acid leachate. The excavated area will end up about 1 m higher than the original level, but will return towards the original contours due to the effects of settlement.

4.13 Odour Control

There will be a local odour problem during excavation of the mangrove mud at Ludmilla WWTP; this episode is expected to persist for about 3 weeks. The principal mitigation measures are to minimise the duration of excavation and to ensure all excavated material is rapidly carted from the site.

The Darwin sewerage system has a significant problem with odours owing to the high wastewater temperature. Odours at the Ludmilla site are controlled at present by a high chlorine dose (about 35 mg/L) but this creates elevated levels of chlorinated organic compounds in the effluent. A substantial reduction in chlorine dose will be essential with a biological treatment system.

The proposed strategy to minimise and control odours involves:

* Pre-aeration (grit removal) tanks to capture odours;
* Soil bed filter to treat odourous air (requires reclaimed effluent for irrigation);
* Odourous air can be ducted to blowers for use in aeration system;
* Odourous air can be ducted to incinerator for thermal oxidation;
* Lime dose in the primary tanks to increase pH and reduce hydrogen sulphide emissions to air;
* Low pre-chlorination dose; and
* Ferric dose to control sulphides.

Aeration for the secondary treatment process would be provided by blowers and submerged diffusers, rather than surface aerators, to minimise odour and noise impacts.

As noted above, the grit tanks also will be aerated, with the exit air collected and scrubbed in a soil bed filter. Additional air scrubbing equipment is being installed at the Ludmilla WWTP to extract air from the incoming sewer at Ludmilla and treat it in a chemical scrubber.

4.14 Biting Insect Control

Discussion were held with Environmental Health, Territory Health Services to establish the best approaches to control mosquitoes and other biting insects. The proposed approach is as follows:

* Manage construction to avoid forming ponds for insect breeding;
* Have near-vertical concrete walls on all new tanks to avoid creating insect habitat;
* Provide aeration to wet weather treatment tank to prevent quiescent pond of fresh water forming during the dry season; and
* Avoid pools of freshwater runoff or effluent at high tide level adjacent to construction works or treatment plant.

This combination of actions should avoid any new problems due to biting insects. The actions will be included in the management plans for the construction and operations phases of the project.

4.15 Infrastructure Requirements

The major requirements of the project in terms of urban infrastructure are as follows:

* Additional power demand (average 300 kW; peak 600 kW): which will be met from existing electricity system;

* Additional telecommunications: which will be met by an enhanced data transmission and equipment control system;

* No requirement for additional water: the project will produce reclaimed water which should satisfy most requirements for process water in the various treatment processes; and

* Small increase in traffic during operations, with a significant short term increase in car and truck traffic during excavation and construction. An improved intersection, with turning lanes, will be constructed in Dick Ward Drive in front of the Ludmilla WWTP to minimise the effects of the project on passing traffic.

4.16 Dangerous Goods

The chemicals which will be stored at the Ludmilla plant in significant quantities are:

* lime;
* polymer;
* chlorine; and
* diesel and waste oil.

Lime is stored in a silo on the site. No change in the lime storage or usage is proposed; future lime use should be about the same as at present, as the increase in flow will balance the decrease in lime dose.

Polymer is brought to the site as 20 kg powder bags and dissolved on a daily basis. A small increase in polymer use is anticipated, due to the larger quantity of sludge to be handled.

Chlorine is brought to the site in 950 kg gas cylinders. Up to six cylinders may be stored on the site, in a storage facility which meets the requirements of Workhealth. The chlorine gas is dissolved in water and transported around the site as a chlorine solution. No changes in the chlorine facilities are proposed in the foreseeable future.

Chlorine use for odour control is expected to decrease but chlorine use for disinfection of effluent (particularly reclaimed water) is expected to increase. Overall, chlorine consumption will remain about the same as at present.

Diesel is stored at the plant in an underground tank. However waste diesel and waste oil (from the power station) is stored at the site in 200 L drums. A bunded storage for the drums will be constructed in accordance with the Australian Standard for the storage and handling of flammable and combustible liquids (AS 1940-1988).

Apart from the new bund for diesel, no significant change to the existing transport, storage, or use of Dangerous Goods at Ludmilla WWTP is planned as part of this proposal.

4.17 Expected Lifetime

The pipelines and structural components of the project will have an expected service life of 50 years or more. The mechanical components will have a life of 10 to 20 years, but will be replaced as necessary to match the life of the structural components.

Overall, it is intended to operate the Ludmilla plant and related facilities in perpetuity.

4.18 Proposed Staging of Upgrade

As described in Section 2.6, it is proposed to construct the project in the following sequence:

* Pipelines constructed in 1999/2000
* First stage of Ludmilla plant upgrade in 1999
* Effluent reuse pipelines in 1999/200
* Commence operations in 2000
* Second stage of Ludmilla upgrade in 2003
* Expand effluent reuse in 2001-2005
* Possibly extend East Point outfall in 2002
* Augmentation of East Point rising main in 2005.

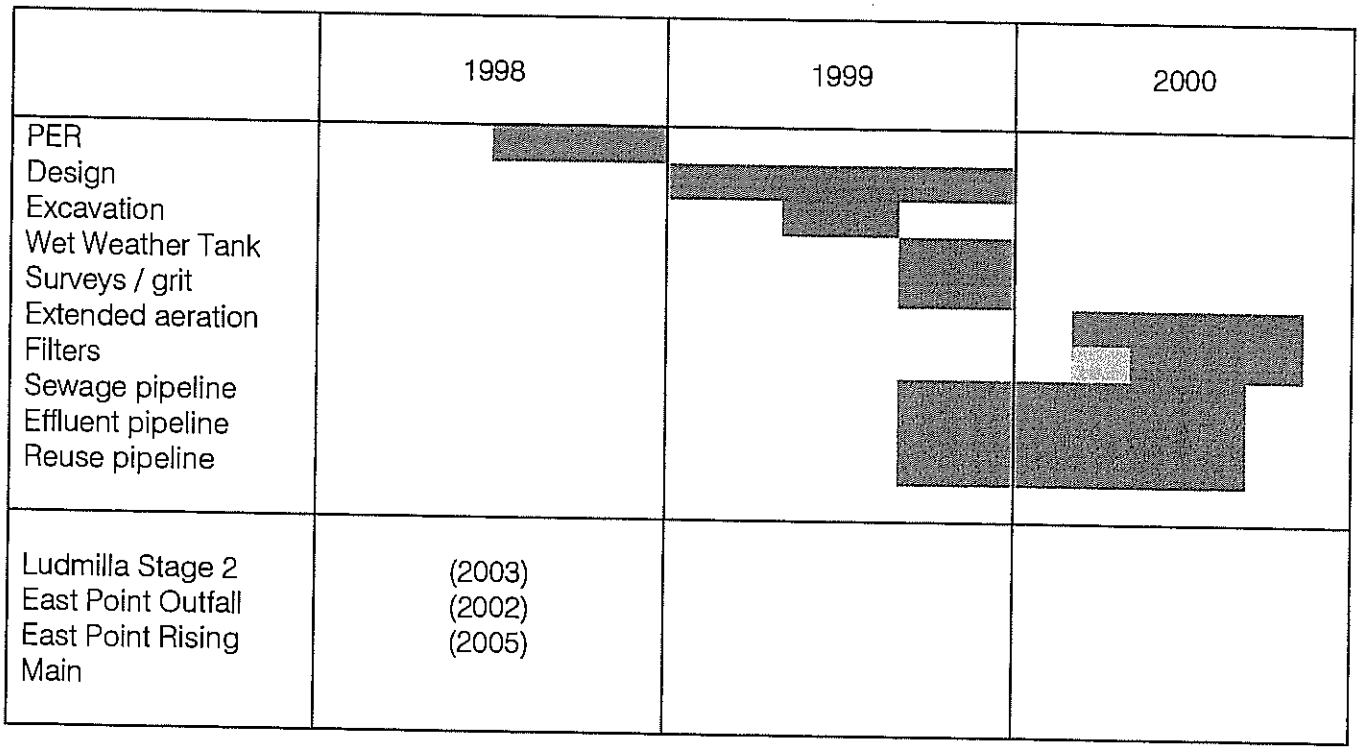
The detailed design and construction program for the next three years is given in Figure 5-1.

5. Construction Phase

5.1 Construction Program

A detailed construction program has not been prepared at this stage, but the expected timing and duration of the key activities is shown in Figure 5-1.

Figure 5-1 Key Components of Construction Program



5.2 Construction Materials

The principal construction materials to be used are as follows:

* Large diameter pipelines: fibreglass (Hobas) pipes
* Small diameter reclaimed water pipelines: HDPE and PVC
* Pumps: standard pumps from normal Australian suppliers
* Concrete: from Darwin concrete batching plants
* Reinforcing steel: from Australian suppliers
* Gravel and sand backfill: from Darwin suppliers
* Mechanical equipment for treatment plant: from Australian suppliers
* Electrical equipment for treatment plant: from Australian suppliers
* Dredging for outfall extension: Darwin dredging contractor
* Steel pipeline for outfall extension: from Australian suppliers.

All construction work is expected to be carried out by local contractors.

5.3 Vehicle Movements

As shown in Figure 5-1, construction of major pipelines is expected to take about 12 months while construction of the upgraded treatment plant at Ludmilla (stage 1) will take about 15 months.

Hours of construction will be specified in the construction contracts to minimise adverse impacts due to noise and disturbance. Hence in residential areas, construction will be permitted only between 8 am and 5 pm on weekdays and from 8 am to 3 pm on Saturdays.

On streets in the CDB, construction may be restricted to night hours (eg, beside offices and shops) or to avoid truck movements during the morning and afternoon traffic peak. The hours of construction will be defined in conjunction with the NTCA and the traffic engineer of the Darwin Council.

Estimates of vehicle movements during the construction period are:

Pipeline Construction: (maximum of 6 weeks at any site)

heavy vehicles	average 1 per day; peak 5 per day
trucks	average 12 per day; peak 25 per day
cars	average 25 per day; peak 55 per day

Ludmilla Excavation (3 week period)

heavy vehicles	average 1 per day; peak 2 per day
trucks	average 35 per day; peak 60 per day
cars	average 10 per day; peak 15 per day

Ludmilla WWTP Construction: (15 months)

heavy vehicles	average 2 per day; peak 6 per day
trucks	average 6 per day; peak 18 per day
cars	average 20 per day; peak 60 per day

East Point Outfall Extension: (6 months)

heavy vehicles	average 1 per day; peak 3 per day
trucks	average 2 per day; peak 6 per day
cars	average 10 per day; peak 30 per day

5.4 Wastes From Construction

As described in Section 4.9, the principal wastes created during the construction activities will be:

* clean fill, from excavations for pipelines and pumping stations; and
* mangrove mud/sludge, from excavations at the Ludmilla WWTP.

The clean fill will be transported to sites being filled and thus reused. A plan has been developed for control of odours and leachate from the excavation of mangrove mud, as described in Section 4.12.

5.5 Vegetation Clearance and Earthmoving

The expansion of the Ludmilla WWTP, provided it takes place to the north as proposed, is onto clear ground and does not involve any loss of vegetation. If all new IDAL tanks have to be constructed within the existing site, a stand of mature mangroves would be removed. No new vegetation clearance is proposed at Leanyer or Hudson Creek.

The proposed pipeline routes have been surveyed with the botanical advisor of Darwin City Council and the alignments adjusted to result in least loss of trees. No registered or important trees will be affected, and all trees cut down will be replaced by the same or an equivalent tree. There is a tradeoff between tree impact and traffic impact, as minimal tree loss could be achieved by constructing all pipelines along the road.

5.6 Soil Conservation and Rehabilitation

Top soil removed from pipeline routes during construction will be stockpiled and replaced, with appropriate seeding. There is no topsoil in the expansion area of the Ludmilla site or at the mud disposal area at the Hudson Creek site.

5.7 Acid Sulphate Control

As described in Section 4.12, a strategy has been developed to minimise the generation of acid leachate. The mud and sludge excavated from the Ludmilla WWTP site will be transported to Hudson Creek, placed and capped on the intertidal mudflats there. The material will be loaded into the trucks and carted to Hudson Creek as soon as it is excavated. Covers will be used over the loads to minimize odour nuisance during cartage operations.

At Hudson Creek, the old sludge and mangrove mud will be placed on a triangular area of land of approximately 0.5 ha just below the high tide line. A clay bund will installed across the lower side of the proposed fill area to prevent leachate escape.

The composition of the old sludge at the Ludmilla site has been tested (SKM, 1998) and found to have low levels of metals. Hence there is not considered to be a leachate problem provided the mud and sludge are prevented from drying out and are quickly placed on mud in an intertidal area and capped.

5.8 Odour Control

As described in Section 4.12, a short term local odour problem is anticipated during excavation of the mangrove mud at Ludmilla WWTP. The potential odour problem is expected to persist for about 3 weeks. The principal mitigation measures are to minimise the duration of excavation, to ensure all excavated material is rapidly carted from the site, to keep the mud wet and anaerobic, and to operate an odour masking system at Ludmilla WWTP during the excavation period.

5.9 Biting Insect Control

As described in Section 4.14, a strategy has been developed to control mosquitoes and other biting insects during construction (and operations). The proposed approach is as follows:

* Manage construction to avoid forming ponds for insect breeding;
* Have near-vertical concrete walls on all new tanks to avoid creating insect habitat;
* Provide aeration to wet weather treatment tank to prevent quiescent pond of fresh water forming during the dry season; and
* Avoid pools of freshwater runoff or effluent at high tide level adjacent to construction works or treatment plant.

This combination of actions should avoid any new problems due to biting insects. The actions will be included in the management plans for the construction and operations phases of the project

6. Operations

6.1 Raw Materials

The raw materials used in the operation of the Ludmilla WWTP are as follows:

* Wastewater (12.4 ML/d in year 2012, and much more in wet weather) arrives in trunk sewers from Parap, Coconut Grove and Fannie Bay;

* Electricity (average of about 400 kW in year 2012) arrives via power lines to plant

* Chemicals: 500 kg/d of lime, 20 kg/d of polymer, 100 kg/d of chlorine delivered periodically by truck (lime in tankers, chlorine in gas cylinders);

* Water: small quantity used for washdown, cleaning and laboratory, as well as for ablutions of operators; and

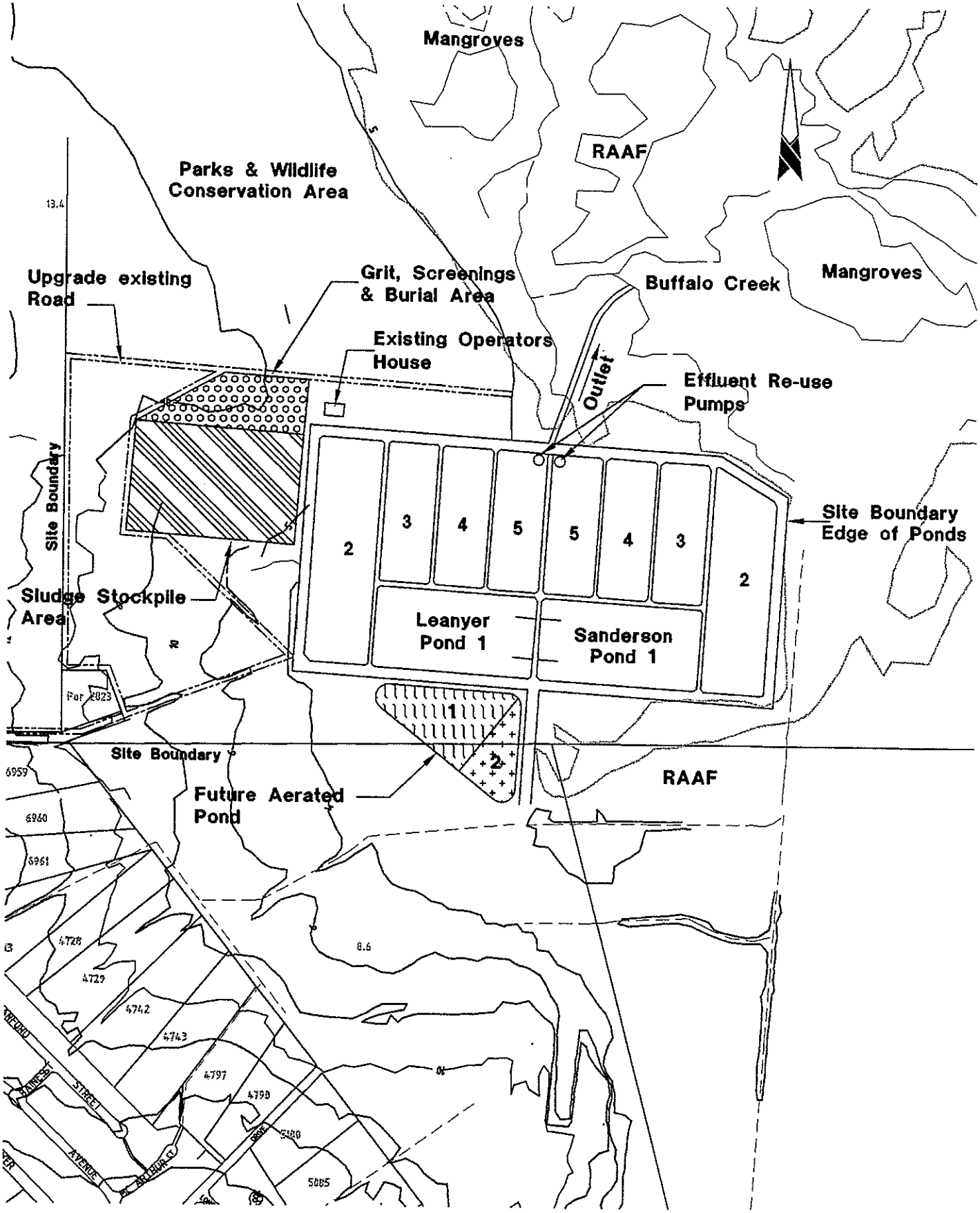
* Diesel: 90 L/day of diesel and waste oil used to keep incinerator idling along between sludge burning activities.

No significant changes in the composition of raw materials is expected, apart from an increase in the wastewater inflow, a major increase in the electricity consumption and a reduction in the chlorine and water usage.

6.2 Wastes (Screenings and Grit)

As discussed in Section 4.9, screenings and grit will be removed in new treatment processes to be installed as part of the Ludmilla plant upgrade. Screenings and grit will be either incinerated at the Ludmilla plant or taken in sealed polyethylene bags to an approved landfill. In the latter case, the grit and screenings would be automatically washed and dropped into polyethylene bags in wheelie bins. Each morning, the bags would be sealed and carted to an approved landfill (either the council landfill or a burial site next to the Leanyer trenches).

Figure 6-1 shows the site at Leanyer which would be used for burial of grit and screenings. Trenches approximately 1.2 m deep would be excavated, and the grit and screenings would be brought to the site in sealed bags, placed in the trench and covered with a minimum of 0.4 m of earth.



LEANYER TREATMENT PONDS
PROPOSED GRIT & SCREENINGS BURIAL AREA
Figure 6-1

6.3 Sludge Management

As discussed in Section 4.10, the existing vacuum filters and incinerator at Ludmilla WWTP will continue to be used to handle sludge at the Ludmilla plant. A dissolved air flotation (DAF) sludge dewatering system will be installed to concentrate waste sludge from the IDAL tanks.

PAWA is developing a future sludge management plant to encourage long term reuse of all biosolids (stabilised sludge) on land. Analyses of sludge from Ludmilla show the metal and pesticide content is low and that Grade A biosolids could be produced, suitable for a range of reuse applications, with appropriate stabilisation procedures.

Possible future sludge stabilisation options include lime stabilisation, composting and thermophilic digestion. Lime stabilisation could handle the whole of the sludge and would allow other disposal routes such as composting to operate in parallel. The reuse and transport operations would be subject to an Environment Management Plan (EMP) prepared to the satisfaction of Territory Health and Lands, Planning and Environment.

As shown in Table 6-1, there will be a 50 per cent increase in the amount of sludge produced on the Ludmilla site, even though the reduction in chemical use and primary sludge production will to some extent counterbalance the secondary sludge production.

Table 6-1 Estimates of Sludge Production at Ludmilla WWTP (dry t/day)

Year	ADWF	Primary	Chemicals	Secondary	Total
1998	7.0 ML/d	820 kg/d	420 kg/d	nil	1240 kg/d
2012	12.4 ML/d	1120 kg/d	500 kg/d	180 kg/d	1800 kg/d

As noted above, sludge will be incinerated on the site using the existing incinerator. The incinerator has adequate capacity to burn the additional sludge (this would increase the incineration period from about 6 hours per week to 10 hours per week).

If sludge were to be dewatered and carted from the site, the quantity would be about 8 to 9 t/day, or about one truck load per day. The future options are dependent on reuse products and markets being developed. In an emergency, dewatered sludge would be carted in a sealed truck to the sludge drying bed beside the Leanyer lagoons.

6.4 Effluent Reuse

As discussed in Section 3-6, effluent reuse will be encouraged by production of reclaimed water and installation of a system of 'green lines' to distribute the reclaimed water through areas of likely demand.

It is anticipated that the demand for reclaimed water will increase progressively from 2 ML/d in the year 2000 to about 6 ML/d in the year 2012. The proposal has the flexibility to increase the production of reclaimed water up to 12 ML/d if the demand reaches that height.

The reclaimed water quality will meet the national (NWQMS, 1998) requirements for use on urban parks and gardens with unrestricted access. The growth in effluent reuse will be encouraged by PAWA but, ultimately, will be determined by users including Darwin City Council, the Botanic Gardens and other agencies and companies responsible for landscape irrigation.

6.5 Effluent Discharge

PAWA holds current licences to discharge effluent through the Larrakeyah and East Point outfalls. In the dry season, effluent in excess of the reuse demand will be discharged through the Larrakeyah outfall (up to a maximum of 28 ML/d). As explained earlier, a small quantity of disinfected secondary effluent will be discharged through the East Point outfall periodically to keep the pipeline clear of sediment and marine growths.

In the wet season, both the Larrakeyah and East Point outfalls will be used to discharge effluent. On the 8 wettest days per year (on average) a small quantity of screened primary effluent will be discharged to Ludmilla Creek.

The suspended solids load discharged from the Larrakeyah outfall is:

Year 1998: 4 ML/d at 180 mg/L = 720 kg/d
Year 2012: 8 ML/d at 15 mg/L = 120 kg/d (dry season)
Year 2012: 28 ML/d at 20 mg/L = 560 kg/d (peak in wet season).

It is clear that there will be a substantial reduction in the solids load discharged to Darwin Harbour over a year, and throughout the dry season. There also will be a 30 per cent reduction in the ammonia and nitrogen loads discharged to the harbour during the dry season, while the nitrogen loads in the wet season would remain about the same as now.

On days of wet weather (about 110 days per year), the distribution of the effluent discharge will be as shown in Table 6-2.

Table 6-2 Projected Distribution of Effluent Discharge in Wet Weather

Days/year	1	10	20	30	40	50	60	70	80	90	100	110
Larrakeyah	28	28	28	28	28	28	28	28	28	28	28	25
East Point	60	57	42	32	27	22	17	12	7	3	0	0
overflow	12	0	0	0	0	0	0	0	0	0	0	0
Total, ML	100	85	70	60	55	50	45	40	35	31	28	25

As shown in the table, during wet weather, the discharge through the Larrakeyah outfall generally will be 28 ML/d of secondary effluent. The discharge through the East Point outfall will range from only 3 ML/d or more on 90 days per year to 57 ML/d on 10 or more days per year to a maximum of 60 ML/d on about 8 days per year (this being the capacity of the East Point outfall).

The capacity of the proposed secondary treatment system will be 32 Ml/d in the year 2012 and 40 Ml/d ultimately. In the year 2012, the composition of the discharge through the East Point outfall will be as shown in Table 6-3. A mixture of primary and secondary effluent will be discharged.

Table 6-3 Quality of East Point Effluent Discharge in Wet Weather

Days/year	1	10	20	30	40	50	60	70	80	90	100	110
Secondary	4	4	4	4	4	4	4	4	4	3	0	0
Primary-CAS	10	10	10	10	10	10	10	8	3	0	0	0
Primary-wet	46	43	28	18	13	8	3	0	0	0	0	0
East Point	60	57	42	32	27	22	17	12	7	3	0	0
% secondary	7	8	10	12	15	18	23	33	57	100	-	-

Note: 28 ML/d of secondary effluent to Larrakeyah outfall

The average daily suspended solids load discharged from the East Point outfall in the years 1998 and 2012 is:

Year 1998: 7 ML/d at 65 mg/L = 450 kg/d (dry season)
Year 1998: 20 ML/d at 50 mg/L = 1000 kg/d (wet season, average)

Year 2012: 0.1 ML/d at 10 mg/L = 1 kg/d (dry season)
Year 2012: 20 ML/d at 35 mg/L = 700 kg/d (wet season, average)

There will be a reduction in the load discharged in both the dry season and the wet season. There also will be a 40 per cent reduction in the nitrogen loads discharged through the East Point outfall over the year.

6.6 Normal Operations

Operators will normally be present six days per week, on a day shift basis. The augmented Ludmilla WWTP will operate continuously under automatic control and supervision. An emergency crew will be on standby at all other times.

6.7 Maintenance Requirements

The plant is designed with sufficient standby and backup equipment to operate at all times except in the event of a power failure. The IDAL system can cope with power failures of up to 6 hours. Standby equipment will be operated during maintenance periods.

6.8 Odour Control

As discussed in Section 4.13, a strategy has been developed and is being implemented to control and reduce odour emissions from the Ludmilla WWTP. The strategy involves:

* Pre-aeration (grit removal) tanks to capture odours;
* Soil bed filter to treat odourous air;
* Odourous air can be ducted to incinerator for thermal oxidation;
* Lime dose in the primary tanks to increase pH and reduce hydrogen sulphide emissions to air;
* Low pre-chlorination dose; and
* Ferric dose to control sulphides.

Aeration for the secondary treatment process would be provided by blowers and submerged diffusers, rather than surface aerators, to minimise odour and noise impacts. As noted above, the grit tanks also will be aerated, with the exit air collected and scrubbed in a soil bed filter. Additional air scrubbing equipment is being installed at the Ludmilla WWTP to extract air from the incoming sewer at Ludmilla and treat it in a chemical scrubber.

6.9 Leachate Control

It is not expected that the mangrove mud and old sludge buried at Hudson Creek will produce significant quantities of acid leachate. The situation will be monitored and if necessary leachate could be pumped into an existing clay-lined lagoon at Hudson Creek and neutralised with lime. However no ongoing leachate control measures are anticipated.

6.10 Vehicle Movements

Most major pumping stations would be visited daily and minor pumping stations weekly. Traffic entering Ludmilla WWTP will be:

heavy vehicles	average 0 per day;	peak 1 per day
trucks	average 2 per day;	peak 5 per day
cars	average 15 per day;	peak 35 per day.

As stated in Chapter 4, an improved intersection, with turning lanes, will be constructed in Dick Ward Drive in front of the Ludmilla WWTP to minimise the effects on passing traffic of vehicles turning to enter the WWTP.

7. Terrestrial Environment

7.1 Climate and Atmospheric Conditions

The climate in the Northern Territory can be described as tropical monsoonal. Table 7-1 presents the climatic data for the Darwin Airport (BOM, 1988). The table shows that the year is divided into two distinct seasons, a dry season which typically runs from May to September, and a wet season which runs from November to March. There is usually one to two months of transitional weather.

Table 7-1 Climatic Conditions at Darwin Airport (taken from BOM, 1988)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
9am Temperature												
Mean	28	28	27	27	25	23	22	24	26	28	29	29
3pm Temperature												
Mean	30	30	31	32	31	30	30	30	31	32	32	31
Daily Temperature												
Min	25	25	24	24	22	20	19	20	23	25	25	25
Max	32	31	32	32	33	32	30	30	31	32	33	33
Rainfall, monthly												
Mean	409	353	316	99	17	2	1	6	18	72	142	224
Median	404	336	286	75	2	0	0	0	7	55	139	199
Raindays per month												
Mean	21	20	19	9	2	0	1	1	2	6	12	16

The dry season can be characterised by minimum temperature at night of about 20°C, low to moderate humidity and very little rain or rain days. The mean rainfall during the seven months of the dry season is only 44 mm.

Climatic conditions are quite different during the wet season. The temperatures are higher with little variation, rainfall and humidity are also much higher and the number of raindays can reach up to 21 days in the wettest month.

The annual average rainfall at Darwin airport 1659 mm, almost all of which falls during the wet season. The urban and rural runoff produced by the high rainfall in the wet season has the major influence on water quality in Darwin Harbour (Padovan, 1997). Groundwater levels rise during the wet season, and there is extensive infiltration of groundwater into the sewers, as well as direct inflow of stormwater, which leads to the very high flows observed in Darwin sewers in the wet season (as discussed in Chapter 2).

7.2 Geology and Soils

The Ludmilla WWTP is located on imported fill. The original mud was removed and a gravel pad formed on which to construct the plant. The same approach is planned for the extension of the plant.

The soils along the pipeline routes vary from shallow gravelly and sandy earths and lithosols on the ridges, to deep sandy and silty material in low lying areas. The ridges generally have shallow soils (less than 1 m deep) often comprising gravelly or clayey sand becoming more clayey with depth. latterite is present in many areas, often outcropping on the ridges.

The seabed conditions near the East Point outfall comprises a shallow layer of sand over mud. Geotechnical investigations were carried out to establish subsurface conditions along potential outfall extension alignments. The investigations involved test pits, dynamic cone penetrometer measurements and mud probes along potential outfall alignments.

The seabed was generally flat or slightly undulating, comprising silty sand over silty and marine mud and clay. During periods of low tide, outcrops of siltstone and claystone are exposed along the shoreline. These remnant outcrops form part of the Darwin Member of the Bathurst Island formation of sedimentary rocks.

Three test pits excavated beside the existing outfall encountered silty sand (0.3 to 0.4 m deep) underlain by very soft organic mud (greater than 1 m in depth). The test pits were discontinued due to walls caving in at depths from 1.2 to 1.8 m. Refusal on rock was encountered at all three pits.

Five dynamic cone penetrometer tests were carried out next to the test pits and in the vicinity of the existing outfall. All these tests encountered loose silty sand and soft marine mud/clay in layers down to refusal on the underlying bedrock.

Mud probing was carried out along the nine radial lines from the end of existing outfall. The mud probes generally reached refusal on the shallow underlying rock or on a hard layer of marine clay, at an average of 2.2 m below the seafloor.

The rock base comprises meta-siltstone, claystone, phyllite, minor occasional shale beds and quartzite/meta-sandstones.

The seabed near Larrakeyah outfall comprises mud near the shore with coarser sediments at greater water depths. There are occasional pockets of mobile sand and shellgrit, and sections of hard marine clay above the underlying bedrock.

7.3 Hydrology and Runoff

All the areas of the existing and future Ludmilla plant which are used to store chemicals are bunded. A new bund will be constructed to store the drums of waste oil and diesel used in the incinerator.

All the treatment areas are concrete tanks. The rest of the plant area drains to the mangroves. The drainage area and runoff volume from the Ludmilla treatment plant site are relatively small.

7.4 Noise

There have been no noise complaints arising from equipment at the existing treatment plant. There are no data on background noise levels at sites around the Ludmilla plant, although it is anticipated that the noise due to traffic would be higher than noise due to the plant.

The proposal involves the installation of new mechanical equipment of which the major noise source are the air blowers. These air blowers will be mounted inside a solid concrete building with extensive noise attenuation measures to minimise the level of noise outside the building.

As shown in Figure 7-1, the closest residential zone is 600 m to the southwest of the treatment plant site. This provides sufficient buffer distance to meet Maximum Noise Pollution Levels in Schedule 2 of the Draft Noise Regulations during the construction and operation of the treatment plant.

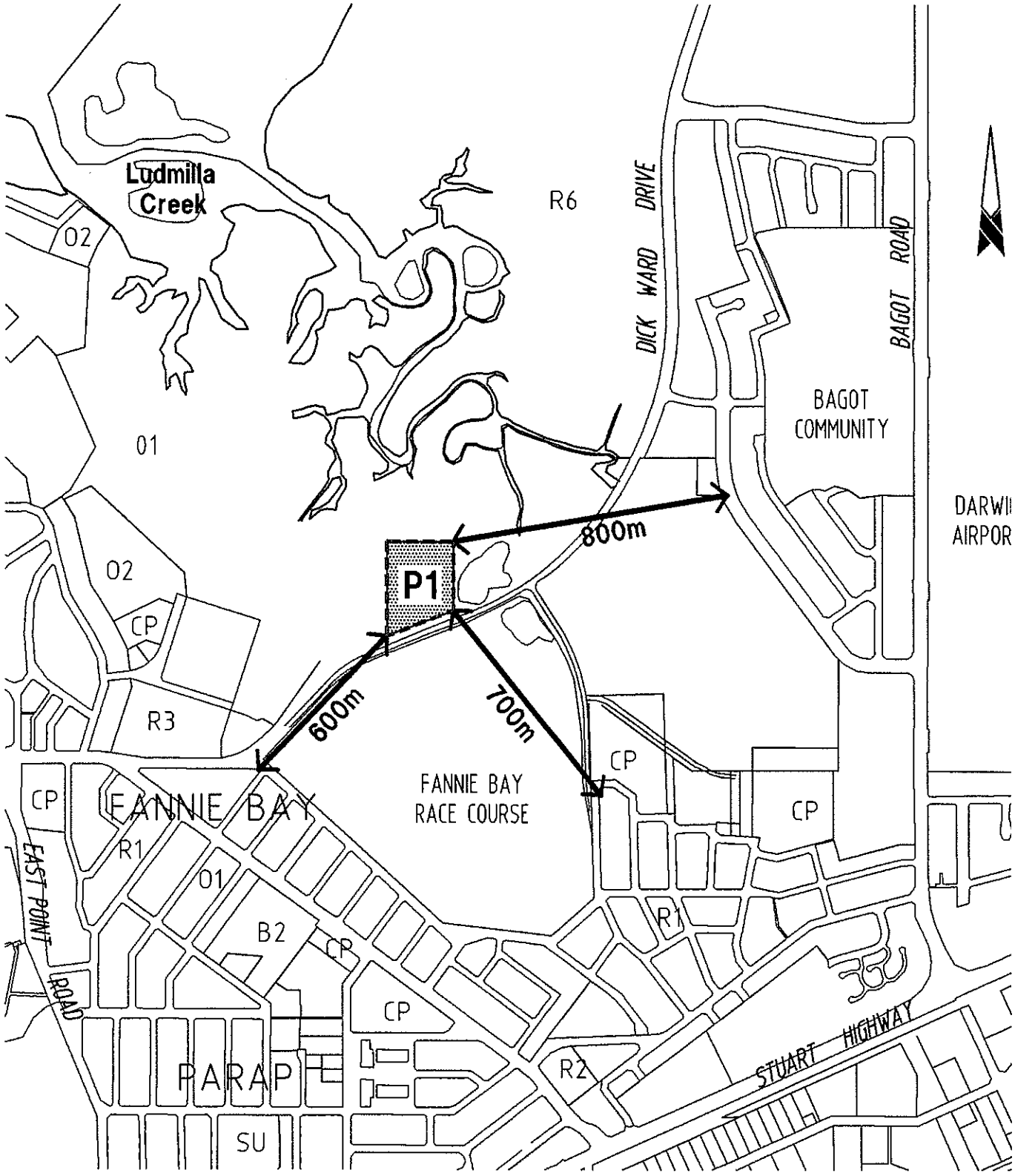
Chapter 10 described the measures proposed to control noise from construction plant used to excavate trenches and install the pipelines.

7.5 Air Quality and Odour

There is an odour problem caused by the existing treatment plant. The odour problem is mostly experienced by persons passing the plant on Dick Ward Drive, although odours have been experienced at the residences to the southwest.

Plans are underway to collect and scrub the incoming gases to reduce the odour problem. Additional odour control measures are part of the proposal, as discussed in Chapter 4, to further reduce odour emissions from the plant.

An incinerator is used to burn sludge at the moment. The quantity of sludge incinerated is very small however emissions to the atmosphere may have slightly elevated constituent levels at times. The proposal involves continuing to use the incinerator to burn sludge; however it will operate for about 40 hours per week instead of 32 hours per week.



P1 Ludmilla WWTP Site

LUDMILLA CREEK CATCHMENT
ZONING PLAN AND BUFFER DISTANCES
Figure 7-1

7.6 Land Planning

Figure 7-1 shows the land planning and zones surrounding the Ludmilla treatment plant. The existing plant is built on land owned by PAWA and zoned for sewage treatment (CP = community purposes).

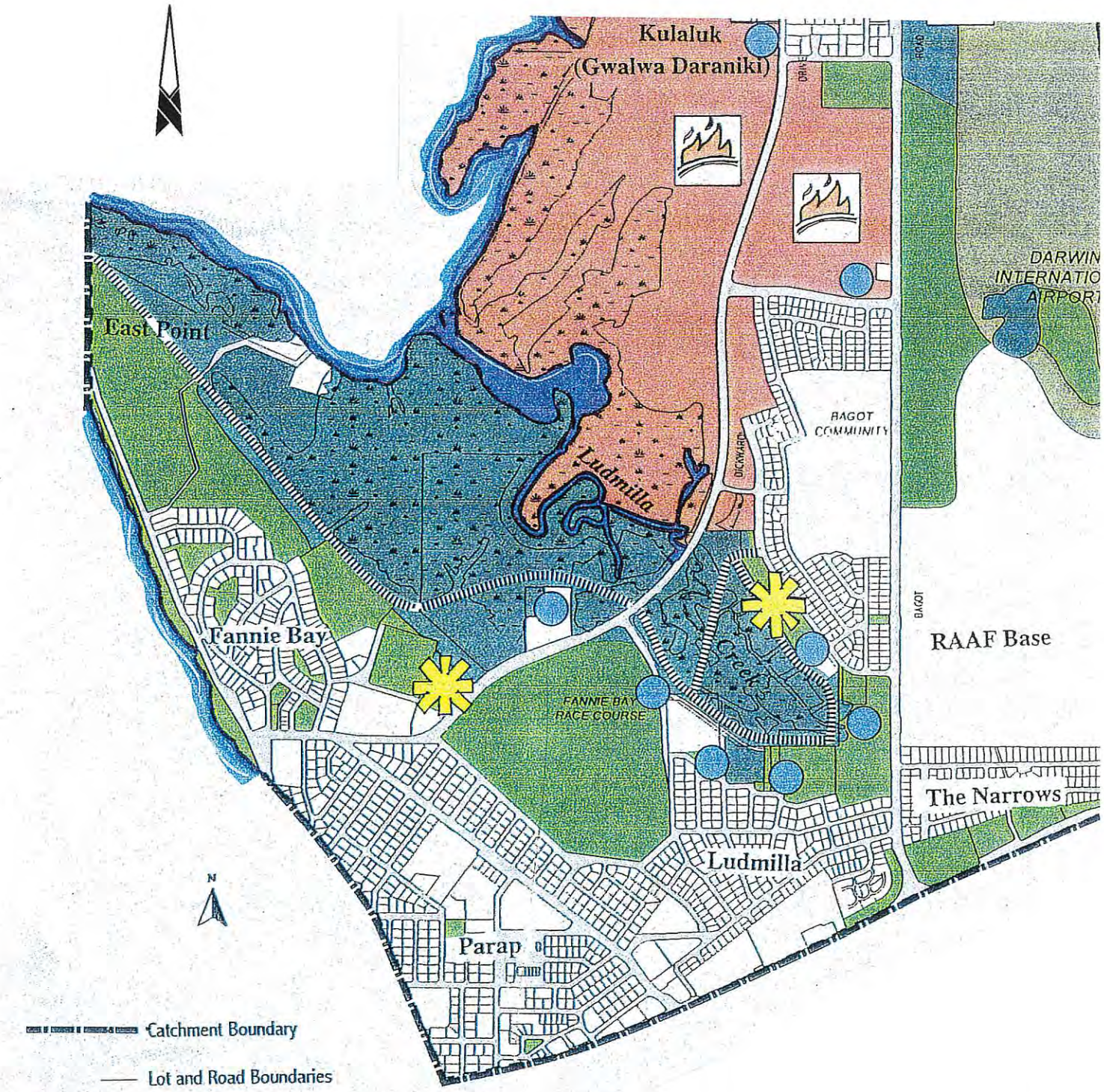
The land surrounding the site has been planned for further expansion of the plant as well as a buffer zone for the plant and open space. The mangroves within the buffer zone will be preserved.

As discussed in Section 1-9, three of the secondary treatment units are to be constructed to the north of the existing site, on cleared land. This land is, however, the subject of two land claims by local Aboriginal groups, and construction of these units will not commence unless and until the land claims have been settled and PAWA has a clear title to the land.

If the event that PAWA does not obtain a title, the additional secondary treatment units could be constructed within the existing PAWA site, but this would involve the destruction of a stand of mature mangroves. The decision of the final location of the secondary treatment modules does not have to be made until 2001.

The Fannie Bay Racecourse is located directly south of the treatment plant site. Residential zones are well separated from the Ludmilla treatment plant, being 600 m to the southwest, 700 m to the southeast and 800 m to the east. Hence there is a good buffer distance between the treatment plant and residential zones for attenuation of noise and odour emissions.

The Ludmilla Creek Landcare Group are currently preparing the Ludmilla Creek Catchment Management Plan. The core of the plan is retain as much as possible of Ludmilla Creek in its natural state. Figure 7-2 shows the concept plan for the Ludmilla Creek. The proposal is consistent with the Landcare Plan and has already been incorporated in the plan. The bike path past the Ludmilla plant could be included in the future development of the plant, although it must be recognized that the path would be very close to the secondary aeration tanks.



Proposed bicycle/walking path. Creates a pedestrian link to the sea and East Point Reserve for residents of Ludmilla and the Narrows. The upper circuit gives access between north and south Ludmilla, a safe route to school for children and exercise circuit. Capacity exists to take short paths or boardwalks off to specific interest spots such as fishing or birdwatching areas.

LUDMILLA CREEK CATCHMENT CONCEPT PLAN

Figure 7-2

7.7 Terrestrial Flora and Fauna

The preferred option for construction of the treatment plant will have no effect on terrestrial flora and fauna since the land has been previously cleared of mangroves.

The pipeline routes are in built up areas and mostly along cleared land, roadsides and grassed reserves. Hence terrestrial fauna is not an issue for pipeline construction. However, there are locations where substantial tree specimens will be affected by removal or nearby trenching. Significant trees along the pipeline route are at:

* Dick Ward Drive where a proportion of the black wattles (*Acacia auriculiformis*) will be removed;

* In the park opposite Lampe Street and East Point Drive where three *Ficus benjamina* will be removed;

* East Point Drive near Conacher Street where a substantial milkwood tree (*Alstonia actynophylla*) remains and will be preserved from any affect of the proposal; and

* Gilruth Avenue where some trees will be removed and replacement trees planted after construction.

The whole of the pipeline route was inspected for significant flora in conjunction with the Darwin Council botanist. As a result, the pipeline route was modified to avoid significant vegetation. The few trees along the pipeline route which will be removed will be replaced with suitable species on completion of construction of the pipeline. The trenches will be replanted using local grasses and shrubs similar to those which occur at present.

8. Marine Environment

8.1 Topography

Beagle Gulf and Darwin Harbour have extensive intertidal mudflats, deep channels, sand bars, gently sloping basins, rocky reef and island outcrops and shallow mangrove creeks and inlets. The seafloor comprises a mosaic of fine silts and muds, sand, coral rubble, coarse gravel and rock outcrops.

The outlet at East Point extends 700 m north-northwest from the shore into the shallow Ludmilla Bay on Beagle Gulf. Effluent discharges through an outlet on the seafloor at 2.2 m below mean sea level. Hence the outlet and most of the seabed in Ludmilla Bay is exposed at low tides.

The seabed offshore to the north and east of the outfall is mostly flat to gently sloping fine silts (Figure 8-1). Rock outcrops along most of the shoreline west of the outfall. The shoreline further east becomes mangrove forest which continues into Ludmilla Creek. Ludmilla Creek is a shallow tidal stream lined with mangrove forest.

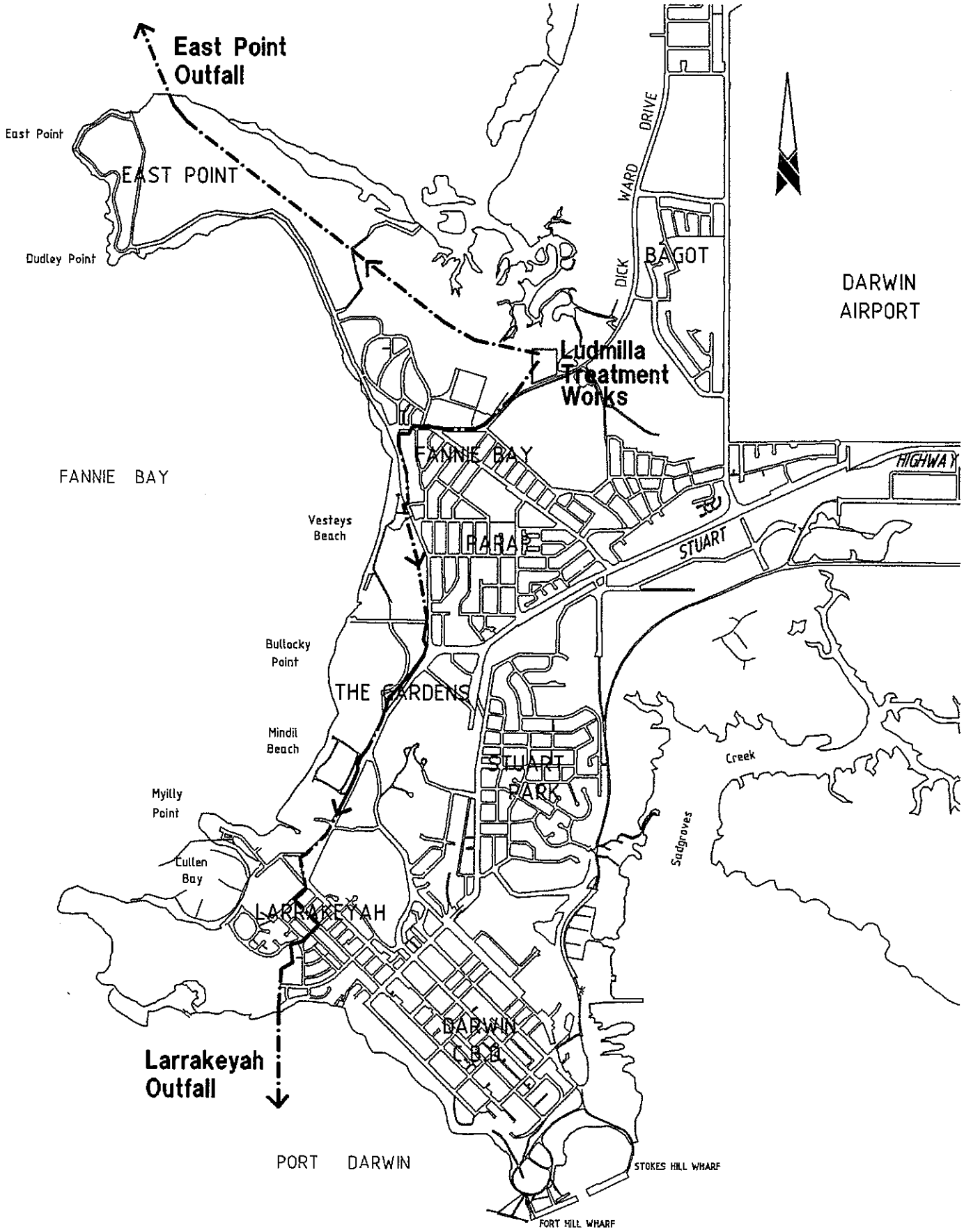
The Larrakeyah outfall extends 850 m southward from the base of the cliff at Larrakeyah into the main channel of Darwin Harbour. The outfall pipeline extends from the cliff base over approximately 200 m of intertidal mudflat and then follows the gravel seabed down to 20 m depth. The seabed south and east of the outfall is soft sediments. Bennett Shoal is 500 m west of the outfall (Figure 8-1).

8.2 Tides and Currents

Darwin Harbour and Beagle Gulf have a very large tidal range which generates strong tidal currents in the main channels. The predominantly semi-diurnal tides in the Harbour have a mean spring tidal range of 5.5 m, but can range up to 8 m.

Currents and effluent dispersion were measured at East Point in 1976 and 1994 (CCE, 1976; NTU, 1995). The tests showed that currents passing East Point generally flowed to the north on the falling tide and to the south on the rising tide. the projection of East Point into the tidal flow causes eddies which circulate in Ludmilla Bay during the ebb tide.

Current speeds at the East Point outfall range from 0.05 to 0.2 m/s, with much stronger currents in the deeper channels. Dilution and dispersion from the outfall depend on the tide, because of the shallow nature of Ludmilla Bay, with low dilutions at low tide when there was little water in the Bay.



LOCATION OF EAST POINT AND LARRAKEYAH OUTFALLS

Figure 8-1

Currents in the main channel and arms of Darwin Harbour are tidal with strong currents flowing into the harbour during the rising tide and out of the Harbour on the falling tide. Peak current speeds of 1.8 m/s (3.6 knots) were measured in Middle Arm (CCE, 1983). Larrakeyah outfall is located on the north side of the main channel where currents speeds are reduced compared to the centre of the channels of the Harbour. However currents are still strong in the vicinity of the outfall with speeds of approximately 0.6 m/s (Acer Vaughan/CEE, 1993, NTU, 1995).

8.3 Water Quality

Water quality in the region is strongly affected by regular, tidal exchange of large proportions of the Harbour waters with the waters of Beagle Gulf and the Arafura Sea. A summary of water quality in Darwin Harbour from October 1990 to November 1991 (Padovan, 1997) is shown in Table 8-1. The waters of the Harbour and Gulf are tropical, with a temperature range between 26°C and 31°C. Turbidity in the Harbour is high due to suspension of fine silts from the extensive intertidal mudflats. The turbidity decreases (water is generally clearer) beyond the Harbour, but high turbidity is measured near East Point and in Ludmilla Bay (Wolstenholme et al. 1997).

The salinity in the harbour at the end of the dry season is 35 ppt (parts per thousand). Freshwater runoff during the wet season affects water quality in rivers and creeks and reduces the salinity in the Harbour from approximately to less than 28 ppt during the wet season. Seasonal variation in runoff also affects the input of nutrients to the Harbour.

Ammonia and total nitrogen concentrations are generally elevated in Darwin harbour, although no higher near the outfalls than at reference stations elsewhere in the Harbour (Parry and Munksgaard, 1997). Chlorophyll concentrations throughout the harbour (see Table 8-1) and the adjacent coastal waters are low indicating a low standing crop of phytoplankton.

8.4 Marine Biological Habitats

The marine biological habitats around Darwin are diverse and include mangroves, mudflats, intertidal rocky reefs, subtidal rock/coral reefs, and soft seabeds ranging from fine silts to coarse gravel (Acer Vaughan/CEE, 1993). The reefs in the Harbour and at East Point provide habitat for rich and unusual fish, invertebrate and algal assemblages. Aquatic Life Reserves were proclaimed at East Point, Doctors Gully and Channel Island in recognition of particularly rich or unusual marine biological features at those locations.

Table 8.1 Water Quality in Darwin Harbour 1990-91 (From Padovan 1997)

Water Quality Measure*	Units	Harbour Location	Number of samples	Percentiles						
				Min	10	25	Median	75	90	Max
Temperature	°C	all	108	24.9	25.9	27.5	29.6	30.8	31.2	32.0
Salinity	ppt	all	107	26.9	30.6	33.2	35.2	35.9	36.2	36.8
pH	pH units	all	108	8.3	8.4	8.4	8.5	8.5	8.6	8.7
Dissolved oxygen	mg L^{-1}	all	108	4.55	4.87	5.10	5.40	5.66	5.81	6.50
Dissolved oxygen	% saturation	all	108	74	78	81	85	87	90	96
Silica	mg/L SiO_2	all	313	0.10	0.30	0.40	0.50	0.60	0.71	1.10
Ammonium	mg L^{-1} - N	all	308	<0.001	0.005	0.005	0.005	0.010	0.020	0.180
Nitrate/nitrite	mg L^{-1} - N	all	314	<0.001	0.001	0.003	0.007	0.011	0.017	0.099
TKN	mg L^{-1} - N	all	315	<0.05	0.16	0.21	0.31	0.44	0.56	1.98
Total nitrogen	mg L^{-1} - N	all	317	<0.05	0.16	0.22	0.32	0.44	0.57	2.00
Reactive phosphorous	mg L^{-1} - P	all	314	<0.001	0.002	0.004	0.005	0.007	0.008	0.015
Total phosphorous	mg L^{-1} - P	all	314	<0.001	0.010	0.012	0.014	0.017	0.020	0.046
Faecal coliforms	per 100 mL	all	67	0	0	0	0	2	12	32
E. coli	per 100 mL	all	126	0	0	0	0	0	1	9
Enterococci	per 100 mL	all	123	0	0	0	0	1	6	140
Plate Count Organisms	permL	all	63	0	3	8	95	315	640	2600
Turbidity	NTU	inner	207	1.5	2.6	3.7	5.5	11.0	19.0	41.0
		outer	107	1.1	2.3	3.1	4.1	5.8	9.4	29.0
Total suspended solids	mg L^{-1}	inner	207	1	3	4	6	10	18.8	59
		outer	108	0.5	2	3	4	6	10	24
Volatile suspended solids	mg L^{-1}	inner	208	1	1	1	2	3	3.7	13
		outer	108	0	1	1	2	2	2	4
Euphotic depth	meters	inner	70	3.0	3.8	5.5	8.2	10.0	10.9	14.2
		outer	36	3.7	7.0	9.6	13.2	14.2	16.3	24.2
Chlorophyll a	ug L^{-1}	inner	208	0.2	1	1.2	1.5	2	3.17	5.5
		outer	108	<0.01	0.4	0.6	0.8	0.9	1.4	5.5

Summary statistics of Darwin Harbour water quality during the 1990-91 survey period (harbour location: "all" indicates data from all sites were pooled, "inner" indicates sites 6 and 7 pooled and "outer" indicates sites 2, 3, 4, 5 and 12 data pooled).

8.4.1 East Point

Marine habitats in the vicinity of the East Point outfall include mudflats, intertidal reefs and mangroves (Figure 8-2, from Hooper). The outfall is located on mudflats, with mangroves to the east and rock to the west.

The fauna of the intertidal and subtidal mudflats around Darwin are generally sparse (CCE, 1983; CCE, 1986: Hanley, 1987). The abundance and diversity of the intertidal infauna generally increases towards the low tide mark and fauna are generally more abundant in areas of higher organic content (Hanley, 1987). There is no specific information on the composition of infauna near the East Point Outfall (Hanley et al, 1997), but there may be an increase in infaunal abundance in the close proximity of the outfall.

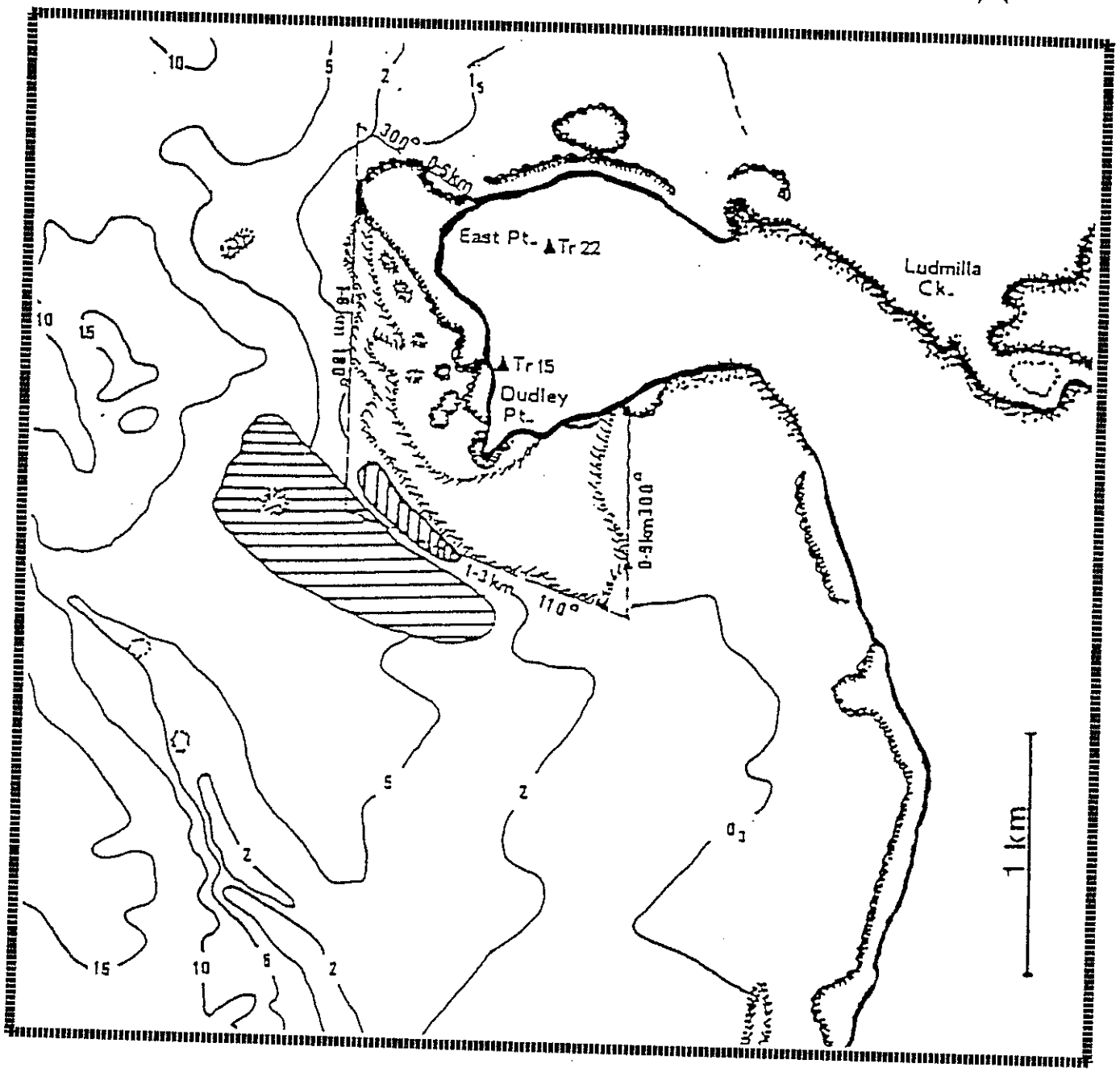
Mangroves become increasingly abundant in the upper intertidal zone eastward of East Point outfall to become a complex mangrove forest at Ludmilla Creek. While there is no information available on mangrove communities at Ludmilla, studies of mangroves and associated burrowing invertebrate aquatic fauna (infauna) at Buffalo Creek (Hanley, 1997) concluded that the discharge of effluent increased productivity and growth of mangrove trees. The effluent discharge to Buffalo Creek decreased the species richness of associated aquatic invertebrates but increased the abundance of aquatic invertebrates which is a usual response of infauna to organic inputs. It is not expected that the effluent discharge from the existing East Point outfall has any detectable effect on the mangroves of Ludmilla Creek.

Rock outcrops to the west of the outfall initially occupy the upper intertidal zone, and have a sparse fauna of hardy invertebrate species. Further towards the west of East Point, rock becomes more abundant over the intertidal zone and extends subtidally.

East Point Aquatic Life Reserve

The northeastern boundary of East Point Aquatic Life Reserve is 400 m west of the outfall. Mr Warren Low Choy and his students at the Darwin Community College recognized that intertidal marine biological assemblages in the area of East Point and Dudley Point were threatened by collectors in the early 1980's. The area was reserved in 1984. The Reserve was expanded by 175 ha to 265 ha in 1992 to include the subtidal sponge and tunicate gardens around Dudley Point as a response to proposals by the Northern Territory Museum.

In the East Point Aquatic Life Reserve, the lower intertidal rocks and coral rubble on Dudley Point (the southwest corner of East Point) provide habitat for a rich association of corals, sponges and fishes. The coral heads, and sea whip, sponge and gorgonian gardens on the subtidal rocks and gravel are considered to be particularly rich (Hooper 1987, Wolstenholme et al. 1997).



EAST POINT AQUATIC LIFE RESERVE AND MARINE HABITATS

Figure 8-2

Approximately 300 species of sponge are known from the area, and 20 of these species were new species discovered in the East Point Aquatic Reserve (Hooper et al, 1997). Over 50 species of tunicates are present in the Aquatic Reserve. More than 100 species of echinoderms are present including sea stars, sea urchins, brittle stars and sea cucumbers.

The NT Museum described 415 fish species in the Darwin region, with the dominant four families considered to be "coral reef" families (Larson and Williams, 1997). More than 100 of the 415 species have been catalogued for the East Point Aquatic Reserve, although it is likely that considerably more species are actually present. Common fish include gobies, pipe fish, cardinal fish, damsels, butterfly fish and clown fish.

A total of 123 species of hard coral are known from the Darwin region, and while corals are well represented at East Point, they are less rich than those at Lee Point and Old Man Rock to the northeast of East Point (Wolstenholme et al, 1997). Turbidity, sediment and light transmission are major factors affecting the vertical distribution of hard corals and as a consequence, most hard corals are restricted to a narrow, 6 m vertical band in Beagle Gulf and Darwin Harbour.

Most hard corals are found between 2 m and 8 m below mean sea level (CCE, 1983, Wolstenholme et al, 1997). Some species such as Turbinaria are also found at greater depths, among the seawhips, sponges and gorgonians.

During falling (ebb) tides, effluent from the East Point Outfall generally travels to the north, away from the East Point Aquatic Reserve. However during flood (inflowing) tides, the diluted effluent field from the outfall is carried through the Aquatic Reserve.

According to the results of dye dispersion experiments carried out by NTU, there is substantial dilution and dispersion of effluent before it reaches the Reserve. Hence exposure to effluent (which is a function of effluent quality, concentration, frequency of contact and duration of contact; see Chidgey and Edmunds 1998) is low and it is not expected that the existing outfall discharge has a detectable effect on marine biota within the East Point Aquatic Life Reserve.

8.4.2 Larrakeyah

There is very limited information available on marine biological communities near the Larrakeyah outfall.

Doctors Gully Aquatic Life Reserve

The Doctors Gully Aquatic Life Reserve is located between the high and low tide marks immediately inshore of the Larrakeyah outfall. The area at Doctors Gully was originally reserved in 1971 to protect fish which aggregate at the fish feeding facility. The area of the Aquatic Reserve increased over the years, and the present area is 14 ha (based on the 1992 definition of the boundaries of the Reserve).

A wide range of fish species aggregate by the shore at high tide where they are regularly fed bread and minced meat. Fish which aggregate include milkfish, mullet, catfish, bream, batfish, garfish, cod, shovelnose ray, and blue-spotted stingrays. Predatory barramundi, queenfish, trevally and mackerel are also sometimes attracted to the area by the aggregation of smaller baitfish.

The Larrakeyah outfall is located in 20 m water depth approximately 500 m offshore of the low tide boundary of the Reserve. There are no available records on the seabed composition or associated marine biological communities around the outfall.

Computer modelling shows there is high initial dilution (averaging 240:1) of the effluent discharged from the outfall at 20 m depth and rapid dispersion in the strong tidal currents. Consequently the effects of the effluent discharge on the marine biota are expected to be very small close to the outfall and are probably undetectable at the Doctors Gully Aquatic Life Reserve.

8.4.3 Ludmilla Creek

Ludmilla Creek is a shallow mangrove-lined creek with a large intertidal zone and a small catchment. The mangroves in Ludmilla Creek are locally significant by providing a substantial area of mangrove and wetland community close to urban Darwin.

Much of the catchment of Ludmilla Creek is urban, and includes Ludmilla, Coconut Grove, and the Narrows as well as parts of Parap, Fannie Bay, Millner and Nightcliff. Parts of the mangrove area have been drained, cleared or infilled. For example, Minmarama Park occupies the site which was previously the Darwin landfill. The Ludmilla STP occupies cleared and filled mangrove wetland.

Freshwater flows in the creek are mostly during the wet season, and urban runoff from the largely urbanised catchment is a concern. Litter and a wide range of chemical soluble contaminants are typical in runoff from urban catchments. Accumulation of sediment runoff is a particular concern for mangroves.

8.5 Effect Of Discharges On Marine Environment

In 1995, a thesis was prepared at NTU by C.M. Moir titled "The Effect of Sewage Discharge on the Water Quality of Darwin Harbour and Buffalo Creek". The summary of this thesis provides a good picture of existing water quality and the effect of the existing discharges on the marine environment.

The aim of this project was to determine the effects on the water quality of sewage receiving waters in Darwin Harbour and Buffalo Creek. In order to assess the impact the following parameters were determined.

* *Physico-chemical - Salinity - Temperature, DO, pH and turbidity*

* *Nutrients and Productivity - total and dissolved phosphorus, orthophosphate, nitrate, nitrite and ammonia. Total and dissolved inorganic carbon and organic carbon; PAR and total chlorophyll.*

* *Organochlorine Pesticides - including DDT, DDE, aldrin and dieldrin*

* *Heavy Metals and As - Dissolve (<0.45um), particulate (>0.45um) and sediment Zn, Cu, Cd, Pd and As*

Seawater and sediment samples were collected from 13 sites and two control sites in Darwin Harbour and Buffalo Creek. Nutrient samples were collected, during both the wet and dry seasons. Total organic and inorganic carbon, chlorophyll and PAR were measured during the dry season and heavy metals and As were measured during the wet season only.

Distinct differences were observed between the results obtained for the Harbour sites and the Buffalo Creek sites. Darwin Harbour receives direct input of sewage effluent from four outfalls: Palmerston, Berrimah, Larrakeyah and East Point, while Buffalo Creek receives effluent from Leanyer/Sanderson.

Comparisons between impacted and control sites in the Darwin Harbour for pH, DO, turbidity, salinity and temperature indicated that seasonal and tidal influences had a more obvious effect on these parameters than the input of sewage at all sites. Nutrient concentrations were below detection limits for all but ammonia during the wet season and ammonia and nitrate during the dry season. The concentrations of nutrients in the sewage samples were several orders of magnitude greater than those in the receiving waters.

These large dilution factors observed for all nutrients analysed, indicate rapid mixing of the effluent discharge with the water column and extreme tidal flushing. As the Harbour control site, Weed Reef, also contained measurable amounts of ammonia during the wet and dry season sampling, it may be concluded that the ammonia concentrations measured in the potentially impacted sites were actually background levels. All seawater nutrient concentrations measured were below the ANZECC (1992) recommended limits for nutrients in seawater.

Total chlorophyll and carbon concentrations measured during the dry season showed only a small variance between all the sites in the Darwin Harbour. This uniformity, coupled with the large tidal attenuation during sampling, indicated that there was no build up of carbon and chlorophyll during a spring tidal cycle. PAR values were high during the dry season indicating the light penetration was not limiting. Thus despite sewage effluent inputs it would appear that nutrients, particularly phosphorus and nitrogen, are the limiting factors for algal growth in the Harbour.

Total concentrations (sum of dissolved and particulate) of Zn, Cd, Cu, Pd and As in the receiving waters were below the ANZECC (1992) recommended limits for saline waters. The highest concentrations of heavy metals were measured at LMP however the depth of the outfall and the large tidal flushing experienced by the Harbour effectively dilutes the metal concentration upon discharge. Sediment concentrations of metals and As were within the range of concentrations reported for other studies in Darwin Harbour (Parry and Munksgaard 1994) including non-impacted areas.

It may be concluded that there has been no significant impact from sewage on receiving waters in Darwin Harbour with respect to physico-chemical parameters, nutrients, productivity and heavy metals and As within the seasonal and tidal variation

9. Cultural and Socio - Economic Environments

9.1 National Estate

The proposal does not involve any areas nominated for listing or listed on the Register of the National Estate or the Interim list of the Register of the National Estate.

9.2 Sacred Sites

In accordance with the requirements of the *Aboriginal Sacred Sites Act 1989*, advice on the location of Registered Sacred Sites which may be affected by the proposal was obtained from the Aboriginal Affairs Protection Authority. The Authority advised on 26 June 1998 that there are no Registered or Recorded Sites within the area affected by the proposal.

9.3 Heritage Sites

In accordance with the requirements of the *Heritage Conservation Act 1991* advice on the location of heritage sites which may be affected by the proposal was obtained from Lands Planning and Environment. The Heritage Conservation Branch advised on 29 June 1998 that no sites are directly affected or will be impacted. The Australian Heritage Commission advised on 17 September 1998 that the sewer pipeline passes near the Palmerston Cemetery; however this site will not be impacted by the proposal.

9.4 Areas with Special Values

The whole of the coastal foreshore including the section occupied by the Ludmilla WWTP is part of the Darwin foreshore heritage. It is desirable to retain the mangroves and associated flora and fauna (including bird) in their natural state. The proposal will not effect this objective.

The wastewater, effluent and reclaimed water pipelines will be below the ground in trenches excavated on roads or is pipeline easements beside roads. Pipeline construction with take place near many areas with special values: Fannie Bay Gaol, Mindil Beach, Botanic Gardens, Northern territory Museum, but will not alter or have lasting impact on these areas.

There are two Aquatic Life Reserves relevant to the proposal; (1) the East Point Aquatic Life Reserve, and (2) the Doctors Gully Aquatic Life Reserve. The Reserves are protected and managed under the *Northern Territories Fisheries Act 1988.*

East Point Aquatic Life Reserve is 400 m west of the Ludmilla effluent outfall. The marine biological communities in the Reserve are discussed in Chapter 8. The issues, potential impacts, mitigation and safeguards relating to the East Point Aquatic Life Reserve are discussed in Section 10.8 and 10.22.

Doctors Gully Aquatic Life Reserve is 300 m north of the Larrakeyah effluent outfall. The marine biological communities in the Reserve are discussed in Chapter 8. The issues and potential impacts relating to the Doctors Gully Aquatic Life Reserve are discussed in Section 10.8.

9.5 Landscape and Visual Aspects

The present Ludmilla WWTP is landscaped where it faces Dick Ward Drive and presents an generally unobtrusive but low key industrial appearance. The expansion of the plant will be to the north, away from the road, and hence will not alter the viewed appearance of the site.

The mangroves to the west, north and east screen the Ludmilla plant from view. The proposed new tanks and buildings have a low profile and will not be visible above the mangroves, or from boats using Ludmilla Creek, and will not alter the appearance of the plant.

The pipelines will be buried and will not have any long term visual effect.

The use of reclaimed water on parks and gardens may lead to greater vegetation cover and growth and hence soften the urban landscape to some extent.

9.6 Tourism and Commercial Aspects

The Ludmilla Creek Catchment Management Plan states that tourism in the Ludmilla Creek area could generate unacceptable levels of traffic and infrastructure that could impact upon the natural values of the area. Therefore access should be limited to pedestrians and cyclists.

9.7 Recreational Aspects

The Ludmilla Creek Catchment Management Plan states that present recreational use of the Ludmilla Creek area is predominantly low key passive use that relies to a large extent on the natural character of the area. It is proposed to construct a bicycle path past the Ludmilla plant, which could cause a conflict unless designed sensitively.

10. Environmental Impacts and Mitigation Measures

This chapter sets out the impacts of the proposal on the biophysical, cultural and socio-economic environment during both construction and operation. The impacts are addressed under the following headings:

1. Land Planning
2. Runoff
3. Noise and Vibration
4. Air Quality and Odour
5. Acid Sulphate Soils
6. Terrestrial Flora and Fauna
7. Sedimentation and Erosion Control
8. East Point Outfall Region
9. Larrakeyah Outfall Region
10. Ludmilla Creek Region
11. Waste Minimisation
12. Sacred Sites
13. Heritage Sites
14. Traffic Issues
15. Landscape and Visual Aspects
16. Tourism and Commercial Aspects
17. Recreational Aspects
18. Community Health
19. Greenhouse Gases.

In each section, the goal is presented, followed by the assessment of impacts and then the description of safeguards proposed to prevent, minimise or ameliorate environmental impacts.

The mitigation measures and safeguards are summarised near the end of the chapter. Implementation of the safeguards will be managed through the preparation and use of Environmental Management Plans (EMPs) for both the construction and operations phases. The EMPs will provide:

* Details of the proposed safeguards and management measures;
* Procedures for applying safeguards;
* Procedures for implementing remedial actions for impacts not originally predicted;
* Measurement of environmental quality and any impacts; and
* Periodic auditing and review.

The EMPs will be prepared during the detailed design phase and prior to commencement of construction. They will be prepared and implemented to the satisfaction of the Department of Lands, planning and Environment.

The discharge of effluent is subject to licences issued under the *Water Act 1992* which specifies various limits and requirements including monitoring.

10.1 Land Planning

Issue

The goal is to carry out the project in accordance with land use zoning and planning, and in a manner consistent with present and future land use.

Impact Assessment

The various aspects of the proposal do not cause any conflicts with present or future land use planning. All existing facilities (Ludmilla WWTP, Larrakeyah outfall, East Point outfall) will be kept in use with the proposal, but will be augmented or improved.

The proposal is compatible with the future land use plan prepared by Lands, Planning and Environment, and also with the Ludmilla Creek Catchment Management Plan prepared by the Ludmilla Creek Landcare Group. No changes to zoning or land use are required.

The pipelines will be constructed under roadways or in easements on open space. The construction will be a short term activity and will not alter land use or zoning.

The augmented treatment plant will be constructed at Ludmilla. The first module of development will take place within the existing site area owned by PAWA and zoned for sewage treatment (CP = community purposes).

The land surrounding the site has been zoned and planned for further expansion of the plant as well as a buffer zone for the plant and open space. The mangroves within the buffer zone will be preserved.

As discussed in Section 1-9, three secondary treatment units are planned to be constructed on cleared land to the north of the existing site. This land is, at present the subject of two land claims by local Aboriginal groups, and construction will not commence unless and until the land claims have been settled and PAWA has a clear title to the land. In the event that PAWA does not obtain a title, the additional secondary treatment units could be constructed within the existing PAWA site, but this would involve the removal of a stand of mature mangroves.

Mitigation Measures and Safeguards

The proposal is in accordance with existing zoning and future planning. No specific mitigation measures are required.

10.2 Runoff

Issue

The goal is to minimise the volume and impact of sediment in runoff occurring during:

* construction of trenches and pipelines;
* construction of pumping stations;
* upgrading of Ludmilla treatment plant; and
* operation of expanded Ludmilla WWTP.

Impact Assessment

There is potential for localised runoff from construction areas during periods of rainfall and for subsequent runoff to arise from pumpout of trenches and excavations. Controls will be applied as part of the EMPs for construction to minimise these impacts (see below).

There should be minimal runoff from the Ludmilla site during operations as rainfall is directly into concrete tanks where it is treated as part of the flow. All potentially contaminated areas are bunded or drain back through the treatment processes.

Mitigation and Safeguards

Safeguards which can be applied to minimise impacts due to contaminated runoff areas follows:

* Carry out excavation and pipeline installation as much as possible during the dry season;

* Limit the excavated/disturbed area and revegetate, backfill or seal the surface soon after excavation;

* Store all chemicals and fuel within bunds, and provide bunds around loading and transfer areas;

* Limit the time and duration of the construction period; and

* Where appropriate, install silt fences or sediment traps to capture sediment.

These safeguards will be incorporated as part of the sediment control procedures in the EMPs for construction.

10.3 Noise and Vibration

Issues

The goal is to construct the pipelines and augment the treatment plant, and operate the system, without causing a noise nuisance, and in accordance with of the Draft NT Noise Regulations attached to the draft Waste Management and Pollution Control Bill.

Key aspects for which noise (and vibration) need to be considered are:
* Construction of pumping stations and excavation of pipeline trenches;
* Construction of treatment plant;
* Operation of pumping stations; and
* Operation of treatment plant, including traffic to treatment plant.

Impact Assessment

Much of the length of pipeline trenches is in soft ground or well away from residential and commercial buildings. Noise and vibration should not be a problem in these areas.

Part of the pipeline construction (by Fannie Bay Gaol, near Darwin High School, near Lambell Terrace) is hard rock which will require a rockbreaker. Blasting will not be used. Large rockbreakers will not be permitted to operate within 20 m of residences or masonry buildings. Care will be needed during excavation through the CBD to ensure that the construction does not cause a noise and vibration nuisance in offices and commercial buildings.

Pumping stations and pipeline routes will be adjacent major roads. Construction will be in normal working hours (8 am to 5 pm, five days/week). Hence noise from construction will be against a background of daytime traffic and activities. There will be no construction noise at night.

Construction at the Ludmilla plant will not cause a noise problem as the ground is soft and only minor trimming of the basement rock will be needed.

Pumping stations will be fitted with submerged pumps and vertical shrouded ventilation discharges. Hence the operation of pumping stations is not expected to cause any noise problems.

Noise from the existing Ludmilla WWTP has not to date caused a problem to adjacent residences. This is due to the generally low noise emissions from the plant and the large existing buffer zone: the nearest residences are 600 m to the southwest, 700 m to the southeast, and 800 m to the east. The proposals will make little change to noise emissions and retain the buffer zone.

The proposal involves the installation of new mechanical equipment at Ludmilla WWTP of which the major noise source is the air blowers. To control noise emissions, the air blowers will be mounted inside a solid concrete building with noise attenuation measures to minimise the noise level outside the building.

The closest residential zone is 600 m to the southwest of the treatment plant site, which provides sufficient buffer distance to meet the Maximum Noise Pollution Levels listed in Schedule 2 of the Draft NT Noise Regulations during the construction and operation of the treatment plant.

Traffic to the treatment plant will include operators vehicles, chemical delivery trucks and one or two trucks a day to remove screenings, grit and solid waste to landfill. The effect of the additional traffic on noise emissions, in the context of the existing traffic level on Dick Ward Drive, is negligible.

Mitigation Measures and Safeguards

To control and minimise noise and vibration impacts of the proposal, the following recommendations will be included in the EMPs for construction and operation:

* Construction of pipelines near residences will be restricted to daytime hours; night time construction may be required near offices;

* Blasting will not be permitted;

* Large rockbreakers will not be permitted to operate within 20 m of residences and masonry buildings;

* The Ludmilla WWTP augmentation will be designed to minimise noise emissions. Plant and equipment will be fitted with silencers and acoustic enclosures as required to meet the regulatory noise limits;

* Submerged pumps and shrouded ventilation outlets will be used at pumping stations: the station buildings will be constructed of noise deadening materials;

* The public will be kept informed on the timing (and a contact person) for pipeline construction in their locality; and

* A complaints register will be kept to monitor noise and traffic complaints during construction and operation. The cause of complaints will be investigated and appropriate steps will be taken to ensure the causes are not repeated.

10.4 Air Quality and Odour

Issue

The goal is to operate the system, including wastewater pipelines, treatment plant and outfalls, without causing an odour nuisance, and in accordance with statutory environmental requirements concerning air quality.

Key aspects for which odour aspects need to be considered are:
* Odour from sewage pump stations;
* Odour from mud and sludge at Ludmilla WWTP during construction; and
* Odour from augmented treatment plant when operating.

Impact Assessment

Odour is not an easy problem to solve in the context of the high temperatures of wastewater in Darwin, which cause rapid decomposition of the organic content, depletion of dissolved oxygen and generation of odours.

To date, odour problems in sewers have been controlled by sealing vents and high chemical doses (generally of chlorine). Although successful in reducing odours, these practices lead to dangerous working conditions in access pits and produce chlorinated byproducts, as well as limiting the future effectiveness of biological secondary treatment.

PAWA is developing a comprehensive new odour control strategy which will control odour emissions from sewers and pumping stations, including the new wastewater pumping stations constructed as part of this proposal. The strategy is expected to involve:

* Addition of oxygen to control sulphide formation;

* Addition of iron salts to capture sulphides;

* More sophisticated control of pumps (and hence reduced residence times) to reduce odour formation;

* Package oxygenation plants at key locations (eg, possibly at the Coconut Grove pumping station); and

* Control of infiltration of stormflow into sewers so that pumps can be better matched to dry flow conditions.

Odours from Ludmilla WWTP

There is an odour problem caused by the existing treatment plant. The odour problem is mostly experienced by persons passing the plant on Dick Ward Drive, although odours have been experienced at residences to the southwest. A scrubber system is being installed at the existing plant to capture and scrub air from the incoming sewers to reduce odour releases. In addition, the furnace is now used to burn air from the solids handling system thereby reducing odour emissions from the vacuum filters.

Additional odour control measures which will be incorporated into the proposal to control odour emissions from the augmented Ludmilla WWTP are:

* Pre-aeration (grit removal) tanks to capture odours;

* Soil bed filter to treat odourous air;

* Odourous air can be ducted to incinerator for thermal oxidation;

* Lime dose in the primary tanks to increase pH and reduce hydrogen sulphide emissions to air; and

* Aerators in the wet weather sedimentation tank.

The overall effect is expected to be a substantial reduction in odour emissions so that the plant is not noticeable, in an olfactory manner, to passing motorists.

Odours During Construction

As discussed in Section 4-13, there will be a local odour problem during excavation of the mangrove mud at Ludmilla WWTP; this episode is expected to persist for about 3 weeks. The principal mitigation measures are to minimise the duration of excavation and to ensure all excavated material is rapidly carted from the site.

An odour masking system will be operated as necessary during the excavation period to reduce the odour impact. The mud will be kept wet and carted in covered trucks.

Mitigation Measures and Safeguards

To control and minimise odour impacts of the proposal, the following recommendations are made:

* Completion and implementation of the PAWA odour control strategy for wastewater sewers and pumping stations, including as many as feasible of the controls listed above;

* Continued operation of the odour scrubbing system for incoming air;

* Inclusion of the odour control measures listed above in the design of the augmented Ludmilla WWTP, including aerated grit removal tanks, soil bed filter, foul air ducting to the furnace, lime dose in the primary tanks to increase pH and reduce hydrogen sulphide emissions to air; and aerators in the wet weather sedimentation tank;

* Aeration for the secondary treatment process and the wet weather tank to be provided by blowers and submerged diffusers, rather than surface aerators, to minimise potential odour (and aerosol) emissions;

* Minimise duration of excavation of mud and sludge at Ludmilla;

* Cart excavated material away quickly in covered trucks to Hudson Creek site, and cover material on the same day; and

* Operate odour masking system during excavation period;

* Include odour control as a key part of the EMP for operation of the augmented Ludmilla WWTP.

10.5 Acid Sulphate Soils

Issue

Acid sulphate soils are wet anaerobic soils which when exposed to air form sulphuric acid. This lowers pH levels and mobilises metals in the soil, creating an acid leachate with elevated metal concentrations. The goal is to construct the pipelines and the treatment plant without creating a significant quantity of acid leachate.

Impact Assessment

As far as is known there is no area of potential acid soils along the pipeline routes. However the pipeline routes will be inspected, and tested if necessary, during the detailed design stage to define any areas with acid sulphate soils. In the event that acid sulphate soils must be excavated, control measures will be developed and written into the EMP for pipeline and pumping station construction.

The mangrove mud and old sludge adjacent to the Ludmilla WWTP, which has to be removed to install the new secondary treatment plant, is a known area of potential acid soils. As described in Section 4-12, the plan is to excavate the mud and sludge quickly, cart it in covered trucks from the Ludmilla site to Hudson Creek, spread and cover it on the intertidal mudflats there.

This procedure will minimise the exposure of the excavated material to the atmosphere and hence minimise the potential for production of acid leachate. An area of about 1 ha at Hudson Creek will be covered with the material excavated from the Ludmilla site.

Mitigation and Safeguards

To control and minimise acid leachate impacts of the proposal, the following recommendations are made:

* Areas of potentially acid sulphate soils found in construction areas will be isolated and handled like the Ludmilla mud;

* Soil removed from acid sulphate areas will be carted quickly to Hudson Creek and placed in excavations or the existing clay-lined lagoons;

* Excavation will be carried out in the dry season to minimise leachate formation; any acid leachate will be neutralised with lime; and

* The EMPs for construction will contain, if necessary, specific provisions for the management and handling of acid sulphate soils.

10.6 Terrestrial Flora and Fauna

Issue

The goal is to minimise the impact of the proposal on terrestrial flora and fauna.

Impact Assessment

The major potential impact would arise from pipeline construction. The impact was minimised by planning the routes of the pipelines so they are mostly on roadways or cleared ground. The whole route was walked twice with botanical advisors from the Darwin City Council to select pipeline routes which had minimal impacts on terrestrial flora. This involved a number of changes and refinements to the route of the effluent pipeline and the 'green line' carrying reclaimed water. Significant trees along the pipeline route are at:

* Dick Ward Drive where a proportion of the black wattles (*Acacia auriculiformis*) will be removed;

* In the park opposite Lampe Street and East Point Drive where three *Ficus benjamina* will be removed;

* East Point Drive near Conacher Street where a substantial milkwood tree (*Alstonia actynophylla*) remains and will be preserved from any affect of the proposal; and

* Gilruth Avenue where some trees will be removed and replacement trees planted after construction.

The grass and trees along the pipeline route which will be removed will be replaced with similar local species after construction of the pipelines.

The expansion of the treatment plant will have no effect on terrestrial flora and fauna since the land has been previously cleared of mangroves.

Mitigation Measures and Safeguards

To control and minimise impacts of the proposal on terrestrial flora and fauna, the pipeline route will avoid trees as far as possible, and additional advice or recommendations from the Darwin City Council botanist will be followed. The construction contracts and EMP for pipeline construction will contain specific provisions requiring protection of vegetation near the routes and revegetation of the ground using local species.

10.7 Sedimentation and Erosion Control

Issue

The goal is to construct the pipelines and augment the treatment plant without creating a sedimentation or erosion problem.

Impact Assessment

Construction of the pipelines and excavation of the treatment plant will largely be carried out in the dry season, so the quantity of runoff produced by rainfall will be very small.

Some runoff will be produced be pumping groundwater from excavations. If the groundwater is seriously contaminated with sediment, it will be discharged into a settling pit and/or screened through hay bales. Groundwater from excavations beside the Ludmilla WWTP which contains acid leachate will be pumped to the treatment plant for neutralisation.

Pipeline routes will be sealed or revegetated progressively after the installation of the pipeline is complete. This should avoid problems with longer term erosion.

Mitigation and Safeguards

To control and minimise sedimentation and erosion, the following recommendations are made:

* Excavation should be confined to the dry season as far as possible;

* If there is acid groundwater from the excavation at the Ludmilla WWTP, it will be pumped into the treatment works and neutralised using the alkaline CAS effluent;

* Pipeline routes will be sealed or revegetated progressively after the installation of the pipeline; and

* The EMPs for construction will contain specific provisions for the management of contaminated groundwater and runoff.

10.8 East Point Outfall Region

Issue

The goal is for the discharge of effluent through the East Point outfall to have minimal impact on marine life and adjacent recreation.

Impact Assessment

As discussed in Chapter 8, there is no specific information on the composition or impacts of discharge on infauna near the East Point outfall. The seabed is relatively mobile so populations may be sparse, but it is anticipated (on the basis of observations at other outfalls) that there may be an increase in infaunal abundance in close proximity to the outfall.

The proposal involves a periodic small discharge of disinfected secondary effluent through the East Point outfall in the dry season (possibly every two days or so) to keep the pipeline clean of sediment and marine growths, and larger discharges during the wet season (1 to 60 ML/d) for 100 days per year during the wet season, with an average of 20 ML/d.

There will be an improvement in the effluent quality and a small reduction in the solids load discharged through the East Point outfall in the wet season:

Year 1998:	7 ML/d at 65 mg/L	= 450 kg/d (dry season)
Year 1998:	20 ML/d at 50 mg/L	= 1000 kg/d (wet season, average)
Year 2012:	0.1 ML/d at 10 mg/L	= 1 kg/d (dry season)
Year 2012:	20 ML/d at 35 mg/L	= 700 kg/d (wet season, average)

These estimates indicate an 18 per cent reduction in the solids discharge during the wet season. There also will be a 40 per cent reduction in the nitrogen loads discharged through the East Point outfall over the year. The expected effect of these changes is as follows:

* During the dry season there will be very little discharge and hence minimal impact on communities or recreation.

* During the wet season there will be an increased discharge rate, but with lower concentrations of solids and nitrogen. Any increase in infaunal abundance in close proximity to the outfall would remain about the same, or perhaps decrease slightly.

* The visibility of the effluent field from East Point at low tides during the wet season would continue to be about the same as now, unless the outfall were extended as described below.

Dilution Prediction and Zone of Impact

The initial dilution is only about 5:1 at high tide, 2:1 at low tide and negligible at very low tides. However the plume disperses rapidly as it is carried away from the discharge point. Dye dispersion tests (NTU, 1995) show that a high dilution occurs within a distance of 300 m. Effluent rapidly disperses to the north away from East Point during ebb tides (CCE, 1976; NTU, 1995). However during flood tides, diluted effluent is carried around East Point, through the Aquatic Reserve (CEE/SKM, 1998). The effect of the present discharge arrangement on marine biological communities in the East Point Aquatic Life Reserve is considered to be minimal (Dames and Moore, 1988).

East Point Aquatic Life Reserve

As discussed in Chapter 8, the marine biological communities in the vicinity of East Point and Dudley Point were first protected from marine specimen collectors in 1984. The present area of the East Point Aquatic Life Reserve was expanded to include offshore areas in 1992.

The present effluent discharge arrangement near East Point was constructed in the mid-1970's and discharges approximately 400 m east of the northwest boundary of the Reserve. Primary effluent is constantly discharged from the outlet, although there is considerable variation in the discharge rate between the dry season (about 7 ML/d) and the wet season (about 22 ML/d).

With the proposed arrangement, effluent discharge will almost cease during the dry season, while a larger quantity of effluent would be discharged during the wet season, 1 to 60 Ml/d, with an average of 20 ML/d.

Runoff from Ludmilla Creek averages about 30 ML/d during the wet season. Thus the quantity of urban runoff exceeds the effluent discharge, even in Ludmilla Bay. The relative contribution of runoff is higher in Darwin Harbour (Padovan, 1997). The daily tidal flux in Ludmilla Bay north of East Point is equivalent to a seawater flow of 750 ML/d. Hence, outside the immediate vicinity of the outfall, the influence of the discharge in the wet season will be minimal.

As discussed in Chapter 7, water quality in Darwin Harbour and Beagle Gulf is strongly influenced by freshwater inputs during the wet season, tidal flows and wave-induced suspension of sediment in shallow water. Natural wet season freshwater inputs are an integral factor which shape the nature of coastal marine biological communities in the Northern Territory.

Wet season runoff contributes substantial freshwater inputs as shown by the widespread lowering of salinity from 36 ppt in the dry season to 30 ppt in the wet season. Turbidity of coastal waters increases during the wet season due to sediment in runoff and wave-induced mixing in shallow water. The high levels of turbidity are apparent in the wet season at East Point, including the waters throughout the Aquatic Reserve.

The present discharge arrangement during the dry and wet seasons is considered to have minimal effect on marine biota and water quality (Moir, 1995; Parry and Munksgaard, 1997) in the East Point Aquatic Life Reserve. Exposure to effluent at the East Point Aquatic Life Reserve is very low due to oceanographic processes which effectively dilute and disperse effluent.

The proposal will improve effluent quality during the wet season leading to reduced solids and nutrient loads discharged. Marine biota in the region are accustomed to substantial seasonal changes and there is no indication that the present arrangement has any affect on marine biota in East Point Aquatic Life Reserve. Exposure to effluent in East Point Aquatic Life Reserve will remain low. Hence it is expected that the proposed effluent discharge arrangement will have no detectable impact on marine biota in East Point Aquatic Life Reserve.

Mitigation Measures and Safeguards

The proposed scheme of effluent treatment and discharge represents an improvement over the existing dry season situation and may be considered a measure to mitigate potential impacts (if any occur) on the East Point Aquatic Life Reserve.

As a safeguard, it is recommended that a marine biological monitoring program be established at East Point to determine:

* the extent of effect of the present and proposed scheme on mudflat infauna; and

* baseline conditions at East Point Aquatic Life Reserve and suitable controls (eg, Old Man Rock and Lee Point) which can be used to compare future conditions when the discharge proposed scheme is commissioned.

The discharge of effluent through the East Point outfall is subject to licences issued under the *Water Act 1992* which specifies various limits and requirements including monitoring.

Additional safeguards will be needed in the event that the East Point outfall is extended further offshore. These would be defined in the EMP for outfall extension which would be developed as part of the detailed design of the extension.

10.9 Larrakeyah Outfall Region

Issue

The goal is for the discharge of effluent through the Larrakeyah outfall to have minimal impact on marine life and adjacent recreation.

Impact Assessment

Larrakeyah outfall presently discharges macerated effluent through a diffuser located in 12 m water depth at about 500 m offshore from the Doctors Gully Aquatic Life Reserve. The outfall was operating before the Reserve was declared in 1971. Current studies and computer models of currents in Darwin Harbour indicate that effluent is seldom if ever carried from the Larrakeyah outfall to the Doctors Gully Aquatic Life Reserve (CEE, 1983).

As discussed in Chapter 8, the Larrakeyah outfall provides a high initial dilution (average 240:1). There is no known adverse affect of the existing effluent discharge on the fish feeding sessions in the Reserve.

There is no specific information on the impacts of effluent discharge on infauna near the outfall. The seabed is relatively mobile, but it is anticipated (on the basis of observations at other outfalls) that there may be an increase in infaunal abundance in close proximity to the outfall.

The proposal involves increasing discharges from the Larrakeyah outfall from the present 4 ML/d to a dry season discharge of about 6 to 8 ML/d (assuming 4 to 6 ML/d of effluent reuse) and a peak wet season discharge of 28 ML/d. There will be a concurrent substantial improvement in the quality of effluent discharged from the outfall, with the suspended solids level in the effluent reducing from 180 mg/L at present to 15 mg/L in the future.

The suspended solids load discharged from the Larrakeyah outfall is:

Year 1998: 4 ML/d at 180 mg/L	= 720 kg/d (wet and dry season)
Year 2012: 8 ML/d at 15 mg/L	= 120 kg/d (dry season)
Year 2012: 28 ML/d at 20 mg/L	= 560 kg/d (peak in wet season).

It is clear that there will be a substantial reduction in the solids load discharged over a year, and throughout the dry season. There also will be a 30 per cent reduction in the ammonia and nitrogen loads discharged to the harbour during the dry season, while the nitrogen loads in the wet season would remain about the same as now.

Dilution Prediction and Zone of Impact

The average initial dilution is predicted to be 200:1 with a discharge of 12.4 ML/d, 180:1 with a discharge of 16 ML/d and 140:1 with the peak discharge of 28 ML/d. The tidal currents will carry the effluent along the 20 m depth contour, with little onshore of offshore water movement. Dye dispersion tests show the dilution exceed 2000:1 within a kilometre (NTU, 1995).

Mitigation Measures and Safeguards

The evidence from studies of Darwin Harbour water quality of the plume from the Larrakeyah outfall, as well as bacteriological monitoring along the shore, is that there is no identified impact from the present discharge (Moir, 1995; Parry and Munksgaard, 1997). As the proposed scheme will substantially improve the quality of effluent discharged from the Larrakeyah outfall, it is unlikely that there will be future adverse impacts.

The scheme will substantially reduce suspended solids loads from the Larrakeyah outfall.

Monitoring effluent quality and flows to the outfall is recommended to ensure that loads are reduced. The potential mitigation measures are:

* Continued effective treatment, so that the reduction in loads discharged is maintained; and

* Promotion of effluent reuse, so the quantity of effluent discharged is reduced.

The discharge of effluent through the Larrakeyah outfall is subject to licences issued under the *Water Act 1992* which specifies various limits and requirements including monitoring.

10.10 Ludmilla Creek Region

Issue

The goal is for the overflows of effluent to Ludmilla Creek to have minimal impact on marine life and adjacent recreation.

Impact Assessment

As described in Chapter 8, Ludmilla Creek is a shallow mangrove-lined creek with a large intertidal zone and a small catchment. Much of the catchment of Ludmilla Creek is urban, and includes Ludmilla, Coconut Grove, and the Narrows as well as parts of Parap, Fannie Bay, Millner and Nightcliff. Parts of the mangrove area have been drained, cleared or infilled. For example, Minmarama Park occupies the site which was previously the Darwin landfill. The Ludmilla WWTP occupies cleared and filled mangrove wetland.

The Ludmilla Creek Landcare Group identified a number of potential water quality problems, including urban runoff from the largely urbanised catchment and litter (Ludmilla Creek Landcare Group, 1998).

At present, overflows of partly treated wastewater from the Ludmilla WWTP occur on up to 100 days per year, at a peak rate of about 80 ML/d. The proposal is to make full use of the capacity of the Larrakeyah and East Point outfalls, and thus reduce overflows to Ludmilla Creek to an average of 8 days per year with a peak rate of 12 ML/d. The overflows would always have screening, grit removal and primary sedimentation before discharge, and therefore would be of much better quality than at present.

Little is know of the effects of the overflows on Ludmilla Creek and associated mangrove and fish communities, but it can reasonably be anticipated that reducing overflow frequency from 100 to 12 days per year, and the peak overflow rate from 80 ML/d to
12 ML/d, can only have beneficial effects.

The overflows occur at high tide level to a channel beside the Ludmilla plant in a zone of established mangroves. A visual inspection showed no readily apparent effects; the mangroves by the channel appeared to be healthier than mangroves further to the south. Detailed studies of mangroves in Darwin Harbour subject to much higher loads of effluent have found no apparent adverse effects (Hanley Caswell Associates, 1997).

Mitigation Measures and Safeguards

The monitoring program should be continued to detect any changes due to the reduced overflow frequency and volume.

10.11 Waste Minimisation

Issue

The goal is to construct and operate the project while minimising the production of wastes.

Impact Assessment

As discussed in Section 4-9, the principal wastes created during the construction activities will be:

* clean fill, from excavations for pipelines and pumping stations; and
* mangrove mud/sludge, from excavations at the Ludmilla WWTP.

The clean fill will be transported to sites being filled and thus reused. A plan has been developed for control of odours and leachate from the mud and sludge, as described earlier.

The principal wastes created during operation of the plant will be:
* screenings and grit removed from the wastewater; and
* sludge, from the treatment processes at the Ludmilla WWTP.

Screenings and grit are not reusable materials and will have to be either burnt or buried at a landfill. However relatively small quantities of these materials are produced.

Procedures are being developed to enable long term reuse of sludge.

Mitigation Measures and Safeguards

To minimise waste generation, the following recommendations are made:

* Excavated material should be used as clean fill wherever possible;

* The EMPs for construction should contain provisions designed to reduce wastes from construction activities;

* The EMP for operation of the Ludmilla WWTP should contain provisions to minimise waste generation; and

* Procedures to reuse sludge (eg, as compost or a soil amendment) should be developed as part of the PAWA sludge management strategy.

10.12 Sacred Sites

Issue

The goal is to construct and operate the project with no impact on Sacred Sites.

Impact Assessment

As noted in Chapter 9, there are no Registered or Recorded Sites within the area affected by the proposal.

Mitigation Measures and Safeguards

No mitigation measures are necessary. As a safeguard, construction will be supervised and if any archeological material is discovered by excavation, work will cease until appropriate action is taken.

10.13 Heritage Sites

Issue

The goal is to construct and operate the project with no impact on heritage sites.

Impact Assessment

As noted in Chapter 9, the proposal does not involve any areas nominated for listing or listed on the Register of the National Estate or the Interim list of the Register of the National Estate.

The Heritage Conservation Branch of Lands Planning and Environment advised that no sites are directly affected or will be impacted. The Australian Heritage Commission advised on 17 September 1998 that the sewer pipeline passes near the Palmerston Cemetery; however this site will not be impacted by the proposal.

Mitigation Measures and Safeguards

No mitigation measures are necessary. As a safeguard, construction will be supervised and if any heritage site is discovered by excavation, work will cease until appropriate action is taken.

10.14 Traffic Issues

Issue

The goal is to construct and operate the project with no unacceptable effect on traffic, or access to residential and commercial sites.

Impact Assessment

Construction of major pipelines is expected to take about 12 months while construction of the upgraded treatment plant at Ludmilla (stage 1) will take about 15 months.

Estimates of vehicle movements during the construction period are listed in Section 5-3 as follows:

Pipeline Construction: (maximum of 6 weeks at any site)

heavy vehicles	average 1 per day;	peak 5 per day
trucks	average 12 per day;	peak 25 per day
cars	average 25 per day;	peak 55 per day

Ludmilla Excavation (3 week period)

heavy vehicles	average 1 per day;	peak 2 per day
trucks	average 35 per day;	peak 60 per day
cars	average 10 per day;	peak 15 per day

Ludmilla WWTP Construction: (15 months)

heavy vehicles	average 2 per day;	peak 6 per day
trucks	average 6 per day;	peak 18 per day
cars	average 20 per day;	peak 60 per day

East Point Outfall Extension: (6 months)

heavy vehicles	average 1 per day;	peak 3 per day
trucks	average 2 per day;	peak 6 per day
cars	average 10 per day;	peak 30 per day

Most major pumping stations would be visited daily and minor pumping stations weekly. Traffic entering Ludmilla WWTP will be:

heavy vehicles	average 0 per day;	peak 1 per day
trucks	average 2 per day;	peak 5 per day
cars	average 15 per day;	peak 35 per day.

As a basis for comparison and assessment, Dick Ward Drive carries an average of 16,800 vehicles/day, of which trucks would comprise approximately 1,700/day. In Darwin, a significant proportion of the vehicles classed as 'cars' are actually four wheel drive vehicles, with the consequent higher noise and exhaust emission factors.

It is apparent from a comparison of the construction traffic with the existing total traffic that construction will not cause a significant increase in traffic volume on Dick Ward Drive.

An improved intersection, with turning lanes, will be constructed in Dick Ward Drive in front of the Ludmilla WWTP to minimise the effects of the project on passing traffic.

The major impact of construction on traffic will be the blockages caused by excavations and construction activities on roadways: (1) through the CBD; (2) in Larrakeyah and (3) along Gilruth Avenue. These will be a short term impact, but it is recognized that construction activities will cause a nuisance to road users during the construction period. The principal mitigation measure is to plan and control construction so that each section is completed in a period of about 6 weeks.

Mitigation Measures and Safeguards

To minimise the impacts of construction on road users, the following measures are recommended:

* Construction is planned so that sections of the roadway are excavated and reinstated in a period not exceeding six weeks;

* Access is maintained at all times to shops and commercial premises;

* Access is maintained to residential premises;

* All property owners are kept advised of the proposed schedule of construction and the person they need to contact in the event of any problems with access;

* Suitable fencing and warning signs are provided to minimise the risk to the public;

* In the CBD and perhaps other commercial areas, construction is scheduled at night to minimise disruption;

* Traffic warnings and signs are installed to maintain efficient traffic flow past the construction area; and

* The EMPs for construction reflect the need to minimise impacts on traffic.

10.15 Landscape and Visual Aspects

Issue

The goal is to construct and operate the project with no detrimental effect, and possibly an enhancement, of the landscape and visual aspects of the proposal.

Impact Assessment

As discussed in Section 9-5, the present Ludmilla WWTP is landscaped where it faces Dick Ward Drive and presents an generally unobtrusive but low key industrial appearance. The expansion of the plant will be to the north, away from the road, and hence will not alter the viewed appearance of the site.

The mangroves to the west, north and east screen the Ludmilla plant from view. The proposed new tanks and buildings have a low profile and will not be visible above the mangroves, or from boats using Ludmilla Creek, and will not alter the appearance of the plant.

The pipelines will be buried and will not have any long term visual effect.

The use of reclaimed water on parks and gardens may lead to greater vegetation cover and growth and hence soften the urban landscape to some extent.

Mitigation Measures and Safeguards

To minimise the impacts of the proposal on visual aspects, the following measures are recommended:

* Rapid and appropriate revegetation of pipeline construction sites;

* Sympathetic landscaping and plantings at pumping station sites; and

* Maintain landscaping of Ludmilla WWTP.

10.16 Tourism and Commercial Aspects

Issue

The goal is to construct and operate the project with no detrimental effect, and possibly an enhancement, on tourism and commercial activities in Darwin.

Impact Assessment

The proposal will have minimal effect on tourism. It is possible that the proposal could offer a slight encouragement of tourism, as the aesthetics of the East Point outfall will be improved, and the increased use of reclaimed water could soften the Darwin urban landscape.

The construction of the pipelines past the shops at Fannie Bay and in the CBD could have a short term adverse impact on trade, unless suitable measures are implemented (for example, construction at night).

The Ludmilla Creek Catchment Management Plan states that tourism in the Ludmilla Creek area could generate unacceptable levels of traffic and infrastructure that could impact upon the natural values of the area. Therefore access should be limited to pedestrians and cyclists.

Mitigation Measures and Safeguards

The proposal is mildly positive with respect to tourism, and removed a potential risk to tourism; ie, adverse publicity about discharge of a poor quality effluent at Darwin. To minimise the impacts of construction on tourism and commercial activities, the following measures are recommended:

* Construction is planned so that sections of the roadway are excavated and reinstated in a period not exceeding six weeks; hence the maximum time any residence or business would be affected is six weeks;

* Access is maintained at all times to shops and commercial premises;

* All property owners are kept advised of the proposed schedule of construction and the person they need to contact in the event of any problems with access;

* Suitable fencing and warning signs are provided to minimise the risk to the public; and

* In the CBD and perhaps other commercial areas, construction is scheduled at night to minimise disruption.

10.17 Recreational Aspects

Issue

The goal is to construct and operate the project with no detrimental effect, and possibly an enhancement, on recreation in Darwin.

Impact Assessment

The proposal will have minimal effect on recreation. It is possible that the proposal could offer a slight encouragement of recreation at East Point, as the aesthetics of the outfall will be improved. There is very little swimming or bathing at East Point, so the removal of effluent during the dry season will not have a beneficial effect on recreation.

The improvement in the quality of effluent discharged through the Larrakeyah outfall should theoretically be a potential benefit to recreation at the Doctors Gully fish feeding site. In practice, there does not appear to be any detectable impact from the present discharge from the Larrakeyah outfall and hence there will not be any detectable improvement.

The proposal could be seen as mildly positive with respect to recreation, as a potential risk to recreation at East Point and Doctors Gully has been reduced.

The Ludmilla Creek Catchment Management Plan states that present recreational use of the Ludmilla Creek area is predominantly low key passive use that relies to a large extent on the natural character of the area. It is proposed to construct a bicycle path past the Ludmilla plant, which could cause a conflict unless designed sensitively.

Mitigation Measures and Safeguards

No specific mitigation measures are necessary as the proposal is a potential benefit to recreation.

10.18 Community Health

Issue

The goal is to construct and operate the project so that it enhances community health.

Impact Assessment

The main potential impacts of the project on community health are;
* worker safety;
* effluent reuse;
* insect vectors;
* stress from noise, disruption and other construction impacts; and
* stress from odour and noise during operations.

The major issue is the risk of accidents and injury during construction. This can be minimised by adherence to appropriate safe working practices.

Effluent reuse, while being beneficial in terms of reusing a valuable resource, reducing the need for another dam and reducing effluent discharge to the marine environment, does introduce a very small risk of transmission of disease. This risk can be reduced to a minimal level by adherence to the NHMRC guidelines for the production of reclaimed water. In this proposal, the highest standards (for application to municipal parks with uncontrolled access) are being applied.

Insect vectors are potentially a problem but stringent controls are being adopted, as discussed earlier.

Stress induced by construction is undoubtably a factor which must be recognized. However construction is essentially a short term activity, and does not involve or create any unusual or unacceptable practices, products or byproducts.

Mitigation Measures and Safeguards

To minimise the impacts of construction on community health, the following measures are recommended:

* Construction is planned and carried out in a safe manner;

* Construction is carried out in a short period with little disruption to residences and commercial premises; and

* Operations do not cause unacceptable noise, odours or insect numbers.

10.19 Greenhouse Gases

Issue

The goal is to construct and operate the project with minimal increase in Greenhouse gas emissions.

Impact Assessment

Unfortunately, it is not possible to achieve a major increase in biological secondary treatment capacity without using additional energy. The major use of energy is to compress air which is distributed to the secondary treatment units to supply the oxygen requirements of the active biomass responsible for the conversion of suspended and dissolved organics in the wastewater to biological growth which can then be removed as sludge.

Present power usage in the Ludmilla and Larrakeyah catchments is as follows:

Pumping stations (sewage)	600 GWhr
Larrakeyah macerators	200 GWhr
Ludmilla WWTP	1,300 GWhr
Pumping station (effluent)	200 GWhr
Total in 1997/98	2,300 GWhr (equivalent to 1,300 t of CO_2)

Power usage after the implementation of the proposal will be as follows:

Pumping stations (sewage)	1,600 GWhr
Larrakeyah macerators	-
Ludmilla WWTP	3,100 GWhr
Pumping station (effluent)	600 GWhr
Saving from reuse	- 100 GWhr
Total in 1997/98	5,400 GWhr (equivalent to 3,000 t of CO_2)

In summary, there will be a 130 per cent increase in Greenhouse gas emissions, even taking into account the reduction in power usage as a result of reclaimed water replacing some water pumped to Darwin.

In addition, the quantity of diesel fuel used in the incinerator will increase from 2,700 L/month to 3,400 L/month. Operation of the furnace to burn sludge adds additional carbon dioxide, although this is a much better option from the perspective of Greenhouse gas emissions than any anaerobic decomposition options, which would release methane, and hence increase the Greenhouse contribution from sludge.

Mitigation Measures and Safeguards

There is no practical alternative to additional energy use if the proposal is to be implemented. The principal mitigation measure is to use energy efficiently, and to continue to explore energy production at the plant.

10.20 Summary of Mitigation Measures

The mitigation measures recommended to minimise impacts are summarised below.

Runoff

* Carry out excavation and pipeline installation as much as possible during the dry season;

* Limit the excavated/disturbed area and revegetate, backfill or seal the surface soon after excavation;

* Store all chemicals and fuel within bunds, and provide bunds around loading and transfer areas;

* Limit the time and duration of the construction period; and

* Where appropriate, install silt fences or sediment traps to capture sediment, and

* Incorporate these measures in the sediment control measures in the EMPs for construction.

Noise And Vibration

* Construction of pipelines near residences will be restricted to daytime hours; night time construction may be required in the CBD;

* Blasting will not be permitted;

* Large rockbreakers will not be permitted to operate within 20 m of residences and masonry buildings;

* The Ludmilla WWTP augmentation will be designed to minimise noise emissions. Plant and equipment will be fitted with silencers and acoustic enclosures as required to meet the regulatory noise limits;

* Submerged pumps and shrouded ventilation outlets will be used at pumping stations: the station buildings will be constructed of noise deadening materials;

* The public will be kept informed on the timing (and a contact person) for pipeline construction in their locality; and

* A complaints register will be kept to monitor noise and traffic complaints during construction and operation. The cause of complaints will be investigated and appropriate steps will be taken to ensure the causes are not repeated.

Odours

* Completion and implementation of the PAWA odour control strategy for wastewater sewers and pumping stations, including as many as feasible of the controls listed above;

* Continued operation of the odour scrubbing system for incoming air;

* Inclusion of the odour control measures listed above in the design of the augmented Ludmilla WWTP, including aerated grit removal tanks, soil bed filter, foul air ducting to the furnace, lime dose in the primary tanks to increase pH and reduce hydrogen sulphide emissions to air; and aerators in the wet weather sedimentation tank;

* Aeration for the secondary treatment process and the wet weather tank to be provided by blowers and submerged diffusers, rather than surface aerators, to minimise potential odour (and aerosol) emissions;

* Minimise duration of excavation of mud and sludge at Ludmilla;

* Cart excavated material away quickly in covered trucks to Hudson Creek site, and cover material on the same day; and

* Operate odour masking system during excavation period;

* Include odour control as a key part of the EMP for operation of the augmented Ludmilla WWTP.

Acid Sulphate Soils

* Pipeline routes will be inspected and tested if necessary to identify areas with acid sulphate soils which must be excavated, and construction documents will specify suitable management procedures;

* Areas of potentially acid sulphate soils found in construction areas will be isolated and handled like the Ludmilla mud;

* Soil removed from acid sulphate areas will be carted quickly to Hudson Creek and placed in excavations or the existing clay-lined lagoons;

* Excavation will be carried out in the dry season to minimise leachate formation; any acid leachate will be neutralised with lime; and

* The EMPs for construction will contain specific provisions for the management and handling of acid sulphate soils; and

Terrestrial Fauna And Flora

* Pipeline route will avoid trees as far as possible;

* Additional advice or recommendations from the Darwin City Council botanists will be followed;

* The EMP for pipeline construction will contain a specific provision requiring protection of vegetation near the routes; and

* All pipeline routes will be revegetated using similar local grasses and shrubs as occur along the routes now.

Sedimentation And Erosion

* Excavation should be confined to the dry season as far as possible;

* Contaminated groundwater will be settled or neutralised;

* Pipeline routes will be sealed or revegetated progressively after the installation of the pipeline; and

* The EMPs for construction will contain specific provisions for the management of contaminated groundwater and runoff.

East Point Outfall Region

* A marine biological monitoring program be established at East Point to determine: (1) the extent of effect of the present and proposed scheme on mudflat infauna; and (2) baseline conditions at East Point Aquatic Life Reserve and suitable control sites.

* All treatment and monitoring will be in accordance with the discharge licence.

Larrakeyah Outfall Region

* Continued effective treatment, so that the reduction in loads discharged is maintained;

* Promotion of effluent reuse, so the quantity of effluent discharged is reduced; and

* All treatment and monitoring will be in accordance with the discharge licence.

Ludmilla Creek Region

* The monitoring program will be continued to detect any changes due to the reduced overflow frequency and volume.

Waste Minimisation

* Excavated material will be used as clean fill wherever possible;

* The EMPs for construction will contain provisions designed to reduce wastes from construction activities;

* The EMP for operation of the Ludmilla WWTP will contain provisions to minimise waste generation; and

* Procedures for reduce of sludge (eg, as compost or a soil amendment) will be developed as part of the PAWA sludge management strategy.

Sacred Sites

* Construction will be supervised and if any archeological material is discovered by excavation, work will cease until appropriate action is taken.

Heritage Sites

* Construction will be supervised and if any heritage site is discovered by excavation, work will cease until appropriate action is taken.

Traffic And Road Users

* Construction is planned so that sections of the roadway are excavated and reinstated in a period not exceeding six weeks;

* Access will be maintained at all times to shops and commercial premises;

* Access will be maintained to residential premises;

* All property owners will be kept advised of the proposed schedule of construction and the person they need to contact in the event of any problems with access;

* Suitable fencing and warning signs will be provided to minimise the risk to the public;

* In the CBD and perhaps other commercial areas, construction may be scheduled at night to minimise disruption;

* Traffic warnings and signs will be installed to maintain efficient traffic flow past the construction area; and

* The EMPs for construction will reflect the need to minimise impacts on traffic.

Visual Aspects

* Rapid and appropriate revegetation of pipeline construction sites;

* Sympathetic landscaping and plantings at pumping station sites; and

* Maintain landscaping of Ludmilla WWTP.

Tourism And Commercial Aspects

* Construction is planned so that sections of the roadway are excavated and reinstated in a period not exceeding six weeks;

* Access is maintained at all times to shops and commercial premises;

* All property owners are kept advised of the proposed schedule of construction and the person they need to contact in the event of any problems with access;

* Suitable fencing and warning signs are provided to minimise the risk to the public; and

* In the CBD and perhaps other commercial areas, construction is scheduled at night to minimise disruption.

Community Health

* Construction is planned and carried out in a safe manner;

* Construction is carried out in a short period with little disruption to residences and commercial premises; and

* Operations do not cause unacceptable noise, odours or insect numbers.

Greenhouse Gases

* Energy is to be used efficiently; and

* Continue to explore energy production at the Ludmilla plant.

10.21 Environmental Management Plan (EMP)

An EMP is a document prepared to ensure that the commitments made in a PER (and subsequent approvals) are met, and that a positive approach is taken to managing the environmental aspects of the project. The main purpose of the EMP is to ensure that all activities are carried out using environmentally sound management practices and procedures.

Separate EMPs are proposed for each of the main construction tasks, with another EMP to cover operations. Thus there is anticipated to be a total of five EMPs prepared for this proposal:

1. Transfer pipelines and sewage pumping stations;
2. Augmenting and upgrading Ludmilla WWTP;
3. Augmentation of rising main and extension of East Point outfall;
4. Operation of augmented Ludmilla WWTP and associated facilities; and
5. Sludge and mud disposal at Hudson Creek site.

All EMPs will be prepared by PAWA during the detailed design stage and completed to the satisfaction of Lands Planning and Environment.

Note that the irrigation systems using reclaimed water are not under the control of PAWA and hence will not have EMPs prepared under the aegis of this EIS. However the agencies (eg, Darwin City Council) using reclaimed water will have their own documented environmental practices.

Construction EMPs

The EMPs for construction will provide the procedures, safeguards and measures required to enable construction of the pipelines in accordance with this EIS and subsequent approval conditions, and address:

* Transfer System Construction EMP Outline
* Project Objectives and Scope
* Regulations and Approvals
* Development Approval Conditions
* Environmental Management Procedures
* Pre-construction Soil Assessment
* Acid Sulphate Soil Management Plan
* Management of Contaminated Soil
* Erosion and Sediment Controls
* Dust Management
* Flora and Fauna Management
* Noise Control
* Traffic Management
* Waste Management
* Visual Aspects
* Archaeological and Heritage Plan
* Access and Public Amenity
* Monitoring and Auditing

Operational Phase EMP

An EMP will be prepared to document the procedures for operation of the Ludmilla WWTP and associated facilities, and address:

* Approvals and licences required for continued operations;
* Sewage pumping station overflow occurrence and reporting;
* Monitoring (sewage, effluent, biosolids);
* Chemicals storage and handling;
* Stormwater management;
* Odours;
* Noise;
* Sludge management;
* Waste management;
* Risks and hazards
* Emergency response procedures;
* Environmental audits; and
* Environmental monitoring.

10.22 Environmental Monitoring

The environmental monitoring recommended for this project is as follows:

1. Licence Requirements
   Effluent (monthly)
   Conductivity
   Total phosphorus
   Total nitrogen
   Faecal coliforms
   BOD
   Suspended Solids
   Volatile suspended solids

2. Water Quality at East Point (four sites) and Larrakeyah (three sites):
   Conductivity
   Turbidity
   Total phosphorus
   Total nitrogen
   Faecal coliforms
   Dissolved oxygen
   Chlorophyll-a
   Light Attenuation

3. Annual marine biological monitoring be undertaken as a safeguard to:
   * Determine the extent of effect of the discharge on infauna in the vicinity of the outfalls; and

   * Confirm that marine biological conditions at the northeastern boundary of the East Point Aquatic Life Reserve are not affected by the discharge in the future.

4. The EMPs for construction include monitoring and auditing procedures to ensure that plans are fully implemented.

5. Additional monitoring:
   * Collection of sediment samples near the discharge location and at a reference site, and analysis to determine organic carbonand metal levels, as well as infauna composition; and

   * Conduct of dye and other tracer dispersion tests to confirm initial dilution achieved by Larrakeyah outfall.

6. Assessment of impacts of East Point discharge to establish need for extension of outfall.

11. Conclusion

The proposal is another step in the development of a modern sewerage system in Darwin. The proposal makes effective use of all existing facilities (Ludmilla WWTP, Larrakeyah outfall and East Point outfall) by augmentation and expansion, while introducing higher levels of treatment and new facilities to produce reclaimed water for irrigation of parkland.

The staged augmentation of Ludmilla WWTP offers a practical method of expansion while waiting for land claims on the land to the north of the existing fenced area to be resolved. The land to the north is zoned for sewage treatment purposes.

Biological secondary treatment is proposed for all dry season flows. Part of the secondary effluent will receive tertiary filtration and disinfection, to produce a reclaimed effluent suitable for irrigation of parks and gardens. The proposal has the flexibility to increase the quantity of reclaimed effluent as the demand for it increases, and also to reduce the production during the wet season, when demand would be lower.

The remaining secondary effluent will be pumped to the Larrakeyah outfall and discharged into the tidal flows of Darwin Harbour.

In the wet season, the peak flows will exceed the capacity of the secondary treatment system on some days and also the discharge capacity of the Larrakeyah outfall. Hence up to 60 ML/d of a mixed secondary and primary effluent will be discharged in the wet season through the East Point outfall.

There will be short term adverse impacts during the construction period, with disruption of traffic, some local noise and dust and loss of a small number of trees along the pipeline route. As discussed in Chapter 10, these impacts will be managed and minimised as much as possible.

There also will be a short term (3 weeks) odour impact during the removal of old sludge and mangrove mud from the north of the Ludmilla WWTP site to provide foundations for the new secondary treatment plant.

There will be mostly positive long term impacts, with improved water quality at Larrakeyah and East Point, a reduction in the loads of solids and nutrients discharged, and production of reclaimed water from effluent for reuse. However the proposal involves increased consumption of energy.

Thus the increased energy use must be balanced against the improved environmental conditions in terms of marine water quality and the creation of new resources (reclaimed effluent and biosolids).

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Appendix A - Ludmilla Waste Water Treatment Plant (WWTP) Upgrade - Guidelines For A Public Environmental Report

LANDS PLANNING ENVIRONMENT

LUDMILLA WASTE WATER TREATMENT PLANT (WWTP) UPGRADE

GUIDELINES FOR A PUBLIC ENVIRONMENTAL REPORT

INTRODUCTION

1 Background

These guidelines are based on the requirements of clause 8 of the Environmental Assessment Administrative Procedures under the Northern Territory *Environmental Assessment Act 1982*.

The object of this Act is to ensure that matters affecting the environment to a significant extent are fully examined and taken into account in decisions by the Northern Territory Government. In preparing a Public Environmental Report (PER) to help achieve this objective, the proponent should bear in mind the following aims of the PER and public review process:

- to provide sufficient information from which interested individuals and groups may gain an understanding of the proposal, the need for the proposal, the alternatives, the environment which it would affect, the impacts that may occur and the measures to be taken to minimise and manage these impacts;
- to provide a forum for public consultation and informed comment on the proposal; and
- to provide a framework in which decision-makers may consider the environmental aspects of the proposal in parallel with economic, technical and other factors.

2 General content, format and style

The proponent should address the issues outlined in these guidelines, giving priority to the major issues associated with the proposal. Matters of lesser concern should be dealt with to the extent required to demonstrate that they have been considered. Additional data not outlined in the guidelines, but considered relevant to the proposal, should also be included within the PER. It is envisaged that the PER will be based on the results of available research, studies and data as appropriate, with further studies being conducted where necessary and practicable.

In these guidelines the terms 'descriptive' and 'discussion' should be taken to include both quantitative and qualitative expression and should be as practicable and meaningful as possible. Similarly, adverse and beneficial effects should be presented in quantitative and / or qualitative terms as appropriate.
The main text of the PER should be written in a clear, concise style that is easily understood by the general reader. Technical jargon should be avoided wherever possible. A detailed glossary and technical information necessary to support the main text should be included as appendices.
The documentation should include references and a list of individuals and organisations consulted. Where appropriate, the text should be supported by maps (showing contours and all named locations), figures, diagrams and tables.

CONTENTS OF THE PER

Include a detailed table of contents, showing all headings.

1 Executive Summary

The Executive Summary is to include a brief outline of each chapter within the PER using text and dot points. It is recommended that the Executive Summary is written as a stand-alone document, able to be reproduced on request by interested parties who may not wish to read the PER as a whole.

The summary should be a concise outline of the matters discussed in the main body of the document, to allow the reader to quickly obtain a clear understanding of the proposal, its environmental implications and management objectives. The summary should include:

- the title of the proposal;
- name and address of the proponent;
- a brief description of the background to and need for the proposal;
- a statement of the objectives of the proposal and its relationship to the Darwin Sewerage Strategy;
- a brief description of the proposal;
- a brief description of the existing environment;
- a brief summary of the principal environmental impacts;

- a statement of the proposed environmental management principles and monitoring procedures;
- a brief explanation of the structure and scope of the PER and its legislative basis; and
- a description of the studies / surveys / consultations conducted in developing the proposal and preparing the PER (results of studies and detailed comments resulting from the consultation should be included as appendices).

2. Background and need for the Proposal

The document should discuss the background to the proposal and provide an explanation of the need for, and justification of the proposal, including:

- current situation / demand etc.;
- reason / justification for proposal;
- capacity for proposal to meet demand;
- consequences of not proceeding;
- discussion of alternatives including site, design (eg. extending the East Point outfall beyond the low water contour, or not using the East Point outfall) and technology (regard should be given to the biophysical, economic and social environment and the principles of ecologically sustainable development);
- current status of the proposal (scientific studies, environmental assessment); and
- relevant Territory government policies, legislation and licence requirements and relevant current and upcoming National and NT standards (this information would best be presented in table form).

3. Description of the Proposal

To assist in determining the environmental impacts associated with the proposal this section should describe the project in sufficient detail to allow an understanding of all stages of the proposal, including infrastructure design and engineering, construction, operation and management. Describe the existing operation in relation to the proposal.

Emphasis should be given to those components with the most potential for significant short and long term environmental impacts. The description of the proposal should include the work proposed at the Ludmilla plant, the outfalls at East Point and Larrakeyah and any work at the Leanyer and Hudson Creek sites associated with the storage and handling of sludge, grit and screenings.

3.1 Location and Design Requirements

- location and siting information;
- land tenure (maps and descriptions should clearly show the boundaries of the land held by the PAWA) and additional planning issues;
- design layout and standards, including drainage, roads, buildings, process descriptions, outfall alignments, discharge points etc;

- design limitations imposed by site characteristics (including adjacent land use);
- operational and infrastructure requirements (roads, power, water supply, ablution, fencing/signage);
- expected lifetime of the proposal; and
- proposed staging of the upgrade

3.2 Construction Phase

- construction program (timing and duration);
- physical requirements for construction (types, quantities, sources and availability of construction materials such as water, aggregate, cement, fabrication products);
- sourcing and transport of construction materials including heavy vehicle movement (numbers and frequency) on public roads;
- construction standards, techniques, site management and supervision (including on-site storage and handling of materials);
- construction wastes and disposal methods;
- extent and methods of vegetation clearance, site preparatory works, earthmoving;
- soil conservation and rehabilitation measures, for example, of access tracks used during the construction phase, of cleared land and of areas affected by the construction of the rising main between Ludmilla and Larrakeyah;
- acid sulfate control measures;
- odour control measures during the relocation of existing sludge, grit and screenings from Ludmilla WWTP to Leanyer WWTP; and
- methods used to prevent and control biting insect populations.

3.3 Operational Phase

- raw materials (sources; quantities and storage) used in the operation of the upgraded plant;
- description of the processes and the products, such as treated wastewater and sludge produced at the plant (including quantities);
- details of sludge burning process at Ludmilla WWTP;
- transport, storage and handling of the sludge, grit, screenings and other materials;
- proposed reuse of treated wastewater and sludge including what guidelines will be met;
- timing of normal operations of facility;
- maintenance requirements and operations;
- odour control measures associated with the upgrade of Ludmilla WWTP and the sludge drying and storage facilities at Leanyer WWTP and Hudson Creek WWTP;
- measures used to control leachates from the sludge drying areas at Leanyer WWTP and Hudson Creek WWTP;
- predictions of overflow events (frequency and volume) to East Point outfall and to Ludmilla Creek during the wet season;

- types and quantities of other wastes produced and methods for disposal or reuse; and
- ongoing measures proposed to minimise the potential for mosquito breeding on site and any off site locations that may be affected by the proposal.

4 Existing Environment

A description of the existing environment that may be affected by the proposal including off site locations, is required to serve as a baseline against which impacts and management of the proposal can be assessed. The extent of the discussion and description should be guided by the need to fully explain the environment in terms of expected and potential impacts and the identification and implementation of management plans. The description should include the Ludmilla area, the outfall areas at East Point and Larrakeyah and the affected areas at Leanyer and Hudson Creek including receiving waters.

4.1 Physical environment

- relevant climate and atmospheric conditions (precipitation, evaporation, wind, temperature, seasonal variability, flooding, cyclonic storms);
- geology, topography, geomorphology, relevant soil characteristics (erodibility, compaction, potential and acid sulphate soils etc);
- hydrology (including marine current regimes associated with the East Point and Larrakeyah outfalls, surface and groundwater systems, catchment and drainage regime);
- existing water and sediment quality of receiving waters affected by the proposed upgrade and declared beneficial uses of receiving waters;
- noise levels;
- air quality and odour;
- existing fire regime;
- past and present land use and land access; and
- current overflow events (frequency and volume) to Ludmilla Creek

4.2 Biological environment (terrestrial and aquatic, freshwater & marine)

- major habitats, communities and flora / fauna species, including their conservation status on a local and regional level and species of commercial importance;
- ecological relationships and their importance to flora/ fauna species, including habitat requirements, dispersal abilities, key components of ecosystems etc.;
- other sensitive environments and areas of significance (breeding sites, feeding sites, monsoon vine thickets, wetlands; marine reserves);
- extent, representation and protection elsewhere of species / communities / habitats affected by the proposal;
- obligations / listings under Territory, national and international registers, conventions or agreements;
- level of vegetation clearance / disturbance;

- feral animals / vermin and weeds / plant pathogens;
- mosquitoes and biting insects; and
- existing biotic conditions in receiving waters affected by the proposed upgrade.

4.3 Aspects of the cultural and socio-economic environments

- areas nominated for listing or listed on the Register of the National Estate or the Interim list of the Register of the National Estate;
- the results of an inspection of the Register of Sacred Sites maintained by the Aboriginal Areas Protection Authority, as well as details of an application lodged with the Authority for an Authority Certificate within the meaning of Part 3, Division 1 of the NT *Aboriginal Sacred Sites Act*. Also, if practicable, include a copy of the Certificate issued by the Authority as a result of that application, containing conditions (if any) relating to the protection of sacred sites on, or in the vicinity, of the project area;
- archaeological and heritage places and objects under the *Northern Territory Heritage Conservation Act 1991;*
- historic sites;
- areas with special values (eg. landscape / visual environment/ recreational / commercial/ tourism/ fisheries); and
- sites of significance to the Aboriginal population and culture (including areas used for aboriginal subsistence food gathering).

5 Environmental impacts

The discussion should cover impacts on the biophysical, cultural and socio-economic environment at the local and regional levels. The text should cover impacts from both the construction and operational phases at all sites associated with the upgrade. Generally the discussion should use the same descriptors used to describe the existing environment.

Direct, indirect, short-and long-term, temporary and irreversible, adverse and beneficial effects should be discussed and quantified where possible. This should also include an assessment of the level of significance of the impact and a discussion on cumulative impacts. The reliability and validity of forecasts and predictions, confidence limits and margins of error should be indicated as appropriate. Interactions between impacts on the biophysical, cultural and socio-economic environments, both individually and collectively, should be covered.

This section should provide information on environmental management practices and safeguards proposed to prevent, minimise or ameliorate environmental impacts. The most economically effective, environmentally sound technology and procedures should be incorporated into the design of the proposal.

Any environmental monitoring associated with the construction phase (ie: monitoring of leachates from the potential acid producing soils; monitoring of dredging operations during the construction of the East Point outfall) and the operational phase (ie: monitoring the quality of water, sediment and biota of receiving waters) should be outlined in this section. Dispersal characteristics of the effluent plume from East Point outfall and Larrakeyah outfall on the water quality regime of Darwin Harbour (including variations due to tides, currents, seasons). Modelling of dispersion and predictions of assimilation zones is required.

Where relevant weed, vermin, feral animal and fire control measures should also be outlined.

A summary table listing potential impacts, environmental management practices and safeguards, monitoring and management methods with cross-referencing to the text of the report should be provided together with the outline of an Environmental Management Plan (EMP). Details of how the EMP will be implemented should be provided.

An EMP should provide:

- details of proposed measures to minimise adverse impacts and the effectiveness of these safeguards;
- ensure that safeguards are being effectively applied;
- enable remedial action for any impacts which are not originally predicted;
- measure the differences between predicted and actual impacts (monitoring); and provide for the periodic review of the management plan itself.

6 Decommissioning and rehabilitation

This section should address the objectives and goals associated with the decommissioning and rehabilitation of the proposal or any part of the proposal.

Discussion should include facilities to remain, progressive and final rehabilitation, site contamination surveys and clean-up, relevant legislation, responsibilities, timings, and potential uses for the decommissioned area.

7 Glossary

A glossary defining technical terms and abbreviations used in the text should be included to assist the general reader.

8 References

The reference list or bibliography should be accurate and concise.

9 Appendices

Information relevant to the PER but not suitable for inclusion in the main text should be included as appendices, for example detailed technical or statistical information, maps, baseline data, supplementary reports etc.

10 Administration

The Project Officer is Lynne Powell of the Environment Protection Division, Department of Lands, Planning and Environment and can be contacted on phone (08) 8924 4022 or fax (08) 8924 4053.

Arrangement for the public display, review and purchase of the PER, including locations and number of copies will be made at the time when the preliminary copy of the draft PER is reviewed.

Appendix B - Glossary and Abbreviations

AEROBIC	Associated with the presence of free oxygen.
ANAEROBIC	A condition in which no free oxygen or nitrates are present.
AQUATIC ECOSYSTEM	The total community of aquatic plants and animals, together with the physical and chemical environment in which they live.
BIOCHEMICAL OXYGEN DEMAND *(BOD)*	The measure of the oxygen in water consumed when micro-organisms breakdown organic matter, an important indicator of organic pollution of water.
BOD_5	Biochemical Oxygen Demand: the oxygen consumed by a unit volume of liquid during biological oxidation over 5 days at 20 degrees Celsius with its suspended solids included. This parameter is an indicator of organic content and is usually expressed in milligrams per litre.
BIOSOLIDS	Sludge treated for beneficial reuse. The particular matter, mainly organic, removed during sewage treatment *(previously referred to as sludge)*.
BIOSOLIDS PRODUCTS - BENEFICIAL LAND APPLICATION	The application of biosolids to an area in quantities whereby the utilisation of nutrients in the products does not exceed the nutrient requirements of the crops, pastures or vegetation and/or the use of the beneficial characteristics of the organic matter in the biosolids.
BUFFER ZONE	A designated area or strip of land to protect a sensitive area.
CATCHMENT	The area of land from which water, stormwater or sewage is collected.
CHEMICALLY ASSISTED SEDIMENTATION *(CAS)*	This process adds chemicals like ferric chloride to increase the removal of suspended solids and grease.

CHLORINE	Chlorine is a disinfectant/bactericide used in the treatment of wastewater. It can be used as an elemental gas or as a reactive compound. Two forms of chlorine are generally described, free and combined chlorine. Free chlorine is much more reactive than combined chlorine and is a far more effective bactericide. Combined chlorine forms when free chlorine reacts with other compounds within the water, particularly ammonia, to form chloramine compounds. Total chlorine is the sum of free and combined chlorine.
COAGULATION	A water treatment process in which chemicals are added to combine with or trap suspended and colloidal particles to form rapidly settling aggregates.
COLIFORM BACTERIA	Bacteria including all the aerobic, gram negative, non-spore forming, rod-shaped bacteria that produce acid from fermentation of lactose within 48-hours at 37 degrees centigrade, such as the bacteria inhabiting the intestines of animals.
CRUSTACEANS	Animals which belong to the Class Crustacea including prawns, lobsters and crabs.
DEMAND MANAGEMENT	Involves the use of price and non-price measures to affect the demand for a product or service.
DENITRIFICATION	The bacterial conversion of nitrate-nitrogen and nitrite-nitrogen to nitrogen gas.
DISINFECTION	The destruction of infectious agents, such as bacteria or viruses, by a disinfectant such as chlorine.
DIURNAL	Daily cycle of variation.
DIVERSITY	The abundance in numbers of species in a given location.
DUAL RETICULATION SYSTEM	Two separate and distinct piping systems, one designed to convey non-potable water, and the other to transport higher quality for potable purposes.
ECOLOGY	The inter-relationships between biota and abiotic elements of the environment.
ECOSYSTEM	A physico-chemical environment together with a community of evolutionarily adapted organisms.

EFFLUENT	Liquid discharge from a sewage treatment plant after treatment.
EMISSION	Anything given off as a result of a process. For example, gases, heat and odours.
ESTUARY	Tidal waterway.
FAECAL COLIFORMS	Faecal coliforms are bacteria of the Coliform type that can only exist within the guts of warm blooded animals. It is for this reason that the presence of faecal coliforms is an indicator of sewage pollution. *E coli* is a bacterium that comes from the faecal coliform group. Expressed as colony forming units per 100 millilitres.
FAECAL STREPTOCOCCI	Bacteria of the streptococci type that can only exist within the guts of warm blooded animals. Ratios of faecal coliforms to faecal streptococci indicate the source of pollution.
FILTERABLE RESIDUE	The solids obtained from a filtered sample of water after evaporating to dryness. Synonymous with total dissolved solids.
FLOCCULATION	The treatment process by which suspended colloidal or very fine particles are assembled into larger masses of floccules which eventually settle out of suspension; the stirring of water after coagulant chemicals have been added to promote the formation of particles that will settle.
FOOD CHAIN	The assemblage of organisms of various trophic levels linked by the transfer of food energy.
GREY WATER *(ALSO CALLED SULLAGE)*	Wastewater from the household baths and showers, handbasins and kitchen sinks, but excluding wastewater and excreta from water closets.
GRIT	Hard and heavier solid matter in sewage. It is generally inorganic. Examples include sand, gravel, ash, glass and metal fragments.
HEAVY METALS	All metals or semi-metals, other than alkali or alkaline earth metals.
HERBICIDE	A pesticide used to control or destroy the growth of weeds and undesirable plants.

INFILTRATION	Stormwater or groundwater which enters the sewerage system through cracked pipes or defective joints.
INFLOW	Water which enters the sewerage system from illegal connections of roof guttering, access covers, cross connections from stormwater drains, and street washing.
INORGANIC	Does not contain compounds with carbon or hydrocarbons.
LICENCE	A permit to operate a sewerage system under agreed conditions.
MARGINAL COST	The cost of making an additional unit of water available *(the sum of the marginal capacity and operating cost).*
MARINE WATERS	Water with dissolved inorganic ions greater than 30 parts per thousand.
MOLLUSCS	Animals which belong to the Phylum Mollusca including clams, oysters, snails and squid.
NITRIFICATION	The bacterial conversion of ammonia to nitrate-nitrogen and nitrite-nitrogen.
NUTRIENT REMOVAL	Removal of nitrogen and phosphorus from wastewater to prevent excessive aquatic plant regrowth in receiving waters.
NUTRIENTS	Compounds required for growth and reproduction of organisms. Nitrogen and phosphorus are the most common nutrients.
OCEAN OUTFALL	A pipeline which carries effluent from coastal sewage treatment plants and discharges it far away from the shore, where the action of sea water, currents and the sun will dilute the effluent and assist biodegradable material to break down.
ORGANOCHLORINES	A specific group of pesticides containing chlorine.
PATHOGENIC	Capable of causing disease.
PATHOGENS	Natural organisms, such as bacteria and viruses which can cause disease in plants and animals.

PESTICIDE	Insecticides, herbicides, rodenticides, fungicides or any substance or mixtures of substances intended for destroying, controlling, repelling, altering life processes or mitigating any insects, rodents, nematodes, fungi, weeds and other forms of plant and animal life.
PHOTOSYNTHESIS	The production of carbohydrates from carbon dioxide and water by plants using light energy.
PLANKTON	Small drifting or feebly swimming organisms.
POTABLE WATER	Water that is free from impurities in such amounts that it is safe for human consumption without treatment.
PRIMARY CONTACT RECREATION	Any recreation or other use such as swimming, diving or water skiing in which there is prolonged and intimate contact with the water.
PRIMARY TREATMENT	Treatment using filtration and settlement to remove trash, floating and settling material from wastewater *(sewage).*
RESIDUAL	Any solid matter captured in the sewage treatment process.
REVERSE OSMOSIS	Reverse osmosis is a purification process where effluent is passed through a membrane which lets pure water pass through but prevents passage *(hence can remove)* almost all viruses, contaminants, and salts.
RUN-OFF	That portion of precipitation of irrigation water which flows across the ground surface, eventually returning to streams.
SALINITY	Total dissolved solids.
SCREENINGS	Materials removed from the sewage by screening processes. For example, rags, plastics and condoms.
SCUM	Any material that floats to the surface of sewage during treatment, for example, in sedimentation tanks.

SECONDARY CONTACT RECREATION	Any recreation or use in which contact with water is either incidental or accidental such as fishing, boating and limited contact incident to shoreline activities.
SECONDARY TREATMENT	Treatment that adds to Primary Treatment by incorporating processes that reduce the level for organic materials in wastewater. Typically these are biological process that digest organic materials including some pathogens.
SEDENTARY	Immobile benthic fauna.
SEWAGE	The wastewater from homes, offices, shops and factories. Most sewage comes from domestic sources *(for example, from washing clothes, dishes and using the toilet and shower)*. Small amounts of trade wastes may also be present.
SEWER MINING	Diversion and treatment of raw sewage, for on-site purposes such as irrigation.
SEWERAGE SYSTEM	The system of pipes in which sewage flows.
SHELLFISH	Any species of fresh, brackish or saltwater mollusc including clams, oysters and mussels.
SLUDGE	Consists of solid matter that settles to the bottom of the sedimentation tank during sewage treatment. It is then processed into a material which can be beneficially used *(biosolids)*.
SOURCE CONTROL	Industry and individuals taking responsibility for preventing matter entering the sewerage system.
STABILISATION	The processing of biosolids to reduce or eliminate the potential for putrefaction and which as a result reduces pathogens, vector attraction and offensive odours.
STANDARDS	Statutory or mandatory limits with legislative force.
STORMWATER	Rainwater which runs off urban and agricultural catchments, often carrying rubbish and animal droppings, sewerage overflows, grass clippings and heavy metals from car exhausts. This untreated water is carried in stormwater channels and discharged directly into creeks, rivers, harbours and the ocean.

SUBSTRATE	The underlying material on which an organism moves or to which it is attached.
SURFACTANT	A surface active agent found in detergents.
SUSPENDED SOLIDS	Particles in sewage that can be removed by sedimentation or filtration.
TERTIARY TREATMENT	Treatment that adds to secondary treatment by refinements such as further biological treatment and fine filtration to produce waters suitable for re-use.
TOTAL COLIFORMS	Total number of bacteria or colonies of the coliform type present within a water sample. Expressed in bacteria or colonies per 100 millilitres *(count/100mL).*
TOXICANT	A substance which is poisonous to living things.
TRADE WASTE	Waste from industry put into the sewerage system.
TURBIDITY	An expression of the optical property that causes light to be scattered or absorbed rather than transmitted in straight lines through water. Turbidity is caused by suspended matter such as clay, silt, finely divided organic and inorganic matter, plankton and microscopic organisms and gives the water a "cloudy" appearance.
VECTORS	Insects and animals, such as flies, mosquitos and rodents, which are attracted to the putrescible organic material in the biosolids and which may spread pathogens.
VERTEBRATES	Animals with a backbone.
VIRUS	A microscopic, non-cellular particle that is composed of only genetic coding material *(DNA).* It is parasitic and reproduces only with a host cell. Viruses are more difficult to deactivate than bacteria.
WASTEWATER	Water which is collected and transported to a treatment plant *(often by the sewer).* Wastewater normally includes water from both domestic and industrial sources.
WASTEWATER TREATMENT PLANT *(WWTP)*	The processing facility that treats sewage to render it acceptable for discharge into the environment and which as a result produces biosolids and minor residuals.

WATER REUSE	The successive use of water, following proper treatment of wastewater and conveyance to point of use.
WETLANDS	Large areas of water and aquatic growth *(natural or artificial)* which play a major role in the water cycle by storing and filtering water, and replenishing underground water supplies. Wetlands also act as a breeding place for wildlife; provide habitat for plants and animals; take up nutrients; reduce flooding; and provide areas for education, research and relaxation.

Abbreviations

ADWF	Average Dry Weather Flow
AHD	Australian Height Datum
ANZECC	Australian and New Zealand Environment and Conservation Council
ASS	Acid Sulphate Soils
BOD_5	Biochemical Oxygen Demand: the oxygen consumed by a unit volume of liquid during biological oxidation over 5 days at 20 degrees Celsius with its suspended solids included. This parameter is an indicator of organic content and is usually expressed in milligrams per litre.
CAS	Chemically Assisted Sedimentation
cfu	Colony forming unit
CPI	Consumer Price Index
DO	Dissolved Oxygen
DLE	Department of Land, Planning and Environment
DWWF	Design Wet Weather Flow
EIA	Environmental Impact Assessment
EIS	Environmental Impact Statement
EMP	Environmental Management Plan
ESD	Environmentally Sustainable Development
GIS	Geographic Information Systems
I/I	Inflow and Infiltration
IDAL	Intermittently Decanted Aeration Lagoon
LEP	Local Environmental Plan
NFR	Non-Filterable Residue
NHRMC	National Health and Medical Research Council

O&G	Oil and Grease
OU	Odour Unit: The assessment of odours involves the exposure of a selected panel of observers to varying concentrations of an odour in a controlled sequence to determine the point at which only half the panel can detect the odour. This point is called the odour threshold or one odour unit (1OU). The number of odour units is the concentration of a sample divided by the odour threshold. There are several odour thresholds that can be determined.
PCBs	Polychlorinated biphenyls, a group of environmentally stable organic compounds.
PDWF	Peak Dry Weather Flow
PER	Public Environment Report
pfu	Plaque forming unit
pH	The negative logarithm of the hydrogen activity concentration when expressed as moles per litre.
PV	Present Value
PWWF	Peak Wet Weather Flow
$ M	Million dollars
SPS	Sewage Pumping Station
TDS	Total Dissolved Solids
UV	Ultraviolet Irradiation *(disinfection process)*
WWTP	Wastewater Treatment Plant