Report and Recommendations by the Environmental Protection Authority

Evaluation of Disposal Options for Effluent from Laporte Titanium Dioxide Manufacturing Plant

Department of Conservation and Environment
Perth, Western Australia
Bulletin 137
May 1983

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PREAMBLE

The Authority has found the evaluation of the Report on disposal options by the Laporte Effluent Disposal Committee a demanding and complex task. The large number of options and alternative strategies, insufficient information and judgement as to the relative environmental values of the marine, estuarine and peninsula environments all complicated the assessment. These matters caused the Authority to take longer than normal to produce its report and recommendations.

To devise an appropriate effluent disposal strategy, the approach taken by the Authority was as follows:—

(a) consider the Laporte effluent stream as capable of being separated into components

(b) identify all possible options for treatment and disposal of each component by reference to the report of the Laporte Effluent Disposal Committee, overseas and interstate practices and published and other information

(c) specify the period of time for which a strategy is to be designed

(d) prepare a chart of all possible options illustrating their lifetimes.

(e) derive environmental criteria for effluent disposal and assess the environmental value and limitations of the local marine, estuarine and peninsula environments

(f) assess the practicability and preliminary environmental acceptability of options

(g) devise a preferred strategy based on (a) to (f) above.

The Authority is well aware that the Agreement between Laporte and the State may impede the implementation of an appropriate strategy. Therefore, either the goodwill of Laporte or amendments to this Agreement may be required for a preferred strategy to be successful.
This report has been arranged as follows:—

Conclusions

Recommendations

Sections 1 to 4 — provide background information on the locality, current and past disposal practices and their consequences

Section 5 — summary of recommendations and conclusions of the Laporte Effluent Disposal Committee

Section 6 — review of effluent treatment and disposal practices employed in overseas and interstate plants using manufacturing processes similar to that of Laporte

Section 7 — specifies environmental criteria for disposal of effluent into the marine environment and onto land

Section 8 — discussion of the practicability and environmental considerations for disposal and treatment options

Section 9 — describes the matters to be considered in developing an environmentally acceptable strategy for effluent disposal.

A.R. MAIN
Chairman

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CONCLUSIONS

The Authority has examined the report of the Laporte Effluent Disposal Committee and has investigated the effluent disposal problem by reference to the Laporte Agreement, published and other information and overseas and interstate practices and concludes that:

i. The Agreement between the State and Laporte inhibits proper environmental management designed to provide the most logical solution.

ii. The substances of most environmental interest in the Laporte effluent are iron and sulphuric acid. However, of these, iron would constitute the major environmental concern and strategies should primarily consider reducing the adverse effects of iron.

iii. To devise an appropriate disposal strategy it should be assumed that the effluent stream from Laporte can be split into strong and weak liquid effluent, solids and copperas. Then for each of these components appropriate options for treatment or disposal should be considered.

iv. The following options have not been adequately considered in the report by the Laporte Effluent Disposal Committee:—

  (a) separation of solids and copperas from the waste stream at the plant and disposal into an appropriate landfill

  (b) co-disposal of the following segments of the Laporte effluent stream

    - copperas and solids with fly ash from the proposed Bunbury power station and/or with red mud from alumina production
    - liquid effluent with reduced iron loadings with cooling water from the proposed Bunbury power station

  (c) programme for the reduction in iron loading of the effluent

  (d) feasibility of acid recovery and other effluent treatment processes for strong filtrates (strong effluent)

  (e) longer offshore pipeline

  (f) discharge of effluent with lower iron loadings via pipeline to the ocean

v. It is apparent from a review of overseas experience that improvements in the treatment of disposal of effluent can be made. However, what is feasible will depend on local circumstances.

vi. The Leschenault Peninsula and Inlet have high conservation value and their proximity to Bunbury will increase pressures for more appropriate uses, such as recreation, of the Leschenault Peninsula.

vii. The report of the Laporte Effluent Disposal Committee presented little information describing the environmental impacts on the ecology of Leschenault Peninsula and adjoining marine and estuarine environments of past, existing and future dune disposal practices.

viii. The strategy favoured by the Laporte Effluent Disposal Committee has as its central theme the use of the Leschenault Peninsula for effluent disposal until the capacity of the system has been exhausted. Ultimately, under the Committee's strategy, total effluent is discharged to the ocean via a 5.5 km pipeline.

ix. Injection of effluent into the limestone aquifer has caused problems of gassing in Leschenault Inlet and therefore there are doubts as to the environmental suitability of this means of disposal.

x. The ocean shoreline of Leschenault Peninsula is eroding at an average rate of one metre or more per year. If the process continues, ultimately the disposal areas of the Peninsula will be exposed to the ocean with the risk of promoting future ocean staining.

xi. The continuation of the existing disposal practices and proposed strategy of the Laporte Effluent Disposal Committee for the rest of the period of the Agreement with Laporte is environmentally undesirable.

xii. The ocean area adjoining the Leschenault Peninsula has relatively low waste assimilation capacity owing to low current speeds and limited depth of water. The area also has commercial fishery and recreational value.

xiii. On the basis of the commercial and recreational values and waste assimilative capacity of the offshore marine environment, the discharge of any total effluent through a 5.5 km pipeline is environmentally unacceptable. A substantial increase in the length of the pipeline and a reduction in iron loadings are required before an ocean pipeline proposal would be considered environmentally acceptable.

xiv. A preferred strategy would involve the following:—

  (a) disposal into the dunes to cease as soon as possible

(b) minimum discharge of iron (50% or greater reduction in aniticipated loading) through an ocean pipeline greater than 5.5 km in length. Recent experience in Western Australia suggests that greater than 20 metres of water depth would be required for suitable initial dilution of effluent

(c) separation of solids and copperas from the effluent stream in the plant and disposal into an appropriate landfill

(d) production and regular review of an environmental management programme which details monitoring, rehabilitation and other means for ameliorating adverse impacts

and further consideration of the following:—

(e) co-disposal of copperas and solids with fly ash from the proposed Bunbury power station and/or with red mud from alumina production, where possible

(f) a programme for the reduction of iron loadings in the effluent (which would include the development of further markets for the sale of copperas).

(g) assessment of the feasibility of disposal of liquid effluent (in combination or as an alternative to (b) above) with cooling water from the proposed Bunbury power station. The environmental acceptability of this proposal will depend on the location of the outfall and iron loading of the effluent

(h) initial assessment and then continual review of the feasibility of acid recovery and chemical treatment of strong filtrates (strong effluent)

RECOMMENDATIONS

The Authority recommends that:—

1. The following criteria be considered for the discharge of effluent into the marine environment—
   (a) No discolouration of water or beaches visible from the shoreline. A concentration of 0.1 mg/L of iron in seawater is generally considered as a reasonable estimation of a lower limit of visibility of iron floc in seawater.
   (b) No significant adverse effect on marine life beyond the immediate area of the discharge. Threshold concentration of iron in seawater which could affect fish behaviour is considered to be 0.5 mg/L. Recent publications suggest this level may also be a rough guide as to the onset of measurable sub-lethal effects. Threshold concentration for iron in seawater which can produce toxic effects on biota is 5.0 mg/L.
   (c) Using 0.5 mg/L of iron as a fish avoidance level, zones encompassing this and higher concentrations should be of a size and location such that it will not significantly inhibit marine life returning towards the shore.

2. The following criteria be considered when evaluating the disposal of effluent onto land.
   (a) No significant discharge of effluent or neutralised effluent, whether diluted with groundwater or not, to Leschenault Inlet.
   (b) No discolouration of waters visible from the shore (ocean or estuarine) or beaches.
   (c) Disposal sites should be secure in the long term (i.e. not subject in the future to flooding, erosion or other environmental disturbance).
   (d) Area to be of low conservation value.
   (e) No significant impact on terrestial biota and any adjoining marine and estuarine biota.
   (f) Not to preclude more appropriate land uses.
   (g) Contamination of groundwater to be minimized and no significant contamination of groundwater with potential for human consumption or necessary for the survival of terrestrial biota.

It will assist to achieve the above criteria and the environmental value of the Leschenault Peninsula would be recognized if the following recommendations are implemented:

3. The principal aim of a disposal stategy be the reduction of iron in the liquid discharge and removal of effluent disposal from Leschenault Peninsula.
4. Investigations should be made to determine means and sites for copperas and solids disposal. Consideration of co-disposal with wastes from other industries or activities be included.
5. A review of the cost and feasibility of acid recovery from strong and total effluent streams be carried out by consultants experienced in the design and operation of chemical plant.
6. Methods for treatment and acid recovery be kept under continual review and where appropriate be developed.

7. Disposal of effluent into dunes be phased out as soon as an alternative method of disposal of copperas and solids is developed. Complete cessation of dune disposal should occur once an ocean pipeline is available.
8. Consideration should be given to an ocean pipeline, substantially greater than 5.5 km in length terminating in water greater than 20 m depth, to discharge effluent carrying minimum iron.
9. An assessment of the feasibility of co-disposal of the following be carried out:
   (a) copperas with red mud from alumina production and/or fly ash from the proposed Bunbury power station.
   (b) liquid effluent of various iron loadings with cooling water from the proposed Bunbury power station.
10. The advice of the Authority be sought, once a decision is made on a final strategy, on further investigations required for environmental assessment.
11. An Environmental Review and Management Programme be produced including a justification and examination of the environmental implications of the chosen strategy.
12. A detailed environmental management programme should be produced which includes a plan for rehabilitation and restoration of the Leschenault Peninsula.

1. INTRODUCTION

Laporte produce titanium dioxide pigment from ilmenite by the sulphate process. Current rated annual production capacity of the plant is 36,000 tonnes.

The Laporte factory is located at Australind, approximately 5 km NE of Bunbury in proximity to the eastern shore of Leschenault Inlet. Effluent from the factory is currently disposed of in the dunes on the Leschenault Peninsula between the Inlet and the ocean.

Current and past disposal practices have given rise to concern by the local community and is also of concern to local authorities.

Pursuant to Section 55(1) of the Environmental Protection Act, the Minister for Resources Development referred to the Minister for Conservation and the Environment a report by the Laporte Effluent Disposal Committee entitled "Laporte Factory Effluent Report on Disposal Options".

In August 1982 the Minister for Conservation and the Environment referred the report to EPA for consideration.

On 3 January 1983 the Conservation Council of Western Australia in accordance with Section 56 of the Environmental Protection Act, referred to the Authority the operations of the above plant as a matter which gives rise to concern as to a possible cause of pollution. The Council was particularly concerned about pollution arising from effluent disposal.

2. BACKGROUND

2.1 History of Laporte

In 1961 the State of Western Australia and Laporte signed an Agreement (which has a term of 50 years) which enabled the establishment of a titanium dioxide manufacturing plant near Bunbury. In 1964 the plant commenced production with an annual production capacity of 10,000 tonnes. In subsequent years the capacity of the plant was expanded to 12,000 tonnes in 1966, 18,000 tonnes in 1969 and 36,000 tonnes in 1975.

Under the Agreement the State has the total responsibility for the disposal of all existing and future effluent and cannot interfere with the works site with the object of alterating the nature of composition of the effluent or compel Laporte to neutralise or otherwise treat the effluent (refer Appendix I).

The Industry has been an important source of employment (approximately 300 in the Bunbury region) and has invested over $25 million since its establishment in 1964.

Most of the product from the plant is exported and has a value in excess of $60 million per year at full production (36,000 tonnes TiO_2 per annum).

2.2 The Process (refer Figure 1)

Locally produced ilmenite is mixed with hot concentrated sulphuric acid (which is purchased or manufactured on site by the burning of sulphur and subsequent catalysed conversion of the combustion gases to sulphur trioxide) to dissolve most of the mineral compounds in the ilmenite.

To this solution iron scrap is added to reduce any ferric ion and the mixture allowed to settle. The settled undissolved solids are then separated, washed and disposed of with the effluent. The solution is cooled and copperas (ferrous sulphate) is crystallised, removed and disposed of with the effluent.

The remaining solution is then boiled and diluted to produce insoluble titanium compounds which are then filtered and washed. The residue is calcined and then further treated to produce titanium pigments suitable for sale.

2.3. The Effluent

Effluent from Laporte varies considerably in composition from day to day. The factors which influence the composition of the effluent are concentration and chemical form of iron in the ilmenite.

On the average, the effluent from Laporte is expected to have the following composition:

Daily discharge rate: 7700 m^3

Composition

Iron (in solution)	6 g/L	Chloride	0.29 g/L
Acidity (as H_2SO_4)		Suspended Solids	1.5 g/L
free	22.4 g/L	Manganese	0.23 g/L
total	36.2 g/L	Aluminium	0.08 g/L
Sulphate	35.5 g/L	Vanadium	0.013 g/L
Titanium	0.31 g/L	Chromium	0.007 g/L
Calcium	0.037 g/L	Solids	1-2 g/L
Magnesium	0.039 g/L	pH	0.94

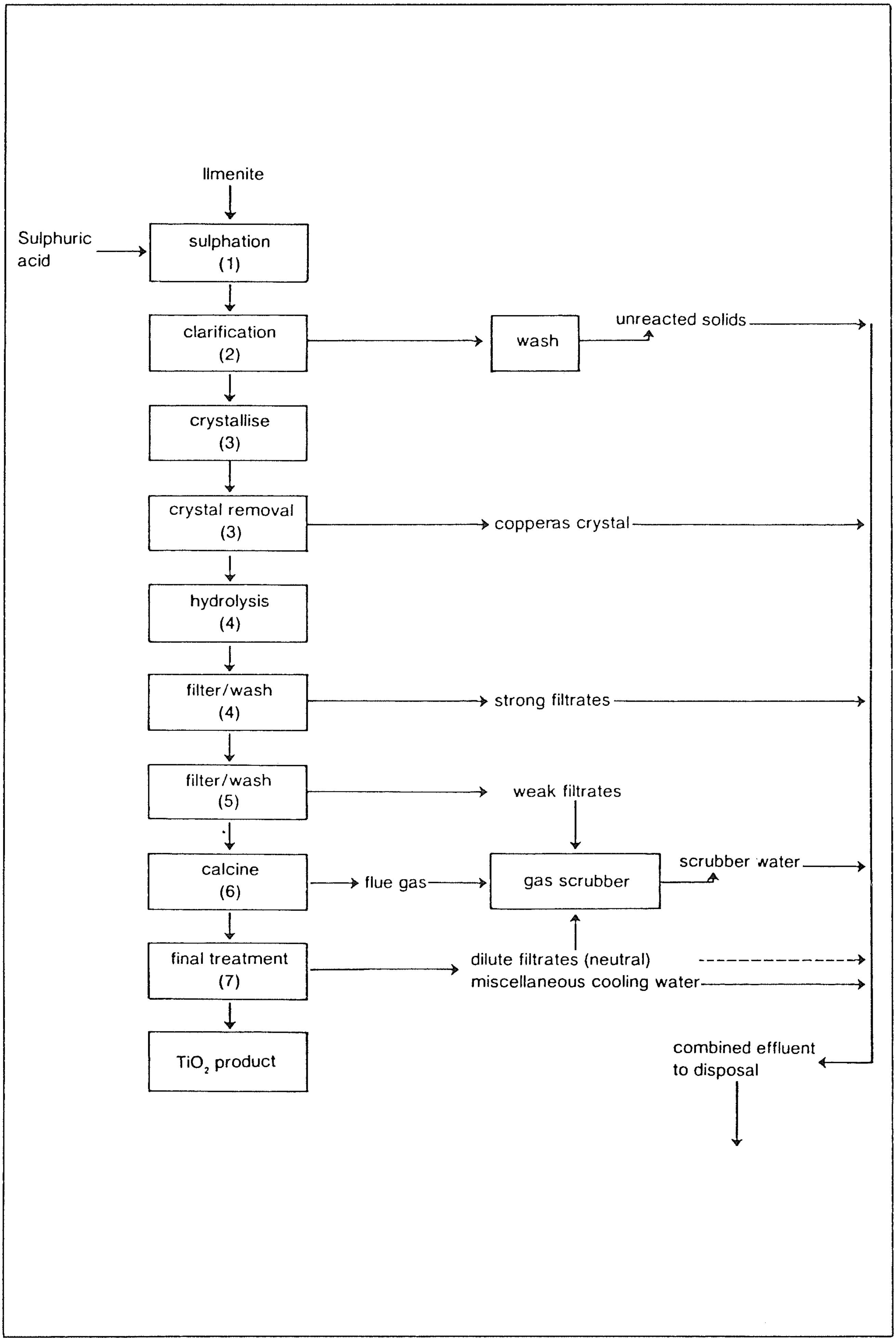


Figure 1 — Titanium Dioxide Sulphate Process Flow Diagram

The effluent also contains radioactive materials which originate from the ilmenite raw material. An Australian Radiation Laboratory report shows that the effluent contains radium 226 (in an insoluble form) at mean levels ranging from 1.0 to 3.2 Bq*/L. Proposed regulations which come into effect in August 1983, specify a limit of 1.1 x 10^3 Bq/L for a discharge containing radium 226 in an insoluble form.

2.4 Past Disposal Practices

2.4.1 Ocean Disposal

When the factory commenced operations in 1964, the effluent was discharged just off-shore on the western side of the Leschenault Peninsula. Following complaints of water staining as far north as Binningup Beach the direct discharge of effluent into the ocean ceased in 1968.

2.4.2 Dune Disposal

After ocean disposal was discontinued, effluent was placed in lagoons on the Peninsula. Analysis of the performance of the dune disposal system by Geological Survey has shown that about half of the lagoons performed successfully. In those instances where a lagoon failed, it was either because it did not accept significant effluent or produced heavy ocean staining. The success of a lagoon is dependent upon its position in relation to the water table, the underlying stratigraphy, distance from ocean and/or inlet, the amount and rate of effluent delivery and calcium carbonate content of the dune sands.

The stratigraphy varies considerably over the Peninsula thereby requiring a thorough investigation of each lagoon site.

Dune disposal continues to produce staining in the ocean and has in the past produced some staining of the Inlet.

2.5 Past EPA Involvement

In February 1974, the matter of the Laporte effluent was referred to the EPA by the then Minister for Development and Decentralisation. In March 1975, the EPA indicated preference for ocean dumping beyond the continental shelf. Also the Authority felt that a 5.5 km pipeline was likely to cause problems of staining and drift of effluent.

Later in April 1975, the Authority set two broad criteria for a 5.5 km pipeline:

(i) No significant adverse effect on marine life.

(ii) No discolouration of water or beaches visible from the shore.

The EPA also set up an Ad Hoc Committee to advise on marine studies for an ocean pipeline.

In December 1976, the EPA provided comment on criteria for the existing practice of dune disposal proposed by the Chairman of the Laporte Factory Agreement Review Committee. The EPA considered the following criteria acceptable:

(i) produce no pollution of aquifers with potential to meet Bunbury, Eaton and Australind's domestic and industrial water supply requirements;

(ii) produce minimum changes in quality of the existing fresh water soaks and seeps in the sand dunes so that the biology of the wildlife dependent on them is not affected;

(iii) produce minimum seepage of diluted and neutralised effluent into Leschenault Estuary and certainly produce no staining or seepage which would affect the biology of the estuary.

The EPA considered dune disposal should also meet the criteria (i) and (ii) specified by EPA in April 1975 for ocean pipeline disposal.

Intermittently up to May 1976, the EPA provided comment on progress reports of marine studies for an ocean pipeline.

3. THE LOCALITY

3.1 Leschenault Peninsula and Inlet

The disposal area used at present is approximately 7 km north of Bunbury (refer to Figure 2) in the southern half of the Leschenault Peninsula. On the eastern side of the Peninsula is Leschenault Inlet which provides habitats for a wide variety of water birds and estuarine biota.

The Leschenault Inlet is a long, narrow, shallow inter-dunal estuarine lagoon connected to the ocean at the southern end. Freshwater inputs from the Collie and Preston rivers during winter produce major changes in salinity of the Inlet. At the northern end the Inlet ranges from brackish in winter to hypersaline in summer owing to the poor exchange with the ocean.

*Bq: becquerel, unit of radioactivity (one disintegration per second).

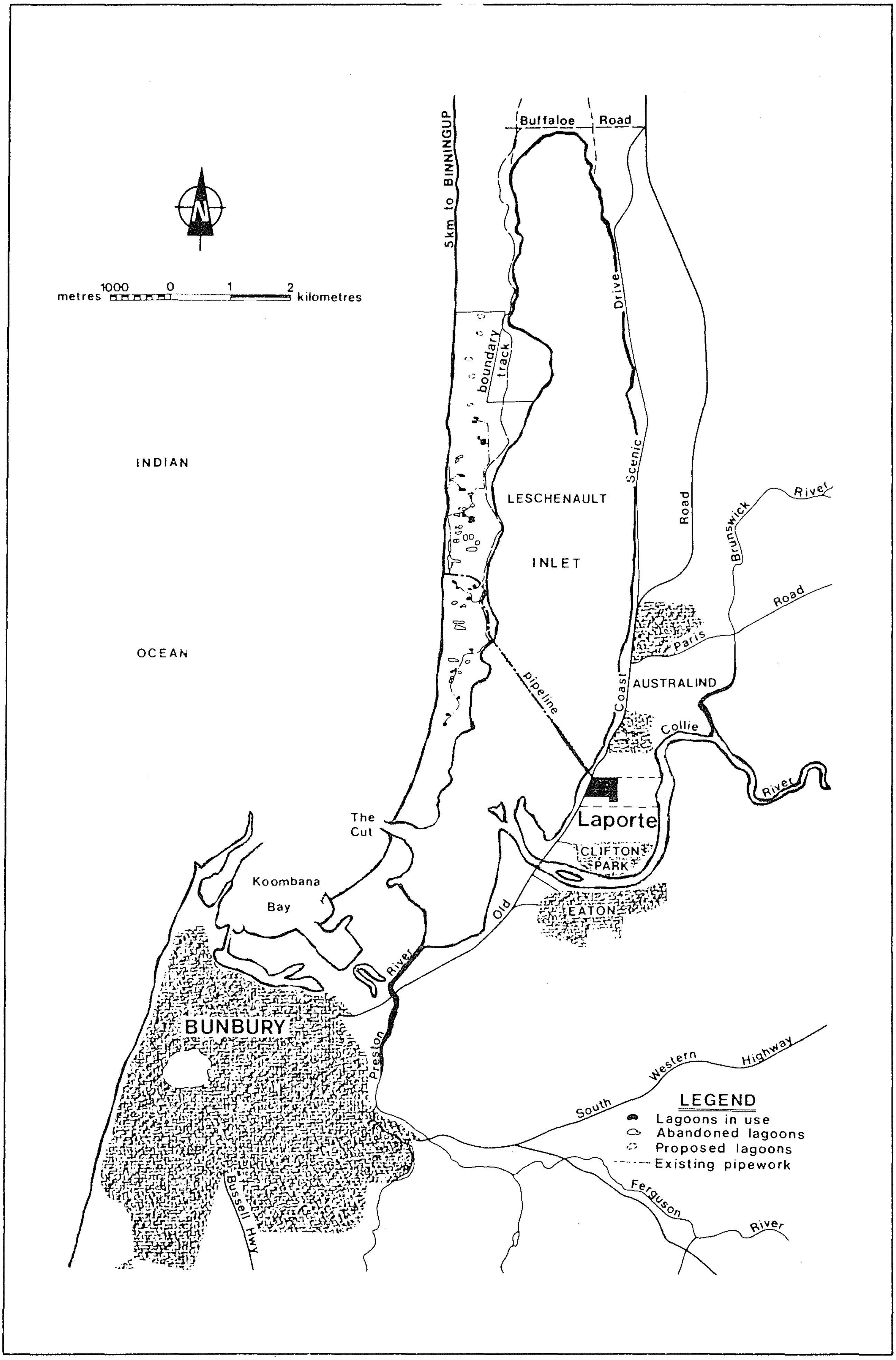


Figure 2 — Location of Factory and Disposal Areas

The estuary is an important feeding ground and nursery for water birds, migratory birds, fish and crabs. The fish and crabs are important to the local tourist and recreational industries. Seagrass meadows which are most extensive in the northern section of the Inlet are an important part of the ecology as they provide either food or habitat for fish, invertebrates and birds.

The conservation value of the estuary and Peninsula has been recognised in the System 6 Study Report (refer Appendix II) which has made recommendations for management control and reservation of the area.

With respect to management control the Authority is aware of the initiatives taken by the Waterways Commission to extend the boundaries of the Leschenault Inlet Management Authority by inclusion of the Peninsula.

3.1.1. Geomorphology, Geology and Hydrology

The Leschenault Peninsula contains a beach ridge system on the western side, mobile and fixed dunes over most of its surface and predominately vegetated dunes and woodland plains on its eastern side. Wind and wave erosion are prevalent and dominant processes in developing the coastal geomorphology and submarine shelf morphology.

Review of photographic records shows there has been overall net erosion of the coastline in the past 35 years. The coastal retreat is estimated to be in the region of one or more metres per year. The bulk of the eroded material is transported north by longshore drift.

Broadly there are four separate formations in decreasing age from the surface downwards (refer Figure 3) in the Leschenault Pensinsula:

(a) Safety Bay Sand

(b) Leschenault Formation

(c) Tamala Limestone

(d) Leederville Formation

Formations (a), (b) and (c) are of most interest when considering dune disposal. The stratigraphy of the Safety Bay Sand, into which effluent is discharged can vary markedly from one location to the next. The formation comprises a sequence of aeolian, beach and littoral sands with variable shell content. Old soil horizons are present in some places and a calcrete sheet of varying composition, structure and thickness, is widespread in this formation.

The presence of these structures in Safety Bay Sand can have a marked effect on the downward and sideways movement of effluent discharged to lagoons.

The internal structure of Tamala Limestone is complex with vugs* and solution channels being common. A laminar or massive calcrete sheet has developed on top and some clayey layers have been observed in some areas. The top of the limestone generally dips towards the west and this Formation underlays the Inlet and goes out under the ocean for a considerable distance.

The Leschenault Formation consists of a sequence of grey clays with intercalated coarse grained poorly sorted sand. The upper surface of this formation consisting of nodular-cemented calcareous clays, shelly clays and calcareous sands has been tentatively named the Belvedere Formation.

There are two principal aquifer systems. The unconfined Safety Bay Sand aquifer and the confined or semi-confined Tamala Limestone aquifer (refer Figure 3). The water table (under natural conditions) fluctuates and reaches a maximum elevation 0.7 m above mean sea level and decreases to 0.2 m prior to recharge.

The hydraulic head of the confined aquifer is sensitive to sea level but has an amplitude less than that of the water table. Over the western half of the Peninsula the hydraulic heads in the confined aquifer are less than those in the unconfined aquifer, whereas the opposite appears true near the Leschenault Inlet shoreline.

As might be expected, the quality of groundwater in these systems has been drastically affected by effluent disposal in the vicinity of disposal lagoons. Prior to disposal the chemical characteristics of the groundwater were generally as indicated in Table 1.

Natural groundwater quality becomes more saline at the interface with the ocean and Inlet. Disposal of effluent has drastically increased concentrations of iron (up to 12,000 mg/L), and sulphate (up to 35,000 mg/L) and decreased the pH (down to 1.0) in some areas. The highest values occur in the proximity of disposal lagoons where unneutralized effluent may be present.

*vugs are discrete macroscopic spaces in the limestone.

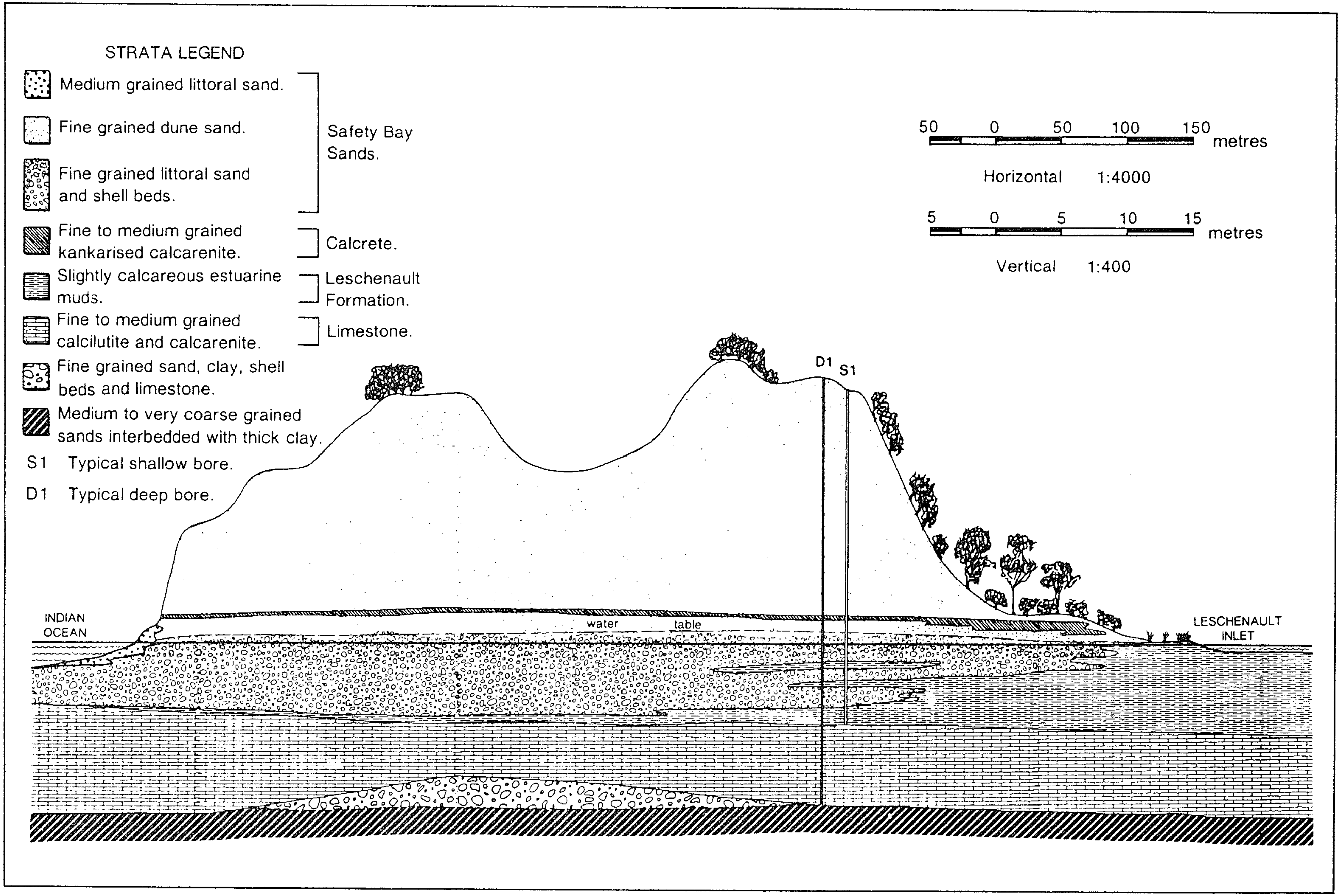


Figure 3 — Typical Cross Section of Leschenault Peninsula and Environs

Table 1. Natural Quality of Groundwater (without salt water intrusion)

	Safety Bay Sand Aquifer	Tamala Limestone Aquifer
Field pH	6.5-8	6.5-8
Chloride (without salt water intrusion)	<300 mg/L	<350 mg/L
Sulphate	<59 mg/L	<60 mg/L
Iron	<1 mg/L	<1 mg/L
Calcium	<150 mg/L	<150 mg/L
Magnesium	<40 mg/L	<40 mg/L

3.2 Marine environment

Offshore from Leschenault Peninsula, the ocean bed is gently sloping with unconsolidated sand overlying beach rock at shallow depths, generally about 0.6 m. Six kilometres offshore water depth is 15-18 m with the edge of the continental shelf about 90 km from the shoreline. The sands are either clean, bare and rippled or colonised by sea grasses. A series of limestone reefs some 3 m high and parallel to the coast occur some 200-300 m offshore and in isolated areas further offshore.

Current speeds in the marine environment are very low with average speeds of only four centimetres per second. The preferred current direction is toward the north-east in response to prevailing westerly to southerly winds. High current speeds occur during winter in response to winter storms.

The tidal range is small as is the tidal current (maximum amplitude of 2.5 centimetres per second). Tidal currents are expected to have little influence on the path of a contamination plume.

Geographe Bay produces some 500,000 kg of fish annually, most of which comes from the area adjacent to Bunbury. The major income-earning species are rocklobsters, Australian salmon, Westralian jewfish, shark and Australian herring.

For amateur fishermen who dive or angle from the shore or boat in the general vicinity, the most important fish species are flathead and whiting.

The nearshore waters are also important for other recreational activities such as swimming, boating, sightseeing and tourism. Obviously the significance of these waters is their proximity to Bunbury and their integration with the valuable fisheries and recreational resources of Geographe Bay.

4. CURRENT DISPOSAL PRACTICE AND ITS CONSEQUENCES

4.1 Lagoon Disposal

The use of lagoons as infiltration ponds has been found to be the most successful means found for the disposal of effluent into the dunes. The selection of lagoon sites by the Public Works Department is based on the following criteria:

(i) as far from both shores of the Peninsula as possible;

(ii) sites to the east of the centre of the Peninsula are favoured;

(iii) high elevation is preferred;

(iv) soil horizons to be avoided;

(v) prefer calcium carbonate content under the site to be less than 15%;

(vi) new sites should be out of the area of influence of old lagoons.

The rate of effluent disposal controls the height of the groundwater table in the area of the lagoon and hence the velocity of groundwater. A desirable disposal rate into a lagoon has been estimated to average 2000 m^3/day over 5 days. Ideally this average rate of disposal necessitates that at least four lagoons or lagoon pairs (in practice seven) outside the hydraulic influence of each other be available to minimise increases in water tables.

Discharge of effluent to a lagoon or set of lagoons may cease when:

- adverse effects on vegetation are detected
- excessive ocean staining occurs
- staining of the Inlet is observed or predicted.

An extensive system of monitoring bores have been sunk in order to monitor changes in water tables and contaminant levels. The contours of concentration have been mapped and show that a substantial proportion of the Safety Bay aquifer under the Peninsula is contaminated with neutralised, partly neutralised and unneutralised effluent.

4.2 Mechanism of Dune Disposal

When effluent disposal into a lagoon commences there is a rise in the water table resulting in the creation of a groundwater mound in the Safety Bay Sand aquifer. The effluent usually sinks to the bottom of the aquifer and then moves away in response to the hydraulic gradient and gravity. While moving through the aquifer the effluent reacts with calcium carbonate (limestone) forming gypsum (which may precipitate), iron carbonate precipitate and carbon dioxide. The solution remaining (termed neutralized effluent after these reactions are completed) contains iron and continues to move in response to the hydraulic gradient until it discharges to the ocean causing some staining.

Sometimes effluent is able to migrate down to the Tamala Limestone aquifer where similar reactions take place.

As the calcium carbonate in the Safety Bay Sand aquifer is exhausted in the vicinity of the lagoon the amount of unneutralized effluent in the system grows. The use of the lagoon is usually discontinued when the interface between the neutralized and partly neutralized effluent (zone of high iron concentration) reaches the point of discharge at the sea shore.

There is a considerable quantity of iron stored in solution in the aquifer after cessation of effluent discharge to a lagoon. The groundwater mound gradually decreases with time to natural levels resulting in diminution of the discharge of this stored iron to the ocean. This discharge is sustained by groundwater recharge and it is worse when water table heights are at a maximum and ocean tides at a minimum.

Through the process of discharge and dilution with groundwater recharge it is estimated that it will take about 20 years for the iron concentration to be below the detection limit within the dunes.

4.3 Chemistry of Dune Disposal

The Safety Bay Sand (of which the dunes are composed) contains between one and 30% limestone and average about 15%.

The sulphuric acid in the effluent reacts with the limestone to form gypsum, water and carbon dioxide according to the following equation:

$$H_2SO_4 + CaCO_3 \rightarrow H_2O + CO_2 + CaSO_4$$

Gypsum can be precipitated from solution and has been responsible for the "clogging" of lagoons (where the limestone content below the lagoon exceeds 15%) and their subsequent failure.

It has not been determined exactly how the iron in the effluent is removed, but is currently thought to be a result of the reaction of ferrous sulphate with calcium carbonate to form ferrous carbonate. carbonate.

$$FeSO_4 + CaCO_3 \rightarrow FeCO_3 + CaSO_4$$

According to information from laboratory studies, ferrous sulphate reacts most readily with one form of limestone (aragonite) to form ferrous carbonate.

Recent work carried out in the vicinity of a lagoon has shown the presence of ferrous carbonate (siderite).

4.4 Iron Discharged to the Ocean and Inlet via the Groundwater Systems

In the report of the Committee very little indication has been presented as to the amount of iron discharged to the ocean and estuarine environments from past and existing effluent disposal activities. Calculations have been carried out by Geological Survey of iron discharges via the groundwater systems from lagoons 7A and 7B (whilst in operation). However, it is not clearly stated as to whether all or a fraction of these discharges have reached the ocean and estuarine environments.

No data has been provided to indicate whether there is any adverse effect on marine biota resulting from the seepage to ocean of effluent containing iron.

5. SUMMARY OF FINDINGS OF THE LAPORTE EFFLUENT DISPOSAL COMMITTEE

The investigation of acceptable means for the disposal of Laporte effluent has lasted for an extraordinary period of time. In 1970 the then Government set up an interdepartmental committee to investigate different means of disposal and this committee recommended in 1972 that barging and chemical recycling be investigated further.

In 1973 another committee, the Laporte Effluent Disposal Committee was set up to examine all options for future disposal of effluent. Finally this Committee published its report and recommendations late in 1982.

The options outlined in the report of this Committee are basically:

(a) Disposal on land (in existing dunes area, further dune area immediately to the north, and limestone injection).

(b) Effluent treatment (limestone, seawater or ammonia neutralisation) prior to discharge to the ocean.

(c) Re-use or recovery of materials in the effluent (including chemical treatment) prior to discharge to the environment.

(d) Ocean disposal (barging or ocean pipeline).

(e) Combination of ocean and land disposal.

The Committee went on to conclude (amongst other things) that:

- It is too costly at this time to employ some form of chemical treatment. Also there is only a limited market for many of the recovered materials.
- There is no method of treatment and disposal of effluent that is more environmentally acceptable and more economically practicable than dune disposal currently employed.
- Barging is too costly.
- All management strategies eventually involve disposal to the ocean.
- Strategies having least environmental effect on the environment all involve separating the effluent into components.

and recommended:

- Detailed studies be undertaken for an ocean pipeline.
- Secure additional land for land disposal of effluent.
- Assess works needed to segregate effluent in the plant.
- Institute studies to confirm the feasibility of long term bore injection of concentrated effluent.
- Undertake further studies on the visibility of iron floc.

6. OVERSEAS AND INTERSTATE PRACTICES

6.1 Overseas

Table 2 presents information from a selection of countries on means of treatment and disposal of waste from titanium dioxide manufacturing plants using the sulphate process.

In the countries reviewed, it is apparent that efforts to reduce environmental impacts are being made by treating effluent, limiting the expansion of plants and reducing iron and acid loadings prior to discharge. Disposal of effluent to coastal waters by pipelines is practised in some countries (Britain, France and Canada) whereas tankering or barging is practised by others. In the United States rules have been proposed which in effect, would mean that complete neutralisation, aeration and settling of effluent prior to discharge is necessary. Under U.S. proposed rules, a plant with production capacity of Laporte, would be permitted to discharge per 30 day period approximately 3.6 tonnes of iron. Laporte at Bunbury under existing conditions would be discharging at full production over 30 days 1,386 tonnes of iron.

6.2 Interstate Practice

There is only one other titanium dioxide plant in Australia which employs the sulphate process. This plant is located at Heybridge near Burnie on the northern coast of Tasmania and has a similar production capacity to that of Laporte.

This plant disposes of solids separately into a landfill site and all iron-containing effluent is discharged 3.2 km offshore and at a depth of 25 m.

The Tasmanian plant discharges through this pipeline approximately 1700 m^3 per day of effluent with an iron concentration of 26.7 g/L.

Recent work has been carried out by Lucas Heights Research Laboratories using radioactive tracers to study the dispersion of discharged effluent. This investigation found that effluent tended to accumulate in the vicinity of the outfall, but was able to mix with ocean water and sometimes produces staining along the shoreline under strong north westerly winds.

Table 2 Means of Treatment and Disposal of Effluent

<table>
<tr><th>Country</th><th>No. of Plants</th><th>Control & Treatment</th></tr>
<tr><td>U.S.A.</td><td>4</td><td>US-EPA proposed rules (July 1980), limitations involve limestone precipitation, clarification, aeration and settling. At the time of proposing above rules one plant had already installed technology to meet the following limitations.
Kg/Tonne production
<table>
<tr><th></th><th>1 day</th><th>30 day ave.</th></tr>
<tr><td>TSS</td><td>110</td><td>30</td></tr>
<tr><td>Iron</td><td>4.1</td><td>1.2</td></tr>
<tr><td>Arsenic</td><td>0.46</td><td>0.24</td></tr>
<tr><td>Antimony</td><td>0.71</td><td>0.38</td></tr>
<tr><td>Cadmium</td><td>0.11</td><td>0.070</td></tr>
<tr><td>Chromium</td><td>0.13</td><td>0.070</td></tr>
<tr><td>Lead</td><td>0.21</td><td>0.14</td></tr>
<tr><td>Nickel</td><td>0.18</td><td>0.10</td></tr>
<tr><td>Zinc</td><td>0.50</td><td>0.24</td></tr>
<tr><td>pH</td><td>6 to 9.0</td><td></td></tr>
</table></td></tr>
<tr><td>Canada</td><td>2, capacities of 30 and 40 thousand tonnes per year</td><td>Separation of solids and disposal of remaining effluent into St. Lawrence River. Expansion of one plant was refused on environmental grounds.</td></tr>
<tr><td>Britain</td><td>3, capacities ranging from 25 to 100 thousand tonnes per year</td><td>Effluent is discharged via pipeline to coastal waters or estuaries. At one plant some ferrous sulphate is roasted. One plant (Laporte) is now shut down.</td></tr>
<tr><td>France</td><td>3, capacities ranging from 24 to 80 thousand tonnes per year</td><td>Effluent at two plants is discharged to coastal waters. At one plant the effluent is neutralised. Storage of effluent is practised when dispersion in coastal waters is not favourable. Some ferrous sulphate is sold.
A programme is in train to gradually reduce pollution from this industry. Reduction in iron discharge has been achieved in part by using ore containing higher levels of TiO_2. A 34% reduction in iron discharged has been achieved in two years.</td></tr>
<tr><td>West Germany</td><td>4 plants, 55 to 75 thousand tonnes per year</td><td>Bayer — Recovers acid from effluent and also recovers and roasts ferrous sulphate. Solids are disposed of separately. Uses 71% TiO_2 ilmenite.
Kronos Titan (2 plants) — Acid waste is dumped at sea (some iron waste also) by tanker. Most of the copperas is either sold and/or roasted. Uses 45% TiO_2 ilmenite. Separate disposal of solids.
Sachtleben Chemie — Acid waste dumped in the sea by tanker. Separate disposal of solids. Uses 71% TiO_2 ilmenite.</td></tr>
</table>

7. CRITERIA FOR ENVIRONMENTAL ASSESSMENT OF OPTIONS

7.1 Disposal into the Marine Environment

In the marine environment the Authority believes that the effects of iron are the most significant environmental impacts. A large environmental benefit would be gained from reductions of the order of 50% or more in iron loading in the effluent.

It is clear from oceanographic data that mean current speeds are low and movement of water is often onshore. Also for a considerable distance offshore the depth of water is less than 25 metres. All of these factors combine to reduce the waste assimilative capacity of offshore waters.

When examining offshore disposal of effluent the Authority believes the following criteria should be met:—

(a) No discolouration of water or beaches visible from the shoreline. A concentration of 0.1 mg/L of iron in seawater is generally considered as a reasonable estimation of a lower limit of visibility of iron floc in seawater.

(b) No significant adverse effect on marine life beyond the immediate area of the discharge. Threshold concentration of iron in seawater which could affect fish behaviour is considered to be 0.5 mg/L. Recent publications suggest this level may also be a rough guide as to the onset of measurable sub-lethal effects. Threshold concentration for iron in seawater which can produce toxic effects on biota is 5.0 mg/L.

(c) Using 0.5 mg/L of iron as a fish avoidance level, zones encompassing this and higher concentrations should be of a size and location such that it will not significantly inhibit marine life returning towards the shore.

7.2 Disposal onto Land

The Authority believes that the disposal of effluent or waste onto land should meet the following criteria:

(a) No significant discharge of effluent or neutralised effluent, whether diluted with groundwater, or not, to Leschenault Inlet.

(b) No discolouration of waters visible from the shore (ocean or estuarine) or beaches.

(c) Disposal sites should be secure in the long term (i.e. not subject in the future to flooding, erosion or other environmental disturbance).

(d) Area to be of low conservation value.

(e) No significant impact on terrestrial biota and any adjoining marine and estuarine biota.

(f) Not to preclude other important land uses.

(g) Contamination of groundwater to be minimised and no significant contamination of groundwater with potential for human consumption or necessary for survival of terrestrial biota.

8. DISCUSSION OF OPTIONS

8.1 Introduction

Comparison of operating costs of various options was sometimes made difficult, owing to some costs being calculated differently. The Authority also noticed that detailed costing of strategies in terms of total cost over 30 years and discounted according to a rate of 15% was carried out on variations of ocean and dune disposal and not other options.

The Authority was not able to undertake a detailed analysis of cost but believes that its task would not have been so difficult if the costing of options was presented on a more uniform basis. However, the Authority acknowledges that areas of cost comparisons and estimations are difficult and has used the figures given as a crude or relative indication of costs of the various options.

Nevertheless the costs provided in the report of the Laporte Effluent Disposal Committee are based on treatment of the total diluted effluent. The report has not examined the cost of treating strong effluent which has a much lower volume but contains the vast majority of the acid and iron.

To assist in the evaluation of the many possible options, a chart or critical path schedule (refer Figure 4) was constructed showing options and corresponding periods and commencement dates. This exercise was felt necessary in order to present available information in a form which would facilitate informed judgements.

The options illustrated (and numbered) by this chart include those examined by the Committee and others which the Authority has identified. The recommended strategy or options (corrected to include the latest information on the disposal of effluent into the dunes) favoured by the Laporte Effluent Disposal Committee are also shown on this chart. The Authority recognises that the

Committee's scheme of disposal may change but the Authority understands that any changes made will incorporate dune disposal of effluent as the main theme.

One factor that influences the lifetime of the Laporte operation (and therefore influences effluent disposal strategies) is the availability of ilmenite suitable for the plant at Bunbury. The Authority has been informed that there are sufficient reserves to supply the plant for 25-30 years. However, estimates of an even shorter lifetime have been suggested.

A knowledge of the available reserves of ilmenite suitable for use in the Laporte plant would be helpful in the resolution of a preferred disposal strategy.

8.2 The Effect of the Laporte-State Agreement

When reviewing options or strategies for effluent treatment and/or disposal, there is one important factor which makes the Laporte plant at Bunbury unique. This factor is the Agreement between the State and Laporte which obliges the State to dispose of effluent and which also prevents in effect, the imposition of effluent limitations by the State. Where the imposition of effluent limitations is not possible and the company is not obliged to meet the cost of disposal, there is little incentive for reduction in pollution loadings. This is in conflict with the "polluter pays" principle which has been adopted throughout Australia. This situation also has a marked effect on the relative "cost" of options to the company. Obviously if a company is paying for effluent disposal there is incentive to reduce effluent volumes, possibly by employing a more expensive treatment method than would be the case if effluent disposal costs did not have to be met.

Therefore, some options, which might be attractive where stringent limitations and costs of disposal are met by dischargers may not be as attractive to Laporte.

Also under the present Agreement the State is not able to impose conditions requiring reduction in pollution loadings from Laporte.

8.3 Separation of the Effluent Stream into Components

Very little consideration was given in the report of the Laporte Effluent Disposal Committee to:—

(a) the separation at the plant of the effluent stream into four basic components; solids, copperas, strong and weak effluent streams; and

(b) the evaluation of appropriate options for each of these components.

The Authority believes that viewing the problem of effluent disposal in this manner increases the options available and therefore provides a better basis for devising an appropriate strategy.

8.4 Effluent Treatment (refer Figure 4, Option nos. 10-16)

The Authority concurs with the Committee that effluent treatment by neutralisation with limestone, ammonia or seawater is costly and probably limestone and seawater neutralisation is of dubious environmental benefit. However, no consideration has been given by the Committee to treatment of segregated effluent streams.

The Authority acknowledges that neutralisation of effluent is practised overseas but believes that these methods may not be practicable in Western Australia. Nevertheless, it may be worthwhile considering treatment of segregated strong effluent.

8.5 Re-use or Recovery of Acid (refer Figure 4, Option nos. 1-9)

There are many schemes that have been devised to recover acid from effluent from titanium dioxide plants employing the sulphate process. The viability of these schemes depends greatly upon the capital cost of installing plant and operating costs which in turn depend markedly on rates of amortization, value of recovered acid and cost of energy expended in the process.

Undoubtedly many of the proposed schemes (Table 3) would be much more environmentally acceptable than existing schemes and the Committee's recommended strategy. However, some of the schemes presented in Table 3 have not been tried on a commercial or even pilot scale. Also on the basis of estimates by the Government Chemical Laboratories, the operating and capital costs of many of the schemes are high. Furthermore, markets for products from some processes of recovery are limited.

One shortcoming in the report of the Committee is that the costing of recovery and treatment processes was done on the basis of a total diluted effluent and not on a strong concentrated stream resulting from the segregation of effluent as recommended by the Committee.

Table 3 Some Options which include Acid Recovery

Valentine Laurie and Davies Process
Lurgi Process
New Jersey Zinc Process
European Economic Community Treatment I-VI
Ion exchange
Concentration to 50% Sulphuric Acid

Given the potentially high environmental acceptability of the acid recovery processes (and the likelihood of segregation of effluent into strong and weak streams) it would seem appropriate to instigate a detailed evaluation by a firm of engineers with extensive experience in chemical plant design and operation to provide an up to date review of the feasibility of acid recovery processes.

However, at present it would seem that there is no acid recovery scheme which could be immediately implemented and be practicable.

8.6 Ocean Disposal

8.6.1 Barging (refer Figure 4, Option nos. 23-25)
Disposal of effluent off the continental shelf by barge would appear at first glance to be more environmentally acceptable than disposal by pipeline close to the coast. However, the cost of such an operation appears to be very high and therefore not practicable.

8.6.2 Pipeline (refer Figure 4, Option nos. 35-37)
This option is economically feasible depending on pipeline length and any necessary pretreatment of the effluent. The environmental acceptability of discharge through a pipeline would depend heavily on location of diffuser, diffuser design and iron and acid loadings.

The results of modelling of the dispersion of iron wastes in the ocean is presented in the Committee's report. The Authority is also aware of modelling carried out by another group which suggests (contrary to results presented in the Committee's report) that the incidence of iron concentrations exceeding the visibility criterion of 0.1 mg/L of iron at the Bunbury shoreline will be very small or nil.

The difference between the results of these two modelling exercises has made the task of evaluation of marine options more difficult. However, the more conservative modelling results contained in the Committee's report have been used a guide by the Authority.

8.7 Land Disposal (refer Figure 4, Option nos. 17, 18, 21, 22, 26-32 and 39)

The present means of disposal onto land is obviously economically feasible. However, there are many options which involve disposal of various components of the effluent stream onto land. Two such options which were not considered adequately in the report of the Laporte Effluent Disposal Committee were the separation of solids and copperas at the plant for disposal into an appropriate landfill.

The life of the present disposal practices is limited, (refer Figure 4, Option nos. 25 and 29) and such practices are not considered to be environmentally desirable as these activities would lead to further degradation of the fragile Peninsula environment.

8.8 Reduction in Iron Content of Ilmenite

The amount of acid and iron in effluent from the sulphate process is highly dependent on the iron content of the ilmenite ore. For instance, if ilmenite slag were used in the process, the generation of copperas would be eliminated, indeed the amount of iron in the effluent would be reduced by at least 75%.

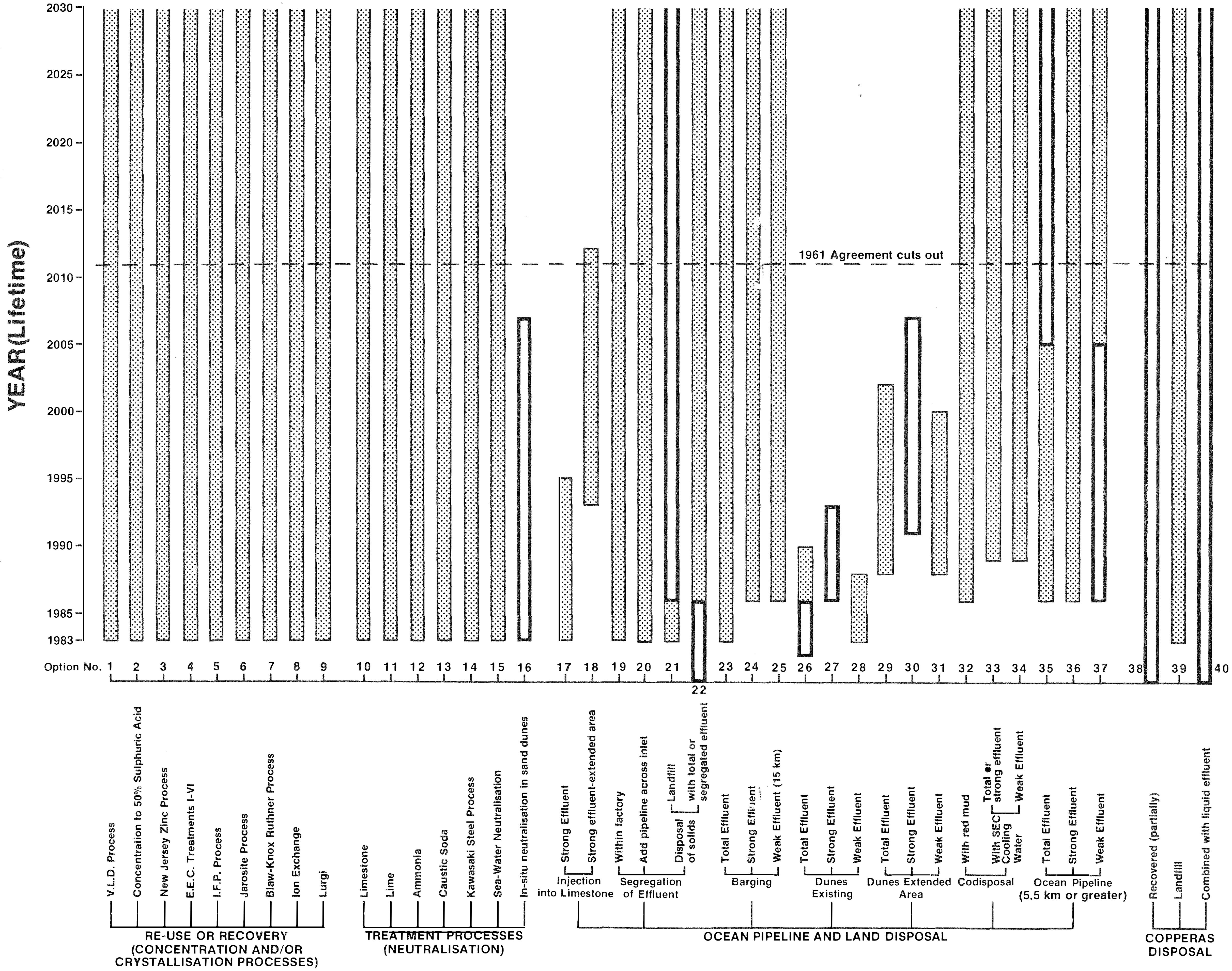
Some plants in Europe have chosen to substantially reduce their environmental problems by use of an ilmenite slag.

Unfortunately, ilmenite slag is not produced in Australia and therefore would have to be imported. The current import price for this material is $150 per tonne compared to approximately $26 per tonne for ilmenite. However, there are cost savings in raw materials such as acid if a slag is used.

The use of slag is feasible and would have obvious environmental advantages, but having to import this material would mean that Laporte would lose the advantage of being close to an ilmenite source. Apparently major alterations to the Laporte plant will be required if slag was to be used as a raw material.

8.9 Co-disposal (refer Figure 4, Option nos. 32-34)

Possibilities, not examined in the report of the Committee for co-disposal of portions of the Laporte



LEGEND

Committee's Recommended Option (without limestone injection)

MISCELLANEOUS

41 Asotoff Manganese Sulphate Process
42 Pigment Production
43 Phosphate Fertiliser Production
44 Solvent Extraction Processes
45 Bacterial Oxidation of Ferrous Iron
46 Other Oxidation Processes
47 Production of Gypsum Related Products
48 Utilisation of Ferrous Sulphate
49 Production of Ferric Sulphate for Water Treatment
50 Miscellaneous Uses for Iron Oxide
51 Ilmenite Benefication

Figure 4 — Chart of Options
This chart shows options considered in the report by the Laporte Effluent Disposal Committee and others identified by the Authority. Also shown in the chart are the lifetimes of options.

effluent stream with other wastes are:—

- solid and/or copperas with red mud from alumina production and/or fly ash from the proposed Bunbury power station.
- liquid effluent with cooling water from the proposed Bunbury power station. Given the large distances between Laporte and the nearest alumina refinery the cost of piping the effluent would seem prohibitive.

The viability of co-disposal of Laporte effluent with SEC cooling water would be dependent on a number of factors:—

(a) operational mode of proposed Bunbury power station;

(b) position of cooling water outfall;

(c) strength of the liquid effluent;

(d) volume of the cooling water discharge.

Co-disposal of components of the effluent stream with red mud wastes from alumina manufacture and cooling water and flyash from the proposed Bunbury power station have potential environmental and economic benefits to the State. Such proposals warrant detailed evaluation to assess their feasibility.

8.10 Summary

In summary, it would appear that the only options immediately economically practicable for the treatment and/or disposal of effluent are ocean disposal by pipeline, dune disposal, separate disposal of copperas, and solids. Possibly recovery of acid by ion exchange or some other means may be viable in the future and therefore should be kept under review.

Co-disposal of liquid effluent with cooling water from the proposed Bunbury power station at an appropriate distance offshore and north of the entrance to Leschenault Inlet may be a proposition well worthwhile examining as an option. Co-disposal of total effluent with red mud from alumina production was seen impracticable given the large distance required to transport the effluent. However, the feasibility of co-disposal of copperas and solids should be investigated. Similarly the feasibility of co-disposal of copperas and solids with flyash from the proposed Bunbury power station should be considered.

9. SELECTION OF A PREFERRED STRATEGY

The Authority believes that nominating a strategy for future disposal of effluent is preferable to nominating a particular option. A strategy can be more flexible (while being comprehensive) and may be composed of many options or elements of options.

In devising a preferred strategy, judgements have to be made as to the relative significance of environmental impacts of various options on the terrestrial, marine and estuarine environments. The judgements are not easy and involve values which can vary from one individual to another.

Any strategy chosen as being preferred will not be necessarily the most environmentally acceptable or the least costly.

9.1 Considerations

In making a determination of an appropriate course of action for future disposal and treatment of Laporte effluent, the Authority took into consideration the following factors:

Lifetime of the ilmenite resource and the Agreement — The Authority believes that the plant could operate for a further 20 to 30 years using the present sulphate process. The Authority is aware that Laporte's sister plant in the United Kingdom has shut down and that it is predicted that plants using the chloride process will in time become more prominent in the production of titanium dioxide. However, any disposal strategy should be designed to satisfy disposal requirements for 20 to 30 years and beyond (refer to Figure 4 for information on lifetimes of options).

The Agreement — (refer also Section 8.2) — The Authority acknowledges that a comprehensive approach or strategy which would lead to progressive improvements in effluent quality may be hard to obtain under the existing Agreement.

The Agreement inhibits the implementation of an optimum strategy as it prevents any regulation of effluent quality and segregation. For instance the segregation of copperas and solids for disposal in a suitable landfill would be difficult to enforce with the Agreement in place.

Progress being made overseas in reducing the impact of effluent from sulphate process plants has been discussed earlier in the Report. Whilst the Agreement is in place progress that has been made in Europe and the United States in the improvement of effluent quality, will be difficult to achieve in Western Australia.

Separation of Effluent into Components (refer also Section 8.3) — The flexibility of a strategy is enhanced if the effluent stream is viewed as being composed of four basic streams; solids, copperas, strong and weak effluent. The separation of the effluent stream at the plant and subsequent treatment and disposal of each individual component should be considered.

Environmental Criteria — In Section 7 of this report, environmental criteria are presented for disposal of effluent on to land and into marine waters. These criteria were used as a guide to assist in determining environmentally acceptable options.

Value of Leschenault Peninsula — (refer also Sections 3.1 and 8.7) — The Authority is aware of the conservation value of the Leschenault Peninsula and Inlet. This matter has also been addressed in the System 6 Study Report and has been emphasised by the Leschenault Inlet Management Authority. The EPA recognises the future pressures and competing uses (such as recreation) of coastal land in the Bunbury region and is concerned that any disposal practices in Leschenault Peninsula do not preclude indefinitely or suspend more appropriate uses of coastal land.

The alienation of larger areas of the Peninsula for effluent disposal for long periods is most undesirable.

Recovery and Rehabilitation of the Peninsula — Even after disposal is discontinued there will be considerable time (approximately 20 years) before the groundwater systems completely recover. To date very little rehabilitation of disused disposal areas has been carried out. No information is available to indicate how long after effluent disposal has ceased, rehabilitation will be complete and the area become available for recreational use. The Public Works Department maintains that the lack of rehabilitation was due to the expectation that disused lagoons might be available for further disposal.

Coastal Erosion — Published information has suggested the ocean side of the Peninsula is eroding at a rate of one or more metres a year. Indications are that the erosion is of a long term nature and if this were the case materials presently deposited in the Safety Bay Sand will be eventually exposed to the ocean. The consequences of this exposure are unknown, but it is likely that such exposure will promote ocean staining well into the future. It would seem therefore that disposal into areas close to an eroding coastline is undesirable. The report of the Laporte Effluent Disposal Committee gives little or no consideration to this aspect or other coastal processes.

Value and waste assimilative capacity of the marine environment — (refer also Sections 3.2 and 8.6.2) — The ocean offshore from Leschenault Peninsula has inherent disadvantages for the assimilation of effluents. Currents in the area are of low average speed and wind patterns are such that movement of water is often onshore. The ocean floor slopes very gently to the west resulting in shallow depths for considerable distances offshore.

The area has value from a recreational and commercial fishery point of view and the potential exists for nearshore water recreational activity such as swimming, boating and tourism.

Results of modelling of the discharge of total effluent (concentration of iron of 9-10 g/L) from a 5.5 km pipeline is presented in the Committee's report. Based on these modelling results the Laporte Effluent Disposal Committee indicated that the following impacts were anticipated:

- toxic effects within an area of 200 hectares;
- effects on fish behaviour within an area of 1000 hectares;
- iron concentrations in excess of the visibility criterion of 0.1 mg/L would be in the nearshore Bunbury waters for between 75 and 130 days of the year.

On the basis of the above intrinsic values and limitations, the Authority believes that discharge of total effluent through a 5.5 km pipeline is environmentally unacceptable. The Authority considers that a substantial increase in the length of the pipeline and reduction in iron loadings is required before an ocean pipeline proposal would be considered environmentally acceptable.

Feasibility of Options — refer Section 8.

Overseas and Interstate experience — The treatment and disposal of effluent from sulphate process plants operating overseas and interstate is described in Section 6. It is obvious from this description that many plants elsewhere have progressed further towards reducing the environmental impacts of effluent disposal than has the plant at Bunbury. This has been achieved by a combination of reductions in acid and iron waste quantities, acid recovery and more appropriate means of disposal.

Environmental management — It is essential that future decisions on disposal options should include a commitment to an environmental management programme including rehabilitation of the Peninsula. Such a programme requires a long term plan for future land uses of the affected area.

Report and Recommendations of the Laporte Effluent Disposal Committee — (refer also Section 5) — The option favoured by the Laporte Effluent Disposal Committee is segregation (possibly in

1986) of effluent into strong and weak streams with strong effluent disposal into the dunes and weak effluent into the ocean. This scheme has some advantages over existing disposal practices by reducing water table rises and possibly increasing the deposition of iron in the dunes. If these advantages do occur some reduction in ocean staining and vegetation damage will result together with an extension in the disposal life of the dunes.

However, operating experience of disposal of strong effluent into the dunes is limited and therefore there is uncertainty as to whether such disposal will have environmental advantages in the long term.

The Committee also sees the possibility of limestone injection as extending the disposal life of the Peninsula. However, trial injection of effluent into the Tamala Limestone aquifer was carried out and was discontinued following observation of gassing in Leschenault Inlet. The Authority believes that this means of disposal is still in the developmental stages. Given that gassing of Leschenault Inlet has occured and the complexity of the Tamala Limestone aquifer the Authority feels this means of disposal may have limited value and involve environmental risks.

Concern has also been expressed by the Leschenault Inlet Management Authority (refer 9.2) as to the potential risks of this means of disposal.

Ultimately the Committee sees the total effluent being discharged to the ocean through a 5.5 km pipeline.

In summary the recommended strategy of the Committee has as its central theme the use of the Peninsula for disposal of effluent until the capacity of the system is exhausted. Effort has been concentrated on extending the life of dunes for effluent disposal, thereby postponing the date for disposal of the total effluent to the ocean.

The Committee's reports gave insufficient attention to the following options, or combination of options which the Authority feels are worthy of further investigation.

(a) separation of solids and copperas from the waste stream at the plant and disposal into an appropriate landfill

(b) co-disposal of the following segments of the Laporte effluent stream

- copperas and solids with flyash from the proposed Bunbury power station and/or with red mud from alumina production
- liquid effluent with reduced iron loadings with cooling water from the proposed Bunbury power station.

(c) programme for the reduction in iron loading in the effluent

(d) feasibility of acid recovery and other effluent treatment processes for strong filtrates (strong effluent)

(e) longer offshore pipeline

(f) discharge of effluent with lower iron loadings via pipeline to the ocean.

9.2 Views of the Leschenault Inlet Management Authority (LIMA)

The Leschenault Inlet Management Authority in its review of the Laporte factory effluent report on disposal options has expressed concern about the effects existing practices have had on the Leschenault Inlet. Below the conclusions of this review are reproduced:

> "Seepage of effluent from the Leschenault Peninsula stratigraphy either as a result of Lagoon seepage or 'deep bore injection' could result in the discharge of oxidising ferrous iron which if released in sufficient quantities and/or over a long enough period of time will result in the degradation of estuarine benthos and in extreme cases fish deaths.
>
> Fish deaths have been observed as a result of pipeline bursts either as a result of low pH, oxidation of ferrous iron or both. The effects of sub-soil seepage on the benthos is currently being investigated.
>
> The disposal of highly acidic waste to lagoons in the dunes or by injection into the aquifer adjacent to the Leschenault Inlet is not in the interests of good estuarine management.
>
> Option 9 allows for the continuation of the effluent disposal to lagoons on the Peninsula enabling the development of a satisfactory ocean disposal system.
>
> The effluent should be treated to reduce its iron concentration as much as practicable and disposed of by ocean pipeline in deep water. The distance initially investigated some 16 km should be further investigated. It is understood that at the point of discharge there will be a zone of degradation, however, the marine environment some 16 km offshore may have a greater capacity to buffer the effects of this than the coastal dunes and associated estuarine ecosystem".

The Authority is sympathetic to concerns raised by LIMA and has taken these into account when considering future disposal options.

9.3 Preferred Strategy

A preferred strategy should preserve the environmental (including recreational) resources of the Leschenault Peninsula by diverting the disposal of components of the effluent elsewhere.

Taking into account all the above factors the environmentally most suitable strategy which appears feasible would involve the following:—

(a) disposal into the dunes to cease as soon as possible

(b) minimum discharge of iron (50% or greater reduction in anticipated loading) through an ocean pipeline greater than 5.5 km in length. Recent experience in Western Australia suggests that greater than 20 metres of water depth would be required for suitable initial dilution of effluent.

(c) separation of solids and copperas from the effluent stream in the plant and disposal into an appropriate landfill

(d) production and regular review of an environmental management programme which details monitoring, rehabilitation and other means for ameliorating adverse impacts.

and further consideration of the following:

(e) co-disposal of copperas and solids with flyash from the proposed Bunbury power station and/or with red mud from alumina production, where possible

(f) a programme for the reduction of iron loadings in the effluent (which would include the development of further markets for the sale of copperas)

(g) assessment of the feasibility of disposal of liquid effluent (in combination or as an alternative to (b) above) with cooling water from the proposed Bunbury power station. The environmental acceptability of this proposal will depend on the location of the outfall and iron loading of the effluent

(h) initial assessment and then continual review of the feasibility of acid recovery and chemical treatment of strong filtrates (strong effluent).

The existing Agreement impedes the implementation of the above because it precludes changes being required by the State for alterations in factory operation or effluent quality. Thus the preferred strategy requires the goodwill of the Company or amendments to the existing Agreement.

The benefits of this strategy are:

- it aims to reduce pollutant loadings;
- with copperas going to a properly designed landfill site the discharge of the remaining effluent to the ocean is possible;
- the Leschenault Peninsula is available for other more appropriate uses, such as recreation;
- risk to Leschenault Inlet from disposal of effluent is minimal;
- very little further impact on the ecology of the Peninsula.

10. FURTHER WORK

Once a decision has been made on a preferred option the advice of the EPA should be sought on requirements of further environmental assessment.

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APPENDIX I

Extract from: Laporte Industrial Factory Agreement 1961.

WESTERN AUSTRALIA.

LAPORTE INDUSTRIAL FACTORY AGREEMENT.

10° Elizabeth II., No. XXXIX.

No. 39 of 1961.

AN ACT to approve and ratify an Agreement relating to the Establishment in the State by Laporte Industries Limited of an Industrial Factory for the manufacture of certain Chemicals; to provide for the carrying into effect of the provisions of that Agreement; and for incidental and other purposes.

[*Assented to 6th November, 1961.*]

BE it enacted by the Queen's Most Excellent Majesty, by and with the advice and consent of the Legislative Council and the Legislative Assembly of Western Australia, in this present Parliament assembled, and by the authority of the same, as follows:—

1. This Act may be cited as the *Laporte Industrial Factory Agreement Act, 1961.* **Short title.**

51906/10/61—1m

industrial purposes supplied to consumers by the Metropolitan Water Supply Sewerage and Drainage Department pursuant to the provisions of the Metropolitan Water Supply Sewerage and Drainage Act, 1909. The Company guarantees to the State that the amount payable by the Company and other consumers of water from a pipeline will be at the rate of not less than twenty thousand pounds (£20,000) per annum.

(12) IF water is supplied by the State from a source or sources other than the Collie River the Company will pay to the State for water so supplied at rates which may from time to time be mutually agreed but not exceeding the rates referred to in the last preceding subclause.

10.—(1) SUBJECT to this Clause the State shall during the term of this Agreement assume total responsibility for the disposal of all effluent including cooling water from the Company's works on the works site including any addition thereto provided that the effluent does not differ in material respects from the present discharge from the Company's comparable factory at Stallingborough, Grimsby, in the county of Lincolnshire in the United Kingdom. For the purpose of such disposal the State shall provide and lay an eighteen (18) inch internal diameter pipeline (or such other capacity pipeline as the parties hereto may mutually agree upon) from the discharge outlets of the Company's pumps on the works site across Leschenault Inlet above water on piles (of a design to be mutually agreed and to include facilities for inspection) and thence to a discharge point in the ocean. The location of this discharge point shall be determined by the State after consultation with the Company's representatives and may be varied from time to time but the length of the pipeline shall not in any case without the consent of the Company exceed three and one half ($3\frac{1}{2}$) miles. Effluent.

(2) THE pipeline to be provided under subclause (1) of this clause shall be of or be lined with such plastic or other material as the parties hereto shall mutually agree upon and shall be laid ready for use by the thirtieth day of June 1963 or by such extended date as the parties hereto may agree.

(3) THE Company shall pay to the State on demand three eighths ($\frac{3}{8}$ths) of the total cost incurred by the State in providing and laying the said pipeline. The State will itself bear and pay the remaining five eighths ($\frac{5}{8}$ths) of such cost.

(4) IF the Company should at any time give notice in writing to the State that it proposes to expand the productive capacity of the factory and for this purpose

requires an additional pipeline for the discharge of effluent including cooling water the State shall with all reasonable despatch provide an additional pipeline accordingly of such capacity and material as may be mutually agreed with the Company and to discharge at the same discharge point for the time being of the first pipeline and the Company shall pay to the State on demand the capital cost incurred by the State in providing and laying the additional pipeline.

(5) THE Company shall keep the State advised in writing from time to time as to the nature composition quantity rate of discharge and hours of discharge of the effluent and will allow the State to inspect the effluent before discharge and to take samples therefrom.

(6) THE State undertakes that it will not during the currency of this Agreement constrain the Company or interfere with the normal operations of the Company on the works site with the object of altering the nature or composition of the effluent or compel the Company to neutralise or otherwise treat the effluent.

(7) UNLESS and until the parties hereto otherwise in writing agree the State shall at the cost of the Company patrol maintain repair renew and be responsible for and do all things necessary for the continuous operation of the effluent pipeline or lines from the boundary of the works site to the discharge point and such cost shall include reasonable charges for supervision and administration.

(8) THE Company shall on request be supplied with details of charges made by the State and shall be consulted from time to time regarding the condition of the pipelines and any major expenditure which the State proposes to incur at the cost of the Company.

(9) THE Company shall at its own cost collect the effluent and pump it into the effluent pipe or pipes under pressure and conditions which will efficiently discharge the effluent completely through the pipe or pipes and will use all reasonable endeavours to ensure that the discharge of effluent will be maintained at a constant rate. The Company shall provide and maintain adequate pumps chambers machinery apparatus and facilities to provide for and maintain such discharge throughout the currency of this Agreement.

Electricity.

11.—WITHIN six months of the request in writing of the Company the State will provide at the boundary of the works site electricity for construction purposes in such quantities and under such conditions as shall be mutually agreed and subject to the Company giving to the State reasonable notice in writing of its requirements will otherwise during the currency of this Agreement supply and maintain a sufficient supply of electric power to the Company on the works site in manner and quantities and at

APPENDIX II
Extract from System 6 Study Report

C66 LESCHENAULT INLET

The area comprises Reserves A18414, for Stopping Place, not vested, and C13531, for Camping and Picnic Ground, vested in the City of Bunbury; vacant Crown land; a temporary Reserve; all of the Leschenault Estuary Inlet north from the mouth of the Collie River; lot 1 (part of Wellington Locations 18 and 24), lots 2, 3 and 4 of Wellington Location 24, Wellington Locations 7 and 14 and part of Wellington Location 22, privately owned freehold land and the swamp on the south-eastern side of Leschenault Inlet on land owned by Laporte Titanium (Australia) Pty. Ltd. It is situated between Australind and the Indian Ocean, a few kilometres north of Bunbury (Figure 46).

The northern part of the Inlet carries a very extensive area of samphire, surrounded by closed-sedgeland, which is bordered by low woodland of salt water paperbark. Adjacent to this there is closed-forest of swamp paperbark, which is surrounded by woodland of flooded gum and Moonah paperbark in the swampy land north of the estuary. The higher ground has been partly cleared, and supports remnants of tall open-forest of tuart. The peninsula between the estuary and the sea carries low closed-forest of peppermint and some open-forest of tuart, with an understorey dominated by cockies' tongue. Bordering the estuary there is a small area of the rare white mangrove *(Avicennia marina* var. *resinifera)*. The peninsula includes fragile mobile dunes with numerous blowouts, so vehicular access should be controlled.

The Leschenault Inlet is of considerable importance for water-birds. More than fifty species, some with populations of over a thousand, have been recorded. The most important area is the northern section, which is a breeding ground and refuge for migratory birds, including greenshank. The estuary is also an important summer refuge for water-fowl, including black duck, black swan, grey teal, mountain duck, musk duck and the pelican. During mid and late summer, most of the swans and ducks move to a point on the western shore, opposite Australind, where there are fresh water seepages. This area is extremely important as a bird refuge.

The shallower waters are an important nursery area for commercial species of fish, which include whiting, cobbler, mullet, bream, tailer, garfish, flathead and flounder. These waters also support the blue manna crab, which is extremely popular for recreational fishing. There are plans to dredge the estuary channel. This should be prevented as it will disturb the ecosystem and badly damage the fish nursery and bird sanctuaries.

The Laporte Egret Swamp, on the south-eastern side of the Estuary, supports one of the few Western Australian breeding colonies of the white egret. The egret colony has bred successfully for a number of years and as a result, Leschenault Inlet has the second largest white egret population in the South-West. Other species, including nankeen night heron, little pied cormorant and little black cormorant, also nest in the swamp. Urban type development in this area would not be in the interest of either conservation or Laporte Titanium (Australia) Pty. Ltd.

The Leschenault Peninsula to the west of Leschenault Inlet has been committed for long term use by the PWD as an area for industrial effluent disposal. The disposal lagoons contain acid effluent and should not therefore be accessible to the general public. Even if an alternative disposal system is adopted it is likely that the peninsula will be used in emergencies, and possibly for continuing disposal of one component of the effluent, basically cooling water, for at least thirty years.

The concept of a 'regional park', as discussed in Chapter 5, may be relevant to portion of Leschenault Inlet and its shores.

The whole area is used heavily for recreation and has very high conservation value. It is under increasing pressure from urban development, which should be restricted as it will have adverse effects upon conservation and recreation. There is increasing pressure for industrial development near Bunbury, which will increase the demand for recreational use of Leschenault Inlet and increase the need to preserve its conservation value. The area may be affected in the future by underground gas pipelines.

Recommendations

C66.1 The purpose of Reserve A18414 should be amended to Conservation of Flora and Fauna and the Reserve should be vested in the Leschenault Inlet Management Authority.

C66.2 The vacant Crown land should be added to Reserve A18414.

C66.3 Leschenault Inlet, its eastern shores, the adjacent low-lying land to the north and the peninsula between the Inlet and the Indian Ocean as shown on Figure 46, should be managed by the Leschenault Inlet Management Authority.

C66.4 The Leschenault Inlet Management Authority, in consultation with relevant authorities and local land owners, should define management objectives for the area and seek ways and means of achieving those objectives, either through joint management arrangements or, where necessary, acquisition of freehold land. Consideration should be given to:

(a) rehabilitating the dunes, partly by restricting access to them;

(b) maintaining the water-bird and fish habitats, particularly the Laporte Egret Swamp;

(c) monitoring the effects of effluent disposal;

(d) allowing only passive recreation, rowing boats and slow-moving power boats.

C66.5 The Public Works Department, in consultation with the Department of Conservation and Environment, should investigate and develop techniques which will minimise the environmental damage caused by the disposal of industrial effluent.

C66.6 Urban development should be prevented, or only allowed if associated with deep sewerage systems which will not lead to pollution of the inlet.

C66.7 The inlet channel should not be dredged.

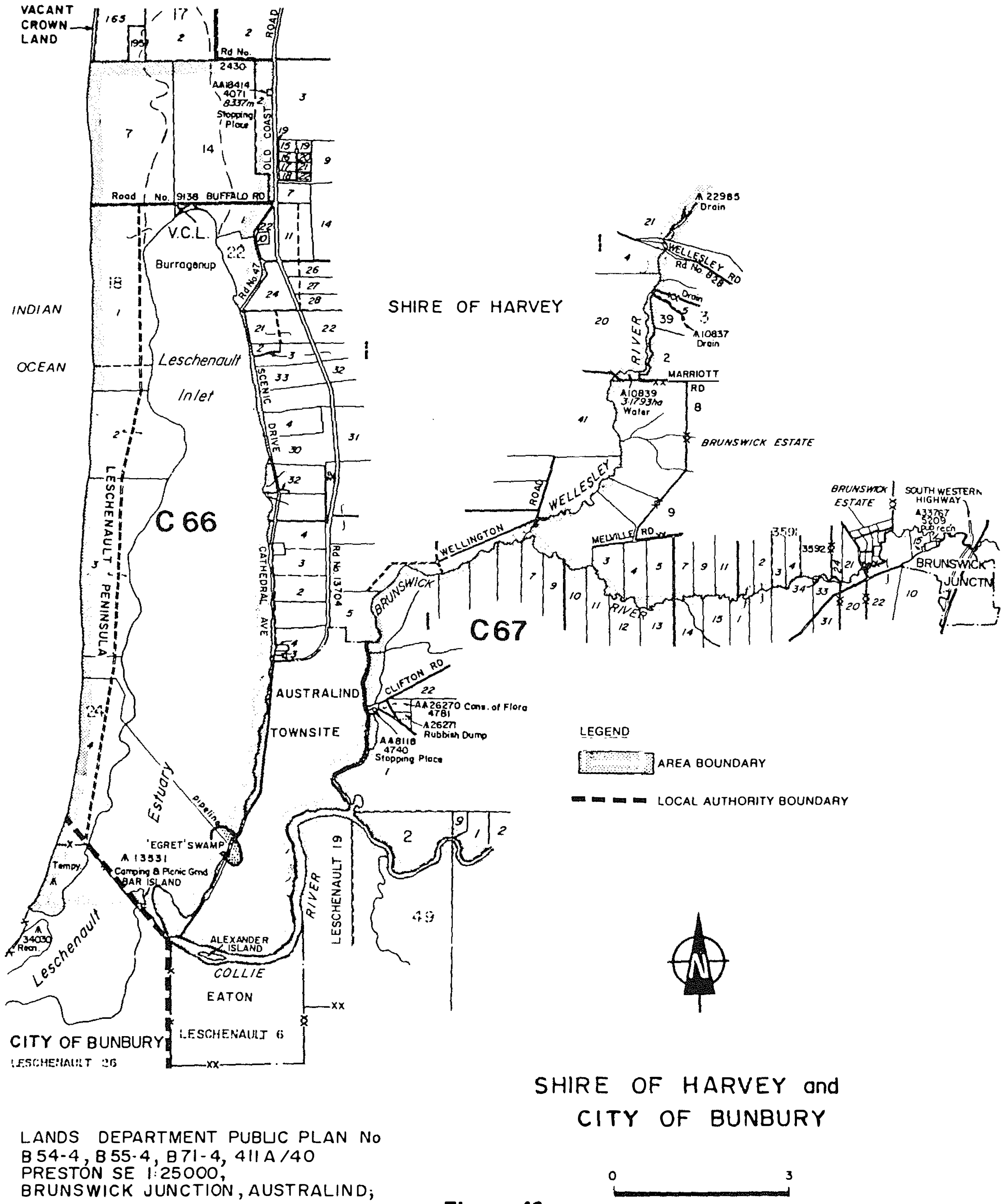

Figure 46