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Environmental impact statement : North Head Water Pollution Control Plant

METROPOLITAN WATER SEWERAGE AND DRAINAGE BOARD
SYDNEY, NEW SOUTH WALES

ENVIRONMENTAL IMPACT STATEMENT

NORTH HEAD

WATER POLLUTION CONTROL PLANT

December 1979

CALDWELL CONNELL ENGINEERS

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60 ALBERT ROAD PO BOX 133 SOUTH MELBOURNE 3205 TELEPHONE 699 5433 TELEX 32071 CABLE BRALCO

3 December 1979

The Secretary
Metropolitan Water Sewerage and Drainage Board
P.O. Box A53
Sydney South, N.S.W. 2001

Attention: Mr. M. W. Whyte, Investigating Engineer Sewerage

ENVIRONMENTAL IMPACT STATEMENT FOR NORTH HEAD WATER POLLUTION CONTROL PLANT (Ref 48/9934)

Dear Sir,

As authorised in your letters of 11 April 1975 and 10 November 1978 we have completed the environmental impact statement for the North Head Water Pollution Control Plant, and are pleased to submit it herewith.

The North Head WPCP has provided preliminary treatment (screening) since 1970 and the effluent is discharged through submerged outlets at the cliff face. In addition, the Board has made considerable progress in preparing the North Head WPCP site for additional treatment facilities, recognising that the present system does not meet all water quality criteria. This impact statement evaluates the various treatment and disposal options available to improve the North Head system. It draws on information obtained from oceanographic studies offshore from Sydney contained in the 1976 "Report on Submarine Outfall Studies."

As a result of the evaluation, we have concluded that the preferred combination of options is construction of a high rate primary treatment plant with discharge of effluent through a deepwater submarine outfall. This recommendation is based on an assessment of the environmental impacts, cost, and consumption of resources associated with many treatment and disposal options.

In concluding this assignment, we wish to express our appreciation for the cooperation and assistance which we received from the Board's officers throughout the study.

Yours faithfully,

CALDWELL CONNELL ENGINEERS

I. G. Wallis D. A. Reinsch G. J. Sewards

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SUMMARY AND CONCLUSIONS

These pages summarise the results and findings of the environmental impact statement for sewage treatment and disposal from the North Head Water Pollution Control Plant (WPCP). The North Head WPCP has provided preliminary treatment (screening) since 1970 and the effluent is discharged through submerged outlets at the cliff face. In addition, the Board has made considerable progress in preparing the North Head WPCP site for additional treatment facilities, recognising that the present system does not meet all water quality criteria. This impact statement evaluates the various treatment and disposal options available to improve the North Head situation. It is concluded that the preferred combination of options is (1) construction of a high rate primary plant to remove screenings, grit, floatable materials, oil and grease, (2) incineration of the materials removed; and (3) a deepwater submarine outfall to discharge the effluent.

The summary is divided into seven sections corresponding to the seven chapters of the impact statement.

1. INTRODUCTION

Chapter 1 presents a historical outline of the development of the North Head sewerage system and describes the objectives and scope of this environmental impact study. Disposal of sewage to the ocean has been practised in the Sydney area for almost 90 years. At the time of construction of Sydney's three major raw sewage ocean outlets at Malabar, North Head and Bondi, the population served was comparatively small. Some contamination of shores and shore waters occurred, but this was generally accepted by the relatively few people who used the beaches for recreational purposes.

However, with increasing use of the beaches, it became evident that the recreational value of some beaches was threatened by pollution of sewage origin. Over the last 15 years or so the increase in discharges combined with a growing public awareness of environmental quality has resulted in conditions which, although earlier considered adequate, are no longer considered acceptable. In response to these trends, the Board has undertaken several major projects with the objective of improving the conditions of beaches and waters in the vicinity of the outfalls.

In 1968 a decision was made to construct a primary treatment plant at North Head having in mind later extension of the cliff face outfall to deep water should receiving water quality requirements indicate a need to do so. The initial phase of the North Head WPCP, comprising screening facilities, was commissioned in 1970 and excavation for the primary treatment works continued progressively.

While this work was proceeding, a primary treatment plant of similar capacity was constructed at Malabar and commissioned in 1975. A significant improvement in conditions at adjacent beaches has been achieved following commissioning of the Malabar plant. However, discharge of primary effluent at the cliff face does not achieve the Board's objectives of eliminating sewage derived beach pollution.

4. THE RECEIVING WATERS

Chapter 4 discusses various aspects of the marine environment in the vicinity of the present outfalls. The receiving water, i.e. the Pacific Ocean in the region offshore from the Sydney coastline, is the component of the environment most affected by the sewage treatment and disposal operation at North Head.

Major beneficial uses of the receiving water include: (1) recreation such as pleasure boating, swimming, surfing, skin diving and fishing; (2) fisheries production; and (3) other uses such as seabird habitat, shipping and aesthetic appeal.

Guideline water quality criteria for the design of treatment and disposal systems discharging to the ocean offshore from Sydney were developed in the "Report on Submarine Outfall Studies" and take into account the beneficial uses of the receiving waters, together with the requirements of the NSW State Pollution Control Commission's (SPCC) "Design Criteria for Ocean Discharge". The guideline criteria cover such aspects as physical appearance, restricted substances, pH, dissolved oxygen and bacteriological conditions.

Descriptions of the characteristics of the receiving waters have been based on the results of the intensive oceanographic and biological investigations undertaken during the Board's 1971 to 1976 study of possible submarine outfalls offshore from North Head, Bondi and Malabar. Four general types of studies were carried out: (1) physical oceanographic; (2) chemical; (3) biological; and (4) special studies. The principal objective of the physical oceanographic studies was to determine current patterns and density structure during various seasons and under different wind and tidal conditions. In the chemical studies concentrations of a variety of substances in seawater and sediments were determined to characterise the study areas and to support the biological studies. Benthic plant and animal communities were studied to establish baseline conditions in the rocky bottom environment of the North Head area and in the sedimentary bottom environment of the Malabar area. Additional biological studies were carried out in nearby areas and elsewhere along the NSW coast to determine if bottom communities there differed substantially from those in the intensively studied areas. Special investigations included geological surveys of the outfall areas, dye studies to determine diffusion and mixing in the surface waters, and determinations of the die-off rates of faecal coliform organisms.

5. IMPACT OF THE PRESENT DISCHARGE

Chapter 5 discusses the impact of the present North Head screened sewage discharge on water quality, beach pollution, marine biota, and the level of restricted substances in marine biota. All are affected to some extent by the present effluent discharge. In addition, the effect of discharges on Norfolk Island pines is considered. It is apparent that water quality criteria for physical appearance and faecal coliform organisms are not met by the present discharge.

Pollution of the swimming beaches along the Sydney coast has been comprehensively monitored by the Board since 1966. The indicators of pollution monitored are faecal coliform density in bathing waters, the grease content of beach sand, and a visual assessment of the degree of pollution on beaches. The data show that present bacteriological water quality criteria are not always met on beaches between Queenscliff and the outfall and that relatively high grease concentrations are found at times during the summer in sand on these beaches.

also Freshwater Beach

The possible sludge disposal options which could be used involve the return of waste constituents to (1) the atmosphere, (2) the land, or (3) the ocean. Disposal to the atmosphere would involve incineration of raw sludge. Disposal to the land would involve digestion to minimise the potential for odours or other nuisances followed by application of the sludge to agricultural land (thereby using it as a soil conditioner), or to landfill. Disposal of sludge to the ocean would involve sludge digestion.

The recovery of energy from "waste" products such as sewage sludge and municipal refuse is also worthy of further study as these materials may eventually represent a viable energy resource to the State. Research is being undertaken overseas into a process known as pyrolysis in which sludge is reduced to ash whilst hydrocarbons are produced in the form of a combustible gas which can be used as a fuel either directly or after liquefaction. A more promising prospect would appear to be joint energy recovery projects using a combination of municipal refuse and sewage sludge. Further development work is required before pyrolysis can be applied locally; however, this process, and other energy recovery processes, are being examined for possible future implementation.

There are many possible combinations of wastewater treatment, effluent disposal and sludge disposal. However, after consideration of the components of each system, as well as their costs, four treatment and disposal systems which would meet water quality criteria were formulated. The main characteristics of these systems (designated System A, B, C and D) are summarised in the accompanying table.

OPTIONS FOR SEWAGE TREATMENT AND DISPOSAL AT NORTH HEAD

WPCP treatment and discharge system	Characteristics of option				Indicative 1978 costs[a]		
	Type of treatment	Effluent discharge	Sludge disposal	Other characteristics	Capital costs $ M	Annual operating costs $ M	Capitalised cost[b] $ M
A	At least secondary	Reclamation/reuse	Land (Digested)	Low level of demand for effluent; high level of treatment required prior to reuse; conveyance of effluent through heavily populated areas. Water quality criteria not applicable.	400[c]	13[c]	550[c]
B	Secondary	Shoreline	Incineration (Raw)	Cost and space requirements create serious constraints. May meet water quality criteria but the discharge would probably be noticeable.	185	8.6	290
C	Conventional primary	Deepwater	Ocean (Digested)	Would meet water quality criteria.	115	4.5	170
D	High rate primary	Deepwater	Incineration[d] (Raw)	Would meet water quality criteria.	62	3.1	100

[a] All costs are at December 1978 level and are based on ultimate WPCP capacity.

[b] Includes cost of operation and maintenance plus fixed charges arising from interest on borrowed capital at 8% per annum over 50 years.

[c] Assumes only secondary treatment will be required; costs will be significantly higher if tertiary treatment is required.

[d] A relatively small quantity of sludge is removed and incinerated in high rate primary treatment.

WPCP treatment and disposal Systems A and B involve provision of at least secondary treatment facilities. System A would involve reuse of the treated wastewater. This option was not recommended because it does not appear to be feasible in the foreseeable future to of potential problems. Several options for spoil disposal are available, including (1) disposal on land (2) dumping over the cliff face at North Head, (3) barging to sea, and (4) use on the WPCP site for landscaping and fill of excavations not required for many years. On the available evidence, it is considered that the fourth option would involve the least environmental impact and little expenditure. The second option would also involve little expenditure and would cause little impact over that caused by previous spoil disposal at the same point. Restoration of this area has been postponed pending a decision on spoil disposal from tunnel excavation. This restoration work should be undertaken on completion of spoil disposal.

Impacts of Operation

The various impacts discussed under operation of the WPCP include appearance of the site, noise levels, odour production, air quality, traffic generation, consumption of chemicals and energy, and sensitivity to disturbances in plant operation. Adequate safeguards are available to minimise these potential impacts.

Impacts of Marine Discharge

Experience overseas has shown that effluent and digested sludge may be discharged through a deepwater outfall without any significant adverse effects where ocean conditions are favourable. There is little difference between the concentrations of most sewage constituents in a combined primary effluent — digested sludge discharge and those in an HRP effluent. Most constituents are beneficial to marine life, providing that the assimilative capacity of the waters for the additional organic and nutrient load is not exceeded. Potentially toxic components of sewage are mainly of industrial origin and are thus amenable to source control.

The impacts of discharge of North Head WPCP effluent to the ocean are considered under six headings: physical appearance, Norfolk Island Pines, restricted substances, dissolved oxygen and pH, microbiological conditions, and biota. The 'no change' option would result in an adverse impact in each case whereas the preferred option would meet water quality criteria and have minimal impact.

Physical Appearance. Predictions of performance of the North Head deepwater submarine outfall showed that the effluent field would be submerged for over 90 per cent of the time in summer. Even when there is a surface field it would not be in the form of a surface discoloration or 'stain', as at present, due to the very large initial dilution. The BOD_5, suspended solids and grease concentrations in the effluent field resulting from discharge through a deepwater outfall would be comparable with those attainable with discharge of secondary effluent at the shoreline. In addition, the nearest diffuser ports would be over 3 km from shore. Overseas experience demonstrates that it is very difficult to see an effluent field with such low constituent concentrations at such a distance offshore. Therefore, it is concluded that the preferred option would meet the physical appearance criteria.

Norfolk Island Pines. There is evidence that detergent in the effluent from the North Head WPCP has had a serious effect on Norfolk Island Pines on beaches near the outfall. This problem should be overcome by the preferred option because of the large initial dilution, the high proportion of the time in which the effluent field would be submerged and the distance that the discharge point would be from shore. The widespread use of biodegradable detergents in recent years would result in more rapid detergent degradation in ocean waters than with early detergent formulations.

CONCLUSION

The table shown previously summarises the costs and major environmental impacts associated with the various options including their ability to meet receiving water quality criteria. It can be seen in the table that the preferred option – high rate primary treatment with incineration of solids and discharge of effluent through a deepwater outfall – would have minimal impact on the environment and would meet water quality criteria at the least cost. This option would ensure that matter of sewage origin does not contribute to beach pollution or represent a public health risk to bathers. The visible effluent field in the ocean offshore from North Head will be eliminated.

Implementation of the high rate primary WPCP and deepwater outfall system should be commenced as soon as possible. Under the most favourable circumstances, it would take at least six years from the date the decision is made to proceed to complete the North Head deepwater submarine outfall and the high rate primary treatment plant.

NORTH HEAD W.P.C.P. MID-1976.

CHAPTER 1
INTRODUCTION

This chapter begins with a brief history of the development of the North Head sewerage system which serves the northern suburbs of Sydney. Following a brief sketch of the Metropolitan Water Sewerage and Drainage Board's overall sewerage system, the objectives and scope of this environmental impact study are described.

1.1 HISTORICAL BACKGROUND

Disposal of sewage to the ocean has been practised in the Sydney area for almost 90 years. The Bondi and Malabar ocean outlets were completed in 1889 and 1916 respectively. The Northern Suburbs Ocean Outfall Sewer (NSOOS) was proposed in 1912 to intercept flow from the existing North Sydney treatment works and discharge it into the ocean at the base of Blue Fish Point on North Head. Construction began in 1916 by the New South Wales Public Works Department and the completed works were taken over by the Board in 1928.

At the time these ocean outfalls were constructed the population served was comparatively small as was the quantity of sewage discharged. Some contamination of shores and shore waters occurred, but this was generally accepted by the relatively few people who used the beaches for recreational purposes. However, with the increase in population and use of the beaches, it became evident that the recreational value of some beaches was threatened by pollution of sewage origin. Over the last 15 years or so, a progressive increase in flows combined with a growing public awareness of environmental quality has resulted in conditions which, although earlier considered adequate, are no longer considered acceptable.

In 1966 the Board began a long range programme to improve arrangements for treatment and disposal of wastewater from the NSOOS system and commissioned Brown and Caldwell to investigate the various alternatives. Following on from that investigation[1], a decision was made in 1968 to construct a primary treatment plant at North Head, having in mind later extension of the cliff face outfall to deep water should receiving quality requirements indicate a need to do so. The initial phase of the North Head Water Pollution Control Plant (WPCP), comprising screening facilities, was commissioned in 1970 and excavation for the primary treatment works continued progressively.

While this work was proceeding, a primary treatment plant of similar capacity was constructed at Malabar and commissioned in 1975. A significant improvement in conditions at adjacent beaches has been achieved following commissioning of the Malabar plant. However, discharge of primary effluent at the cliff face does not achieve the Board's objectives of eliminating sewage derived beach pollution.

In 1976 the Board received a report[2] from its consultants, Caldwell Connell Engineers, confirming the feasibility of constructing deep water ocean outfalls from its major coastal WPCP's. Recently available information indicated that a slightly lower degree of wastewater treatment, known as "high rate" primary treatment, coupled with a deep water effluent outfall should be examined for North Head. A similar concept is currently under consideration by sewerage authorities in Australia and elsewhere because it offers

The Board also provides water service to about 3.2 million persons within the metropolitan and adjacent areas. The unsewered population, representing approximately 8 percent of the population served by water, resides in sparsely populated areas which are expensive to sewer, or in built-up areas to which sewer extensions have yet to be constructed.

The Board's sewerage systems consist of separate sanitary sewers; that is, sewers intended for waste flows from domestic, commercial, and industrial sources, but not for storm water flows. However, the earliest sewers in the City of Sydney, now in the Bondi Ocean Outfall System, were constructed as combined sewers for conveyance of both sewage and storm water, but these are gradually being separated in the course of a continuing programme. Although the Board's systems are generally considered to be separate, ingress of some surface water does occur during periods of excessive rainfall. It should be noted that this situation is not unique to the Sydney area. Almost all major sanitary sewerage systems in the world are faced with problems of a similar nature.

1.3 OBJECTIVES OF THE ENVIRONMENTAL IMPACT STUDY

The responsibility for municipal sewage collection, treatment and disposal includes an obligation to dispose of the effluent and solid residues in a manner which will protect public health, prevent nuisances from occurring at the points of treatment and disposal and, in the case of effluent disposal, maintain receiving water quality consistent with beneficial uses of the water. The objectives of this study are: (1) to describe the environmental impacts of the North Head WPCP; (2) to examine the various options available to the Board which may be required to meet water quality criteria, and (3) to prepare an Environmental Impact Statement covering the WPCP in accordance with the applicable provisions of the NSW State Pollution Control Commission's Environmental Standard EI-4 "Principles and Procedures for Environmental Impact Assessment in NSW"[4]. Caldwell Connell Engineers was authorised by the Board in its letter of 11 April 1975 to undertake a study and prepare an environmental impact statement for Malabar and North Head WPCP's. On 11 November 1978 the Board requested that separate EIS be prepared for these two plants incorporating additional information.

1.4 SCOPE OF THE STUDY

In developing the scope of the environmental impact study, it was recognised that the Board is clearly committed to the existing treatment plant site and no consideration was given to alternative sites in the investigation. However, the Board has deliberately retained a range of treatment and disposal options which may be implemented, if required, to meet future effluent and receiving water quality criteria.

The environmental impact study concentrated on the long range development of the North Head plant. As noted in Chapter 2, the Board is investigating possible means for relief of the NSOOS system by amplification or diversion. However, consideration of alternative proposals to provide relief is beyond the scope of this study which has been prepared on the basis of the conservative assumption that all flow from the NSOOS catchment would be treated at, and discharged from the North Head WPCP.

CHAPTER 2
NORTH HEAD SEWERAGE SYSTEM

This chapter describes the North Head catchment and major sewers; presents projections of population, industrial growth, sewage flows and loadings; and describes the existing works at North Head WPCP.

2.1 NORTH HEAD CATCHMENT AND MAJOR SEWERS

The NSOOS system serves most northern and some western suburbs of Sydney. The catchment has a population approaching one million persons and the system will ultimately serve an area of 47 000 hectares.

As shown in Fig. 2, the route of NSOOS is generally parallel to the northern shore of the harbour and the Parramatta River, extending a distance of about 45 km from Blacktown in the west to the ocean at North Head. Sewage flows by gravity to the treatment plant at North Head. The NSOOS is generally situated above sea level, except for two inverted siphons; one at Lane Cove River and the other at Middle Harbour. Overflows or relief points are strategically located on the NSOOS and its tributary submains. The major overflows at Quaker's Hat Bay, the Lane Cove siphon, and the West Middle Harbour Submain relieve the hydraulic load on the system during periods of heavy rainfall.

2.2 POPULATION AND INDUSTRIAL GROWTH

Population growth and predictions for the North Head catchment used in this investigation were compiled by the Board for future planning. During dry weather, sewage flows to the North Head WPCP largely comprise domestic sewage and industrial wastes, and estimates of sewage flows are derived from estimates of population growth and industrial development in the catchment. Industrial flows and loadings are often expressed as being equivalent to the flows and loadings from a specified number of resident persons. Thus, the total contributing population is expressed as the sum of a residential population and an industrial equivalent population (EP).

The Board's population growth prediction for the North Head catchment is given in Table 1. The ultimate equivalent population in the catchment is 2.1 million, corresponding to maximum or saturation development. The residential population is expected to increase from about 74 percent of the total equivalent population in 1980 to about 83 percent at

Table 1 Population Projections for the North Head Sewerage Catchment

Population	Year				
	1980	1990	2000	2025	Ultimate
Residential	1 000 000	1 110 000	1 180 000	1 300 000	1 710 000
Industrial EP	350 000	350 000	350 000	350 000	350 000
Total EP	1 350 000	1 460 000	1 530 000	1 650 000	2 060 000

In sewerage system design, the Board utilises factors to relate PDWF and DWWF to ADWF. These factors have been determined from records of sewage flows during dry and wet weather conditions compiled over a number of years. For the North Head system, the Board has defined that PDWF is 1.4 times ADWF; and that DWWF is 3 times PDWF, or 4.2 times ADWF.

The contribution of domestic sources to ADWF can usually be predicted fairly accurately from records of population served and unit flow factors. Table 2 shows the unit flow factors adopted by the Board for the North Head catchment. The unit factor for ADWF is expected to increase from 250 litre/EP.day in 1980 to 273 litre/EP.day in 1990 and remain constant thereafter.

Table 2 Unit ADWF Factors from the North Head Sewerage Catchment

Unit ADWF factor	Year			
	1980	1990	2025	Ultimate
litre/EP.d	250	273	273	273

litre/EP.d = litres per equivalent population per day.

Using the projected populations shown in Table 1, the unit ADWF factors shown in Table 2 and the fact that DWWF is 4.2 times ADWF, the projected ADWF and DWWF from the catchment have been calculated and are shown in Table 3. As can be seen in the table, ADWF is expected to increase to 450 Ml/d and DWWF to 1900 Ml/d by the year 2025 and may ultimately reach 560 Ml/d and 2400 Ml/d, respectively.

Table 3 Projected Sewage Flows to the North Head WPCP

Flows (Ml/d)	Year				
	1980	1990	2000	2025	Ultimate
ADWF	340	400	420	450	560
PDWF	470	560	590	630	790
DWWF	1 400	1 700	1 800	1 900	2 400

Sewer System Capacity

Flows arriving at the North Head WPCP are recorded at a gauging station at Eustace Street, Manly. This station is close to the WPCP and the recorded flow is representative of the actual flow passing through the plant. There are, however, several overflows or relief points upstream of the gauging station which have substantial overflow capacities.

Daily flow data from this gauging station were compiled by the Board for the Submarine Outfall Studies for the period from January 1972 to June 1975. The flow data include average daily flows, ADWF on a monthly basis, instantaneous minimum and peak dry weather flows, and peak wet weather flow during each month. The ADWF during the period of record increased from 245 Ml/d in January 1972 to 275 Ml/d in June 1975.

NSOOS sewage at trace concentrations only as a result of this trade waste policy and the fact that the NSOOS serves relatively few industries.

Table 4 North Head WPCP Sewage Loadings

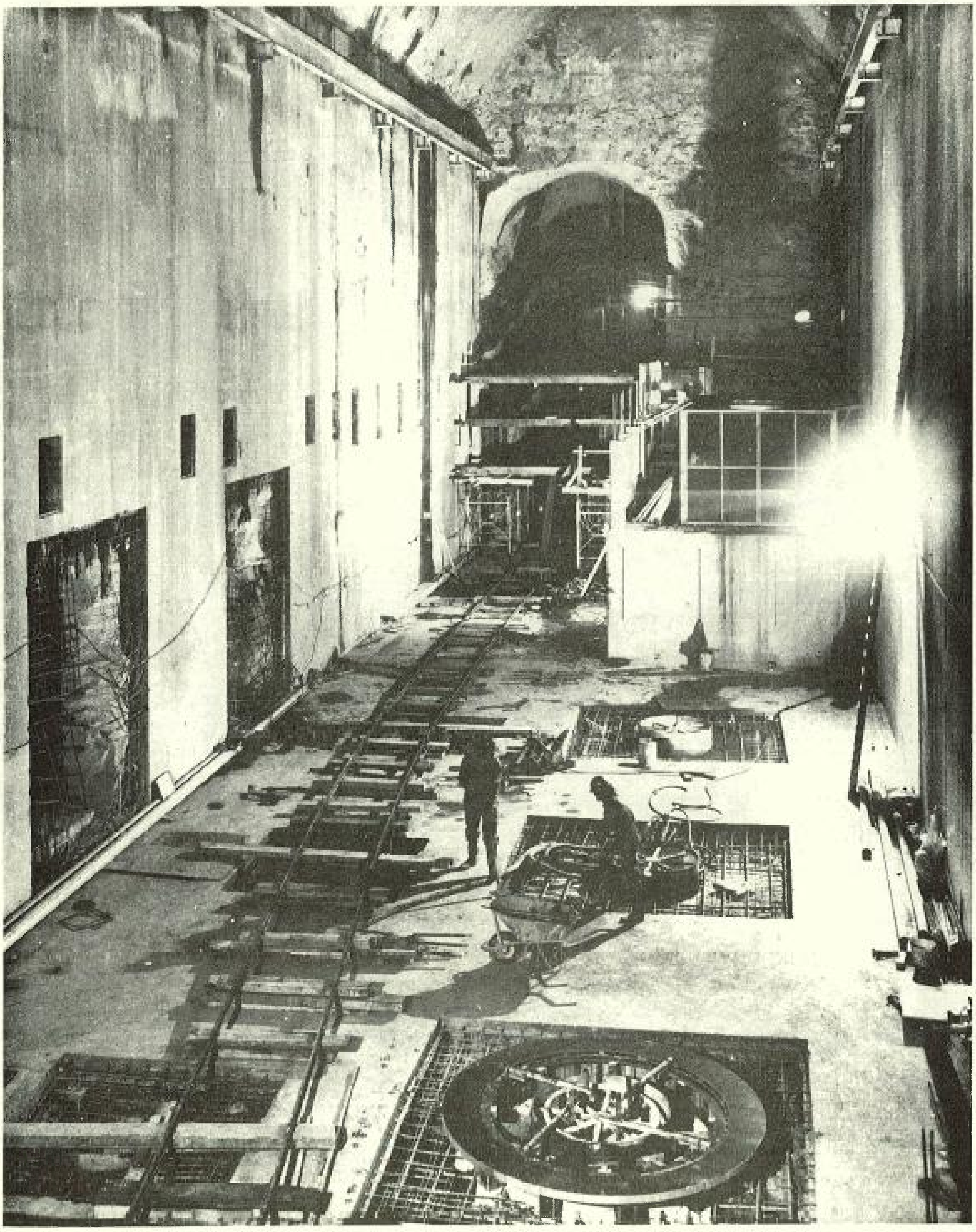
Constituent	Prediction for year 1980		Prediction for year 2025	
	Concentration mg/l	Loading t/d[a]	Concentration mg/l	Loading t/d[b]
BOD_5	260	88	300	135
Suspended solids	240	82	280	126
Grease	60	20	100	45
Phosphorus – P	11	3.7	11	5.0
Nitrogen – N	47	16	50	23
Ammonia – N	30	10	30	14
Arsenic	< 0.1	< 0.04	<0.1	< 0.05
Cadmium	< 0.01	< 0.01	<0.01	< 0.01
Total Chromium	0.05	< 0.02	0.05	< 0.03
Copper	0.15	0.05	0.15	0.07
Lead	0.07	0.02	0.07	0.03
Mercury	0.003	< 0.01	0.003	< 0.01
Nickel	0.05	< 0.02	0.05	< 0.03
Silver	0.02	< 0.01	0.02	< 0.01
Zinc	0.70	0.24	0.70	0.3
Cyanide	< 1.0	< 0.34	<1.0	< 0.5
Phenolic Compounds	0.4	0.14	0.4	0.2
Total Chlorine Residual	0.00	0.00	0.00	0.00
Chlorinated Hydrocarbons[d]	0.001	0.001	0.001	0.001
Faecal Coliforms[c]	30×10^6		30×10^6	

a Based on ADWF of 340 Ml/d (see Table 3)
b Based on ADWF of 450 Ml/d (see Table 3)
c Unit is organism per 100 ml.
d Organochlorine pesticides, polychlorinated biphenyls and other compounds with similar molecular configuration and persistence.

2.5 EXISTING NORTH HEAD WPCP FACILITIES

The existing facilities of the North Head WPCP consist of screens located about 60 m below ground level at the elevation of the main NSOOS sewer. Work commenced on the screening plant in July 1967 with the sinking of the main access shaft, 6.7 m in diameter. By mid-1968, the excavations for the tunnels and chambers were commenced and the screening machinery was commissioned in December 1970.

Screening is accomplished by two mechanically raked coarse screens and three rotary fine screens. Inflow to the screens is via a totally enclosed concrete channel 3.7 m wide by 3 m deep, which is fully lined with plastic sheeting to protect the concrete from corrision



The North Head Water Pollution Control Plant
Underground Pumping Station During Construction

CHAPTER 3
NORTH HEAD LAND ENVIRONMENT

This chapter describes the character of the natural and manmade land environment in the vicinity of the North Head WPCP. The general features described include site location, topography, geology and soils, climate, vegetation, surrounding land use and the visibility and general appearance of the site. Environmental impacts associated with further construction and the operation of the plant are discussed in Chapter 7.

3.1 LOCATION

North Head is the northern promontory at the entrance to Sydney Harbour. It is about 3 km long and 1.5 km wide, flanked by tall cliffs, and is a dominant feature of the Sydney coastline. The headland is mostly reserved for military and recreational uses, and many people enter the area each year to see the spectacular views of Sydney from the headland. The North Head WPCP is being constructed in a shallow gully on the seaward side of the headland, out of sight from the more popular areas (see Fig. 5). The present site covers about 16 ha, and according to preliminary layouts this will be sufficient area for any proposed expansion of the WPCP.

3.2 TOPOGRAPHY

North Head is an upraised sandstone plateau that has been subjected to considerable weathering. On the south and east it has been exposed to severe erosion from sea action. The cliffs are nearly vertical, but have a natural talus slope of broken stone extending 30 m in height from a rock platform about 30 m wide near sea level. The platform is submerged at high tide and washed by high waves, and is a favourite area for rock fishermen.

The rock platform on the northern side is backed by cliffs about 60 m high. On the western side the promontory has weathered to a relatively gentle grade sloping to the Harbour and to the residential areas of Manly. A central ridge runs north-south along the promontory about 500 m from the eastern cliff edge, and the land slopes gently east and west to the cliff tops. The headland is divided into a number of small drainage basins, one of which contains the WPCP.

Within the WPCP site a number of terraces have been formed for possible future sedimentation tanks by excavations to levels 3 to 6 m below the natural land surface. The excavation for possible future sludge digestion tanks and connecting galleries have been sunk below this level. During this work 320 000 m^3 of material was excavated and disposed of to the sea via a narrow section of the cliff face. Both the newly cut rock surfaces and the spoil slope are the light yellow of the underlying sandstone.

3.3 GEOLOGY AND SOILS

The North Head promontory is composed of Hawkesbury sandstone which may contain lenses of shales and conglomerates, and is underlain by beds of Narrabeen shale which are evident in the seaward cliff faces. The sandstone headland is connected to the mainland by a wide sandy isthmus on which the suburb of Manly stands. In places the sandecclesiastical college. The whole of North Head is defined as "Foreshore Scenic Protection Area" in the planning scheme.

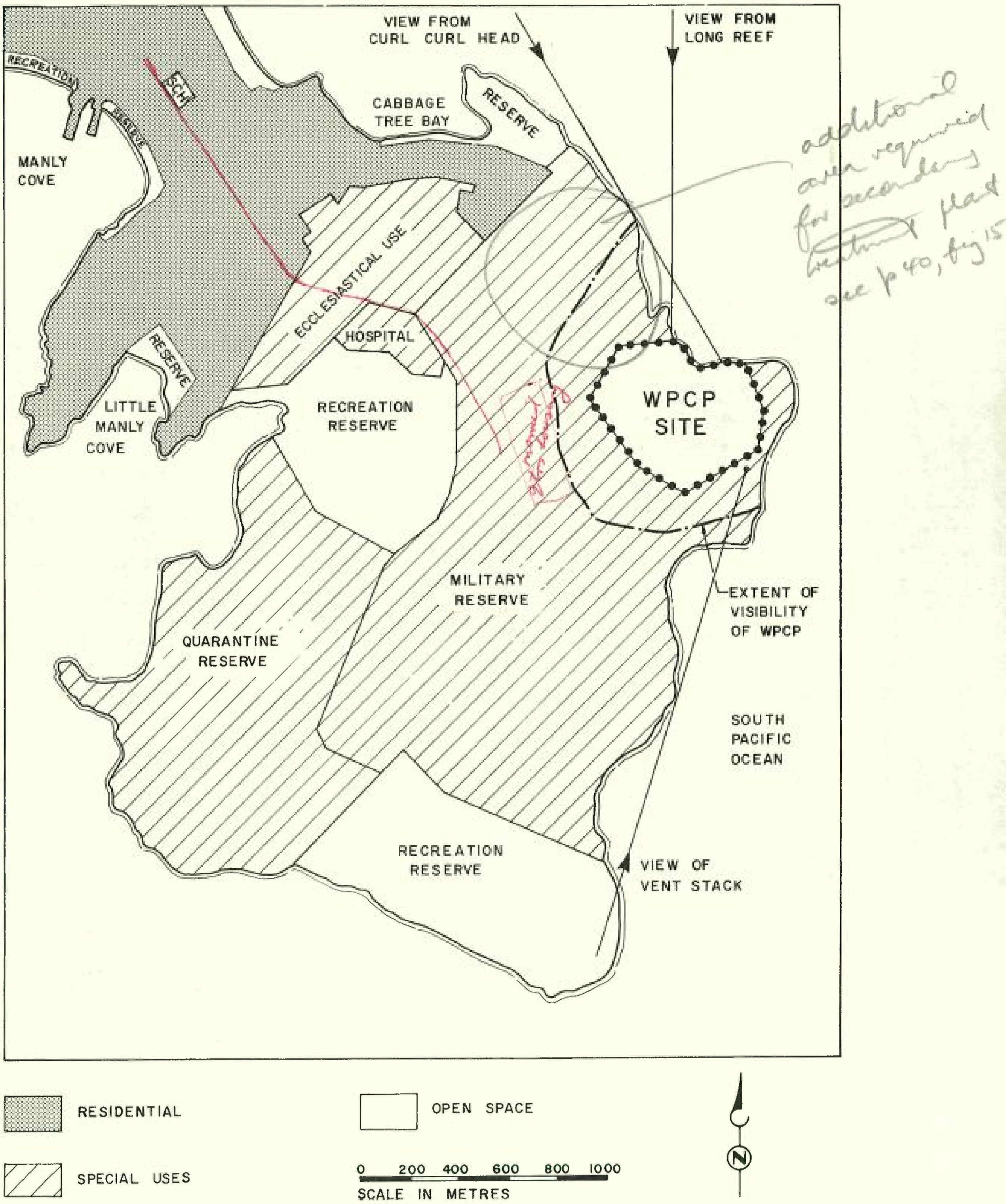


Fig. 5 Land Use Surrounding the North Head WPCP

At present there is no area zoned for sewerage purposes on the planning scheme. The bulk of the WPCP site is located on the military reserve, while the remainder is on a small

CHAPTER 4
RECEIVING WATERS

The component of the environment most likely to be affected by the North Head sewage treatment and disposal operation will be the receiving waters, i.e., the Pacific Ocean in the region offshore from the Sydney coastline. This chapter discusses various aspects of the marine environment in the vicinity of the present outfalls. Beneficial uses of the water body and coastline are defined, then water quality criteria required to maintain these uses are outlined. The physical and physico-chemical processes in the water body are then described, and the biological characteristics of the water body reviewed. The impacts of present and future discharges from the North Head WPCP on water quality are considered in Chapter 5.

4.1 BENEFICIAL USES OF THE OCEAN AND NEARSHORE WATERS

Beneficial uses for the Sydney coastal waters were discussed in the report on the submarine outfall studies[2] and apply in the vicinity of North Head outfall. The water quality criteria presented in Section 4.2 of this report were developed during the submarine outfall studies.

Recreational Use

The waters of the Pacific Ocean and the harbours and bays adjacent to the Sydney Metropolitan Area constitute one of the area's most valuable recreational assets. Virtually the entire ocean shoreline from Botany Bay to Broken Bay is used to some extent for recreational purposes. Important recreational uses are pleasure boating, swimming, surfing, skindiving, and fishing. The present growth in recreational use of the shoreline and nearshore waters is expected to continue at a faster rate than the rate of population growth. Impairment of this use would be a serious aesthetic and economic loss to the region.

To maintain the amenity of recreational waters, waste disposal should be accomplished without modifying the physical appearance of the water, producing odours or creating a public health hazard. Physical appearance is influenced by water turbidity and colour, the presence of an oil or grease film on the water surface and the accumulation of solids. Odour production may result from the discharge of wastes which are not rapidly diluted with seawater. Bacterial contamination may be present without any visual evidence of sewage.

Fisheries Production

The waters of the Pacific Ocean support fish and other marine life, and are fished both commercially and for recreation. Rock fishing is a popular sport; North Head is a particularly popular location, and fishing directly adjacent to the effluent field is common. Principal species of game and commercial fish taken in the ocean adjacent to Sydney are mullet, tuna, morwong, flat-head, Australian salmon and schnapper.

The maintenance of suitable conditions for fisheries production depends on a wide range of factors including the availability of food, shelter and adequate levels of dissolved oxygen. Providing that dissolved oxygen concentrations do not fall below approximately 5 mg/l, the discharge of sewage to ocean waters will not harm fisheries and can lead to localised increases in fisheries production due to the input of organic matter and nutrients.

(b) **Restricted Substances.** The maximum concentrations of restricted substances in the effluent seawater mixture after initial dilution should not exceed those values listed in Table 5. This initial dilution is achieved in a limited area adjacent to the discharge, termed the 'initial dilution zone'.

Table 5 Criteria for Ocean Discharge of Restricted Substances

Substance	Maximum allowable[a] concentration at boundary of initial dilution zone, mg/l
Arsenic	0.1
Cadmium	0.2
Total chromium	0.02
Copper	0.2
Lead	0.1
Mercury	0.001
Nickel	0.1
Silver	0.02
Zinc	0.3
Cyanide	0.2
Phenolic compounds	0.5
Total chlorine residual	1.0
Ammonia (expressed as N)	5.0
Total Identifiable chlorinated hydrocarbons	0.002

at a discharge rate of say 500 Ml/d 0.1 mg/l = 500 kg/d of metal!

[a]The significance of these values relative to effluent concentrations is discussed in Chapter 7 ? p 64

(c) **pH and Dissolved Oxygen.** The pH value of the effluent should not be less than 6.5 or more than 8.5. The discharge should not induce a variation in the pH of more than 0.1 in any waters outside the initial dilution zone. The discharge should not induce a variation in dissolved oxygen of more than 0.2 mg/l in any waters outside the initial dilution zone.

(d) **Bacteriological.** The SPCC criteria for bacterial conditions were adopted directly, but were amplified in discussions with SPCC staff, and took the following form: 'Protection of Beaches': For these purposes, 'beaches' are defined as the sands in the tidal shoreline and the waters adjoining such shoreline extending out to 100 metres from the mean high water shoreline, or to 3 metres in depth whichever is the furthest point, and, where limited by rocky shoreline, to 50 metres beyond either end of such sands. Beaches, or sections of beaches, commonly used for bathing may be designated by the SPCC as 'bathing areas'. It is considered that all sandy beaches along the Sydney metropolitan coastline will be designated as bathing areas.

For bathing areas, the geometric mean of the number of faecal coliform bacteria resulting from the operation of the proposed outfall is not to exceed 200 organisms/100 ml for any month. This is to be based on not less than five water samples taken during a 30 day period. Additionally, the number of faecal coliform bacteria is not to exceed 400 organisms/100 ml in more than 10 percent of the samples taken in a designated bathing area during the period 1st November to 1st May. This is to be based on not less than 30 samples taken within this six month period.

The predominant direction of water movement in the study region is southerly, tending towards southwesterly during the autumn and winter. Current velocities tend to be highest in summer and lowest in spring, and generally increase as the water moves south from North Head to Malabar.

Stratification. Both temperature and salinity affect density, although offshore from Sydney temperature differences are usually of more importance in causing stratification due to the small variation of salinity with depth. The factors influencing the ocean's temperature include large scale effects such as deep ocean currents and upwelling, and nearshore or local effects such as seasonal heating and cooling. Solar heating at the surface is a major cause of stratified conditions during the summer because of the lower density of the warmer surface layer. Loss of stratification typically occurs in the May – June period when surface cooling causes an increase in surface density, and mixing can occur readily throughout the depth.

Turbulent Diffusion. After the effluent plume has stopped rising, subsequent dilution occurs due to turbulent diffusion. The rate of dilution may be characterised by a diffusion coefficient which is dependent upon local conditions, and was determined by diffusion studies conducted in the study area by release of dye and monitoring its concentration and movement.

Physico-Chemical Factors

Extensive field studies of several physico-chemical parameters were made during the three year period, 1972 to 1974 to define the pre-discharge baseline conditions. This information can be compared with conditions occurring after commissioning of an outfall to assess the impact of the outfall on the regional water quality. The four physico-chemical characteristics considered were water clarity, dissolved oxygen (DO), hydrogen ion concentration (pH), and nutrient levels.

Water Clarity. The Secchi disc method was used for water clarity measurements. Clarity is reduced by increased concentrations of suspended solids including plankton and therefore may be affected by waste discharges. In any given location, clarity varies with time over a wide range. Minimum clarity values of 1 m were obtained near the existing outfalls, but in general, the results indicated that sea water in the region is clear and comparable with average coastal conditions. Annual mean values in the range of 10 to 14m were obtained throughout the region offshore from Sydney.

Dissolved Oxygen. Dissolved oxygen (DO) concentrations in coastal waters are influenced by many interrelated physical, chemical and biological factors. Supersaturated conditions near the surface were common during the summer due to photosynthetic activity and wave action. Minimum DO levels were nearly always associated with stratified conditions in the November – March period. When stratified conditions persist over an extended period, the DO in the lower zone is progressively depleted by biological respiration. The occurrence of DO readings of 5.0 mg/l or less was investigated as this represents the minimum desirable DO level in the receiving waters. These occurrences were generally less than one percent of the readings in all areas, with the exception of Malabar where the value was about two percent. No DO readings below 4.0 mg/l were recorded.

Hydrogen Ion Concentration. The hydrogen ion concentration (pH) in the ocean environment tends to be stable, and the ocean's natural buffering capacity prevents any marked shift as a result of local discharges. Consequently, pH is of relatively minor importance in this study other than to establish background values.

influenced by two major factors, depth and turbidity, both of which influence the amount of light reaching the seabed.

The community structure of the biota on the sea bed is strongly influenced by the depth of water above the bed. The percentage cover of algae decreases with increasing depth and a change in the species composition and type of algae present occurs. At 21 m depth, red, brown and green algae were present; while well offshore at 46 m depth only red and some brown algae were found. As the cover of algae decreased with depth, the area covered by sponges, polyzoans and coelenterates increased. Population of plants and associated herbivores predominate over suspension feeding animals in shallower and less turbid water, while the concentration of suspension feeders increased and plant population decreased in deeper and more turbid areas.

Settlement studies were carried out to establish the relative growth rates of organisms colonising artifical substrate boxes fastened to the seabed in a number of different locations on the 20 m depth contour. Algae were rarely observed on boxes located close to the outfall, however the growth of some animals which require sediment to build their tubes, such as the corophiid amphipod (shrimp-like crustacean) was more abundant on these boxes. Barnacles were more common on the boxes located away from the outfall, presumably due to the absence of particles of suspended material which tend to block their filter feeding apparatus.

Benthic Communities of Soft Bottom Areas. Studies of the biology of sedimentary or soft bottom areas were concentrated in a zone offshore from Malabar, with some additional sampling offshore from North Head. The studies were designed to obtain data on the structure of the benthic community in the soft bottom area and to document seasonal changes in both numbers of individuals and species.

The major groups of animals found in the soft bottom studies at Malabar and North Head included solitary corals, sipunculins, polychaetes, crustaceans, echinoderms, molluscs, ascidians and fish. Over 400 species were collected during the soft bottom studies and considerable differences in the diversity and abundance of organisms collected at adjacent sampling stations were often observed. These changes appeared to be primarily related to the characteristics of the sediments, including particle size distribution and organic content. Of the 215 mollusc species identified, 119 were carnivores, 65 were suspension feeders, 21 were deposit feeders, 9 were ectoparasites and one was a commensal. The proportion of deposit feeders was larger when both the mud fraction and the organic carbon content of the sediments were higher.

Baseline studies of the population dynamics of selected organisms were undertaken to provide information on the stability of biological communities and to form a basis for evaluating the biological effects of changes in the marine environment.

Fish. The fish fauna of the mid-New South Wales coastal waters is recognised as transitional between tropical and temperate water faunas. Because of this, the area supports both tropical and southern fish. Many of the species found in waters off the coast of South Queensland and New South Wales reach their greatest abundance here.

The surveys of fish inhabiting rocky bottom areas were conducted by SCUBA divers at North Head. Seventy four species of fish were collected in the rocky bottom areas. The most common species were the Port Jackson Shark ***Heterodontus portusjacksoni***, Trevally ***Caranx georgianus***, Goatfish ***Parupeneus signatus***, Bullseye ***Pempheris compressa***, White Ear ***Parma microlepis***, Brown Puller ***Chromis hypsilepis***, Kelpfish ***Chironemus marmoratus***, Red upwelling of cold water occurs and the East Australian Current moves offshore, while the subtropical shearwaters, gannets and terns occur mainly in summer when the southward flowing Current is closer inshore.

During the course of the study, 22 species of seabirds were observed within the study region, including albatrosses, petrels, gannets, skuas, terns, penguins and gulls.

4.5 FAECAL COLIFORM DIE-OFF IN RECEIVING WATERS

The density of faecal coliform organisms is commonly used as an indicator of sewage pollution of bathing waters. Existing data on faecal coliform densities at beaches under the North Head outfall are presented in Chapter 5.

Studies were undertaken in Sydney Harbour during May 1975 and February 1976 to determine the rate of die-off of faecal coliform bacteria in the marine environment. Sewage

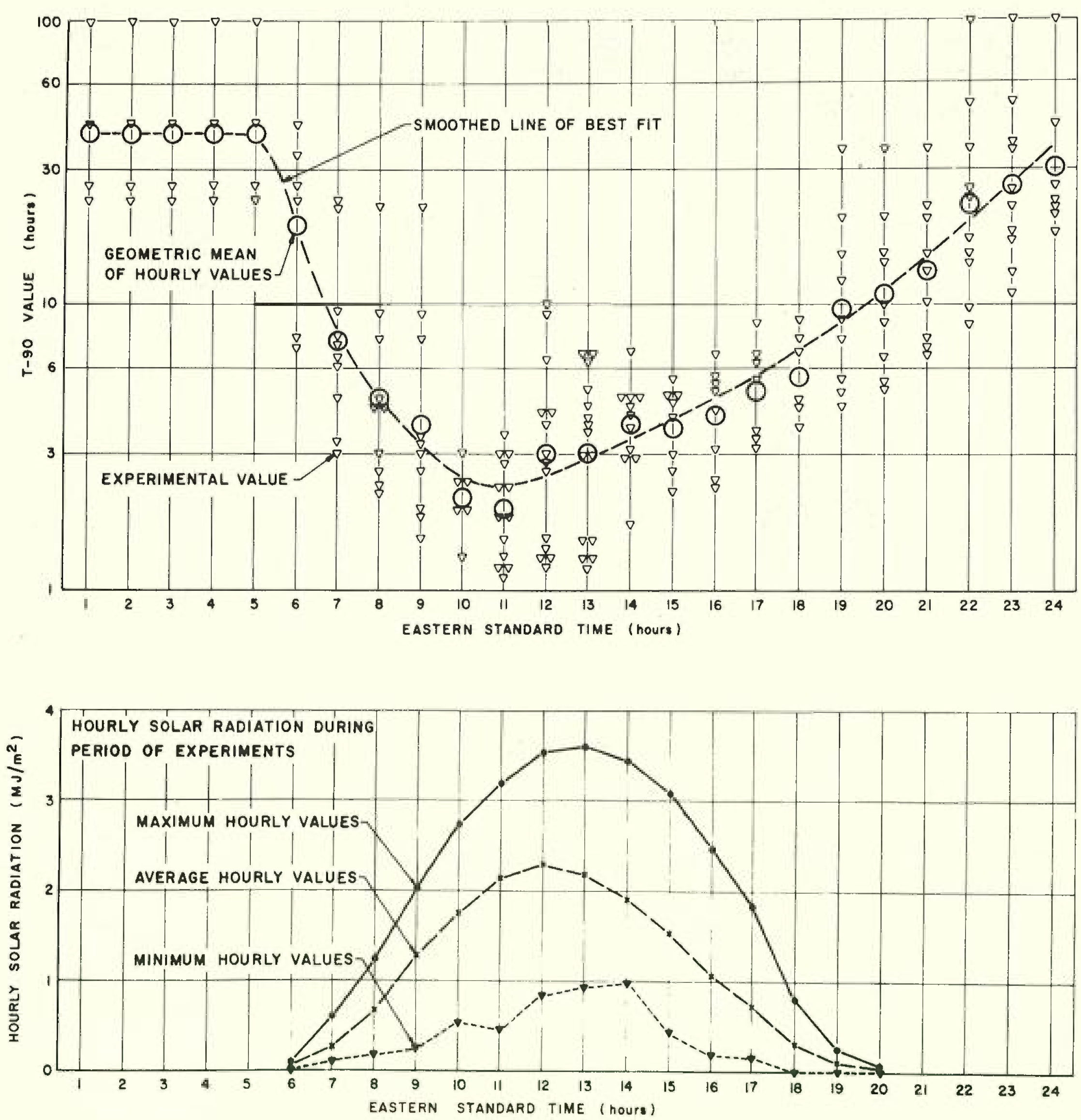


Fig. 7 Summary of Hourly Variation in T-90 Values and Solar Radiation

CHAPTER 5
IMPACT OF THE PRESENT DISCHARGE

This chapter discusses the impact of the present North Head screened wastewater discharge on water quality, beach pollution, marine biota, and the level of restricted substances in biota. All are affected to some extent by the present effluent discharge. In addition, the effect of sewage discharges on Norfolk Island pines on the shoreline in areas near North Head is also considered.

5.1 PRESENT WATER QUALITY

Water quality in the nearshore area adjacent to the present North Head outfall is influenced by the discharge of screened sewage. Offshore water quality is also influenced to a lesser degree which is largely determined by the direction of movement of the effluent field.

As part of a water quality monitoring programme to determine the effect of present effluent discharges on nearshore waters in the Sydney area, investigations of the influence of the Malabar WPCP discharge were carried out by the Board between July 1975 and June 1976. Data collected include the concentrations of grease, suspended solids, total phosphorus, ammonia, chloride and faecal coliforms in surface water samples. No investigations comparable to those carried out at Malabar have been carried out at North Head but the oceanographic conditions and potential impacts are similar for both Malabar and North Head. Consequently the results of the Malabar studies may be used to predict likely water quality conditions offshore from North Head. Constituent concentrations in the two discharges are much the same even though the Malabar WPCP discharges primary effluent whereas the North Head plant discharges screened sewage. This is because the additional treatment at Malabar compensates for the higher concentration of constituents in the Malabar raw sewage.

but actually lower than originally designed; see Malabar, page ii

Malabar Water Quality Investigations

In the Malabar study, surface water samples were collected as close as possible to the effluent 'boil' (i.e. the point of the ocean where the effluent surfaces) and at various distances from the outfall along the centreline of the visible sewage field. Samples were also taken in clear seawater away from the sewage field to establish background levels for comparison. Trasmissometer readings indicated that the field extended from the surface to a depth of 2 to 8 metres; however, the wastes were concentrated near the surface in each case. Although the variability between samples was high, as expected, the data taken as a whole provide a useful insight into the general pattern of dispersion and assimilation of wastes in the receiving waters.

The chloride concentration of the sewage-seawater mixture was used to determine initial dilutions, as the chloride concentration in the effluent is negligible in comparison with seawater. Dilutions at the surface of the Malabar effluent field, calculated on this basis, using averaged values for all runs, are shown in Fig. 8. It can be seen that the intial dilution at the surface in the boil area adjacent to the discharge point is about 8:1. The dilution approaches 40:1 at a distance of about 1000 m from the discharge point.

The reductions in concentration with distance from the Malabar discharge point for grease, suspended solids, total phosphorus and ammonia are shown in Fig. 9. Based on the

Existing North Head Water Quality

The initial dilution at the surface of the 'boil' area adjacent to the North Head discharge point is expected to be slightly greater than the estimated 8:1 value observed at Malabar. Considering the slightly greater discharge depth and smaller outlet diameters, the estimated initial dilution at North Head is about 10:1 under average conditions. This dilution is not sufficient, however, to enable water quality requirements for physical appearance to be met by the present discharge. The reduction in concentration with distance for grease, suspended solids, total phosphorus and ammonia which could be expected at North Head are probably similar to those observed at Malabar.

5.2 BEACH POLLUTION

A potential major impact of effluent discharge in the ocean arises from return of pathogens and floatables to the shoreline and beaches. Such contamination poses both a potential public health risk and an aesthetic nuisance. The degree of contamination is affected by the type of treatment, location of the effluent discharge and oceanographic conditions prevailing in the discharge area.

Two measures applied as indices of sewage pollution are the density of faecal coliform organisms in bathing waters and the concentration of grease in beach sand. In the case of waters used for recreational purposes, very little evidence is available relating faecal coliform density to the incidence of water borne disease. A specific faecal coliform limit does not distinguish between safe and hazardous recreational waters but rather is intended as a desirable goal for water quality management. Water quality criteria for faecal coliform organisms were presented in Chapter 4.

The second measure of sewage pollution is the concentration of grease in beach sand, which gives a better indication of aesthetic nuisance than faecal coliform counts. Grease deposits create unpleasant conditions for beach users, and require the Board and foreshore Council to maintain beach cleaning operations.

Beach Pollution Surveys. Pollution of the swimming beaches along the Sydney coast has been comprehensively monitored regularly by the Board since 1966 and the results have been reported in internal "Beach Pollution Survey" reports covering each summer (September to April) and winter (April to September). The indicators of pollution monitored in this programme are faecal coliform density in shallow water, the grease content of sand, and a visual assessment of the degree of pollution on most beaches.

Samples for faecal coliform and grease determinations are taken from 22 metropolitan and 11 Illawarra beaches throughout the summer and winter sampling periods. Outlying beaches are usually sampled only 6 or 7 times in a sampling period but beaches close to Sydney are sampled up to 74 times. The density of faecal coliform organisms is determined using the membrane filtration technique with incubation at 44.5^{o}C. Results are presented as numbers of samples with faecal coliform counts in four density ranges: 0-9, 10-99, 100-999, and greater than 1000 organisms per 100 ml for water samples and per 100 g for wet sand samples. Sand samples for grease determination are taken from the area of greatest grease concentration on the beach. Grease concentrations in sand are calculated as grams of grease per kilogram of sand and results are presented as the seasonal minimum, average and maximum levels for each beach.

The Beach Pollution Reports from 1967 to 1978 were reviewed and the results summarised for four beaches near the North Head outfall: Curl Curl, Queenscliff, South

Higher densities are common in the beaches nearest the outfall. Densities greater than 100 org/100 ml are uncommon at Curl Curl Beach, but at other beaches this condition has occurred frequently. Conditions at Fairy Bower Beach, which is about 1.5 km from the North Head discharge point, are the worst of any of the four beaches.

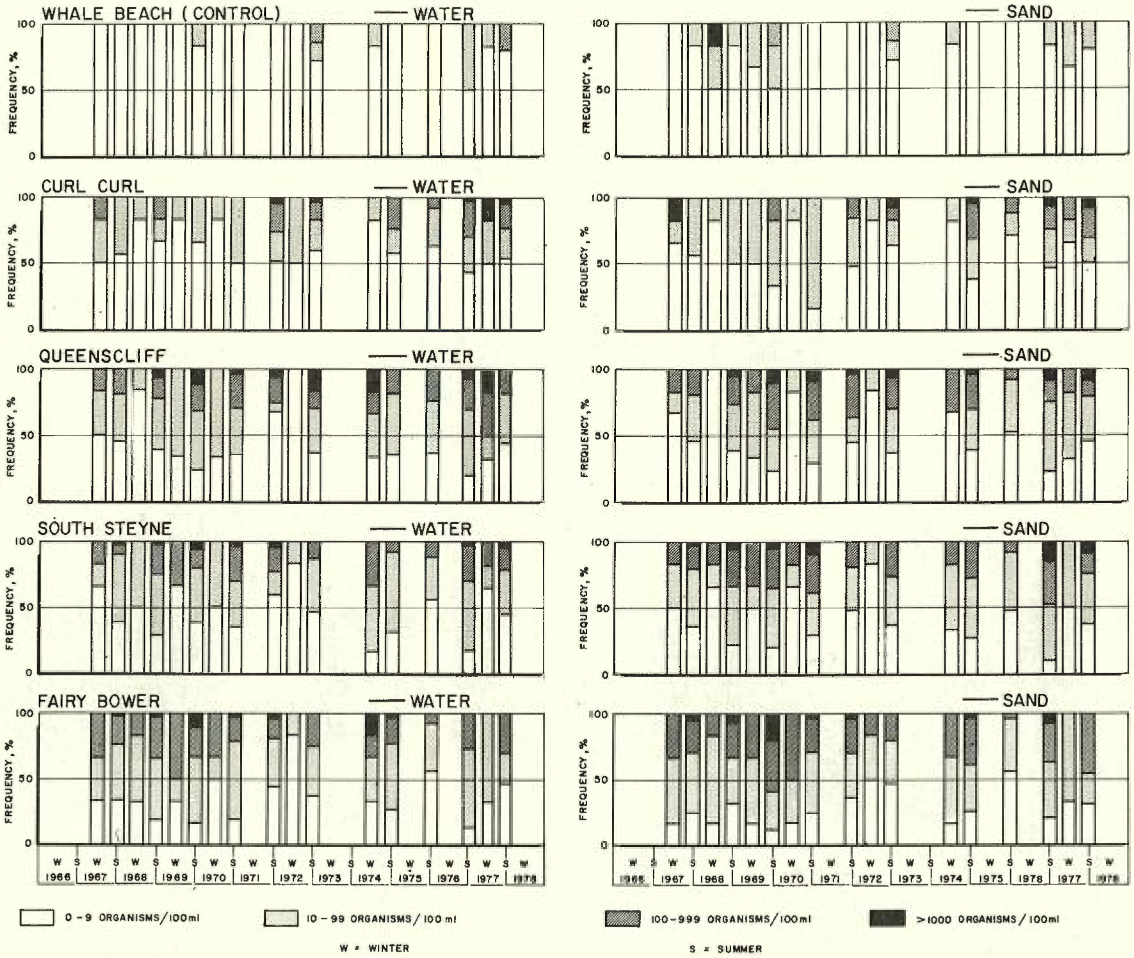


Fig. 11. Faecal Coliform Levels at Beaches near the North Head Discharge, 1967 to 1978.

The water quality criteria presented in Chapter 4 require that the geometric mean faecal coliform density in bathing waters should not exceed 200 org/100 ml (based on 5 samples taken during any 30 day period) and that no more than 10 per cent of the samples collected in bathing waters during the summer period should have densities exceeding 400 org/100 ml (based on not less than 30 samples collected during the six month period). The data presented in Fig. 11 cannot be compared directly with the faecal coliform criteria. However, only Curl Curl would be likely to meet the criteria regularly and Queenscliff, South Steyne and Fairy Bower would probably meet the criteria only rarely.

Grease Concentrations. The average and maximum grease concentrations for these beaches are shown in Fig. 12. The distribution of grease levels does not follow the pattern of the faecal coliform data. Whereas the occurrence of high faecal coliform densities was greatest on beaches nearer the outfall, the opposite trend was recorded for grease concentrations, with the concentrations higher at Curl Curl and lower at Fairy Bower. Marked differences between summer and winter concentrations also occur, but the differences are much greater at Curl Curl than at Fairy Bower.

Grease floatables widespread along all northern beaches after S.E. storms.

The data on grease concentrations appear to be directly related to the position and orientation of beaches near North Head and the patterns of offshore surface currents and wind movement. Earlier studies of water movement near the North Head outfall have shown that south easterly to easterly winds transport surface water from the outfall towards South Steyne beach. South easterly and southerly winds transport surface water further north into Curl Curl and Harbord beaches. Northeasterly winds take waters south, and other winds cause the surface waters to move offshore. Northeasterly to southerly winds dominate during the summer months in the Sydney area, and winds with a westerly component dominate during winter.

always. Not these seen at S.S with a NE blowing & see how clean it is!

Visual Appearance. The introduction of screening at North Head WPCP in 1970 has resulted in a marked improvement in aesthetic conditions on the northern beaches. Prior to this time the Beach Pollution reports indicate frequent visual contamination of these beaches, but after 1970 reports of visual contamination have occurred infrequently, although occasional authenticated complaints of visual pollution of beaches in the Manly area have been recorded.

Damage to Norfolk Island Pines on the Sydney Coast. One of the most attractive features of the Sydney beaches for many years has been the plantations of Norfolk Island pines that were established on the beach fronts in the 1880's. In the last 15 years these trees have suffered severe defoliation, and many have died and subsequently been removed. The die-off has been linked to the presence of waste components in the waters of the affected areas. The effect is seen clearly at South Steyne beach, and therefore is considered among the effects of the North Head discharge.

A special committee to examine the cause of deterioration was established in 1971 and reported to the Premier of New South Wales in 1975. The committee concluded that deterioration and death of the pines was caused by the entry of excessive amounts of salt into leaves following breakdown of the wax cuticle which normally prevents excessive salt intake. The breakdown was attributed by the committee to surfactants from household detergents and the committee concluded that these surfactants could reach the foilage in the form of an aerosol carried by the wind from the present effluent field. The possibility that other factors, e.g. detergents in motor vehicle emissions, contribute to the problem is being investigated but no results are available.

5.3 MARINE BIOTA

The coastline at North Head is dominated by cliffs and headlands which have been cut by wave action. Consequently, the nearshore waters conceal many exposed rock faces which provide a suitable substrate for sessile (i.e. attached) organisms and a habitat for a wide range of aquatic animals. As described in Chapter 4, studies of benthic (bottom dwelling) organisms, fish and birds were conducted in the vicinity of North Head by the Shelf Benthic Survey Team of the Australian Museum as part of the submarine outfall study[2].

Benthic Organisms. Overall, as discussed in Chapter 4, the investigation of the benthic community offshore from North Head indicated that biota in areas close to the outfall are somewhat impoverished and altered in composition, while adjacent areas which also come under the influence of the effluent plume are colonised by very rich assemblages of sedentary and benthic organisms.

The presence of transient sludge layers on the bottom immediately to the south of the outfall was noted on several occasions by SCUBA divers. This material appeared to be

The reconnaissance study aimed to establish whether a detailed investigation of heavy metal and pesticides levels in marine organisms should be undertaken in the vicinity of the outfall, and was carried out under the direction of Caldwell Connell Engineers by the Australian Museum's Shelf Benthic Survey Team and the Board's Chemical Sub-Branch. The results of the surveys are summarised in Table 6; no level of statistical significance can be assigned to the results as only single samples were analysed. The Board has implemented a Trade Waste Policy since the reconnaissance survey was undertaken, and therefore some reduction in the concentration of restricted substances shown in the table may occur.

The data indicate that the heavy metal and pesticide levels in samples taken offshore from North Head were only marginally higher than in samples taken offshore from Marley Head and that levels in very few samples approached or exceeded the figures recommended by the National Health and Medical Research Council as listed in Table 7. A blue groper collected at Marley Head and a brown groper collected at North Head both marginally exceeded the mercury standard of 0.5 µg/g. A mussel collected at North Head exceeded the lead and zinc standards and a mollusc collected at North Head exceeded the copper and zinc standards. All other values were well within the NH&MRC standards. Although not exceeding the standards, measurable pesticide concentrations were found in several samples collected at North Head and Marley Head.

Table 7. Summary of Recommended Levels for Heavy Metals and Pesticide Residues in Foods.

Substance	Recommended level	Foods
Mercury	0.5 µg/g	fish, molluscs, crustaceans
Cadmium	5.5 µg/g	solid foods
Copper	30.0 µg/g	solid foods
Lead	2.0 µg/g	solid foods
Zinc	40.0 µg/g	solid foods
Aldrin	200 ng/g	meat
DDT + DDE	1,000 ng/g	fish
Dieldrin	200 ng/g	meat
Lindane	1,000 ng/g	fish

Source: National Health and Medical Research Council of Australia. Reports of the 73rd and 75th sessions, held in 1971 and 1972, respectively.

The concentration of restricted substances in raw sewage has been considerably reduced by the progressive implementation of the Board's trade waste control policy since 1972. The concentration of these substances in biota and sediments in the vicinity of the existing outfalls should, therefore, also be progressively reduced. As discussed in Section 7.4, an ongoing programme is to be undertaken to monitor restricted substances in marine biota to gauge the effectiveness of existing control measures and to indicate the need, if any, for further measures.

5.5 SUMMARY OF EXISTING IMPACTS

In summary, the present North Head screened wastewater discharge has a detrimental impact on water quality in terms of physical appearance of the effluent field, high faecal coliform levels at times on nearby beaches and elevated grease levels in beach sand. Occasionally solids of sewage origin are washed onto nearby beaches. There is evidence that beachfront Norfolk Island pines have also been affected by the present discharge. In addition, marine organisms in the vicinity of the discharge show a response to the effluent, with impoverishment observed close to the outfall and enrichment within the restricted zone adjacent to the discharge area. Further treatment and/or disposal facilities are therefore required if the present adverse impacts are to be reduced or eliminated.

Sludge Treatment and Disposal Options

The materials removed from wastewater during treatment are screenings (rags, trash, large solid objects); grit (sand, discrete largely inorganic particulate matter); scum (floating oil and grease) and sludge (solids which settle in a sedimentation tank). In modern wastewater treatment, screenings, grit and scum are usually incinerated and the very small amount of ash buried on land or discharged to the ocean. Methods to handle and dispose of sludge, however, require more detailed evaluation.

The possible sludge disposal options which could be used involve the return of waste constituents to (1) the atmosphere; (2) the land or (3) the ocean. Disposal to the atmosphere would involve incineration of sludge. Disposal to the land would involve stabilisation of the sludge to minimise the potential for odours or other nuisances followed by application to agricultural land or to landfill. Disposal of sludge to the ocean could involve some form of pretreatment. In evaluating the options it should be borne in mind that, whichever sludge disposal option is adopted, fine materials would remain in the effluent after treatment (approximately half the solids in the case of primary treatment) and these solids would be discharged to the ocean in any event. A higher proportion of the solids would be discharged to the ocean in the effluent from a high rate primary plant.

Wastewater Treatment and Effluent Disposal Options

Fifteen combinations of wastewater treatment and effluent disposal options may be formulated from the range of options available for wastewater treatment and effluent disposal. These combinations are shown in Table 8. It is not necessary to discuss several of these combinations of options in detail for the reasons given below.

Table 8. Wastewater Treatment and Effluent Discharge Options.

Option	Effluent discharge	Wastewater treatment	Comment	Discussed in detail
1	Reclamation/Reuse (reduced discharge)	• Tertiary	Considered together	Section 6.2
2		• Secondary		–
3		• Primary	Treatment and effluent discharge options obviously incompatible	–
4		• High-rate primary		–
5		• Preliminary		–
6	Shoreline	• Tertiary	Excessive treatment	–
7		• Secondary	–	Section 6.3
8		• Primary	–	Section 6.3
9		• High-rate primary	Would not meet criteria	–
10		• Preliminary	No change option	Section 6.3
11	Deepwater	• Tertiary	Excessive degree of treatment	–
12		• Secondary		
13		• Primary	–	Section 6.4
14		• High-rate primary	–	Section 6.4
15		• Preliminary	–	Section 6.4

Water-using industries are generally located too far from the present treatment plants for reuse to be economically viable. Industry requires water for a variety of uses, and the water quality required ranges from low quality washdown to potable grade and even higher. The requirements for cooling water are less demanding than for process water but even so a high degree of treatment is required, including effluent filtration and possible nutrient removal, to prevent slime growth on the cooling equipment.

Local reuse may also be accomplished by groundwater recharge, either by surface spreading or by injection. In the first case, large areas of land are required and in the second case a high degree of treatment including secondary treatment and effluent filtration is required to prevent clogging of aquifers. In some cases even nitrate removal may be necessary.

As a guide, it would cost at least 165 million dollars to upgrade North Head WPCP to provide effluent of suitable quality for reuse, excluding the cost of sludge treatment and disposal. In addition a reclaimed water distribution system (separate from the potable water system) would need to be established to supply potential reuse points. While a precise cost cannot be established for such a distribution system because reuse points are unknown, distribution costs could be expected to be at least equal to the cost of treatment. Surplus effluent in excess of reuse demand would still need to be disposed of to the ocean at the cliff face outfall. The unit cost of this reclaimed water would be very high in comparison with the unit cost of water from the normal distribution system, being more than ten times that of water from the Shoalhaven scheme.

In conclusion, the reuse of sewage within the Sydney region to an extent which would cause a significant reduction in discharge does not appear to be feasible in the foreseeable future. In any case, the Board's inland plants, which produce a very high quality effluent, would probably prove to be a more economical source of effluent for reuse than the North Head WPCP.

(2) Reuse West of the Dividing Range

Major inter-basin water transfer projects such as the Snowy Mountains Project and the California Water Project have been constructed to transport water from areas of excess supply to areas of demand. It might be suggested that effluent from the major Sydney sewerage systems could be pumped over the Dividing Range to supply long term needs to the west.

This may appear attractive from a water conservation standpoint, but the physical and economic obstacles are formidable. A conduit in excess of 100 km in length with a static lift approaching 1000 m would be required to reach the saddle traversed by the Sydney-Bathurst Railway. This conduit would have to be constructed through urban Sydney and the natural bushland of the Blue Mountains, which would involve major adverse environmental impact. The power required to lift the North Head ADWF over the Divide at this point would probably exceed 70 megawatts, at an annual energy cost of about $12 million. This is about the same power requirement as needed to serve a population of about 300 000 persons. Capital costs for such a scheme would be at least $500 million, including the cost of supplementary treatment to produce an effluent suitable for reuse. Based on information provided by the Water Resources Commission of NSW, the unit capital charges and operating cost for such a reuse project (more than $400/Ml) is about twenty times that of a viable irrigation supply project.

In conclusion, the foreseeable demand for reconditioned water west of the Great Dividing Range does not appear to justify the expenditure of capital, energy and other resources needed to export effluent from the North Head WPCP.

Similar results could be expected for beaches near the North Head outfall following shoreline discharge of primary effluent.

(3) Biological Secondary Treatment

Various methods of biological secondary treatment could be used including the activated sludge process. Conventional air activated sludge and the more recently developed oxygen activated sludge process should be capable of providing sufficient BOD_5 and suspended solids removal for satisfactory effluent discharge through the existing shoreline outfall. The oxygen process using deep tanks would have the advantage of minimising the land area requirements of a secondary treatment plant.

A flow diagram of a plant providing secondary treatment of primary effluent by the conventional activated sludge process and discharging to the existing shoreline outfalls is shown in Fig. 14. Secondary treatment would produce substantial reductions in BOD_5 and suspended solids, resulting in a high quality effluent in which the concentration of these constituents was less than 20 mg/l. Chlorination of the secondary effluent would be required to meet receiving water quality criteria for faecal coliforms. The criteria for other restricted substances would probably be met considering the removals expected for secondary treatment and the observed effluent dilution at the existing outfalls. However, this dilution would probably not be sufficient to prevent the discharge being noticeable. Discharge of digested sludge with the secondary effluent through the shoreline outlets would considerably increase the visibility of the effluent field and so sludge would have to be either dewatered and incinerated or discharged to deeper water.

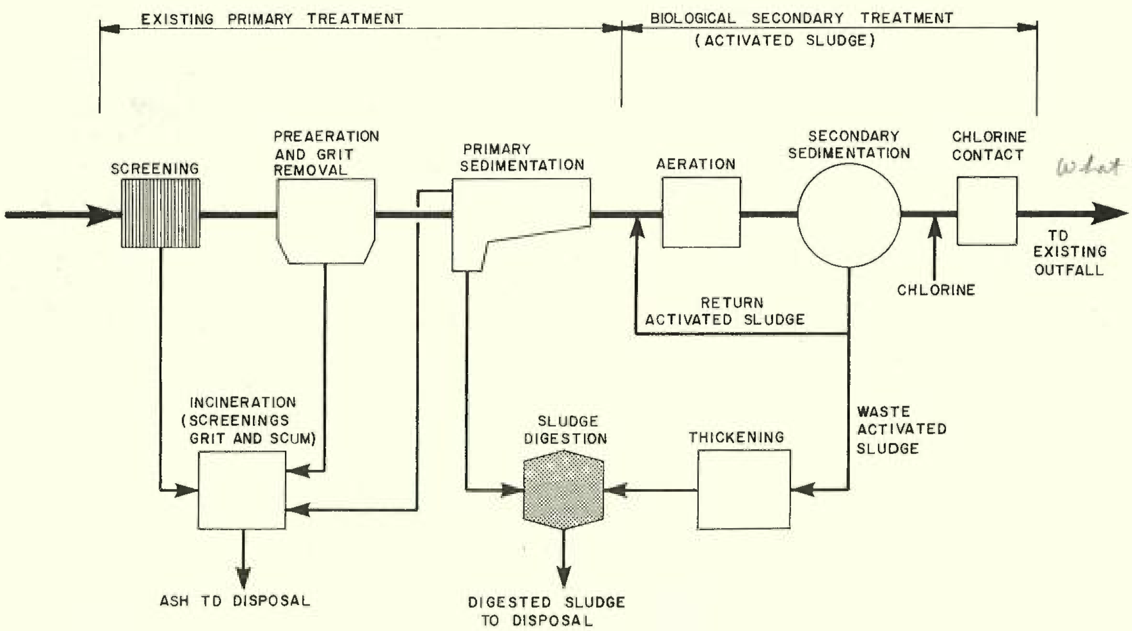


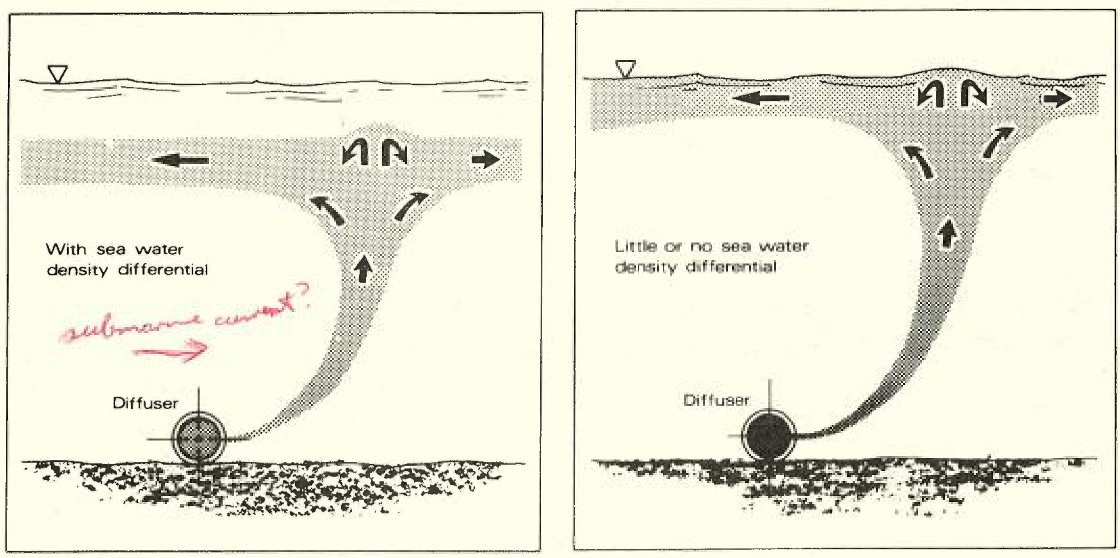
Fig. 14. Flow Diagram of Biological Secondary Treatment Option.

The present North Head WPCP site has insufficient land area to accommodate the usual form of secondary treatment facilities. Adjoining land which might be acquired is at a higher elevation and would require extensive excavation, additional pumping or undergound construction. In addition, expansion of the area of treatment facilities on North Head would disturb the scenic and recreational potential of the area. Fig. 15 shows that extensive additional area would be required to construct secondary treatment facilities on the surface of the existing North Head WPCP site. The additional area would cover most of the existing military reserve which, as discussed in Chapter 3, will form part of the Sydney Harbour National Park.

6.4 DEEPWATER SUBMARINE DISCHARGE

Ocean disposal of sewage through deepwater submarine outfalls is commonly adopted by coastal communities where deepwater is available close to shore. These outfalls are designed to use the natural processes of the receiving waters which dilute and disperse wastes so that the discharge is assimilated by the marine ecosystem without significant adverse environmental effects.

The principle of operation of deepwater submarine outfalls is illustrated schematically in Fig. 16. Effluent is discharged through a series of ports along the diffuser section of the outfall which is generally located normal to the direction of the prevailing currents. The buoyancy of the effluent causes the plume to rise and turbulence associated with the rising plume mixes the effluent with seawater. The density structure of the ocean water in the discharge zone determines whether the diluted effluent either remains submerged or rises to the surface. During the summer months, when normally there is a marked density differential between surface and bottom waters, the effluent field would remain submerged; during the cooler months and following severe storms, when there is little or no density differential, the effluent field would reach the ocean surface. However, the large dilution would mean that the surface effluent field would not be visible. Subsequent dispersion and decay of wastes would occur as the effluent field was transported from the discharge zone by currents. + "floaties" + grease back on beaches after every winter storm?



Submerged field

Surface field

Fig. 16. Schematic Representation of Deepwater Submarine Outfall Operation.

The deepwater submarine outfall option was the subject of detailed investigation and preliminary design in the submarine outfall study. Two alternative deepwater outfall construction methods have been developed as shown in Fig. 17. Both involve constructing a tunnel below the ocean floor from the coast to several kilometres offshore. In the first alternative, a vertical ocean shaft would be constructed at the seaward end of the tunnel to connect the tunnel to a diffuser section laid on the seabed. In the second alternative, a longer tunnel would be constructed and a diffuser section created by drilling a series of boreholes to connect the tunnel to the ocean floor. The construction cost, outfall performance and environmental impact are very similar for these two alternatives and therefore it is not necessary to distinguish between them in this EIS.

developed in Australia over the last two years and data for predicting the performance of a high rate primary treatment plant at North Head are available from the results of (1) a pilot plant operated by the Geelong Waterworks and Sewerage Trust (GWST) under the direction of Caldwell Connell Engineers, and (2) a full scale test carried out by the Board's staff at the Malabar WPCP.

The HRP option at North Head is designed (1) to incorporate the existing screening facility and the incinerator currently under construction, (2) to make use of the existing excavations and (3) to allow later development to a conventional primary plant or other appropriate treatment facilities should this ever become necessary.

A flow diagram of the HRP option is shown in Fig. 18. After screening, the flow passes through aerated grit chambers and then through high rate primary sedimentation tanks. Key hydraulic features of the sedimentation tanks are the provision of uniform flow throughout the tank achieved by providing baffling at the inlet end and an extensive submerged effluent collection system at the downstream end. A comprehensive scum collection system is also provided. The volume of the tank provides a hydraulic detention at ADWF of about 25 minutes and at PDWF of about 15 minutes. This detention is about one-third to one-quarter of that used in conventional primary sedimentation and, correspondingly, HRP treatment requires only one-third to one-quarter of the sedimentation tank volume. In addition the HRP option would involve substantially lower capital and operating costs for solids handling and disposal.

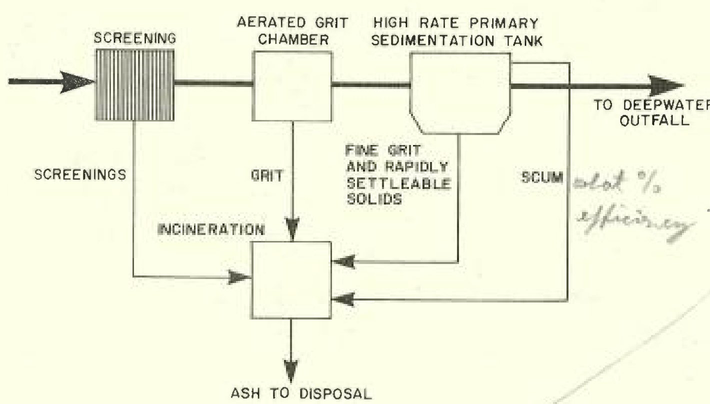


Fig. 18. Flow Diagram of High Rate Primary Treatment Option.

In 1978, the Board carried out a number of tests in which the hydraulic loading of the Malabar primary plant was increased to the same rate as a HRP plant. This high hydraulic loading was achieved by by-passing four of the sedimentation tanks and settling all flow in the other two tanks. The Malabar plant was not designed for such high hydraulic loadings and this created some operating difficulties. Despite these, on the basis of the tests it was concluded that satisfactory floating grease and scum removal could be achieved in a HRP sedimentation tank specifically designed for that purpose.

A more definitive prediction of the performance of the HRP treatment can be made using the results of pilot plant tests conducted at Black Rock in early 1979 by the Geelong Waterworks and Sewerage Trust. These tests were carried out in a 3.7 m long sedimentation tank specifically designed for HRP treatment, and incorporating the key hydraulic features discussed above. The Black Rock results show that good removal of floating grease and scum was obtained for detention times in excess of 15 minutes. In addition, at this loading rate about 5 per cent of the BOD_5 and suspended solids were removed with the grease and a further 25 per cent of the suspended solids (primarily grit and the heavier solids) settled

Table 9 shows the predicted effluent characteristics of conventional primary and high rate primary effluents, assuming that in the case of conventional primary effluent the digested sludge is discharged with the effluent, as occurs at Malabar. As can be seen from Table 9, the concentrations of BOD_5 and suspended solids in conventional primary and high rate primary effluents are similar. The grease concentration in HRP effluent is marginally higher than in a conventional primary effluent mixed with digested sludge. Substantially all floating grease, which is responsible for the most readily visible forms of beach pollution, is removed with the HRP option. Effluent faecal coliform levels are expected to be similar in both cases, and the concentration of restricted substances would be the same in both effluents.

It is considered that the HRP option would meet water quality criteria for physical appearance. Most of the floatable material, including substantially all floating grease, would be removed, and there would be few occasions (9 per cent of the time in summer) on which the effluent discharged from a submarine outfall would form a surface field. In addition, because of the high dilution produced by a deepwater outfall, similar BOD_5, suspended solids and grease concentrations in the effluent field would result from discharge of high rate primary or conventional primary effluents (with or without digested sludge disposal). Criteria for restricted substances, pH, dissolved oxygen and faecal coliform would also be met in both cases.

Table 10. Comparison of Sewage Treatment and Effluent Disposal Options.

Option	Summary of major characteristics of options	Indicative 1978 costs[a], $ million		
		Capital cost[c]	Annual operating cost[c]	Total capitalised cost[d]
Reduced Discharge				
Reuse within catchment	Low level of demand for effluent; possible lack of public acceptance; supplemental treatment required; conveyance of effluent through heavily populated areas.	350[b]	10[b]	470[b]
Reuse outside catchment	Formidable physical and economic obstacles; power requirements for pumping equivalent to demand from a population of 300 000; supplementary treatment required prior to reuse.	500	15	720
Shoreline Discharge				
Preliminary	The 'no change' option. Would not meet receiving water quality criteria.	16	0.8	25
Primary treatment	Would not meet receiving water quality criteria.	66	3.6	110
Secondary treatment of primary effluent	Costs and space requirements create serious constraints; separate disposal of digested sludge will be required; may meet water quality criteria but the discharge would probably be noticeable.	165	5.7	235
Deepwater Submarine Discharge				
Preliminary	Would not meet receiving water criteria for physical appearance.	39	0.9	50
High rate primary treatment	Would meet receiving water quality criteria	57	2.7	90
Primary treatment	Would meet receiving water quality criteria.	90	3.7	135

[a]Indicative costs are based on December 1978 levels; costs do not include capital or operating costs attributable to the existing screening plant or sludge treatment or disposal but include commitments under existing contracts.

[b]Assumes secondary treatment is required to provide effluent suitable for reuse.

[c]All costs are based on ultimate WPCP capacity.

[d]Total capitalized cost taken over 50 years at an interest rate of 8 per cent.

secondary sludge. The volume of sludge produced generally represents less than one per cent of the volume of the effluent. The concentration of solids can vary between 10 000 mg/l (secondary sludge) and about 50 000 mg/l (primary sludge).

The composition of primary sludge depends on a number of factors including the characteristics of the raw wastewater and the performance of the primary sedimentation process. Apart from water, the components of primary sludge may be divided into the following categories: (1) mineral solids, including sand, soil particles and colloidal clay; (2) organic solids, including grease, fat, proteins and cellulose; (3) nutrients, including nitrogen (N), phosphorus (P) and potassium (K); (4) microorganisms, including pathogenic bacteria, viruses and protozoa, as well as many non-pathogenic microorganisms; and (5) trace amounts of toxic materials, including heavy metals, chlorinated hydrocarbon pesticides and polychlorinated biphenyls (PCB's).

Digested sludge is produced by stabilising primary and secondary sludges, i.e. by reducing the putrescible organic material to minimise handling and disposal problems. The most common stabilisation process used is anaerobic digestion although aerobic digestion is sometimes practised in smaller plants. Another advantage of digestion is reduction in the levels of many pathogenic organisms. No change in the quantity of heavy metals or other restricted substances is produced by digestion. Typical values for the major constituents of primary and digested sludge are presented in Table 11. It can be seen that about one third of the total solids is mineral matter and about two-thirds is organic material. Sludge digestion also produces methane gas which has an energy value.

Table 12. Heavy Metal Levels in Raw Sewage and Digested Sludge.

Metal	Raw sewage, mg/l		Digested sludge, mg/kg dry solids		
	Malabar (mean)	North Head (mean)	Malabar (mean)	33 USA Plants[a] (mean)	London[b] (range)
Chromium	0.7	0.05	790	1100	200-1065
Copper	0.4	0.15	660	1230	505-2500
Lead	0.3	0.07	410	830	n.d. [c]
Zinc	2.0	0.7	1410	2780	2390-5860
Cadmium	0.1	0.01	20	31	30-70
Nickel	0.2	0.05	160	410	150-350
Mercury	0.02	0.003	1.6	6.6	2-150

a. Ref. 8
b Ref. 9
c Not determined

Heavy metals and pesticides are normally present in sludge in trace amounts: however, they may be of special significance in some situations because of their potentially toxic effects. The concentrations of heavy metals in raw sewage and digested sludge for a number of plants are presented in Table 12. The data for raw sewage illustrate the effect of industrial waste loads on heavy metal concentrations; the concentrations for Malabar, which include significant industrial inputs, are between four and ten times higher than those for the predominantly domestic sewage at North Head. Heavy metal concentrations in digested sludge are also presented in Table 12 for Malabar, the Hyperion plant at Los Angeles, and for London.

treatment plant which discharged digested sludge with the effluent would contain about 80 per cent of the incoming solids, of which half would be raw solids and the other half digested primary sludge.

The key issue therefore is the ability of the various sectors of the environment to receive these solids without adverse impacts. Organic matter is readily assimilated in the ocean. Therefore, if it is satisfactory to dispose of digested sludge from a primary treatment plant to the ocean it will also be satisfactory to discharge a similar quantity of solids from a high rate primary treatment system to the ocean, provided other water quality criteria associated with the effluent discharge are also met.

Discharge to the Ocean

Ocean disposal of digested sludge may be accomplished by barging or by discharging through deepwater submarine outfalls. Where berthing facilities are in close proximity to the WPCP, or where long distances to satisfactory deepwater outfall locations would result in excessive outfall costs, barging of sludge is often preferred. Where adequate depths can be reached close to shore, deepwater outfalls have been found to have cost and operational advantages over barging. Ocean disposal by submarine outfall has significant advantages over barging at North Head WPCP, including lower capital and annual operating costs and less energy consumption. Barging could entail a significant amount of road hauling of sludge to the barge loading facility.

Disposal to Land

Application to land is an accepted method for disposal of digested sludge. It is not considered appropriate to dispose of raw solids on land because of the high potential for odour production. Disposal of digested sludge to land may be accomplished by (1) application to agricultural land (with or without prior composting) to use the sludge as a soil conditioner or (2) burial in landfill operations.

Conditions in the Sydney region are relatively unfavourable for land application due to the terrain, soil characteristics, and meteorological conditions. As a result, land application could be practised effectively only during the drier period of the year, and another means of disposal or sludge storage facilities would be required for the remainder of the year. For these reasons landfill disposal, which is often practised at inland plants, would be more suitable. However, there are no regional landfill sites in the vicinity of the North Head WPCP and the sludge would have to be transported to sites in the far western suburbs. The transport distances to reach such sites would be about 60 km.

Disposal to Air by Incineration

Advances in incinerator design and gas scrubbing equipment have made incineration of raw sludge a feasible sludge disposal option. With this approach, expensive sludge digestion facilities would not be required. An afterburner would be used to control odours and meet air emission requirements. A significant disadvantage of an incinerator used only for burning sewage sludge is that supplementary energy is required for the combined dewatering-incineration process. This need for supplementary fuel has spurred technological development of both combined sludge/refuse incineration and pyrolysis. These show promise of being attractive alternatives to conventional sludge incineration in communities where a source of refuse derived fuel (RDF) can be developed economically to provide supplementary fuel.

where does the scrubbing sludge go? p57?

Table 13. Comparison of Sludge Disposal Options.

Item	Disposal to ocean water	Disposal to land	Disposal to air by incineration
Impacts of Sludge Components			
Mineral fraction	Insignificant in comparison with sediment input from rivers, coastal erosion and spoil from dredging.	No impacts as expected as material is buried.	Collected as ash after incineration. No adverse impact expected with ash disposal.
Organic fraction	Valuable food source for marine organisms. No significant oxygen demand will be exerted.	Possible release of odours if uncovered. Odourous generated by decomposition if sludge not fully digested.	Gases produced by incineration insignificant in comparison with total emissions in urban areas.
Nutrients	Nutrient concentration rapidly reduced to background levels by dilution and dispersion.	Possibility of contamination of ground and surface water by leachate. Would need controls to prevent this.	Phosphorus is recovered in ash and so care is needed in ash disposal. Nitrogen discharged to atmosphere either in flue gases or in scrubber water.
Pathogens	Density of micro-biological indicator organisms similar to levels in primary effluent. Unlikely to increase levels in waters receiving primary effluents.	Possible contamination of ground and surface waters by leachate carrying viable pathogens.	Pathogens are destroyed by incineration.
Toxic materials	No serious accumulation of toxic materials observed following long term discharge to raw sewage at North Head. Wide dispersion will rapidly reduce levels. Source control should be used to limit discharge of materials to sewers.	Possible contamination of ground and surface waters by leachate. Would need controls to prevent this.	Most potentially toxic materials, except mercury, are converted to oxides and appear in ash or scrubber water. May require after-burners for complete destruction of pesticides.
Summary of Major Impacts	Organic material is food source for marine organisms. Possible accumulation of heavy metals and pesticides in sediments and marine life, but disperson by currents would make this unlikely. Source control should be continued to limit discharge of these materials to sewers.	Noise, nuisance and energy impacts associated with heavy truck traffic; potential of odour production and contamination of ground and surface waters by leachate. However methods are available to control all of these potential impacts.	Need for supplemental energy. Care needed in disposing of ash containing heavy metals and phosphorus but methods are available to do this. Complete destruction of pesticides by incinceration.
Sludge Deposition	Any accumulation of sludge will be swept away within a day or two.	Not applicable.	Not applicable.
Resource Recovery	Potential for energy recovery from sludge gas. Possible to install pyrolysis plant at future date if economically justifiable.	Potential for energy recovery from sludge gas. Possible to install pyrolysis plant at future date if economically justifiable. Recovery of nutrients through agricultural application.	Potential for energy recovery by future installation of pyrolysis plant if economically justifiable.

Disposal to Land. The potential environmental impacts associated with the landfill operation are a consequence of the noise, nuisance and energy usage associated with

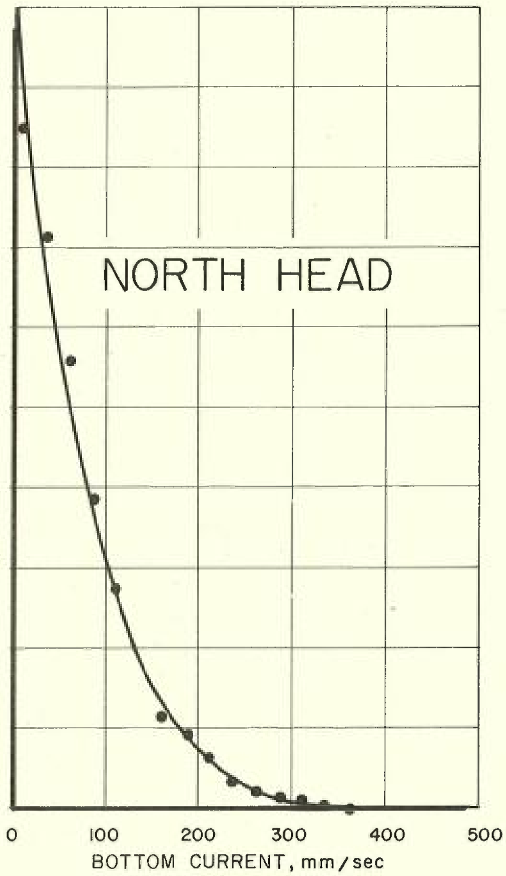


Fig. 19. Cumulative Frequency Distribution of Bottom Currents.

(b) Jump Camera Observations. Inspection of photographs taken during the outfall study and the subsequent monitoring studies with the jump camera at North Head in depths of about 45 m and deeper failed to show any accumulation of sediments which could be likened in particle size to digested sludge. As silt carried from the mouth of Port Jackson also would be expected to contain many particles with settling velocities similar to those of digested sludge, the jump camera observations confirm that oceanographic conditions offshore from Sydney do not allow other than temporary accumulation of sludge. They also confirm that benthic organisms are abundant in the vicinity of the existing outfalls.

Another significant potential impact of ocean disposal of sludge through deepwater submarine outfalls is the accumulation of heavy metals, pesticides and PCB's in sediments and marine life. However, no serious accumulation of these toxic materials has been observed following discharge of raw sewage at North Head for over 60 years. With the deepwater discharges, the possibility of accumulation would be even less as these substances would be distributed over a much wider area than with the existing outlets. Adequate protection of the marine environment at North Head will continue to be achieved through emphasis on strict source control of contributions of toxic materials to the sewerage system, coupled with an effective monitoring programme.

Summary. There are no major impacts associated with any of the sludge disposal options. Impacts associated with incineration include energy consumption while impacts associated with landfill disposal include trucking through residential areas which also involves consumption of energy. An advantage of ocean disposal is that it involves a relatively small commitment of resources and does not preclude an alternative sludge combinations could be combined with almost any of the available sludge disposal options it was convenient to discuss sludge disposal separately. A summary of the characteristics and costs of available sludge disposal options is shown in Table 14.

This section evaluates wastewater treatment, effluent disposal and sludge disposal systems. The main characteristics of the selected treatment and disposal systems are summarised in Table 15, which also includes indicative capital, annual and capitalised costs based on ultimate plant capacity.

A preferred sludge disposal option is selected in Table 15 for each of the wastewater treatment and effluent disposal combinations which meet water quality criteria. Land disposal of sludge is selected for System A involving wastewater reuse or reclamation as this system involves application to land of all the wastewater components without any discharge to the ocean. Incineration of sludge with this system is also possible but involves expenditure of energy. Ocean discharge is costly because of the need for a separate deepwater sludge outfall. Incineration is selected for disposal of sludge from a secondary plant discharging effluent at the shoreline (System B) because it is the most economical option. Ocean discharge of sludge from a conventional primary plant (System C) is selected because it would be convenient to operate and cost less than sludge incineration, i.e. \$35m compared with \$45m capitalised cost (table 14). It should be noted, however, that the effluent discharged (principally in terms of BOD_5, suspended solids and grease), would be of a higher quality if the sludge was incinerated as then no sludge would be discharged with the effluent. On the other hand, with combined ocean discharge of effluent and digested sludge, the increase in BOD_5, suspended solids and grease at the point of discharge of the deepwater submarine outfall (as a result of the digested sludge component) would only be 1 to 2 mg/l because of the large dilution available (see Table 9). Adoption of the ocean disposal option does not preclude other sludge options being adopted in the future. In the case of HRP treatment (System D), scum and fine settleable grit and solids removed in the high rate sedimentation tanks would be incinerated with screenings and coarse grit.

Table 15. Comparison of Selected Sewage Treatment and Disposal Systems

WPCP treatment and discharge system	Characteristics of option				Indicative 1978 costs[a]		
	Type of treatment	Effluent discharge	Sludge disposal	Other characteristics	Capital costs \$ M	Annual operating costs \$ M	Capitalised cost[b] \$ M
A	At least secondary	Reclamation/ reuse	Land (Digested)	Low level of demand for effluent; high level of treatment required prior to reuse; conveyance of effluent through heavily populated areas. Water quality criteria not applicable.	400[c]	13[c]	550[c]
B	Secondary	Shoreline	Incineration (Raw)	Cost and space requirements create serious constraints. May meet water quality criteria but the discharge would probably be noticeable.	185	8.6	290
C	Conventional primary	Deepwater	Ocean (Digested)	Would meet water quality criteria.	115	4.5	170
D	High rate primary	Deepwater	Incineration[d] (Raw)	Would meet water quality criteria.	62	3.1	100

[a] All costs are at December 1978 level and are based on ultimate WPCP capacity.

[b] Includes cost of operation and maintenance plus fixed charges arising from interest on borrowed capital at 8% per annum over 50 years.

[c] Assumes only secondary treatment will be required; costs will be significantly higher if tertiary treatment is required.

[d] A relatively small quantity of sludge is removed and incinerated in high rate primary treatment.

CHAPTER 7
ENVIRONMENTAL SAFEGUARDS AND IMPACTS OF THE PREFERRED SEWAGE TREATMENT AND DISPOSAL OPTION

The discussion in Chapter 5 on beach conditions and water quality in the vicinity of the present discharge from the North Head WPCP indicates that the existing treatment and disposal facilities do not meet water quality criteria. A wide range of options for the treatment and disposal of effluent and sewage solids are evaulated in Chapter 6, where it is concluded that the preferred system for treatment and disposal of sewage at North Head WPCP involves (1) high rate primary treatment of the sewage, (2) incineration of solids, and (3) effluent disposal through a deepwater submarine outfall. The preferred option involves the incineration of screenings, scum (grease, oil and floatables), grit and other coarse solids separated in the high rate primary tanks. Ash from the incinerator would be discharged to the ocean at the cliff face. This system is referred to as the 'preferred option.'

cf 63

The preferred option provides, at considerably lower cost, similar safeguards (and has similar impacts) to conventional primary treatment with effluent disposal through a deepwater ocean outfall system. Previous studies indicated that discharge of primary effluent together with digested sludge through a deepwater ocean outfall would meet all water quality criteria. It is concluded in Chapter 6 that high rate primary effluent would have similar concentrations of BOD_5, suspended solids, grease and oil, and other constituents as conventional primary effluent and, therefore, also would meet water quality criteria.

The preferred option involves construction of a deepwater submarine outfall and a WPCP incorporating the existing screen system and incineration facilities with new aerated grit chambers, high rate primary sedimentation tanks and solids handling facilities. A possible layout of the preferred WPCP is shown in Fig. 20. This layout fits into existing excavations and makes efficient use of existing designs and facilities. It should be recognised that this is a preliminary layout and that some variations may be made during final design. It can be seen in Fig. 20 that, should it ever be necessary, expansion of the high rate primary treatment plant to a conventional primary treatment plant could easily be accomplished.

This chapter reviews the environmental safeguards and impacts of the preferred option. The present method of treatment and disposal is examined as a 'no change' option for comparison purposes only.

7.1 IDENTIFICATION OF ENVIRONMENTAL SAFEGUARDS AND IMPACTS

The discussion of safeguards and impacts is divided into three parts:

- Impacts of Construction. This includes impacts on both the land and the marine environment.
- Impacts of Operation of the WPCP. Impacts discussed here include appearance, noise, odour, air quality, consumption of chemicals, and sensitivity of the WPCP operation to disturbances including industrial disputes, non-availability of chemicals, major mechanical failures, and power failures.

- Impacts of the Discharge of Effluent and Sewage Solids. These include impacts such as the appearance and aesthetics of the discharge (including the presence of colour, grease and floatables, nuisance odours), accumulation of solids on the seabed, effects on the marine biota and the quality of the receiving waters.

In examining the environmental safeguards and impacts, it should be recognised that the sewage collection, treatment and disposal system provides a significant environmental safeguard in itself. The objective of the system is to collect sewage and provide a degree of treatment such that the disposal of effluent and sewage solids does not exceed the assimilative capacity of the receiving waters. Although the Board may take all reasonable measures to mitigate adverse impacts, it is inevitable that sewage treatment and disposal will have some localised adverse impacts on both the land and marine environments. These adverse impacts must be weighed against the costs and benefits of achieving a safe and effective means of sewage collection and disposal capable of meeting water quality criteria.

7.2 IMPACTS OF CONSTRUCTION

Further construction is involved in expanding the existing screening facility to a high rate primary plant and in providing the deepwater ocean outfall. The preferred option involves much less construction than any of the other treatment and disposal systems considered.

As mentioned in Chapter 2, the existing fine and coarse screens at North Head WPCP are installed in a chamber situated 60 m below ground, at the level of the main NSOOS sewer. A pumping station adjacent to the screening plant would lift the sewage to preaeration and grit removal and high rate primary sedimentation tanks constructed on the surface. Incineration facilities would also be constructed on the surface. Excavations for all structures required for high rate primary treatment have already been completed together with provisions for extension to conventional primary treatment facilities if this is found necessary in the future.

Construction Impacts on the Land Environment

Most aspects of submarine outfall construction do not present significant adverse impacts, but spoil disposal and traffic associated with construction require further study and possible safeguards.

Excavation. Major excavations at the North Head WPCP have already been completed, and if maximum use of these is made, only minor excavations would be required for any additional treatment facilities. This would have a minimal effect on the site and established landscaping.

Excavation of submarine outfalls requires establishment of a shaft or adit to enable driving of the tunnel (and for later access) and of temporary construction facilities to service tunnelling operations. Facilities required may include a concrete batching plant, cement and aggregate storage, air compressors, and a minor amount of storage for concrete lining operations. The area excavated for the sedimentation tanks would provide an ideal site for the outfall construction facilities, as it is flat, and has immediate road access which is partially hidden from view and does not impinge on existing areas of native vegetation.

Disposal of Spoil. Several options for spoil disposal are available, including (1) disposal on land, (2) disposal over the cliff face at North Head, (3) barging to sea and (4) use on the WPCP site for landscaping and temporary fill for excavations not required

Lighting. Extensive increases in lighting levels at the WPCP will depend primarily on whether night shift construction is undertaken but should not have a significant impact because the works area is remote from residential development.

Air Quality. Two aspects of construction could affect air quality; (1) pollution from vehicles approaching and leaving the plant and (2) dust from truck movements over dirt roads. Neither is expected to cause a serious problem. Suitable controls on vehicle emissions and road watering in dry weather should provide adequate control.

Consumption of Energy. Energy requirements for operation of transport, tunnelling and construction machinery are an inevitable part of construction activity. In this project, the environmental costs of energy inputs are far outweighed by the environmental benefits gained.

Construction Impacts on the Marine Environment

The deepwater submarine outfall requires construction of a 600 m to 1100 m long diffuser section. The diffuser construction would involve levelling a section of the ocean floor if a seabed diffuser is constructed. This would affect marine life in a narrow strip for the length of the diffuser, however, observations elsewhere indicate that the area would be recolonised following the completion of construction. If a drilled diffuser is constructed, only a minor disturbance of the ocean floor would occur.

7.3 IMPACTS OF OPERATION OF THE WPCP

The various impacts discussed under operation of the plant are appearance of the site, noise levels, odour production, air quality, traffic generation, consumption of chemicals and energy, and sensitivity to disturbances in plant operation.

Appearance

The structures and roads presently under construction have been designed to minimise the visual impact of the WPCP on the surrounding landscape. The existing plan design recognises the constraints required in building a major treatment plant adjacent to areas to be developed as a National Park. Its visibility from distant locations on the northern shoreline has been reduced by excavating the site to a level where structures do not protrude above the horizon, although this excavation resulted in deposition of spoil over the cliff face. Site landscaping will be implemented as construction of the work progresses and the site will be planted with native species, some of which occur on the adjacent reserve. Special attention is to be given to the bare rock faces created by excavation within the site and to the rock dump on the cliff face. The latter will be returned to a state approaching the natural appearance of the cliff face. Other planting will consist of large free-form beds with some grassed areas between, designed in harmony with the new landforms created on the site. The access shafts and tunnels for the outfall will not affect the general appearance of the completed site.

Noise

Very little noise should emanate from the WPCP; adequate noise protection safeguards were provided in the original design and they will be retained for the high rate primary treatment plant.

Odour and Air Quality

In March 1973 the Department of Health approved the application by the Board to install fuel burning equipment at the proposed treatment plant at North Head. The licence was granted subject to certain conditions imposed on the advice of the Air Pollution submarine outfall as dilution is high and the point of discharge is a considerable distance from bathing beaches. Similar impacts to those discussed for power failure would occur if industrial disputes prevent effluent pumping.

Ash Disposal

A small quantity of ash remains after incineration of screenings, grit and scum. Operating experience at the Malabar WPCP shows that ash is composed principally of silica, which is 2.5 times heavier than water. The ash generally settles and is dispersed by prevailing currents when disposed of to ocean waters. No visible surface field or slick occurs as a result of such disposal.

Initially, therefore, ash from the North Head WPCP would be discharged with the effluent via the existing cliff-face outfalls. With the preferred option such disposal would need to be discontinued, however, to avoid accumulations of the silica fraction of the ash in the deepwater outfall. Alternatives which may be implemented include trucking ash away from the site for disposal elsewhere or discharge at the cliff-face via a separate pipeline. It is also possible that the material may have some commercial value, for example, as road base material.

7.4 IMPACTS OF EFFLUENT DISCHARGE

Treated sewage effluent is discharged to the ocean by many coastal cities. Experience has shown that the discharge of effluent and digested sludge may be accomplished without any significant adverse effects where ocean conditions are suitable and appropriate outfall structures are provided. Most constituents of sewage are in fact beneficial to marine life, providing that the capacity of the waters to assimilate the additional organic and nutrient load is not exceeded. Potentially toxic components of sewage are mainly of industrial origin and are thus amenable to source control.

Safeguards and impacts of the effluent discharge are discussed below in relation to physical appearance, restricted substances, Norfolk Island Pines, dissolved oxygen and pH, microbiological criteria and biota.

Physical Appearance

The guideline criteria for physical appearance described in Chapter 4, require that there should be no obviously visible oil, grease or floatable material, and no nuisance odours or appreciable accumulation of solids, either in the receiving water or on shore. These characteristics are difficult to define quantitatively. Thus the performance of the outfalls in these respects must be judged in qualitative terms.

No Change Option. As discussed in Chapter 5, the quality of the nearshore waters in the vicinity of the North Head outfall would not meet the guideline criteria for physical appearance. A visible effluent plume would continue to extend from the discharge point for several kilometres in a direction which depends on prevailing winds and currents, as occurs now. Surface slicks and accumulations of grease and other floatable material would be observed in the receiving waters and on the shore.

Preferred Option. The deepwater submarine outfall option was extensively investigated during the submarine outfall studies, and the predicted performance of the recommended North Head deepwater diffuser is shown in Table 16. The design is governed by initial dilution and field submergence requirements. The predictions indicate that the effluent field would be submerged 91 per cent of the time in summer. When there would be

No Change Option. Based on an estimated dilution of 10:1 at the surface of the existing North Head effluent plume under average conditions, and assuming that the boundary of the initial dilution zone is not more than 250 m from the discharge point, it appears that the SPCC limitations on cyanide and ammonia-N (see Table 17) are probably exceeded at times although no measurements have been made to verify this.

Preferred Option. Based on results in the report on submarine outfall studies, it is concluded that the deepwater submarine outfall option will meet SPCC limitations for all restricted substances. For surface fields, a minimum initial dilution of 47:1 is predicted to occur less than 2 per cent of the time and greater dilutions will occur at all other times. As discussed earlier, heavy metals and pesticides are not effectively removed by conventional treatment processes and the most effective means of limiting the discharge of these materials is source control. The available data on heavy metal and pesticide levels in the vicinity of the existing North Head outfall suggests that the Board's source control programme is effectively protecting the marine environment from possible adverse impacts of those materials. The discharge of restricted substances in the effluent from North Head WPCP will continue to be strictly monitored following commissioning of a deepwater outfall. The collection of fish for heavy metal and pesticide analysis should be undertaken on an annual basis both before and after construction of the deepwater submarine outfall, to determine the effectiveness of control methods. Preliminary discussions have been held with the N.S.W. State Fisheries to ensure that this monitoring programme will be compatible with baseline studies currently being conducted to the north of the Sydney Metropolitan Area.

Table 17. Required Dilutions of Restricted Substances in the North Head Discharge.

Substance	Maximum Allowable Concentration[a] (mg/l)	Effluent Concentration (mg/l)	Minimum Required Dilution
Arsenic	0.1	< 0.1	1
Cadmium	0.2	0.01	1
Total Chromium	0.02	0.05	3
Copper	0.2	0.15	1
Lead	0.1	0.07	1
Mercury	0.001	0.003	3
Nickel	0.1	0.05	1
Silver	0.02	0.02	1
Zinc	0.3	0.70	3
Cyanide	0.2	< 1.0	5
Phenolic compounds	0.5	0.4	1
Total chlorine residual	1.0	0.00	0
Ammonia-N	5.0	30	6
Total identifiable chlorinated hydro-carbons	0.002	0.001	1

[a] At boundary of specified initial dilution zone

Preferred Option. The predicted performance for the North Head deepwater submarine outfall is shown in Table 16 and indicates that this option would meet the microbiological criteria.

Biota

The protection of the marine flora and fauna against adverse effects of waste discharges is an important factor in assessing the environmental impact of the options. Marine biota in the North Head area may be affected by discharges of restricted substances, suspended particulate matter, oxygen demanding substances and nutrients. The discharge may also increase local marine productivity provided the increased supply of organic material does not exceed the assimilative capacity of the natural systems.

No Change Option. SCUBA diving surveys have been carried out in the North Head area within the zone of influence of the outfall. On occasions a layer of dense, mobile material attributable to the outfall was observed although its presence appeared to depend on low velocity currents which do not persist for extended periods. The effect of the material has been to slightly impoverish and modify the fauna in the area directly affected by the discharge. Adjacent to this zone, the effluent appears to have stimulated the growth of a very rich assemblage of sedentary and benthic organisms.

The no change option has two other effects on the marine biota that are readily visible from the shore. One is the increase in the amount of algae on the rock platform adjacent to the discharge point, and this is caused by the high nutrient levels in the nearby waters. The other is the presence of numerous sea birds feeding from the effluent field. The birds apparently take particulate matter from the effluent, as well as fish feeding on the discharge.

Preferred Option. The high dilutions achieved with this option will provide substantial protection to marine biota. The addition of particulate matter in the form of suspended solids would increase natural levels by less than 2 mg/l after an initial dilution of 140:1. Transport and subsequent dilution would distribute these particles widely, and ensure that significant accumulations of particulate matter would not occur. This matter was discussed in Chapter 6.

The small change in suspended solids concentrations is not expected to significantly alter water clarity outside the mixing area. Hence there should be no significant effect on marine flora, especially in the 45 to 55 m deep waters of the mixing zone where the growth of benthic flora are already severely limited by the lack of light. Discharge of nutrients should not result in any significantly increased levels of phytoplankton growth in the discharge region.

The zones that would come under the direct influence of the outfall would be localised and represents only a small proportion of the waters and seabed offshore from the Sydney coastline. It is unlikely, therefore, that operation of the outfall could constitute a threat to any marine species endemic to the mid-NSW coast.

It is concluded that the preferred option would not cause any significant adverse effects on the marine environment, providing that the loads of potentially toxic material such as heavy metals and organochlorine pesticides continue to be effectively limited by source control. Pre- and post-discharge monitoring of fish and other marine organisms in the vicinity of the outfall will determine the effectiveness of existing source control and the need, if any, for further measures.

APPENDICES

APPENDIX A
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Borrower's name	Date	Ext