PEER REVIEW OF MICROLAYER STUDIES ASSOCIATED WITH SEWAGE DISCHARGE FROM MALABAR

Prepared for

The New South Wales State Pollution Control Commission
Sydney, Australia

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December 1991

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EXECUTIVE SUMMARY

This report presents a peer review--conducted by Parametrix Inc., on behalf of the New South Wales State Pollution Control Commission (SPCC)--on the microlayer studies associated with sewage discharge from Malabar, Sydney, Australia.

The objective of the report was to review the conclusions and recommendations of a single interpretative report submitted to the SPCC, paying particular attention to the reputed impact of aerosols. The review was also to consider the data and its interpretation contained in five supporting documents.

Each of the documents were reviewed in detail, resulting in a series of specific and general comments on each. Overall, it was apparent that the conclusions of the interpretive report went beyond not only the data presented in the report but also that provided by each of the five supporting documents. The impact of aerosols on the health of individuals along the Sydney coastline cannot be determined from the study conducted. No aerosol data were collected, nor were the risks associated with potential contaminant exposure evaluated. Before any further studies are planned or conducted, it is highly recommended that a screening level risk assessment be conducted to determine whether any potential for risks to human health exist.

1. INTRODUCTION

The following document presents a peer review--conducted by Parametrix Inc., on behalf of the New South Wales State Pollution Control Commission (SPCC)--on the microlayer studies associated with sewage discharge from Malabar, Sydney, Australia. An external review of these reports is required by the SPCC before finalizing the post-commissioning phase of the microlayer project.

This assignment involved a detailed review of the single interpretative report and five supporting documents. General comments and recommendations resulting from this review are presented in Section 2. Section 3 presents specific comments on the interpretative report and on each of the five supporting documents.

2. GENERAL COMMENTS AND RECOMMENDATIONS MADE ON THE INTERPRETATIVE REPORT

2.1 GENERAL COMMENTS ON THE INTERPRETATIVE REPORT

The author of this report (and indeed, the authors of all the supporting reports) should be commended on undertaking a study of this magnitude on the microlayer. Given the difficulties encountered in sampling and analyzing the microlayer, it is not surprising that there have been few such studies conducted. However, the conclusions made by the author of the interpretative report went beyond the data presented in the supporting reports. The studies were designed to provide data on the concentrations of metals, organic contaminants, and microbes in the microlayer, and on the morphology of the neustonic ichthoyplankton. The studies were not designed to evaluate the risks of the sewage outfall to human health as suggested by the author. In particular, inferences were made about the impacts of exposure to aerosols that were not supported by the data (there were no aerosol data per se). Specific conclusions are given below:

1) It appears that the study was treated as an academic exercise, rather than an attempt to answer concrete questions about whether the impacts were significant. The analyses were much more involved and comprehensive than necessary.

2) The interpretative report is simply too long and detailed for profitable use. The report is written in a very rambling style which made for difficult reading and obscured the important points. The absence of graphical data representation makes the results even more difficult to interpret. The tables included in the interpretative report were not well constructed. Table numbers were repeated, the titles to the tables were not self explanatory and many of the tables lacked footnotes, thus making interpretation difficult. The document would have been more clear if the author had made use of appendices. The report would benefit from professional editing to streamline the text and add clarity. In addition, there are more grammatical and spelling errors than might be appropriate for a final report.

3) The question of contaminant bioavailability is not even addressed. The author seems to make the assumption that the mere presence of the contaminants in the microlayer is sufficient to exert toxicity to aquatic organisms. This is a severe limitation of the report. Contaminants bound to particulate matter and/or colloidal material will be unavailable for uptake by organisms at the base of the food chain (aquatic or terrestrial). If these contaminants are not bioavailable (e.g., the contaminants are not absorbed across gill membranes), then their toxicity will be significantly reduced.

4) Because metal concentrations were presented in nmol/L and chronic toxicity data in µg/L, direct comparisons can only be made after the reader has made the appropriate unit conversions. The reader should not have to work to understand the document.

5) It is not appropriate to compare maximum contaminant concentrations with chronic toxicity data. Chronic toxicity data should be compared (where appropriate) to reasonable expected environmental concentrations (e.g., long-term averages) having taken into account such factors as contaminant dilution and dissipation in the environment.

6) The author writes with excessive detail about analyzing spatial (longitudinal and depth) and temporal variation when the study was not adequately designed to investigate such variables.

7) The study used unproven (e.g., ASV) and state-of-the-art (e.g., ICP-MS) techniques that ultimately failed to deliver useful results. The interpretation of these results should therefore be restricted as appropriate to reflect these limitations.

8) Is the control site truly unimpacted? Should it not be situated upcurrent of the outfall as suggested by Kingsford and Suthers (1990)?

9) A list of tables should have been included in the table of contents.

2.2 RECOMMENDATIONS ON THE INTERPRETATIVE REPORT

Overall, it is recommended that the risks associated with the sewage outfall be evaluated by conducting a formal screening-level risk assessment. This is essential before any recommendations regarding further work and future studies be made. The future studies recommended by the author of the interpretative report may not be necessary and could be costly. Specific recommendations are given in detail below.

1) The conclusions of the interpretative report should be based on the scientific findings within the documents, not on inferences made by the author as to potential effects on human health. Therefore, objective (iv), to assess the impact on human health and the biota, needs to be modified. This objective cannot be achieved using the data in the supporting or interpretative reports. Only the effects of the sewage outfall on the aquatic biota (neustonic ichthyoplankton) can be reported.

2) It is recommended that any conclusions regarding toxicity of the contaminants be made by a toxicologist, so that factors such as contaminant bioavailability, the use of chronic toxicity data and the toxicity of different metal species can be appropriately addressed.

3) It is recommended that more evidence for microlayer adjustment factors be found. The adjustment factors used in the study appear to be based on a single 1972 reference. Since numerous conclusions and recommendations are based on these adjustment factors, they need to be further validated. This may take the form of further literature studies, or simply soliciting expert opinion from reputable authors in the field (e.g., Drs. E. Crecelius and J. Hardy at the Battelle Marine Research Laboratory in Sequim, Washington, and Dr. R. Duce at the University of Rhode Island).

4) It is strongly recommended that a formal screening-level human health risk assessment be conducted before any of the phase-two special studies are initiated. It is quite possible that the proposed studies for the aerosols and the coastal contaminants, are not needed if there are no risks to human health as a result of current or future post-commissioning conditions.

Typically, a risk assessment consists of four phases. The first is data collection and the identification of contaminants of concern (based on their concentrations and toxicity). The second phase is the exposure assessment. This consists of analyzing contaminant fate and transport to estimate expected environmental concentrations (EECs). In addition, the exposure assessment identifies potential exposed populations through pathway analysis. In the third phase, the toxicity assessment, relevant toxicity information is collected and the appropriate dose-response values are determined. The final phase of the risk assessment is risk characterization. The results of the exposure and toxicity assessments are combined to determine the potential for adverse health effects, either by using simple hazard quotients or by using a probabilistic approach.

It is recommended that a tiered risk assessment be conducted using both present day and future conditions. Tier 1 would be a screening-level risk assessment (SLRA). The SLRA would determine which of the contaminants pose a high enough risk to warrant further investigation. At the same time, the SLRA would determine which contaminants pose negligible risk so that they can be eliminated from further consideration. It is recommended that the SLRA use the microlayer contaminant concentrations presented in the supporting data reports. It is also recommended that reasonable contaminant concentrations be used, not the maximum found. If a potential risk is apparent, then a tier 2 risk assessment would be necessary. This would involve a refinement of the exposure assessment process. For example, it may be necessary to utilize computer-based models to simulate aerosol transport and contaminant dissipation through dilution and/or decay mechanisms. If such a tier 2 risk assessment suggests the potential for risks, then it is recommended that a tier 3 risk assessment be conducted using, for example, site-specific data on contaminant concentrations in aerosols along the coast.

It will probably be necessary to conduct some type of sensitivity analysis to determine which of the variables and parameters are most important in determining the risk. For example, it may be extremely important to obtain actual data for the concentration of contaminants in the aerosols. However, it may be more important to determine the frequency of onshore winds, the variability in composition of the sewage outfall, the lifetime of the aerosols relative to the lifetime of the contaminants (i.e., will the contaminants have decayed to negligible concentrations, will bacterial organisms and other associated pathogens still be viable?).

5) If the results of the risk assessment show that potential risks do indeed exist, then it is recommended that studies be conducted to determine if there is any evidence of elevated human health problems in the coastal areas that might be associated with the outfall. In addition, it is recommended that data from other studies on aerosols and potential human health effects be sought to determine if such effects have been reported elsewhere.

3. SPECIFIC COMMENTS ON THE INTERPRETATIVE REPORT AND EACH OF THE SUPPORTING REPORTS

3.1 THE ROLE OF THE AIR-SEA INTERFACE IN THE CYCLING AND FATE OF SEWAGE AND INDUSTRIAL EFFLUENT DISCHARGED FROM A POINT SOURCE

Espey Q., May 1991.

Summary page: First paragraph, second sentence regarding the importance of the microlayer as a medium for impacting neustonic biota. The importance of the microlayer remains to be established.

Fourth paragraph, line 6, in reference to the use of "a comparative deductive approach." Is this sufficient, or should more statistical analyses of the data in the supporting documents have been conducted. In only one of those documents (Kingsford and Suthers 1990) were any statistical analyses conducted.

Fourth paragraph, lines 8 and 9, regarding enrichments in the microlayer. Were metals and organic and inorganic material found to be enriched up to four orders of magnitude at the air-sea interface? Should the sentence read "...grease and metals in association with organic and inorganic material"? The sentence is poorly constructed.

Page 1: Second paragraph, line 6, regarding the potential production of aerosols containing high levels of contaminants and bacteria. Note that only one reference is alluded to (Blanchard 1983). If the author thought this risk significant, such statements should be supported by substantially more references. If such studies do not exist, then definitive conclusions cannot be made at this stage of the SPCC study.

Page 3: Objective number (iv). This objective should be modified since the study was not designed to assess the impact of the microlayer on human health (see general comments above).

Page 9: Third paragraph, line 10 regarding the Blanchard (1982) reference. Is this correct, or should the reference be Blanchard (1983)?

Page 10: Second paragraph, last sentence, regarding the short time scale for impact of a pollution source. This sentence needs further clarification. The time scale over which potential impact of the outfall takes place is important. It will determine the relative risks associated with the production of "contaminated" aerosols.

Last paragraph, regarding the transportation of contaminated aerosols onto land with subsequent incorporation into the food chain and/or inhalation/ingestion of particulate material by individuals. These phenomena appear to be speculation by the author. To prove such an impact, the author would need air quality and surface soil data from along the shoreline and inland to see if there is indeed a correlation between proximity to the aerosol source and contaminant concentrations both in the atmosphere and soils near the coast.

Last paragraph, line 5, again regarding incorporation of the aerosol transported pollutants into the terrestrial food chain and direct human inhalation/ingestion. Only one reference (Easkins et al. 1982) was made to these phenomena. Is this sufficient supportive evidence for such a phenomenon. If such fate processes are possible, then the question becomes one of bioavailability. For example, if the majority of the pollutants are attached to particulate matter within the aerosols (as the supporting documents suggest), then their bioavailability to organisms at the base of the terrestrial food chain will be substantially reduced.

Page 11: First paragraph, first sentence, regarding the reference made to "the discovery that aerosol borne surfactants caused Norfolk Pines at Manley to shed their leaves." What supporting documentation does the author have for such a statement?

First paragraph, second sentence, regarding the conclusion of the author that aerosol transportation constitutes a greater risk to humans than shoreline transport of the microlayer and slicks. How has the author arrived at such a conclusion? Is it just his opinion?

First paragraph, third sentence, regarding the statement by the author that increasing both the offshore distance of the discharge and the depth of the discharge will not substantially reduce the potential risk from aerosols. What evidence and documentation does the author have to support such a statement? A mass balance study would need to be conducted to determine the relative magnitude of contaminant input from the different sources. One would expect that increasing the depth of the sewage discharge would decrease the concentration of contaminants in the microlayer (reduced scavenging through bubble formation, increased scavenging by particulate matter and sedimentation at depth), thereby reducing the risk of pollutant transport through aerosol formation.

Page 13: Third paragraph, first sentence, regarding the statement "It is also an advantage to simultaneously collect subsurface plankton...." The words "an advantage" should be replaced with "essential." Microlayer samples have to be compared with subsurface samples, otherwise enrichment cannot be ascertained.

Page 15: First paragraph, last sentence, regarding adjustment factors of 10 to 100 for particulates and 100 to 1000 for dissolved compounds. What is the basis for these numbers? The author must defend such statements with documentation.

Second paragraph, last sentence, regarding the appropriateness of collecting a 40 μm microlayer for lipids and associated material. Why is a 40 μm microlayer particularly important for lipids and associated material?

Page 16: Fourth paragraph, line 10 regarding the assumed microlayer depth for dissolved organic carbon (DOC) of 0.1 μm. Is 0.1 μm an accurate estimate? On page 14, first paragraph, line 11, the dissolved phase is *thought* to have a thickness of 0.05 μm. If this value was obtained by multiplying 0.01 μm (for a theoretical monolayer) by 5 (for 5 molecular layers) following the rationale of Duce et al. (1972), then the author should state this. Note that such an assumption was made in 1972. Is this still the only piece of evidence available for the thickness of the dissolved phase in the microlayer?

Page 19: Paragraph four, lines 13 to 24, regarding the *opinion* of the author that aerosol production (relative to slick accumulation and greaseball production) is the most dangerous aspect of high metal (and organic) pollution in the microlayer. This is a very sweeping statement; it is only the author's opinion, since he does not appear to have any evidence to substantiate such statements. His statements appear to be based on extrapolating from microlayer data to aerosol data and from there to expected environmental concentrations in the atmosphere, to pathways of exposure, to some target human population. Such statements can only be made after a formal analysis of the risks has been conducted. Initially, this would take the form of a screening level risk assessment which would be superseded by a more comprehensive risk assessment, if needed (see recommendations above).

Page 28: Paragraphs two, three, and four regarding the inability to collect samples due to bad weather conditions and (worse) the unavailability of staff, suggests that the sampling program was poorly planned.

Page 31: Fourth paragraph, regarding the toxicity data. It is noted that chronic toxicity data are given in units of μg/L while metal concentrations from the supporting data reports are given in units of nmol/L. This does not make for easy comparisons.

Page 32: First paragraph, last sentence, regarding the toxicity of arsenic and chromium. Why was toxicity quoted for the reduced form of arsenic and chromium when it is likely that in the aerobic surface environment, the oxidized form of these metals will be most common. This is particularly important for chromium when it is known that the oxidized form of chromium, Cr^{6+}, is the most toxic species (U.S. EPA 1984). (It is acknowledged that the reduced form of arsenic, As^{3+}, is the most toxic species).

Page 34: Last paragraph, regarding the comparison of total metal concentrations (and particulate metal concentrations) to chronic aquatic toxicity data. Such comparisons are inappropriate because particulate phase metals are not available for uptake by aquatic organisms (i.e., particulate bound metals will not be able to cross absorptive membranes). This would significantly reduce their toxicity. It is only the dissolved form of the metals that is bioavailable and therefore, the concentrations against which toxicity data should be compared.

Page 35: First paragraph, regarding the comparison between the highest metal concentrations with chronic toxicity data. This is effectively "a worst case scenario." Maximum concentrations, if they are to be compared with any toxicity data (which is questionable since this is for particulate metals), should be compared with acute and not chronic toxicity data.

Regarding Table 2.1. This table should include the actual concentrations measured, both adjusted and unadjusted. In addition, it would be useful for the author to include the metal concentration data in μg/L alongside the chronic toxicity data so that the reader does not have to make unit conversions and then the comparisons. Finally, the table (and all other tables) needs to "stand alone" (i.e., it needs to have a complete title and footnotes explaining the table acronyms).

Page 36: First paragraph, first sentence, regarding the statement that the highest concentrations of metals found bound to the particulate matter in the microlayer are representative of the minimum concentrations that are expected in the aerosols. What evidence does the author have for such a statement? Personal communication with Dr. Eric Crecelius of the Marine Research Laboratory, Sequim, WA, would indicate that aerosol concentrations are likely to be very similar to microlayer concentrations. In addition, following a literature search, Dr. Dan Hinkley of EA Engineering, Science and Technology Inc., Sparks, Maryland, came to the conclusion that "The chemistry of seafoam appears to be similar to that of the surface film."

Second paragraph under section 2.1.1.C, regarding enrichment factors. It appears that enrichment factors (E) were calculated using metal concentrations (nmol/L) prior to correction for suspended solids (mmol/kg). The authors of the supporting data report (Szymczak and Waite 1991) concluded (page 20 of their report), that following such a correction, "significant enrichment in trace metal concentration in the microlayer over that obtained in the subsurface...is not observed for any of the trace elements." Indeed, if corrected concentrations are used, then the enrichment factor for Ca in DOOM 2, for example, is reduced from 28.8 to 5.2. Even if the author does not agree with the conclusions of Szymczak and Waite, it is suggested that the corrected concentrations be used when calculating enrichment factors.

Table 2.2. This table needs to have a "stand alone" title, footnotes, and the inclusion of the actual concentrations measured.

Third paragraph, last sentence, regarding reference to suspended sediment concentrations. The author appears to be differentiating between particulates and suspended sediments. It is not clear how the author is differentiating the two.

Page 37: Table 2.3. Same comments as for tables 2.1 and 2.2.

Page 38: Second paragraph, second sentence, regarding the phase change from dissolved to particulate metal. This sentence needs clarification. What is the difference between particulate metal and total particulates? Does total particulates include the material that passes through a 0.4 μm filter (e.g., colloidal material)?

Page 40: Second paragraph, first sentence, regarding a reduced particle load. The scenario given by the author is speculation since particle loading was not measured.

Third paragraph, first sentence, regarding the case of severely polluted sites. This is a judgement by the author since a severely polluted site has not yet been established.

Page 43: First paragraph, line 13, regarding the sentence beginning "This data..." The sentence should begin "These data..."

Third paragraph, regarding the Si/Al ratio. The author needs to explain why using this ratio is indicative of lithogenic or biogenic controlled water and the influence of sewage on individual sites.

Last paragraph, regarding the influence of atmospheric input to the microlayer. This is an important phenomenon which appears to have been given a cursory comment. It seems to have been added as an afterthought.

Page 44: Second paragraph, line 6 regarding "... the California data is below detection limits." This should read '... the California data are below detection limits."

Page 45: Paragraph four, second sentence regarding, the adjustment factor of 800 for the dissolved trace metal concentrations. These concentrations are based on a microlayer thickness of 0.05 μm for the dissolved phase of the microlayer. Given the magnitude of the adjustment factor, shouldn't this value be ascertained with a little more certainty than extrapolation from a single 1972 reference?

Page 47: Paragraph four, regarding the comparison of microlayer chromium concentrations in the "table above." To which table is the author referring?

Paragraph five, point (i). regarding problems associated with the analysis of dissolved metals by anodic stripping voltammetry (ASV). If this were the case, then why wasn't atomic absorption spectrometry (AAS) used, since this is the preferable technique for routine analysis. Unproven techniques should not be used in a formal study.

Page 50: Last paragraph, line 1, regarding the adjustment factor of 800. Since this has a significant effect on the concentrations of the metals in the dissolved phase, validation of the 800 value is essential.

Page 51: Table 2.5, concerning dissolved trace metal concentrations. Given the concern voiced by the author over the supporting data report (Batley and Brockbank 1991) regarding the validity of the analytical data, the results and subsequent manipulation of the dissolved trace metals analyses must be treated with caution.

Table 2.5 and the third paragraph, regarding comparison of dissolved trace metal concentrations to toxicity data. Again, since reference is being made to chronic toxicity data, it would be advantageous to have metal concentrations in units of μg/L to enable a direct comparison with the toxicity data. In addition, it not valid to compare maximum trace metal concentrations with chronic toxicity data (see page 35 comments). Finally, since the "dissolved phase' by definition, consists of material that passes through a 0.4 μm filter (page 32), and therefore includes material that behaves more like particulates (e.g., colloids), the bioavailability of the "dissolved trace metals" has to be addressed. By making direct comparisons with the toxicity data, the author is assuming that all of the "dissolved" metal is available for uptake, whereas some of the "dissolved phase" is actually bound to colloidal material and unavailable for uptake.

Page 55: First paragraph, line 6, regarding the acknowledgement by the author that the adjustment factors are only "guesstimates." Despite this, much emphasis has been placed on these enrichment estimates, including many inferences concerning environmental risk. It would have been more appropriate to simply tabulate these "enrichment factors," label them as speculative, and avoid using them to estimate concentrations or speculate on environmental risk.

Page 57: Item (iii) line 8, regarding interlaboratory comparisons. From a quality control viewpoint, the most cost-effective approach is to analyze Standard Reference Materials, which are widely available. The objective of interlaboratory comparisons is to check on the reproducibility of the method between laboratories.

Page 59: Table 2.7? There appear to be three tables labeled 2.7: they appear on pages 59, 61 and 67.

Page 67: Table 2.7? Again the enrichment factors shown for coprostanol are dependent upon the initial assumptions made with respect to the actual thickness of the microlayer and that which was sampled.

Page 69: Fourth paragraph, regarding the PAH concentrations. Is there a statistically significant difference in the PAH concentration of 6 ng/L found in the microlayer and the 3 ng/L found in the subsurface? How does the author explain the 11 ng/L found at the first DOOM site if this is located at a greater distance from the outfall? How significant are these concentrations with respect to human health through inhalation and/or ingestion and food chain uptake following deposition inland? In surface waters these compounds will be subject to several degradation processes. For example, the half-lives for phenanthrene, fluoranthene and pyrene through photolysis in an aquatic environment (and in the atmosphere) are estimated to be between 3 to 25 hrs, 21 to 63 hrs and 0.68 to 2.04 hrs, respectively (Howard et al. 1991).

Page 74: First paragraph, concerning the contention of the author that even after commissioning, in turbulent conditions, bacteria may reach the surface on buoyant particles and be encapsulated in particles. At what depth are bubbles able to form? Will scavenging through bubble formation at depth be able to dominate over the binding of contaminants to particulate matter and gravitational settling to the sediments?

Page 77: Second paragraph, line 1, concerning budget limitations. Here and throughout the report, references to budget limitations should be eliminated. There are always budget limitations in any study, and alluding to them serves no other purpose than to detract from the public's confidence in the study.

Fourth paragraph, line 5, regarding the statistical design of the ichthyoplankton study. The author is overstating the importance of the statistics here. Having "only" one control isn't unusual and not necessarily a detriment. In a pilot study, one would not expect the variances to be formally partitioned among factors.

Page 78: Second paragraph, line 8, regarding sampling subsurface ichthyoplankton. The author makes a good point that subsurface ichthyoplankton be sampled. Failure to sample them is a severe limitation to interpreting these data.

Third paragraph, concerning the recommendation that more water be collected so that ichthyoplankton sample size is sufficient to support the study objectives. This recommendation needs to be strengthened. Hundreds of larvae per sample should be collected.

Page 79: Last paragraph, concerning the Latin species name. These should always be underlined in the text (e.g., Sardinops and Apoganops), or italicized.

Page 80: Third paragraph, regarding the trends in deformed notochords. Such trends should be illustrated graphically and include the variabilities.

Page 91: Section 3.1.4, regarding the objective to assess the impact on humans and the biota. Since the study was not designed to assess potential impact on the coastal human population either through direct inhalation/ingestion via food chain exposure, it is recommended that any conclusions concerning the impact of the outfall on human health be omitted. Such conclusions go far beyond the data and supporting analyses within the reports (see general comments and recommendations).

Page 94: First paragraph, regarding the acknowledgement by the author that no quantitative measurements have been made with respect to the transportation of contaminated aerosols from the microlayer--and so the potential for impact on the coastal population can only be made from inferences. Note that the production of aerosols (sea-salt aerosol) is primarily dependent upon the formation of whitecaps and wind speed. When assessing the likely production of aerosols, factors such as the increase in whitecap formation at higher wind speeds, and the decrease in bubble flux with the age of the whitecap (Blanchard 1983) have to be taken into account. For example, few bubbles are produced at wind speeds less than 3 m/s. Blanchard (1983) also noted that on rising to the sea surface, bubbles will adsorb dissolved organic material from the water which *lowers* the bubble surface free energy, thereby *decreasing* the height to which the jet drops are ejected.

Once aerosols are produced, their transportation onshore will be dependent upon wind direction and wind speed. As noted in the interpretative report, there are numerous changes in wind direction, even over the short term (within an hour). In addition, since Malabar appears to be an industrial/urban complex (page 92, paragraph five), it is likely that any aerosols reaching the coast will be mixed with aerosols produced as a result of any coastal industrial activity. Aerosols that are transported from the sea surface will also be diluted and dissipated with time through advection and through degradative mechanisms. As a result, aerosol exposure concentrations will be substantially reduced from those generated directly above the air-sea interface.

Page 95: Section II, regarding the cause for concern over aerosol formation. This cause for concern appears to be only speculative by the author. Before any conclusions concerning aerosols are made, it is essential that the potential risks associated with microlayer concentrations of the pollutants be assessed by conducting a screening level risk assessment (SLRA) (see recommendations).

Page 100: Section 3.2.5, regarding the implementation of special studies in 1992. It is recommended that before any special studies be implemented, the potential risks to human health from the microlayer pollutants be assessed. This should initially take the form of an SLRA. If no risks are found, it may not be necessary to conduct the special studies outlined in Section 3.2.5. If potential risks are implied by the SLRA, it is recommended that a more comprehensive risk assessment be conducted, still before initiation of the studies outlined in Section 3.2.5. This will be the most cost-effective approach and will focus attention on those areas where more (site-specific) data are needed.

Page 101: Section 3.2.5 B, regarding the recommended aerosol study. Based on the discussion above, this recommendation is not advocated until the results of the SLRA are obtained.

In addition, the "relative risk" from aerosol exposure needs to be ascertained. Why does the author believe that the risks from aerosol exposure are greater than from exposure to the slicks? At the moment such conclusions are suppositions only; there are no data to support the arguments, either from this study or from the literature.

3.2 SPCC MICROLAYER PROJECT PRECOMMISSIONING SURVEY OF MALABAR OUTFALL FOR DISSOLVED HEAVY METALS

Batley G.E. and Brockbank C.I. January 1991

GENERAL COMMENTS

There are no summary statements.

No statistical analyses were conducted to compare the control with "impacted" sites. Conclusions are based on observed numerical differences between sites.

SPECIFIC COMMENTS

Figure 1: This figure is badly situated within the document.

Page 1: First paragraph is poorly constructed. The second and third sentences do not connect. Introductory material and objectives are combined in the same paragraph.

Page 5: Paragraph 3: the sentence "...and in not all cases a disparity is observed between the data obtained." is not well written. Does the author mean that, in some cases, there was a disparity observed between the data obtained?

Page 5: Paragraph 4: The problem of column blanks for small microlayer samples analyzed on the seastar columns (< 2 liters) needs to be resolved. There appears to be a correlation between low sample volume and elevated metal concentration. Despite this problem, it is noted that the concentrations of dissolved metals in the microlayer are low (μg/L range).

3.3 MALABAR OCEAN SEWAGE OUTFALL PRECOMMISSIONING STUDY OF PARTICULATE METALS IN SEASURFACE MICROLAYER AND SUBSURFACE WATERS

Szymczak R. and Waite T.D. February 1991.

GENERAL COMMENTS

1: There is no summary.

2: No statistical analyses were conducted to compare data from the control site with those from the "impacted" sites.

3: There are no concluding remarks. The reader has to sift through the results to locate the overall findings, i.e., particulate trace metal concentration in the microlayer does not appear to be elevated over subsurface concentrations. This lack of significance may be a result of the variability between replicates at a site, but since no statistical analyses were conducted, it is difficult to tell.

SPECIFIC COMMENTS

Page 20:	Section 4.3.1: Second bullet: Why would the variability between replicates at the control site be expected to be less than the variability between replicates at Long Bay?
Page 20:	Given the variability observed between replicates, it would be difficult to make any definitive conclusions. Is the variability real, is it a function of sampling difficulties, or a time-dependent variability?
Page 20:	Section 4.3: ICP-OES should read ICP-AES. (Similarly on page 28, Section 4.3.2).
Page 20:	Third bullet: "significant enrichment in trace metal concentration in the microlayer..." How significant is significant?
Page 20:	Need to explain correction of trace metal concentration for suspended solids concentration (i.e., why this was deemed necessary?).

3.4 MICROLAYER STUDY - MICROBIOLOGICAL TESTING
Water Research Laboratory, University of Western Sydney.

GENERAL COMMENTS

1: There is no summary.

2: There is no map. This is important if the document is to "stand alone."

3: No statistical analyses were conducted to defend statements regarding the observed differences between control and "impacted" sites. If there were insufficient data to warrant such analyses, then this should at least be noted.

4: For the uninformed reader, there needs to be an explanation as to why it is important to measure the concentrations of microbiological organisms and what organisms in particular are indicative of the outfall. The report launches straight into the methods and results.

5: There needs to be more explanation of the findings given within the discussion. A great deal of interpretation is left to the reader.

SPECIFIC COMMENTS

Page 2: Method descriptions are very brief. If the techniques used are routine methods written up elsewhere, then references to the pertinent documents should be made. The assumption is that the reader is familiar with the methodology.

Table 1: Although Table 1 does show that the water at the Long Bay and Malabar sites is enriched with indicator bacterial species over the control and DOOM sites, no explanation is given for the lack of marine agar microlayer enrichment (above the subsurface samples) observed on two sampling occasions at both of these sites.

Page 4: Need to explain the significance of marine agar versus plate count agar assays for the aerobic heterotrophic populations (i.e., why were they both conducted? what differences were expected? were those differences seen in this study?). If it was to differentiate between freshwater and marine derived organisms (as suggested in the results on page 5), then this should be spelled out somewhere in the methods.

Page 5: The last sentence does not make sense unless the word "of" is omitted.

Tables and Figures: None of the tables and figures have captions and therefore do not stand alone within the document.

Figure 8: From observation, it does not look as if surface and subsurface aerobic heterotrophic count concentrations at Long Bay are enhanced above those at the DOOM site, especially with respect to the marine agar. This is why statistical analyses are important. If the marine agar counts are expected to be approximately the same at all sites (if the outfall is essentially a "freshwater" input), then why are the marine agar counts at Malabar elevated?

3.5 ABUNDANCE AND DEFORMITIES OF LARVAL FISH NEAR THE MALABAR SEWAGE OUTFALL: A PRELIMINARY STUDY.

Kingsford, M.J and I.M Suthers. November 1990.

GENERAL COMMENTS

1: Well written and constructed document. Includes summary and needed background information

SPECIFIC COMMENTS

Page 1:	Third and fourth paragraphs: The remarks made concerning fronts (regions of convergence) developing at the edge of sewage plumes (and the observed accumulation of larval fish and planktonic organisms) is important and should be included in the interpretative report.
Page 4:	The use of statistical analyses is noted, especially that because the variances of the analyses were significantly heterogeneous even after log-transformation, any conclusions must be treated with caution.
Page 4:	Third paragraph: Need to explain why larval fish were apparently more abundant (although not statistically so) nearshore in the vicinity of the outfall and within the sewage plume than at the control site. Is it simply because it is a nearshore site, and/or because of the presence of elevated organic carbon?. Is this a common phenomenon?
Page 5:	Fourth recommendation: The recommendation that the control site should be upcurrent of the plume is a good one.

3.6 CHARACTERIZATION OF URBAN SEWAGE EFFLUENT IN SYDNEY'S COASTAL WATERS AND SEDIMENTS USING SPECIFIC ORGANIC MARKERS I: MALABAR PRECOMMISSIONING

Leeming, R., M. Rayner, V. Latham, and P. Nichols. January 1991

GENERAL COMMENTS

1: No map is included.

2: No statistical analyses were conducted to compare the control with "impacted" sites. Comparisons were based upon observed order-of-magnitude numerical differences.

3: Several references were made to the concentration of organic markers in the sediments. The significance of the sediments is not fully developed in the interpretative report (i.e., the fact that they provide "an integrated measure of component distribution over time," and can act as a source or a sink for the organic material). The impact to benthic community of elevated hydrocarbon levels in the sediment is not addressed.

4: Add some explanation regarding the typical chemical profile of the sewage (e.g., the significance of lipids, fatty acids etc., why were these measured?). This is discussed to some extent in the results and discussion, but should be included in the introductory remarks to orientate the reader.

5: The need to identify an organic marker is to be commended, and the use of coprostanol looks promising.

SPECIFIC COMMENTS

Page 14: First paragraph: Given the apparent temporal variability of the organic indicators (here, particulate organic carbon, POC), shouldn't sampling have taken place more than twice?

Page 14: Second paragraph: Sediment organic carbon should be related to particle size. Was particle size determined? Organic carbon is associated with the finer fraction (silt/clay-sized particles) of soils and sediments. Therefore, enrichment could simply be the result of a greater proportion of silt and/or clay content in the sediments sampled.

Page 27: Third paragraph: Expand on the discussion of odd over even predominance of aliphatic hydrocarbons of biogenic origin. Are there any references to substantiate the statements made? This is an important organic marker.

Page 30: Fourth paragraph: The first sentence is ambiguous. Is the author trying to say that the deposition of material from the air to the microlayer via aerosols is the reason for elevated PAH concentrations in the microlayer, or is the author speculating on the microlayer being a source of PAHs to the air via aerosol formation? Note that this is the first reference made to aerosols in any of the supporting documents. In addition, would this microlayer enrichment be apparent if PAH concentrations were normalized for suspended solids concentration (see Szymczak and Waite (1991) study on particulate metals)?

Page 32: Second paragraph: pesticide concentrations in sediment expressed in units of ng/L? (expressed as ng/g in table 9).

Table 7 and Table 9: Show conflicting results in terms of possible sediment flow. For example, Table 7 shows PAH concentrations to be highest in sediment (and particulate matter) near the Malabar outfall (i.e., no sediment flow), while Table 9 shows total pesticide concentrations to be elevated at site 16 (distant site near DOOM) which the authors interpreted as being indicative of sediment flow away from the outfall. If this is the case, wouldn't the same trends be seen in the PAH sediment data?

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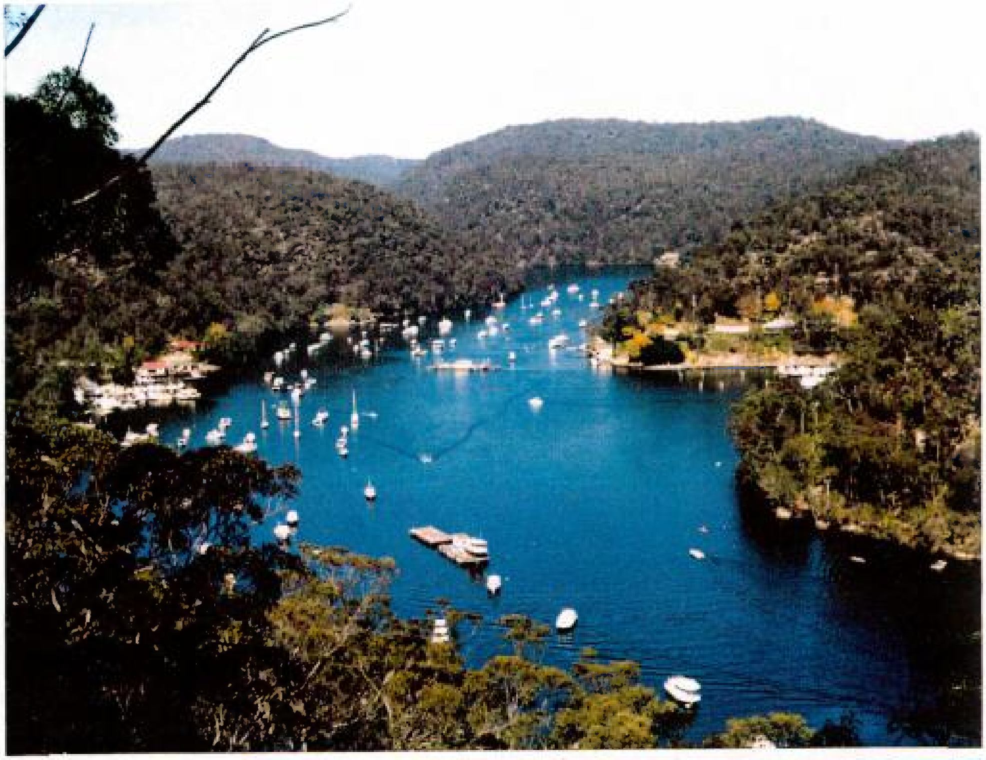
BEROWRA CREEK COMMUNITY CONTRACT



WEST HORNSBY AND HORNSBY HEIGHTS SEWAGE TREATMENT PLANTS

Options for Sewage Treatment and Effluent Disposal

Wastewater and Reuse Planning
September 1994

WATER BOARD
SYDNEY - ILLAWARRA - BLUE MOUNTAINS

BEROWRA CREEK COMMUNITY CONTRACT

WEST HORNSBY AND HORNSBY HEIGHTS SEWAGE TREATMENT PLANTS

OPTIONS FOR SEWAGE TREATMENT AND EFFLUENT DISPOSAL

Waste Water and Reuse Planning

September 1994

Cover Photograph: Berowra Creek - a tributary of the Hawkesbury-Nepean River system. View showing Berowra Ferry and Berowra Waters (a popular local waterway).

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EXECUTIVE SUMMARY

INTRODUCTION

In an endeavour to improve the environmental condition of Berowra Creek, a Statement of Joint Intent has been agreed to by the Department of Planning, EPA, Hawkesbury- Nepean Catchment Management Trust, Hornsby Council and the Water Board.

STATEMENT OF JOINT INTENT

The Statement of Joint Intent, signed on the 27th April 1994 and endorsed by the Minister of Planning and Housing, represents the first Community Contract for Clean Waterways. The Contract includes commitments from the Water Board to:

- Immediate operational changes to existing facilities at West Hornsby and Hornsby Heights sewage treatment plants (STPs) to improve disinfection and nutrient removal by August 1994.
- Work with other authorities to develop catchment monitoring and management programmes.

Furthermore, the Board is obligated to:

- Prepare and exhibit an options report for Hornsby Heights and West Hornsby sewage treatment plants by the end September 1994.

The Water Board has also agreed to prepare and publicly exhibit an EIS for each of those options warranting further consideration by the Berowra Creek Technical Working Party (TWP) by end June 1995 with expeditious implementation of the option approved by the Minister for Planning.

Effluent Quality Targets for Berowra Creek Discharges

The Technical Working Party has requested effluent quality targets of 15, 10 and 5 mg/L of total nitrogen to be examined for the plant effluent. Further options were to be considered for zero discharge by transferring out of the catchment and reuse schemes.

OPTIONS CONSIDERED

All of the Options considered were evaluated based upon equivalent population projections (EP) of 72,000 EP for the catchment in 2019. Current EP within the catchment is 57,000 EP.

There are three general strategies relevant to the short to medium-term treatment and disposal of sewage in the Berowra Creek catchment:

- **Treatment and discharge within the catchment.** All dry and wet weather flows would be discharged to Berowra Creek. Options 1 to 4 represent alternatives for treating sewage within the Berowra catchment including:
    - Retain, upgrade and amplify existing facilities.
    - Build a new treatment plant, decommission existing facilities.
    - Retain existing facilities and build a new treatment plant.

- **Transfer of sewage to the ocean sewage treatment plants for treatment or disposal.** Treated or untreated sewage would be transferred by tunnels to the ocean plants during dry weather or dry and wet weather up to the transfer capacity. Excess wet weather flows would be discharged to Berowra Creek. Options 5 to 10 represent alternatives for transfer to Warriewood or North Head STPs.

    Investigations are currently being undertaken by the Board on a number of proposals for amplifying and upgrading the North Suburbs Ocean Outfall Sewer (NSOOS). These are being developed through a detailed system planning process, which will consider the merits and financial implications of several options. The investigations will be completed in 1995. Therefore Options 6 and 9 involving sewage transfer to North Head STP have been based on a "dedicated tunnel" system for this report.

- **Treatment of sewage within the catchment with reuse of effluent.** Non-potable or potable quality effluent would be produced by the existing treatment plants (after modification) for direct or indirect reuse within the Berowra catchment. Option 11 uses the upgraded facilities to produce indirect potable water for reuse.

ECONOMIC APPRAISAL OF COSTS

Table 1 and figure 1 summarises the capital, operating and net present values of costs for the options investigated (Options 1 to 11).

Based on current information, the economic analysis indicates that the retention and upgrade of both the West Hornsby and Hornsby Heights STPs (Options 1 and 2) are the most cost-effective options. Building a new treatment plant (Options 3 and 4) requires considerably higher capital expenditure than upgrading existing facilities. The transfer options to the ocean (Options 5 to 10) are all expensive and entail initial large capital outlays for constructing the tunnel infrastructure. Effluent reuse schemes (Option 11) also require high capital and operating expenditure. Consideration of non-economic factors and strategic planning confirmed this selection.

TABLE 1. SUMMARY OF COSTS AND NPVs

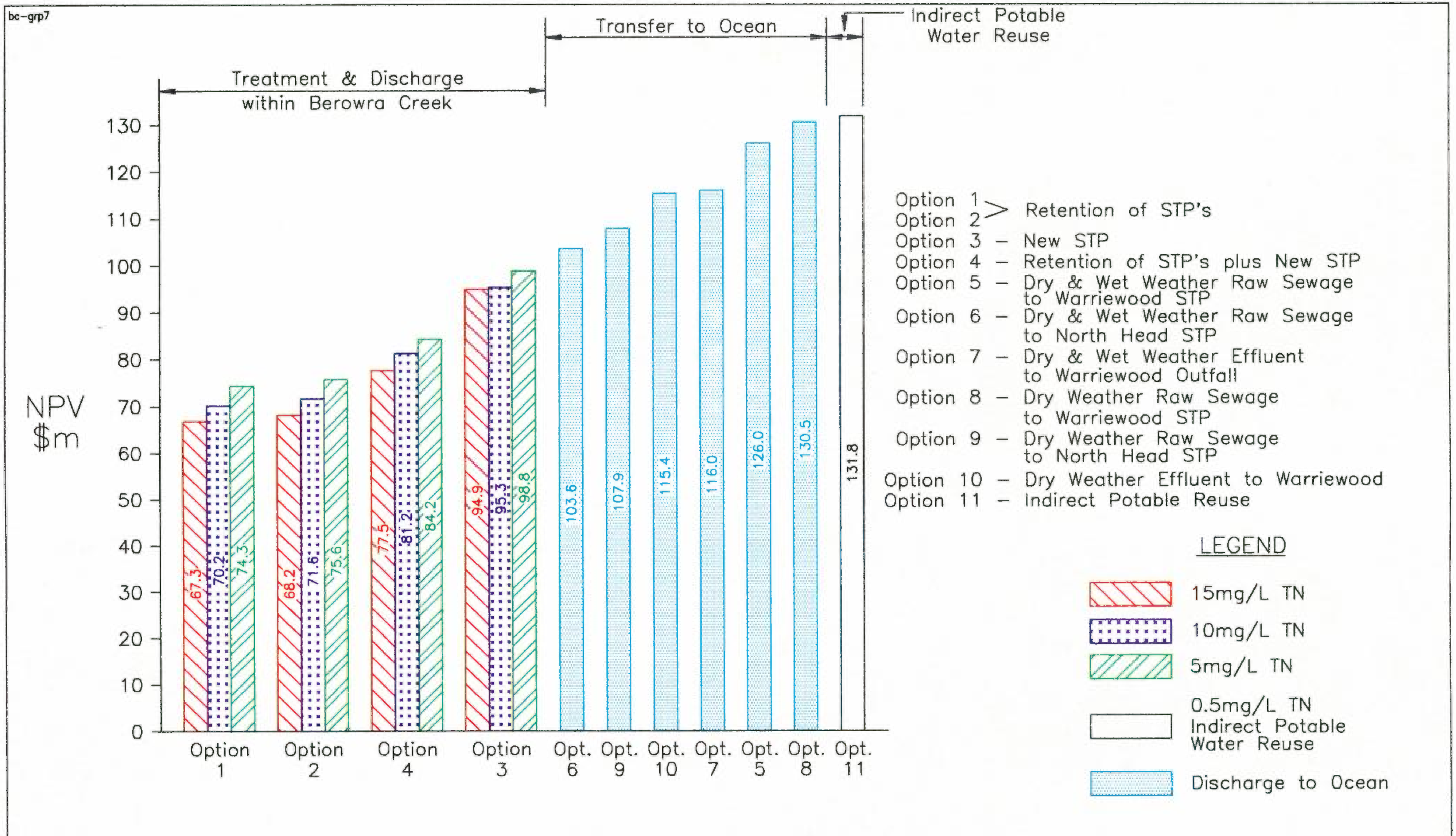
Option	Treatment Level	Capital Cost ($M)	Operating Cost ($M/yr)		NPV[a] over 25 years			Option Ranking[c]
			2000	2019	4%	7%	10%	
Option 1	1 (15) 2 (10) 3 (5)	14.6 18.1 23.1	4.8 4.9 5.0	5.4 5.4 5.5	88.9 92.1 96.8	67.3 70.2 74.3	53.0 55.6 59.2	1
Option 2	1 (15) 2 (10) 3 (5)	14.3 18.2 23.2	4.8 4.9 5.0	5.4 5.4 5.5	90.3 94.1 98.7	68.2 71.6 75.6	53.6 56.6 60.0	2
Option 3	1 (15) 2 (10) 3 (5)	63.0 63.2 67.0	4.3 4.4 4.5	4.8 4.9 5.0	116.2 116.8 121.0	94.9 95.3 98.8	79.0 79.4 82.3	4
Option 4	1 (15) 2 (10) 3 (5)	27.0 31.9 35.3	5.0 5.1 5.1	5.8 5.9 6.0	100.7 104.8 108.3	77.5 81.2 84.2	61.9 65.1 67.7	3
Option 5	b	145.9	4.9	3.9	141.2	126.0	110.0	9
Option 6	b	131.0	4.9	1.1	109.4	103.6	94.0	5
Option 7	b	121.0	4.9	4.5	131.6	116.0	100.5	8
Option 8	b	148.0	4.9	4.5	147.9	130.5	113.0	10
Option 9	b	135.0	4.9	1.7	114.8	107.9	97.0	6
Option 10	b	120.0	4.9	4.5	130.8	115.4	100.0	7
Option 11	Potable Water	69.8	8.1	9.1	169.1	131.8	106.0	11

Values in brackets refer to effluent Total nitrogen 90 percentile values.

Note: Costs are based on an order of accuracy of ± 25 percent.

a. NPV analysis is over period 1994 to 2019.
b. Zero discharge to Berowra Creek during dry weather as sewage is transferred to the ocean STPs at either Warriewood or North Head.
c. Options ranking based on NPVs at 7 percent discount rate.

Option 1	Retention, upgrade and amplification of Hornsby STPs with MLE process
Option 2	Retention, upgrade and amplification of STPs with high biomass MLE
Option 3	New Treatment Plant
Option 4	Retention of Hornsby STPs plus new STP
Option 5	Dry and wet weather raw sewage to Warriewood STP
Option 6	Dry and wet weather raw sewage to North Head STP
Option 7	Dry and wet weather effluent to Warriewood outfall
Option 8	Dry weather raw sewage flow to Warriewood STP
Option 9	Dry weather raw sewage to North Head STP
Option 10	Dry weather effluent to Warriewood outfall
Option 11	Indirect potable water reuse



WATER BOARD
SYDNEY–ILLAWARRA–BLUE MOUNTAINS
WASTEWATER AND REUSE PLANNING

WEST HORNSBY & HORNSBY HEIGHTS S.T.P'S
SEWAGE TREATMENT AND DISPOSAL OPTIONS
NET PRESENT VALUE (7% DISCOUNT RATE)

Figure
1

The provision of the recommended option may equate to an indicative implementation cost per lot of:

TABLE 2. INDICATIVE COST PER LOT FOR OPTION 1

Total Effluent Total Nitrogen Target (90%ile Value)	**$ Per Lot**	
	Existing Lots	**New Development Lots**
15	242	2750
10	369	2865
5	551	3050

The costs per lot are indicative only and are in addition to the current rating charge within the catchment, and does not include any costs that may be recovered.

CONCLUSION

The report finds that based on information to date, the most cost-effective option to achieve the levels of nitrogen removal specified plus serve new development is to retain, upgrade and amplify the existing Hornsby STPs. To achieve a total nitrogen of 15 mg/L (90 percentile) for 72,000 EP involves a capital cost of approximately $14.6 million, with a 25 year NPV of $67 million at a 7% discount rate.

RECOMMENDATION

In summation, it is recommended that any future works at the Hornsby STPs require clear evidence of environmental benefit, direction from the Board's regulator as to the level of treatment required and submission to the government's pricing tribunal for consideration.

It should be noted that the Board has invested considerable capital and operating funds over the last 4 years at the STPs to significantly improve levels of treatment in terms of disinfection, ammonia removal, phosphorus and some nitrogen removal.

It is also recommended that the environmental benefit of this work be scientifically evaluated together with Hornsby Council's initiatives prior to committing to further works so that the community can be assured that their funds are being spent to best effect. The environmental benefit should be determined via an environmental assessment process and environmental monitoring of the receiving waters.

SECTION 1

INTRODUCTION

As a result of the establishment of the Berowra Creek Community Contract[1], the Board is obligated to prepare an Options Report that examines the possible upgrading of existing facilities at West Hornsby and Hornsby Heights STPs. Additionally, the report will examine alternate sewerage strategies for the STPs as requested by the Contract. Various effluent quality targets are proposed and are particularly aimed at effluent total nitrogen levels of 15, 10 and 5 mg/L (90 percentile values). Pumping out of the catchment to achieve zero discharge to Berowra Creek was also specifically requested to be considered.

The Berowra Creek Technical Working Party report[1] has indicated that improved sewage treatment and effluent disposal at West Hornsby and Hornsby Heights STPs is an integral step towards improving the environmental health of Berowra Creek and will help provide for the ecologically sustainable development of the Berowra Creek Catchment.

Future sewage treatment and effluent disposal strategies for the Hawkesbury-Nepean sewage treatment plants (which include the Berowra Creek catchment) are also currently being examined under the Government's Clean Waterways Programme (CWP) and is planned for public exhibition in 1995. In response to the Berowra Creek Community Contract, however, the Sewage Treatment Manager, Northern engaged Waste Water and Reuse Planning on 15 May 1994, to prepare a report outlining options for West Hornsby and Hornsby Heights STPs to ensure that:

- Expected development in the area can be served adequately.
- Sewage is treated to an acceptable standard to prevent further deterioration of Berowra Creek and the Hawkesbury River, where both plants currently discharge.
- The recommended works result in outcomes in accordance with the Berowra Creek Community Contract[1].

The scope of work for this report, as specified in the Brief[2], is listed below:

- Existing Conditions Review.
- Quality and Quantity Investigation.
- Review of Incorporation of ANZECC Requirements for Berowra Creek, Hawkesbury/Nepean and Ocean Discharges.
- Preliminary Assessment of Treatment/Effluent Disposal Options.
- Costing of Options.
- Selection of Preferred Option(s).
- Recommended Strategy(s).
- Approval and Public Exhibition by September 1994.

  It is important to note that the planning horizon for the provision of treatment facilities is up to 2019 and it is compatible to the 25-year period requested to be analysed by the State Treasury for major expenditure projects.

This report will provide input into an environmental impact study (EIS) for the Berowra Creek Catchment which is due to commence in 1994. That study will consider the best apparent option(s) outlined in this report as well as other viable options which may be developed or chosen as a result of public consultation.

BEROWRA CREEK TECHNICAL WORKING PARTY

As a result of concerns regarding the deteriorating environmental quality of Berowra Creek and concerns regarding the performance and treatment capacity of the West Hornsby Sewage Treatment Plant (WHSTP), Hornsby Council commenced a moratorium on 1 September 1993 on the determination of development applications for waste water generating development in the WHSTP catchment.

The Minister for Planning convened the Technical Working Party (TWP) in October 1993 and asked it to report promptly to him on the:

- Nature and causes of the pollution problems that are of concern to Council; and
- Current capacity of the treatment plant (ie. WHSTP) and its ability to handle additional waste water from development.

In December 1993 Hornsby Council extended the moratorium on the determination of development applications for waste water generating development to the catchment of Hornsby Heights STP.

The TWP held its first meeting on 4 November 1993 and has the following representation:

Department of Planning.
Environment Protection Authority (EPA).
Hornsby Council.
Hawkesbury-Nepean Catchment Management Trust.
Water Board.

POLLUTION CONCERNS

The TWP has carried out a number of inspections in the Berowra Creek Catchment and has reviewed several years of monitoring data provided by Hornsby Council, the Water Board and the EPA. They have also reported back to the Minister for Planning and have recommended a Water Quality Management Strategy to be adopted for the Berowra Creek Catchment.

Members of the working party have reported a significant deterioration in the water quality of Berowra Creek and the growth of red algal blooms in the estuarine waters of the creek.

A number of areas within the creek system have become unfit for swimming. Boats can no longer navigate parts of the creek because of siltation and algal blooms are regularly occurring in the lower estuary.

Preliminary Water Quality Assessment[3] undertaken by the TWP indicates that the three main contributors to pollution in Berowra Creek are:

- Sediments from urban development.
- Nutrients (point/diffuse sources), especially nitrogen from the Board's STPs and phosphorus from diffuse sources.
- Contamination by faecal micro-organisms (diffuse sources and miscellaneous point sources).

The TWP realise that improved treatment capability at both West Hornsby and Hornsby Heights STPs is required to reduce nitrogen levels and that diffuse sources of pollution (including storm overflow and urban runoff) also need to be controlled to prevent increased nutrient loads into Berowra Creek.

BEROWRA CREEK COMMUNITY CONTRACT

In order to put in place a co-ordinated programme of measures to improve the environmental health of Berowra Creek and to resolve the moratorium, a Statement of Joint Intent has been agreed to by the Department of Planning, EPA, Hawkesbury-Nepean Catchment Management Trust, Hornsby Council and the Water Board.

The Statement of Joint Intent, signed on the 27th April 1994, represents the first Community Contract for Clean Waterways and details specific goals for water quality improvement in Berowra Creek. The Community Contract will facilitate management of the ecologically sustainable development of the Berowra Creek Catchment and could serve as a model for involvement of the community in developing wastewater strategies.

The Berowra Creek Community Contract[1] contains a commitment from the Water Board to the following:

- Installation by end July 1994 of measures at West Hornsby Sewage Treatment Plant to endeavour to achieve an arithmetic mean of 20 to 25 mg/L Total Nitrogen concentration in the discharged effluent.
- Immediate operational changes to reduce phosphorus and faecal coliform concentrations in discharged effluent from West Hornsby Sewage Treatment Plant and Hornsby Heights Sewage Treatment Plant.
- Preparation and exhibition of an options study for Hornsby Heights Sewage Treatment Plant and West Hornsby Sewage Treatment Plant by the end September 1994. The options study will propose technically feasible measures for further nitrogen reduction. The options of 15 mg/L, 10 mg/L and 5 mg/L Total Nitrogen (90 percentile) in discharged effluent and pumping effluent out of the catchment are to be specifically considered.
- Preparation and public exhibition by end June 1995 of an EIS for each of those options considered feasible, warranting such examination.
- Implementation of a catchment survey to identify and quantify sources of pollution so that appropriate remediation and enforcement action can be undertaken.
- A co-operative monitoring programme of Berowra Creek, undertaken by the EPA, Hornsby Council, Department of Planning (DOP) and the Water Board, so that the effectiveness of changes can be measured and assessed.
- Expeditious implementation by the Water Board of the option approved by the Minister for Planning.

CLEAN WATERWAYS PROGRAMME AND STRATEGIC PLANNING

The Berowra Creek Community Contract has been facilitated by the Technical Working Party established by the Minister for Planning to develop a Strategy to improve the environmental quality of Berowra Creek. The Contract will be a model for the involvement of the community in developing wastewater strategies and is the first example of community involvement as outlined in the Government's "Choices for Clean Waterways[4]" document issued in March 1994. The Choices for Clean Waterways document is an integral part of the Clean Waterways Programme (CWP).

Strategic Planning

The New South Wales Government's Clean Waterways Programme (CWP) was established in response to significant community concern over the state of our beaches, harbours and rivers. Since December 1989, the Government has promoted a series of works and initiatives to help ensure that the waterways of Sydney, the Blue Mountains and the Illawarra region are protected from the effects of sewage pollution.

In the first four years of the programme, major improvements were achieved, especially in beach protection and protection of the Hawkesbury-Nepean River. Independent monitoring has clearly shown that ocean beaches are now free of sewage pollution for approximately 95 per cent of the time, as compared with 50 per cent during the late 1980s. This is due to the installation in 1990 and 1991 of deep water ocean outfalls for effluent discharges from and subsequent incremental upgrading of the largest Sewage Treatment Plants (STPs) at North Head, Bondi and Malabar. The initiatives undertaken to reduce the amount of nutrients being discharged in treated effluent from STPs in the Hawkesbury-Nepean Valley resulted in a marked decrease in the occurrence and intensity of algal blooms in the Hawkesbury-Nepean River. This is due to the extensive upgrading of the regional STPs, including extensive use of new technology.

The programme's priorities are now being reviewed to ensure that it is addressing the environmental and service quality issues that are important to customers and the community, and that it contains the works and activities that the community are willing to pay for.

The Board's Strategic Plan will form the basis for implementation of the Clean Waterways Programme and set the direction for the Board's Wastewater business for the next fifty years. The Plan is to be completed in the latter part of 1995, and it will identify methods as to how the Board can best utilise its own wastewater and stormwater assets to help prevent pollution of Sydney's waterways. It will address long-term sewerage system needs for Sydney, Illawarra and Blue Mountains.

Decisions about the range of activities and works to be included in a strategic plan must be made in consultation with the community. The publication in March 1994 of "The Choices for Clean Waterways" begins a programme of public consultation on the Board's strategies for its storm and waste water services. It encourages all customers, interested groups, organisations and individuals to become involved in the consideration of options to help shape the future of our waterways. This consultation programme will be integrated into other consultation processes to be conducted by Government regulators on water quality goals.

There will be several phases in the consultation programme, from seeking and listening to comments from community and key stakeholders to refining the strategic plans in light of those comments. The Board's consultation process for the strategic plan will run for approximately 12 months. In parallel with the consultative process the Board will be refining the technical details and cost estimates of the options outlined in "Choices for Clean Waterways". Public input will assist in the determination of the direction and scope of the Strategic Plan.

It is anticipated that the Board's submission to the Government Pricing Tribunal in 1995 will contain the details of the Strategic Plan.

Clean Waterways Programme Components

The proposed upgrading and amplification of West Hornsby and Hornsby Heights STPs is a component project of the Clean Waterways Programme (CWP). This Options Report will identify and assess sewage treatment and effluent disposal alternatives which aim to improve the quality of treated effluent in a manner which mitigates environmental impacts.

A Rationalisation Study[5], completed by Pollution Abatement Branch, as a component of its strategic planning work, examined the amalgamation of sewerage catchments in the Hawkesbury-Nepean Basin. A strategy considered in that study was the closure of West Hornsby and Hornsby Heights STP and the transfer of flow elsewhere (i.e. to inland STPs or to ocean STPs) for treatment. The study did not identify, however, overwhelming benefit in implementing that strategy in advance of the completion of the strategic plan.

Traditionally, strategic planning is generally completed before detailed plans are commenced. While the ideal situation would be to defer consideration of the future of West Hornsby and Hornsby Heights STPs until the longer term studies are complete, this is not feasible because:

- Higher effluent standards are being sought in a short time frame by the Berowra Creek TWP and EPA.
- Broader strategic planning will not meet this time frame.

Recommendations made in this Options Report, however, will be reviewed in the light of the strategic plan. The strategy finally adopted after the completion of the EIS and consultation processes must be flexible enough to enable integration with the overall strategic plan.

ECOLOGICALLY SUSTAINABLE DEVELOPMENT GOAL

The Berowra Creek Contract has called for the ecologically sustainable development of the Berowra Creek catchment and the recovery of the environmental health of the Creek, within the framework of the current Urban Development Program .

Ecologically Sustainable Development (ESD) is a development path for human activity which meets the needs of the present generations without compromising the ability of future generations to meet their own needs. This implies that we should maintain all essential ecological processes and life support systems on which human survival depends.

All CWP projects aim to be environmentally sensitive, conserve resources and safeguard natural resources for future generations. Further, they incorporate waste minimisation strategies and innovative technological solutions that control and reduce waste generation rather than rely on traditional end-of-pipe solutions.

In planning, the long term development of West Hornsby and Hornsby Heights STPs, the following ESD guidelines have been used:

- Construction and operation of the treatment plant and facilities, including discharge of the treated effluent to Berowra Creek or the ocean, will not cause irreversible environmental impacts or changes.
- Environmentally sound processes and technologies will be selected and facilities planned to provide environmental enhancements at an affordable cost.
- An effective, efficient and aesthetically appealing plant and facilities (including transfer units) will be constructed which will serve as a valuable asset for the present and future generations, avoiding later unnecessary replacement of facilities.
- The planned facilities will make efficient use of energy and will recover energy to the maximum reasonable extent.
- Plant operations will be reliable with low risk of malfunction or failure, so that the function of the plant (which is to treat sewage) is achieved essentially 100 per cent of the time.

SCOPE OF REPORT

The scope of work for this report is described on page 1-1. The major component of the scope of work includes the examination of a range of sewage treatment and effluent disposal options for both the West Hornsby STP and Hornsby Heights STP. The on-site treatment options of achieving 15 mg/L, 10 mg/L and 5 mg/L Total Nitrogen in the plants' effluent (90 percentile readings) before discharging into Berowra Creek are specifically considered. Options of pumping of raw sewage or plant effluent out of Berowra Creek catchment (ie. transferring flows/load to Warriewood or North Head STPs for treatment and disposal) are also specifically considered.

As discussed, the planning horizon is to be taken for the short to medium term (ie. up to the year 2019). This time period also is in line with the State Treasury requirement to undertake a financial analysis over a 25 year period.

REFERENCES

1. Berowra Creek Technical Working Party, *Report of Berowra Creek Technical Working Party*, May 1994.

2. Water Board, *Brief for Berowra Creek STPs Options Study*, May 1994.

3. AWT Science and Environment, *Water Quality Berowra Creek Catchment*, Water Board, Sydney, October 1993.

4. Water Board, *Choices for Clean Waterways*, March 1994

5. Pollution Abatement Branch, Sewage Treatment Planning, *Preliminary Hawkesbury-Nepean Rationalisation Study*, Water Board, Sydney, May 1992.

SECTION 2

THE HAWKESBURY-NEPEAN CATCHMENT

The West Hornsby and Hornsby Heights Sewage Treatment Plants are located in the north eastern area of Sydney and discharge treated effluent via Berowra Creek to the Hawkesbury River (refer figure 2-1). The total average flow of the Berowra plants accounts for a total of approximately 5.5 per cent of the average effluent flow discharged by the Board to the Hawkesbury/Nepean River system.

The Board operates 23 STPs which discharge effluent into the Hawkesbury-Nepean River. In addition, there are a large number of private, Council and Commonwealth operated sewage treatment plants discharging into the river from as far away as Goulburn, Mittagong, Moss Vale and Wollongong.

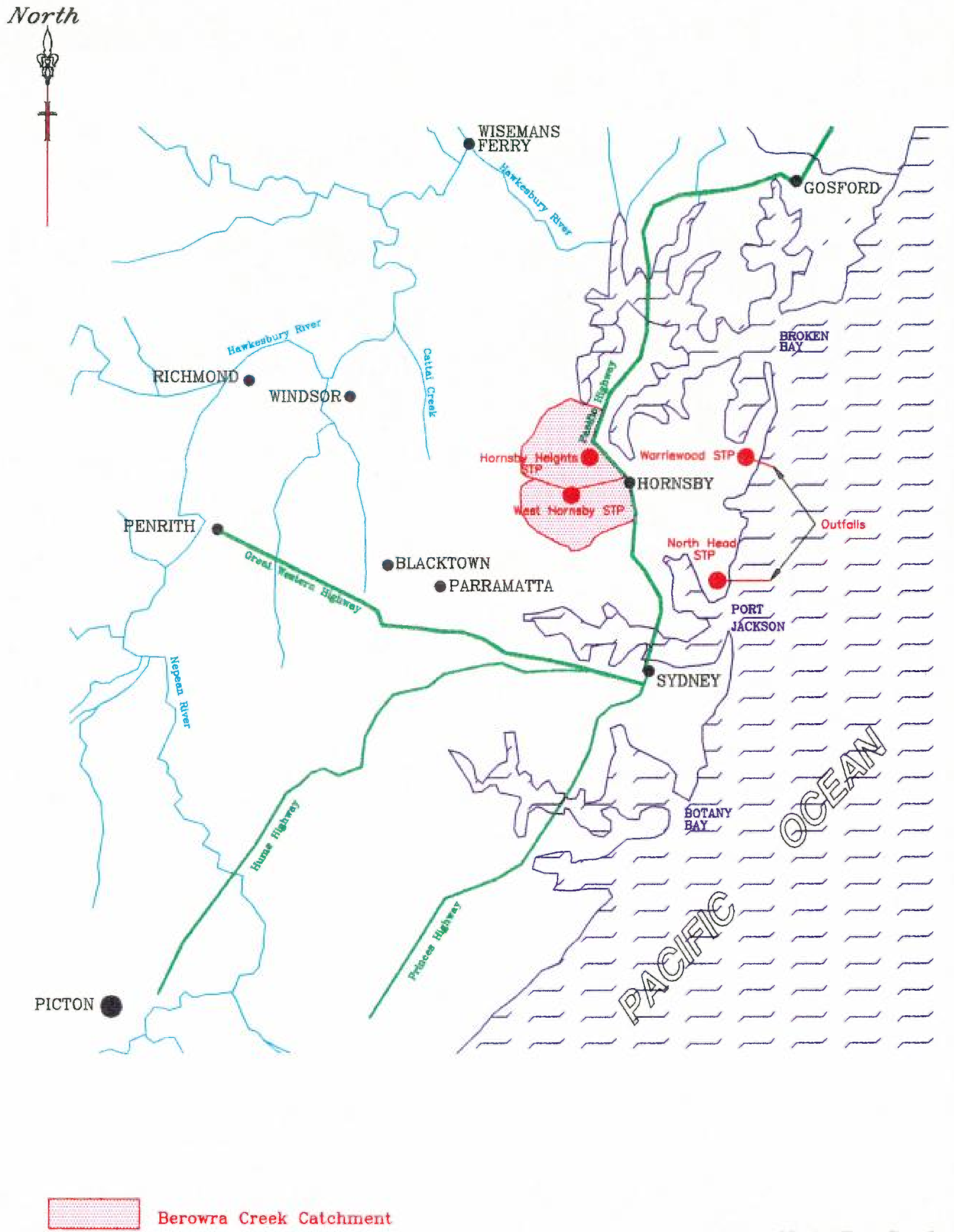
The following section gives a brief discussion of both the Hawkesbury/Nepean and Berowra Creek catchments in which the Board has a major impact.

PHYSICAL ENVIRONMENT

The Hawkesbury-Nepean River is about 530 kilometres long and drains a catchment of approximately 22,000 square kilometres[1] to the north, west and south-west of metropolitan Sydney (figure 2-2). Water from as far away as Goulburn and the Illawarra Range in the south, Lithgow and the Great Dividing Range in the west, the Broken Bay Plateau (which separates this catchment from the Hunter Basin) in the north, joins the river on its way to the Tasman Sea at Broken Bay.

The river catchment extends to the Wollondilly River near Goulburn and includes the Blue Mountains in the west and north west of metropolitan Sydney. Over 60 per cent of the catchment is forested, including parts of nine national parks. About 30 per cent of the area is agricultural land and less than 10 per cent is developed for urban and industrial use. Urban areas are increasing as Sydney expands westward and as towns in the catchment expand.

The Hawkesbury-Nepean catchment is the most significant river system in the Water Board's area of operations and has always occupied an important position in the history of NSW. The first main expansion of Sydney occurred in the Hawkesbury River district. It is an area of special natural beauty and one of great environmental bc-regc



WATER BOARD
SYDNEY–ILLAWARRA–BLUE MOUNTAINS
WASTEWATER AND REUSE PLANNING

WEST HORNSBY & HORNSBY HEIGHTS SEWERAGE

STP LOCATIONS IN A REGIONAL CONTEXT

Figure 2–1

bc-hnct

WATER BOARD
SYDNEY-ILLAWARRA-BLUE MOUNTAINS
WASTEWATER AND REUSE PLANNING

HORNSBY HEIGHTS & WEST HORNSBY STPS

HAWKESBURY-NEPEAN RIVER CATCHMENT

Figure 2-2

significance and for the people who use the river.

Topography in the catchment varies widely[1], from high plateau mountains and upland valleys in the west to the low plateau and shallow valleys of the east. The highest elevations are in the west, where Mount Bindo (1,362 metres) is the highest point. The lowest extensive land units, the Emu and Cumberland plains are less than ten metres above sea level. Most of the northern and north western areas are heavily timbered, rugged, and have mountainous terrain. Undulating hilly areas occur in the south west near Goulburn and Moss Vale and large areas of flood plains border the Nepean and Hawkesbury River between Camden and Windsor.

The plant communities of the catchment are diverse, reflecting the various conditions of elevation, geology, soil type and depth and rainfall. Much of the underdeveloped areas consist of wet and dry sclerophyll forest, but there are also appreciable areas of scrub and heath, temperate rainforest and mangrove and other wetlands.

About half of the total catchment is Crown Land. Most of this is forested, comprising national parks, water supply catchments and state forests, and lies in the more rugged and dissected parts of the catchment. Of the nine national parks, the largest are the Blue Mountains, Kanangra-Boyd, Wollemi, Marramarra and Dharug.

USES OF THE HAWKESBURY-NEPEAN RIVER

The Hawkesbury-Nepean River is used for a wide variety of recreational, social and economic activities[2]. Some of these activities are increasingly coming into conflict, as described below.

Drainage

The river's natural function is to transport water from the catchment to the ocean. Clearing of forests for agriculture and urban development has increased the quantity of runoff in some areas and has also contributed to decreased water quality.

Agricultural runoff includes silt, nutrients, bacteria and pesticides while urban runoff contains a range of heavy metals such as lead, copper and zinc in addition to nutrients, bacteria and other pollutants.

Potable Water

The upper reaches of the river system have been dammed and provide 97 per cent of Sydney's water supply. This has affected the hydrology of the river. Drinking water is also drawn downstream from the dams. Approximately 30 ML/day of water is extracted at North Richmond Water Treatment Works. Raw river water is treated and disinfected, and because of problems with blue-green algae, now undergoes dissolved air flotation and granular activated carbon filtration.

Wastewater Disposal

Impoundment of the river to provide Sydney's potable water supply means that approximately 600,000 ML of water is piped to urban areas every year, instead of flowing in the river. Some of this water is returned to the river in the form of treated sewage effluent.

Treated effluent is discharged into the river and its tributaries from plants operated by the Water Board, local councils and private institutions such as caravan parks, hospitals, retirement villages and country clubs. Wastewater discharges from HMAS Nirimba and Richmond RAAF Base do not require licences from the Environment Protection Authority (EPA) as they are discharged from Commonwealth properties. Other private dischargers have licences which stipulate dry weather flows and levels of biochemical oxygen demand (BOD) and suspended solids (SS) but not concentrations of phosphorus or nitrogen/nutrients.

Some industries discharge wastewater (meeting specified quality requirements) to Water Board sewers although over 200 premises hold EPA waste discharge licences. Several of the latter are piggeries and poultry farms that produce wastewater containing high levels of phosphorus and nitrogen. Most of these have licences specifying spray-irrigation of wastewater. Other premises are licensed to discharge directly into the river, including, for example, a poultry processing plant and a vehicle cleaning operation.

There is no restriction on the discharge of sewage from boats at present. It is considered to be a significant problem and the provision of land-based pump-out facilities for larger boats is under investigation.

Recreation

Distance from the sea and higher summer temperatures in Western Sydney mean that the river is used extensively for swimming, boating and water sports. These uses are expected to increase with increasing urban development. Recreational boating which includes houseboats and large cruisers, also affects water quality through discharges of unburnt fuel, oil, sullage and untreated toilet waste.

Agriculture and Irrigation

Water is used for irrigating pastures, feed crops, horticultural crops and turf farms and is used as drinking water for livestock both upstream and downstream of Wallacia and from tributaries including South Creek. Depending on weather conditions, between 4,000 and 14,000 ML/yr are extracted for these purposes between Penrith Weir and Windsor Reach on the Hawkesbury River.

Fishing and Shellfish Culture

Commercial fishing occurs as far upstream as the Colo River and downstream into Broken Bay. While the river does not support a major fishing industry, the Hawkesbury and its tributaries are nursery areas for many species of fish and invertebrates. There is an estuarine prawn fishery in the lower estuary producing about 100 tonnes per annum and oyster farming occurs in Berowra, Mooney and Marramarra Creeks[6].

Amateur fishing is popular and takes place in both the fresh and saline sections of the river. Increasing numbers of undesirable exotic species, such as European carp, are reported in the freshwater section.

Processing Sand and Gravel

Large amounts of river water are used for processing sand and gravel particularly in the area of the Penrith Lakes Scheme[6]. Currently, water is discharged back to the river with minimal treatment.

CURRENT WATER QUALITY PROBLEMS

The Hawkesbury-Nepean River system and tributaries are showing considerable signs of ecological stress as a result of the many competing demands being made on it. The quality of water in the river is deteriorating and this has led to an increase in the growth of aquatic weeds and algae with high bacteriological contamination in some areas.

Concerns regarding water quality have intensified as a result of detailed planning work being undertaken for the North-West Sector, South Creek Valley and Macarthur South, which are Sydney's planned three major urban growth sectors. As the population in the catchment grows, the quantity of both point sources (e.g. sewage effluent discharges) and non-point source (e.g. urban runoff) pollutants in the river will increase. There will also be a demand for additional potable water and an increasing reliance on the river as a recreational asset for expanding urban areas.

Runoff from natural landscapes, farms and urban development, sewage effluent and raw sewage from pleasure craft is overloading the river with nutrients. Phosphorus and nitrogen can cause growth of algae that can poison the water and interfere with the food chain and aquatic life. Ammonia discharged from STPs can be toxic (particularly under high temperature and high pH conditions) to aquatic life and depletes oxygen concentrations within the river. Algal blooms (including blue green algae) commonly occur in areas between Camden to Pitt Town. Previously, studies have indicated that the Board's STPs contribute large nutrient loads during dry weather[1,3].

Over the past decade, however, there has been a marked reduction in nutrient loadings (particularly phosphorus and ammonia) from Water Board STPs discharging to the Hawkesbury-Nepean system. The average phosphorus loading in 1990 was about 45 per cent of the 1985 loading and the level in 1991/93[2] was reduced by a further 29 per cent. The average daily load of ammonia discharged by the Board's STPs to the river system has in the period 1989/90 to 1992/93 has dropped by 60 per cent (refer to figure 2-3 for more details).

Extraction and dredging of river sands, loam and gravels has caused banks to collapse in some areas, releasing silt into the river (siltation). Extraction in the catchment has resulted in siltation of tributaries and wetlands. Extraction has also changed the shape and depth of the river, increasing detention times, resulting in increased potential for nutrient "sinks". This has encouraged release of stored nutrients into the water body, further stimulating algae growth.

Considerable lengths of river bank are losing tree cover and are eroding and collapsing into the river. Infestations of blackberry, lantana, castor oil plant, and privet are developing and spreading into indigenous bushland throughout the catchment. Water weeds capable of choking the river and creek systems are common. Widespread spraying with herbicides has failed and has the potential of causing further stress to the river.

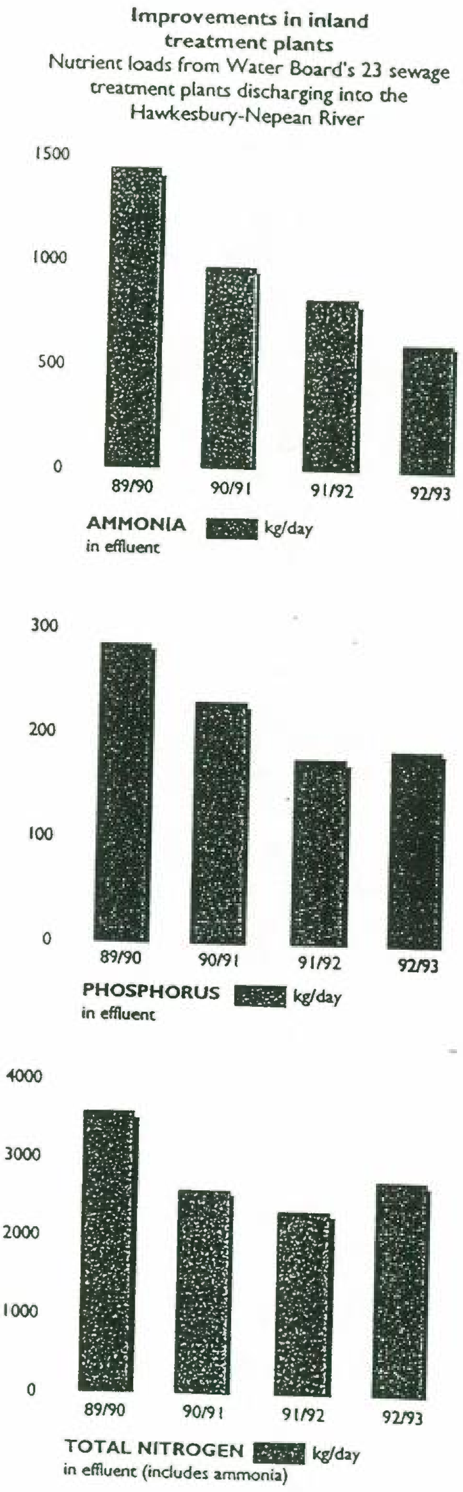
The river supports recreational water pursuits with speed boats and large cruisers exacerbating bank erosion. Raw sewage from these vessels may be discharged to the river due to lack of pump-out facilities. Notably in the Lower Hawkesbury, large-scale hotel, marina and other commercial proposals have the potential to impact water quality, wetlands and mangroves, fishery habitat, unique scenic escarpments and river foreshores.

A number of rubbish depots are found within the Hawkesbury-Nepean catchment and leachate management is a critical issue. Some depots are located near the flood plain of the river.

BEROWRA CREEK CATCHMENT

The catchment of Berowra Creek is generally bound by Castle Hill Road to the south, Old Northern Road to the west, Pennant Hills Road and Pacific Highway to the east. The Berowra Creek study area is largely bushland, however, many of its upstream ridges are urbanised. The urban and industrial/commercial development within this catchment is served by two Water Board treatment plants, the West Hornsby and Hornsby Heights Sewage Treatment Plants.

Both STPs discharge tertiary treated effluent. West Hornsby STP discharges to Waitara Creek, approximately one kilometre upstream of its confluence with Berowra Creek, while Hornsby Heights STP discharges to Calna Creek, approximately five bc–iitp



Note: Nutrient loads from Water Board's 23 sewage treatment plants discharging into the Hawkesbury–Nepean River

WATER BOARD
SYDNEY–ILLAWARRA–BLUE MOUNTAINS
WASTEWATER AND REUSE PLANNING

IMPROVEMENTS TO INLAND TREATMENT PLANTS

Figure 2–3

kilometres upstream of its confluence with Berowra Creek (which is tidal at this point). In addition to effluent from the STPs, Berowra Creek catchment also receives runoff from residential areas, light agricultural regions and possible sullage discharges from unsewered urban areas.

Figure 2-4 shows Berowra Creek, its tributaries and location of the Board's STPs.

Part of the catchment is included in the Mougamurra Nature Reserve and is noted for its scenic beauty. The area is popular for both recreational and commercial fishing. Prawns are caught in the creek and there are a number of oyster leases along the shores of the downstream portion of the creek.

Hornsby Heights Subcatchment

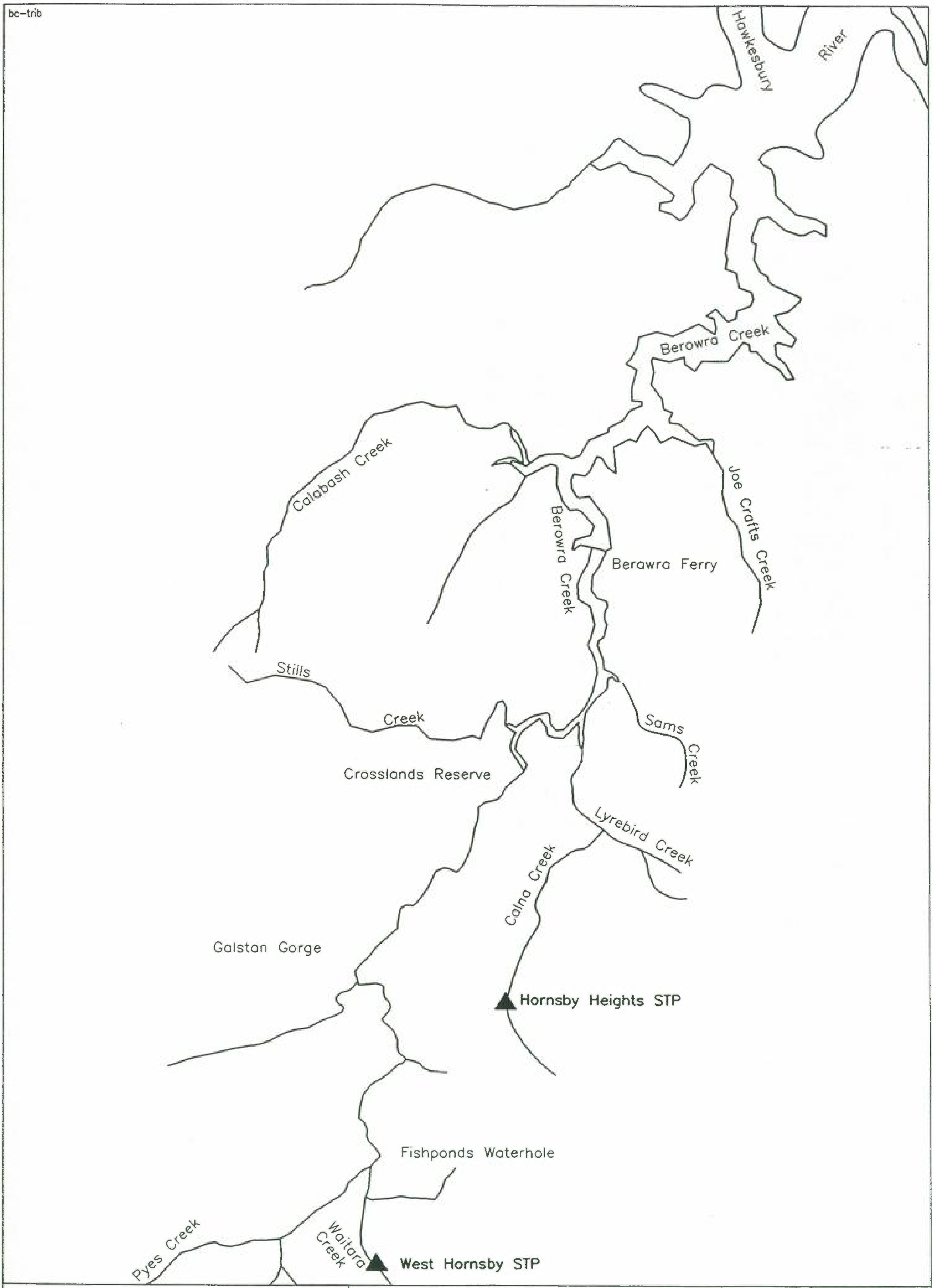
Hornsby Heights Sewage Treatment Plant (STP) lies on Calna Creek between the suburbs of Hornsby Heights and Mount Colah. The Calna Creek catchment above the STP is approximately 2.6 kilometres long by 1.2 km wide and has an area of approximately 315 hectares. Approximately 65% of the catchment is urbanised while the remaining 35% is native bushland. The urban landscape dominates the high ground along the ridges which make up the catchment's boundaries. Native bushland lies along Calna Creek and its steep valley sides.

Beyond the STP, Calna Creek continues to flow North through bushland for 5 kilometres before reaching Berowra Creek. The Creek's character, both above and below the STP is similar to many of the creeks in the area. Calna Creek has some quite steep reaches of boulders and rocks, intermixed with quiet pools. During dry weather, there is frequently no flow in Calna Creek upstream of Hornsby Heights STP. At these times the flow downstream of the plant consists entirely of treated effluent.

West Hornsby Subcatchment

West Hornsby Sewage Treatment Plant is located within the south western section of Hornsby Shire and is situated at the base of a locality known as Old Mans Valley, at the confluence of Old Mans Creek and Waitara Creek. The walls of the valley are fairly steep, rising from a minimum of about 65 metres above sea level to more than 180 metres at the Pacific Highway. Waitara Creek flows northwards for approximately four kilometres to join Berowra Creek.

The catchment area forms part of the ridge and valley topography of the Hornsby Plateau, characterised by steep-sided valleys which become progressively deeper towards the centre and north. The catchment areas include both residential and light industrial development upstream and downstream of the sewage treatment plant.



WATER BOARD
SYDNEY-ILLAWARRA-BLUE MOUNTAINS
WASTEWATER AND REUSE PLANNING

BERUWRA CREEK, TRIBUTARIES AND S.T.P's LOCATION

Figure No.
2-4

According to Hornsby Shire Council[7], recreation downstream of the West Hornsby and Hornsby Heights STPs includes:

- Bushwalking, for example along the Benowie Walking Track which follows Berowra Creek to Berowra Waters.
- Water ski-ing in Berowra Waters.
- Fishing north of Crossland Reserve.
- Camping, swimming and picnicking at Crosslands Reserve and the Seventh Day Adventist Youth Camp (near Crosslands).
- Boating in the upper tidal reaches of Berowra Creek (north of Rocky Fall Rapids midway between Crosslands Reserve and Galston George Bridge).

REFERENCES

1. State Pollution Control Commission, 1993, *Water Quality in the Hawkesbury-Nepean River: A Study and Recommendations* SPCC, Sydney.
2. Farrier, D., 1988 *Environmental Law Handbook: Planning and Land Use in New South Wales*, Redfern Legal Centre Publishing.
3. State Pollution Control Commission, *A Strategy for the Management of the Water Quality of the Hawkesbury and Nepean Rivers, 1985.*
4. Pollution Abatement Branch, Sewage Treatment Planning, Quarterly Statistics, Water Board, June 1992.
5. State Pollution Control Commission, *Water Quality Criteria for NSW, Discussion Paper*, January 1991.
6. Water Board, *Lower Hawkesbury-Nepean Study Area, Sewerage Systems, Existing Conditions*, December 1991.
7. Water Board, *West Hornsby Sewage Treatment Plant Proposed Interim Upgrading, Review of Environmental Factors*, August 1991.

SECTION 3

DEVELOPMENT OF WEST HORNSBY AND HORNSBY HEIGHTS STPS

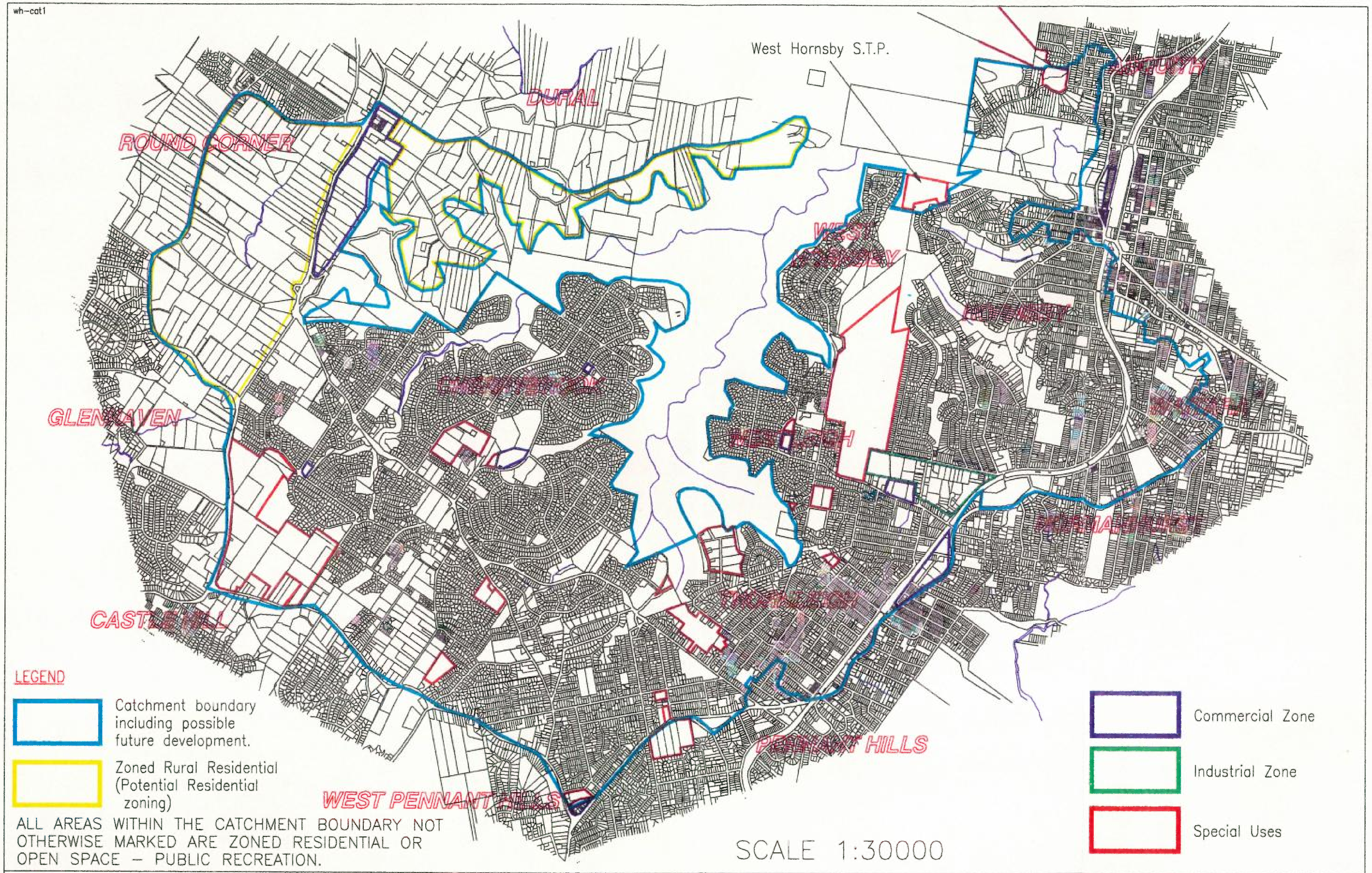
A brief description of the Hornsby Heights and West Hornsby Sewage Treatment Plants (STPs) is provided, together with details of site availability, raw sewage characteristics, current EPA licence requirements and actual plant performance.

WEST HORNSBY STP

West Hornsby STP was commissioned in 1974 and serves the areas of Hornsby, Waitara, Normanhurst, Thornleigh, Cherrybrook and Pennant Hills, as shown in figure 3-1. The catchment area of approximately 2,100 ha is predominantly developed as residential with small pockets of commercial and light industrial (refer figure 3-1). Treated sewage effluent is discharged to the Hawkesbury River system via Waitara Creek which flows into Berowra Creek thence into the Hawkesbury River.

West Hornsby STP is located about two kilometres west of Hornsby and occupies a site of approximately 7.0 hectares. The current buffer between the STP and the closest residential development is less than 10 metres, as seen in the aerial photograph,(refer figure 3-2). The STP is the fourth largest STP discharging to the Hawkesbury-Nepean system, contributing 7 per cent of the total effluent flow entering the river system as at January 1994. The STP contributes 65 per cent of the total effluent entering Berowra Creek (Hornsby Heights STP contributes to the remaining 35 per cent). Based on current average dry weather flows of approximately 9.2 megalitres per day (ML/d), the existing EP (equivalent population) load on the plant is 34,000 (assuming 270 litres per EP per day). The nominal capacity of the plant prior to 1992 was 25,000 EP (based on capacity for nitrification). An Interim Upgrading has recently been constructed at the plant with most units operational, resulting in a nominal minimum plant capacity of 45,000 EP. Digester upgrading and the installation of permanent sludge dewatering facilities is due for completion in early 1995.

The existing facilities consist of an activated sludge process initially designed to removal suspended solids and BOD and was later provided with tertiary (dual media) filtration and chlorination facilities to disinfect treated effluent. The recent plant upgrading provides for biological nitrification and chemical phosphorus removal. The upgrading included the provision of three lamella plate primary sedimentation



WATER BOARD

SYDNEY–ILLAWARRA–BLUE MOUNTAINS

WASTEWATER AND REUSE PLANNING

WEST HORNSBY STP CATCHMENT AREA

Figure No.

3–1

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WATER BOARD
SYDNEY-ILLAWARRA-BLUE MOUNTAINS
WASTEWATER AND REUSE PLANNING

WEST HORNSBY S.T.P.
SEPTEMBER 1993

Figure
3-2

tanks, conversion of four aeration tanks to anoxic/aerobic reactors, construction of two additional anoxic/aerobic reactors, four filter cells fitted out, additional screening and grit removal, increased hydraulic capacity, stormflow screening, automated pickle liquor dosing pumps and upgrading of the sludge digestion. The STP is licensed by the EPA to discharge to Waitara Creek.

Other work at West Hornsby STP includes the construction of a permanent sludge thickening and dewatering plant, the upgrading of electrical systems and the installation of a control and monitoring system. This work is due for completion by end 1994.

The existing plant comprises:

- An inlet structure consisting of screens, two aerated grit tanks and flume.
- Storm flow fine screens.
- Two conventional primary sedimentation tanks and three lamella plate sedimentation tanks; five tanks in total.
- Six reactor tanks modified for configuration for full nitrification or partial denitrification.
- Two circular and two rectangular secondary clarifiers.
- Eight dual media downflow rapid gravity filters.
- Spent Pickle Liquor dosing for phosphorus removal (simultaneous precipitation).
- Alum post dosing facilities for residual phosphorus removal.
- Lime dosing for alkalinity control.
- Two anaerobic sludge digesters (includes partial energy recovery).
- One sludge holding basin.
- One mobile sludge dewatering centrifuge (permanent sludge thickening and dewatering facility to be available at end 1994).
- Disinfection by chlorination of the treated effluent prior to discharge to Waitara Creek.

The process flow diagram for the plant after commissioning of the Interim Upgrading is shown in figure 3-3.

WASTEWATER CHARACTERISTICS AND ADOPTED DESIGN VALUES FOR WEST HORNSBY STP

Tables 3-1A and 3-1B summarise the raw sewage characteristics measured at the West Hornsby STP over the period 1987 to May 1994. As realistic characteristics are necessary for the proper design and operation of sewage treatment plants, they have been adopted for the investigation and design of treatment processes in this options report. These values, however, may be subject to change and this will be taken into the consideration when implementing the approved sewage treatment and effluent disposal strategy for the site. Adopted design Raw Sewage Characteristics for West Hornsby STP which are compared to the Board's standard theoretical design values are shown in Table 3-2.

TABLE 3-1A. WEST HORNSBY STP RAW SEWAGE CHARACTERISTICS FOR PERIOD 1987 TO 1994 (References 1 and 2)

Raw Sewage Characteristics	**Concentration Values (mg/L)**			
	Mean	**50%ile**	**90%ile**	**Maximum**
Biochemical Oxygen Demand (BOD)	244	230	385	490
Chemical Oxygen Demand (COD)	630	575	927	928
Suspended Solids (SS)	240	210	400	720
Ammonia (NH_3)	28	27	37	45
Oxidised Nitrogen (NOx)	0.6	0.4	1.0	6
Total Nitrogen (TN)	44	42	55	72
Total Phosphorus (TP)	9.5	9.8	13	15.5

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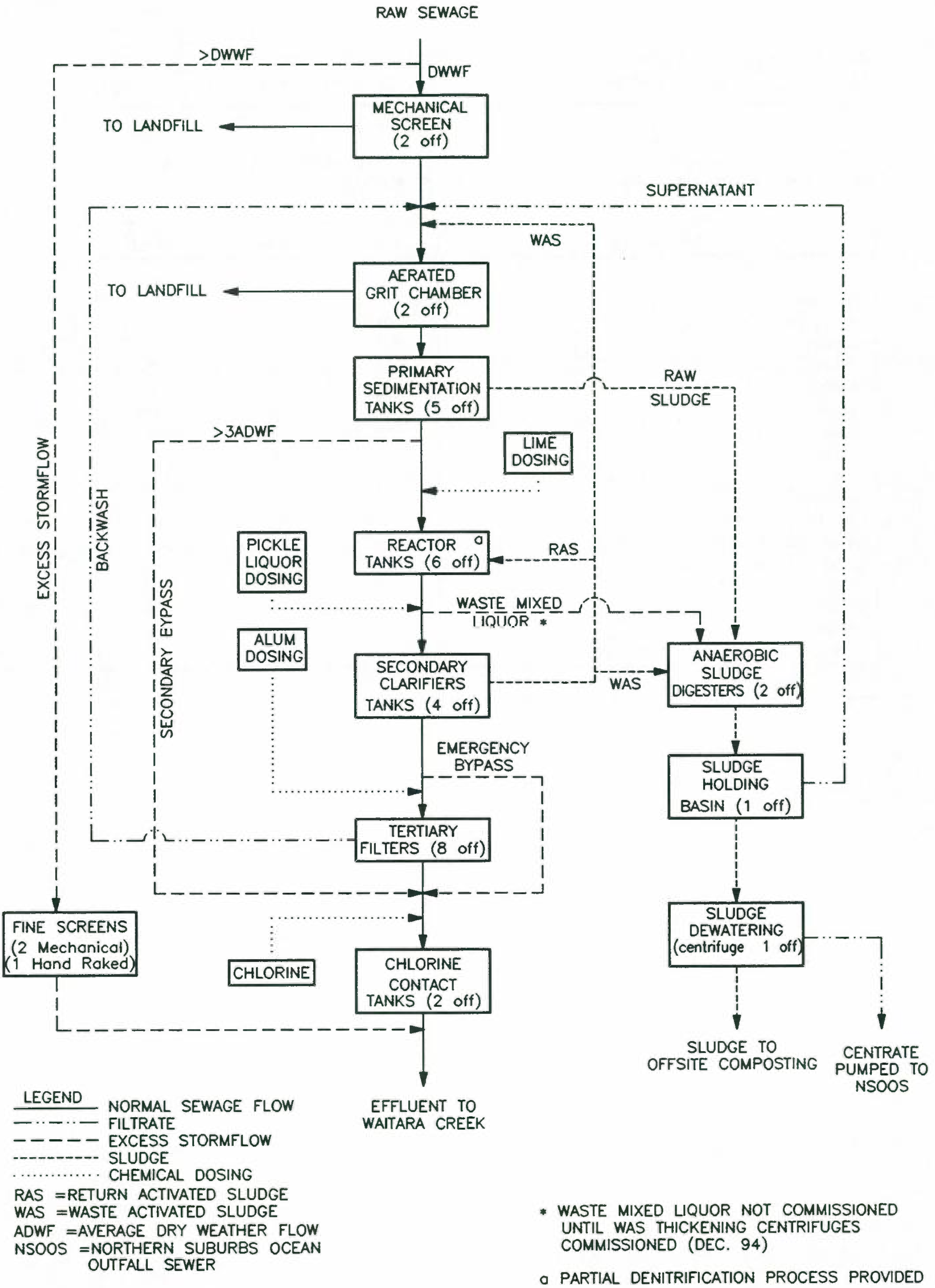

* WASTE MIXED LIQUOR NOT COMMISSIONED UNTIL WAS THICKENING CENTRIFUGES COMMISSIONED (DEC. 94)

a PARTIAL DENITRIFICATION PROCESS PROVIDED

WATER BOARD
SYDNEY-ILLAWARRA-BLUE MOUNTAINS
WASTEWATER AND REUSE PLANNING

WEST HORNSBY S.T.P.
PROCESS FLOW DIAGRAM

Figure
3-3

TABLE 3-1B. RESTRICTED SUBSTANCES IN INFLUENT SEWAGE (μg/L) FOR THE PERIOD BETWEEN 1 NOVEMBER 89 AND 1 JUNE 93 (Reference 3)

Substance	Min	Max	Average
Arsenic	0	270	15
Cadmium	0	2	0
Hexavalent Chromium	0	20	8
Copper	80	390	197
Lead	0	50	17
Mercury	N/A	N/A	N/A
Nickel	0	20	5
Selenium	0	400	36
Silver	0	20	2
Zinc	0	20	131
Cyanide	0	0	0
Phenolic Compounds	0	60	10
Chlorinated Phenolic Compounds	N/A	N/A	N/A
Total Chlorine Residual	N/A	N/A	N/A
Ammonia (expressed as nitrogen)	25,900	47,000	32,828
Endrin	0	0	0
Hexachlorocyclohexane (aplha, beta, delta & gamma isomers)	N/A	N/A	N/A

N/A Not Available.

TABLE 3-2. DESIGN RAW SEWAGE CHARACTERISTICS FOR WEST HORNSBY STP

Parameter	Theoretical[1]	Design[2]
Biochemical Oxygen Demand (BOD_5)	280 mg/L	250 mg/L
Chemical Oxygen Demand (COD)	560 mg/L	630 mg/L
Suspended Solids	295 mg/L	240 mg/L
Total Kjeldahl Nitrogen (TKN)	55 mg/L	45 mg/L
Total Phosphorus (TP)	12 mg/L	10 mg/L
Unbiodegradable Soluble fraction of COD (f_{us})	0.07	0.07
Unbiodegradable Particulate fraction of COD (f_{up})	0.13	0.13
Readily biodegradable fraction of COD (f_{bs})	0.24	0.24
Ammonia fraction of TKN (f_{na})	0.7	0.65
Unbiodegradable soluble fraction of TKN (f_{nu})	0.03	0.03
Alkalinity	250 mg/L as $CaCO_3$	240 mg/L
Peak/Average COD	1.5	1.5
Peak/Average TKN	1.5	1.5
Minimum Temperature	15°C	15°C
Maximum Temperature	25°C	25°C

1. Standard Water Board Design Values.
2. Criteria based on Board's standard sewage characteristics and sampling of West Hornsby STP raw sewage flow.
When no measured values were available theoretical values were adopted.

Average and Peak Dry Weather Flows

Incoming sewage is measured at the West Hornsby's treatment plant inlet works. Measurements taken between 1991 to 1994 indicate the following trends (refer figure 3-4).

The current Average Dry Weather Flow (ADWF) at the plant is estimated at 9.24 ML/d and there has been little variation in the ADWF since 1991. This is attributed to reduction of flows due to the dry weather in 1993.

The dry weather peaking factor is estimated at 1.8, based on the diurnal flow patterns measured at the plant. A typical diurnal flow curve for the West Hornsby STP is shown in figure 3-5 and indicates morning and evening peaks. The current peak dry weather flow (PDWF) is 16.8 ML/d.

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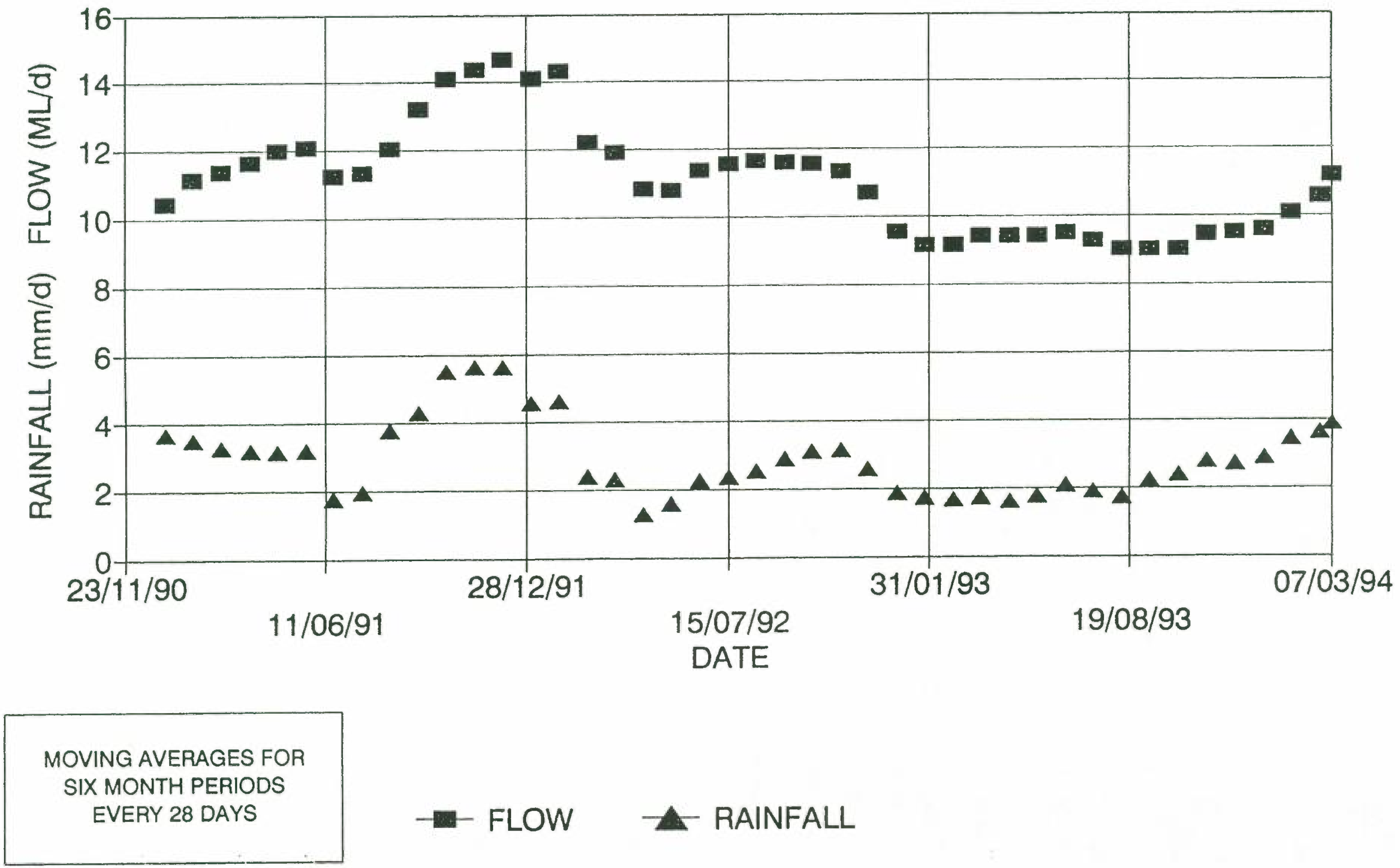

MOVING AVERAGES FOR
SIX MONTH PERIODS
EVERY 28 DAYS

WATER BOARD
SYDNEY-ILLAWARRA-BLUE MOUNTAINS
WASTEWATER AND REUSE PLANNING

WEST HORNSBY S.T.P.
AVERAGE DAILY FLOW VERSUS ANNUAL RAINFALL

Figure
3-4

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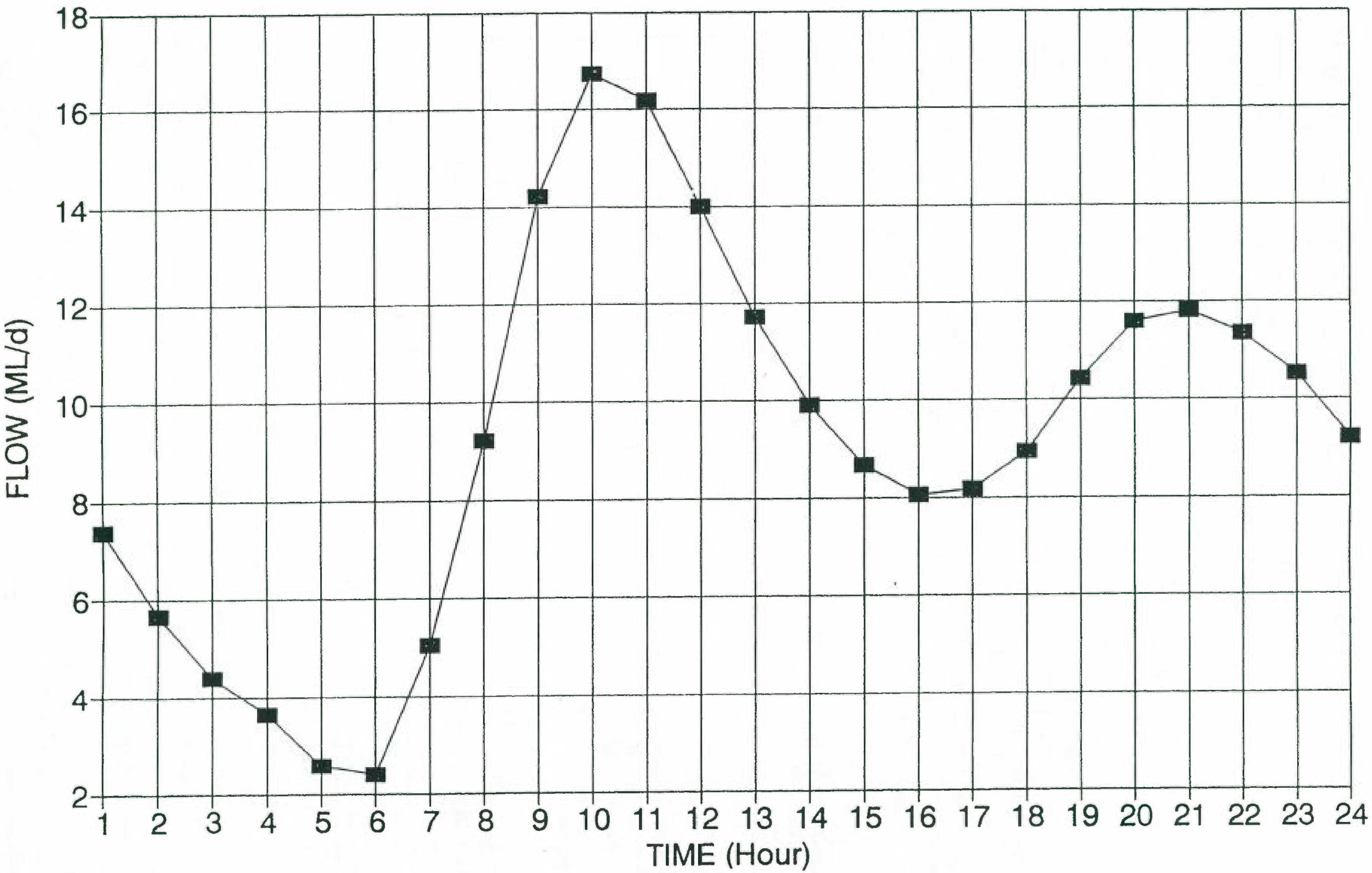


WATER BOARD
SYDNEY-ILLAWARRA-BLUE MOUNTAINS
WASTEWATER AND REUSE PLANNING

WEST HORNSBY S.T.P.
DIURNAL FLOW CURVE

Figure
3–5

Wet Weather Flows

Table 3–3 (and figure 3–6) details the distribution of daily raw sewage flows into the West Hornsby STP.

For the period investigated, wet weather flows occurred on about 48 days per year; 95 per cent of the daily flows are less than 15.3 ML/d (1.66 ADWF) and 99 per cent are less than 35 ML/d ADWF (3.8 ADWF).

The maximum recorded daily flow for the period 1991 to 1993 was 140.6 ML/d (15.3 ADWF) and the maximum peak one hour flow recorded was 45 ML/d on 14 September 1993. The peak 5 day flow was also recorded at 14.47 ML/d (1.57 ADWF) average for each of the five days.

TABLE 3–3. WEST HORNSBY STP RAW SEWAGE DESIGN FLOWS AND PEAKING FACTORS FOR THE PERIOD 1 JANUARY 1991 TO 31 DECEMBER 1993

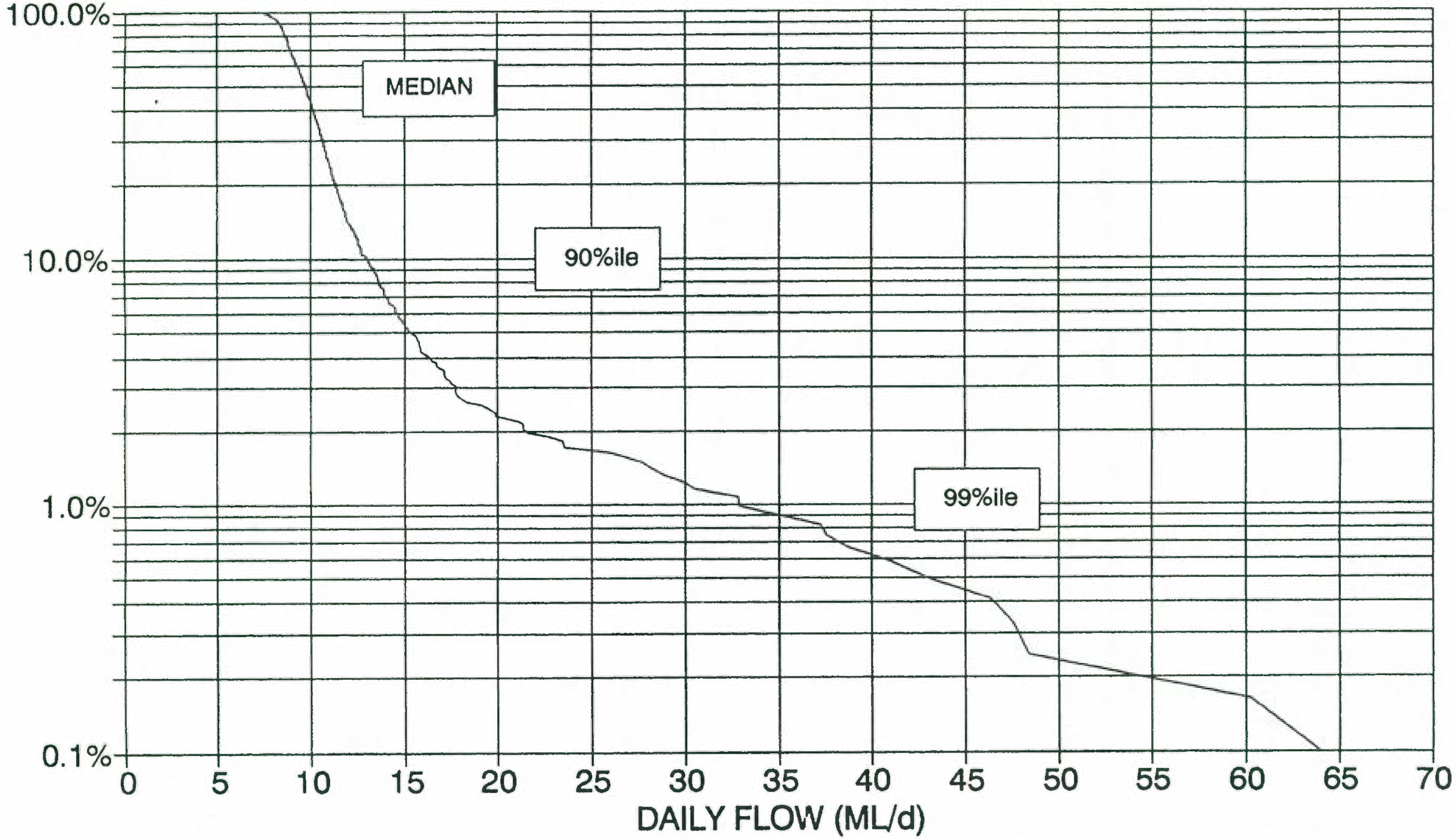
Item	Peaking Factor	ML/d
ADWF	1.00	9.2
50 percentile (median)	1.05	9.63
Minimum hour (MDWF)	0.23	2.14
Maximum hour (PDWF)	2.39	22.0
90 percentile (1 in 10 days)	1.36	12.53
95 percentile	1.66	15.27
Peak 5 days	1.57	14.47
99 percentile (4 days/year)	3.82	35.10
99.7 percentile	8.03	73.87
Peak 1 day	15.22	140.61
Peak 1 hour	4.85	44.66
Sewer capacity	16.85	155 (approx)

Note:
Minimum hour (MDWF), Maximum hour (PDWF) and Peak 1 hour flows are during 1993 only.

Excessive Flows

The presence of excessive inflow/infiltration (I/I) in the West Hornsby and Hornsby Heights STP catchments has significant impact on the sewage treatment and transport methods. At present flows in excess of 4 PDWF (DWWF) can enter the plants and upset processes downstream.

Although the Board has carried out a number of studies to reduce I/I, this information and remedial work to be adopted will not be available for a considerable period of time. For the purposes of this report, flows in excess of 4 PDWF will be provided with fine screening only (as currently occurs). As the site has limited space for storm retention basins, these will also not be considered. Over the long term, bc-drsa



WATER BOARD
SYDNEY-ILLAWARRA-BLUE MOUNTAINS

WASTEWATER AND REUSE PLANNING

WEST HORNSBY S.T.P.
DISTRIBUTION OF RAW SEWAGE
AVERAGE FLOW

Figure
3-6

however, the Water Board's I/I control program can be expected to produce a reduction in excessive storm flows.

DESIGN ALLOWANCE FOR WEST HORNSBY STP

The following design practice has been adopted by the Board in the treatment and disposal of sewage at West Hornsby STP:

- Preliminary and primary treatment units and disinfection units treat DWWF (4 PDWF).
- Secondary and tertiary treatment units treat up to 3 ADWF.
- Excessive storm flows (i.e. greater than 4 PDWF) will receive fine screenings prior to discharge.

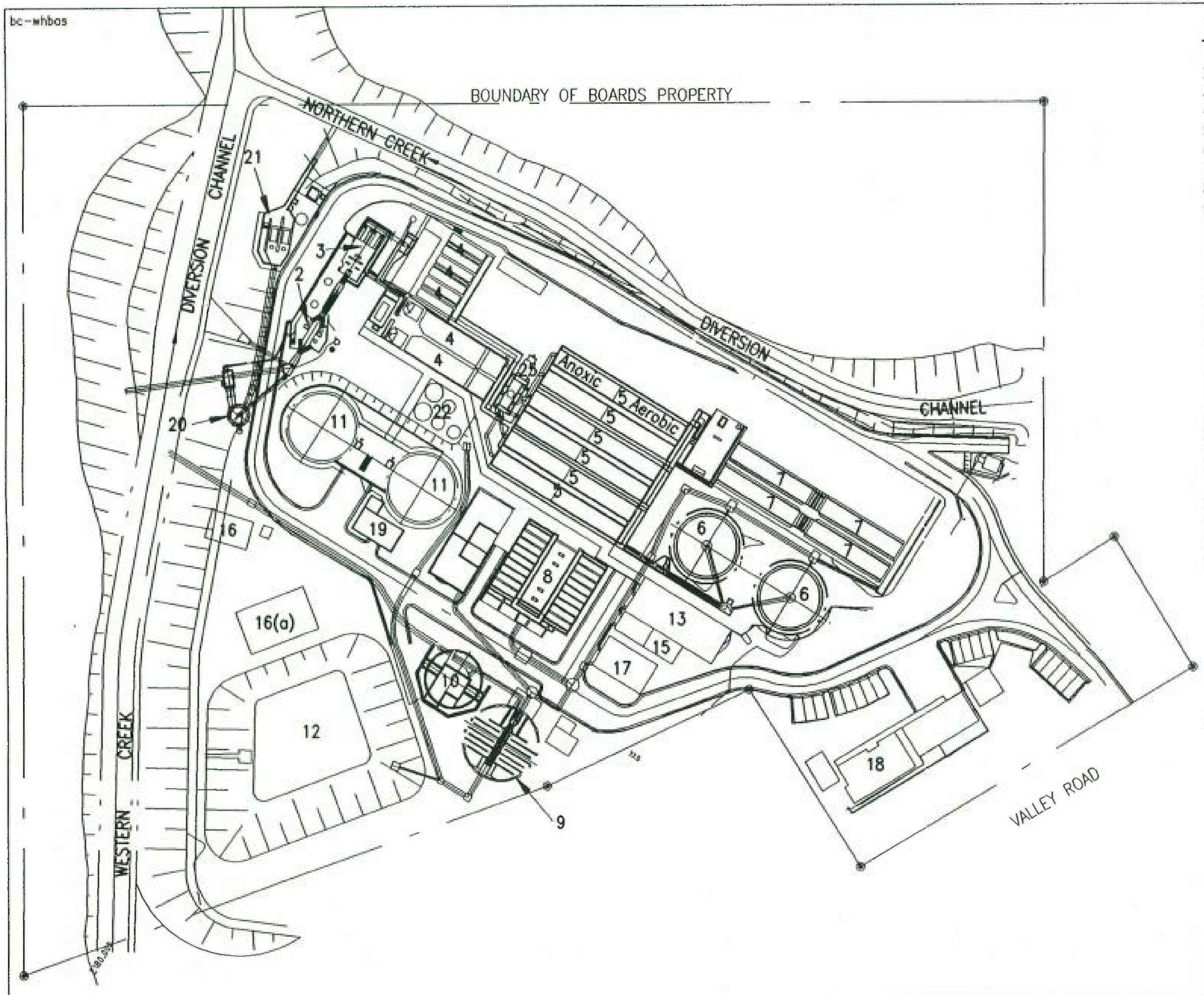
The above design flows for treatment and transport are in accordance with current Water Board practice and EPA guidelines.

DESCRIPTION OF CURRENT PROCESS AT WEST HORNSBY STP

A description of each of the current treatment process is given in the following subsections. West Hornsby STP has recently undergone an interim upgrading to increase the plant capacity from a nominal 20,000 EP to 45,000 EP. The general arrangement for the existing plant is shown in figure 3–7.

Preliminary Treatment

Raw sewage enters the plant inlet which is provided with a vortex overflow structure to bypass excessive stormflows (ie. flows greater than 4 PDWF). The raw sewage passing to the main plant is screened by two mechanically raked bar screens of 18 mm spacings. Screenings are bagged and disposed of to Eastern Creek landfill. Screened sewage then enters two aerated grit tanks. Chain operated buckets collect grit from the grit chamber floor and convey it to eight 240 L mobile carts seated on a timer controlled turntable similar to screenings collection. Grit is also disposed of at Eastern Creek landfill. A two channel cut–throat flume is provided for measurement of influent plant flow (upstream of grit tanks). Measurement is undertaken by ultrasonic devices. Excessive stormflows are bypassed at the vortex structure, which minimises the amount of solid material in the overflow. The bypass flow is screened, using two drum screens with 1 mm slots. A hand raked bar screen is also provided. Stormflows are measured before discharged to Old Mans Creek, while screenings are disposed with those from the main plant.



LEGEND

1	SPS 490
2	SCREEN
3	AERATED GRIT CHAMBER
4	PRIMARY SEDIMENTATION TANKS
5	ANOXIC / AERATION TANKS
6	CIRCULAR SECONDARY SEDIMENTATION TANKS
7	RECTANGULAR SEDONDARY SEDIMENTATION TANKS
8	DUAL MEDIA FILTERS
9	CHLORINE CDNTACT TANK
10	EFFLEUNT PUMPING STATION
11	DIGESTERS
12	HOLDING BASIN
13	BLOWER HOUSE / RAS PUMPING STATION
14	RAS PUMPING STATION
15	11kV SUBSTATION
16	SLUDGE DEWATERING AREA
17	CHLORINATION BUILDING
18	ADMINSTRATION BUILDING
19	SLUDGE PUMPING STATION SPS 212
20	RAW SEWAGE FLOW SPLITTER
21	STORM FLOW FINE SCREENS
22	CHEMICAL DDSING FACILITIES (PHOSPHORUS REMOVAL) + ALKALINITY ADDITION
23	FILTERED WATER TANK
24	FOUL WATER TANK
25	FLOW SPLITTER
26	MIXED LIQUOR PUMPING STATION + MIXED LIQUOR RECYCLE

(a) SLUDGE DEWATERING FACILITY CURRENTLY UNDER CONSTRUCTION (INCLUDES CENTRIFUGES).

WATER BOARD
SYDNEY-ILLAWARRA-BLUE MOUNTAINS

WASTEWATER AND REUSE PLANNING

WEST HORNSBY S.T.P.
GENERAL ARRANGEMENT OF EXISTING PLANT

Figure
3–7

Primary Treatment

The sewage then flows to a flow splitter which discharges to two horizontal flow mechanically scraped, rectangular primary sedimentation tanks (PSTs) and three lamella plate primary sedimentation tanks.

The main function of the PSTs is to remove the readily settleable solids which reduce the BOD load on the biological treatment process downstream by around 30%. Each tank is fitted with scum and sludge removal facilities. Sludge and scum are transferred to the digesters by centrifugal sludge pumps. The combined capacity of the five tanks is 45,000 EP.

Flow from the PSTs is discharged to the primary effluent channel which incorporates the secondary treatment bypass. All flow up to 3 ADWF passes to the secondary flow splitter where it is evenly split to all reactor tanks which are on-line. Flow over 3 ADWF is bypassed directly to the chlorinator contact tank. The secondary flow splitter has been designed with provision for future expansion of the plants both in capacity and conversion to the MLE process (to achieve "full" denitrification).

Secondary Treatment

There are six reactor tanks at West Hornsby STP. The influent settled sewage and return activated sludge are discharged to the "anoxic" zone of each tank and mix together to form mixed liquor. The mixed liquor is aerated in each tank to keep micro-organisms in suspension and provide them with oxygen. Ammonia is converted to nitrate by the action of nitrifying micro-organisms whilst phosphorus is removed chemically by the addition of spent pickle liquor (SPL) upstream of the aeration tanks. The phosphorus precipitate is ultimately removed from the system with wasted sludge. Compressed air is supplied to the aeration tanks by up to four positive displacement blowers. All reactor tanks have the front 17 per cent set up to operate either as an anoxic zone or as an aerated zone. This scheme will allow partial denitrification when all reactor tanks and clarifiers are available. In the event that one reactor tank and/or clarifier is off line, the anoxic zone will be switched to aeration and the plant will still achieve full nitrification.

The mixed liquor passes out of the reactor tanks to two circular clarifiers and two rectangular clarifiers. They are all of similar surface area (160 m^2) but have differing depths. The circular clarifiers are 3 m deep whilst the longitudinal ones are 4.5 m deep. Settled activated sludge is drawn from the clarifiers and returned to the biological reactor.

The existing air sock diffusers have been replaced with membrane diffusers and upgrading of part of the air supply system (ie. blower replacement, suction filters and pipelines) has also been undertaken.

Flow splitting to both the reactor tanks and clarifiers has been upgraded to provide accurate control and to ensure that the maximum secondary flow treated is 3 ADWF. A new PLC based control system will control the reactor tanks and the RAS/WAS system.

There are two RAS/WAS pumping stations each serving two identical clarifiers. Upgrading of RAS and WAS pumps was required to meet the increased flows and to ensure reliability. The RAS pipelines from each pumping station is combined prior to delivery to the reactor tanks to ensure consistent mixed liquor concentrations throughout the system. Facility to waste mixed liquor from reactor tanks has also been provided. Each RAS/WAS pumping station is controlled by a PLC with the two PLCs linked to ensure the installation acts as a whole.

Tertiary Treatment

Tertiary treatment is provided by eight dual media downflow filters and all mechanical equipment has been refurbished. Backwash water passes to the backwash holding tank from where it is then pumped (at a much lower rate) to the inlet to the grit tanks. Backwashing is carried out using air and water.

Chemical Dosing

The spent pickle liquor (SPL) dosing facilities have been upgraded to provide automated dosing for 45,000 EP. The SPL is dosed to the settled sewage flow for phosphorus precipitation. Alum dosing is also provided prior to the tertiary filters to remove residual phosphorus. Lime dosing facilities provide alkalinity control for full nitrification.

Disinfection

Sewage flows are disinfected by chlorination in a circular chlorine contact tank with internal labyrinthine walls. The existing chlorination system comprises three chlorinators. One chlorinator was provided to chlorinate raw sewage at the inlet works, but this facility is no longer used. One chlorinator is provided to chlorinate the filtered effluent. A normal dose rate of 4 mg/L is required to achieve an effluent residual in the range 0.2 mg/L to 0.6 mg/L. The third chlorinator is provided for superchlorination of the filters to remove algae accumulation on filter media.

Sludge Treatment

Two heated floating lid anaerobic digesters are provided. Sludge mixing is achieved by centrifugal recirculating pumps that pump from the bottom of the digester cones through a gas fired heater and discharge at mid tank level. This system is currently being modified to use gas mixing and a much larger gas heater to ensure reliability and enhance performance.

Digested sludge is then directed to the sludge holding basin for storage prior to subsequent dewatering by centrifuge followed by offsite use by soil composters. Centrate from the centrifuge is pumped to the Northern Suburbs Ocean Outfall Sewer (NSOOS). Facilities to pump sludge to the NSOOS exist but are currently not used.

Bypasses

The existing facilities provide full treatment for flows up to 3 ADWF (for 45,000 EP). Flows in excess of 3 ADWF and up to 6 ADWF receive primary treatment and chlorination.

There are four by-pass facilities at West Hornsby STP:

- Diversion of excess stormflows greater than 6 ADWF for 45,000 EP at the head of the plant.
- Secondary treatment by-pass which directs settled sewage flows greater than 3 ADWF but less than 6 ADWF to the chlorine contact tank.
- Emergency mixed liquor by-pass which directs mixed liquor to the sludge lagoon via manual control valve.
- Filter by-pass which allows secondary effluent to by-pass the dual media filters and discharge directly to the chlorine contact tank.

Table 3-4 summaries design capacities, capacities currently served and principle dimensions for each unit process.

TABLE 3-4. WEST HORNSBY STP CAPACITY OF EXISTING PROCESS UNITS

Item	No. Units	Principal Dimensions (m)	Area m^2	Volume ML	Capacity EP
Screening	2	0.9 x 18 mm bar aperture	-		80,000
Fine Screens	2	1 mm slot	-	-	80,000
Grit Removal	2	10.70 x 2.44 x 2.75	52		68,000
Primary Sedimentation (Conventional)	2	28.96 x 5.49 x 2.67	318		18,000
Lamella plate PSTs	3	9.75 x 5.6 x 5.2	164		27,000
Nitrification and BOD Removal	6	36.6 x 3.90 x 5.37	766	4.6	45,000
Rectangular Secondary Sedimentation	2	48.0 x 5.74 x 4.53	550	2.49	22,500
Circular Secondary Sedimentation	2	18.30 dia x 2.93 swd	526	1.54	22,500
Tertiary Filtration	8	24.8 m^2 / filter	198	-	68,000
Disinfection	2	18.25 dia x 2	262	-	80,000
Phosphorus Removal (Simultaneous) & Post Dosing	-	-	-	-	45,000
Lime Dosing		-	-	-	45,000
Sludge Digestion (Anaerobic)	2	16.7 dia x 10.5 swd	438	4.6	80,000
Sludge Holding Basin	1	-	-	-	-
Sludge Dewatering[a]		-	-	-	45,000
Effluent Outfall Pumping Station	1	-	-		80,000

[a] Permanent Facilities currently nearing completion.

CURRENT EFFLUENT QUALITY AT WEST HORNSBY STP

Table 3–5 compares the EPA licence with plant effluent performance at West Hornsby STP for 1992/93 and 1993/94.

TABLE 3–5. WEST HORNSBY STP EFFLUENT QUALITY 1992/93 AND 1993/94 (mg/L)

Parameter	**Licence**			**Plant Effluent**		
	50% ile	**90% ile**	**Geo Mean**	**50% ile**	**90% ile**	**Number Exceeding Geo Mean Limit**
1992/93 Period						
BOD_5	15	25	40	1	6	0
SS	15	25	40	1	10	0
NH_3-N	15	25		0.6	14	–
TP	1.5	3		0.3	1.0	–
TN	–	–	–	34	41	–
1993/94 Period						
BOD_5	10	20	40	1	4	0
SS	10	20	60	1	5	0
NH_3-N	7	25		0.6	1.6	–
TP	1.5	3		0.4	0.7	–
TN	–	–	–	31	40	–
Faecal Coliforms	–	–		14	1800	

Key:

BOD_5	Biochemical Oxygen Demand (5 days)
SS	Suspended Solids
NH_3-N	Ammonia Nitrogen
TP	Total Phosphorus
50% ile	50% of samples must be less than licence limit indicated
90% ile	90% of samples must be less than licence limit indicated
mg/L	milligrams per litre
Faecal Coliforms	Units Counts per 100 mL sample

PAST PROBLEMS AND IMPROVEMENTS AT WEST HORNSBY STP

Table 3–6 summarises problems identified by plant staff and actions taken to rectify the respective problem.

TABLE 3-6. PAST PROBLEMS AND IMPROVEMENTS PROVIDED

Past Problem	Modifications Undertaken
Poor Nitrification	Additional aeration tanks, upgraded WAS/RAS system, alkalinity control facilities
Poor Phosphorus Removal	Upgrading/amplification of SPL dosing and provide alum dosing
Bypass Facilities	New stormflow overflow structure, new primary treatment flow splitter
Excessive Storm Flow	New fine screening facilities
Primary Sedimentation Tanks Capacity	Three additional lamella plate PSTs
Aeration Tank Capacity	Two additional aeration tanks
Blowers	New blowers, diffusers and suction filters
RAS/WAS System	Upgraded WAS/RAS system
Dual Media Filters	New PLC control, new instrumentation, fitting of 4 additional cells
Chlorination	New chlorine residual analyser
Digesters	Upgrading of mixing and control system
Spent Pickle Liquor (SPL) Dosing	Upgrading and automated dosing
Sludge Lagoon Supernatant Return	Sludge lagoon decommissioned
Instrumentation	General upgrading plus SCADA

Comments where applicable on each problem in Table 3–6 are listed below:

- Poor Nitrification. Additional aeration tanks and an upgraded WAS/RAS system and alkalinity control facilities have been provided to achieve ammonia nitrogen 90 percentile concentrations of 1 mg/L.

- Poor Phosphorus Removal. The upgraded SPL dosing facility plus post dosing facilities are now achieving effluent phosphorus levels of 0.5 mg/L (90 percentile).

- Bypass Facilities. The past problems of dry weather bypass has been addressed by the recent Interim Upgrade.

- Primary Sedimentation Tanks Capacity. The provision of three additional PSTs have addressed hydraulic problems previously experienced on site. Overseas experience shows that the proposed Lamella type solid separator will require frequent maintenance, eg. cleaning of plates.

- Aeration Tank Capacity. The Interim Upgrade has provided sufficient capacity to fully nitrify up to 3 ADWF (for 45,000 EP). Also the small anoxic zones provided have been fitted with mixers to maintain sludge in suspension. Some denitrification will be achieved.

- Sludge Lagoon Supernatant Return. This flow is a large source of phosphorus and ammonia. Lime dosing facilities has been provided in conjunction with a strategy to control the timing of the return of supernatant to the head of the works. The sludge lagoon, however, has been decommissioned.

IMMEDIATE TOTAL NITROGEN REDUCTION AT WEST HORNSBY STP

As part of the Berowra Creek Community Contract, the Water Board's Inland Wastewater Branch is urgently undertaking process modifications at West Hornsby STP to reduce total nitrogen levels discharging to Berowra Creek. The Board is endeavouring to install (by the end of July 1994) measures at the plant to achieve between 20 to 25 mg/L total nitrogen concentration in the discharged effluent. At present the plant is currently showing promising results in reducing nitrogen to the above levels but further installation of infrastructure and sewage conditioning is required to continuously meet the above requirement.

HORNSBY HEIGHTS STP

Hornsby Heights Sewage Treatment Plant (STP) was commissioned in November 1980 as a 20,000 EP conventional activated sludge plant capable of achieving a high degree of removal of organic matter (BOD) and suspended solids as well as nitrification. Dual media filtration was provided for tertiary treatment and chlorination facilities for disinfection. An aerial photograph of the Hornsby Heights STP is shown in figure 3–8.

The Technical Data for Stage 1 and 2 issued on 11.3.75, estimated the ultimate equivalent population (EP) for the Hornsby Heights catchment as 40,000 although the layout of the plant provided sufficient space for a possible ultimate capacity of 60,000 EP. The plant was not designed to remove nutrients (nitrogen and phosphorus) but areas were set aside for the provision of these facilities. It was assumed that nutrient removal requirements would be reviewed periodically.

Hornsby Heights STP is located on a 12 hectare site off Pike Road, Hornsby Heights, about four kilometres north of Hornsby. The current buffer provided between the STP and the closest residential development is less than 200 metres. The STP is the seventh largest discharging to the Nepean–Hawkesbury system, contributing 4.6 per cent of the total effluent entering the river system as at March 1994. Based on current average dry weather flows of approximately 4.89 megalitres per day (ML/d), the existing EP (equivalent population) load on the plant is 18,100 (assuming 270 litres per capita per day). The present nominal capacity of the plant is 19,000 EP (based on nitrification capacity).

The original scheme adopted to provide sewerage facilities to the area extending between Asquith and Berowra Heights, as described in the Review of Environmental Factors[2], required two separate sewage treatment plants, one at Hornsby Heights and the other at Berowra. Both of these plants were to cater for an ultimate capacity of 40,000 EP to be developed in two 20,000 EP stages. Subsequently, it was decided to defer the development of Berowra STP by treating sewage from developed areas in both catchments at Hornsby Heights. Under this scheme, the Berowra STP would only proceed when the Hornsby Heights site was fully developed.

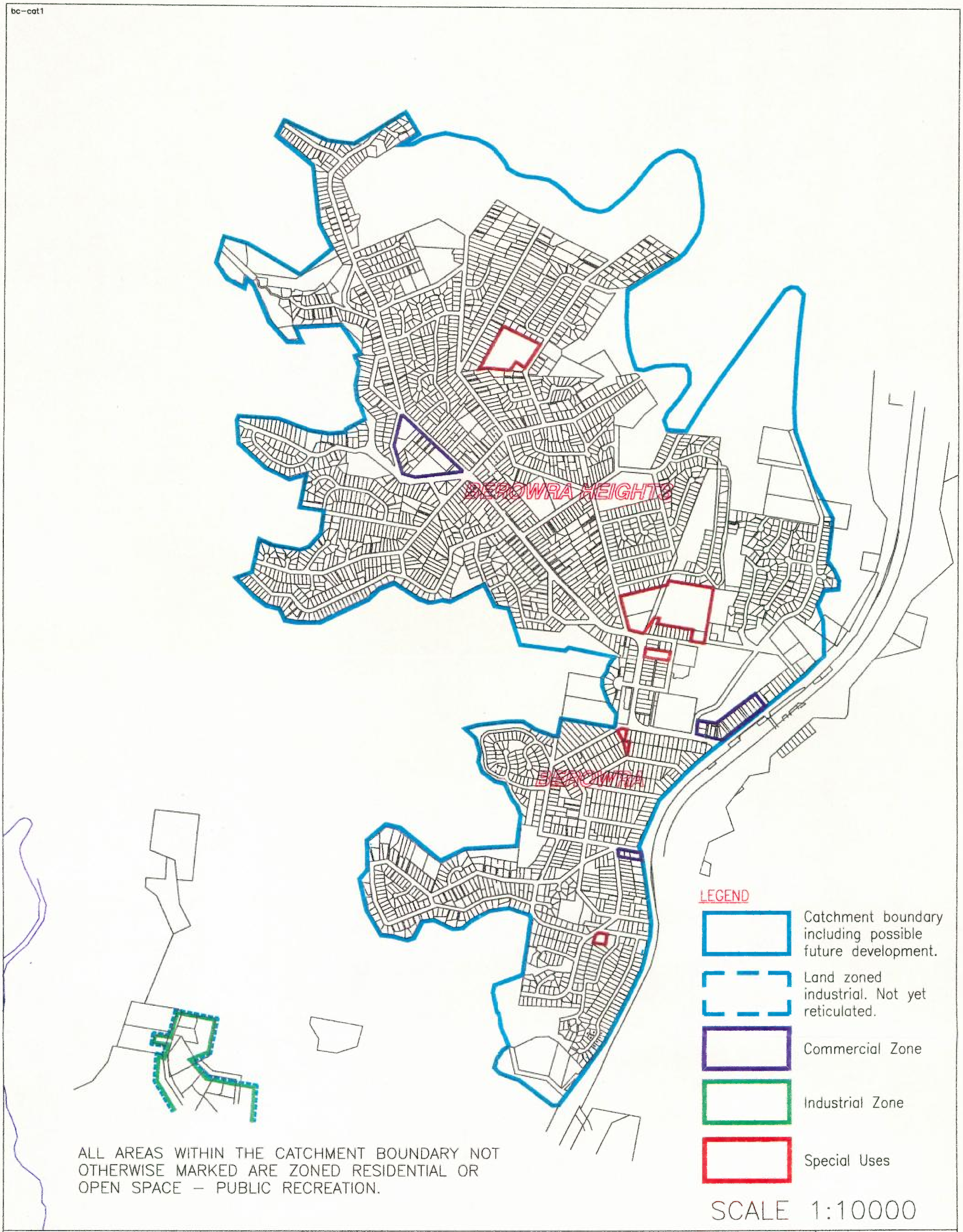
Presently, the Hornsby Heights system serves parts of Hornsby Heights, Mt Colah, Mt Ku–ring–gai as well as some areas of Berowra and Berowra Heights as shown in figures 3–9A and 3–9B. Due to the additional loads received by Hornsby Heights STP from the Berowra catchment, as well as development within the Hornsby Heights catchment, the plant is nearing capacity.

Hornsby Heights STP was designed as a conventional activated sludge plant to remove suspended solids and BOD_5. The biological treatment was, however, modified during the early stages of design by increasing the aeration capacity to that required for nitrification. All flows to the plant receive screening, degritting, primary bc-pl2

WATER BOARD
SYDNEY-ILLAWARRA-BLUE MOUNTAINS
WASTEWATER AND REUSE PLANNING

HORNSBY HEIGHTS S.T.P.
AUGUST 1992

Figure
3-8



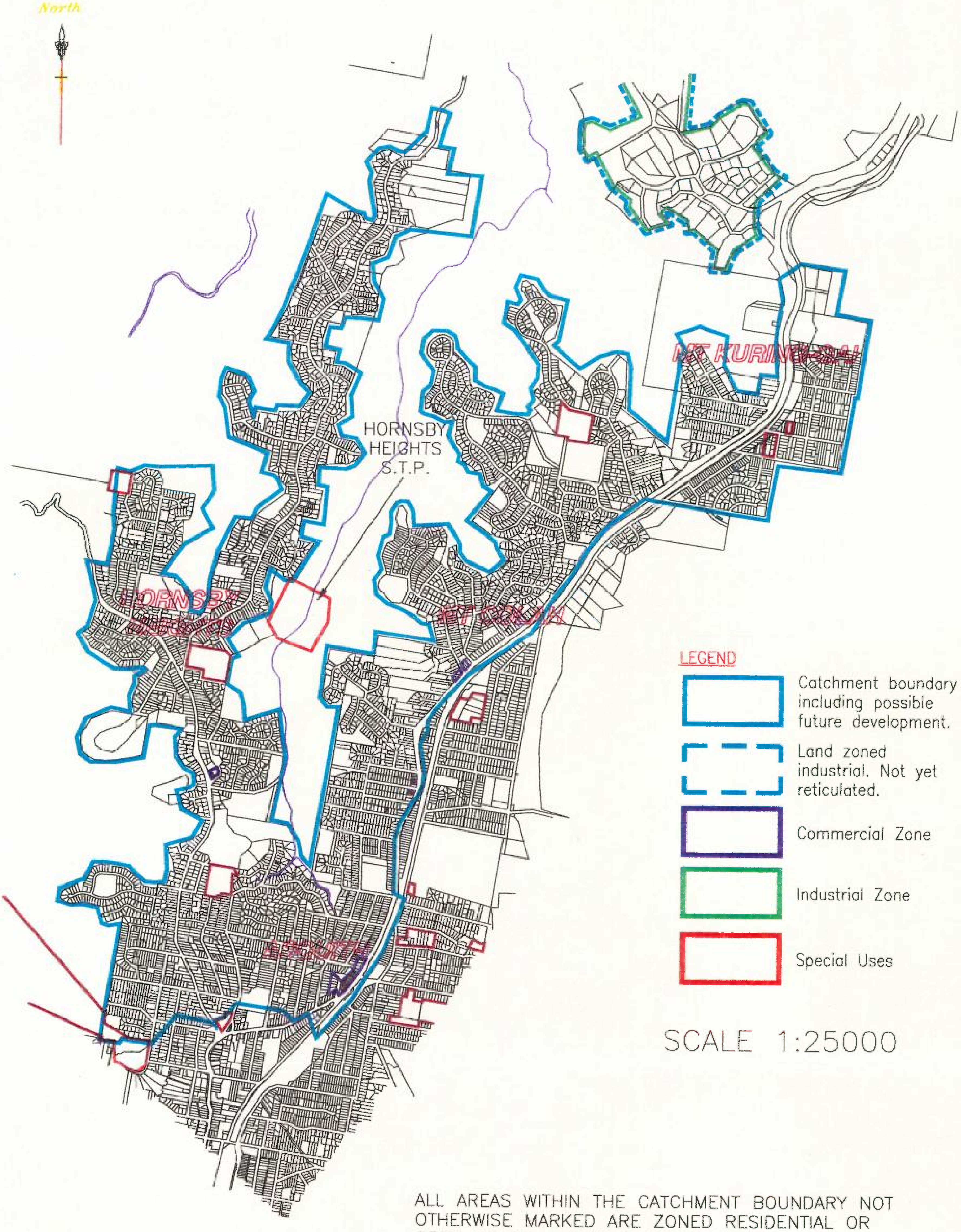
ALL AREAS WITHIN THE CATCHMENT BOUNDARY NOT OTHERWISE MARKED ARE ZONED RESIDENTIAL OR OPEN SPACE – PUBLIC RECREATION.

WATER BOARD
SYDNEY–ILLAWARRA–BLUE MOUNTAINS
WASTEWATER AND REUSE PLANNING

HORNSBY HEIGHTS S.T.P.
CATCHMENT AREA
BEROWRA, BEROWRA HEIGHTS

Figure 3–9(a)

hh-cat1



ALL AREAS WITHIN THE CATCHMENT BOUNDARY NOT OTHERWISE MARKED ARE ZONED RESIDENTIAL OR OPEN SPACE – PUBLIC RECREATION.

WATER BOARD
SYDNEY–ILLAWARRA–BLUE MOUNTAINS
WASTEWATER AND REUSE PLANNING

HORNSBY HEIGHTS S.T.P.
CATCHMENT AREA
ASQUITH, HORNSBY HEIGHTS
MT COLAH, MT KURING–GAI

Figure
3–9(b)

treatment and disinfection by chlorination, with flows up to 3 ADWF receiving secondary and tertiary treatment also. The existing Stage 1 plant comprises:

- Inlet pump station (using archimedean screws) and inlet chamber.
- One mechanical bar screen and one aerated grit chamber (the civil works for the second chamber has already been built). A bypass screen is also provided.
- Two conventional rectangular primary sedimentation tanks.
- Three aeration tanks with waste and return activated sludge system.
- Lime dosing facility for alkalinity control.
- Spent Pickle liquor dosing for phosphorus removal (simultaneous precipitation)
- Alum post dosing facilities for residual phosphorus removal.
- Two secondary clarifiers (a third secondary clarifier is currently being constructed).
- Two dual media downflow tertiary filters.
- Two chlorine contact tanks.
- Two anaerobic sludge digesters.
- Two sludge holding basins.
- One temporary dewatering centrifuge. Dewatered sludge is trucked away for use in composting operations.

The process flow diagram for the existing plant is shown in Figure 3–10.

WASTEWATER CHARACTERISTICS AND ADOPTED DESIGN VALUES FOR HORNSBY HEIGHTS STP

As realistic raw sewage characteristics are imperative for the proper design and operation of sewage treatment facilities, a sampling and analysis programme of influent raw sewage is carried out by the Board at its STPs. For Hornsby Heights STP, at three monthly intervals, a 24 hour composite sample of the plant influent is analysed for the conventional pollutants, nutrients and various restricted substances including metals and various organochlorines. A review of this data was undertaken for the period from January 1989 to May 1994 and is detailed in Table 3–7A and 3–7B.

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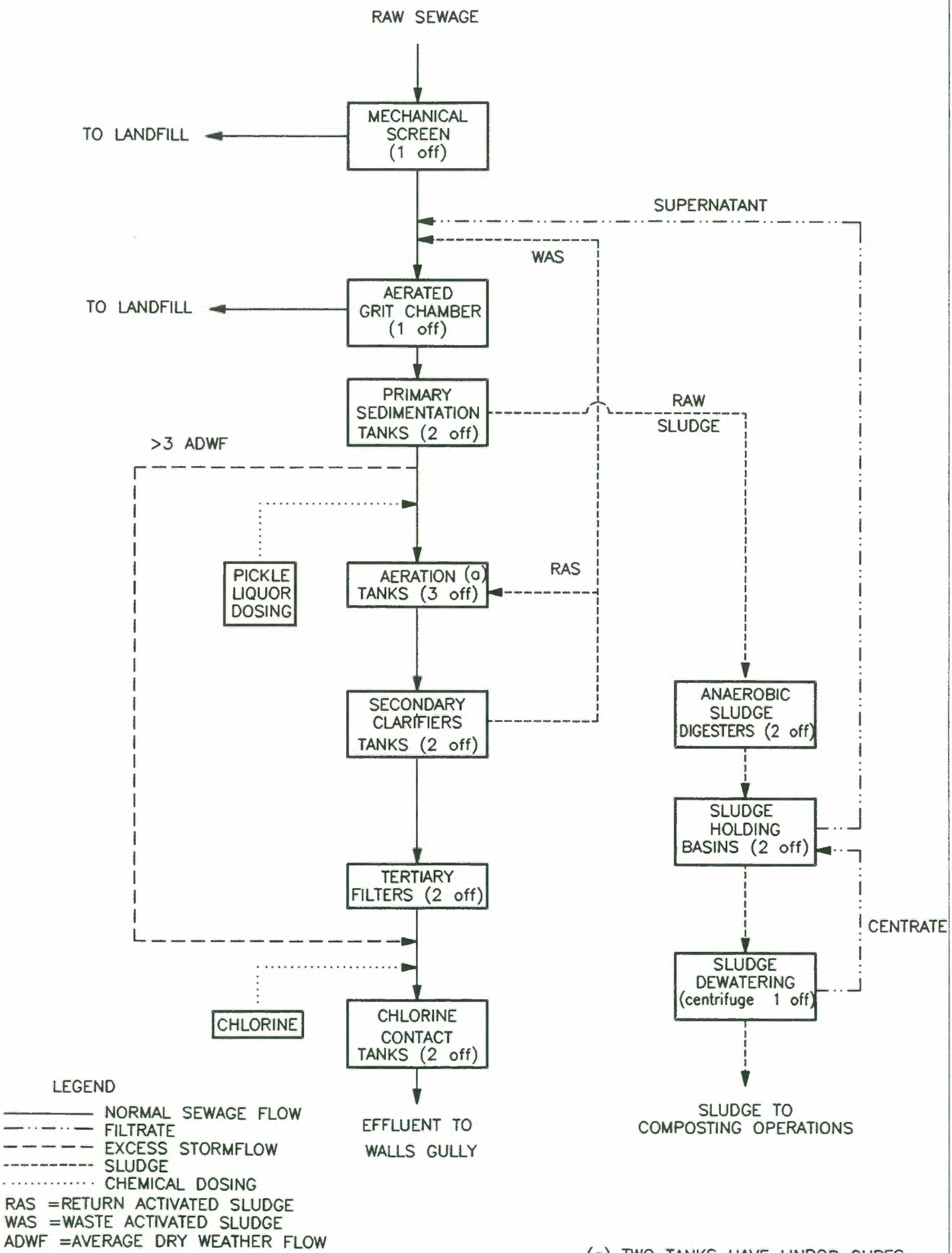

(a) TWO TANKS HAVE LINPOR CUBES

WATER BOARD
SYDNEY-ILLAWARRA-BLUE MOUNTAINS
WASTEWATER AND REUSE PLANNING

HORNSBY HEIGHTS S.T.P.
PROCESS FLOW DIAGRAM

Figure
3-10

TABLE 3-7A. HORNSBY HEIGHTS STP RAW SEWAGE CHARACTERISTICS FOR PERIOD BETWEEN JANUARY 1989 TO MAY 1994 (References 1 and 2)

Raw Sewage Characteristics	**Concentration Values (mg/L)**			
	Mean	**50%ile**	**90%ile**	**Maximum**
Biochemical Oxygen Demand (BOD)	211	200	300	410
Chemical Oxygen Demand (COD)	538	541	700	717
Suspended Solids (SS)	233	209	365	518
Ammonia (NH_3)	37	36	47	65
Oxidised Nitrogen (NOx)	0.74	0.4	3.0	7
Total Nitrogen (TN)	55.6	54.5	73	87
Total Phosphorus (TP)	12.5	12.6	16.7	17.8

TABLE 3-7B. RESTRICTED SUBSTANCES IN INFLUENT SEWAGE (µg/L) FOR THE PERIOD BETWEEN 1 NOVEMBER 89 AND 1 JUNE 91 (Ref: Trade Waste Branch)

Substance	**Min**	**Max**	**Average**
Arsenic	0	1	0
Cadmium	0	1	0
Hexavalent Chromium	0	20	5
Copper	59	270	170
Lead	0	33	10
Mercury	0.005	1.7	0.4
Nickel	0	20	6
Selenium	0	140	30
Silver	0	1	0
Zinc	34	270	134
Cyanide	0	0	0
Phenolic Compounds	0	2100	151
Chlorinated Phenolic Compounds	N/A	N/A	N/A
Total Chlorine Residual	N/A	N/A	N/A
Ammonia (expressed as nitrogen)	30,000	50,500	37,500
Endrin	0	0	0
Hexachlorocyclohexane (aplha, beta, delta & gamma isomers)	N/A	N/A	N/A

For the purposes of this report and based on site specific conditions, the raw sewage characteristics as detailed in Table 3-8 shall be used to assess and design the process capacities for Hornsby Heights STP. These vary to the standard Board's design values for sewage characteristics which are also summarised in Table 3-8.

These values are subject to change when more up to date information becomes available.

TABLE 3-8. DESIGN RAW SEWAGE CHARACTERISTICS FOR HORNSBY HEIGHTS STP

Parameter	Theoretical[1]	Design[2]
Biochemical Oxygen Demand (BOD_5)	280 mg/L	212 mg/L
Chemical Oxygen Demand (COD)	560 mg/L	540 mg/L
Suspended Solids	295 mg/L	240 mg/L
Total Kjeldahl Nitrogen (TKN)	55 mg/L	56 mg/L
Total Phosphorus (T-P)	12 mg/L	13 mg/L
Unbiodegradable Soluble fraction of COD (f_{us})	0.07	0.07
Unbiodegradable Particulate fraction of COD (f_{up})	0.13	0.13
Readily biodegradable fraction of COD (f_{bs})	0.24	0.24
Ammonia fraction of TKN (f_{na})	0.70	0.67
Unbiodegradable soluble fraction of TKN (f_{nu})	0.03	0.03
Alkalinity	250 mg/L at $CaCO_3$	250 mg/L as $CaCO_3$
Peak/Average COD	1.5	1.5
Peak/Average TKN	1.5	1.5
Minimum Temperature	15°C	15°C
Maximum Temperature	25°C	25°C

1. Standard Water Board Design Values.
2. Criteria based on Board's standard sewage characteristics and sampling of Hornsby Heights STP raw sewage flow. When no measured values were available, theoretical values were adopted.

Average and Peak Dry Weather Flows

At present raw sewage flows at Hornsby Heights STP is measured at both the inlet works and after the chlorine contact tank. The flow records for the years 1991 to 1994 indicate the following trends.

The daily raw sewage flows at the Hornsby Heights STP over the past three years are shown in figure 3-11. This is based on data provided by the Board's Hydrographic Branch and daily plant data. The following observations are made with respect to average flows over the past three years.

- There has been an increase of about 10 per cent in average daily flows since 1991 and is attributed to development within the catchment.

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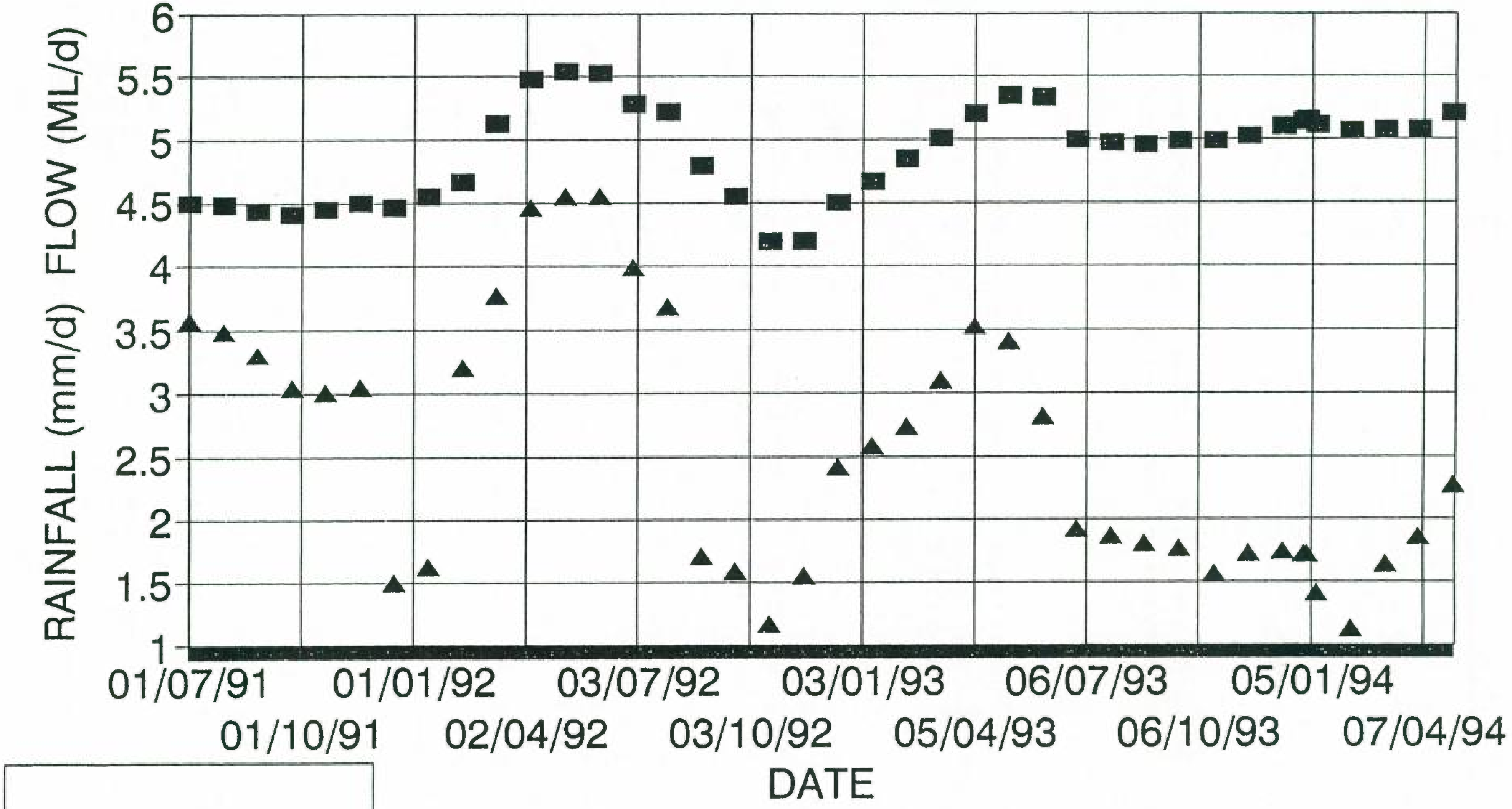


MOVING AVERAGES FOR
SIX MONTHS PERIODS
EVERY 28 DAYS

■ FLOW ▲ RAINFALL

WATER BOARD
SYDNEY-ILLAWARRA-BLUE MOUNTAINS
WASTEWATER AND REUSE PLANNING

HORNSBY HEIGHTS S.T.P.
AVERAGE DAILY FLOW VERSUS ANNUAL RAINFALL

Figure
3-11

- The existing ADWF is estimated at 4.8 ML/d. This value is based on assessment of ADWF for all years (dry and wet) over the three year period.
- The dry weather peaking factor is estimated at 1.8, based on diurnal flow patterns measured at the plant. The typical diurnal flow curve for the plant is shown in figure 3–12.
- Daily flows vary through the week and of weekends and public holidays, flows are often higher. The Saturday morning peak flow rate is about 200 per cent of the daily average.

Wet Weather Flows

Figure 3–13 shows the distribution of daily raw sewage flows into the Hornsby Heights STP for the period January 1991 to December 1993. A summary of relevant dry and wet weather flows for the period are also shown in Table 3–9.

Wet weather flows occur on about 16 per cent of days and account for about 20 per cent of the total annual volume. Ninety five (95) per cent of the daily flows are less than 1.5 ADWF and 99 per cent are less than 2.7 ADWF. The maximum recorded daily flow for the period 1991 to 1993 was 16 ML/d (i.e. 3.6 ADWF), and the estimated peak one hour flow recorded was 14 ML/d on 26 March 1993.

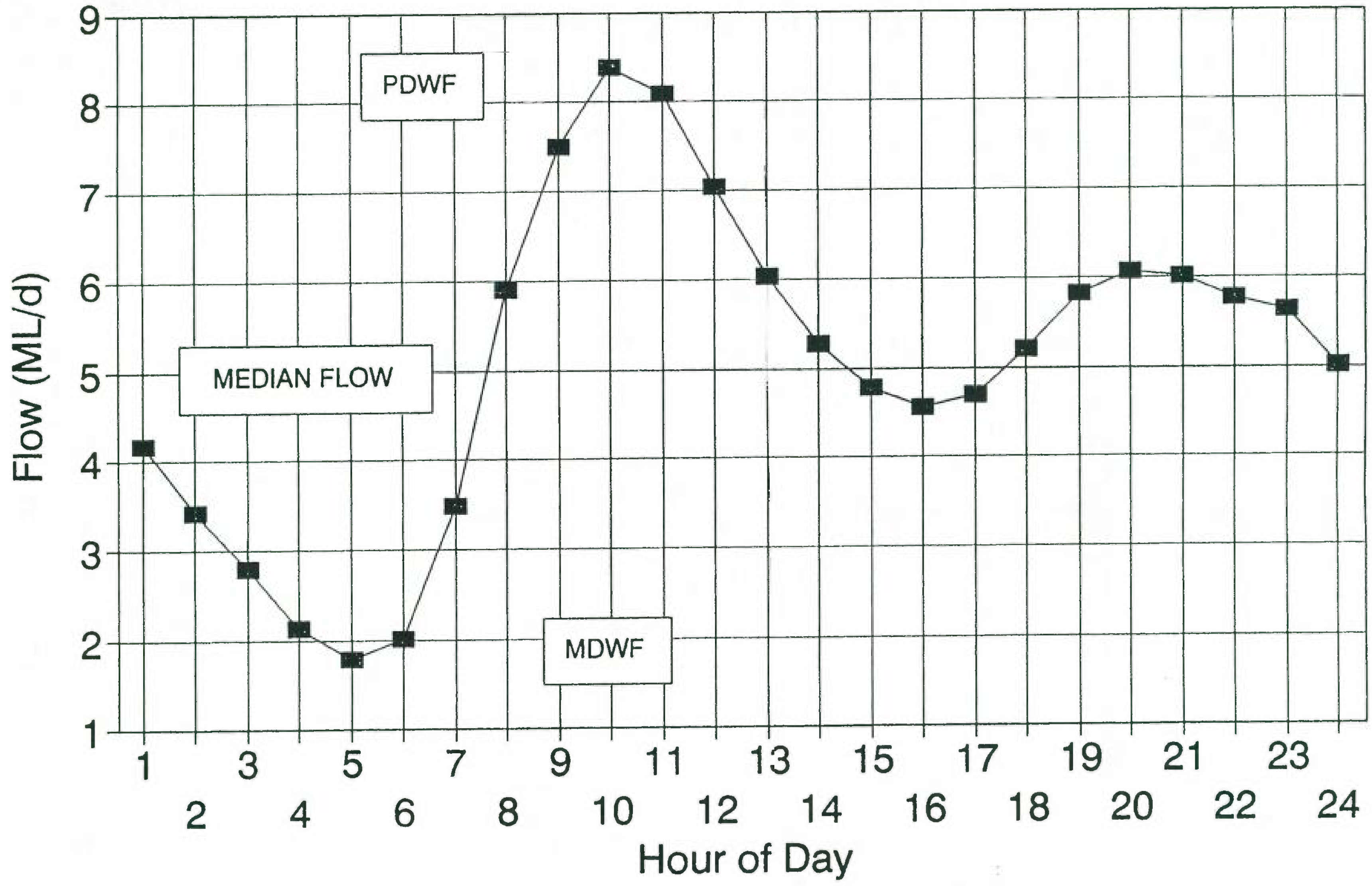
Review of the flow records during periods of high rainfall (1989 to 1994) indicates that wet weather flows to Hornsby heights STP can persist for lengthy periods. The peak 5 day flow each year is typically 12.9 ML/d and the peak monthly flow ranges between 7 to 12 ML.

TABLE 3–9. HORNSBY HEIGHTS STP RAW SEWAGE DESIGN FLOWS AND PEAKING FACTORS FOR THE PERIOD FROM 1 JANUARY 1991 TO 31 DECEMBER 1993

Item	Peaking Factor	ML/d
ADWF	1.00	4.42
50 percentile (median)	1.05	4.64
Minimum hour (MDWF)[a]	0.20	0.86
Maximum hour (PDWF)[a]	2.04	9.0
90 percentile (1 in 10 days)	1.27	5.59
95 percentile	1.45	6.40
Peak 5 days	2.93	12.93
99 percentile (4 days/year)	2.78	12.28
99.7 percentile (1 day/year)	3.44	15.19
Peak 1 day	3.66	16.19
Peak 1 hour[a]	3.17	14.01

Note:
a. Values during 1993 only.

bc-dfc2



WATER BOARD
SYDNEY-ILLAWARRA-BLUE MOUNTAINS
WASTEWATER AND REUSE PLANNING

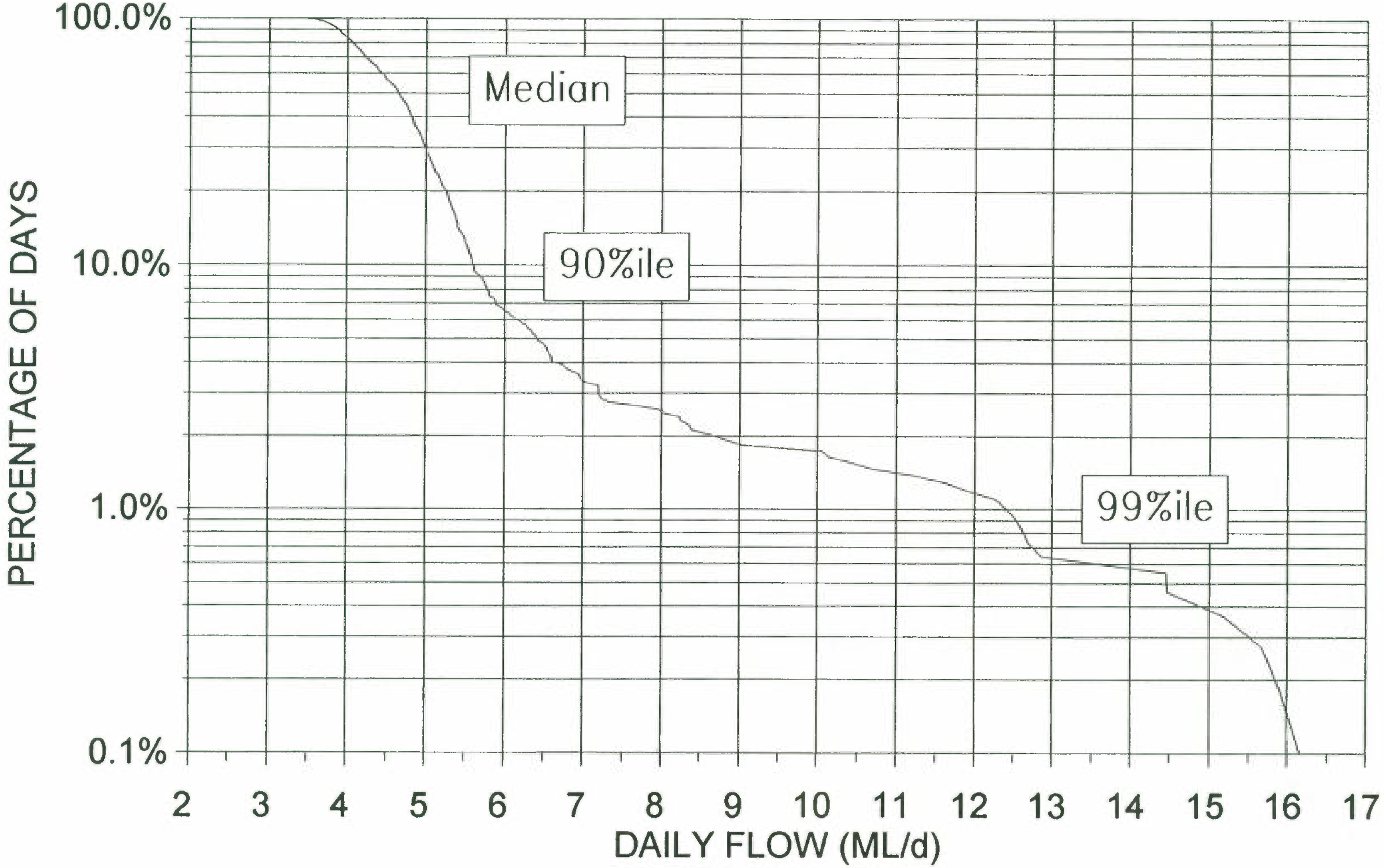
HORNSBY HEIGHTS S.T.P.
DIURNAL FLOW CURVE

Figure
3-12

bc-drsa2

HORNSBY HEIGHTS STP

% OF DAYS FOR FLOW



WATER BOARD
SYDNEY-ILLAWARRA-BLUE MOUNTAINS
WASTEWATER AND REUSE PLANNING

HORNSBY HEIGHTS S.T.P.
DISTRIBUTION OF RAW SEWAGE
AVERAGE FLOW

Figure
3-13

DESIGN ALLOWANCE FOR HORNSBY HEIGHTS STP

The design flow allowances that are treated at Hornsby Heights STP are similar to that discussed on page 3–7. At present no fine screens are installed but shall be considered in this report.

DESCRIPTION OF CURRENT PROCESS AT HORNSBY HEIGHTS STP

A description of each of the treatment processes is given in the following subsections. The general arrangement for the existing plant is shown in figure 3–14.

Preliminary Treatment

The raw sewage influent to Hornsby Heights STP is screened by a mechanically raked bar screen. The screen has 20 mm apertures. Screenings are collected in 240 L bins, bagged, and disposed of at the Eastern Creek landfill. A parallel emergency hand raked screen of 20 mm openings is also provided.

Screened sewage then enters an aerated grit chamber with a minimum detention time of 15 minutes at ADWF. The grit chamber removes heavy, sand–like material which could cause abrasion in pumps and/or reduce the effectiveness of sludge treatment processes. The grit is disposed of with the screenings. The screen and grit chamber are both rated at 20,000 EP. The structure for the second tank has already been built but is not fitted out.

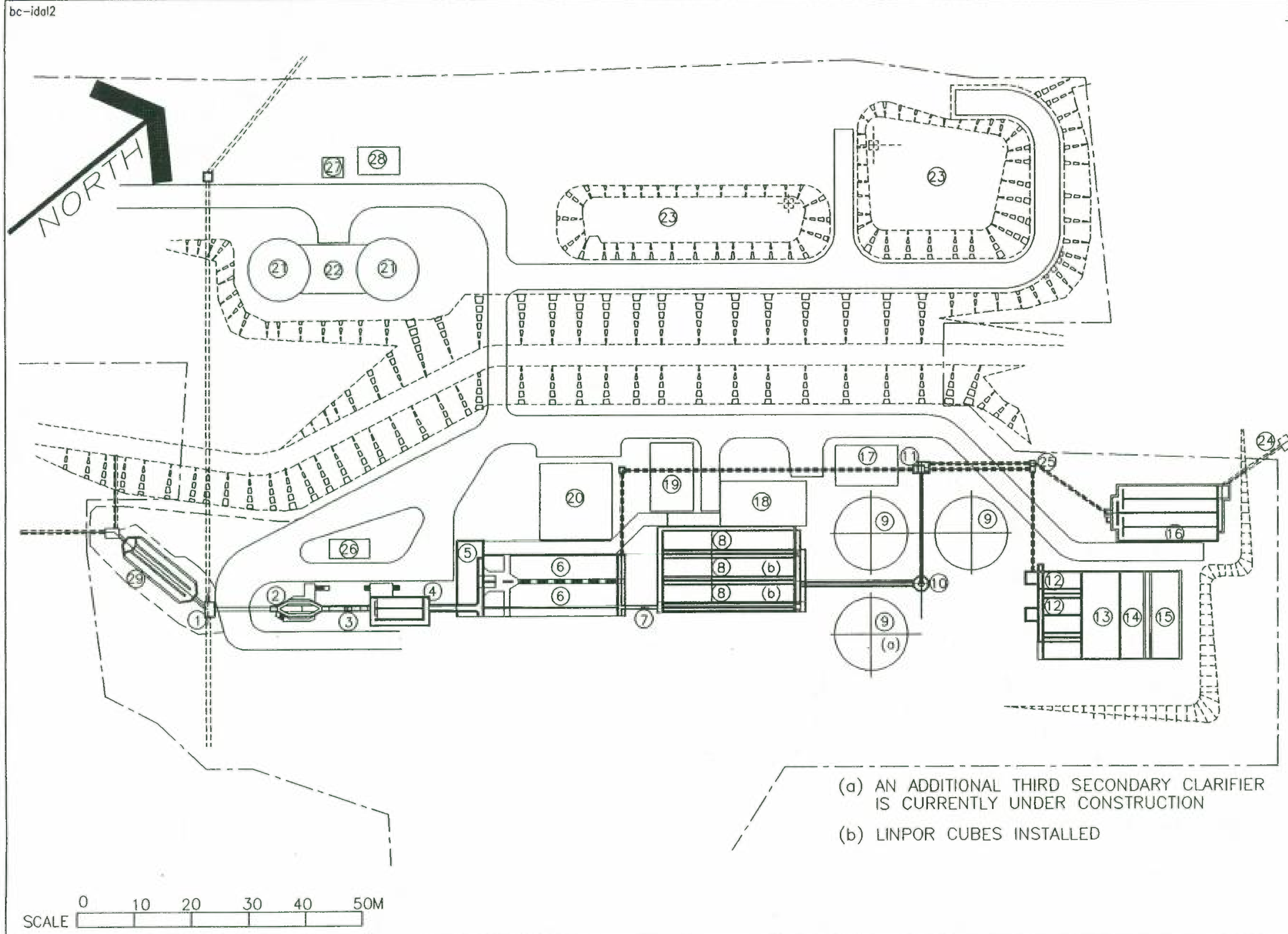
Primary Treatment

The degritted sewage flows to two primary sedimentation tanks (PSTs) with a combined capacity of 20,000 EP (providing 1.2 hours detention time at DWWF). The main function of the PSTs is to remove the readily settleable solids, so reducing the biological load on the secondary process. Each tank is fitted with endless chain type scrapers consisting of two chains with timber flights fixed at regular intervals across them. The timber flights are drawn along the bottom of the tank, moving the settled sludge to a hopper at the inlet end of each tank. In the return direction, the timber flights move along the surface of the tank, moving the floating scum and grease toward the downstream end into a scum collector basin. Scum is removed to a scum hopper by a helical screw conveyor. Sludge and scum are transferred to the anaerobic digesters.

Pickle liquor is dosed to the settled sewage prior to the aeration tanks.

Secondary Treatment

There are three plug flow reactor tanks at Hornsby Heights STP. The combined design capacity of the aeration tanks is reported to be 19,000 EP, based on



LEGEND

1 COLLECTING MANHOLE
2 MECH. RAKED BAR SCREENS
3 CUT–THROAT FLUME (RAW SEWAGE)
4 AERATED GRIT CHAMBER
5 PRIMARY CONTROL BUILDING
6 PRIMARY SEDIMENTATION TANKS
7 CUT–THROAT FLUME (SETTLED SEWAGE)
8 AEROBIC REACTOR
9 SECONDARY SEDIMENTATION TANKS
10 MIXED LIQUOR DISTRIBUTION & EFFLEUNT COLLECTION CHAMBER
11 SECONDARY EFFLUENT DIVERSION STRUCTURE
12 DUAL MEDIA FILTERS
13 FILTER CONTROL BUILDING
14 BACKWASH WATER HOLDING TANK
15 BACKWASH EFFLUENT HOLDING TANK
16 CHLORINATION TANKS
17 CHLORINATION BUILDING
18 BLOWER HOUSE INCLUDING RETURN & WASTE ACTIVATED SLUDGE PUMPS
19 ELECTRICITY SUB–STATION
20 ADMINISTRATION BUILDING
21 DIGESTION TANKS
22 DIGESTION CONTROL BUILDING
23 SLUDGE LAGOONS (DISUSED)
24 OUTFALL TO CREEK
25 SECONDARY EFFLUENT MANHOLE
26 INFLAMMABLE LIQUID STORE
27 WASTE GAS BURNER
28 SLUDGE DEWATERING BUILDING
29 SPS 542

(a) AN ADDITIONAL THIRD SECONDARY CLARIFIER IS CURRENTLY UNDER CONSTRUCTION

(b) LINPOR CUBES INSTALLED

WATER BOARD
SYDNEY–ILLAWARRA–BLUE MOUNTAINS
WASTEWATER AND REUSE PLANNING

HORNSBY HEIGHTS S.T.P.
EXISTING GENERAL ARRANGEMENT

Figure 3–14

nitrification capacity. The influent settled sewage and return activated sludge (RAS) are mixed together in the aeration tanks to form mixed liquor. The mixed liquor flows through each tank and is aerated to keep micro–organisms in suspension and provide them with oxygen. Air is supplied through fish tail distributors.

In order to meet EPA licence requirements of phosphorus concentration in the plant effluent, pickle liquor and alum dosing facilities have been installed in the plant. The lowering of pH due to pickle liquor dosing and nitrification is counteracted by the dosing of lime which raises the pH to an acceptable level. Construction of the lime dosing facilities and alum post–dosing plant have recently been completed to supplement or replace pickle liquor in the removal of phosphorus and ensure sufficient alkalinity is available for nitrification.

The mixed liquor passes out of the aeration tanks to two secondary clarifiers of 19,000 EP nominal capacity.

Scum baffles and mechanical skimming equipment are provided on each clarifier. Settled activated sludge is continuously drawn from the bottom of the clarifiers, and returned to the aeration tanks (as RAS). Activated sludge can be wasted as mixed liquor or settled activated sludge. Currently, Hornsby Heights STP is wasting settled sludge to the primary sedimentation tanks (PSTs).

Tertiary Treatment

Tertiary treatment for flows of up to 3 ADWF for 20,000 EP is provided by two dual media downflow filters. Foul backwash water passes to a 'dirty water' tank and is returned to the head of the plant with sludge supernatant and WAS. Although the present capacity is 20,000 EP, structures for 40,000 EP were provided and the empty cell basins would need to be fitted out and commissioned to increase capacity.

Chemical Dosing

To ensure substantial reduction in the plant's phosphorus level, multi–point dosing is currently being employed. Both pickle liquor (i.e. ferrous chloride) and alum are being used to precipitate phosphorus, with ferrous chloride dosing occurring upstream of the biological reactor, and aluminium sulphate dosing occurring prior to the tertiary filters.

Lime dosing for alkalinity control is also carried out to the settled sewage upstream of the aeration tanks with the flexibility to also dose to the primary sedimentation tanks.

Sludge Treatment

Two heated anaerobic digesters (nominal capacity 40,000 EP) receive the raw sludge and scum from the primary sedimentation tanks. The digested sludge is discharged to a sludge holding basin. Supernatant from the basin is returned to the head of the works while sludge is withdrawn and dewatered with a temporary centrifuge. The polymer Zetag 53 is added to the sludge to improve the dewatering characteristics. Dewatered sludge is trucked away to be used by private companies in the production of compost. This product (biosolids) is used in accordance with the requirements of the Department of Agriculture and the EPA.

Disinfection

All sewage flows are disinfected by chlorination in a chlorine contact tank. The chlorine dose is manually controlled. The chlorination facilities have a nominal design capacity of 20,000 EP.

The chlorinated effluent is discharged to Calna Creek.

Bypasses

Flows greater than 3 ADWF (for 20,000 EP) are bypassed from the downstream end of the PSTs to the secondary effluent diversion structure. The diversion structure collects the secondary effluent and bypassed settled sewage and limits the flow to the tertiary treatment stage to 3 ADWF. The portion of the flow that is greater than 3 ADWF is bypassed directly to the chlorine contact tanks for disinfection and discharge.

Table 3–10 summarises design capacities, capacities currently served and principal dimensions for each unit process.

TABLE 3–10. HORNSBY HEIGHTS STP CAPACITIES AND PRINCIPAL DIMENSIONS OF CURRENT UNIT PROCESSES

Unit Process	**Design EP Capacity (Thousands)**	**Number & Type**	**Dimensions (m)**	**Total Surface Areas (m^2)**	**Total Volume (m^3)**
Screens	20	1 Mechanically (chain driven)	0.6 m wide 20 mm spacing		
Grit Chambers	20	1 Aerated	10.0 m long 2.15 m wide 2.59 m AWD (Average Water Depth)	22	56
Primary Sedimentation Tank	20	2 Rectangular	29.0 m long 5.5 m wide 3.1 AWD	319	989
Biological Reactors	23	3 Rectangular	28.7 m long 5.5 m wide 3.1m AWD		1468
Secondary Clarifiers	19	2 Circulars & 1 Circular	16.1 dia x 3.5 m AWD 21.0 dia x 4 m AWD	407 346	1425 1385
Tertiary Filters	20	2 Dual Media		28	
Chlorine Contact	20	2	20.5 m long 2.8 m wide 2.0 m AWD		230
Digestion	40	2 Anaerobic	12.2 dia x 9 m AWD		2408
Chemical Dosing	20	-			
Sludge Dewatering (Temporary)	20	Centrifuge			

CURRENT EFFLUENT QUALITY AT HORNSBY HEIGHTS STP

Performance data from Hornsby Heights STP for the licence periods, 1992/93 and 1993/94 are summarised in the Table 3–11.

During the 1989/90 licence period the plant failed to comply with the 50 and 90 percentile limits for the total phosphorus and ammonia nitrogen and the 90 percentile BOD limit.

Implementation of flow paced pickle liquor dosing and construction of alum and lime closing facilities and interim upgrading work such as the replacement of the existing diffused air equipment with rubber membrane diffusers has led to dramatic improvements in plant performance.

The effect of the interim upgrading work is reflected in the plant achieving 100 per cent licence compliance as show in Table 3-11 for the 1992/93 and 1993/94 period, especially with regard to phosphorus and ammonia.

TABLE 3-11 HORNSBY HEIGHTS STP EFFLUENT QUALITY 1992/93 and 1993/94 (mg/L)

Parameter	**Licence**			**Plant Effluent**		
	50%ile	**90%ile**	**Geo. Mean**	**50%ile**	**90%ile**	**No Exceeding Geo Mean Limits**
1992/93 Period						
BOD$_5$	15	25	30	2	5	0
SS	15	25	50	1	6	0
NH$_4$-N	15	25		9	22	
TP	2	4		0.4	1	
TN	–	–	–	45	55	–
1993/94 Period						
BOD$_5$	10	15	30	1	3	0
SS	10	20	50	1	5	0
NH$_3$- N	5	20	–	0.3	1.5	–
TP	1.5	3	–	0.5	1.1	–
TN	–	–	–	43	54	–
Faecal Coliforms	–	–	–	2	41	–

Key:

BOD$_5$	Biochemical Oxygen Demand (5 days)
SS	Suspended Solids
NH$_4$-N	Ammonia Nitrogen
TP	Total Phosphorus
TN	Total Nitrogen
50ile	50 of samples must be less than licence limit indicated
90ile	90 of samples must be less than licence limit indicated
mg/L	milligrams per litre
Faecal Coliform units	Counts per 100 mL of sample

LINPOR ACTIVATED SLUDGE PROCESS AT HORNSBY HEIGHTS STP

In late 1992, modifications were carried out upon two of the reactor tanks at Hornsby Heights STP in order to install and trial the Linpor C/N activated sludge process[1].

The Linpor C/N process is a suspended media biological system where the great majority of the biomass is fixed on a highly porous foam in the form of polyurethane cubes. The cubes, create a pseudo–fluidised bed process and are retained within the reactor basins by a perforated metal screen at the effluent weir which only allows mixed liquor to pass through.

Biomass is held at high concentrations within the cubes (generally up to 20,000 mg/L) allowing a higher mass of volatile solids to be carried in the reactor basins. This increased mass of biological solids can achieve greater BOD_5 and ammonia mass reductions for a given volume of tankage without placing extra solids loads on the secondary clarifiers.

The trial aimed to quantify the performance of the Linpor C/N system based upon:

BOD_5 removal efficiency.
Ammonia removal efficiency.
Denitrification potential.

Porous Biomass Support System

The traditional remedy for the improvement of plant efficiency is the enlargement of reactor and/or clarifier volume. Extra reactor volume, aside from being a costly and time consuming action, is very often restricted by land availability. In such cases activated sludge plants with fine bubble aeration can be conveniently upgraded by the application of fixed or suspended media biological system.

The attached biomass are active in BOD degradation, nitrification and denitrification. Simultaneous denitrification is attributed to an anoxic zone in the attached biomass. The establishment of such an anoxic zone may be the result of two separate or synergistic factors. Firstly, the attached film, which develops in the cube pore structure, may be of adequate size to develop substantial anoxic zones. Secondly the cubes themselves may be of sufficient size to limit the transfer of oxygen to the interior of the cubes when they become loaded with biomass.

The Porous Biomass Support System (PBSS) technology has been developed independently in the United Kingdom and West Germany over a period of approximately 10 years. In the United Kingdom researchers at the University of Manchester Institute of Science and Technology develop what is now commercially marketed as the Captor Process by Simon Hartley Ltd. In West Germany, Linde AG has developed what is known as the Linpor Process. The processes, however, differ in both pad size and operational configuration. For Hornsby Heights STP the Linpor process was adopted for trial.

In the Linpor process, the biomass concentration contained within the cube is dependent on the turbulence and shearing action in the reactor basin. Sheared biomass exists as free mixed liquor in the basins and thus a secondary clarifier is required. The Linpor process also uses solids recycle. The cube biomass concentrations of 8,000 to 25,000 mg/L are typical in Linpor systems. To determine the "equivalent" MLSS concentration in a Linpor system, a mass balance including both "cube" and "free" solids must be performed.

Studies have shown that the use of fixed media provides increased BOD removal, nitrification and denitrification per unit volume of tanks by increasing the effective biomass concentration in the aeration tanks. This avoids the high cost of tank enlargement or new tank construction and provides a better ability to accommodate large hydraulic surges.

Advantages of Fixed Biomass System/PBSS

A fixed biomass system has potential advantages not offered by conventional systems. These include :

- The ability to better resist failure from large hydraulic surges.
- Relatively stable nitrification under transient inhibitory conditions resulting from temperature changes, hydraulic surges and/or toxic chemical.
- The ability to establish stable operating conditions with respect to both carbon oxidation and nitrification at short hydraulic retention times and low sludge ages.

Works Undertaken

Polyurethane cubes were put into reactor tanks 2 and 3 taking up 15 per cent of the volume of the tanks. The small, porous, polyurethane cubes are approximately 1 cm^3 with a pore size of approximately 1 mm and an internal surface area per unit volume of 4,000 m^2/m^3. The cubes followed the hydraulic motions of the mixed liquor and build up an internal MLSS concentration of around 20,000 mg/L. At the end of the reactor tank, a mesh screen prohibits cubes carrying over to the secondary clarification system. An air lift pump recycles the cubes to the inlet end of the reactor tank where they impact upon a metal plate, releasing some of the biomass and controlling the cube biomass concentration.

There are two distinct forms of biomass within the Linpor cubes. An outer layer, which has characteristics similar to the free biomass within the aeration tank, and an inner core of fixed biomass which is not regularly exchanged with the free biomass and forms an anoxic zone. Microscopic analysis has revealed that the biomass consists of predominantly stalked ciliates and rotifers with some free swimming ciliates.

The anoxic zone formed in the centre of the cube, produced by a combination of attached films and poor oxygen transfer, has the potential to denitrify resulting in lower lime consumption, lower total nitrogen and lower aeration costs.

Findings

The findings of the recent Linpor Process full scale trial at Hornsby Heights are summarised below:

- Fixed biomass systems have the potential advantage over conventional treatment systems where large hydraulic surges occur, and when stable nitrification and stable operating conditions are required.

- The analytical assessment of the Linpor reactor tanks show an average at ninety seven (97) per cent BOD removal at current peak flow loads for approximately 19,000 EP. The Linpor System provides a better than 60 per cent increase in the nitrifying capacity than a conventional activated sludge system. This analysis is based on reducing the peak ammonia load (PDWF and peak ammonia concentration) below 1 mg/L. This reduction would ensure that time based daily composite samples of effluent ammonia values of less than 0.5 mg will consistently be achieved.

- The present trial configuration of two Linpor and one conventional reactor tank cannot fully nitrify the current PDWF (120 L/s) at peak ammonia loads of around 50 mg/L under existing conditions (free MLSS 3,000 mg/L, cube MLSS 18,000 mg/L, 15 per cent cubes by volume). The use of two Linpor 2 tanks will fully nitrify this current load if the free MLSS is increased to 5,500 mg/L and the Linpor cube concentration is increased by 30 per cent by volume. The adoption of this system would also cope up to a PDWF of 140 L/s. Based on the adoption of this option, the treatment plant capacity for nitrification can be rated at a nominal equivalent population of approximately 19,000 EP at a design TKN value of 55 mg/L. The additional advantage in adopting this Linpor option is that one aeration tank is spare and can be utilised as an anoxic zone if total nitrogen reduction is being considered.

- The trial also found that a number of operational facilities need to be improved and optimised. These included improving screening and grit removal to avoid excessive macro–solids infiltration of the activated sludge process, optimise the operation of the primary sedimentation tanks to avoid excessive solids carry over and avoid anaerobic digestion in the PSTs optimise the pickle liquor and lime addition for proper alkalinity control and chemical dosing optimise the aeration system to ensure D.O levels of 2 mg/L to 4 mg/L are maintained uniformly in the reactor tanks alter the returns of digester and sludge storage supernatant and dewatered sludge centrate into the plant inflow to a lower flowrate for longer periods in order to minimise the peak increases in pollutant loads such as NH4 and TKN and ensure RAS return to biological reactor is not excessive during dry weather conditions.

Installation of the Linpor System in the activated sludge reactor tanks has resulted in an increase of micro–organism concentration per unit volume of aeration tank. This method is, therefore, a viable alternative to extending the reactor volume as the capital costs may be significantly lower.

Better suspended solids control has been observed in the Linpor tank compared to the reactor tanks not fitted with Linpor. Use of the Linpor cubes promotes a high attached growth fraction, allowing increased effective tank MLSS. The solids load imposed on the secondary clarifiers only increases with increasing free mixed liquor concentration, not with the total solids concentration in the reactor tanks. This will maintain the quality of clarified effluent while promoting nitrification. Available literature suggests that the sludge settleability improves with the addition of Linpor cubes which would enhance the performance of the clarifiers.

Substantial ammonia reduction (average 93 per cent at peak load) was obtained in the Linpor tanks, giving a 60 per cent increase over a conventional tank. The Linpor system is, therefore, achieving the performance claimed by the supplier. The system reduces the total space required for aeration and defers the capital expenditure involved in building new tankage.

Recommendation

Implementation of the recommendation stated in the above findings will improve the performance of the plant, giving 24 hour composite effluent ammonia values of 0.5 mg/L consistently. The option to increase the Linpor C/N system volume in two of the reactor tanks will enable the plant to be modified to nitrify for 19,000 EP and allow one reactor tank to be spare. With additional hydraulic modifications to the plant process the plant may be configured to a nitrogen removal plant to reduce total nitrogen in the effluent. This option will be considered further in the upgrading option for Hornsby Heights and West Hornsby STPs.

IMMEDIATE TOTAL NITROGEN REDUCTION AT HORNSBY HEIGHTS STP

Like West Hornsby STP, the Water Board's Inland Wastewater Branch is urgently undertaking process modifications at Hornsby Heights STP to reduce total nitrogen levels discharging to Berowra Creek. At present the plant is currently showing promising results in reducing nitrogen but further installation of infrastructure and sewage conditioning is required.

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SECTION 4

EQUIVALENT POPULATION PROJECTIONS

In order to adequately plan sewage treatment and disposal facilities for a sewage treatment plant catchment, future loads must be projected with a reasonable degree of confidence. These population projections are carried out over a 25 year time span and are reported in terms of equivalent population (EP). An EP is flow-based unit of measurement used to indicated the actual load on, or capacity of, a sewage treatment plant. One EP is defined as 270 litres per day. Note that one EP is not necessarily equal to one head of population.

As they are used within Sewage Treatment Planning for short to medium term planning, it is the first 10 years of the projection which are most relevant to these activities. The further 10 to 15 years projection should be considered as only a broad indication of possible future load. The Board's strategic planning process will consider longer planning horizons.

Keys Young Pty. Ltd. (KY) was engaged to assess and provide the population projection for the West Hornsby and Hornsby Heights catchment. The report is entitled "Water Board Demographic Projections : Hornsby Heights and West Hornsby STP Catchments"[1] . The report findings are summarised and discussed in this section.

This Section provides a brief description of the equivalent population projections for West Hornsby and Hornsby Heights catchments. As the transfer of these catchments to Warriewood and North Head STPs will also be investigated in this study, population growth rates for Warriewood and North Head catchments are also provided. Information relating to Warriewood and North Head catchments are taken from Sewage Treatment Planning's internal planning data.

REGIONAL GROWTH TRENDS

Expectations with respect to population growth in Sydney have been declining over the past four years. The sharp rise in growth rate experienced in 1987 and 1988 failed to be sustained in the face of economic recession and concomitant reductions in nett overseas migration and long-stay movements.

The Department of Planning forecasts and co-ordinates residential and industrial developments in Sydney. The Urban Development Programme[2] (UDP) identified future residential release areas, lot development and infill over a five year planning horizon. The Employment Lands Development Programme[3] (ELDP) identifies proposed industrial zoning in the Local Government Areas (LGAs). In addition, the estimated up-take rate is based on current trends indicated by the Board's Land Availability Data System[4] (LADS).

From the recent trend, it is revealed that the "medium" projections of Sydney's population by the year 2000 are now 5.6% lower than the NSW Population Projections Group (PPG) were anticipating in 1990. Even so, the migration assumptions in the 1993 revision appear to be generous in the light of recent nett gains from overseas. The current policy of containing overseas intakes for a protracted period suggests that the most recent projections may have to be revised downwards yet again in the near future. While growth rates in any one year do not constitute a trend, marked divergence from projection assumptions constitutes one cause for concern. In this context, metropolitan growth of 0.5% pa in 1992-93 is substantially lower than the average level of 0.78% pa that PPG (1993) assumed would occur over the five years from 1991-96 in formulating their low projection.

Development Implications

The implicit potential for reduced pressure on housing demand in the West Hornsby and Hornsby Heights STP catchments is unlikely to have any great effect since land supply is now limited and current rates of subdivision and take-up have remained at sustained levels through the recession.

As land supplies are strictly limited in Berowra and nearing the end of current UDP releases in West Hornsby, it seems likely that current rates of development can be sustained in both catchments while land can be readily converted to urban use.

The need for additional releases in West Hornsby is far more questionable given slower regional growth and the increasing effects of consolidation policies that are being given even greater emphasis in Sydney's new draft planning strategy.

The prospects for urbanising the high quality rural residential projections which comprise the bulk of the non-urban land with the potential for development in this West Hornsby catchment are poor. These properties are valuable now and their value will increase as adjacent urban land is fully developed.

DEVELOPMENT SCENARIOS

The scenarios considered for each catchment reflect the context outlined in "Regional Growth Trends", together with recent trends in residential development and information from Council on the extent of developable land outside the UDP area.

West Hornsby

In line with recent experience, all scenarios, ie. high, medium and low EP projection, for West Hornsby assume that 1.3 dwellings will be built on all UDP lots created after 1991, reflecting a recent trend towards dual occupancy occurring at the development stage. One dwelling per lot has been allowed on lots existing in 1991 or created by infill from 1991 onwards since separate allowance has been made for dual occupancy in existing urban areas.

Setting aside the retirement units in the major villages, about 3% of the 1991 dwelling stock was either multi-unit or dual occupancy. Dual occupancy constitutes the main potential for increasing residential density, although large homes will inhibit this trend. The number of additional dwellings that might be created in the existing area through dual occupancy or infill has been assumed, therefore, to vary between 925 and 1260 between 1991 and 2012, representing total proportion of between 10% and 12% for low, medium and high projections.

All three scenarios anticipate that 200 lots will be created on the Reservoir holdings.

The medium and high projections assume that the UDP areas develop fully, with higher lot yields in the high projection. Both assume that only 59 ha of the Round Corner land (the Lyons holding) will be developed, to yield 725 lots, due to rural residential constraints.

The high projection, however, assumes that additional yield from the remaining UDP lands will be 1600 lots, which is 600 higher than the latest Regional Consultation estimate but a little lower than the LADS upper limit of about 1800 lots.

The low projection assumes that the Round Corner land is not developed before 2012 due to reducing pressure for new lots as population growth is restrained and consolidation effects become greater.

Remaining Rural Residential land in the catchment is expected to continue unsewered. Should this eventually develop (a very remote possibility at best) perhaps 3200 dwellings would be added to the catchment. This is equivalent to eight dwellings per hectare gross, reflecting the constraints that would arise from the fragmented rural subdivision and existing dwellings.

Hornsby Heights

Council has identified three sources of additional land for subdivisions, namely:

- Crown land around Gully Road (capable of yielding 384 lots).
- RTA land at the tollway (to yield 40 lots).

- About 81 ha of other parcels zoned for residential development (capable of yielding about 810 lots).

The high and medium projections assume that all of this new land is developed, while the low projection assumes that the Gully Road area does not develop due to a Land Rights claim.

Dual occupancy and infill have recently run at around 60 dwellings pa. The low, high and medium projections assume that the current rate declines until the 1991 level of 2.6% of dwelling stock increases to 8%, 10% and 12% respectively.

OCCUPANCY RATES

West Hornsby

Two thirds of the 1991 housing stock in West Hornsby was in urban areas outside the UDP. Having developed earlier, occupancy rates (OR) in these areas averaged 3.11 and are declining as expected.

The UDP areas have now been developing for 20 years, and the earlier parts have passed the demographic peak and begun to decline, although recent development continues to keep pressure on detached dwelling OR. Detached dwelling OR appears to be about 4.5% higher than that of the standard release area profile due to the prevalence of 4 and 5 bedroom houses.

Overall OR for all private occupied dwellings in the UDP area is lower than would otherwise be expected due to the inclusion of a series of major retirement village complexes. These have little capacity to expand. Their OR is unlikely to decline greatly or rise as retirees will always make up the resident population.

The OR projection profile for existing dwellings in the catchment has been compiled by combining three individual OR profiles in proportion to the current percentage that they constitute of the existing population, namely:

- The original urban area in which the OR is assumed to decline in line with projected Average Household Size (AHS) for Sydney.
- The retirement complexes, where a nominal decrease has been assumed.
- The UDP lands developed to date, where the OR is assumed to have peaked but to remain about 4.5% above the default profile which has been applied with this general increase.

These assumptions are likely to be generous and actual rates may well be lower.

Dual Occupancies are a recent phenomenon. As Council considers that these mostly consist of three to four bedroom dwellings, a higher-than-average OR has been assigned.

Hornsby Heights

The rate of decline in the OR of existing housing declined more quickly than average Average Household Size (AHS) between 1986 and 1991, but the future decline has been limited to the projected AHS rate.

New detached housing has been projected using the standard release area profile escalated by 4.5%, while the higher than usual higher local rate of 3.2 persons per dwelling has been adopted for dual occupancies as these dwellings are tending to be large.

RESIDENTIAL ADWF

Calibration suggests that the 1993 residential ADWF was 190 L/c/d in Hornsby Heights, and 200 L/c/d in West Hornsby. This appears to be reasonable given the elevation, topography and geology of this area.

The decreasing scenario assumes that generation is declining at 1% pa under the influence of campaigns and technical advances, but that this will bottom out in 1998.

The escalating scenario assumes compound growth at 0.25% pa throughout this period.

INDUSTRIAL DEVELOPMENT

West Hornsby Industry

West Hornsby contains two industrial areas. The Thornleigh estate is fully developed and has a relatively high trade waste component of about 40.7 EP/ha due mainly to one food processing plant. Allowing for domestic generation, this estate appears to be generating about 58 EP/ha in total.

Stage 2C in the UDP area is zoned 3(e) for special industry and commercial use. 17.9 ha is in use and 18 ha remains to be taken up.

This land does not generate significant trade waste and an allowance of 18 EP/ha is likely to be generous. The current average of both industrial areas (40 EP/ha), however, has been used to project demand arising from take-up in the 3(e) zone. This will provide a cushion against some intensification of uses in Thornleigh.

Little demand has been experienced in respect of the remaining 3(e) land, and a nominal take-up rate of 2.0 hectare per annum has been allowed for most of the land with lesser rates at the start and finish of take-up. All of the land has been assigned to development in the next 10 years.

Hornsby Heights Industry

The Beaumont Road estate has a gross area of 91.8 ha, of which 53.6 ha is undeveloped. This remaining land is very steep and may prove slow to develop, the more so since access is not readily available to the freeway and local population/housing growth, which might have attracted occupants, will soon decline.

This estate is restricted to low waste generating uses and employment densities are low. An ADWF of 18 EP/ha has been assumed with little potential to intensify.

This area does not drain to Hornsby Heights STP at present but could be connected to the Cowan-Berowra tunnel. This has been assumed to occur in 1998 for the purpose of this projection.

COMMERCIAL DEVELOPMENT

Neither West Hornsby or Hornsby Heights STPs contains a major commercial centre. Of the current retail provision of 1.6 m^2 per resident, 0.6 m^2 per resident has been assigned to each catchment. About 20% of this area has been added to allow for local commercial services.

An ADWF of 15 EP/1 000 m^2 Gross Floor Area (GFA) has been assumed.

No major "Special Uses" occur in either catchment and no land has been set aside for such uses.

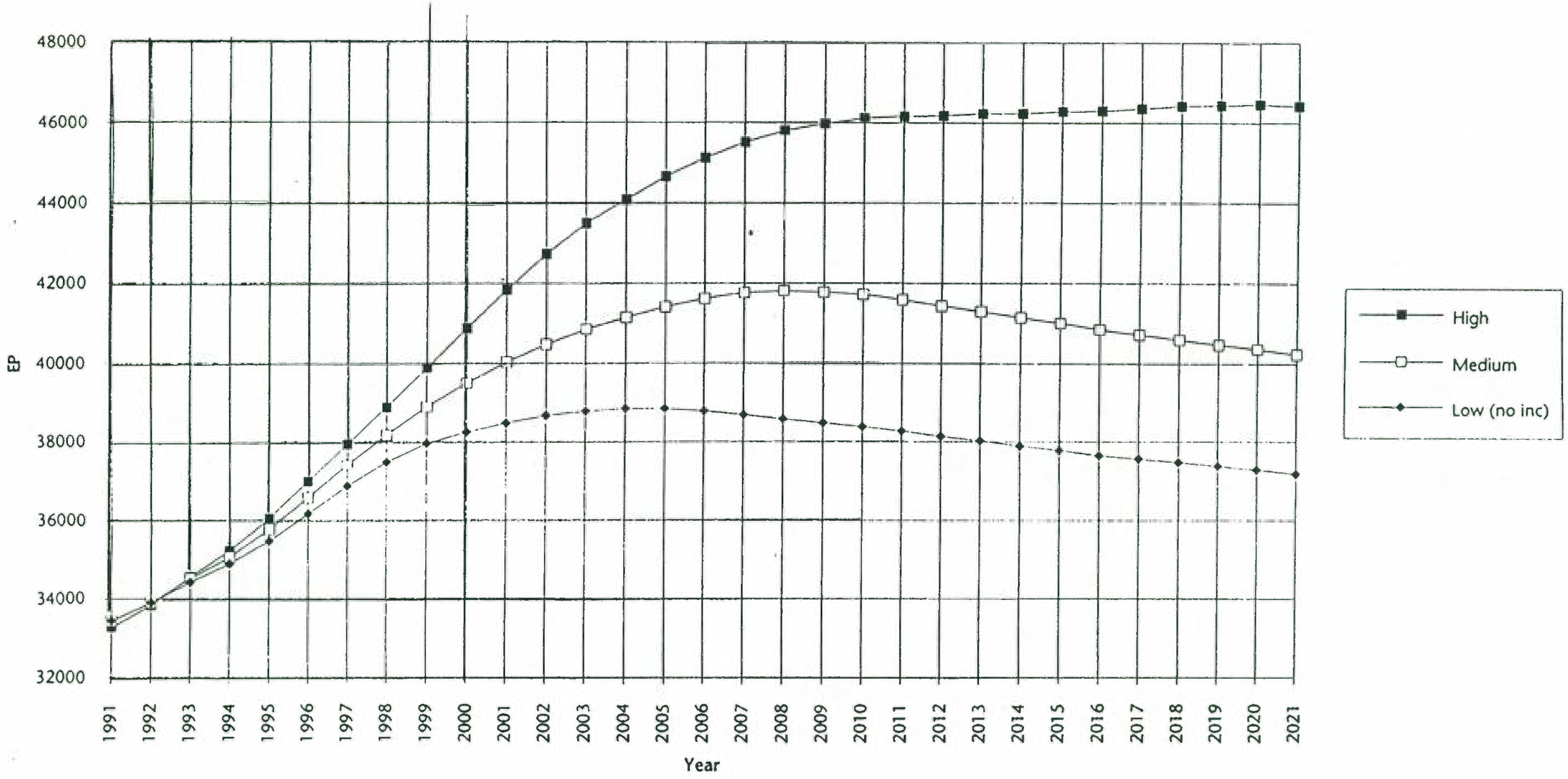
PROJECTED STP LOADS

Tables 4-1 and 4-2 (and the corresponding figures 4-1 and 4-2) show the projected range of growth in the EP to 2019 on West Hornsby and Hornsby STPs respectively.

TABLE 4-1. PROJECTED EQUIVALENT POPULATION FOR WEST HORNSBY

Projections	1994	1996	1998	2000	2005	2010	2015	2019
High	35,209	36,967	38,867	40,864	44,650	46,105	46,284	46,419
Medium	35,043	36,562	38,170	39,496	41,403	41,714	40,997	40,595
Low	34,873	36,142	37,470	38,235	38,839	38,392	37,782	37,463

bc-epp1



WATER BOARD
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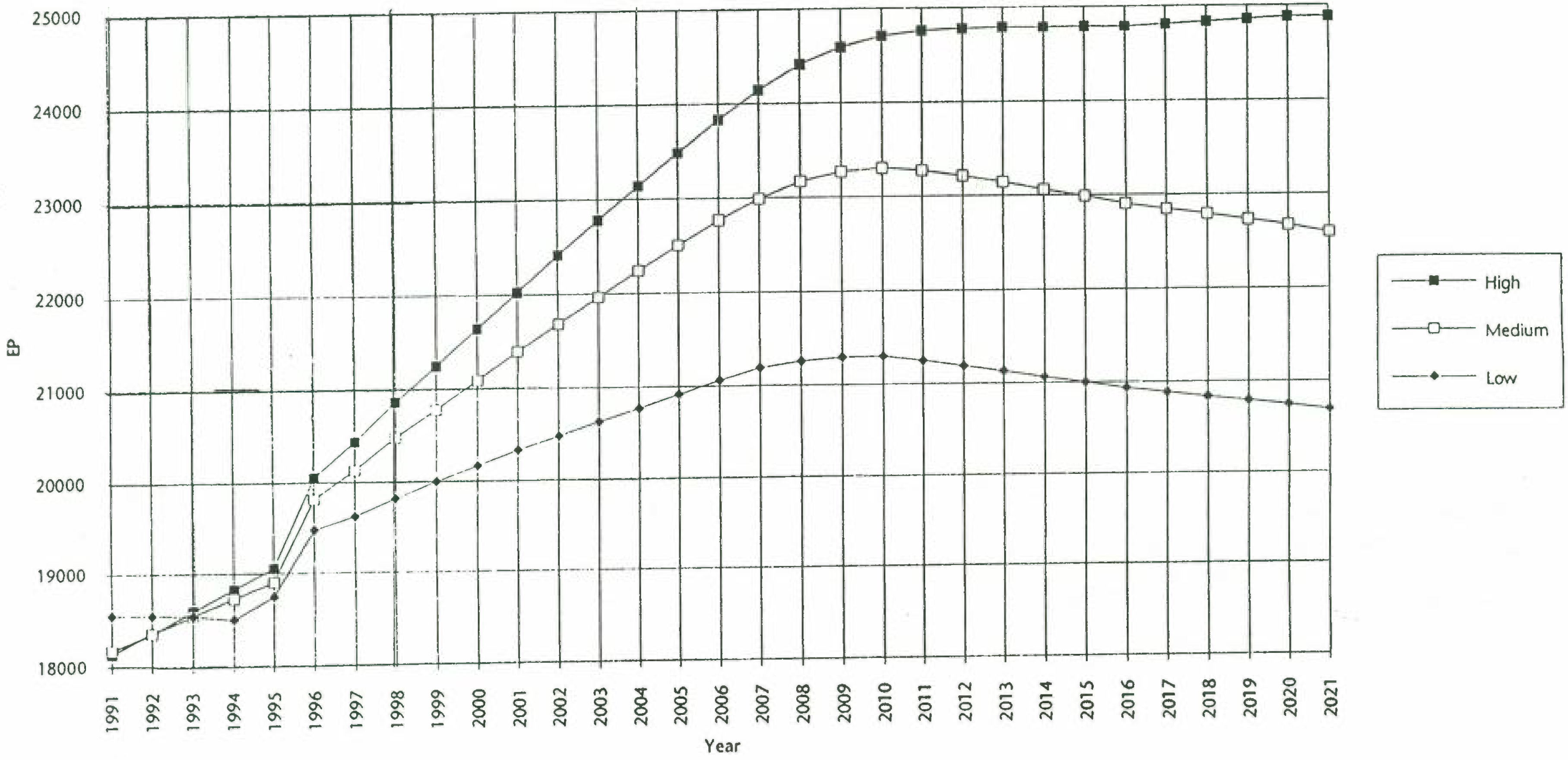
WASTEWATER AND REUSE PLANNING

WEST HORNSBY S.T.P.
EQUIVALENT POPULATION PROJECTION

Figure
4–1

bc-epp2



WATER BOARD
SYDNEY-ILLAWARRA-BLUE MOUNTAINS
WASTEWATER AND REUSE PLANNING

HORNSBY HEIGHTS S.T.P
EQUIVALENT POPULATION PROJECTION

Figure
4-2

TABLE 4-2. PROJECTED EQUIVALENT POPULATION FOR HORNSBY HEIGHTS

Projections	1994	1996	1998	2000	2005	2010	2015	2019
High	18,821	20,048	20,859	21,638	23,480	24,705	24,794	24,836
Medium	18,723	19,822	20,490	21,113	22,553	23,372	23,085	22,891
Low	18,499	19,485	19,828	20,181	20,943	21,335	21,055	20,899

The projection utilises three growth scenarios, based on the adoption of different trends in sewage generation, housing occupancy rates and industrial development densities. The adoption of these scenarios provides a sensitivity analysis on possible growth patterns in the catchment.

West Hornsby

West Hornsby will peak within this period under these assumptions and should continue to decline unless the Rural Residential lands are converted to urban use.

The future maximum ADWF load is likely to range between 10.5 ML/d (38,900 EP-low projection) in year 2010 and 12.5 ML/d (46,400 EP) in the year 2019 (refer Table 4-1).

If the Rural Residential land as discussed previously, was also developed by about 2030, the high projection would rise to about 13.0 ML/d (approximately 50,000 EP).

Hornsby Heights

The future maximum ADWF load is likely to range between 5.8 ML/d (21,400 EP - low projection) in year 2010 and 6.7 ML/d (24,800) in the year 2019 (refer Table 4-2).

Ultimate development of this catchment may involve further infill, but progressive decline in Occupancy Rates will offset gains through redevelopment so that this peak of approximately 25,000 EP should not be exceeded.

WARRIEWOOD CATCHMENT

Warriewood STP is located on Warriewood Road, Warriewood and was commissioned in January 1975. Presently the catchment covers areas north of Whale Beach, Warriewood and parts of North Narrabeen. In total, the catchment measures 25 square kilometres.

As a number of the options under investigation involve the transfer of sewage from the Hornsby plants to Warriewood, the projected load on the STP must be examined. Table 4-3 shows the population projection for Warriewood STP catchment, excluding the effects of any transfers.

TABLE 4-3. PROJECTED EP AND SEWAGE LOADS FOR WARRIEWOOD STP (excluding possible transfers)

Projections	1994	1996	1998	2000	2005	2010	2015	2019
EP	53,300	54,800	57,100	59,900	66,900	73,100	81,300	86,000
ADWF (ML/d)	14.4	14.8	15.4	16.2	18.1	19.7	22.0	23.2

NORTH HEAD CATCHMENT

As with Warriewood transfer of effluent to North Head STP is also an effluent disposal option under investigation. The STP is located on Bluefish Road, Manly and serves most of the northern suburbs between the Parramatta and Hawkesbury Rivers. In total, the catchment measures 416 square kilometres.

Flow projection for North Head is made assuming an ADWF of 374 ML/d in 2011 with no transfers into the system. Table 4-4 shows the projected load in terms of flow (ADWF) and equivalent population (EP).

TABLE 4-4. PROJECTED EP AND SEWAGE LOADS FOR NORTH HEAD STP (excluding possible transfers)

Projected Load	1994	1996	1998	2000	2005	2010	2015	2019
EP (thousands)	307	315	323	331	350	370	390	402
ADWF (ML/d)	1,137	1,166	1,196	1,226	1,296	1,370	1,444	1,489

REFERENCES

1. Keys Young Pty. Ltd., *Water Board Demographic Projections : Hornsby Heights and West Hornsby STP Catchments*, August 1994.

2. Department of Planning, *Sydney Residential Land Urban Development Programme*, 1993.

3. Department of Planning, *Employment Lands Development Program - Sydney Region*, 1991, 1993.

4. Water Board, *Land Availability Data System*, 1991, 1992, 1993.

SECTION 5

WATER QUALITY IN THE STUDY AREA

In 1983 the then State Pollution Control Commission (SPCC) reported an increasing concern about aquatic plant growth associated with high nutrient concentrations in the Hawkesbury-Nepean and its tributaries. Comprehensive sampling/monitoring programmes were implemented, firstly by the Board and the SPCC and then by the newly created Environment Protection Authority.

Available data from the Board's monitoring programme[1] spans the period 1984-1989, while the EPA's most recent monitoring programme covers the period June 1990 to December 1991[2]. The Board has also conducted a separate study on Berowra Creek and its tributaries during 1993 as part of its involvement with the Berowra Creek Technical Working Party. These reports present a good understanding of the overall water quality of the Hawkesbury-Nepean over this period as well as the baseline conditions in Berowra Creek, where both West Hornsby and Hornsby Heights STPs discharge treated effluent.

NEPEAN RIVER

The Board's monitoring of the river through the years 1984-1989[1] show that water quality in the upper areas of the Nepean (Pheasants Nest to Wallacia) was not only affected by agricultural and ever increasing urban development pressures but also by water harvesting from the Board's Avon, Cordeaux, Cataract and Warragamba Dams. During low flow periods point source inputs, such as West Camden STP were found to have a dramatic impact on water quality in the river exacerbated by the lack of diluting flows from upstream.

The water quality of the Nepean was also found to deteriorate downstream of the Penrith weir. A significant increase in the concentration of nutrients, faecal coliforms and ammonia as well as a significant decrease in dissolved oxygen concentrations was considered to be largely as a result of effluent disposal from Penrith STP and also inputs from effluent discharges from Blue Mountains creeks.

The latter EPA monitoring[2] show some improvement in water quality from the 1980's. Significant decreases in concentrations of total phosphorus and ammonia nitrogen have occurred, most likely as a result of the implementation of phosphorus removal and nitrification facilities at STPs throughout the catchment. The impact of sewage effluent on water quality during low flow periods, however, was still found to be significant.

HAWKESBURY RIVER

The Hawkesbury River receives effluent from 23 of the Board's STPs and also from another 4 council and commonwealth operated treatment plants.

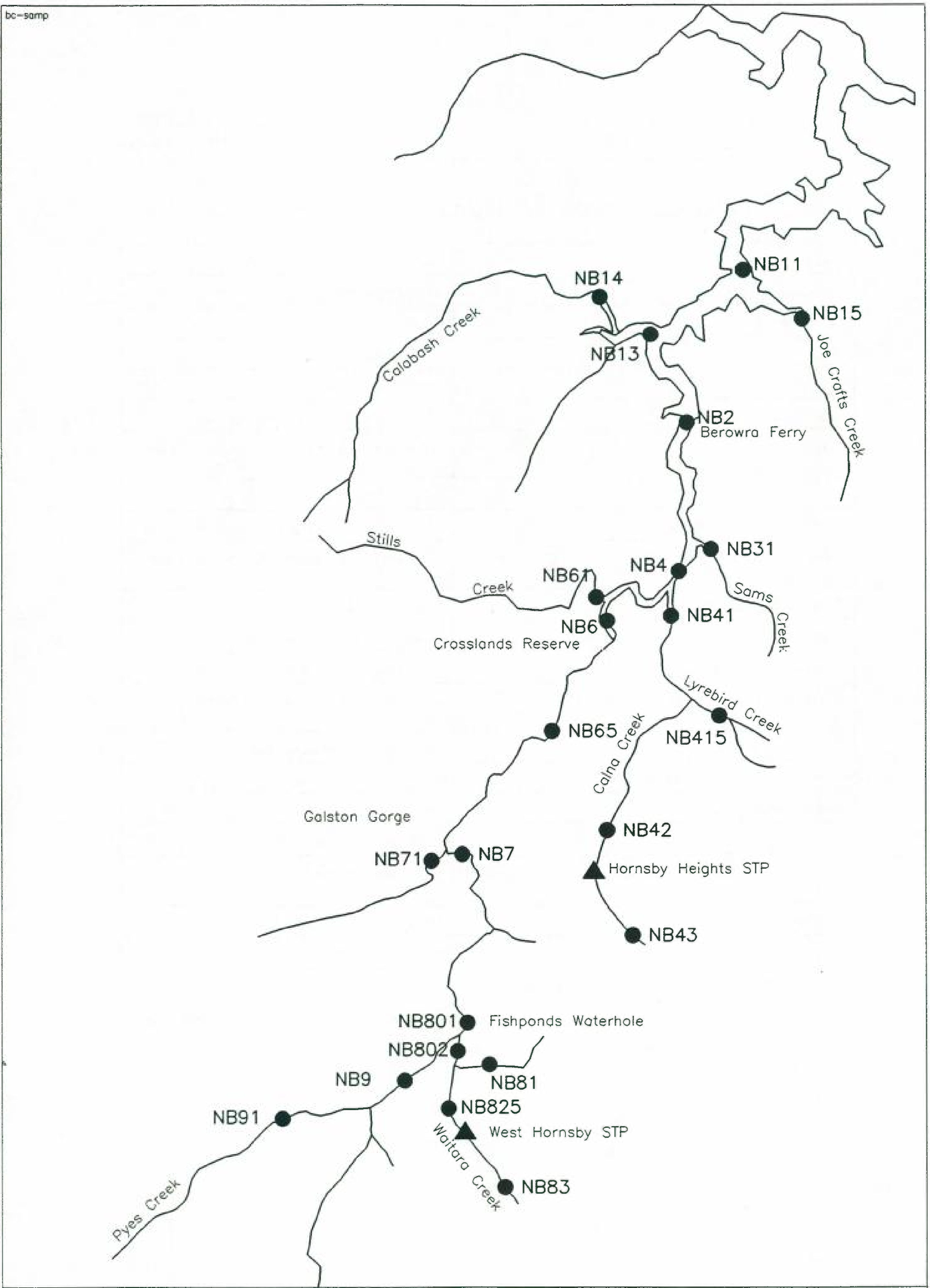
The Board's monitoring for 1984-1989[1] found the water quality to be generally poor for that stretch above the confluence with the Colo River. This was attributed to the influence of several tributaries, namely Redbank, Rickabys, South and Cattai Creeks all of which receive significant sewage effluent flows. Of these, South Creek (which receives effluent from the large Quakers Hill and St Marys plants as well as 4 other plants) appeared to have the largest impact on water quality. This creek causes increased levels of nutrients, faecal coliforms, turbidity and decreased dissolved oxygen in the river.

Again, in the more recent work of the EPA[2], results showed reductions in the concentrations of plant nutrients (particularly phosphorus) in the river. Nitrogen levels have remained static despite there being significant increases in population within the catchment.

BEROWRA CREEK

AWT - Science and Environment was commissioned in November 1992, to carry out a water quality monitoring programme in the Berowra Creek catchment for the Water Board[3]. The sampling programme was designed to assess "baseline" water quality in the catchment during normal operation of the STPs and to assess water quality in the catchment during "event" discharges from the sewage treatment plants (ie. when STPs are on partial bypass). The report[3] describes and interprets data gained during baseline conditions in Berowra Creek, predominantly during dry weather. No attempt had been made to determine the impact of urban runoff, especially in relation to faecal bacteria and nutrients during wet and dry weather conditions, so the relative impact of urban runoff and STP effluent has not been quantified in terms of pollutant loads to Berowra Creek.

Twenty three sites within the Berowra Creek catchment were chosen to characterise Berowra Creek and its tributaries and a large number of water quality variables was measured (Table 5-1). Figure 5-1 and Table 5-2 also details Berowra Creek and its tributaries showing sampling locations and description. Three major types of sites were identified as representative of this catchment. These were freshwater sites up-stream of the plants not influenced by the STP effluent (upstream waters), freshwater downstream of sewage treatment plants (receiving waters) and waters in the inter-tidal zone further downstream (estuarine waters).



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BEROWRA CREEK AND TRIBUTARIES
SHOWING SAMPLING LOCATIONS

Figure No.
5-1

TABLE 5-1. WATER QUALITY VARIABLES MEASURED FOR BEROWRA CREEK

Variable	**Method of Analysis/Measurement**
Temperature (TEMP)	WTW Oxical 196 Dissolved Oxygen Meter
Conductivity (COND)	WTW LF 196 Conductivity Meter
Salinity (SAL)	WTW LF 196 Conductivity Meter
pH	Orion 290A pH Meter
Dissolved Oxygen (DO)	WTW Oxical 196 Dissolved Oxygen Meter
Dissolved Silica (SI)	Automated Skalar Instrument, molybdosilicate method
Total Nitrogen (TN)	TKN + NOx
Total Uncombined Ammonia (AMM)	Automated Skalar Instrument, salicylate method
Oxidised Nitrogen (NOx)	Automated Skalar Instrument, cadmium reduction method
Total Kjeldahl Nitrogen (TKN)	Technicon industrial method 334-74
Total Phosphorus (TP)	Automated Ascorbic Acid Reduction
Suspended Solids (SS)	Gravimetric Filtration through Glass Fibre
Methylene Blue Active Surfactants (MBAS)	chloroform extraction spectrophotometric determination
Chlorophyll-a (CHLA)	Spectrophotometric determination
Biological Oxygen Demand (BOD)	Relative O_2 Requirement
Faecal Coliforms (FC)	Membrane Filtration
Faecal Streptococci (FS)	Membrane Filtration
Boron (B), Aluminium (Al), Iron (Fe), Zinc (Zn), Lead (Pb), Copper (Cu), Cadmium (Cd)	Microwave Digestion ICP-MS
Magnesium (Mg)	Microwave Digestion ICP-AES
Organic Screen# - major contaminants	GC-MS (modified EPA methods 624 and 625)

1 Method for organic screen EPA modified method.

\# Organic compounds screened include phenols, polycyclic aromatic hydrocarbons (PAHs), polychlorinated biphenyls (PCBs), hydrocarbons and organochlorine pesticides (OCPs).

TABLE 5-2. SAMPLING SITES FOR BEROWRA CREEK CATCHMENT

Site	Type	Description
NB11	Estuarine	Berowra Creek at Square Bay
NB13	Estuarine	Berowra Creek at Calabash Point
NB14	Upstream	Calabash Creek above tidal limit
NB15	Upstream	Joe Crafts Creek about tidal limit
NB2	Estuarine	Berowra Creek at Berowra ferry
NB31	Upstream	Sams Creek above tidal limit
NB4	Estuarine	Berowra Creek, midway between Sams & Calna Creek
NB41	Receiving	Calna Creek above tidal limit
NB415	Upstream	Lyrebird Creek upstream of Calna Creek
NB42	Receiving	Calna Creek 100 metres downstream of Hornsby Heights STP
NB43	Upstream	Calna Creek 100 metres upstream of Hornsby Heights STP
NB6	Estuarine	Berowra Creek at Crosslands Reserve
NB61	Upstream	Stills Creek above tidal limit
NB65	Receiving	Berowra Creek at Rockyfalls Rapids, above tidal limit
NB7	Receiving	Berowra Creek at Galston Gorge, upstream of Tunks Creek
NB71	Upstream	Tunks Creek upstream of Berowra Creek
NB801	Receiving	Berowra Creek at Fishponds Waterhole
NB802	Receiving	Waitara Creek upstream of Berowra Creek & approximately 800 metres downstream of West Hornsby STP
NB81	Upstream	Old Man's Creek, adjacent to West Hornsby STP
NB825	Receiving	Waitara Creek 100 meters downstream of West Homsby STP & upstream of Old Man's Creek
NB83	Upstream	Waitara Creek 100 metres upstream of West Hornsby STP
NB9	Upstream	Berowra Creek, midway between Pyes & Waitara creeks
NB91	Upstream	Pyes Creek, off Quarry Road, approximately 1.5 kilometres upstream of its confluence with Berowra Creek

Those sites upstream of the plants include tributaries of Berowra Creek remote from developed areas, and not influenced by STP effluent, as well as those influenced by urban, agricultural runoff, other point sources and septic tank seepage.

WATER QUALITY CRITERIA

The Berowra Creek catchment is used for a number of recreational activities including bushwalking, picnicking and water based activities, such as fishing, boating and swimming. Although these activities appear to be confined to the estuarine sections of the catchment, large pools which are ideal for summer swimming exist in upstream areas.

As the EPA has not defined any protection categories for the Berowra Creek catchment, current uses of the area were considered when determining the most appropriate water quality criteria for comparison with the existing baseline conditions. Thus, all following interpretations are based on comparison of the results with appropriate recreational and modified ecosystem water quality guidelines. This is in line with the Berowra Creek Community Contract which states that "the initial goal for Berowra Creek at Fishpond's Waterhole and downstream shall be consistent with the pursuit of recreational activities such as swimming, canoeing and boating. Furthermore, it is agreed that fishing with confidence and safety and the protection of the shell fish industry is the longer term goal". The values to be protected are defined by ANZECC's "Australian Water Quality Guidelines for Fresh and Marine Waters" and are characterised as Primary Contact Recreation and Protection of Modified Aquatic Ecosystems for Fish, Crustacean and Shellfish.

WATER QUALITY CRITERIA FOR RECREATION AND ECOSYSTEM PROTECTION

Two guidelines, described in the EPA draft Water Quality Criteria for NSW[4], for recreational waters appropriate to this catchment are considered applicable and include primary and secondary contract. These guidelines define the maximum acceptable concentrations of faecal coliforms, pH, nutrients and chemical and toxic substances. The recommended concentrations of chemicals and toxicants in primary contact recreational waters are based on levels recommended in untreated drinking waters as described in the Australian Water Quality Guidelines for Fresh and Marine Waters[5].

Other criteria or guidelines are available for the protection of modified aquatic ecosystems and can be used as an indication of water quality in the catchment[4,5].

The criteria adopted from the above sources for a preliminary comparison of existing conditions are detailed in Table 5-3.

TABLE 5-3. PRELIMINARY WATER QUALITY CRITERIA ADOPTED FOR COMPARISON WITH EXISTING BEROWRA CREEK WATER QUALITY

Water Quality Variable	Primary Contact Recreation (1)	Secondary Contact Recreation (1)	Aquatic Ecosystem Protection (2)
Faecal Coliforms (CFU/100mL)	<150	<1000	-
pH	6.5-8.5	5-9	6.5-9
Total Nitrogen (mg/L)	<0.5	<0.5	<0.5 (1)
Total Phosphorus (mg/L)	<0.05	<0.05	<0.05 (1)
Suspended Solids (mg/L)	-	-	<10 (3)
Ammonia	-	-	Refer to (2) Table 2.3 page 2-31
Boron (μg/L)	<1000	-	-
Aluminium (μg/L)	<200	-	<100
Iron (μg/L)	<300	-	<300
Copper (μg/L)	<1000	-	<5
Zinc (μg/L)	<5000	-	<50
Cadmium (μg/L)	<5	-	<2
Lead (μg/L)	<50	-	<5

(1) Adapted from SPCC, 1990.
(2) Adapted from ANZECC, 1992.
(3) Adapted from SPCC, 1989.

WATER QUALITY RESULTS

The following summary (from Reference 3) addresses water quality in the catchment during dry weather. No attempt had been made to account for the effects of wet weather nor have there been any comparisons of the results between wet and dry weather conditions. The impact of urban runoff during wet weather periods is likely to be significant in terms of sediment, faecal coliforms, nutrient loads and some trace metals.

Tables 5-4 and 5-5 below, provide a comparison of the data sampled at the individual sampling sites to the Water Quality Criteria summarised in Table 5-3 for Primary and

Secondary recreational contact and modified ecosystems. The results are reported as the percentage of time the water quality criteria were exceeded at each site during baseline conditions.

Faecal Coliforms

From the investigations undertaken, faecal coliforms and faecal streptococci concentrations were highly variable across the Berowra Creek catchment and the results indicate that the STPs are not the major source of faecal contamination in the catchment.

In general, sites in the upstream receiving waters had the greater mean concentration of faecal bacteria in the catchment, indicating urban runoff and other sources such as septic tank seepage is a major source of faecal contamination in Berowra Creek. In contrast, the lowest mean concentration of faecal coliforms for the freshwater sites was found in Calabash Creek which is remote from development areas.

TABLE 5-4. PERCENTAGE EXCEEDENCE OF WATER QUALITY CRITERIA AT EACH SITE BASED ON INDIVIDUAL DATA (ADAPTED FROM SPCC, 1990. SCHEDULE 10 AND SCHEDULE 11)

Group	Site	Secondary Contact (%)	Primary Contact (% Exceedance)										
		FC	FC	pH	TN	TP	B	Al	Fe	Cu	Zn	Cd	Pb
		≥1000 CFU/100mL	≥150 CFU/100 mL	6.5-8.5	≥0.5 mg/L	≥0.5 mg/L	≥1000 µg/L	≥200 µg/L	≥300 µg/L	≥1000 µg/L	≥5000 µg/L	≥5 µg/L	≥50 µg/L
Estuarine	NB11	0	0	0	60	0	100	91	100	0	0	9.1	0
	NB13	0	0	18.2	100	0	100	0	100	0	0	18.2	0
	NB2	0	0	0	100	0	100	36.4	100	0	0	9.1	9.1
	NB4	0	0	0	100	36.4	100	54.6	100	0	0	9.1	0
	NB6	0	0	0	100	72.7	100	63.7	100	0	0	9.1	0
Receiving	NB65	0	36.4	0	100	90	0	91	100	0	0	9.1	0
	NB7	11.1	44.4	0	100	100	0	66.7	77.8	0	0	0	0
	NB801	36.4	72.8	9.1	100	100	0	63.7	100	0	0	0	0
	NB41	9.1	18.2	0	100	100	0	27.3	54.6	0	0	9.1	0
	NB42	9.1	9.1	0	100	100	0	9.1	91	0	0	0	0
	NB802	27.3	54.6	0	100	100	0	9.1	72.8	0	0	0	0
	NB825	27.3	36.4	0	100	100	0	9.1	63.7	0	0	0	0
Upstream	NB9	45.4	63.7	0	100	40	0	81.9	100	0	0	0	0
	NB91	36.4	63.7	0	100	18.2	0	91	100	0	0	0	0
	NB31	9.1	18.2	0	10	80	0	63.7	100	0	0	9.1	0
	NB43	36.4	81.9	0	10	0	0	18.2	100	0	0	0	0
	NB81	63.7	100	63.6	40	20	0	54.6	100	0	0	0	0
	NB83	36.4	81.9	0	80	30	0	45.5	100	0	0	0	0
	NB61	0	0	0	50	10	0	91	91	0	0	9.1	0
	NB71	0	0	9.1	20	10	0	18.2	91	0	0	18.2	0
	NB415	27.3	63.7	0	10	0	0	54.6	100	0	0	0	0
	NB15	9.1	27.3	0	10	0	0	63.7	100	0	0	9.1	0
	NB14	0	0	50	11	0	0	30	100	0	0	10	0

TABLE 5-5. PERCENTAGE EXCEEDANCE OF WATER QUALITY CRITERIA FOR THE PROTECTION OF MODIFIED AQUATIC ECOSYSTEMS (ADAPTED FROM ANZECC, 1992)

(% Exceedance)									
Group	**Site**	**SS[a]**	**Amm[b]**	**Al**	**Fe**	**Cu**	**Zn**	**Cd**	**Pb**
		≥ 10 mg/L		**≥100[c] µg/L**	**≥300 µg/L**	**≥25 µg/L**	**≥50 µg/L**	**≥2 µg/L**	**≥5 µg/L**
Estuarine	NB11	27.3	0	100	100	100	27.3	9.1	27.3
	NB13	18.2	0	36.4	100	100	45.5	18.2	27.3
	NB2	9.1	0	63.7	100	100	63.7	9.1	45.5
	NB4	27.3	0	81.9	100	100	36.4	9.1	45.5
	NB6	0	0	91	100	100	27.3	9.1	18.2
Receiving	NB65	36.4	0	100	100	54.6	9.1	9.1	18.2
	NB7	22.2	0	88.9	77.8	88.9	0	0	11.1
	BN801	27.3	0	81.9	100	100	45.5	9.1	18.2
	NB41	0	0	45.5	54.6	72.8	18.2	18.2	9.1
	NB42	0	27.3	27.3	91	91	36.4	0	9.1
	NB802	9.1	0	45.5	72.8	91	9.1	9.1	27.3
	NB825	0	0	18.2	63.7	100	18.2	9.1	27.3
Upstream	NB9	45.4	0	100	100	45.5	27.3	0	45.5
	NB91	45.4	0	100	100	27.3	27.3	0	18.2
	NB31	10	0	100	100	36.4	18.2	9.1	9.1
	NB43	0	0	63.7	100	18.2	27.3	9.1	18.2
	NB81	40	0	63.7	100	27.3	18.2	0	0
	NB83	9.1	0	63.7	100	63.7	27.3	9.1	18.2
	NB61	0	0	36.4	91	0	27.3	9.1	9.1
	NB71	0	0	72.8	91	91	0	18.2	27.3
	NB415	0	0	100	100	0	27.3	9.1	18.2
	NB15	9.1	0	81.9	100	27.3	27.3	18.2	9.1
	NB14	0	0	70[c]	100	20	10	10	10

a. Adapted from SPCC, 1989.
b. Criteria for ammonia dependent on pH and temperature.
c. Criteria <5 µg/L at pH <6.5.

Overall, upstream sites exceed the guideline concentrations for faecal coliforms recommended for safe bathing a greater percentage of the time than sites receiving sewage effluent. The estuarine sites did not exceed recommended guideline concentrations for faecal coliforms for primary or secondary contact recreation on any occasion during baseline conditions. Sites remote from urban areas did not exceed the bathing water guideline concentrations on any occasion sampled.

Nutrients

Concentrations of total nitrogen and total phosphorus were higher downstream of the STPs than those measured upstream, indicating that the STPs are a major source of total nitrogen and total phosphorus in the catchment during dry weather. Concentrations of total nitrogen and total phosphorus in the receiving waters exceeded the guideline values (0.5 mg/L and 50 µg/L) most of the time. Mean concentrations of total nitrogen and total phosphorus were greatest immediately downstream of West Hornsby STP, and gradually decreased away from the STP. Upstream sites exceeded the guideline concentrations occasionally indicating some of the total nitrogen and phosphorus entering the system is from urban runoff. Small unsewered areas in the upstream part of the catchment may also account for higher levels of nutrients.

Total nitrogen levels in the estuarine section exceeded the recommended criteria of 0.5 mg/L. Concentrations of total phosphorus of estuarine sites, however, only exceeded recommended criteria at Crosslands Reserve and downstream of Calna Creek confluence with Berowra Creek.

A long term trend analysis showed a significant linear decrease in total phosphorus concentrations in the Berowra Creek mouth over the period 1982 to 1992.

Biochemical Oxygen Demand (BOD)

The majority of samples collected for BOD analysis were below the detection limit of 1 mg/L.

Concentrations were greatest at Fishponds Waterhole which is downstream of West Hornsby STP and also receives water from Berowra Creek upstream of West Hornsby STP. The highest concentration of BOD recorded during baseline conditions was in Calabash Bay which is adjacent to areas with septic waste disposal systems.

Suspended Solids

Average concentrations of suspended solids were greatest at sites upstream of the STPs and downstream of the developing residential area of Cherrybrook indicating runoff from the Cherrybrook area is effecting water quality in Berowra Creek. Measures need to be put in place to reduce solids loading into the creek system.

Chlorophyll-a

Mean concentrations of chlorophyll-a were greatest in the estuarine group of sites (eg. NB11-11μg/L). The greatest concentration was measured also at site NB11 of 53.53μg/L with the maximum concentration of chlorophyll-a in the freshwater sites not exceeding 10μg/L.

Prior to the November 1992 - October 1993 Berowra Creek Catchment water quality programme, there had only been one sampling point routinely monitored in the Creek and this was located at near the mouth (NB11)[3]. In the period January 1990 to June 1991 a similar median chlorophyll-a concentration was recorded at 9.0μg/L with a 90 percentile of 22μg/L. This data indicates that bloom conditions may occur approximately ten per cent of the time in the downstream end of Berowra Creek.

Metals

Both Tables 5-4 and 5-5 indicate that the concentration of heavy metals measured in the receiving waters generally exceeded either the guideline concentrations for primary contact recreation and/or ecosystem protection.

Guideline concentrations for iron and aluminium were exceeded across the whole catchment, decreasing with dilution from tributaries. Lower concentrations found downstream of the STPs indicated that sewage effluent is diluting the concentrations in the catchment rather than increasing them. Mean concentrations of iron and aluminium were also high in the estuarine section of Berowra Creek and at sites remote from urban areas indicating they are common constituents of the soils and are entering the system through runoff from the catchment.

Copper concentrations recommended for safe bathing were not exceeded at any of the sites in the catchment, however, all estuarine sites on all occasions exceeded the recommended ecosystem protection concentration. Mean concentrations of copper were greatest in the estuarine sites but were greater downstream of the treatment plants than upstream.

Mean concentrations of lead and zinc were low across the catchment and recommended criteria for safe bathing were generally not exceeded. Overall percentage failures were much greater and wide spread across the catchment when concentrations were compared with recommended levels for ecosystem protection.

Toxicants

No organic compounds, with the exception of trihalomethanes (THMs), were detected above 5μg/L. A few sites, downstream of the STPs, had detectable concentrations of THM's which include chloroform, and bromoform. These compounds were most probably formed from the combination of residual chlorine (from plant dosing) and organic matter in the effluent with the highest concentration of THMs being measured downstream of West Hornsby STP.

Based on guideline concentrations for drinking water compliance of THMs, the concentrations found in Berowra Creek catchment are well below the 200μg/L value, and are of little concern. The organic screening for other contaminants also did not identify any compounds in concentration above the detection limit.

MAJOR POLLUTANTS

The preliminary examination by the Berowra Creek Technical Working Party of the progression and changes of water quality in the natural water courses[3,6] indicates that the urbanised West Hornsby and Hornsby Heights subcatchments contain the following primary contributors of pollutants.

Nutrients

The high concentration of nutrients in the estuarine waters has contributed to the regular occurrence of red algal blooms in the lower estuary of Berowra Creek. Immediately downstream of the West Hornsby STP nutrient concentrations are high (typically total nitrogen 20 mg/L and total phosphorus 0.36 mg/L) and similar concentrations are found downstream of Hornsby Heights STP (ie total nitrogen of 15 mg/L and total phosphorus of 0.27 mg/L). Tables 5-6 and 5-7 respectively provide water quality data for Berowra Creek and tributaries to which the Water Board's plants discharge. The concentrations gradually decrease through dilution and assimilation as the waters travel to the estuarine section of the Creek. The measured nutrient concentrations may result in algal blooms in both the fresh and estuarine waters downstream of the plants.

On an annual basis, West Hornsby and Hornsby Heights STPs contribute approximately 22 percent of the total phosphorus and 85 per cent of the total nitrogen load entering Berowra Creek. Runoff from developed areas appears to be the dominant source of phosphorus.

TABLE 5-6. WATER QUALITY DATA CALNA CREEK AND BEROWRA CREEK NOVEMBER 1992 - OCTOBER 1993

Site		Median Values (mg/L)						Faecal Coliforms CFU[a]/100 mLs	Chlorophyll[a] (ug/L)
		Total Phosphorus	Total Nitrogen	Total Ammonia	SS	BOD	DO		
NB 43	(just upstream of Hornsby Heights STP)	0.019	0.30	0.01	1.2	0.60	6.0	429	0.4
NB 42	(just below STP discharge)	0.27	15	0.15	1.30	0.63	8.3	13	0.2
NB 41	(just upstream of Berowra Creek confluence)	0.17	14	0.14	0.9	0.53	8.5	57	0.3
NB 4	(below Berowra Creek confluence)	0.042	1.72	0.09	2.4	0.53	5.4	11	4
NB 2	(Berowra Ferry)	0.035	1.05	0.07	1.6	0.70	6.3	9	7
NB 13	(confluence of Berowra Creek & Calabash Creek)	0.028	0.78	0.06	2.3	0.96	7.5	7	10
NB 11	(confluence of Berowra Creek and Hawkesbury River)	0.024	0.57	0.04	5	0.9	7.6	2	11

[a] CFU = Colony forming units

Source:
AWT Science and Environment Reference 3.

TABLE 5-7. WATER QUALITY DATA WAITARA AND BEROWRA CREEK (TO CROSSLANDS RESERVE) NOVEMBER 1992 - OCTOBER 1993

Site		**Median Values (mg/L)**							
		Total phosphorus	**Total Nitrogen**	**Total Ammonia**	**SS**	**BOD**	**DO**	**Faecal Coliforms CFU/100 mL**	**Chlorophyll a(ug/L)**
NB83	(Just upstream of West Hornsby STP)	0.04	0.8	0.08	1.8	1.0	6.2	456	0.60
NB825	(Just downstream of STP)	0.36	20	0.10	1.0	0.80	7.5	104	0.30
NB802		0.35	21	0.06	1.4	1.2	8.0	228	0.60
NB801	(Confluence of Pyes Creek and Waitara Creek at Fishponds Waterhole)	0.19	13	0.14	5.3	1.8	7.8	359	0.30
NB7	(Galston George Berowra Creek)	0.13	16	0.06	4.3	0.80	8.5	163	0.80
NB65	(Berowra Creek)	0.12	10.10	0.03	5.4	0.60	8.1	106	1.30
NB6	(Crosslands Reserve)	0.058	3.7	0.1	2.5	0.63	5.6	42	4.4

a. CFU = Colony Forming Units

Source: AWT Science and Environment Reference 3.

Further work is required to understand the relative roles of nitrogen and phosphorus in algal growth in the particular waters of Berowra Creek. Indicative receiving water guidelines reflect the view that lower nitrogen levels are needed in estuarine waters than freshwater if algal growth is to be prevented.

Median chlorophyll-a in Berowra Creek was relatively low, indicating the extent of suspended algae in the water column is relatively low on most occasions.

Based on the above preliminary findings the TWP has recommended that nitrogen removal at West Hornsby and Hornsby Heights STPs, or transfer of effluent out of the catchment, is necessary to reduce creek nutrients to an acceptable level. A program to identify and control other sources of nutrient discharges is imperative to help progress Berowra Creek's ecological sustainability.

The TWP had also directed the Water Board to immediately implement measures at the existing West Hornsby STP to reduce Total Nitrogen discharges by June 1994 if feasible. A considerable amount of effort is currently underway at the plant to endeavour to achieve a Total Nitrogen concentration of 20 to 25 mg/L (arithmetic mean) in the discharged effluent using existing facilities on site. Also, the Board is making operational changes to further reduce phosphorus and faecal coliform concentrations in the discharge effluent from West Hornsby and Hornsby Heights STPs.

Faecal Contamination

Monitoring by both the Water Board and Hornsby Council has found very high levels of faecal bacteria occur during and after wet weather both upstream and downstream of the Water Board's sewage treatment plants. Prior to the TWP being formed, high levels of faecal bacteria may have been attributable to bypasses of the sewage treatment plants, however, the plants would not appear to have been the cause of recent episodes of high levels of faecal bacteria.

The TWP has indicated their concern with the continuing high levels of faecal bacteria in the catchment, especially with regard to Pyes and Georges Creek upstream of West Hornsby STP.

Immediate catchment investigation has been recommended to identify the particular sources of faecal pollution so that appropriate action to protect health can be taken. Some operational improvements are currently being undertaken by the Board at Hornsby Heights and West Hornsby STPs in order to achieve greater consistency in disinfection.

Sediments

Severe sedimentation of the tidal and fresh water sections of Berowra Creek is apparent in all waterways downstream from urban development. A considerable quantity of sand has entered Berowra Creek over the last 20 years. The principle sources of silt are unvegetated construction sites and development areas.

Sediments are carriers for a wide range of pollutants including nutrients and thus a reduction in sediment input would greatly assist in reducing nutrient problems in the Creek. As stipulated previously, runoff controls for sediments and, especially with regard to phosphorus loadings, would seem to be imperative.

Metals

Although not detailed as a major concern by the Berowra Creek Technical Working Party, heavy metals that are either directly being discharged via point sources or entering by leachate or urban runoff may pose a problem in meeting the proposed ANZECC guidelines for the protection of modified aquatic ecosystems and primary recreational contact. From Table 5-4 and 5-5, guideline concentrations for the major metals are exceeded across the whole catchment, decreasing with dilution from tributaries. Lower concentrations downstream of the STPs indicate that sewage effluent is diluting the concentrations rather than increasing them. Adequate catchment management practices will need to be put in place to minimise their potential effect.

SUMMARY

Although the Berowra Creek Technical Working Party has indicated that the treatment plants may have a major impact on the receiving waters, especially with regard to high nitrogen discharges, other contributions such as urban and natural bushland runoff, sewer storm overflows, diffuse dry weather inputs from septic systems etc, will impact on the water quality in Berowra Creek. A total catchment management approach needs to be adopted to prevent further deterioration in the creek and provide a frame work to help achieve the water quality goals set by the Community Contract.

REFERENCES

1. Water Board, *Hawkesbury-Nepean Programme River Water Quality* 1984-1989, March 1992.

2. Environmental Protection Authority, *Interim Water Quality Report Hawkesbury-Nepean River System*, from June 1990 to December 1991, November 1992.

3. AWT Science and Environment, *Water Quality in Berowra Creek Catchment*, October 1993.

4. SPCC, *Water Quality Criteria for New South Wales, Discussion Paper*, 1990.

5. ANZECC, *Australian Water Quality Guidelines for Fresh and Marine Waters*, 1992.

6. Berowra Creek Technical Working Party, *Report of Berowra Creek Technical Working Party*, May 1994.

SECTION 6

EFFLUENT QUALITY AND DISPOSAL

This section outlines the background to the development of appropriate water quality targets for the Hawkesbury-Nepean River catchment and it's tributaries and their relevance to the effluent targets requested to be examined by the Technical Working Party and Community Contract for Berowra Creek. It also examines the effluent quality to be achieved if the strategy of exporting sewage from the West Hornsby and Hornsby Heights catchments to the ocean is adopted. If effluent is beneficially used, the level of treatment required will be determined by the type of reuse envisaged. Effluent reuse and associated effluent quality will also be discussed.

HAWKESBURY-NEPEAN CATCHMENT

In the late 1970's and early 1980's, the concerns of increased water pollution within the Hawkesbury-Nepean River catchment led the then State Pollution Control Commission (SPCC) to undertake studies into the water quality of the river system. These studies led to the publishing of two principal reports[1,2] which outlined the SPCC's strategies for progressive control of point source nutrient discharges from both existing and future STPs.

The SPCC's 1985 Hawkesbury-Nepean strategy[2] generally involved the correction of the existing low flow water quality problems and the provision of a substantial measure of protection of water quality into the next century. The strategy was formulated as a joint task between the SPCC and Water Board, and included specific design options for the Board's future plant upgrades and augmentations.

A number of ultimate goals were set by the SPCC for river water quality depending upon the classification of the water. Mean concentrations for mainstream water of the river (under dry conditions) were set as follows:

Total Phosphorus	≤0.05 mg/L
Total Nitrogen	≤0.5 mg/L
Total Chlorophyll	≤0.02 mg/L

In order to attempt to achieve these river standards, the SPCC's strategy recommended the following targets for the reduction of nutrient concentrations in treated effluent from specific groups of treatment plants to be achieved by mid 1989:

Total Phosphorus	1 mg/L (90 percentile)
Total Nitrogen	15 mg/L (weighted mean for all plants discharging to or downstream of South Creek)
Ammonia	2 mg/L (50 percentile) 5 mg/L (90 percentile)

Immediate priority was to provide nitrification and phosphorus removal facilities at large and medium sewage treatment plants (STPs).

In March 1985 the Water Board adopted the following staged nutrient control policy to improve water quality in the Hawkesbury-Nepean River:

- Continue the then current programme of installing nitrification (ammonia removal) facilities at major STP's. Such facilities would lower the oxygen demand on receiving waters and reduce the potential toxic impacts of ammonia on aquatic life.

- Continue the then current programme of installing phosphorus removal facilities at existing large and medium sized STPs and some small STPs as appropriate. Whilst this phosphorus removal was initially to be carried out using chemical means, biological methods of phosphorus removal were to be investigated and used at future plants whenever practicable.

- Implement partial (summer only) denitrification (nitrogen removal) where feasible at existing major STPs and implement year round denitrification at future plants or augmentations of existing plants where economically viable. It was also agreed to continue the monitoring of the river (which the Board had done since 1972) and to liaise with the SPCC to determine the need for, and degrees of, further nitrogen removal.

In 1991 the SPCC advised that it believed a blanket effluent 90 percentile quality of 15 mg/L nitrogen and 1 mg/L phosphorus would protect the main body of the River from further rapid water quality deterioration.

Recently, the Environment Protection Agency (EPA) has indicated that a higher effluent quality is required for discharges from STPs to facilitate recovery of the river rather than merely halting further degradation. Ultimate in-stream water goals of 0.5 mg/L nitrogen and 0.05 mg/L phosphorus for the Hawkesbury/Nepean river and its tributaries were suggested in "Water Quality Goals and Objectives for New

South Wales"[3].

The EPA recognised, however, the difficulties and financial burden that would be imposed on sewerage authorities to achieve the very high levels of treatment that would be needed to meet the water quality goals and proposed an interim effluent quality target that is described as Best Available Technology Economically Achievable (BATEA). The BATEA effluent nutrient target is 10 mg/L total nitrogen and 0.3 mg/L phosphorus (both on 90 percentile bases). This is also the effluent quality currently proposed by the EPA for discharge of effluent into sensitive inland waters[4] as shown in Table 6-1. This effluent quality is also similar to that identified as being required for the protection of the receiving waters in the Environmental Assessments carried out for the Winmalee, Picton and Rouse Hill STP's.

TABLE 6-1. EPA SEWAGE EFFLUENT OBJECTIVES FOR EFFLUENTS DISCHARGED TO SENSITIVE WATERS[a,b] (90 PERCENTILE)

Pollutant	Requirement
Biochemical Oxygen Demand (mg/L)	10
Non Filterable Residue (mg/L)	15
Total Nitrogen (mg/L)	5 - 10
Ammonia Nitrogen (mg/L)	1
Total Phosphorus (mg/L)	0.3
pH	6.5 - 8.5
Faecal Coliforms (org/100 mL)	200

a. The level of sensitivity of receiving waters would be determined by the EPA.

b. The standard achievable with current technology commercially available to be required immediately for sensitive waters (eg. potable water supplies, body contact recreation, fish shellfish production etc).

Although the EPA has sought to impose tight controls on the discharge concentrations of both phosphorus and nitrogen from the Board's inland STPs, there is considerable debate as to the need to reduce **both** of these nutrients to very low levels.

A recent review carried out by Kinhill Metcalf and Eddy[5] (KME) concluded that there could be little justification for reducing total nitrogen levels below 15 mg/L provided that phosphorus concentrations in the river were maintained below 0.05 mg/L. The degree to which the effluent phosphorus concentration would need to be reduced to meet this in-stream requirement is not certain. An initial goal of 0.3 mg/L total phosphorus in the effluent, however, would seem to be reasonable.

The KME review also forwards the view-point of ignoring effluent total nitrogen limits in favour of applying only low ammonia and phosphorus levels.

The basis for minimising the importance of nitrogen removal in the KME report was that there are a number of species of blue-green algae that can exploit both high and low nitrogen concentrations. When nitrogen is in short supply relative to phosphorus, the species of blue-green algae with the ability to fix atmospheric nitrogen may have a competitive advantage over other species (for example, in the 1991 blooms along the Darling River[3]). At higher concentrations of nitrogen in water bodies blooms of other species which cannot fix nitrogen may result. It is argued that nitrogen control may make little difference to the blue-green algae water quality problem other than to change the species responsible for causing it.

Discharging effluent containing a low concentration of phosphorus but with little associated nitrogen removal, results in high N:P ratios. This is the strategy adopted by the Australian Capital Territory (ACT) in the design and operation of its Lower Molonglo Water Quality Control Centre, which discharges to the Murrumbidgee River. It is often accepted that an N:P ratio of 15:1 is the minimum needed in receiving waters to avoid nitrogen limitation and the possible development of undesirable blue-green algae. The ACT strategy has been successful in controlling algal blooms in the Murrumbidgee River and Burrinjuck Dam.

An additional consideration is the nature of the nitrogen discharged in effluents. Nitrogen in the form of ammonia is acutely toxic to fish and high concentrations can decrease the growth of plants and decrease the assimilative capacity of a waterway. It is necessary, therefore, to ensure low levels of ammonia in effluent discharged to receiving streams offering a low level of dilution irrespective of the overall degree of nitrogen removal.

An effluent ammonia concentration of 1 mg/L has been suggested in the guidelines prepared by the Australian and New Zealand Environment and Conservation Council (ANZECC)[6]. This level is based on data derived from the U.S. Environmental Protection Agency (USEPA) for cold water fish. The appropriate level is a function of both pH and temperature, and as reported in the Kinhill Report[5], the suggested limit of 1 mg/L may prove to be overly restrictive for Australian fish species.

BEROWRA CREEK COMMUNITY CONTRACT REQUIREMENTS

With reference to the Berowra Creek Technical Working Party's Report[7], nitrogen removal at West Hornsby and Hornsby Heights STPs or pumping of effluent to outside the catchment are considered necessary to reduce creek nutrients.

Further work is required to understand the relative roles of nitrogen and phosphorus in algal growth in the particular waters of Berowra Creek. Indicative Australian Water Quality guidelines reflect the view that lower nitrogen levels are needed in estuarine waters than freshwaters if algal growth is to be avoided. This has led to the request for an options study for the two Hornsby STPs. This options study examines technically feasible measures for further nitrogen reduction. The options of 15 mg/L, 10 mg/L and 5 mg/L total nitrogen in discharged effluent to the creek are to be specifically considered. Although no actual value for effluent phosphorus levels were specified, operational improvements were requested at and below current performances. This relates to a total effluent phosphorus level of approximately 0.3 mg/L (90 percentile values). Faecal coliforms were also to be lowered to more stringent levels and be consistently achieved.

Selection of Effluent Quality Targets for Berowra Creek

Based on the above information, this options report considers a number of total nitrogen effluent quality targets that have been selected by the Technical Working Party, with total phosphorus and other effluent quality targets being supplemented by the expected future or existing requirements of the Environment Protection Authority.

The various effluent quality targets that have been adopted will enable the TWP and community as a whole, to assess the relative impact of improved effluent quality on capital and operating costs, and determine an appropriate staged implementation program for the catchment if considered feasible.

Table 6-2 indicates the three principal target effluent qualities adopted for determining future sewage treatment needs at the plants which will continue discharging to the riverine systems under options developed in this report.

The Level 1 target in Table 6-2 is considered to represent the minimum acceptable standard for effluent discharges to the Hawkesbury-Nepean River. This is based on the premise of the emerging belief that minimising total nitrogen removal may make little difference in reducing the incidence of toxic algal blooms. This target concentrates on achieving a high level of phosphorus and ammonia removal and partial nitrogen removal only. It is also noted that utilising the denitrification potential of the process will reduce aeration and lime costs.

The Level 2 target is considered to represent that level of treatment which the EPA believes will lead to an improvement in river water quality, rather than merely halting further degradation.

The Level 3 has been requested by the TWP and is based on the target effluent quality expected from the recently commissioned Rouse Hill plant and the EPA sewage effluent draft objectives for effluents discharged to sensitive waters (Table 6-1 above).

TABLE 6-2. TARGET EFFLUENT QUALITIES (90 PERCENTILE) FOR WEST HORNSBY AND HORNSBY HEIGHTS STPs

Parameter	Level 1	Level 2	Level 3
Biochemical Oxygen Demand (BOD_5)	10	10	10
Suspended Solids (SS)	10	10	10
Ammonia (NH^3)	5	1	1
Total Nitrogen (TN)	15	10	5
Total Phosphorus (TP)	0.3	0.3	0.3
Faecal Coliforms (Org/100 ml)	200	200	200
pH range	6.5 - 8.5	6.5 - 8.5	6.5 - 8.5

a. TN level requirement would be consistent with current plant performance.

OCEAN DISCHARGES

As an alternative to the discharge of effluent into the Berowra Creek or Hawkesbury-Nepean Catchments, the transfer of West Hornsby and Hornsby Heights sewage to the ocean plants at either Warriewood and North Head will be developed in this options study.

Due to the extensive nature of marine discharge requirements for the Sydney Region, Appendix A identifies the main environmental requirements/guidelines to be considered if discharging to the ocean. A summary of the effluent quality criteria applicable to sewage treatment plants discharging to the ocean off Sydney is provided below.

Effluent Quality Criteria Adopted. From discussion in Appendix A, the major effluent quality criteria to be considered in this report, when discharging to ocean and marine waters, are based on the NSW Environment Protection Authority's 'Environmental Guidelines for Discharge to Ocean Waters (EG-1 Water)' and the Australian and New Zealand Environment and Conservation Councils (ANZECC) draft 'Effluent Management Guidelines for Sewerage Systems' for these parameters and are summarised in Table 6-3 below.

TABLE 6-3. NSW EPA AND ANZECC-AWRC GUIDELINES CRITERIA FOR MARINE DISCHARGES IN SYDNEY REGION

Effluent and Water Quality Requirements	**EPA EG-1 Water Guidelines**		**Draft ANZECC-AWRC Effluent Management Guidelines**	
	Case 1	**Case 2**	**Level B Treatment**	**Level C Treatment**
Suspended Solids (50% ile)	≤ 60 mg/L	85% removal	25-50% removal (80-150 mg/L)	75-90% removal (25-40 mg/L)
Oil and Grease (50% ile)	≤ 25 mg/L	< 25 mg/L	50-75% removal (30-70 mg/L)	80-100% removal (< 10 mg/L)
Faecal Coliform (Org/100mL)	-	-	10^6 - 10^7	10^5 - 10^6
Water Quality				
▪ Faecal Coliforms (CFU/100 ML)[b]				
50% ile	≥ 150	≥ 150	-	
90% ile	≥ 600	≥ 600	-	
▪ Ammonia[c]	0.6 mg/L	0.6 mg/L	No recommendation	
▪ Restricted Substances	d	d	d	

a. Major requirements shown only.

b. The bacteriological criteria provides for public health protection for inshore waters ie. those waters within a zone bounded by the shoreline and a distance of 300 meters from the shoreline.

c. At boundary of initial dilution zone.

d. Refer to Table A-1 in Appendix A.

The NSW EPA's EG-1 Guidelines set a minimum effluent quality (Case 1) requirement of 60 mg/L of suspended solids (50 percentile value) and 25 mg/L of oil and grease (50 percentile value). These guidelines also recommend that the general aim for sewage treatment works (Case 2) will be at least an 85 per cent efficiency of removal of suspended solids (50 percentile) and less than 25 mg/L of oil and grease (50 percentile value).

In late 1992, ANZECC and Australian Water Resources Council (AWRC) jointly issued a set of National Guidelines in draft form focusing on specific water resource issues as part of the National Water Quality Management Strategy. The Effluent Management Guidelines for Sewerage Systems, which is a component of the National Water Quality Management Guidelines, recommend specific levels of wastewater treatment depending on the environmental values or beneficial uses of receiving waters and the nature of discharge sites. The discharge sites to ocean and marine waters are classified as those discharging to open and unpopulated oceans, high tidal range oceans, nearshore or populated, open bays and estuaries, and enclosed bays and estuaries.

For a high tidal range ocean discharge and secondary contact recreational use, the ANZECC-AWRC Effluent Management Guidelines specify 'Level B' treatment, which is equivalent to primary treatment. For a nearshore or populated zone discharge and primary contact recreational uses the guidelines specify 'Level C' treatment which is equivalent to secondary treatment. Level B treatment would be the appropriate classification for North Head STP with the deepwater ocean outfall since effluent is discharged into a high tidal zone secondary contact recreational use water. If discharging to Warriewood, secondary treatment (Level C) plus primary contact recreational use would be applicable. As consideration must be given to reducing the effect of ammonia toxicity for shoreline discharging plants, nitrification facilities may also need to be considered for Warriewood STP, and is dependent on the dilution afforded by the existing ocean outfall.

EFFLUENT REUSE

Reuse may be incorporated into the Board's total water cycle planning strategy aimed at:

- Reducing wastewater discharge to the environment, thereby helping to preserve the health and integrity of our waterways and;
- Conserving potable water resources thereby delaying or avoiding the need for water supply augmentation.

All water reclamation projects should be developed with public participation so that the water reuse plan which is finally adopted by the Board, reflects the reasonable expectations of the communities which it serves.

The potential environmental benefits to the community from using reclaimed water include:

Waste minimisation.
Water conservation.
Nutrient recycling.
Preserving sensitive receiving waters.

The business objectives of the Water Board, as stated in the 1993-1997 Corporate Direction, are to supply water to the Board's customers and to transport, treat and discharge or reuse effluent in a manner consistent with current legislation, regulations and guidelines.

The position of the Board, having responsibility for both water supply and waste management, provides it with a unique opportunity to combine these two services. This may be effected by supplying reclaimed water to customers when deemed both economically and environmentally beneficial. Hence, water reclamation should be incorporated into the options for sewage disposal at all existing and proposed sewage treatment plants.

Types of Reclaimed Water Uses

A survey of potential reclaimed water customers in industry indicated that they would be keen to use reclaimed water if it is:

Of consistent and suitable quality,
A reliable supply, and
Financially beneficial for them to use.

Reclaimed water projects in Sydney will generally fall into one of the following categories:

Industrial Use. The industrial market has potential for water reuse albeit only minor when compared to the total water use. Water used for industrial purposes includes use in cooling towers, washing/hosedown, process water, quenching/cooling, irrigation and toilet flushing on site. Generally, unless the treatment process train includes reverse osmosis, boiler feed water and demineralisation plant feedwater can be ruled generally out as potential users as there is a need to treat potable water for these uses. Any lesser quality water will, therefore, require more treatment on-site and thus increase the company's operating costs.

The key industrial centres are located in the Port Kembla, Kurnell, Camellia and Botany areas. The SWB Report *Reuse Market Analysis* (June 1992)[8] found that cooling towers create the largest potential market for reclaimed water in industry. As such, most proposed water reclamation plants for industrial uses will be expected to produce a quality reclaimed water suitable for (recycling) cooling tower use. Currently, the quality of reclaimed water for cooling towers is under review by the Reclamation and Reuse Section of the Board to ensure that users will not have to drastically change their management procedures or water usage to successfully adapt to using reclaimed water.

Currently, no official reclaimed water guidelines exist for industry. The Water Reclamation and Reuse Section has undertaken meetings with the major industrial water users which may be able to substitute potable supply for reclaimed water. It was found that the different sites required a diverse range of reclaimed water quality. Hence, the Water Reclamation and Reuse Team should be consulted prior to seeking advice on actual quality parameters for specific projects which include industrial applications.

Agriculture/Irrigation Use. Major agricultural irrigation areas are concentrated at Windsor, Camden and the Hills District in the Sydney area. There are a number of impediments associated with the use of reclaimed water for agricultural irrigation. Of these, the most critical is the availability of abundant and virtually unregulated surface water (eg. the Hawkesbury-Nepean River). Potential reuse markets within the urban irrigation category include properties such as sporting ovals, public reserves, parks, golf courses and race courses. Analyses have shown that the existing urban irrigation market is quite limited and highly seasonal.

The EPA intends to publish a document entitled *Guidelines for the Utilisation of Treated Sewage Effluent by Irrigation*[9] in August 1994. It is currently available in draft form (May 1993). These guidelines apply to the use of disinfected, secondary treated effluent for irrigation.

Advice from the Department of Agriculture may be sought in order to gain knowledge of appropriate watering techniques and nutrient loads for irrigation. At the same time, a water and nutrient balance of the irrigable area will be required to identify the limiting quality parameters for irrigation use and for EPA acceptance.

Indirect Potable Reuse. Potable reuse of highly treated reclaimed water represents a significant potential reuse market. It will be limited, however, by the economics of providing the necessary high level of required treatment to reclaim the water to better than potable quality and mixing with the potable supply to ensure it loses identity. The amount of tertiary effluent expected to be available from inland STPs in the year 2011 is 417 ML/d. This large scale reuse plan would allow postponement of any other water supply augmentation project for approximately 14 years.

As yet, no guidelines have been established for this type of reuse. The Reclamation and Reuse Section is currently studying the viability of indirect potable reuse for Sydney. Quality requirements, mixing points and community acceptance are the main issues. Based on overseas pilot trials (Denver, USA and Windhoek, SA), it has been assumed that a multi-barrier treatment approach incorporating reverse osmosis will be necessary.

Residential Reuse. Residential reuse of effluent through dual reticulation in new development areas represents a significant market for reuse. Market potential would depend upon the degree of support provided by the Water Board and the degree of acceptance by developers and the public. Proposed urban developments on the fringe areas of Sydney include the Rouse Hill Release Area, Macarthur South, and South

Creek Valley Sector. The retrofitting of existing housing estates to accept reclaimed water was deemed to be too expensive.

The New South Wales Recycled Water Co-ordinating Committee published a set of guidelines in May 1993 entitled *NSW Guidelines for Urban and Residential Use of Reclaimed Water*[10]. These guidelines generally outline suggested treatment processes and some quality parameters required for a water reclamation plant intended to be used for residential supply. Any process train which differs from these guidelines has to be approved by the EPA prior to use. The document states that for urban irrigation, the EPA's *WP-8 Guidelines for the Utilisation of Treated Wastewater on Land* is to be used in conjunction. The guidelines, however, were superseded in May 1993. Another updated draft is expected to be available from the EPA through publication in August 1994. Any residential reclaimed water project undertaken will be expected to equal or better the requirements specified in these two guidelines.

Recreational Reuse. Multi purpose lakes, in conjunction with land development programs can provide aesthetic and recreational benefits. Effluent reuse may be used as an alternative means of providing make-up water to replace high evaporation losses usually associated with artificial lakes. Although there are public health risks, the main concern arising from this type of reuse project would be how to manage the system to avoid eutrophication caused by excessive phosphorous loads.

There are no existing guidelines for recreational reuse, however, overseas projects indicate that this type of reuse would be highly regulated. The critical quality parameters for this type of reuse will be microbiological, nutrient loading, TDS and colour.

Groundwater Recharge. Groundwater recharge with reclaimed water is an approach to water use that results in the planned augmentation of groundwater resources. It has not yet been adopted in Australia, however, the Botany Aquifer is a significant aquifer used for non-potable industrial and irrigation purposes. The main benefits of such a scheme include prevention of saltwater intrusion and prevention of declines in groundwater supply.

There are no guidelines for groundwater recharge in Australia. Stringent hydrological and environmental studies would be expected by the relevant authorities for such a reuse project to ensure no adverse effects.

Guidelines

Generally the quality of reclaimed water should:

Minimise health risks.
Be aesthetically acceptable.
Meet the quality standards at the point of use.

The following three organisations have produced guidelines for the use of reclaimed water in NSW.

NHMRC. The National Health and Medical Research Council (NHMRC) and the Australian Water Resources Council (AWRC) prepared general guidelines for the reuse of treated wastewater titled *Guidelines for Use of Reclaimed Water in Australia.* These guidelines were designed to assist water authorities establish baseline treatment levels to ensure minimum microbiological standards.

The guidelines pay particular attention to ensuring that the use of reclaimed wastewater does not present any risks to public health. It is important to note, however, that these guidelines have not been developed for regulatory purposes and the values given should not be construed as standards.

Environment Protection Authority. Any proposal to utilise treated effluent for reclaimed water purposes must be approved by the EPA. It would be wise to discuss any proposal with the EPA at the early stages. This ensures that all the relevant issues are addressed before the design and approval stages. A Pollution Control Approval under Section 17(k) of the Pollution Control Act, must be obtained from the EPA prior to constructing an effluent reuse scheme. The Health Department works in conjunction with the EPA on approvals.

The following publications are now superseded by *Guidelines for the Utilisation of Treated Sewage Effluent by Irrigation*, EPA, Draft, May 1993. Another updated draft for reclaimed water land irrigation is due in August 1994.

Design Guide for the Disposal of Wastewater by Land Application, SPCC, Design Guide WP-6.

Water Conservation by Reuse - Guidelines for the Use of Recycled Water in NSW, SPCC Design Guide WP-7.

Design Guide fo Reuse of Treated Wastewater by Land Application, WP-8, SPCC.

The current draft aims to provide guidance for the planning, design, operation and monitoring of a wastewater irrigation system.

NSWRWCC (Recycled Water Co-ordinating Committee). This committee has published guidelines for residential use of reclaimed water entitled *NSW Guidelines for Urban and Residential Reuse of Reclaimed Water*, NSWRWCC, Final Draft June 1992. These guidelines propose suitable quality parameters for residential use of reclaimed water as well as indicate suitable treatment trains for the water reclamation plant. Any variation in nominated quality or treatment train process requires a proof of process study acceptable to the EPA and Department of Health to demonstrate that the process meets the guidelines. This publication, along with the EPA draft for land irrigation form the basis for reclaimed water guidelines for NSW.

Reclaimed Water Quality. The Water Reclamation and Reuse Section of the Board has produced several reports pertaining to water reclamation. In these, potential projects for the Sydney and Illawarra Regions have been identified and evaluated. Also, a review of worldwide guidelines on water reclamation has been undertaken to produce a set of guidelines for planning purposes. The following table (Table 6-4) is intended to give an idea of what quality parameters will/may be required for each market type.

Each proposed reuse project should be investigated individually to determine specific quality parameters and process trains most suitable to satisfy the majority of the market. The reclaimed water quality requirement would be normally be taken as that of a suitable quality for the majority of potential uses at a cost effective price, eg. reclaimed water suitable for cooling towers may be the determining level of quality which is most economically viable on a $/ML basis for a particular project.

TABLE 6-4. TARGET RECLAIMED WATER QUALITY

Parameter	**Level A**	**Level B**	**Level C**	**Level D**
BOD_5	20[c]	10	5	ND
SS	30	10	5	ND
Ammonia	25	5	1	ND
Total N	40	40	15	0.5
Total P	3	3	0.3	0.05
Faecal Coliforms (org/100ml)	300[d]	200	5[a]	ND
TDS	500	500	500[g]	25
Turbidity (NTU)	15	10	5[a]	0.1
Sulphate	100	100	100	0.5
Silicate	12	12	12	0.1
Chloride	175	175	175[g]	10
Calcium	70	70	70	0.3
Magnesium	10	10	10	ND
Potassium	20	20	20	1
Sodium	120	120	120	7
Heavy Metals	ND	ND	ND	ND
TYPICAL USES	agric. irrigation[e], dust suppression, quenching	urban irrigation[e]	non-potable residential, rec. lakes[f], cooling towers[g]	indirect potable and boiler feed[b]

NOTES: All units mg/L unless otherwise specified

a NSWRWCC Guidelines (95 per cent) - refer to process trains
b further treatment may be required by customers on site
c italics - CWP STP effluent target
d NSW EPA - WP8 (or proceeding draft)
e nutrient removal may not be required
f primary contact
g currently under review
ND not detectable

REFERENCES

1. State Pollution Control Commission, *Water Quality in the Nepean/Hawkesbury River, A Study and Recommendation,* September 1993.

2. State Pollution Control Commission, *A Strategy Report for the Management of the Water Quality of the Nepean/Hawkesbury Rivers,* June 1985.

3. State Pollution Control Commission, *Water Quality Goals and Objectives for New South Wales,* November 1993.

4. Paper by David Leece, EPA, *Sewage Disposal Options for Inland Australia, Environment Protection Considerations.*

5. Kinhill Metcalf and Eddy, *Appropriate Limits for the Discharge of Ammonia and Total Nitrogen from Inland Sewage Treatment Plants,* May 1992.

6. Australian and New Zealand Environment and Conservation Council, *Australian Water Quality Guidelines for Fresh and Marine Waters,* November 1992.

7. Berowra Creek Technical Working Party, *Report of Berowra Creek Technical Working Party*, May 1994.

8. Sydney Water Board, *Reuse Market Analysis*, June 1992.

9. EPA, *Draft Guidelines for the Utilisation of Treated Sewage Effluent by Irrigation*, May 1993.

10. NHMRC/AWRC, *Guidelines for Use of Reclaimed Water in NSW.*

SECTION 7

OPTIONS FOR INVESTIGATION

The scope of this study is to assess a number of options available to the Board for the treatment and discharge of sewage effluent from and within the Berowra Creek catchment. The options investigated include the retention and augmentation of the West Hornsby and Hornsby Heights STPs; new plants; transfer of flows from the catchment for discharge to less sensitive waters; and the potential for effluent reuse.

A particular requirement of the project brief is that three target levels of effluent quality are specified for nutrients where options involve STPs discharging to Berowra Creek.

Although this report is to consider the short to medium term sewage treatment and effluent disposal options for the West Hornsby and Hornsby Heights STPs, recommendations made in this option report will need to be reviewed in light of the findings of the longer term studies being developed by the Board.

The overall strategies being considered are discussed below. Options are then presented in the context of these strategies and are examined for their suitability in achieving the stated effluent quality objectives.

STRATEGIC PLANNING FOR WASTEWATER

Choices For Clean Waterways

The "Choices for Clean Waterways" document[1] (March 1994), presents broad strategies which represent a wide range of possible methods for achieving four major objectives:

- Improving the quality of receiving waters.
- Providing for future growth in Sydney.
- Improving the cost-effectiveness of operating the wastewater infrastructure.

- Working towards ecologically sustainable development by employing the principles of total catchment management.

The strategies target three main areas - inland waterways; oceans and beaches; and estuaries, river and coastal waterways, and apply to the Sydney, Hawkesbury and Illawarra catchments.

Strategies being considered for treatment of sewage and disposal of effluent include:

- Treatment and discharge within the major catchments of origin.
- Export (transfer) from one catchment to less sensitive receiving waters.
- Reuse of effluent for non-potable use.
- Reuse of effluent for potable use.
- "Local" treatment facilities.
- Wastewater source control and other "non-structural" options.

Variations on these themes are also possible, e.g. transfer of all flows, transfer of dry weather flows only, transfer of treated effluent or transfer of raw sewage, etc. The wastewater strategies being developed for the CWP represent the broadest level at which the planning process occurs.

At this stage strategy options have been developed as discrete solutions to facilitate investigation activities such as concept development, costing, assessment against performance objectives, etc., with no attempt yet to identify an optimal solution. It is most likely that the optimal solution would involve elements from more than one option.

It should also be noted that the nature of the strategic investigations is such that they are constrained to a high level of consideration of options and take the longer term view. Accordingly, the work will not generate specific and detailed prescriptions for individual plants. The strategic investigations do, however, provide a context for specific and detailed plant scale investigations such as those presented in this report. Of relevance to this study are:

Treatment and Discharge within the Catchment

This strategy assumes that wet and dry weather sewage flows would be treated to an appropriate level, and effluent discharged within the major catchments of origin; that is, there will be no inter-catchment transfers. Wet and dry weather flows will discharge to a combination of inland and coastal waterways using a system configuration similar to that presently existing.

The most significant outcome of this strategy would be that wastewater generated within the Hawkesbury-Nepean catchment would continue to be collected, treated, and effluent discharged into the Hawkesbury-Nepean River and its tributaries.

Similarly, sewage collected within Berowra Creek is treated and discharged to Berowra Creek.

This might not necessarily be by the same plants as presently exist, however, and if it was demonstrated superior in terms of technical, economic and environmental performance, the number and size of plants may be rationalised. Inland and ocean receiving water quality would be protected by upgrading and amplifying treatment plants and controlling wet weather overflows.

Reduce Dry Weather and Wet Weather Sewage Loads on Inland Waterways

This suite of options aims to reduce effluent discharge to inland waterways during dry weather conditions and wet weather flows up to a specific design condition by exporting the flow to less sensitive waters. Dry weather and wet weather flows would be transported to the coast via a system of pipelines, tunnels and pump stations. Wet weather flows greater than the design condition would continue to be discharged to inland waterways but the circumstances when this would occur would be such that substantial dilution would be available due to elevated flows in the receiving waters.

This strategy has two variations with the first variation involving the transfer of untreated sewage to the ocean STP's for treatment. In the second, sewage flows would be treated at inland plants to a specified standard and the effluent transferred to the coast for disposal through the ocean outfalls.

Reduce Dry Weather Sewage Loads on Inland Waterways

This strategy aims to relieve inland waterways of sewage-origin pollutant loads during dry weather by transporting dry weather flows to the ocean. During wet weather, flows in excess of the transfer capacity would be discharged to the inland waterways after suitable treatment. This strategy presumes that in times of wet weather, river flows are sufficiently high to provide dilution for the flow discharged within the catchment, and thus minimise any adverse water quality impacts.

The configuration of sewage transport systems and STPs for options in this Strategy would be essentially the same as for the alternatives developed for wet and dry conditions discussed above. This is because dry weather flow transfer requirements govern the location of the sewer facilities in both strategies. The differences are primarily in sizing of facilities and the volume of discharges to inland receiving waters.

The same two basic variations apply and include the transfer of untreated sewage flows, or the transfer of treated effluent.

Maximise Reuse of Effluent

This strategy would enable the achievement of two objectives. Firstly, it offers the potential to reduce the impacts on receiving waters by reducing the volume of effluent discharged. Secondly, by providing an alternate source of water, it would reduce the demands upon existing supply storages and offers their potential to defer supply augmentation.

Effluent would be treated to various levels depending upon the type of reuse. Reuse of effluent would apply primarily to dry weather flows; wet weather flows would continue to be discharged to inland waterways in a similar fashion to the previous strategies discussed.

Effluent could be reused for potable and/or non-potable purposes.

Non-Potable Reuse. Non-potable reuse is most readily achievable for three purposes: industrial, agricultural, and domestic non-potable water supply in new urban developments. The viability of each type of use varies, important factors being the location and size of potential markets and the price of the water. It should also be noted that dual water supply demand is seasonal with the likely peak rate achievable from November through to March.

Investigations for proposed dual water systems in the Rouse Hill and Picton areas indicate that, depending on the price set, ADWF from the STP could readily be reused with probably higher peak flow demand rates achieved during summer periods (November to March). During this period, discharges to inland river systems could effectively be minimised thus lessening the impact of sewage effluent.

Indirect Potable Reuse. Indirect potable reuse refers to the return of highly treated effluent (water) of potable standard to the supply system at a point where it loses its identity through mixing with water from other sources. This could be through discharge to a major storage such as a dam, or to a river from which it is subsequently withdrawn further downstream. Other indirect reuse options could include return of highly treated effluent to storage reservoirs.

OPTIONS FOR CONSIDERATION

In the context of the strategic directions discussed above, the requirements of the Berowra Creek Community Contract and advice from the operators of the Berowra Creek STPs, three broad strategies have been identified for consideration within the Berowra Creek catchment. They include:

- Treatment and Discharge to Berowra Creek.
- Transferring of sewage or effluent to the ocean catchment.
- Effluent reuse in Berowra Creek Catchment.

These three broad strategies have been developed into more specific options (options 1 to 11) outlined below and described in more detail in the subsequent sections. The options are also shown schematically in figures 7-1 to 7-11.

Effluent Quality Targets

Before discussing the specific options, each option adopted will fall into the above three broad strategies and will need to meet specific effluent quality targets, as requested by the Berowra Creek Community Contract. The effluent quality targets have been discussed in more detail in Section 6 and are summarised below.

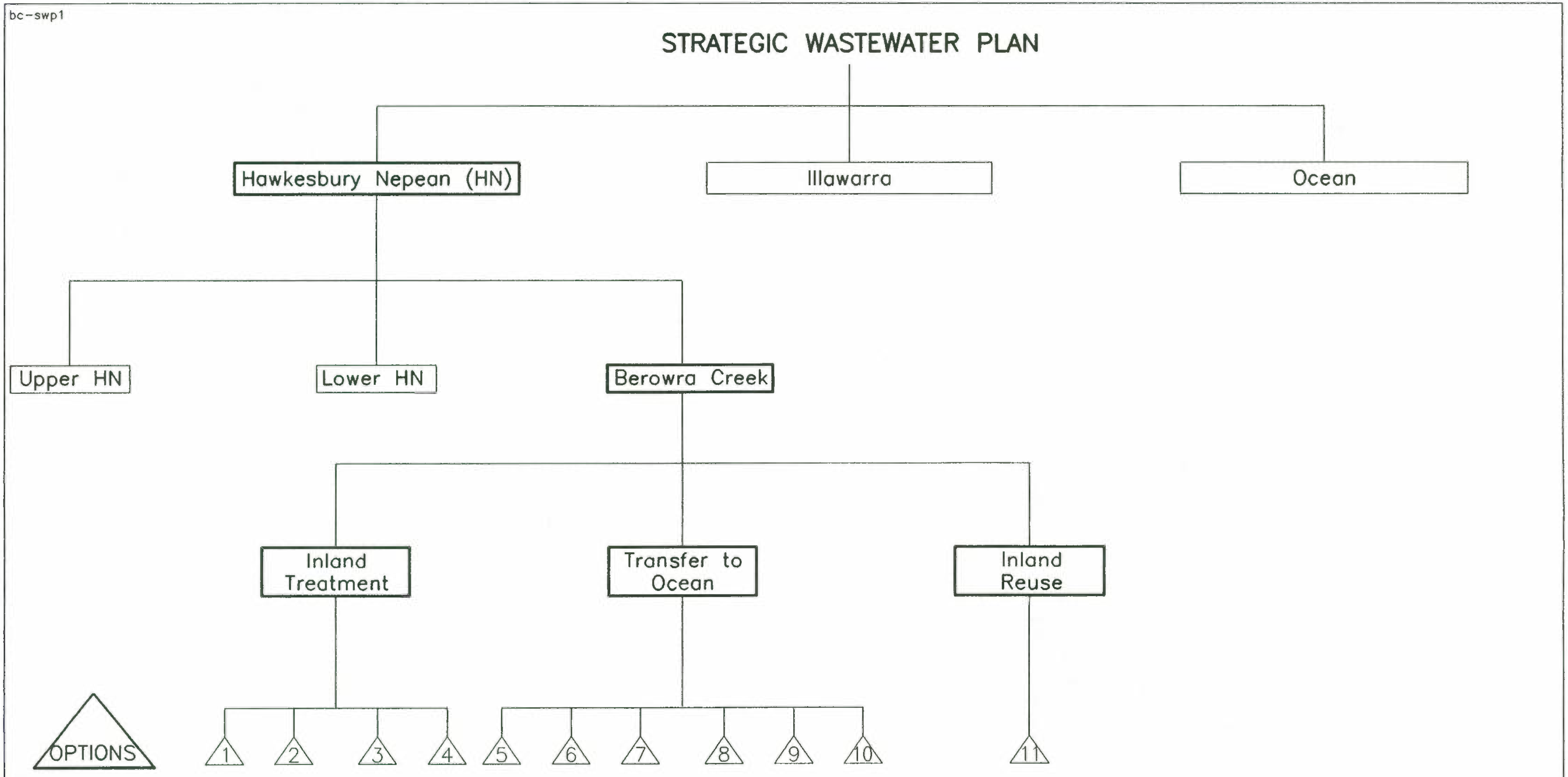
Treatment and Discharge to Berowra Creek. If the plants discharge to the Hawkesbury River via the Berowra Creek, the treatment facilities are to be capable of meeting the effluent quality targets as summarised in Table 7-1 below. The three target levels for nutrient reduction reflect the requirements of the Community Contract (refer Section 1 and 6 for more detail).

TABLE 7-1. TARGET EFFLUENT QUALITIES (90 PERCENTILE) FOR THE BEROWRA CREEK CATCHMENT

Parameter	Level 1	Level 2	Level 3
Biochemical Oxygen Demand (BOD_5)	10	10	10
Suspended Solids (SS)	10	10	10
Ammonia (NH_3)	5	1	1
Total Nitrogen (TN)	15	10	5
Total Phosphorus (TP)	0.3	0.3	0.3
Faecal Coliforms (org/100 ml)	200	200	200
pH range (numerical value)	6.5 - 8.5	6.5 - 8.5	6.5 - 8.5

Note:
Values are mg/L unless otherwise specified.
Effluent Quality Criteria based on EPA and Berowra Creek Technical Working Party Requirements (refer Section 6).

Discharge to the Ocean. For options involving transfer to the ocean, the NSW EPA and ANZECC - AWRC Guidelines for Marine Discharges have been adopted for assessing the treatment facilities necessary (refer Table 7-2 below).



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WASTEWATER AND REUSE PLANNING

RELATIONSHIP OF OPTIONS TO STRATEGIC WASTEWATER PLAN

Figure 7–1

TABLE 7-2. NSW EPA AND ANZECC-AWRC GUIDELINES CRITERIA FOR MARINE DISCHARGES

Effluent and Water Quality Requirements	**EPA EG-1 Water Guidelines**		**Draft ANZECC-AWRC Effluent Management Guidelines**	
	Case 1	**Case 2**	**Level B Treatment**	**Level C Treatment**
Suspended Solids (50% ile)	≤ 60 mg/L	85% removal	25-50% removal (80-150 mg/L)	75-90% removal (25-40 mg/L)
Oil and Grease (50% ile)	≤ 25 mg/L	< 25 mg/L	50-75% removal (30-70 mg/L)	80-100% removal (< 10 mg/L)
E Coli (mg/100 mL)	-	-	10^6 - 10^7	10^5 - 10^6
Water Quality				
• Faecal Coliforms (cfu/100 ml)[b]				
50% ile	≤ 150	≤ 150	-	
90% ile	≤ 600	≤ 600	-	
• Ammonia[c]	0.6 mg/L	0.6 mg/L	No recommendation	
• Restricted Substances	d	d	d	

Note:
Refer to Appendix A for a more detailed description of ocean discharge requirements.

a. Major requirements shown only.

b. The bacteriological criteria provides for public health protection for inshore waters ie. those waters within a zone bounded by the shoreline and a distance of 300 meters from the shoreline.

c. At boundary of initial dilution zone.

d. Refer to Table A-3 in Appendix A.

A more detailed discussion of the above criteria is found in Appendix A, "Ocean Discharge Requirements", and should be referred to, especially with regard to the EPA's EG-1 effluent and water quality guidelines.

Effluent Reuse. For the effluent reuse schemes investigated Table 7-3 provides the effluent quality criteria that have been adopted for different types of reuse. For Berowra Creek Level D is considered more applicable in achieving potable water reuse.

TABLE 7-3. EFFLUENT QUALITY TARGETS FOR REUSE SCHEMES

Parameter	Level A	Level B	Level C	Level D
BOD_5	20[c]	10	5	ND
SS	30	10	5	ND
Ammonia	25	5	1	ND
Total N	40	40	15	0.5
Total P	3	3	0.3	0.05
Faecal Coliforms (org/100ml)	300[d]	200	5[a]	ND
TDS	500	500	500[g]	25
Turbidity (NTU)	15	10	5[a]	0.1
Sulphate	100	100	100	0.5
Silicate	12	12	12	0.1
Chloride	175	175	175[g]	10
Calcium	70	70	70	0.3
Magnesium	10	10	10	ND
Potassium	20	20	20	1
Sodium	120	120	120	7
Heavy Metals	ND	ND	ND	ND
TYPICAL USES	agric. irrigation[e], dust suppression, quenching	urban irrigation[e]	residential, rec. lakes[f] cooling towers[g]	indirect potable boiler feed[b]

Notes:
All units mg/l unless otherwise specified
Refer Section 6 for a more detailed discussion.

[a] NSWRWCC Guidelines - refer to process trains
[b] Further treatment may be required by customers on site
[c] CWP STP effluent target
[d] NSW EPA - draft guidelines for Land Irrigation, May 1993
[e] Nutrient removal may not be required
[f] Primary contact
[g] Currently under review

ND Not detectable

Treatment and Discharge to Berowra Creek

Four options are considered feasible for further detailed investigation if the treatment of sewage and effluent disposal is contained within the Berowra Creek catchment. A number of treatment processes have also been identified which are capable of meeting the effluent quality targets (especially with regard to effluent total nitrogen) as summarised in Table 7-1. The treatment processes adopted under each option described below are discussed later in this section with details of the selection process provided in Appendix B.

Option 1 and 2 - Retention of West Hornsby and Hornsby Heights STP Without Any Transfer

These options assume that both the West Hornsby and Hornsby Heights Sewage Treatment Plants are retained, upgraded to meet effluent quality objectives and amplified to provide capacity for increasing loads (if required). The treatment processes adopted for Options 1 and 2 differ and involve the use of best available technology economically achievable at both sites (refer figure 7-2).

Option 3 - New Treatment Plant

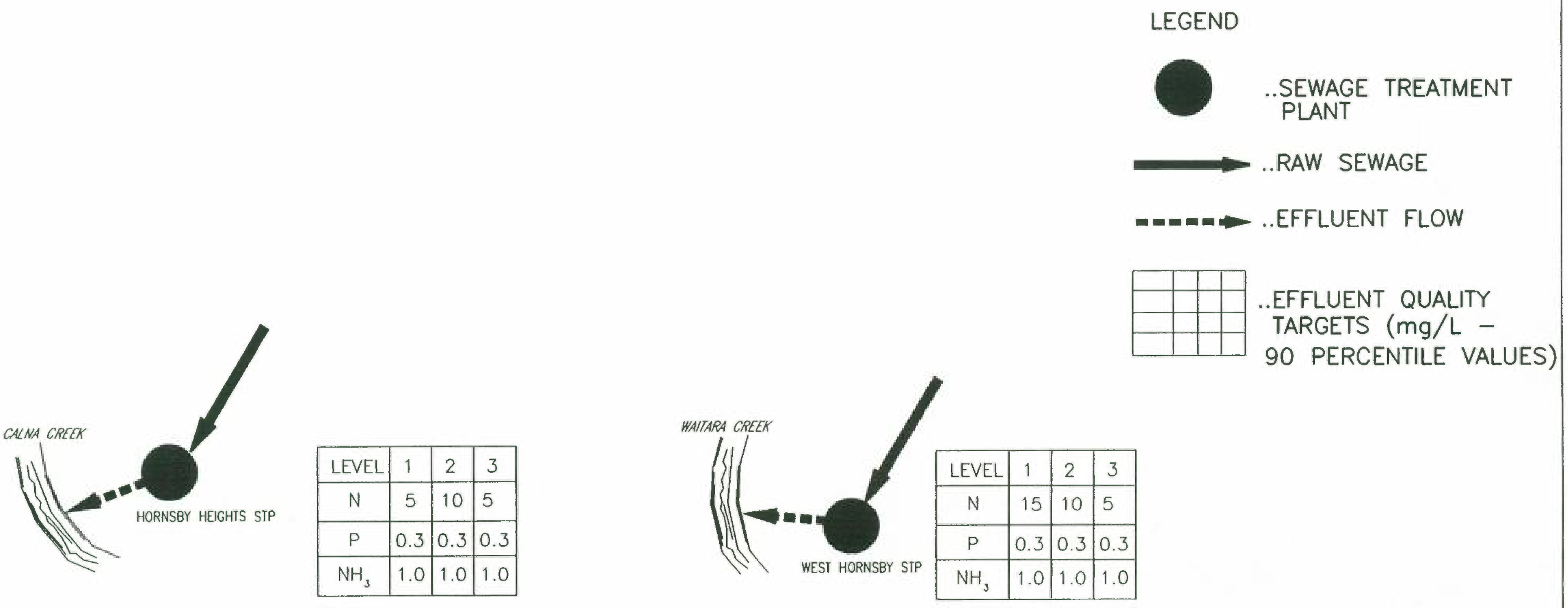
This option involves the decommissioning of West Hornsby and Hornsby Heights STPs and construction of a new plant within the catchment. The three effluent levels for discharge are considered (refer figure 7-3).

Option 4 - Retention of Upgraded Plants and New Treatment Plant

This option is a combination of Options 1 and 2, and involves the upgrading of West Hornsby and Hornsby Heights STP to their current stated treatment plant capacity. Flows in excess of this capacity are to be transferred to a new proposed treatment plant at Berowra Creek site (refer figure 7-4).

Other sub-options were initially considered and included: decommissioning of West Hornsby STP and transfer all Berowra Creek catchment flows to an amplified and upgraded Hornsby Heights STP; decommissioning of Hornsby Heights STP and the transfer of all sewage flows to an upgraded and amplified West Hornsby STP. Also the sub-options of retaining either West Hornsby or Hornsby Heights STPs in combination with a new treatment plant was also considered. Limited space, provision of expensive transfer infrastructure and not maximising the use of existing treatment facilities to their maximum potential, however, do not warrant their further investigation.

bc-opt1



LEVEL	1	2	3
N	5	10	5
P	0.3	0.3	0.3
NH_3	1.0	1.0	1.0

LEVEL	1	2	3
N	15	10	5
P	0.3	0.3	0.3
NH_3	1.0	1.0	1.0

OPTIONS 1 AND 2– RETAIN PLANTS PERMANENTLY AND DISCHARGE TO TRIBUTARIES OF BEROWRA CK. DISCHARGE TO THE ESTUARINE SECTION OF BEROWRA CREEK OR HAWKESBURY – NEPEAN WAS NOT CONSIDERED AS NO MAJOR BENEFIT IS AVAILABLE.

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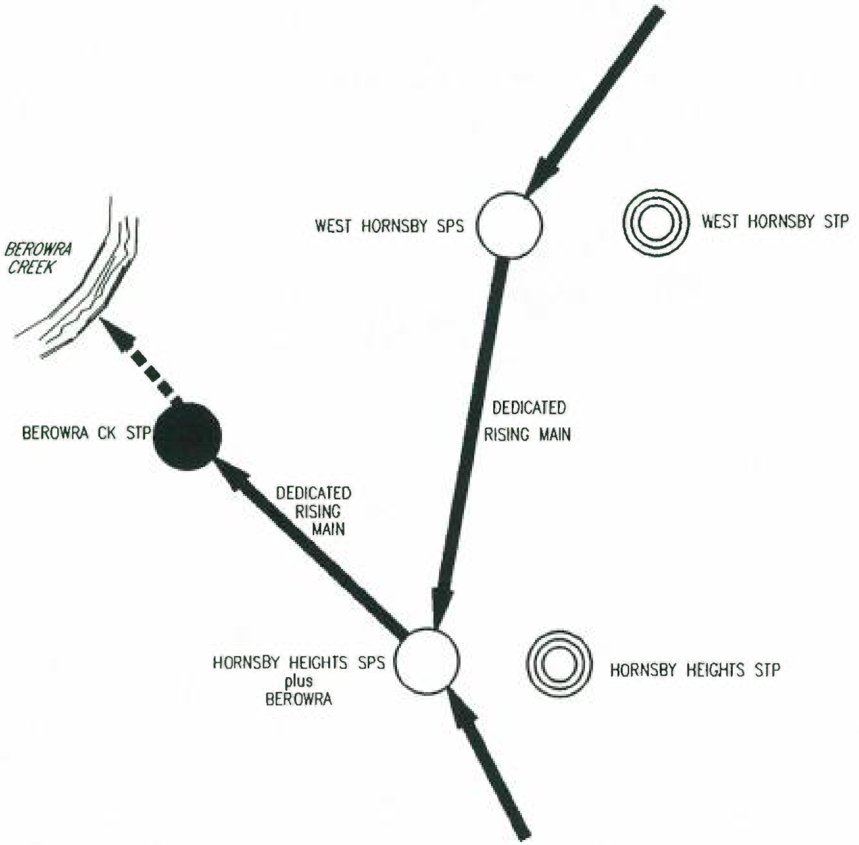
WEST HORNSBY & HORNSBY HEIGHTS STPS OPTIONS STUDY
SCHEMATIC DIAGRAM OF OPTIONS 1 AND 2

Figure
7–2

bc-opt2

LEVEL	1	2	3
N	15	10	5
P	0.3	0.3	0.3
NH_3	1.0	1.0	1.0



LEGEND

○ ....SEWAGE PUMPING STATION.

● ....SEWAGE TREATMENT PLANT.

◎ ........DECOMMISSIONED PLANT.

→ ..RAW SEWAGE FLOW

- - → ..EFFLUENT FLOW

▦ ..EFFLUENT QUALITY TARGETS (mg/L)

OPTION 3 – DECOMMISSION WEST HORNSBY STP & HORNSBY HEIGHTS STP IN SHORT TERM
TRANSFER ALL FLOWS TO NEW BEROWRA CREEK STP

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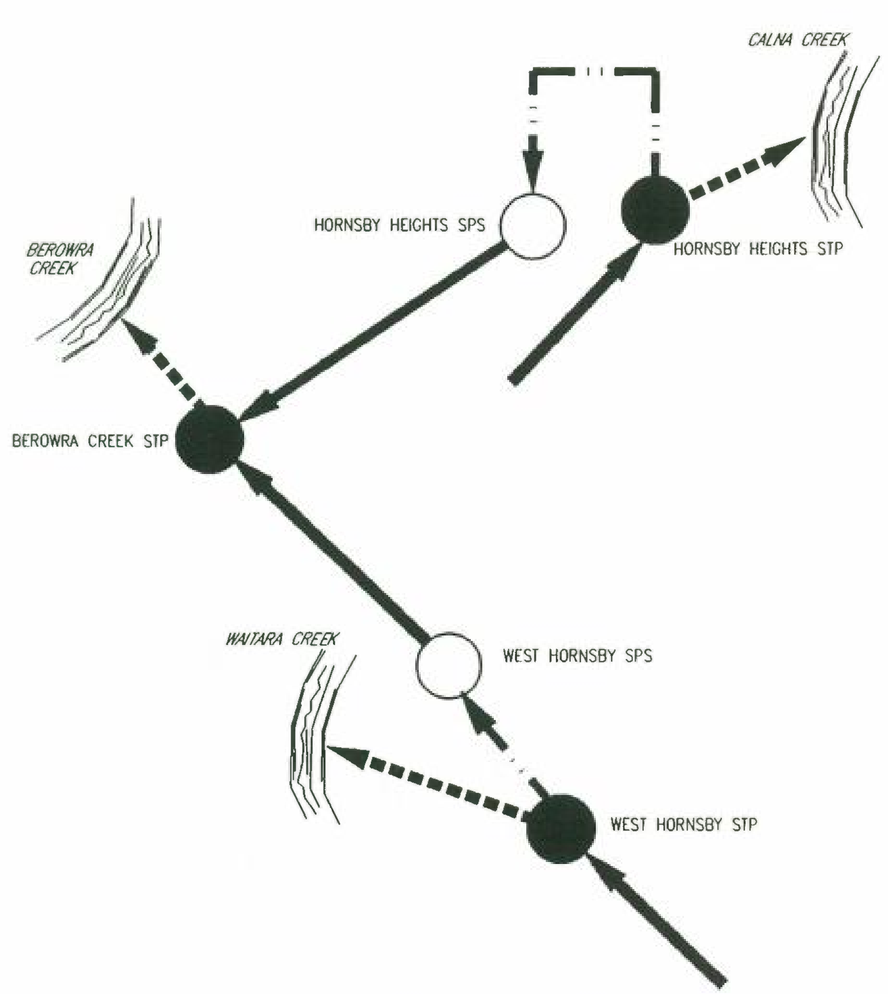
WEST HORNSBY & HORNSBY HEIGHTS STPS OPTIONS STUDY
SCHEMATIC DIAGRAM OF OPTION 3

Figure
7–3

bc-opt3



LEGEND

○ ....SEWAGE PUMPING STATION.

● ....SEWAGE TREATMENT PLANT.

━━▶ ..RAW SEWAGE FLOW

▪▪▪▶ ..EFFLUENT FLOW

▬ · · ▶ ..FLOW IN EXCESS OF PLANT CAPACITY TRANSFERRED.

▦ ..EFFLUENT QUALITY TARGETS (mg/L) (For all plants)

LEVEL	1	2	3
N	15	10	5
P	0.3	0.3	0.3
NH_3	1.0	1.0	1.0

OPTION 4 – RETAIN WEST HORNSBY & HORNSBY HEIGHTS STPS INDEFINITELY AND TRANSFER FLOWS IN EXCESS OF NOMINAL CAPACITY.

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WEST HORNSBY & HORNSBY HEIGHTS STPS OPTIONS STUDY
SCHEMATIC DIAGRAM OF OPTION 4

Figure
7–4

Transfer of Sewage (or Effluent) to Ocean Catchment

After a preliminary review, the more appropriate options that warrant further investigation when removing the effect of sewage on Berowra Creek are listed below. These options consider two discharge locations, Warriewood and North Head STPs; two flow conditions, dry weather and wet weather flows; and the transfer of raw sewage and treated effluent. Table 7-4 below summaries the transfer to the coast options.

Option 5 - Dry and Wet Weather Raw Sewage to Warriewood STP

This option consists of transferring all flows up to DWWF to Warriewood STP for treatment and disposal. Transfer infrastructure and amplification of treatment facilities at Warriewood STP will be required. The existing Hornsby STPs will be converted to wet weather holding facilities plus provide storm treatment for excessive flows (refer figure 7-5).

Option 6 - Dry and Wet Weather Raw Sewage to North Head STP

This is similar to Option 4 except that the sewage flows from the West Hornsby and Hornsby Heights STP catchments is transferred to North Head STP via a dedicated line (refer figure 7-6). Alternatives to a "dedicated tunnel" may exist, and this information will be available in 1995. These are being developed through a detailed system planning process, which will consider the merits and financial implication of several options. Refer Section 12 for further details.

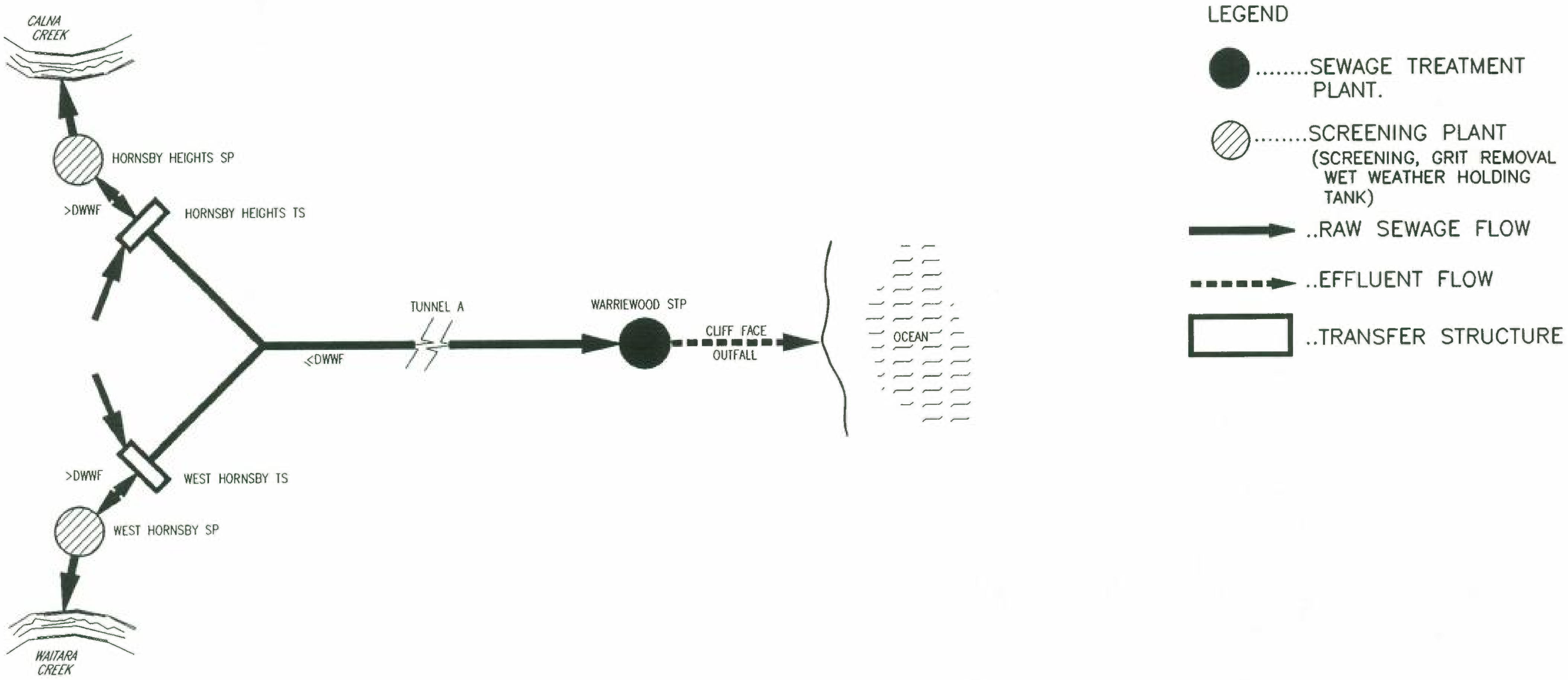
Option 7 - Dry and Wet Weather Effluent to Warriewood Outfall

This option consists of treating all flows up to DWWF at the local plants in Hornsby, but only to secondary standard for 3 ADWF. Flows of up to 3 ADWF will be transferred to Warriewood outfall for disposal. Flow in excess of 3 ADWF will be retained in a suitably sized storm tank after primary treatment. The stored primary effluent will be returned to the secondary treatment train during dry weather conditions. Unless the STP experiences extreme wet weather limited discharge to Berowra Creek is envisaged (refer figure 7-7).

Option 8 - Dry Weather Raw Sewage to Warriewood STP

This is similar to Option 5 except that the sewage flow of up to 3 ADWF will be transferred out of the catchments. The existing STPs will be converted to storm flow STPs which will treat flows in excess of 3 ADWF and then discharge to Berowra Creek (refer figure 7-8).

bc-opt5



OPTION 5 – DRY AND WET WEATHER RAW SEWAGE TRANSFERED TO WARRIEWOOD STP FOR TREATMENT AND DISPOSAL VIA CLIFF FACE OUTFALL

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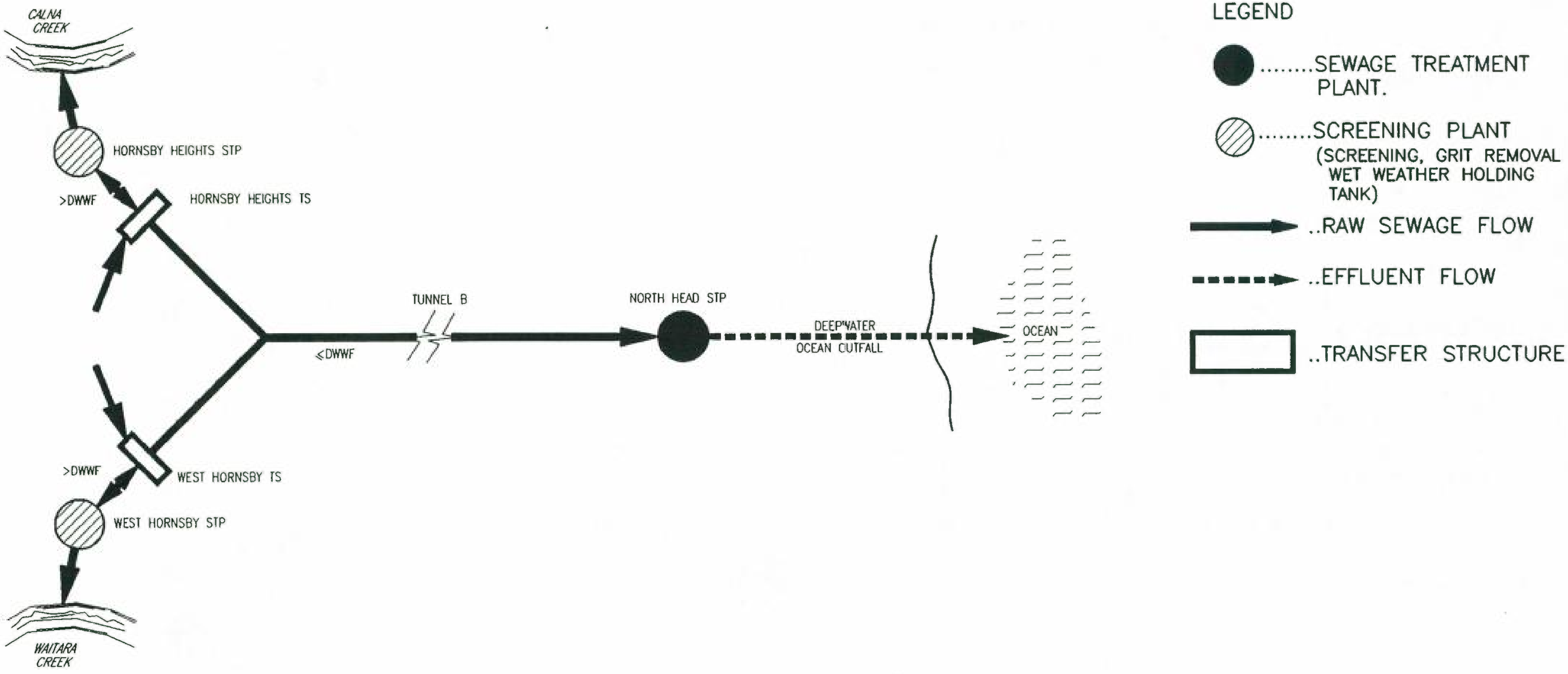
WEST HORNSBY & HORNSBY HEIGHTS STPS OPTIONS STUDY
SCHEMATIC DIAGRAM OF OPTION 5

Figure
7–5

bc-opt6



OPTION 6 – DRY AND WET WEATHER RAW SEWAGE TRANSFERED TO NORTH HEAD STP FOR TREATMENT AND DISPOSAL VIA DEEPWATER OCEAN OUTFALL

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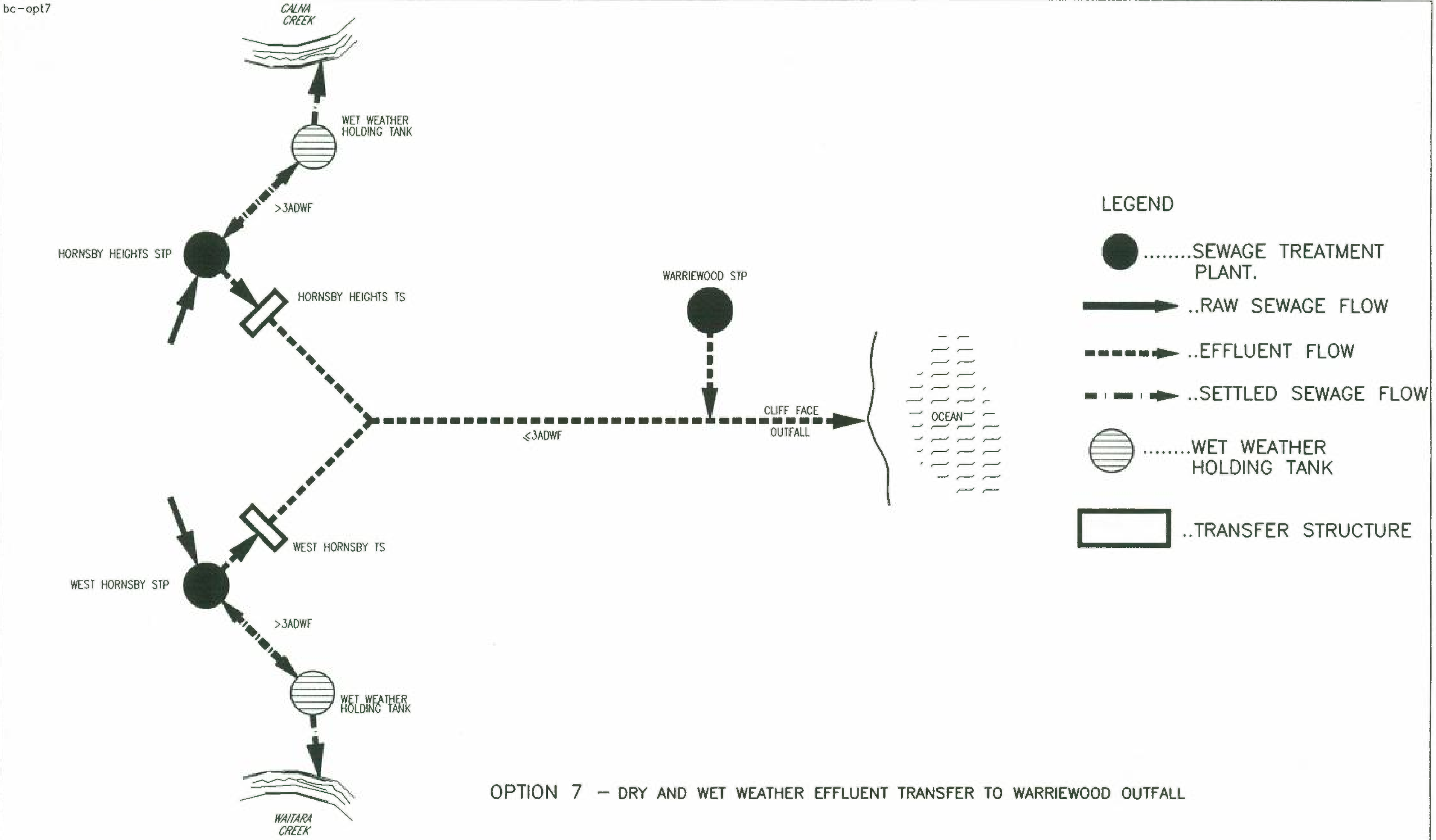
WEST HORNSBY & HORNSBY HEIGHTS STPS OPTIONS STUDY
SCHEMATIC DIAGRAM OF OPTION 6

Figure
7–6



OPTION 7 — DRY AND WET WEATHER EFFLUENT TRANSFER TO WARRIEWOOD OUTFALL

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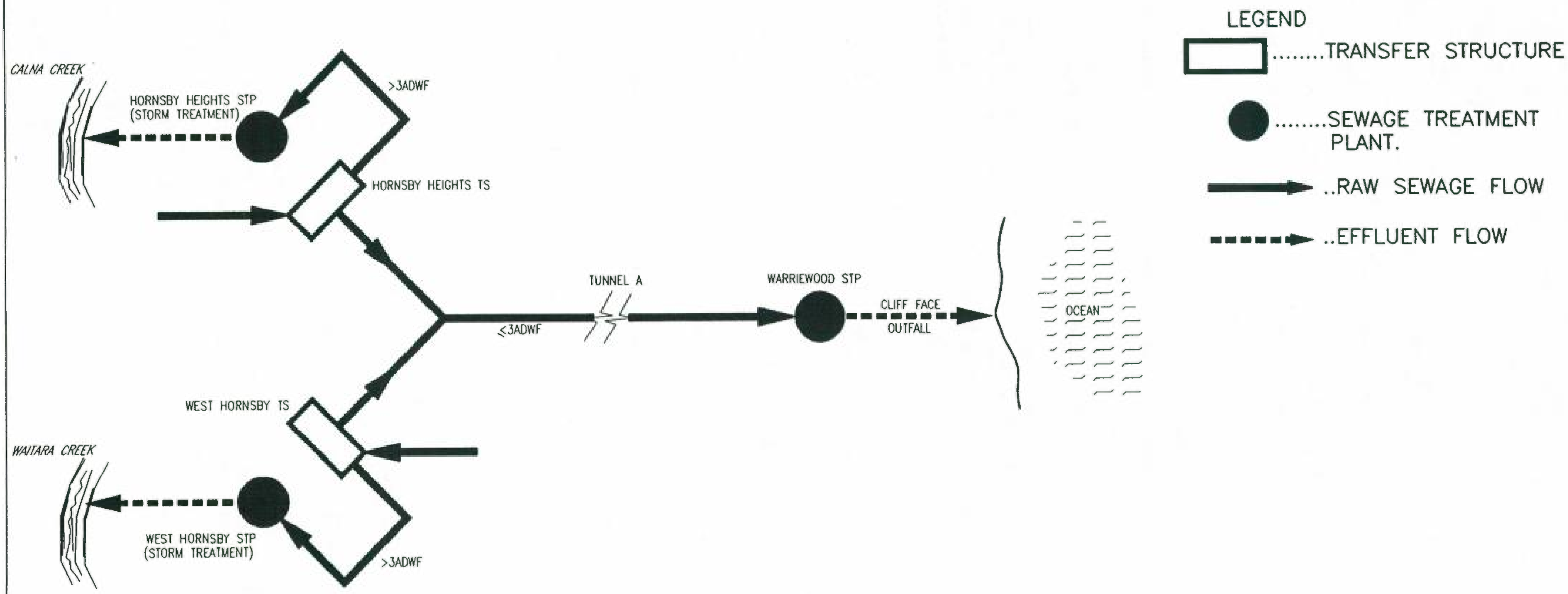
WEST HORNSBY & HORNSBY HEIGHTS STPS OPTIONS STUDY
SCHEMATIC DIAGRAM OF OPTION 7

Figure
7–7

bc-opt8



OPTION 8 – DRY WEATHER RAW SEWAGE TRANSFERRED TO WARRIEWOOD STP FOR TREATMENT AND DISPOSAL VIA CLIFF FACE OUTFALL

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WASTEWATER AND REUSE PLANNING

WEST HORNSBY & HORNSBY HEIGHTS STPS OPTIONS STUDY
SCHEMATIC DIAGRAM OF OPTION 8

Figure
7–8

Option 9 - Dry Weather Raw Sewage to North Head STP

This is similar to Option 8 except that the Berowra Catchment Dry Weather Flow (up to 3 ADWF) is transferred to North Head STP (refer figure 7-9).

Option 10 - Dry Weather Effluent to Warriewood Outfall

This is similar to Option 7 except that a storm tank will not be provided. Flows greater than 3 ADWF will be treated to primary standard before discharge to Berowra Creek (refer figure 7-10).

TABLE 7-4. SUMMARY OF COASTAL TRANSFER OPTIONS TO BE INVESTIGATED

Discharge Location	Dry and Wet Weather Flows		Dry Weather Flows	
	Raw Sewage	Treated Effluent	Raw Sewage	Treated Effluent
Warriewood STP	Option 5	-	Option 8	-
Warriewood Outfall	-	Option 7	-	Option 10
North Head STP	Option 6	-	Option 9	-

Note:
The transfer of treated effluent from the Hornsby STPs to North Head STP ocean outfall was not examined in detail as no major economic benefit is gained over the proposed raw sewage transfer.

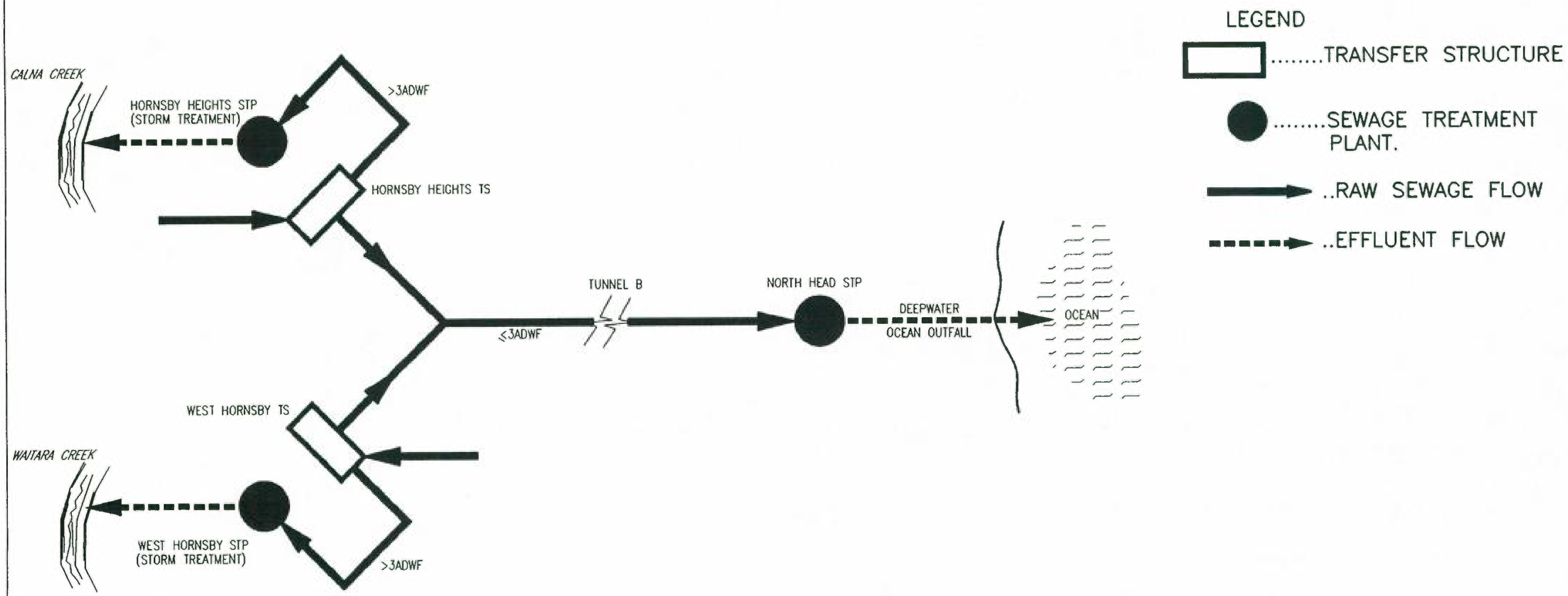
Unlike Options 7 and 10, the option of transferring treated effluent to the North Head STP Deepwater Ocean Outfall (DOO) was not considered in this study and this decision was based on the following:

- High capital cost in providing a high-lift effluent pumping station, i.e. to lift effluent from the tunnel level to the DOO's entry level.
- High operating cost in running the effluent pumping station.
- No major environmental benefit in the mixing of the secondary effluent of the two Hornsby STPs with the primary effluent of North Head STP.

Effluent Reuse in Berowra Creek Catchment

A number of options were investigated to ascertain viability of reusing effluent in large quantities in Berowra Creek catchments so as to dramatically reduce and achieve zero effluent total nitrogen discharge to Berowra Creek. Options investigated included irrigation, dual water supply and indirect potable water reuse. Of the options considered potable water reuse shall be examined further. As no major

bc-opt9



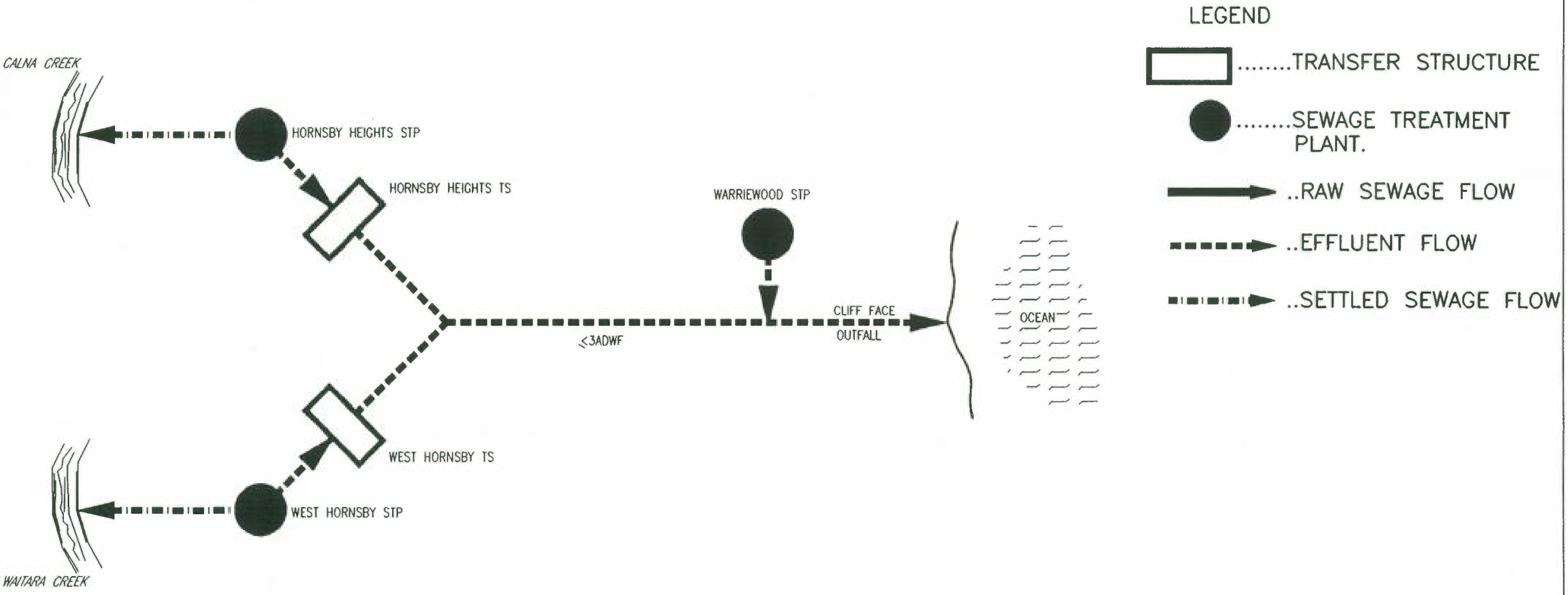
OPTION 9 – DRY WEATHER RAW SEWAGE TRANSFER TO NORTH HEAD STP FOR TREATMENT AND DISPOSAL VIA DEEPWATER OCEAN OUTFALL

WATER BOARD
SYDNEY–ILLAWARRA–BLUE MOUNTAINS
WASTEWATER AND REUSE PLANNING

WEST HORNSBY & HORNSBY HEIGHTS STPS OPTIONS STUDY
SCHEMATIC DIAGRAM OF OPTION 9

Figure
7–9

bc-opt10



OPTION 10 – DRY WEATHER EFFLEUNT TRANSFER TO WARRIEWOOD STP OCEAN OUTFALL

WATER BOARD
SYDNEY–ILLAWARRA–BLUE MOUNTAINS
WASTEWATER AND REUSE PLANNING

WEST HORNSBY & HORNSBY HEIGHTS STPS OPTIONS STUDY
SCHEMATIC DIAGRAM OF OPTION 10

Figure
7–10

potential also exists in reusing effluent in the near vicinity of coastal plants, redistribution shall be limited to Berowra Creek and its close environs.

Option 11 - Indirect Potable Water Reuse

This option involves the retention and upgrading of both the West Hornsby and Hornsby Heights STPs, to potable water standard and distributes all dry weather effluent for commercial and potable water reuse. No major potential exists for reuse involving irrigation and dual water supply within Berowra Creek. Discharges to the receiving waters may still occur under some situations, especially during wet weather conditions (refer figure 7-11).

STRATEGIES NOT CONSIDERED VIABLE

The eleven options adopted for further analysis do not represent the limit of possible options but are considered to be a reasonable range of alternatives. Several other strategies exist but have not been considered in detail for reasons of practicality and economics. The following is a brief outline of those strategies eliminated from detailed consideration.

Non Potable Effluent Re-use

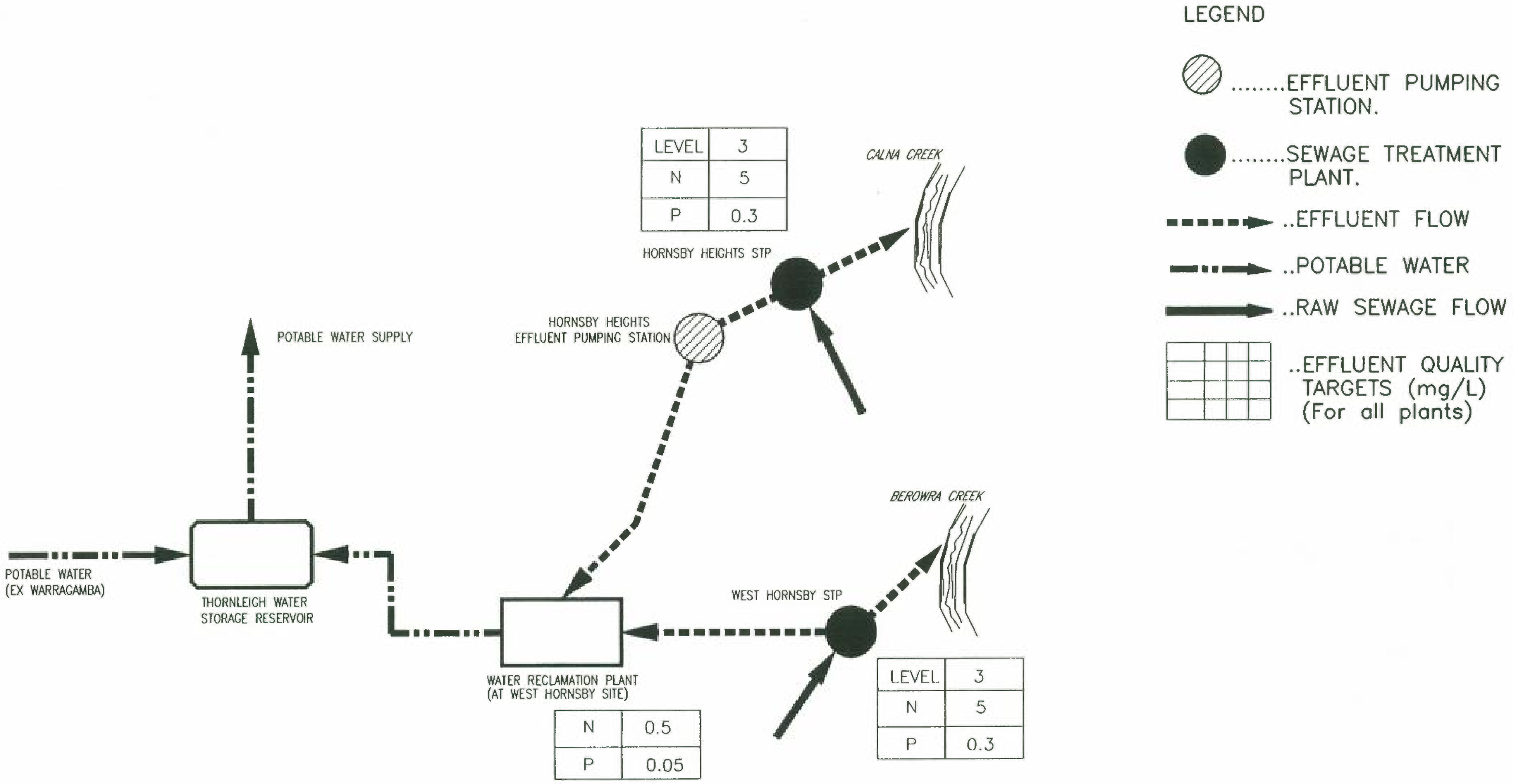
An alternative to disposing of all Berowra Creek Catchment treated effluent, to either the Hawkesbury - Nepean system or the ocean, is to recycle it for irrigation and or industrial applications in the areas surrounding the plant.

Generally, the SPCC and Health Department require that the effluent disinfection criteria for re-use be met by ponding followed by chlorination in the effluent distribution line. No land is available on the existing plant site for ponds, however, chlorination is accepted as an alternative disinfection process where adequate ponding is impractical.

For effluent re-use to be a viable option, the effluent must be offered to potential users on attractive terms. The location of the treatment plant causes some difficulty in providing the effluent transfer infrastructure at a viable cost. All of the identified re-use sites (for example Asquith Golf Course, Rolf Park, Parklands Oval and a number of small reserves) are located on the ridges, some 70 to 100 metres above the treatment plant sites. The transfer scheme would also have to pass through existing residential areas as well as crossing the rail line and the Pacific Highway.

Actual re-use areas are limited. There are several small parks and one golf course within a 5 km radius of the plant but, unfortunately, these are scattered in various directions making the use of one delivery main impossible. Industrial re-use potential is restricted to small industrial areas in the catchment. While re-use at these sites should be encouraged, they do not offer an alternative for total disposal of the plant

bc-opt4



OPTION 11 – INDIRECT POTABLE WATER REUSE IN BEROWRA AND SURROUNDING ENVIRONS.

WATER BOARD
SYDNEY–ILLAWARRA–BLUE MOUNTAINS
WASTEWATER AND REUSE PLANNING

WEST HORNSBY & HORNSBY HEIGHTS STPS OPTIONS STUDY
SCHEMATIC DIAGRAM OF OPTION 11

Figure
7–11

effluent.

Dual Water Supply

Dual water supply systems use a high quality water (potable) for all plumbing services inside properties and residences, and a lower quality water (non potable) for toilets and external uses (such as garden watering).

In the reticulation of reclaimed effluent, the protection of public health is of paramount importance. The risk of a cross connection of effluent polluting the potable supply together with the overall costs of such a system, have historically been considered to be too high to justify implementation. As a result of potential impacts on the water quality of the Nepean-Hawkesbury system, however, the Board has recently endorsed the concept of dual water supplies for the Rouse Hill Development Area. Dual water supplies, which are only utilised for external non-potable uses, enable the low quality water to meet peak summer demands (approximately 20% of average dry weather flows). For most of the time (periods of low demand) there is minimal demand for a secondary quality water supply. During these periods, the effluent must be discharged to the waterways.

The maximum benefit of a dual water supply scheme would be gained if the lower quality water supply were used for both external purposes and toilet flushing purposes. Toilet flushing provides a base demand load (about 10% of average dry weather flows) irrespective of weather conditions.

Secondary treated effluent, with adequate disinfection and nutrient reduction, is considered by the NSW Recycled Water Co-ordination Committee to be the minimum required for dual water supply systems.

For the ultimate Rouse Hill catchment, dual water supply systems have the potential to reduce the amount of effluent flowing to the receiving waters, in dry weather, by up to 40 percent[2] (ie. by approximately 30 to 50 ML/d for 300,000 EP). During low demand and unfavourable weather conditions, however, the reduction in discharge quantity would be significantly less (about 16 ML/d).

The feasibility of significant use of dual water supply in the Berowra Creek catchment is questionable. The dual system is only economical in newly developed areas (eg. the Rouse Hill development area mentioned above) and it would be impractical to extend the system to existing developed areas. It is estimated that new residential areas will increase the load on the treatment plants from about 55,000 EP to an ultimate of 75,000 EP. Thus, the maximum use of dual water supply systems is confined to be approximately 20,000 EP if development proceeds to this ultimate level. Therefore, reductions of sewage effluent flow are unlikely to approach the expected reductions at Rouse Hill.

Irrespective of the quantity of effluent supplied for dual water usage, the remainder of flows from the treatment plant would still need to be disposed of to the receiving waters, and would still need to meet either Levels 1, 2 or 3 treatment requirements.

Hawkesbury-Nepean Catchment Rationalisation

This report will consider a number of options for transferring the West Hornsby and Hornsby Heights flow, for disposal or treatment and disposal to the ocean.

Another alternative, for catchment amalgamation, could involve combining the Hornsby Heights and West Hornsby catchments and transferring their flows to Rouse Hill STP for treatment and subsequent disposal to the Hawkesbury-Nepean River upstream of Berowra Creek's confluence.

With reference to the Board's rationalisation study which examined the potential for the amalgamation of a number of existing Hawkesbury-Nepean STPs[3], no major economic benefit was found in transferring flows from Berowra Creek to the new Rouse Hill STP. Also, the Rouse Hill STP environmental assessment report[2] limits development to a maximum of 300,000 EP within its catchment which forms an integral part of the North West Development Sector. The amalgamation of Berowra Creek catchment with Rouse Hill will not only limit further development of the North West Sector but prevent the rationalisation potential for smaller plants, such as Castle Hill and Round Corner, which are in close proximity to Rouse Hill. Also, major capital outlay is necessary to provide a safe crossing over Berowra Creek to carry raw sewage flows from this catchment to Rouse Hill. Based on these limitations this option was not considered further.

Dispersed Treatment

The concept behind this strategy is to generally treat and dispose of sewage in the Berowra Creek Catchment where it is generated by providing a large number of small treatment plants in not only new development area, but also existing sewered areas.

This strategy has three variations. One option involves local treatment whereby sewage is collected by a conventional reticulation system of gravity mains and neighbourhood pumping stations to designated sites where the STPs are located. It has been assumed that these plants will have a capacity of not more than 10,000 EP. Treated effluent would be reused where possible and discharged to local water courses. If this approach was applied to Berowra Creek, approximately eight (8) treatment plants would need to be functioning throughout the catchment. Not only would this be an expensive strategy, not many sites are available for the proposed 6 additional treatment plants.

For the remaining two sub-options, on-site treatment is used which involves individual household users operating a proprietary treatment system for on-site disposal where practical, or discharge to the stormwater system. On-site treatment may be achieved at each individual dwelling by either adopting a domestic activated sludge treatment (DAST) system or biological composting toilets.

Although the concept of dispersed treatment may be applied system-wide, it is recognised that this strategy is only applicable in isolated settlements remote from a central treatment facility (as already exists in Berowra Creek catchment) and in some new development areas. Therefore, this strategy shall not be considered further.

Inland Disposal

This strategy involves the transportation of all dry weather flows from Sydney and the Blue Mountains to the inland regions west of the Great Dividing Range. The aim is to relieve all inland and coastal waterways of sewage-origin pollutant loads during dry weather flows and at the same time use the resource value of the treated effluent (water and nutrients) to increase agricultural productivity. For this scheme to be properly analysed this strategy would need to be examined holistically with all of the Sydney Region STPs and cannot be considered in isolation. Therefore, this strategy will not be examined further.

TREATMENT PROCESS SELECTION

Based on the detailed discussion included in Appendix B, the treatment processes that have been selected to meet the effluent quality targets in Options 1 to 4, (Treatment and Discharge to Berowra Creek), Options 5 to 10 (Transfer of Sewage to the Ocean) and Option 11 (Indirect Potable Water Reuse) are detailed below:

Treatment and Discharge to Berowra Creek

The following activated sludge processes were selected as being most appropriate for augmenting and upgrading West Hornsby and Hornsby Heights STPs to achieve effluent quality targets level 1 and 2 (Total Nitrogen 15 and 10 mg/L):

- Option 1 - Continuous flow activated sludge process incorporating biological nitrogen and chemical phosphorus removal facilities (sometimes referred to as the Modified Ludzack Ettinger (MLE) process).
- Option 2 - Continuous flow MLE process with high biomass system.
- Option 3 - The intermittent activated sludge process incorporating biological nitrogen and chemical phosphorus removal facilities (sometimes referred to as the intermittently decanted aeration lagoon (IDAL) system).

- Option 4 - Incorporation of both the MLE process at the Hornsby plants plus the IDAL system at the new treatment plant site.

Effluent Quality Target Level 3 (Total Nitrogen of 5 mg/L)

The above process options selected for further investigation are considered capable of achieving the Level 1 and 2 effluent quality targets. To achieve the Level 3 requirements (especially with regard to total nitrogen level of 5 mg/L in the effluent) the following facilities are to be added to Options 1 to 4 treatment process train:

- Post biological denitrification facilities.

- External carbon source dosing facilities to sustain denitrification.

For the purposes of this report methanol shall be used as the supplementary carbon source.

Ocean Discharge Options (zero Total Nitrogen)

To meet a zero effluent total nitrogen discharge target for the Berowra Creek catchment, Options 5 to 10 shall be examined in more detail in the following sections of this report. As the options involve the transfer of sewage to the ocean the following treatment processes were considered adequate for further examination and to meet additional effluent quality criteria detailed in Table 7-2 :

- Option 5, 7, 8 and 10 - Continuous flow activated sludge process (incorporating biological nitrification) at either the Hornsby plants or Warriewood STP.

- Option 6 and 9 - High rate primary treatment and deep ocean outfall process at North Head STP.

Also for the transfer options, storm flows greater than three times average dry weather flow (3 ADWF) shall be treated by the treatment facilities detailed below:

- Option 5 - Storm treatment via wet weather holding basins at Hornsby plants plus preliminary treatment (including fine screens) for excessive storm flows prior to discharge to Berowra Creek.

- Option 6 - Similar to Option 5

- Option 7 - Primary treatment plus storage. If discharge to Berowra Creek eventuates fine screening is also provided prior to discharge.

- Option 8 - Storm flows treated by a chemical assisted sedimentation (CAS) process at both the Hornsby plants before discharge to Berowra Creek.

- Option 9 - Similar to Option 8

- Option 10 - Similar to Option 7 but without storage.

Effluent Reuse in Berowra Creek Catchment

To maximise the potential for effluent reuse in Berowra Creek and its surrounding environs plus achieve a zero effluent total nitrogen discharge to the Creek, indirect potable water reuse has the greatest potential within the catchment. The following treatment process was considered the minimum required to meet the zero discharge requirements plus Table 7-3 Level D effluent quality goals.

- Option 11 - Continuous flow biological nitrogen and chemical phosphorus removal process (MLE, Level 3) plus reverse osmosis and effluent disinfection incorporating UV and chlorination.

SUMMARY

Options 1 to 11 are to be investigated in more detail in Sections 8 to 19 that follow. The treatment process selected for each option is discussed in the following sections as well as Appendix B.

REFERENCES

1. Water Board, *Choices for Clean Waterways*, March 1994.

2. Manidis Roberts Consultants, *Environmental Impact Statement, Proposed Rouse Hill Sewage Treatment Plant*, Sydney 1990.

3. Clean Waterways Programme, PAB, *Preliminary Hawkesbury-Nepean Rationalisation Study Volume I - IV*, May 1992.

SECTION 8

OPTION 1 RETENTION AND UPGRADE WITH MLE PROCESS

Option 1 involves the permanent retention, upgrade and amplification (if required) of West Hornsby and Hornsby Heights STPs respectively.

The upgrade will provide facilities to achieve the effluent quality Levels 1 to 3 as detailed in Table 7-1, with particular regard to meeting Total Nitrogen discharges of 15 mg/L, 10 mg/L and 5 mg/L during dry weather conditions. The upgraded sewage treatment plants will be capable of removing organics and suspended solids as well as achieving biological nitrification, denitrification and chemical phosphorus removal. For the purpose of the report the biological nitrogen and chemical phosphorus removal system adopted is commonly referred to as the Modified Ludzack Ettinger (MLE) process which is a continuous flow activated sludge process with separate reactor and clarifiers.

Based on the equivalent population projection forecasts discussed in Section 5 for the two Hornsby STPs, Hornsby Heights STP requires amplification around the year 1997 or 1998. From Table 4-2, a nominal amplification stage of 5,000 EP has been adopted and is acceptable beyond the year 2019. Also, based on the Key Young's equivalent population projections, amplification of Hornsby Heights STP to 25,000 EP could well represent the ultimate for the catchment. There is also no major difference between the medium (23,400 EP) and high (25,000 EP) population projections for Hornsby Heights STP. In the case of West Hornsby STP, upgrading to a capacity of 46,500 EP will mean that no major amplification will be required at the plant for some time beyond year 2019. The 46,500 EP value was chosen as this is near the current nominal 45,000 EP capacity of the STP and there was no major difference between the medium and high EP population projections shown in Table 4-1.

OPTION 1 FOR WEST HORNSBY STP

For West Hornsby STP Option 1 involves upgrading the existing plant for biological nitrogen and chemical phosphorus removal with the Modified Ludzack Ettinger (MLE) system.

The MLE system is a continuous flow activated sludge process, which achieves nitrification, denitrification carbonaceous oxygen reduction by biological means and phosphorus removal by chemical means.

Although prefermentation was originally not provided with the MLE design, experience with biological nutrient removal plants indicates that an ideal sewage feed, containing adequate concentrations of readily biodegradable COD (RBCOD), enhances denitrification. Prefermentation increases RBCOD and is, therefore, considered an important enhancement of this process type, particularly for Levels 2 and 3 treatment. Figure 8-1 shows diagrammatically the prefermentation process.

FACILITIES REQUIRED

The following facilities are recommended to be provided to achieve the Level 1, 2 and 3 effluent quality targets. Table 8-1 and figures 8-2 to 8-7 also summarise the works required, the process train and plant layouts respectively. A more detailed discussion is provided in Appendix C and should be read in conjunction with the description given below.

Level 1 Treatment Requirements (Total Nitrogen of 15 mg/L)

Inlet Works/Screening/Grit Removal. No major upgrade of the inlet works (including coarse screening) is required. Modifications to the current hydraulic arrangement, however, will need to be undertaken to improve the performance of the existing grit removal facilities. This shall be achieved by providing one additional grit tank.

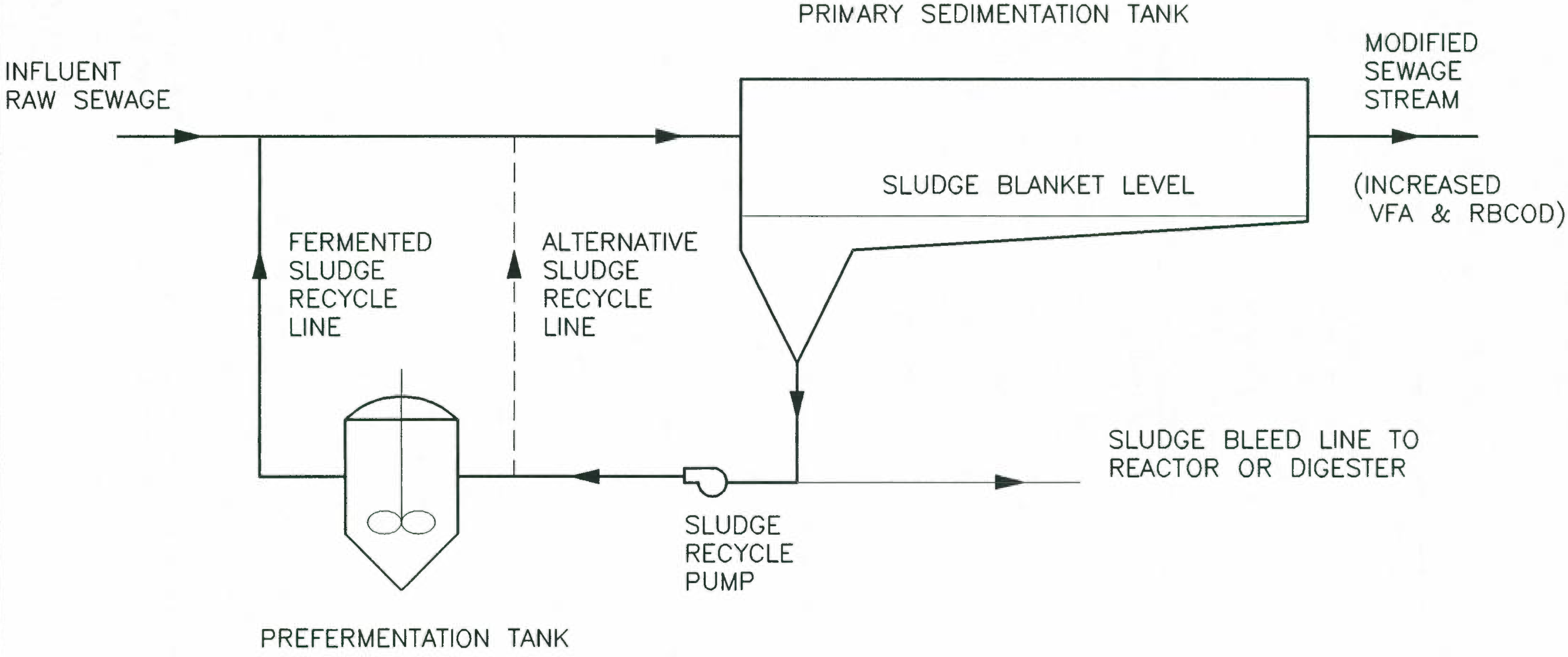
The existing fine screen facilities shall not be modified and shall continue to be utilised to treat excessive storm flows above Design Wet Weather Flow (DWWF).

Primary Sedimentation and RBCOD Generation. To improve denitrification performance, and reduce the size of downstream biological treatment facilities, the existing primary sedimentation tanks will be retained and upgraded to achieve RBCOD generation (via the prefermentation process), allow the plant to be operated in the settled sewage mode and still be capable of providing for basic storm treatment. Primary sedimentation automated weirs shall also be provided to optimise solids removal during dry weather.

Biological Reactor. The existing six aeration tanks will be modified to achieve biological nitrification/denitrification and BOD removal and chemical phosphorus removal. The zones of the reactor will perform the following functions:

- Anoxic Zone - Denitrification and oxidation of organic matter.

bc-whap



WATER BOARD
SYDNEY-ILLAWARRA-BLUE MOUNTAINS
WASTEWATER AND REUSE PLANNING

SCHEMATIC DIAGRAM OF
ACTIVATED PRIMARY SEDIMENTATION TANKS

Figure
8-1

■ Aeration Zone	-	Oxidation of organic matter, nitrification and phosphorus removal via chemical dosing within the aerobic zone.
■ Re-aeration Zone	-	Increase the DO level of mixed liquor to minimise the possibility of denitrification occurring in the clarifiers leading to solids carry over into the effluent; this zone may or may not be physically separated from the aeration zone.

Mixed liquor recycle (up to 5 ADWF) will be provided from the downstream end of the anoxic zone to promote denitrification. Sludge recycle from the secondary clarifiers to the reactor inlet will be provided to maintain the concentration of organisms in the mixed liquor within the reactor. Excess activated sludge will be wasted from the aeration zone and discharged to the sludge processing facilities.

Secondary Clarification. Existing clarification will be augmented by the provision of one additional rectangular clarifier.

Tertiary Filtration. The existing dual media filters, on site have adequate capacity and will not require amplification.

Phosphorus Removal. Phosphorus removal will continue to be carried out by dosing chemicals upstream of the aerobic zone of the reactor and tertiary filters.

Alkalinity Control. Existing lime dosing facilities will be retained and optimised for pH control.

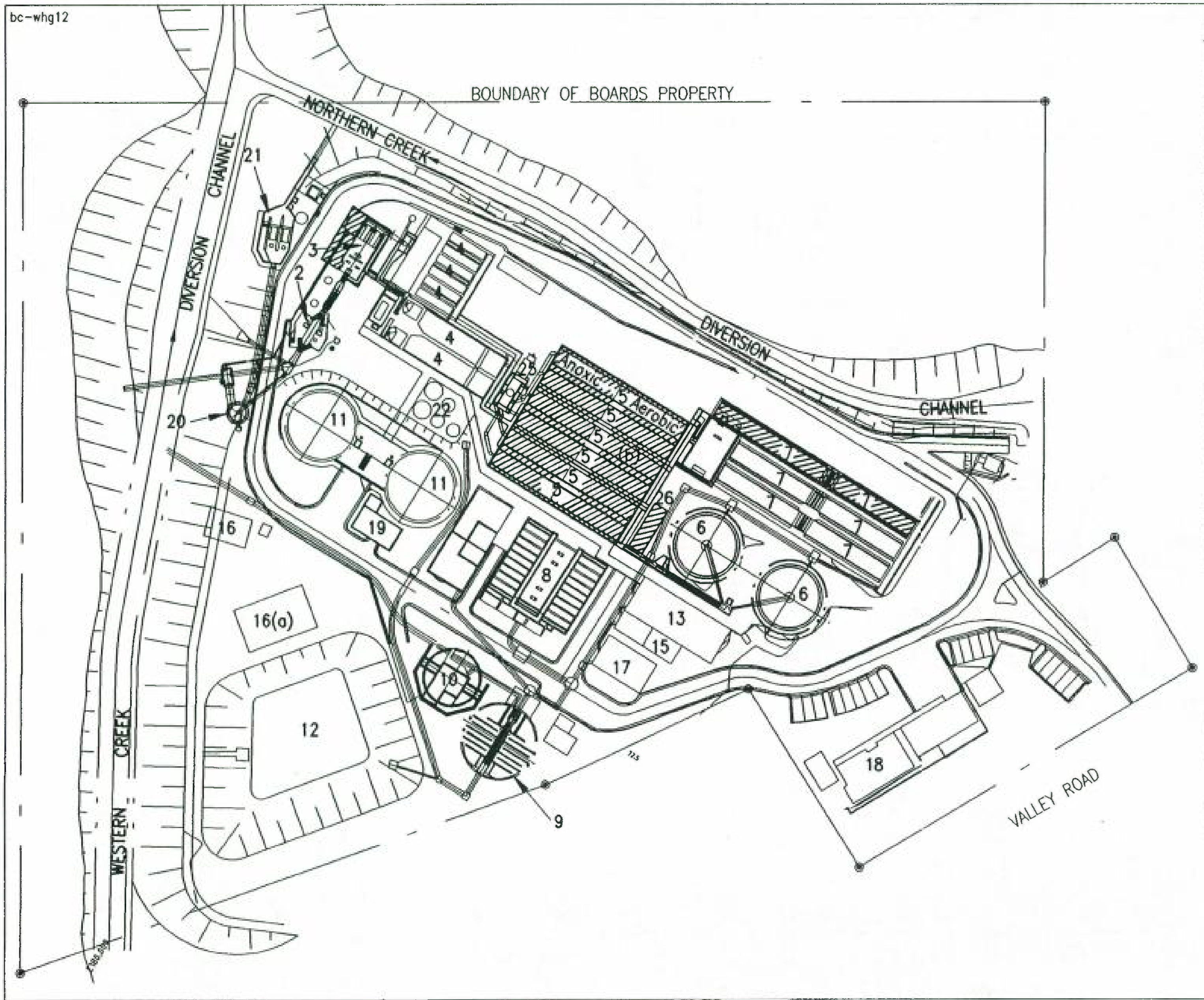
Disinfection. The existing chlorination facilities will be optimised to improve performance and reliability.

Sludge Digestion. The existing anaerobic digesters have sufficient capacity when operated in the primary mode and waste activated sludge is thickened prior to entry.

Sludge Thickening and Dewatering. Permanent dewatering facilities are currently being provided on-site and will be sufficient for the future projected loads. Sludge thickening, however, will be needed for the waste activated sludge and raw sludge extracted from the biological reactor and primary sedimentation tanks respectively.

Process Flow Diagram and Plant Layout. Process flow diagram and plant layout are shown on figures 8-2 and 8-3 respectively for the proposed Level 1 facilities. Refer to Appendix C for more details of the proposed settled sewage MLE.

Centrate from the sludge handling facilities shall be directed to the NSOOS via the existing centrate SPS. Supernatant will be returned to the head of works over the



LEGEND

1	SPS 490
2	SCREEN
3	AERATED GRIT CHAMBER
4	PRIMARY SEDIMENTATION TANKS
5	ANOXIC / AERATION TANKS
6	CIRCULAR SECONDARY SEDIMENTATION TANKS
7	RECTANGULAR SEDONDARY SEDIMENTATION TANKS
8	DUAL MEDIA FILTERS
9	CHLORINE CONTACT TANK
10	EFFLEUNT PUMPING STATION
11	DIGESTERS
12	HOLDING BASIN
13	BLOWER HOUSE / RAS PUMPING STATION
14	RAS PUMPING STATION
15	11kV SUBSTATION
16	SLUDGE DEWATERING AREA
17	CHLORINATION BUILDING
18	ADMINSTRATION BUILDING
19	SLUDGE PUMPING STATION SPS 212
20	RAW SEWAGE FLOW SPLITTER
21	STORM FLOW FINE SCREENS
22	CHEMICAL DOSING FACILITIES (PHOSPHORUS REMOVAL) + ALKALINITY ADDITION
23	FILTERED WATER TANK
24	FOUL WATER TANK
25	FLOW SPLITTER
26	MIXED LIQUOR PUMPING STATION + MIXED LIQUOR RECYCLE

(a) SLUDGE DEWATERING FACILITY CURRENTLY UNDER CONSTRUCTION (INCLUDES CENTRIFUGES).

(b) EXISTING AERATION TANKS MODIFIED TO ANOXIC / AEROBIC REACTOR (MLE).

▨ ADDITIONAL FACILITIES FOR 46,500EP

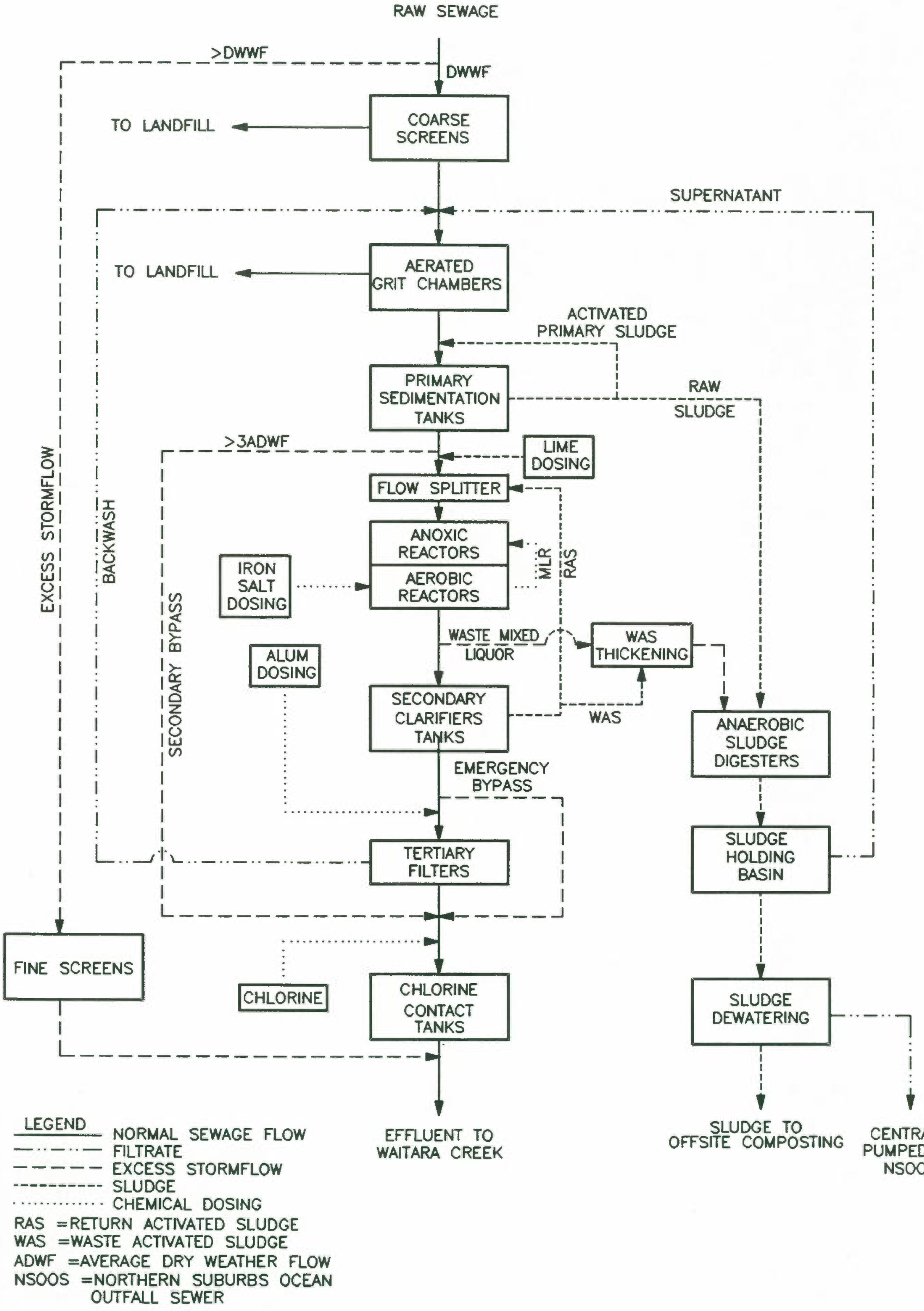
WATER BOARD
SYDNEY-ILLAWARRA-BLUE MOUNTAINS

WASTEWATER AND REUSE PLANNING

WEST HORNSBY S.T.P.
OPTION 1 – LEVEL 1 (15 mg/L TN)
GENERAL ARRANGEMENT FOR 46,500EP MLE

Figure
8–2

bc-pfd2



WATER BOARD
SYDNEY-ILLAWARRA-BLUE MOUNTAINS
WASTEWATER AND REUSE PLANNING

WEST HORNSBY S.T.P.
PROCESS FLOW DIAGRAM
OPTION 1 – LEVEL 1 (15mg/L TN)
46,500EP

Figure
8–3

full day and not cause undue process upsets.

Level 2 Treatment Requirements (Total Nitrogen of 10 mg/L)

To achieve the Level 2 effluent quality targets, the Level 1 facilities described above will be required plus the addition of the following:

For more details of the works required refer to Table 8-1 and Appendix C.

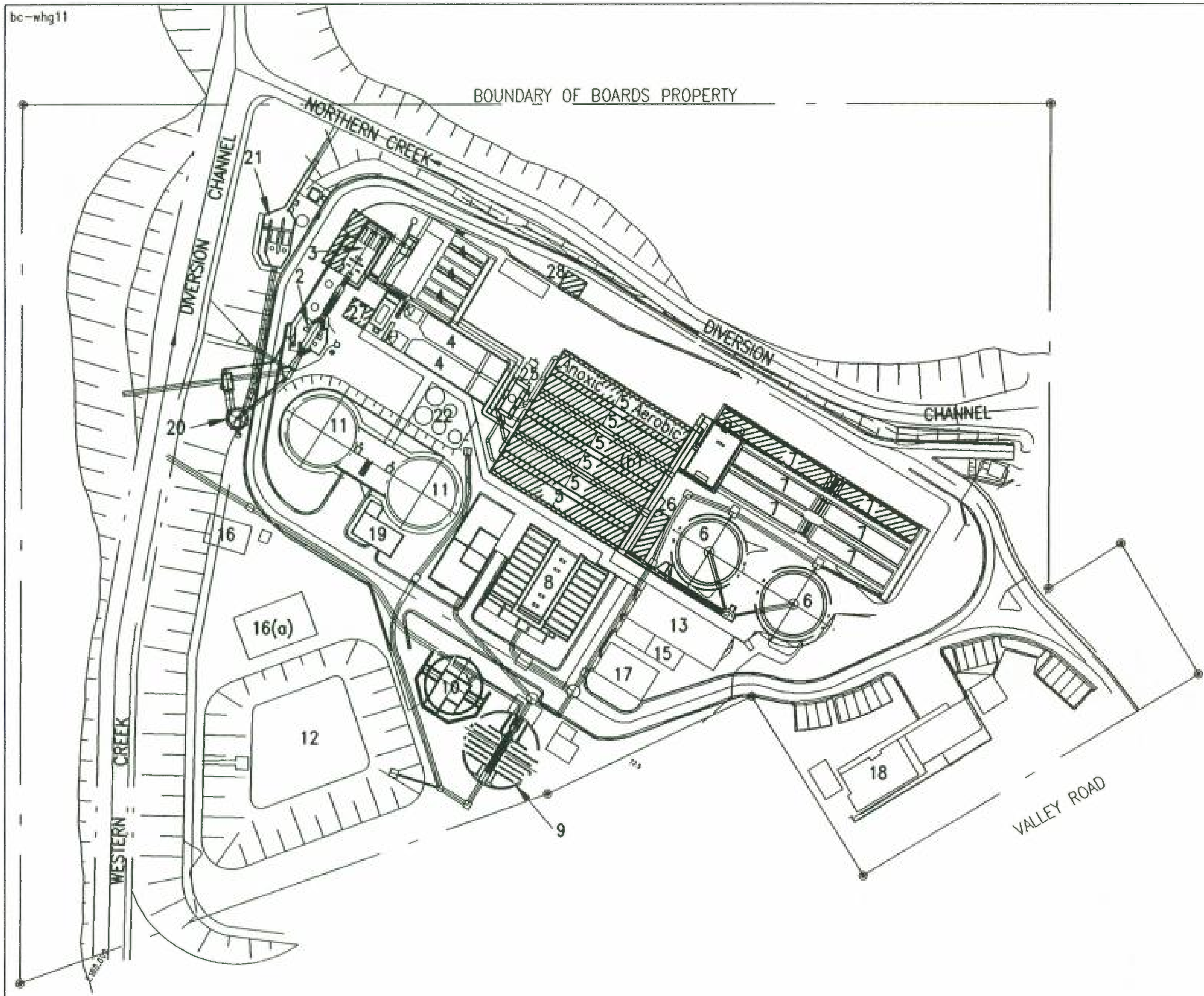
Methanol Dosing Facilities. In order to not limit the potential for biological denitrification, an external carbon source (such as methanol) dosing facility shall be provided and operate in conjunction with the proposed prefermentation facilities. Alternate carbon sources also exist and may be acceptable in replacing methanol.

Process Flow Diagram and Plant Layout

The proposed settled sewage MLE facilities and its process train are shown on figures 8-4 and 8-5 respectively.

Level 3 Treatment Requirements (Total Nitrogen of 5 mg/L)

In addition to installing the Level 2 facilities, post denitrification will be provided to reduce total nitrogen levels to the Level 3 effluent target of Table 7-1. Figures 8-6 and 8-7 detail the Level 3 facilities and its process train respectively while Appendix C discusses post denitrification in more detail. Table 8-1 also summaries the facilities required for the proposed Level 3 plant at West Hornsby.



LEGEND

1	SPS 490
2	SCREEN
3	AERATED GRIT CHAMBER
4	PRIMARY SEDIMENTATION TANKS
5	ANOXIC / AERATION TANKS
6	CIRCULAR SECONDARY SEDIMENTATION TANKS
7	RECTANGULAR SEDONDARY SEDIMENTATION TANKS
8	DUAL MEDIA FILTERS
9	CHLORINE CONTACT TANK
10	EFFLEUNT PUMPING STATION
11	DIGESTERS
12	HOLDING BASIN
13	BLOWER HOUSE / RAS PUMPING STATION
14	RAS PUMPING STATION
15	11kV SUBSTATION
16	SLUDGE DEWATERING AREA
17	CHLORINATION BUILDING
18	ADMINSTRATION BUILDING
19	SLUDGE PUMPING STATION SPS 212
20	RAW SEWAGE FLOW SPLITTER
21	STORM FLOW FINE SCREENS
22	CHEMICAL DOSING FACILITIES (PHOSPHORUS REMOVAL) + ALKALINITY ADDITION
23	FILTERED WATER TANK
24	FOUL WATER TANK
25	FLOW SPLITTER
26	MIXED LIQUOR PUMPING STATION + MIXED LIQUOR RECYCLE
27	PREFERMENTATION
28	METHANOL DOSING FACILITY

(a) SLUDGE DEWATERING FACILITY CURRENTLY UNDER CONSTRUCTION (INCLUDES CENTRIFUGES).

(b) EXISTING AERATION TANKS MODIFIED TO ANOXIC / AEROBIC REACTOR (MLE).

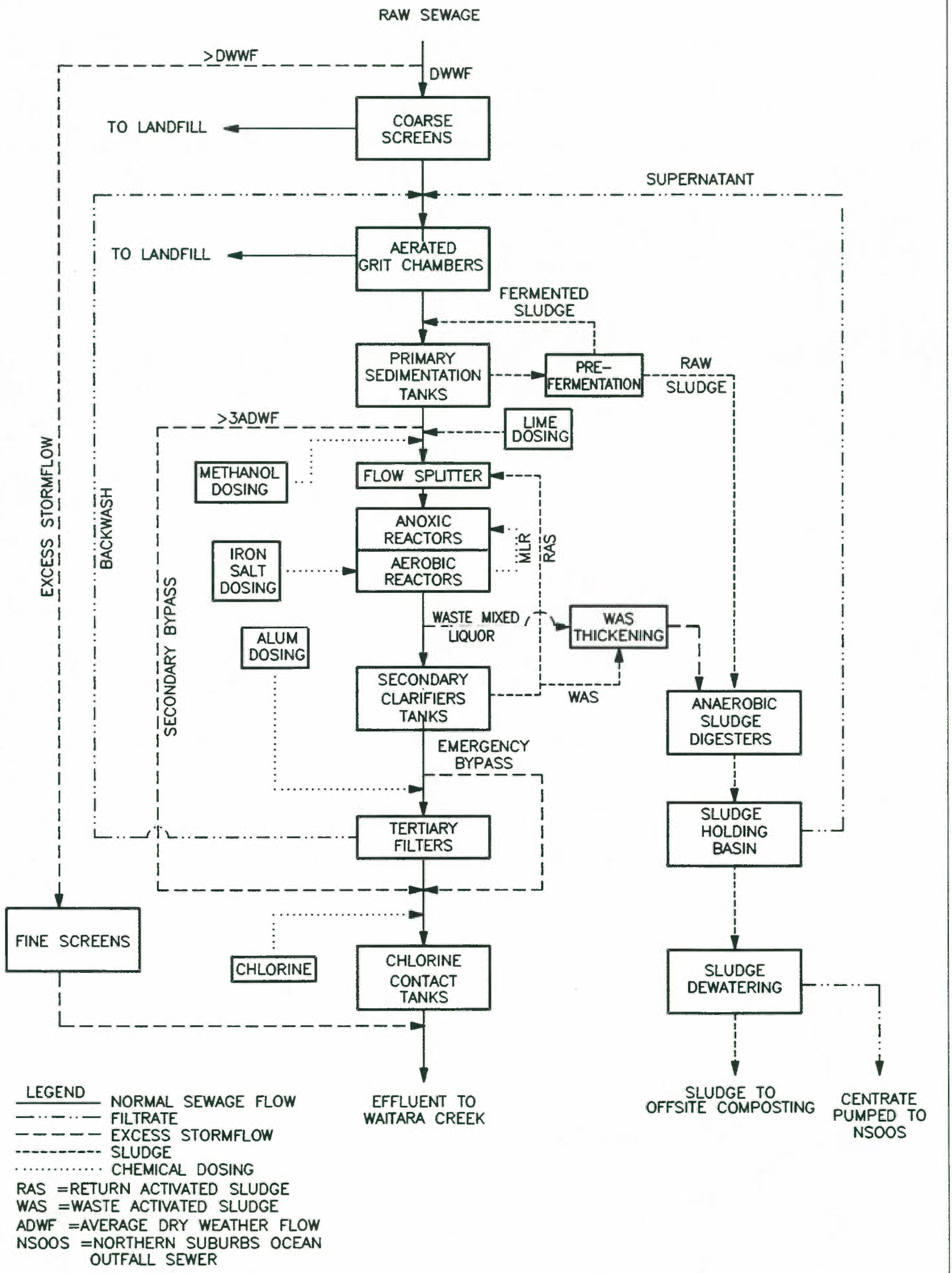
▨ ADDITIONAL FACILITIES FOR 46,500EP

WATER BOARD
SYDNEY-ILLAWARRA-BLUE MOUNTAINS
WASTEWATER AND REUSE PLANNING

WEST HORNSBY S.T.P.
OPTION 1 – LEVEL 2 (10 mg/L TN)
GENERAL ARRANGEMENT FOR 46,500EP MLE

Figure
8–4

bc-pfd3

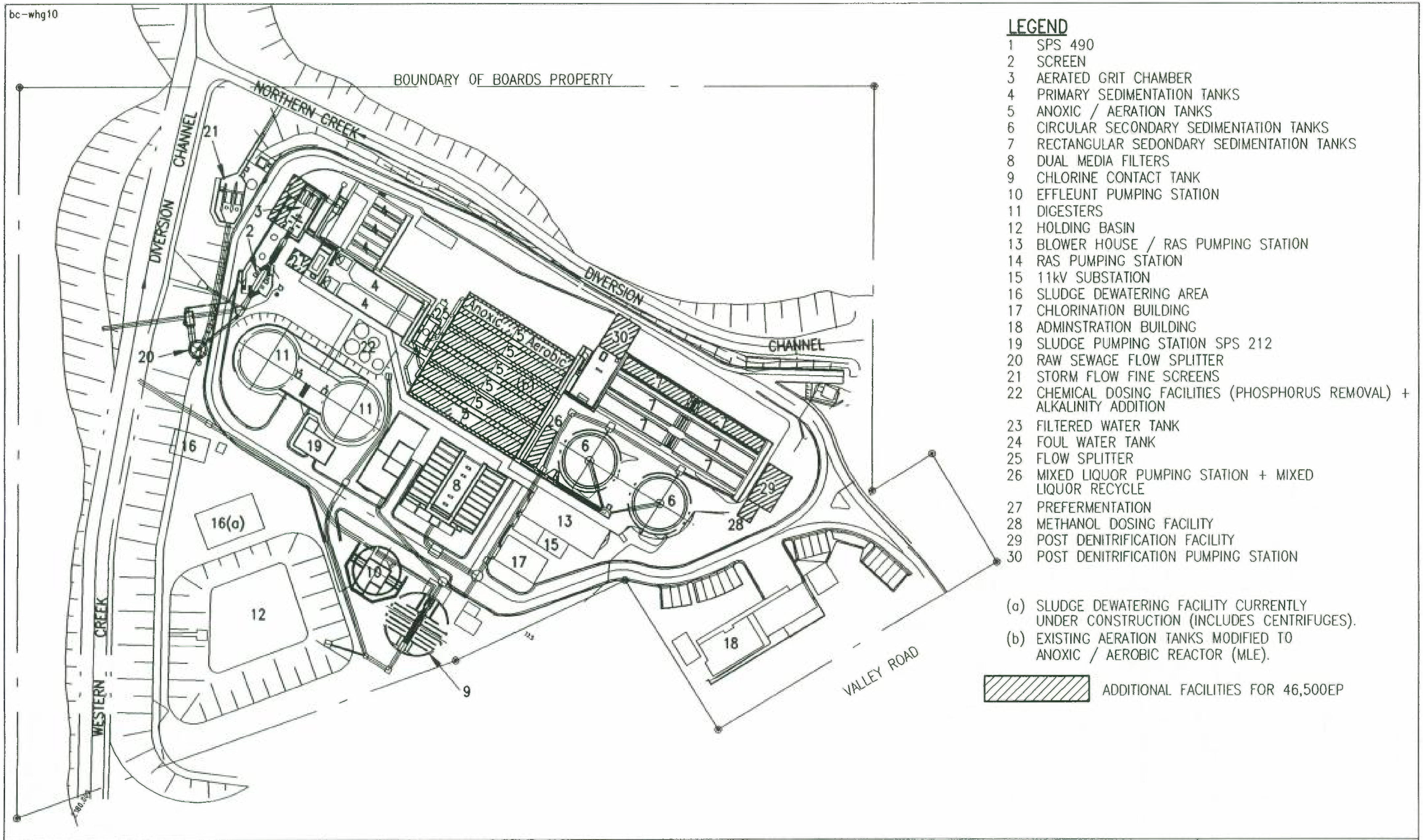


RAS =RETURN ACTIVATED SLUDGE
WAS =WASTE ACTIVATED SLUDGE
ADWF =AVERAGE DRY WEATHER FLOW
NSOOS =NORTHERN SUBURBS OCEAN OUTFALL SEWER

WATER BOARD
SYDNEY-ILLAWARRA-BLUE MOUNTAINS
WASTEWATER AND REUSE PLANNING

WEST HORNSBY S.T.P.
PROCESS FLOW DIAGRAM
OPTION 1 – LEVEL 2 (10mg/L TN)
46,500EP

Figure
8–5



LEGEND

1	SPS 490
2	SCREEN
3	AERATED GRIT CHAMBER
4	PRIMARY SEDIMENTATION TANKS
5	ANOXIC / AERATION TANKS
6	CIRCULAR SECONDARY SEDIMENTATION TANKS
7	RECTANGULAR SEDONDARY SEDIMENTATION TANKS
8	DUAL MEDIA FILTERS
9	CHLORINE CONTACT TANK
10	EFFLEUNT PUMPING STATION
11	DIGESTERS
12	HOLDING BASIN
13	BLOWER HOUSE / RAS PUMPING STATION
14	RAS PUMPING STATION
15	11kV SUBSTATION
16	SLUDGE DEWATERING AREA
17	CHLORINATION BUILDING
18	ADMINSTRATION BUILDING
19	SLUDGE PUMPING STATION SPS 212
20	RAW SEWAGE FLOW SPLITTER
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22	CHEMICAL DOSING FACILITIES (PHOSPHORUS REMOVAL) + ALKALINITY ADDITION
23	FILTERED WATER TANK
24	FOUL WATER TANK
25	FLOW SPLITTER
26	MIXED LIQUOR PUMPING STATION + MIXED LIQUOR RECYCLE
27	PREFERMENTATION
28	METHANOL DOSING FACILITY
29	POST DENITRIFICATION FACILITY
30	POST DENITRIFICATION PUMPING STATION

(a) SLUDGE DEWATERING FACILITY CURRENTLY UNDER CONSTRUCTION (INCLUDES CENTRIFUGES).

(b) EXISTING AERATION TANKS MODIFIED TO ANOXIC / AEROBIC REACTOR (MLE).

▨ ADDITIONAL FACILITIES FOR 46,500EP

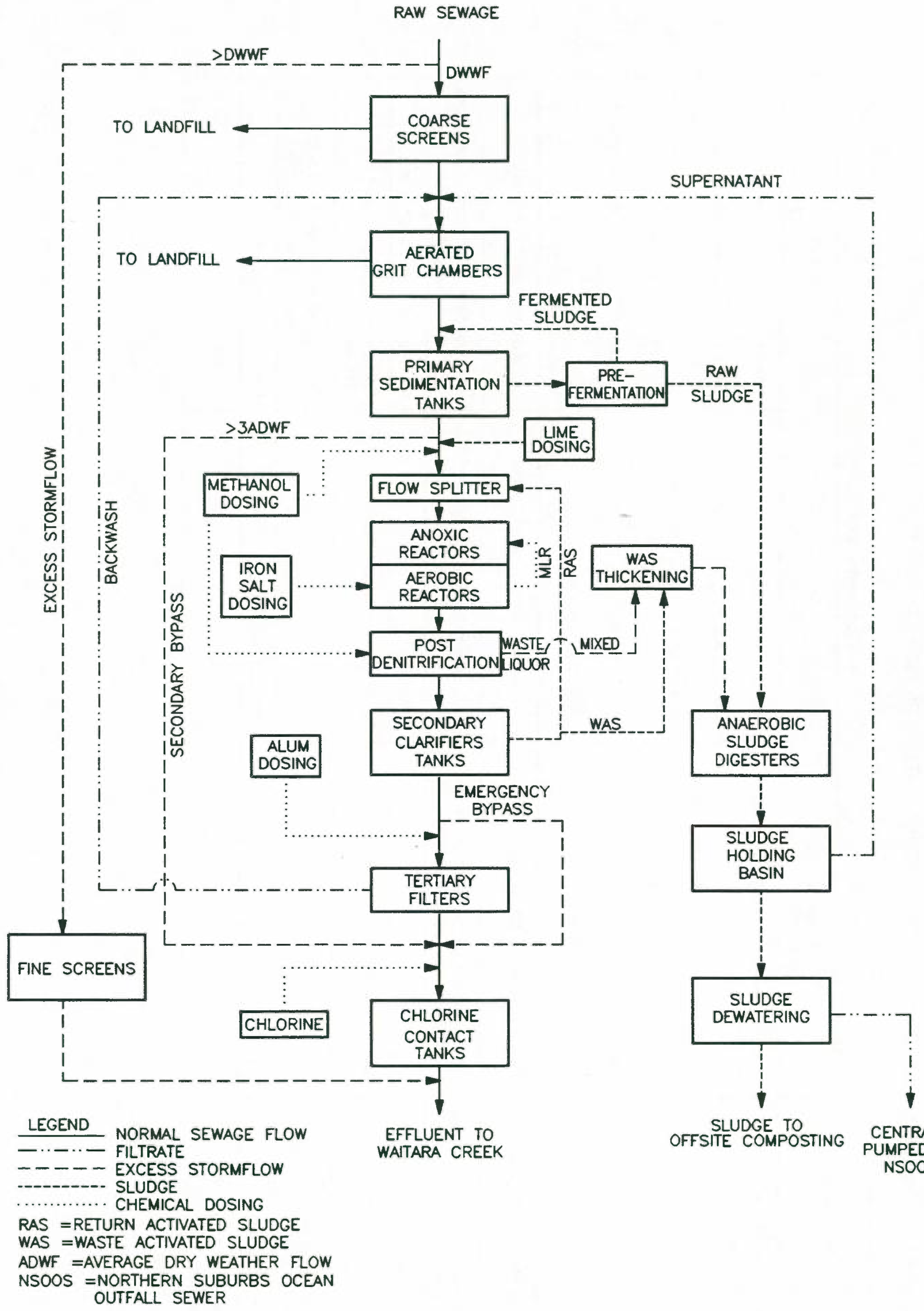
WATER BOARD
SYDNEY-ILLAWARRA-BLUE MOUNTAINS

WASTEWATER AND REUSE PLANNING

WEST HORNSBY S.T.P.
OPTION 1 – LEVEL 3 (5 mg/L TN)
GENERAL ARRANGEMENT FOR 46,500EP MLE

Figure
8–6

bc-pfd4



WATER BOARD
SYDNEY-ILLAWARRA-BLUE MOUNTAINS
WASTEWATER AND REUSE PLANNING

WEST HORNSBY S.T.P.
PROCESS FLOW DIAGRAM
OPTION 1 – LEVEL 3 (5mg/L TN)
46,500EP

Figure
8–7

TABLE 8-1. SUMMARY OF OPTION 1 PROPOSED WORKS - WEST HORNSBY STP FOR 46,500 EP

Actions Proposed	**Treatment Level**		
	Level 1 (15 mg/L TN)	**Level 2 (10 mg/L TN)**	**Level 3 (5 mg/L TN)**
Upgrading of nitrogen removal facilities	Provide anoxic/aerobic zones in existing 6 aeration tanks (42% anoxic). Relocate aeration system in aerobic zone. Provide activated primaries recycle system. Provide mixers in anoxic zone Install mixed liquor recycle	Install mixed liquor recycle Provide prefermentation system Increase size of anoxic area to at least 42% in existing 6 aeration tanks Provide mixers in anoxic zone Relocate aeration system	Install mixed liquor recycle Relocate aeration system in aerobic zone Provide mixers in anoxic zone Increase size of anoxic area to 42% in existing 6 aeration tanks Provide prefermentation tank
Upgrading of phosphorus removal facilities	Optimise multi-point dosing system	Optimise multi-point dosing system	Optimise multi-point dosing system
Upgrading primary sedimentation	Install automatically controlled penstocks for COD removal optimisation	Install automatically controlled penstocks for COD removal optimisation	Install automatically controlled penstocks for COD removal optimisation
External Carbon Source	-	Provide methanol dosing facility	Provide methanol dosing facility
Clarifiers	Provide one rectangular clarifier of 180m^2	Provide one rectangular clarifier of 375 m^2	Provide one rectangular clarifier of 375 m^2 area
Suspended Growth Post Denitrification	-	-	Provide post anoxic reactor (1.5 hr anoxic detention plus 1 hr aerobic)
Process Type	Settled Sewage MLE	Settled Sewage MLE	Settled Sewage MLE
Estimated minimum capacity (EP)	46,500	46,500	46,500

OPTION 1 FOR HORNSBY HEIGHTS STP

To maximise the use of existing structures, Option 1 for Hornsby Heights STP involves the following tasks:

- Modify the existing Stage 1 plant to achieve biological nitrogen removal (Stage 1 Upgrade).
- Continue to remove organics and suspended solids.
- Optimise the existing multi-point chemical dosing facilities for phosphorus removal.
- Provide flow equalisation facilities for dry weather flows.
- Amplify the proposed MLE system by 5,000 EP to a total EP capacity of 25,000 (Stage 2 Amplification).

FACILITIES REQUIRED

The following sections provide a brief description of the facilities that could be employed to achieve the Technical Working Party's Level 1, 2 and 3 effluent quality targets (refer Table 7-1). Tables 8-2 and 8-3 summarises the actual works required while figures 8-8 to 8-13 provide the process train and plant layouts respectively. Refer to Appendix C for a more detailed discussion of the facilities proposed.

Level 1 Treatment Requirements (Total Nitrogen of 15 mg/L)

The facilities recommended to be installed at Hornsby Heights STP is described below in two parts, the Stage 1 Upgrade and Stage 2 Amplification.

Stage 1 Upgrade (20,000 EP)

Flow Equalisation. The existing raw sewage pumping station (SPS 542) will be modified and augmented to provide for flow equalisation at dry weather flows. Gravity flows to the plant will also be diverted to the flow equalisation facility to ensure equalisation of all dry weather flows to Hornsby Heights STP. Refer to figure 8-8 for a general layout of the facilities proposed.

Inlet Works/Screenings/Grit Removal. No upgrading of the existing inlet works, screenings and grit removal facilities is required. Fine influent screens, however, will be provided to treat excessive storm flows before discharge.

Primary Sedimentation and RBCOD Generation. Prefermentation facilities will be provided to generate readily biodegradable COD. Also to ensure optimum COD collection and removal, and to minimise the size of downstream biological facilities, automated weirs shall be provided to regulate flows to the primary sedimentation tanks.

Biological Reactor. The existing three aeration tanks will be modified to achieve biological nitrification/denitrification, BOD removal and chemical phosphorus removal. The proposed three settled sewage MLE reactors will be operated in parallel to provide process redundancy during maintenance and breakdown conditions.

The zones of each reactor will consist of an:

- Anoxic Zone.
- Aeration Zone.
- Re-aeration Zone.

Refer to Appendix C for a more detailed discussion of the function, sizing and additional facilities required for the proposed MLE reactors.

Secondary Clarification. An additional circular clarifier will be provided.

Phosphorus Removal. Phosphorus removal shall continue to be achieved by dosing chemicals (iron and alum salts) upstream of the aerobic zone of the reactor and tertiary filters.

Alkalinity Control. The existing lime dosing facilities on-site will be retained, operated and optimised for pH control.

Disinfection. The existing chlorination facilities will be optimised to improve performance and reliability.

Sludge Digestion. The present two anaerobic digesters have adequate capacity for 40,000 EP when operated in the primary made and sludge is thickened prior to entry. All waste sludge will be thickened prior to further stabilisation.

Sludge Thickening and Dewatering. Permanent sludge thickening and dewatering facilities shall be provided. All sludges prior to entry into the sludge digesters will be thickened. The stabilised sludge will then be dewatered and exported off-site for either land disposal or beneficial use.

Process Flow Diagram and Plant Layout. Figures 8-8 and 8-9 show the proposed settled sewage MLE flow train and additional facilities required to achieve the Level 1 effluent targets for 20,000 EP.

Stage 2 Amplification (25,000 EP)

In addition to the Stage 1 20,000 EP Upgrade, the biological nitrogen removal plant will still need a Stage 2 amplification of 5,000 EP. The additional facilities required are discussed below.

Flow Equalisation. In the Stage 1 Upgrade, modifications to the existing raw sewage pumping station shall provide for a 25,000 EP flow equalisation facility and no further amplification is required in Stage 2.

Inlet Works/Screens/Grit Removal. A 5,000 EP amplification of inlet works, screens and grit removal facilities is proposed. Fine effluent screens will also need to be amplified to 25,000 EP capacity.

Primary Sedimentation and RBCOD Generation. Amplification of the primary sedimentation tanks and prefermentation facilities to 25,000 EP capacity will be necessary. Automated PST weir shall also be provided.

Biological Reactor. The proposed Stage 1 MLE reactor will need to be amplified to treat up to 25,000 EP. Further details of the facilities required are discussed in Table 8-3 and Appendix C.

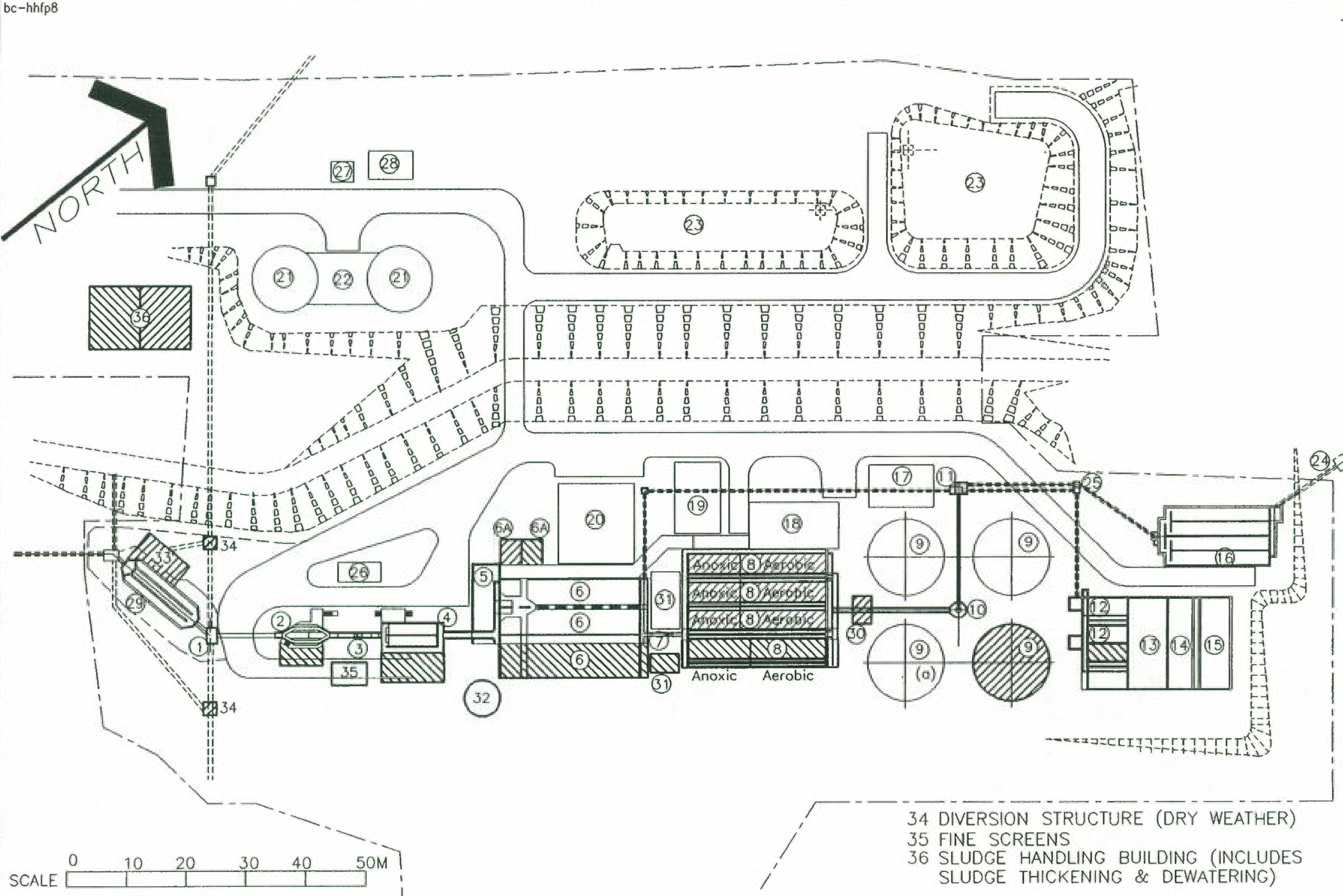
Secondary Clarification. No additional amplification is required as the Stage 1 Upgrade provides adequate clarifier capacity for 25,000 EP with the proposed biological reactor process volume.

Tertiary Filtration. The existing dual media filters will need to be fitted out to provide 25,000 EP filtration capacity.

Phosphorus Removal (and Alkalinity Control). The existing multi-point chemical dosing facilities for phosphorus removal will be amplified to 25,000 EP capacity. The existing lime dosing facilities will also need to be optimised for 25,000 EP capacity.

Disinfection. The existing chlorine dosing facility will be amplified to 25,000 EP capacity. To also ensure adequate detention time is provided for chlorination, the existing disused chlorination tank on-site will be commissioned and utilised.

Sludge Digestion. As discussed above, the existing anaerobic digesters will be converted to primary mode operation with all sludges being thickened prior to entry.



LEGEND

1 COLLECTING MANHOLE
2 MECH. RAKED BAR SCREENS
3 CUT-THROAT FLUME (RAW SEWAGE)
4 AERATED GRIT CHAMBER
5 PRIMARY CONTROL BUILDING
6 PRIMARY SEDIMENTATION TANKS
6A PREFERMENTATION
7 CUT-THROAT FLUME (SETTLED SEWAGE)
8 ANOXIC/AEROBIC REACTOR
9 SECONDARY SEDIMENTATION TANKS
10 MIXED LIQUOR DISTRIBUTION & EFFLEUNT COLLECTION CHAMBER
11 SECONDARY EFFLUENT DIVERSION STRUCTURE
12 DUAL MEDIA FILTERS
13 FILTER CONTROL BUILDING
14 BACKWASH WATER HOLDING TANK
15 BACKWASH EFFLUENT HOLDING TANK
16 CHLORINATION TANKS
17 CHLORINATION BUILDING
18 BLOWER HOUSE INCLUDING RETURN & WASTE ACTIVATED SLUDGE PUMPS
19 ELECTRICITY SUB-STATION
20 ADMINISTRATION BUILDING
21 DIGESTION TANKS
22 DIGESTION CONTROL BUILDING
23 SLUDGE LAGOONS (DISUSED)
24 OUTFALL TO CREEK
25 SECONDARY EFFLUENT MANHOLE
26 INFLAMMABLE LIQUID STORE
27 WASTE GAS BURNER
28 SLUDGE DEWATERING BUILDING
29 SPS 542
30 FLOW DISTRIBUTION CHAMBER
31 CHEMICAL STORAGE (PHOSPHORUS REMOVAL)
32 CHEMICAL STORAGE (ALKALINITY ADDITION)
33 FLOW EQUALISATION
34 DIVERSION STRUCTURE (DRY WEATHER)
35 FINE SCREENS
36 SLUDGE HANDLING BUILDING (INCLUDES SLUDGE THICKENING & DEWATERING)

▨ STAGE 1 UPGRADE FOR 20,000EP

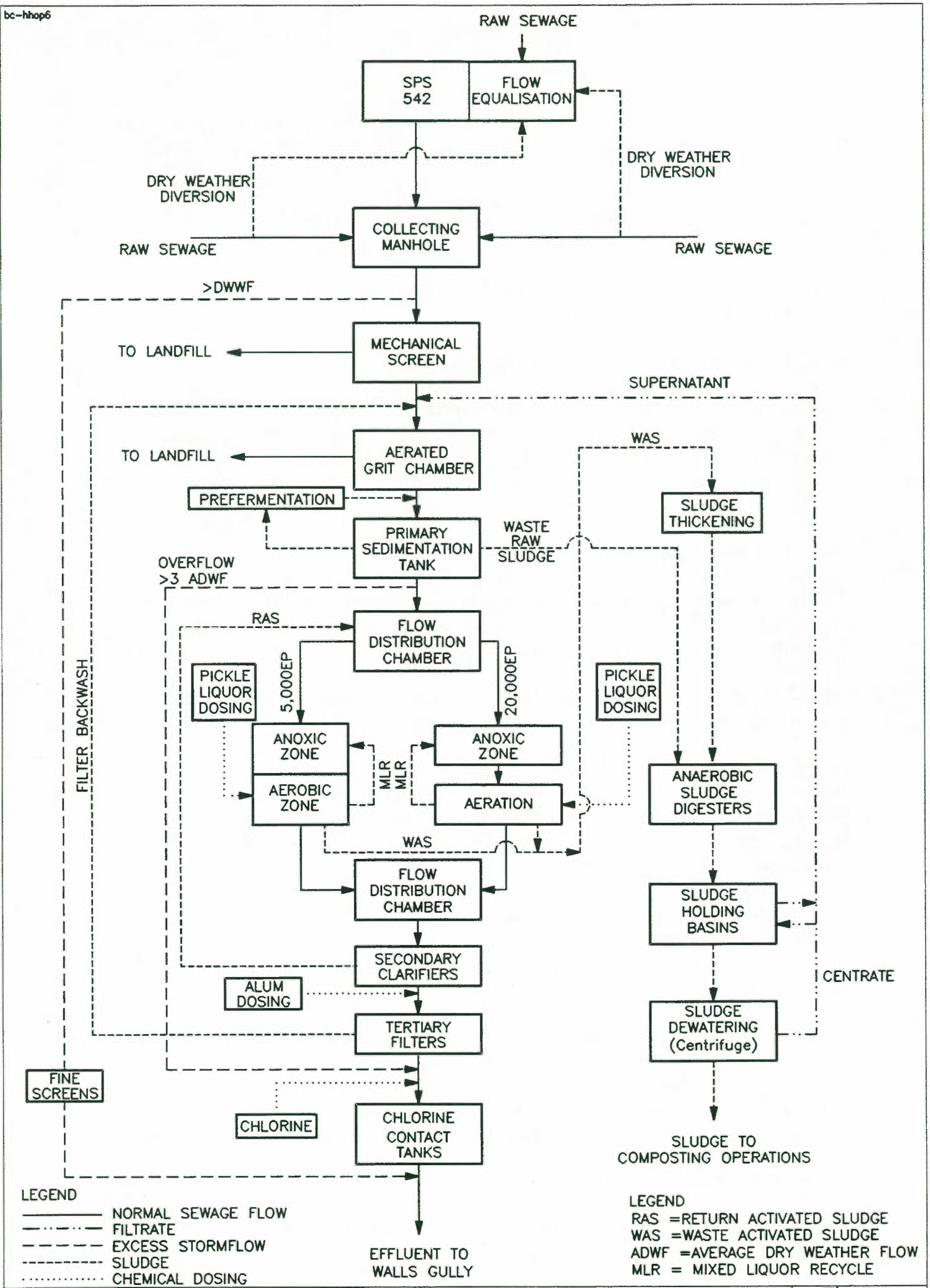
▨ STAGE 2 AMPLIFICATION TO 25,000EP

(a) AN ADDITIONAL THIRD SECONDARY CLARIFIER IS CURRENTLY UNDER CONSTRUCTION

WATER BOARD
SYDNEY-ILLAWARRA-BLUE MOUNTAINS
WASTEWATER AND REUSE PLANNING

HORNSBY HEIGHTS S.T.P.
GENERAL ARRANGEMENT FOR 20,000EP & 25,000EP FOR MLE OPTION 1 - TREATMENT LEVEL 1 (15mg/L TN)

Figure
8-8



WATER BOARD
SYDNEY-ILLAWARRA-BLUE MOUNTAINS
WASTEWATER AND REUSE PLANNING

HORNSBY HEIGHTS S.T.P.
PROCESS FLOW DIAGRAM
OPTION 1 – LEVEL 1 (15mg/L TN)
20,000EP & 25,000EP

Figure
8–9

Sludge Thickening/Dewatering. The proposed Stage 1 Upgrade facilities will be amplified from 20,000 to 25,000 EP.

Process Layouts. Refer to figures 8-8 and 8-9 for layouts of the Stage 2 amplification facilities.

Level 2 Treatment Requirements (Total Nitrogen 10 mg/L)

To achieve the 10 mg/L effluent total nitrogen target, the existing Hornsby Heights STP plant will need to be upgraded and operated as a raw sewage MLE system. Table 8-2 and Appendix C provide a detailed examination of the facilities required for both the Stage 1 Upgrade and Stage 2 Amplification. A brief overview is provided below.

Stage 1 Upgrade (20,000 EP)

Flow Equalisation. The existing raw sewage pumping station will be modified and augmented to provide for flow equalisation of all dry weather flows up to 25,000 EP (Refer figure 8-10 and 8-11 for general arrangement).

Inlet Works/Screening/Girt Removal. No upgrade required, however, fine screens shall be provided for excessive storm flow treatment.

Primary Sedimentation and RBCOD Generation. The existing PSTs will be capable of collecting all raw sludge collected prior to entry to a proposed prefermentation facility. As all sludges shall be directed to the prefermentation facility during dry weather, no automated PST weirs are required. During storm flows, however, facilities will be provided to collect and transfer sludges to the sludge handling equipment if the need arises.

Methanol Dosing Facilities. Facilities shall be provided for dosing methanol direct to the anoxic zone of the proposed raw sewage MLE if the need arises. The dosing facility will be operated in conjunction with the prefermentation tanks.

Biological Reactor. The existing aeration tanks will need to be modified to an MLE process with distinct anoxic and aerobic zones being provided in each tank. An additional MLE biological reactor will also be required to provide a total process volume of 3,100 m^3 for 20,000 EP. Further works required are summarised in Table 8-2 with Appendix C providing a more detailed description.

Secondary Clarification. An additional secondary clarifier will need to be provided.

Tertiary Filtration. No upgrade of existing tertiary filters is required in the Stage 1 Upgrade.

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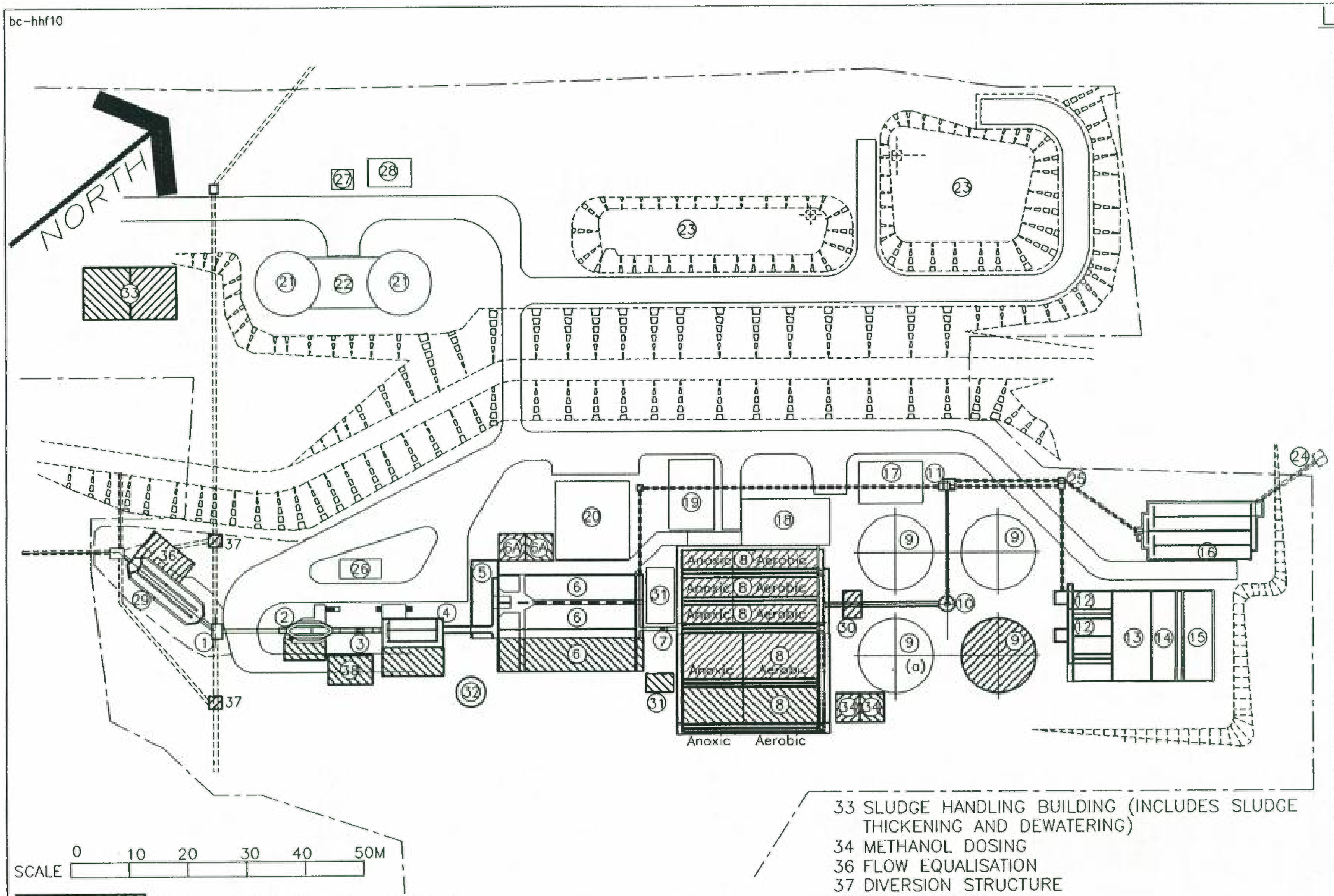


▨ STAGE 1 UPGRADE FOR 20,000EP

▧ STAGE 2 AMPLIFICATION TO 25,000EP

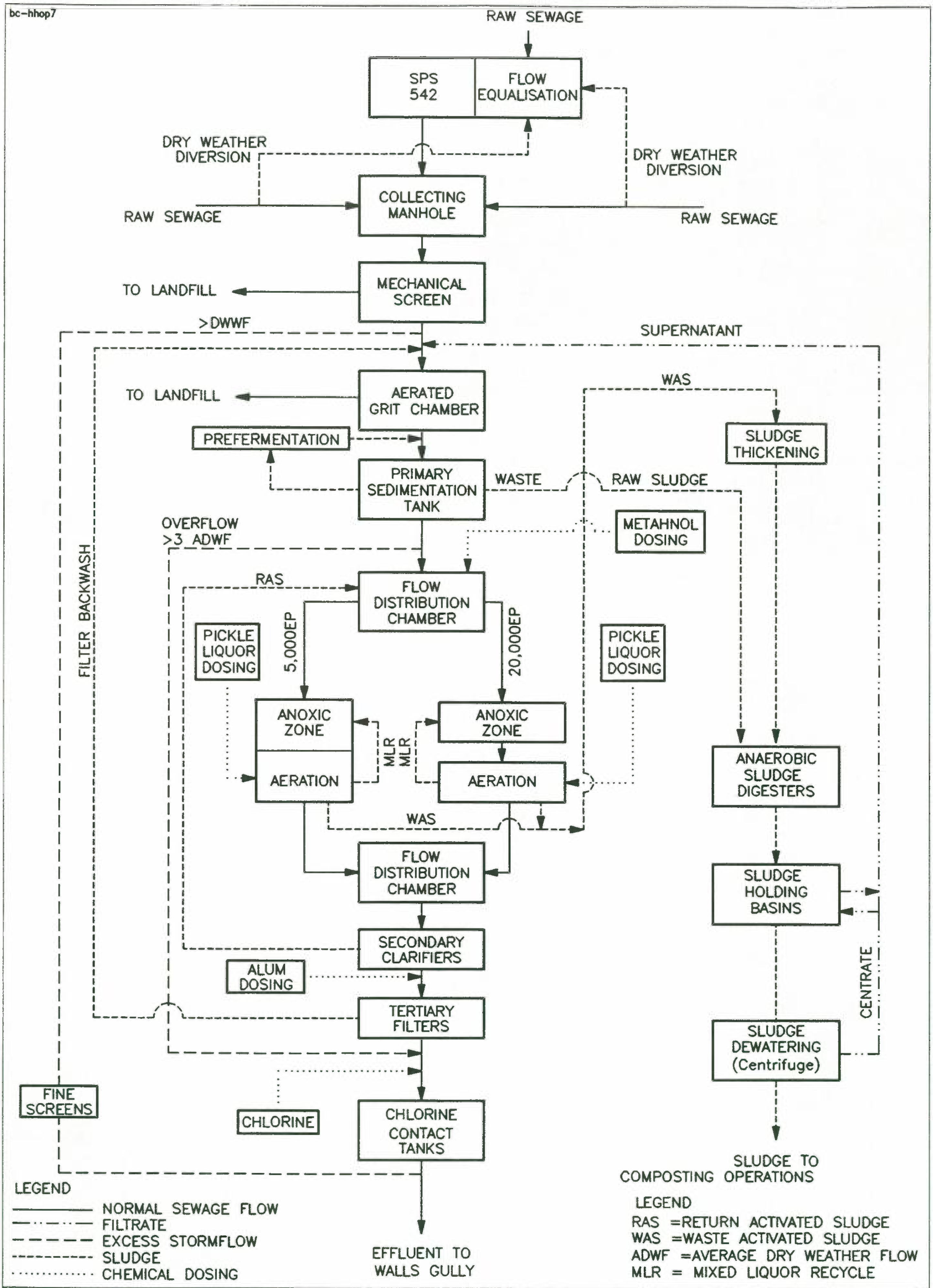
LEGEND
1 COLLECTING MANHOLE
2 MECH. RAKED BAR SCREENS
3 CUT-THROAT FLUME (RAW SEWAGE)
4 AERATED GRIT CHAMBER
5 PRIMARY CONTROL BUILDING
6 PRIMARY SEDIMENTATION TANKS
6A PREFERMENTATION
7 CUT-THROAT FLUME (SETTLED SEWAGE)
8 ANOXIC/AEROBIC REACTOR
9 SECONDARY SEDIMENTATION TANKS
10 MIXED LIQUOR DISTRIBUTION & EFFLEUNT COLLECTION CHAMBER
11 SECONDARY EFFLUENT DIVERSION STRUCTURE
12 DUAL MEDIA FILTERS
13 FILTER CONTROL BUILDING
14 BACKWASH WATER HOLDING TANK
15 BACKWASH EFFLUENT HOLDING TANK
16 CHLORINATION TANKS
17 CHLORINATION BUILDING
18 BLOWER HOUSE INCLUDING RETURN & WASTE ACTIVATED SLUDGE PUMPS
19 ELECTRICITY SUB-STATION
20 ADMINISTRATION BUILDING
21 DIGESTION TANKS
22 DIGESTION CONTROL BUILDING
23 SLUDGE LAGOONS (DISUSED)
24 OUTFALL TO CREEK
25 SECONDARY EFFLUENT MANHOLE
26 INFLAMMABLE LIQUID STORE
27 WASTE GAS BURNER
28 SLUDGE DEWATERING BUILDING
29 SPS 542
30 FLOW DISTRIBUTION CHAMBER
31 CHEMICAL STORAGE (PHOSPHORUS REMOVAL)
32 CHEMICAL STORAGE (ALKALINITY ADDITION)
33 SLUDGE HANDLING BUILDING (INCLUDES SLUDGE THICKENING AND DEWATERING)
34 METHANOL DOSING
36 FLOW EQUALISATION
37 DIVERSION STRUCTURE
38 FINE SCREENS

(a) AN ADDITIONAL THIRD SECONDARY CLARIFIER IS CURRENTLY UNDER CONSTRUCTION

WATER BOARD
SYDNEY-ILLAWARRA-BLUE MOUNTAINS
WASTEWATER AND REUSE PLANNING

HORNSBY HEIGHTS S.T.P.
GENERAL ARRANGEMENT FOR 20,000EP & 25,000EP FOR MLE
OPTION 1 - TREATMENT LEVEL 2 (10mg/L TN)

Figure
8-10



LEGEND

RAS =RETURN ACTIVATED SLUDGE
WAS =WASTE ACTIVATED SLUDGE
ADWF =AVERAGE DRY WEATHER FLOW
MLR = MIXED LIQUOR RECYCLE

WATER BOARD
SYDNEY-ILLAWARRA-BLUE MOUNTAINS
WASTEWATER AND REUSE PLANNING

HORNSBY HEIGHTS S.T.P.
PROCESS FLOW DIAGRAM
OPTION 1 – LEVEL 2 (10mg/L TN)
20,000EP & 25,000EP

Figure
8–11

Phosphorus Removal. The existing multi-point chemical dosing facility will be optimised and continue to dose iron salts upstream of the biological reactor and alum prior to the tertiary filters.

Alkalinity Control. The existing lime dosing system shall be optimised and retained for pH control.

Disinfection. The present chlorination facility shall be optimised and retained for the disinfection of effluent from the plant.

Sludge Digestion. The two anaerobic digesters on-site will be retained, converted to primary mode operation and optimised. All sludges will be thickened prior to entry.

Sludge Thickening/Dewatering. Permanent sludge thickening and dewatering facilities shall be provided.

Process Flow Diagram and Plant Layout. Figures 8-10 and 8-11 show the additional facilities required at the plant for the Stage 1 Upgrade and to meet the Level 2 effluent quality targets.

Stage 2 Amplification (25,000 EP)

To ensure adequate facilities are on-site to treat 25,000 EP, the following additional structures are required. Refer to Appendix C for more detailed information.

Biological Reactor. In addition to the Stage 1 Upgrade, the amplification of the proposed raw sewage MLE to 25,000 EP capacity will involve the adding of a new separate reactor containing an anoxic and aerobic zone. A total volume of 1.2 ML is required in addition to the proposed 3.10 ML Stage 1 reactor size.

Secondary Clarification. The provision of a fourth secondary clarifier in the Stage 1 Upgrade will be adequate to cater for 25,000 EP. Therefore, no additional clarifier will be necessary in the Stage 2 amplification.

Other Facilities. The amplification of inlet works, fine and coarse screens, grit removal, primary sedimentation and prefermentation facilities and chemical dosing facilities (including methanol, chemical phosphorus removal systems and chlorination dosing) will be required to cater for the 25,000 EP future load. The tertiary filters have empty beds which when fitted out will be adequate for the Stage 2 amplification. The optimisation of alkalinity facilities and the recommissioning of the spare chlorination tank will also be necessary. Refer Appendix C for further information.

In Stage 1, flow equalisation for 25,000 EP will be provided and no further amplification will be needed. For sludge handling and processing, the sludge thickening and dewatering units of Stage 1 will also need to be upsized.

Process Flow Train and Plant Layout. Refer to figures 8-10 and 8-11 for the process flow diagram and plant layout of the proposed 25,000 EP raw sewage MLE process.

Level 3 Treatment Requirements (Total Nitrogen of 5 mg/L)

To achieve the Level 3 effluent total nitrogen target of 5 mg/L, post denitrification facilities are to be added to the Level 2 Stage 1 Upgrade and Stage 2 Amplification structures recommended above. Table 8-2 and 8-3 indicate the works needed while figures 8-12 and 8-13 show the proposed process train for both 20,000 and 25,000 EP capacity. Refer to Appendix C for more details.

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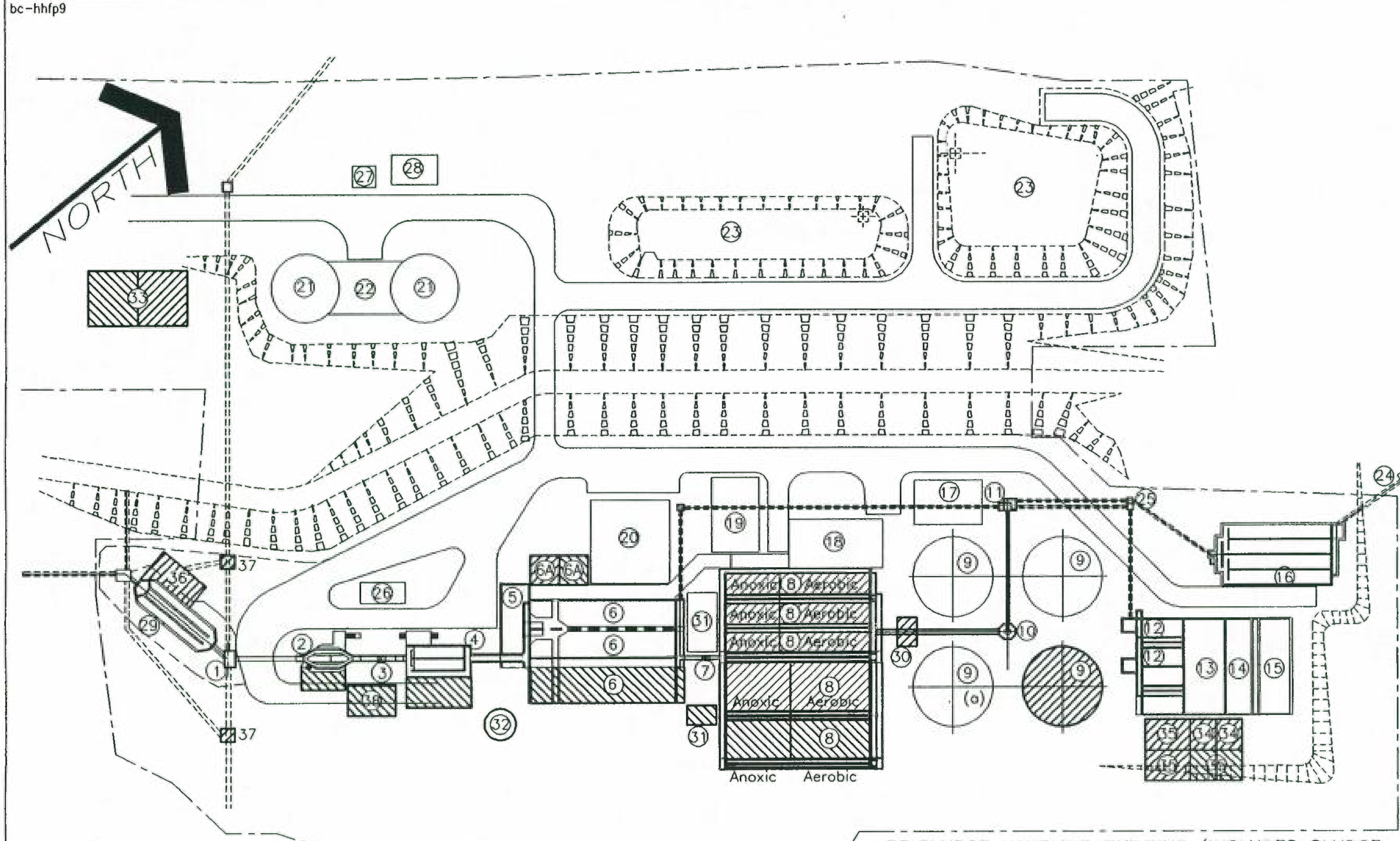


LEGEND
1 COLLECTING MANHOLE
2 MECH. RAKED BAR SCREENS
3 CUT-THROAT FLUME (RAW SEWAGE)
4 AERATED GRIT CHAMBER
5 PRIMARY CONTROL BUILDING
6 PRIMARY SEDIMENTATION TANKS
6A PREFERMENTATION
7 CUT-THROAT FLUME (SETTLED SEWAGE)
8 ANOXIC/AEROBIC REACTOR
9 SECONDARY SEDIMENTATION TANKS
10 MIXED LIQUOR DISTRIBUTION & EFFLEUNT COLLECTION CHAMBER
11 SECONDARY EFFLUENT DIVERSION STRUCTURE
12 DUAL MEDIA FILTERS
13 FILTER CONTROL BUILDING
14 BACKWASH WATER HOLDING TANK
15 BACKWASH EFFLUENT HOLDING TANK
16 CHLORINATION TANKS
17 CHLORINATION BUILDING
18 BLOWER HOUSE INCLUDING RETURN & WASTE ACTIVATED SLUDGE PUMPS
19 ELECTRICITY SUB-STATION
20 ADMINISTRATION BUILDING
21 DIGESTION TANKS
22 DIGESTION CONTROL BUILDING
23 SLUDGE LAGOONS (DISUSED)
24 OUTFALL TO CREEK
25 SECONDARY EFFLUENT MANHOLE
26 INFLAMMABLE LIQUID STORE
27 WASTE GAS BURNER
28 SLUDGE DEWATERING BUILDING
29 SPS 542
30 FLOW DISTRIBUTION CHAMBER
31 CHEMICAL STORAGE (PHOSPHORUS REMOVAL)
32 CHEMICAL STORAGE (ALKALINITY ADDITION)
33 SLUDGE HANDLING BUILDING (INCLUDES SLUDGE THICKENING AND DEWATERING)
34 METHANOL DOSING
35 POST DENITRIFICATION REACTOR
36 FLOW EQUALISATION
37 DIVERSION STRUCTURE
38 FINE SCREENS
(a) AN ADDITIONAL THIRD SECONDARY CLARIFIER IS CURRENTLY UNDER CONSTRUCTION

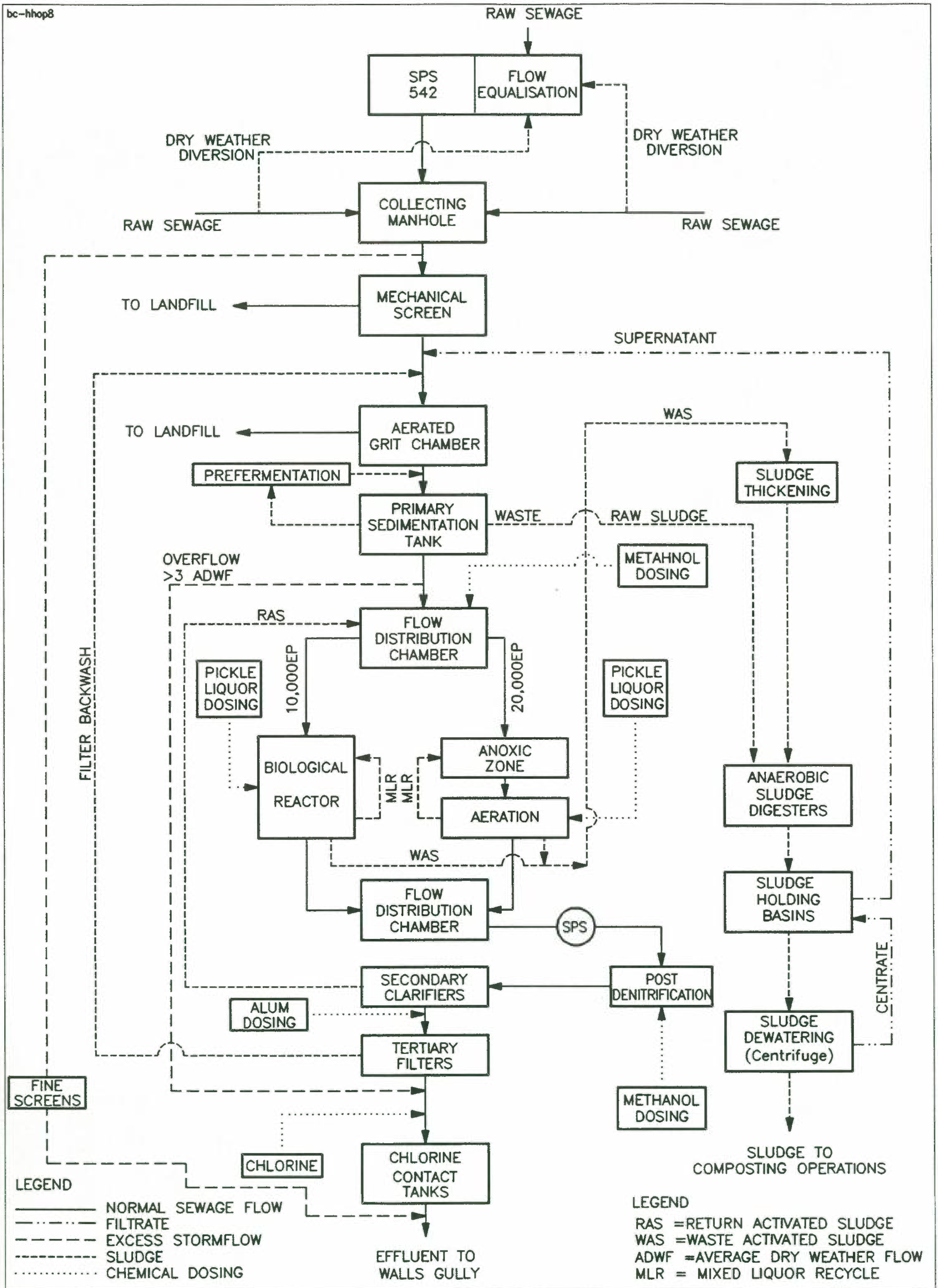
SCALE 0 10 20 30 40 50M

▨ STAGE 1 UPGRADE FOR 20,000EP
▨ STAGE 2 AMPLIFICATION TO 25,000EP

WATER BOARD
SYDNEY-ILLAWARRA-BLUE MOUNTAINS
WASTEWATER AND REUSE PLANNING

HORNSBY HEIGHTS S.T.P.
GENERAL ARRANGEMENT FOR 20,000EP & 25,000EP FOR MLE OPTION 1 - TREATMENT LEVEL 3 (5mg/L TN)

Figure 8-12



WATER BOARD

SYDNEY–ILLAWARRA–BLUE MOUNTAINS

WASTEWATER AND REUSE PLANNING

HORNSBY HEIGHTS S.T.P.
PROCESS FLOW DIAGRAM
OPTION 1 – LEVEL 3 (5mg/L TN)
20,000EP & 25,000EP

Figure
8–13

TABLE 8-2. SUMMARY OF OPTION 1 PROPOSED WORKS - HORNSBY HEIGHTS STP STAGE 1 UPGRADE 20,000 EP

Actions Proposed	**Treatment Level**		
	Level 1 (15 mg/L TN)	**Level 2 (10 mg/L TN)**	**Level 3 (5 mg/L TN)**
Upgrading of nitrogen removal facilities	Provide Diurnal Flow Equalisation. Provide anoxic/aerobic zones in existing 3 aeration tanks (42% anoxic). Provide MLR and mixers in anoxic zone Relocate aeration system and optimise Provide Prefermentation and Waste Mixed Liquor Facility	Provide anoxic/aerobic zones in existing 6 aeration tanks (45% anoxic) plus addition reactor with 1.2 ML volume Relocate aeration system and upgrade Anoxic Zone 45% of volume MLR, Mixers, plus aeration in new reactor Provide Diurnal Flow Equalisation Provide Prefermentation and Waste Mixed Liquor Facility	As per Level 2
Upgrading of phosphorus removal facilities	Optimise multi-point dosing system	Optimise multi-point dosing system	Optimise multi-point dosing system
Upgrading primary sedimentation	Install automatically controlled weirs for COD removal optimisation	Treat Raw Sewage and Retain PST for collection of COD and Storm Treatment	Treat Raw Sewage and Retain PSTS for collection of COD and Storm Treatment
External Carbon Source	-	Provide methanol dosing	Provide methanol dosing
Clarifiers	Provide one circular clarifier of 350 m^2 area (fourth clarifier)	Provide one circular clarifier of 350 m^2 area (fourth clarifier)	Provide one circular clarifier of 350 m^2 area (fourth clarifier)
Suspended Growth Post Denitrification	-	-	Provide post anoxic reactor 2.5 hr detention (including 1 hr aerobic)
Sludge Handling	Provide sludge thickening and sludge dewatering facilities	Provide sludge thickening and sludge dewatering facilities	Provide sludge thickening and sludge dewatering facilities
Capacity (EP)	20,000	20,000	20,000
MLE Type	Settled Sewage	Raw Sewage	Raw Sewage

TABLE 8-3. SUMMARY OF OPTION 1 PROPOSED WORKS - HORNSBY HEIGHTS STP STAGE 2 AMPLIFICATION 25,000 EP

Actions Proposed	**Treatment Level**		
	Level 1 (15 mg/L TN)	**Level 2 (10 mg/L TN)**	**Level 3 (5 mg/L TN)**
Amplification of nitrogen removal facilities	As per Level 1 Stage 1 Upgrade plus provision of new biological reactor 0.6 ML (42% anoxic zone) Provision of MLR and anoxic zone mixers. Amplification of aeration system Amplification of Prefermentation Unit Amplify facility for wasting mixed liquor	As per Level 2 Stage 1 Upgrade plus additional reactor of 1.2 ML Anoxic Zone 45% of Volume MLR and mixers plus aeration in new reactor Amplification of aeration system Amplification of Prefermentation Unit Amplification of Waste Mixed Liquor	As per Level 2 Stage 2 Amplification
Flow Equalisation	No amplification required	No amplification required	No amplification required
Secondary Clarifiers	No additional clarifier required	No additional clarifier required	No additional clarifier required
Phosphorus Removal	Amplify system by 5,000 EP	Amplify system by 5,000 EP	Amplify system by 5,000 EP
Alkalinity Control	Amplify system by 5,000 EP	Amplify system by 5,000 EP	Amplify system by 5,000 EP
Tertiary Filtration	Fit out cells for 5,000 EP	Fit out cells for 5,000 EP	Fit out cells for 5,000 EP
Chlorination	Amplify system by 5,000 EP	Amplify system by 5,000 EP	Amplify system by 5,000 EP
Sludge Thickening/Dewatering	Amplify by 5,000 EP	Amplify by 5,000 EP	Amplify by 5,000 EP
Digestion	Operate in Primary Mode	Operate in Primary Mode	Operate in Primary Mode
Screens/Inlet Works/Grit Removal	Amplify by 5,000 EP	Amplify by 5,000 EP	Amplify by 5,000 EP
Primary Sedimentation Tanks	Amplify by 5,000 EP/Provide automatic weir	Amplify by 5,000 EP	Amplify by 5,000 EP
Methanol Dosing Facility	-	Amplify Methanol Dosing Facility by 5,000 EP	Amplify Methanol Dosing Facility by 5,000 EP
Suspended Growth Post Denitrification	-	-	Amplify Post Anoxic Reactor by 5,000 EP
MLE Type	Settled Sewage	Raw Sewage	Raw Sewage

OPTION OVERVIEW

To allow an adequate comparison to be made between the options investigated, Option 1, which involves the retention, upgrade and amplification of the Hornsby STPs, has the following characteristics. An additional overview is provided in the Section discussing "comparison of options":

Capital and Operating Costs

Based on the Board's costing system the Order of Cost estimate for upgrading and amplifying Hornsby Heights STP and upgrading West Hornsby STP are summarised in Table 8-4 below.

TABLE 8-4. OPTION 1 - CAPITAL AND OPERATING COSTS

Effluent Total Nitrogen Target (90%ile Values)	Capital Cost $M			Operating Cost $M/Yr[a]	
	West Hornsby STP	Hornsby Heights STP	Total	West Hornsby STP	Hornsby Heights STP
15	4.95	9.6	14.6	2.92	1.91
10	6.20	12.0	18.2	2.96	1.92
5	9.40	13.7	23.1	3.01	2.0

a) Operating cost based at Year 2000 EP load.

Expected Implementation Time Frame

If the environmental assessment and all necessary approvals are obtained by end 1995, Option 1 may be completed by 1998. While the augmentations are being carried out, the existing Hornsby STPs will continue to discharge high total nitrogens. At present West Hornsby STP is discharging an average effluent total nitrogen concentration of 30 mg/L, while Hornsby Heights STP, has an average effluent total nitrogen of around 50 mg/L in the discharge. Although the Board is endeavouring to reduce effluent total nitrogens to around 25 mg/L on average, major works will be necessary to achieve lower levels.

Nitrogen Loading to Berowra Creek

The adoption of Option 1 will significantly reduce the Board's contribution of total nitrogen loads to the river. Table 8-5 shows the reductions in average yearly nitrogen loads to Berowra Creek that could be expected around year 2000 for the various effluent quality targets being examined.

TABLE 8-5. YEARLY TOTAL NITROGEN LOADS TO BEROWRA CREEK (YEAR 2000)

Effluent Quality Target	West Hornsby STP			Hornsby Heights STP			Expected Total
	Yr 2000 Flow	Average Effluent TN	Total Nitrogen kg/Yr	Yr 2000 Flow	Average Effluent TN	Total Nitrogen kg/Yr	Nitrogen Load/Yr from Hornsby STPs
Baseline[a]	11.05	30	121,000	5.8	50	105,850	226,850
Level 1	11.05	10	40,330	5.8	10	21,200	61,530
Level 2	11.05	7	28,250	5.8	7	14,800	43,050
Level 3	11.05	3	12,100	5.8	3	6,350	18,450

a. Baseline condition refers to maintaining the Hornsby STPs as nitrification plants.

Land Requirements

No additional lands will be required at the Hornsby STPs under Option 1 and all facilities proposed will be contained within the current plant boundaries. It must be stressed, however, that the standard 400 metre buffer zone generally applying to Board STPs does not exist at both West Hornsby and Hornsby Heights STPs. No further development should be allowed to encroach even closer.

Operational Aspects

The conversion of the existing nitrification plants to the proposed MLE process will not dramatically affect the current operation of the STPs. In fact, economic paybacks can be expected as reduction in oxygen and lime usage are inherent to biological nitrogen removal plants. As the MLE process also does not represent complex technology no additional skills or increased staff numbers are necessary above the current operating level. Also no major increases in odours, noise or energy consumption above the existing sewage treatment process is expected when converting to the MLE system.

As phosphorus removal shall continue to be removed by chemical means, a high degree of process reliability in achieving low effluent phosphorus levels is also expected. Current sludge handling and dewatering is also expected not to be adversely affected and will not need major modifications to process treatment philosophy.

Environmental Impacts

If adopted, Option 1 will improve the quality of effluent currently being discharged from the Hornsby plants to Berowra Creek. Without the benefit of an intensive environmental investigation and continual water quality monitoring within Berowra Creek, the effluent quality target to be adopted to help endeavour to achieve the Berowra Creek goal of recreational and modified ecosystem water quality criteria is unknown. Other issues, including the control of diffuse source pollutant inputs from urban and bushland runoff and limiting development to the current Urban Development Programme will also play an important role in returning the creek to environmental health.

Additional impacts that may be expected in Option 1, include increased noise and truck movements during the construction phase of the scheme, but this is only for the short term. Minimum increases in truck movements can also be expected during the operational phase of the proposed MLE processes at both West Hornsby and Hornsby Heights STPs, and will have no major impact in increasing noise and odour levels.

Beneficial Reuse

With the Board's policy of maximising the beneficial use of effluent and sludges, Option 1 has limited potential for effluent reuse and can be maximised within the STPs only. External markets are limited to golf courses, nurseries and council parks and require large outlays from the community before their inception. Even if this is achieved, no guarantee to continual reuse can be given as it is generally dependant on weather conditions and is generally limited in quantity.

At present, all digested and dewatered sludges from the Hornsby STPs are used for composting at the ANL site. This will continue to occur provided the sludge produced is of good and consistent quality.

Grit and Screening products will also continue to be dewatered, bagged and disposed of in landfill sites.

SECTION 9

OPTION 2 RETENTION AND UPGRADE WITH HIGH BIOMASS MLE

Option 2 is similar to Option 1 as it also involves the retention, upgrade and amplification (if required) of the West Hornsby and Hornsby Heights STPs.

The only difference in Option 2 is that a High Biomass Modified Ludzack Ettinger (HBMLE) process shall be installed at the Hornsby Heights plant, rather than Option One's standard MLE. This is based on the premise that Hornsby Heights STP has a full scale Linpor nitrification system in operation (refer Section 3), which can be readily modified to a HBMLE process.

At West Hornsby STP, however, no major cost benefit will occur in installing the HBMLE over the standard MLE system proposed in Option 1.

Therefore, the recommendations to upgrade the West Hornsby STP via the standard MLE process as summarised in Section 8 for Option 1 shall also be adopted in Option 2. In future stages for the plant, consideration should be given to its installation.

For Hornsby Heights STP, the plant will be modified for biological removal incorporating a high biomass system. The HBMLE reactor will be designed to achieve biological nitrification/denitrification and BOD removal, with phosphorus removal being achieved chemically. The zones of the proposed reactor will perform the following functions:

■	Anoxic Zone	-	Denitrification and oxidation of organic matter.
■	Aeration Zone	-	Oxidation of organic matter, nitrification and phosphorus removal via chemical dosing within the aerobic zone. A high biomass will be added to the aerobic zone.

■ Re-aeration Zone	-	Increases the DO level of mixed liquor to minimise the possibility of denitrification occurring in the clarifiers leading to solids carry-over into the effluent; this zone may or may not be physically separated from the aeration zone.

High biomass systems provide a medium of growth of biological solids within the biological reactor of an activated sludge plant. The effect of this is to increase the solids retention time of the system thereby increasing the nitrification (and denitrification) potential.

In the 'Linpor - C/N' process, plastic foam cubes are added to the biological reactor. Biomass grows in the pores of the cubes and, because there is a dissolved oxygen gradient through the cube cross-section, denitrification occurs (provided the conditions for nitrification have been provided as well).

Mixed liquor recycle and return sludge facilities will be provided, similar to those outlined for the standard MLE in Option 1. The operating SRT of the MLE process is normally in the range of 15 to 25 days (depending on the ratio of anoxic to aerobic volume). If operated at an SRT greater then about 20 days, separate sludge digestion will not be required but the size of the biological reactor will be larger than for operation at a lower SRT. To minimise construction on-site, the operating SRT adopted will be relatively low thus requiring that separate digestion be provided.

RBCOD Generation

To improve denitrification performance the HBMLE process will include prefermentation for the production of a readily biodegradable food source. The addition of either activated primaries or pre-fermentation will convert part of the settled primary sludge into fatty acids which are readily biodegradable. As a result, the ratio of TKN/COD will be reduced and RBCOD will be increased. There are other methods of modifying the primary effluent and include raw sludge feed or the addition of an external carbon source such as methanol. For the purposes of this report, methanol dosing facilities will be installed in conjunction with the above sludge conditioning methods where warranted.

Chemical Dosing

Phosphorus removal will still be carried out by the dosing of chemicals upstream of the aerobic zone of the reactor (simultaneous precipitation) and upstream of the tertiary filters (post precipitation).

Secondary Clarification

Secondary clarifiers will provide removal of excess sludge and clarification of effluent (SS removal).

Tertiary Filtration

Tertiary filters will be used to polish secondary effluent prior to disinfection and discharge. The filters will also remove residual phosphorus, chemically fixed by the dosing of alum to the secondary effluent.

OPTION 2 FOR WEST HORNSBY STP

As stated above, the major benefit or potential in introducing the high biomass MLE system at West Hornsby STP in achieving Levels 1, 2 and 3 effluent quality goals, is the utilising of the system in future amplifications and after the proposed Stage 1 Upgrade is undertaken as described in Option 1. In summary, although the HBMLE process will increase process capacity, the current hydraulics for West Hornsby STP is limited to treat flows between 45,000 EP and 47,000 EP. Major modifications and considerable disruption to plant operation would ensue if increased flows are to be catered for as well as retrofitting high biomass systems in the existing biological reactor.

Therefore, the HBMLE will be used in future stages above the standard 46,500 EP MLE process as proposed in Option 1.

FACILITIES REQUIRED

A summary of the facilities required in this option is given below and is based on Option 1 findings for West Hornsby STP.

Level 1 Treatment Requirements (Total Nitrogen of 15 mg/L)

Inlet Works/Screening/Grit Removal. One additional grit tank will be provided to improve the hydraulic arrangements at West Hornsby STP inlet works. No additional work is required to the inlet works coarse and fine screens.

Primary Sedimentation and RBCOD Generation. Existing primary sedimentation tanks (PST) will be modified to achieve RBCOD generation. Automated weirs shall also be provided to optimise solids removal during dry weather. The primary sedimentation tanks will continue to treat all flows up to DWWF and ensure downstream facilities treat settled sewage.

Biological Reactor. The existing six aeration tanks will be modified to achieve biological nitrogen removal by the standard MLE configuration and a high biomass system such as Linpor shall not be installed. Table 9-1 provides more detail of the additional works required. Mixed liquor recycle and waste activated sludge system shall also be provided within the biological reactor. The existing aeration distribution shall be relocated and modified to suit the new process layout.

Secondary Clarification. The existing clarification system at West Hornsby STP will be augmented by the provision of one additional rectangular clarifier.

Tertiary Filtration. The existing dual media filters have adequate capacity and will not need to be amplified.

Phosphorus Removal. Phosphorus shall continue to be removed by chemical dosing upstream of the aerobic zone and the tertiary filters. The process shall be optimised to reduce excessive use of chemicals.

Alkalinity Control. The existing lime dosing facilities shall continue to be operated and ensure replenishment of alkalinity in the effluent as well as optimise nitrification and phosphorus removal.

Disinfection. The existing chlorination facilities shall be retained and will be optimised to improve performance and reliability.

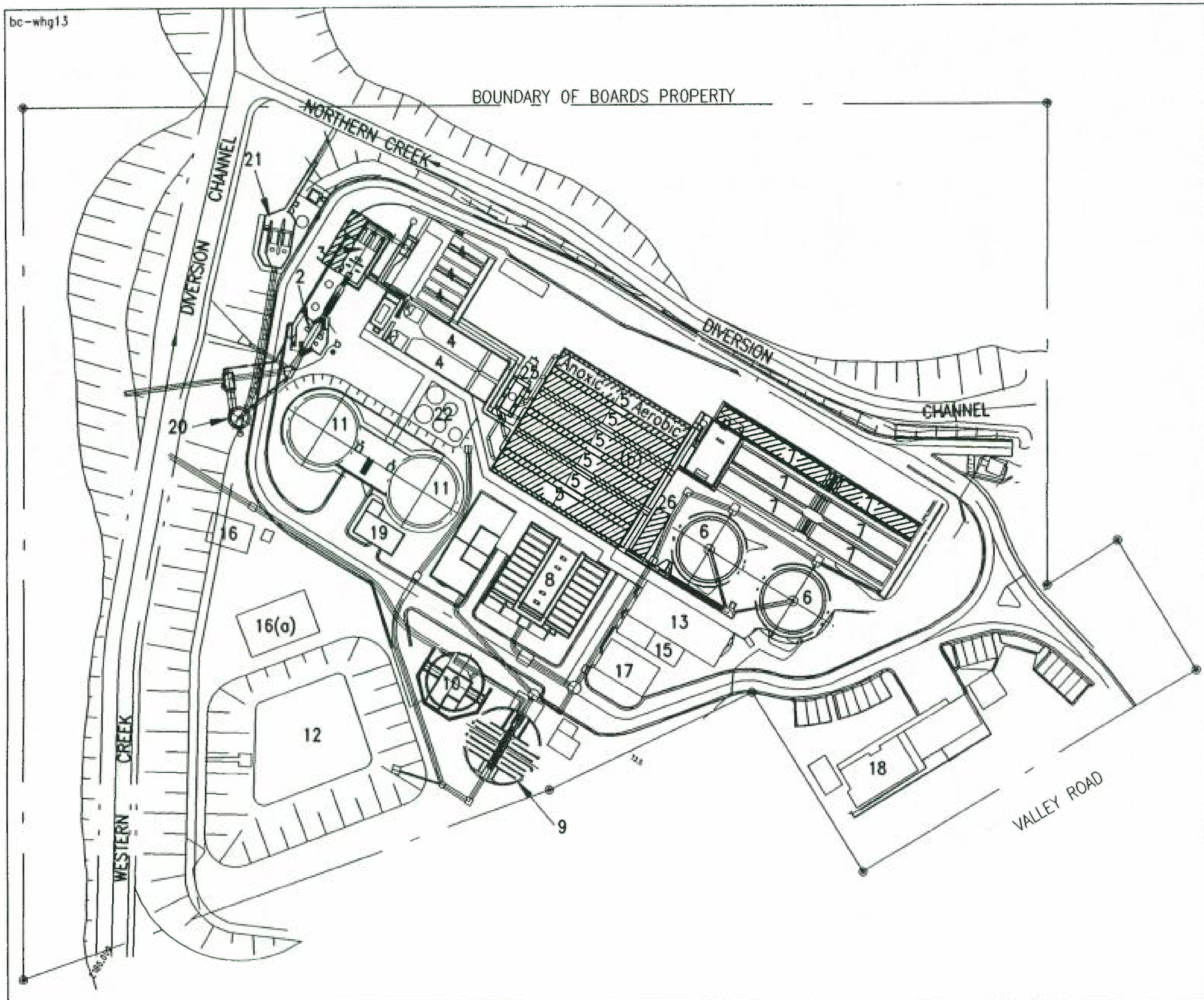
Sludge Digestion. The existing anaerobic digesters will remain in service and operate in the primary mode. All sludges will be thickened prior to entry and further stabilisation.

Sludge Thickening and Dewatering. Permanent sludge thickening facilities shall be provided and run in conjunction with the currently installed sludge thickening facilities. Supernatant from the sludge handling facilities shall be returned back to the Head of Works continuously and not as slug loads. Centrate will be pumped to the NSOOS via the existing centrate SPS.

Process Flow Diagram and Plant Layout. Refer to figures 9-1 and 9-2 for the proposed process flow diagram and plant layout.

Level 2 Treatment Requirements (Total Nitrogen of 10 mg/L)

As discussed in Section 8, the Level 1 facilities above plus the addition of Methanol Dosing facilities will be required to achieve the Level 2 effluent quality targets. Alternate carbon sources also exist and may be acceptable in replacing methanol. Also the secondary clarifier required under Level 2 is larger to that required in the Level 1 requirements. For more details of the works required, refer to Table 9-1, Section 8 and Appendix C. Refer to figures 9-3 and 9-4 for the proposed settled sewage MLE facilities and process train.



LEGEND
1 SPS 490
2 SCREEN
3 AERATED GRIT CHAMBER
4 PRIMARY SEDIMENTATION TANKS
5 ANOXIC / AERATION TANKS
6 CIRCULAR SECONDARY SEDIMENTATION TANKS
7 RECTANGULAR SEDONDARY SEDIMENTATION TANKS
8 DUAL MEDIA FILTERS
9 CHLORINE CONTACT TANK
10 EFFLEUNT PUMPING STATION
11 DIGESTERS
12 HOLDING BASIN
13 BLOWER HOUSE / RAS PUMPING STATION
14 RAS PUMPING STATION
15 11kV SUBSTATION
16 SLUDGE DEWATERING AREA
17 CHLORINATION BUILDING
18 ADMINSTRATION BUILDING
19 SLUDGE PUMPING STATION SPS 212
20 RAW SEWAGE FLOW SPLITTER
21 STORM FLOW FINE SCREENS
22 CHEMICAL DOSING FACILITIES (PHOSPHORUS REMOVAL) + ALKALINITY ADDITION
23 FILTERED WATER TANK
24 FOUL WATER TANK
25 FLOW SPLITTER
26 MIXED LIQUOR PUMPING STATION + MIXED LIQUOR RECYCLE

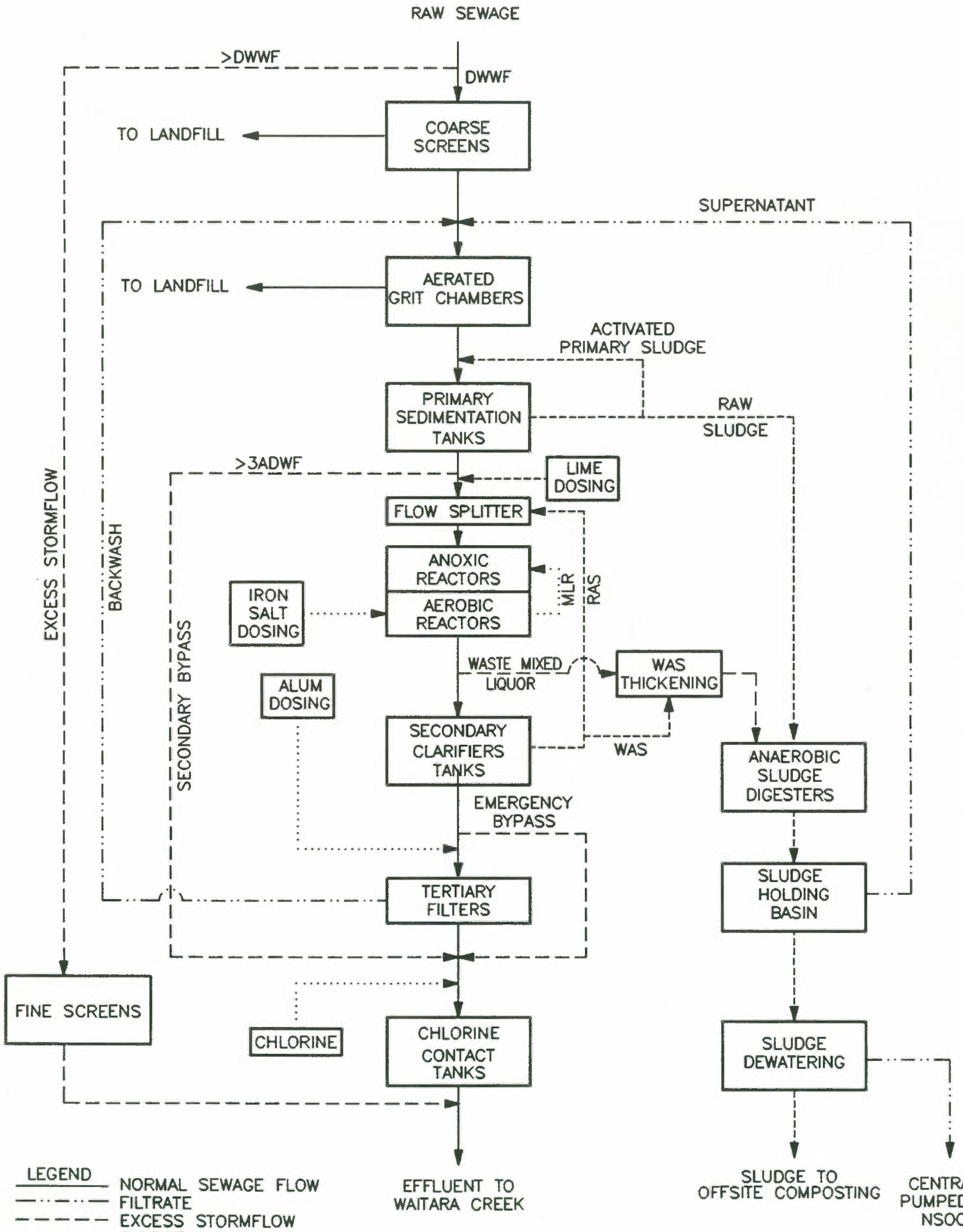
(a) SLUDGE DEWATERING FACILITY CURRENTLY UNDER CONSTRUCTION (INCLUDES CENTRIFUGES).
(b) EXISTING AERATION TANKS MODIFIED TO ANOXIC / AEROBIC REACTOR (MLE).

▨ ADDITIONAL FACILITIES FOR 46,500EP

WATER BOARD
SYDNEY-ILLAWARRA-BLUE MOUNTAINS
WASTEWATER AND REUSE PLANNING

WEST HORNSBY S.T.P.
OPTION 2 - LEVEL 1 (15 mg/L TN)
GENERAL ARRANGEMENT FOR 46,500EP MLE

Figure
9-1



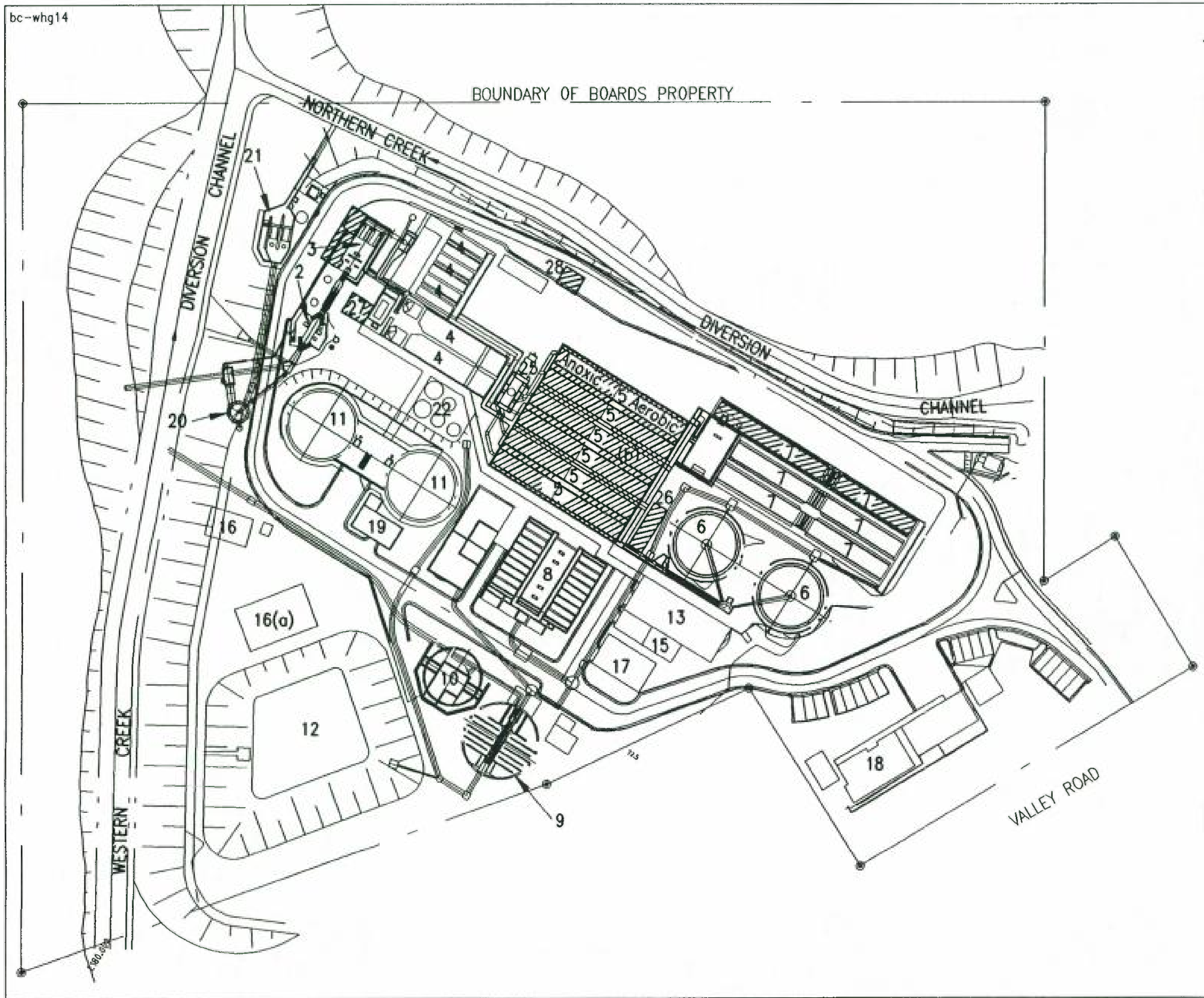
LEGEND
- ——— NORMAL SEWAGE FLOW
- —·—·— FILTRATE
- — — — EXCESS STORMFLOW
- - - - - SLUDGE
- ·········· CHEMICAL DOSING

RAS =RETURN ACTIVATED SLUDGE
WAS =WASTE ACTIVATED SLUDGE
ADWF =AVERAGE DRY WEATHER FLOW
NSOOS =NORTHERN SUBURBS OCEAN OUTFALL SEWER

WATER BOARD
SYDNEY-ILLAWARRA-BLUE MOUNTAINS
WASTEWATER AND REUSE PLANNING

WEST HORNSBY S.T.P.
PROCESS FLOW DIAGRAM
OPTION 2 – LEVEL 1 (15mg/L TN)
46,500EP

Figure
9-2



LEGEND

1	SPS 490
2	SCREEN
3	AERATED GRIT CHAMBER
4	PRIMARY SEDIMENTATION TANKS
5	ANOXIC / AERATION TANKS
6	CIRCULAR SECONDARY SEDIMENTATION TANKS
7	RECTANGULAR SEDONDARY SEDIMENTATION TANKS
8	DUAL MEDIA FILTERS
9	CHLORINE CONTACT TANK
10	EFFLEUNT PUMPING STATION
11	DIGESTERS
12	HOLDING BASIN
13	BLOWER HOUSE / RAS PUMPING STATION
14	RAS PUMPING STATION
15	11kV SUBSTATION
16	SLUDGE DEWATERING AREA
17	CHLORINATION BUILDING
18	ADMINSTRATION BUILDING
19	SLUDGE PUMPING STATION SPS 212
20	RAW SEWAGE FLOW SPLITTER
21	STORM FLOW FINE SCREENS
22	CHEMICAL DOSING FACILITIES (PHOSPHORUS REMOVAL) + ALKALINITY ADDITION
23	FILTERED WATER TANK
24	FOUL WATER TANK
25	FLOW SPLITTER
26	MIXED LIQUOR PUMPING STATION + MIXED LIQUOR RECYCLE
27	PREFERMENTATION
28	METHANOL DOSING FACILITY

(a) SLUDGE DEWATERING FACILITY CURRENTLY UNDER CONSTRUCTION (INCLUDES CENTRIFUGES).

(b) EXISTING AERATION TANKS MODIFIED TO ANOXIC / AEROBIC REACTOR (MLE).

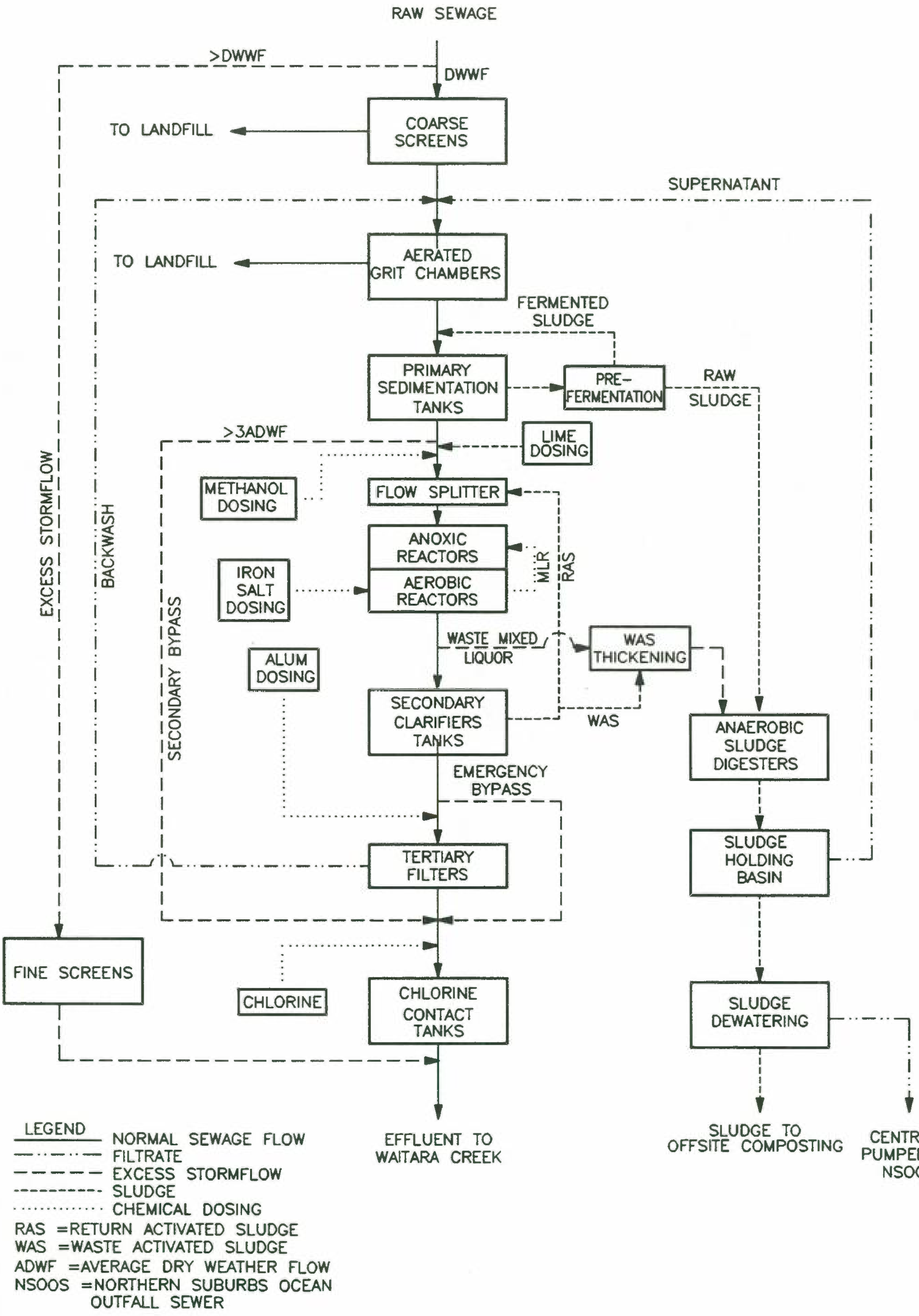
▨ ADDITIONAL FACILITIES FOR 46,500EP

WATER BOARD
SYDNEY-ILLAWARRA-BLUE MOUNTAINS
WASTEWATER AND REUSE PLANNING

WEST HORNSBY S.T.P.
OPTION 2 – LEVEL 2 (10 mg/L TN)
GENERAL ARRANGEMENT FOR 46,500EP MLE

Figure
9–3

bc-pfd9



WATER BOARD
SYDNEY-ILLAWARRA-BLUE MOUNTAINS
WASTEWATER AND REUSE PLANNING

WEST HORNSBY S.T.P.
PROCESS FLOW DIAGRAM
OPTION 2 – LEVEL 2 (10mg/L TN)
46,500EP

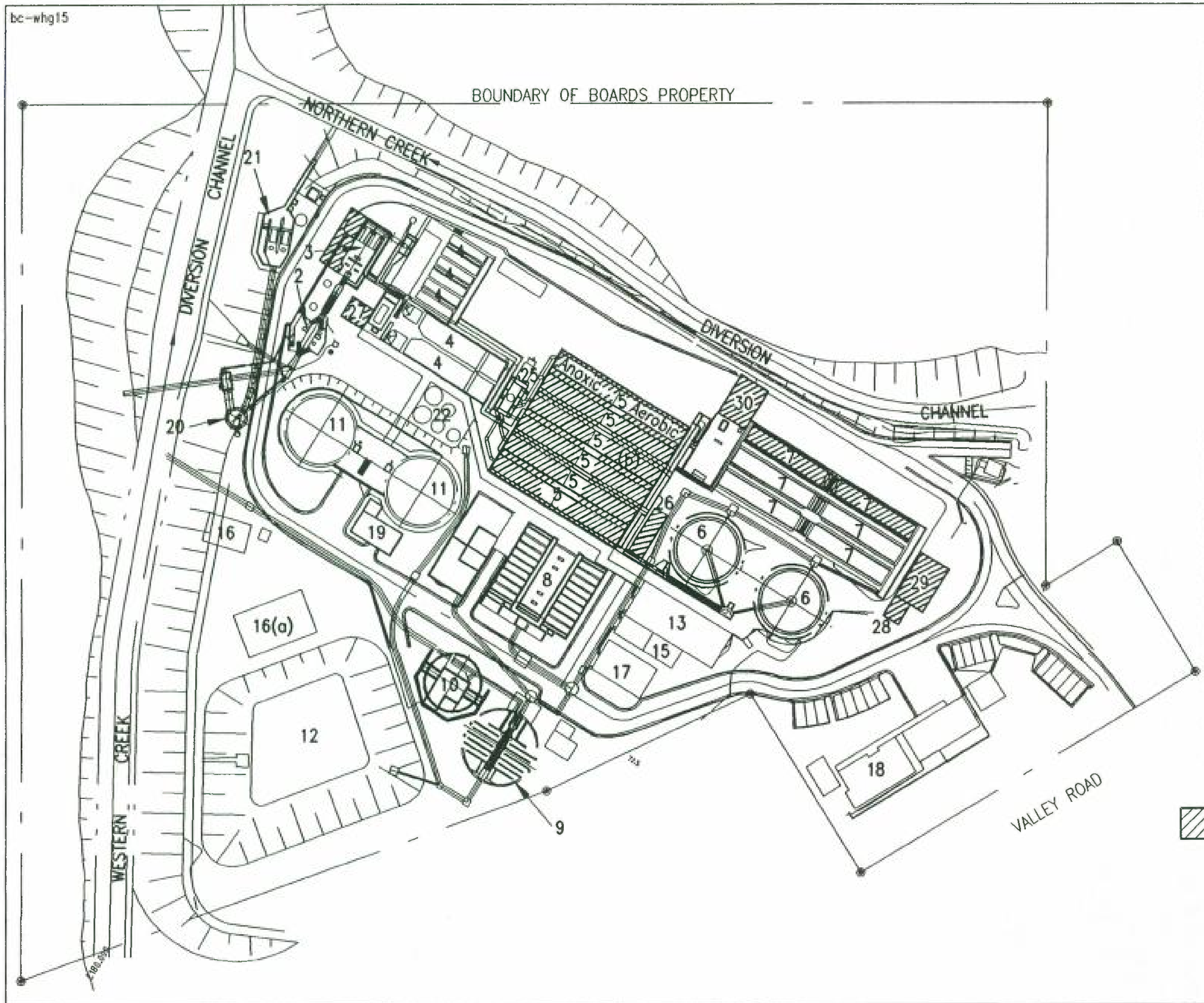
Figure
9–4

Level 3 Treatment Requirements (Total Nitrogen of 5 mg/L)

In addition to installing the proposed Level 2 facilities, post denitrification is needed to reduce effluent total nitrogen Levels to 5 mg/L (Level 3 effluent quality target). Refer Table 9-1 and Appendix C for more details. Figures 9-5 and 9-6 highlight the Level 3 facilities and the proposed process train.

Summary of Actions Required for Levels 1, 2 and 3 Requirements

Table 9-1 shows the actions required at West Hornsby STP to meet the proposed treatment levels for 46,500 EP and are based on Option 1 findings. For a more detailed discussion in achieving the proposed Level 1, 2 and 3 effluent quality for 46,500 EP refer to Option 1. Refer figures 9-1 to 9-6 for the additional facilities required at the plant and the new process flow trains.



LEGEND

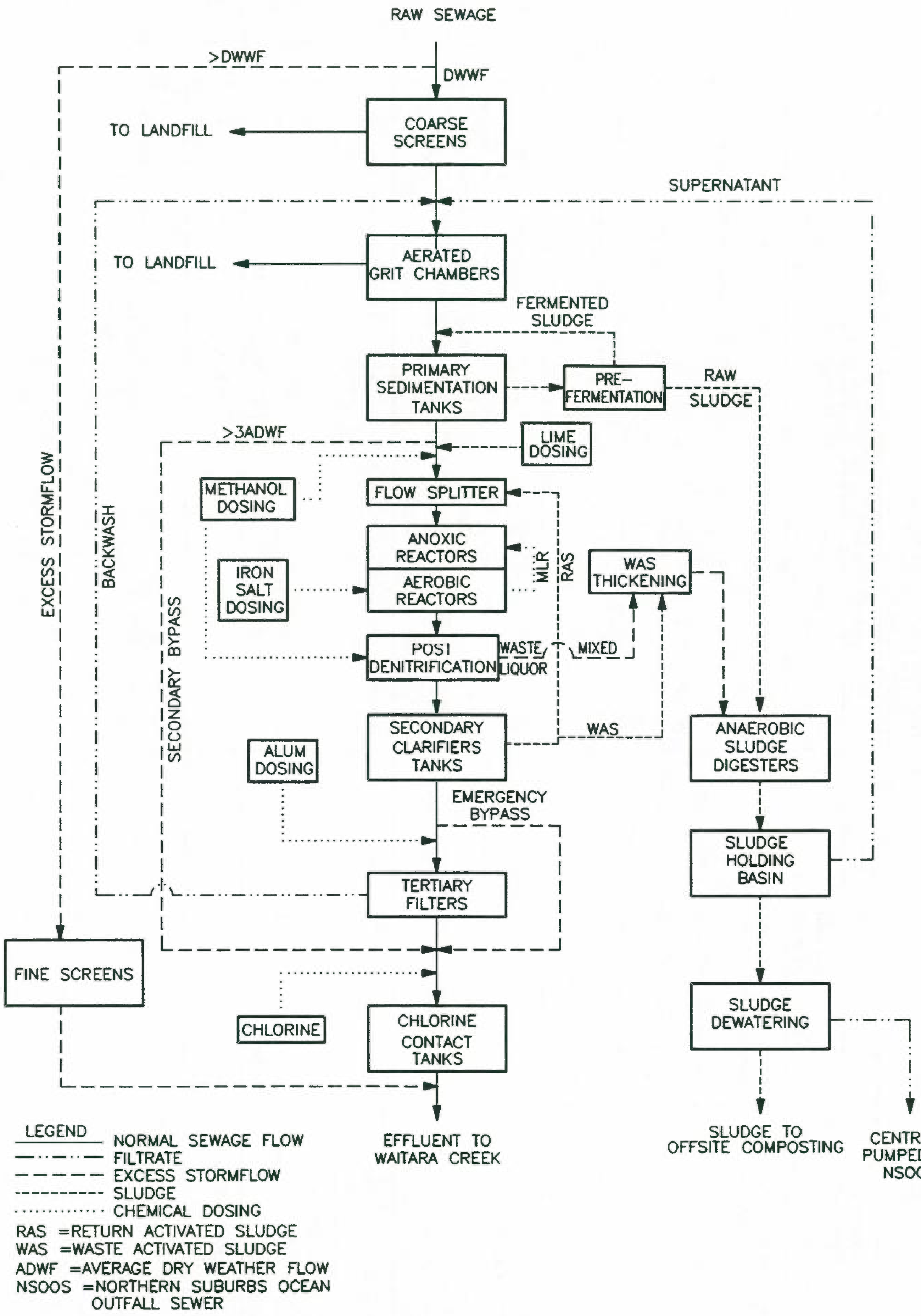
1	SPS 490
2	SCREEN
3	AERATED GRIT CHAMBER
4	PRIMARY SEDIMENTATION TANKS
5	ANOXIC / AERATION TANKS
6	CIRCULAR SECONDARY SEDIMENTATION TANKS
7	RECTANGULAR SEDONDARY SEDIMENTATION TANKS
8	DUAL MEDIA FILTERS
9	CHLORINE CONTACT TANK
10	EFFLEUNT PUMPING STATION
11	DIGESTERS
12	HOLDING BASIN
13	BLOWER HOUSE / RAS PUMPING STATION
14	RAS PUMPING STATION
15	11kV SUBSTATION
16	SLUDGE DEWATERING AREA
17	CHLORINATION BUILDING
18	ADMINSTRATION BUILDING
19	SLUDGE PUMPING STATION SPS 212
20	RAW SEWAGE FLOW SPLITTER
21	STORM FLOW FINE SCREENS
22	CHEMICAL DOSING FACILITIES (PHOSPHORUS REMOVAL) + ALKALINITY ADDITION
23	FILTERED WATER TANK
24	FOUL WATER TANK
25	FLOW SPLITTER
26	MIXED LIQUOR PUMPING STATION + MIXED LIQUOR RECYCLE
27	PREFERMENTATION
28	METHANOL DOSING FACILITY
29	POST DENITRIFICATION FACILITY
30	POST DENITRIFICATION PUMPING STATION
31	REVERSE OSMOSIS BUILDING
(a)	SLUDGE DEWATERING FACILITY CURRENTLY UNDER CONSTRUCTION (INCLUDES CENTRIFUGES).
(b)	EXISTING AERATION TANKS MODIFIED TO ANOXIC / AEROBIC REACTOR (MLE).
▨	ADDITIONAL FACILITIES FOR 46,500EP

WATER BOARD
SYDNEY-ILLAWARRA-BLUE MOUNTAINS
WASTEWATER AND REUSE PLANNING

WEST HORNSBY S.T.P.
OPTION 2 - LEVEL 3 (5 mg/L TN)
GENERAL ARRANGEMENT FOR 46,500EP MLE

Figure
9-5

bc-pfd10



WATER BOARD
SYDNEY-ILLAWARRA-BLUE MOUNTAINS
WASTEWATER AND REUSE PLANNING

WEST HORNSBY S.T.P.
PROCESS FLOW DIAGRAM
OPTION 2 - LEVEL 3 (5mg/L TN)
46,500EP

Figure
9-6

TABLE 9-1. SUMMARY OF OPTION 2 PROPOSED WORKS - WEST HORNSBY STP FOR 46,500 EP

Actions Proposed	**Treatment Level**		
	Level 1 (15 mg/L TN)	**Level 2 (10 mg/L TN)**	**Level 3 (5 mg/L TN)**
Upgrading of nitrogen removal facilities	Provide anoxic/aerobic zones in existing 6 aeration tanks (42% anoxic). Relocate aeration system in aerobic zone. Provide activated primaries recycle system. Provide mixers in anoxic zone Install mixed liquor recycle	Install mixed liquor recycle Provide prefermentation system Increase size of anoxic area to at least 42% in existing 6 aeration tanks Provide mixers in anoxic zone Relocate aeration system	Install mixed liquor recycle Relocate aeration system in aerobic zone Provide mixers in anoxic zone Increase size of anoxic area to 42% in existing 6 aeration tanks Provide prefermentation tank
Upgrading of phosphorus removal facilities	Optimise multi-point dosing system	Optimise multi-point dosing system	Optimise multi-point dosing system
Upgrading primary sedimentation	Install automatically controlled penstocks for COD removal optimisation	Install automatically controlled penstocks for COD removal optimisation	Install automatically controlled penstocks for COD removal optimisation
External Carbon Source	-	Provide methanol dosing facility	Provide methanol dosing facility
Clarifiers	Provide one rectangular clarifier of 180m^2	Provide one rectangular clarifier of 375 m^2	Provide one rectangular clarifier of 375 m^2 area
Suspended Growth Post Denitrification	-	-	Provide post anoxic reactor (1.5 hr anoxic detention plus 1 hr aerobic)
Process Type	Settled Sewage MLE	Settled Sewage MLE	Settled Sewage MLE
Estimated minimum capacity (EP)	46,500	46,500	46,500

OPTION 2 FOR HORNSBY HEIGHTS STP

Since Hornsby Heights STP has a high biomass nitrification system and requires amplification to serve increasing population load, the high biomass system has potential in being implemented at the plant. Its incorporation will result in smaller biological reactor volumes when compared to the standard MLE biological reactor of Option 1.

High Biomass System (Linpor C/N)

The Linpor C/N is a fixed media biological system where a majority of the biomass is fixed on a highly porous foam in the form of 1 cm^3 polyurethane cubes. The cubes, create a pseudo-fluidised bed process and are retained within the aeration basins by a perforated metal screen at the effluent weir which only allows free mixed liquor to pass.

Biomass is held at high concentrations within the cubes (generally up to 20,000 mg/L) allowing a higher mass of volatile solids to be carried in the aeration basins. This increased mass of biological solids can achieve greater BOD_5 and ammonia mass reductions for a given volume of tankage without placing extra solids loads on the secondary clarifiers.

Studies have shown that the use of fixed media provides increased BOD removal, nitrification and denitrification per unit volume by increasing the effective biomass concentration in the aeration tanks. This avoids the high cost of tank enlargement or new tank construction and provides a better ability to accommodate large hydraulic surges.

As hydraulic modifications are expected to be carried out both for the Stage 1 Upgrade and Stage 2 Amplification, the HBMLE will be used in both the Stages.

The major advantage in adopting this option include the reduction in process volume required for the biological reactor. With reference to Table 9-2 below the use of Linpor cubes with thirty per cent by volume in the aerobic zone reduces the biological reactor size by approximately 25 per cent when compared to the standard MLE.

FACILITIES REQUIRED

A detailed discussion of the works required at Hornsby Heights STP for Option 2 are provided below. As the major difference between Option 1 and Option 2 is the use of a high biomass system MLE rather than the standard MLE, the majority of facilities proposed in Option 2 are similar to Option 1, with the exception of the sizing of the biological reactors.

TABLE 9-2. HORNSBY HEIGHTS STP: COMPARISON OF PROCESS DESIGN REQUIREMENTS BETWEEN OPTION 1 AND OPTION 2

Design Parameter	**Stage 1 Upgrade (20,000 EP)**						**Stage 2 Amplification (25,000 EP)**					
	Option 1			**Option 2**			**Option 1**			**Option 2**		
	Level 1	**Level 2**	**Level 3**	**Level 1**	**Level 2**	**Level 3**	**Level 1**	**Level 2**	**Level 3**	**Level 1**	**Level 2**	**Level 3**
Biological Reactor ML	1.9	3.10	3.10	1.9	2.60	2.60	2.5	4.3	4.3	1.9	3.3	3.3
• Anoxic Volume	0.8	1.40	1.40	1.0	1.40	1.40	1.1	2	2	1.0	1.8	1.8
• Aerobic Volume	1.1	1.70	1.70	0.9	1.20	1.20	1.4	2.3	2.3	0.9	1.5	1.5
FX_a	0.42	0.45	0.45	0.42	0.45	0.45	0.42	0.45	0.45	0.42	0.42	0.42
SRT	15	16	16	15	16	16	15	16	16	15	15	15
Clarifier Requirement (m^2)	965	1100	1100	754	1100	1100	1100	1100	1100	1100	1100	1100
MLSS (free) mg/L	5900	6200	6200	4200	6200	6200	5625	5625	5625	5625	5500	5500
MLSS (Linpor) mg/L	-	-	-	18,000	18,000	18,000	-	-	-	18,000	18,000	18,000
Post Denitrification	-	-	Provided	-	-	Provided	-	-	Provided	-	-	Provided
Total Nitrogen (mg/L)	15	10	5	15	10	5	5	10	5	15	10	5

Level 1 Treatment Requirements (Total Nitrogen of 15 mg/L)

The facilities required at Hornsby Heights STP to achieve the Level 1 effluent quality target is described below in two parts, the Stage 1 Upgrade and Stage 2 Amplification.

Stage 1 Upgrade (20,000 EP)

Biological Reactor. The existing three aeration tanks at Hornsby Heights STP will be modified to contain distinct anoxic and aerobic zones. In the anoxic zone mixers will be provided while in the aerobic zone a high biomass system such as Linpor C-N shall be installed. At present, two out of the three tanks have the Linpor C-N system and will only need to be modified to accommodate an anoxic zone.

The existing aeration distribution system will also need to be modified to accommodate the proposed HBMLE. Each tank will be operated in parallel to ensure adequate process is available. A mixed liquor recycle will be provided to return nitrate rich mixed liquor back to the anoxic zone. Activated sludge will continue to be drawn from the underflow of the secondary clarifiers and returned upstream of the biological reactor. Waste activated sludge will be extracted directly from the biological reactor and thickened prior to entry to the anaerobic digesters for further stabilisation.

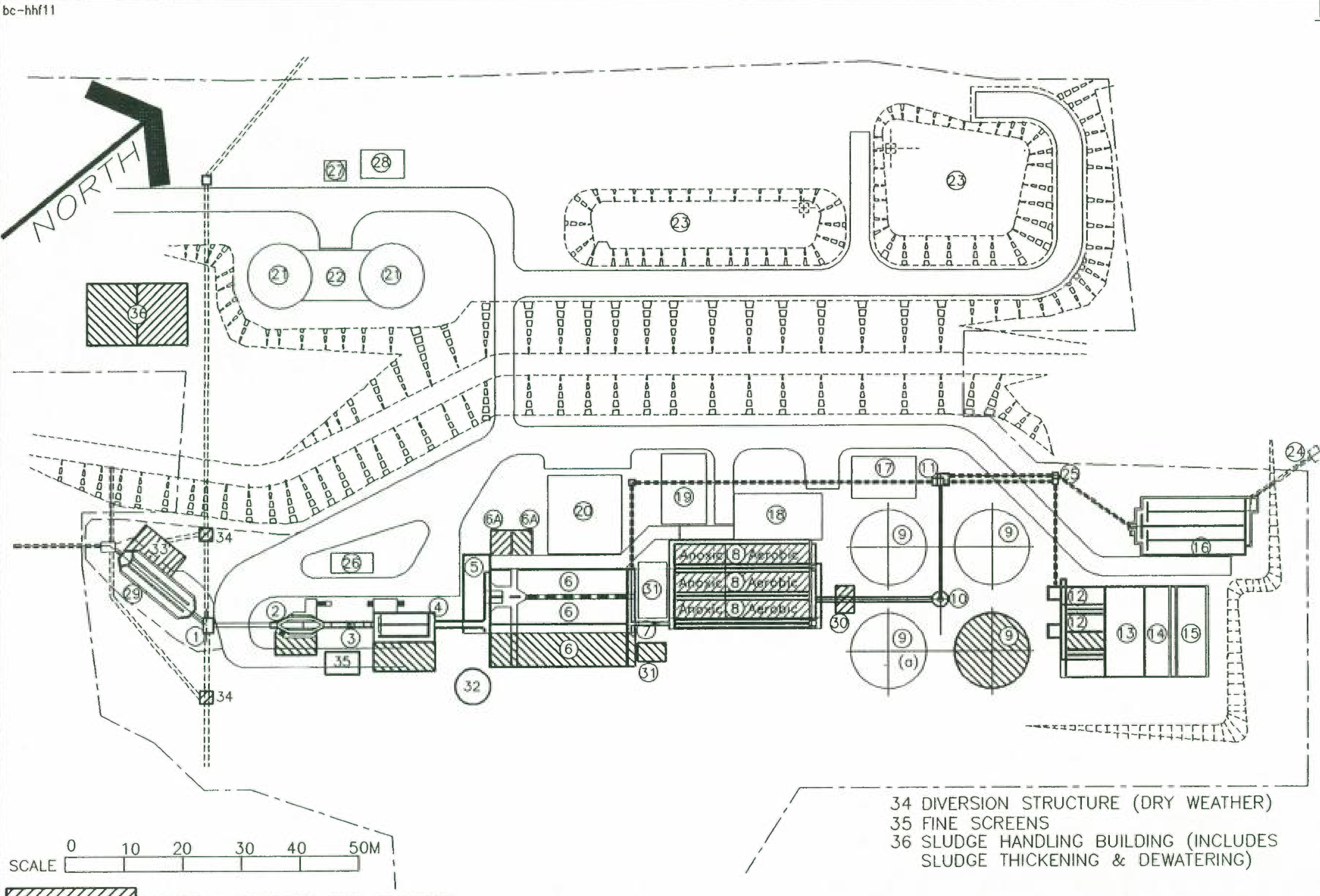
Secondary Clarification. For Option 2, the Stage 1 Upgrade does not require an additional fourth clarifier. As additional flows need to be accommodated in the near future, however, the Stage 2 amplification requires a fourth clarifier. This will be provided for in Stage 1 as per Option 1.

Other Facilities. As discussed previously, the only difference between Option 1 and Option 2 is the provision of a Linpor or high biomass biological system in the MLE reactor. All other facilities that need to be upgraded are, therefore, similar to Option 1 for Hornsby Heights STP and are to be referred to under this Option 2. Pages 8-6 to 8-7 of Section 8 detail the works required to achieve the Level 1 effluent quality target.

Process Flow Diagram and Plant Layout. Figures 9-7 and 9-8 provide the proposed plant layout and process train for the proposed Level 1 facilities.

Stage 2 Amplification (25,000 EP)

Biological Reactor. To treat additional flows the proposed Stage 1 HBMLE will need to be amplified. A additional biological reactor of similar size to one existing tank will need to be provided with a high biomass system installed mixed liquor recycle and sludge wasting facilities will also be required. The aeration system will also need to be amplified.



LEGEND
1 COLLECTING MANHOLE
2 MECH. RAKED BAR SCREENS
3 CUT-THROAT FLUME (RAW SEWAGE)
4 AERATED GRIT CHAMBER
5 PRIMARY CONTROL BUILDING
6 PRIMARY SEDIMENTATION TANKS
6A PREFERMENTATION
7 CUT-THROAT FLUME (SETTLED SEWAGE)
8 ANOXIC/AEROBIC REACTOR
9 SECONDARY SEDIMENTATION TANKS
10 MIXED LIQUOR DISTRIBUTION & EFFLEUNT COLLECTION CHAMBER
11 SECONDARY EFFLUENT DIVERSION STRUCTURE
12 DUAL MEDIA FILTERS
13 FILTER CONTROL BUILDING
14 BACKWASH WATER HOLDING TANK
15 BACKWASH EFFLUENT HOLDING TANK
16 CHLORINATION TANKS
17 CHLORINATION BUILDING
18 BLOWER HOUSE INCLUDING RETURN & WASTE ACTIVATED SLUDGE PUMPS
19 ELECTRICITY SUB-STATION
20 ADMINISTRATION BUILDING
21 DIGESTION TANKS
22 DIGESTION CONTROL BUILDING
23 SLUDGE LAGOONS (DISUSED)
24 OUTFALL TO CREEK
25 SECONDARY EFFLUENT MANHOLE
26 INFLAMMABLE LIQUID STORE
27 WASTE GAS BURNER
28 SLUDGE DEWATERING BUILDING
29 SPS 542
30 FLOW DISTRIBUTION CHAMBER
31 CHEMICAL STORAGE (PHOSPHORUS REMOVAL)
32 CHEMICAL STORAGE (ALKALINITY ADDITION)
33 FLOW EQUALISATION
34 DIVERSION STRUCTURE (DRY WEATHER)
35 FINE SCREENS
36 SLUDGE HANDLING BUILDING (INCLUDES SLUDGE THICKENING & DEWATERING)

(a) AN ADDITIONAL THIRD SECONDARY CLARIFIER IS CURRENTLY UNDER CONSTRUCTION

▨ STAGE 1 UPGRADE FOR 20,000EP

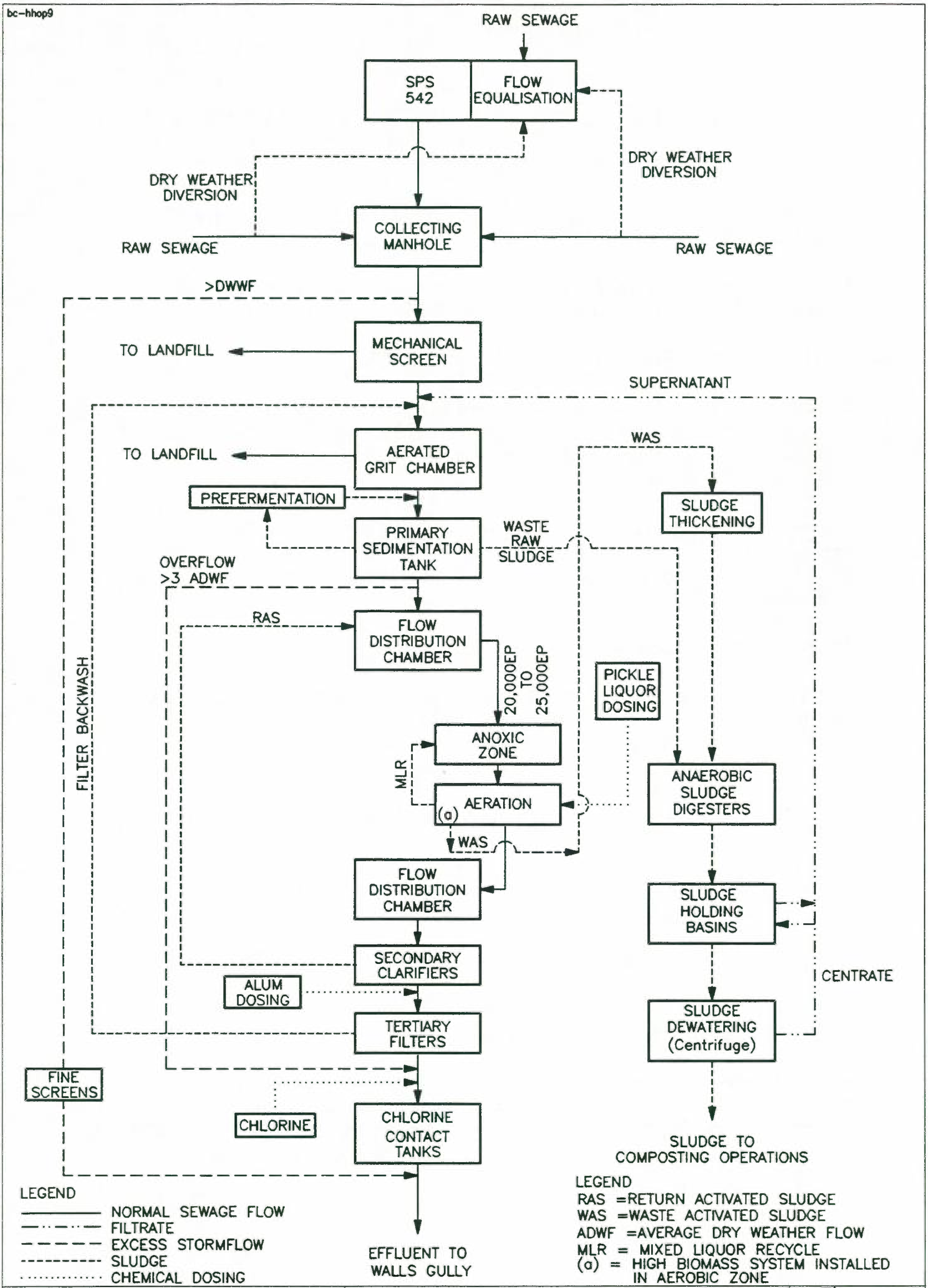
▨ STAGE 2 AMPLIFICATION TO 25,000EP

WATER BOARD
SYDNEY-ILLAWARRA-BLUE MOUNTAINS

WASTEWATER AND REUSE PLANNING

HORNSBY HEIGHTS S.T.P.
OPTION 2 - TREATMENT LEVEL 1 (15 mg/L TN)
GENERAL ARRANGEMENT FOR 20,000EP & 25,000EP FOR MLE

Figure
9-7



WATER BOARD
SYDNEY-ILLAWARRA-BLUE MOUNTAINS
WASTEWATER AND REUSE PLANNING

HORNSBY HEIGHTS S.T.P.
PROCESS FLOW DIAGRAM
OPTION 2 – LEVEL 1 (15mg/L TN)
20,000EP & 25,000EP

Figure
9–8

Other Facilities. Refer to Section 8 discussion for additional facilities required under this option. To achieve Level 1 effluent quality targets.

Process Flow Diagram and Plant Layout. Figures 9-7 and 9-8 provide the proposed plant layout and process train for the 25,000 EP Level 1 HBMLE.

Level 2 Treatment Requirements (Total Nitrogen of 10 mg/L)

To achieve the 10 mg/L effluent total nitrogen target, the existing Hornsby Heights STP will be operated as a raw sewage high biomass MLE system. Table 9-3 and 9-4 provide a detailed summary of the facilities required for both the Stage 1 Upgrade and Stage 2 Amplification.

A brief overview is provided below. As the only difference between Option 1 and Option 2 is the use of a high biomass system over the standard MLE process all other works as discussed in Option 1 - Level 2 for Hornsby Heights STP are applicable (refer Section 8 pages 8-9 to 8-11).

Stage 1 Upgrade (20,000 EP)

Biological Reactor. The existing three aeration tanks will need to be modified to a high biomass MLE process as discussed in Level 1 requirements above. An additional HBMLE reactor will also be needed to provide a total process volume of 2,600 m^3 for 20,000 EP. Further works required are summarised in Table 9-3.

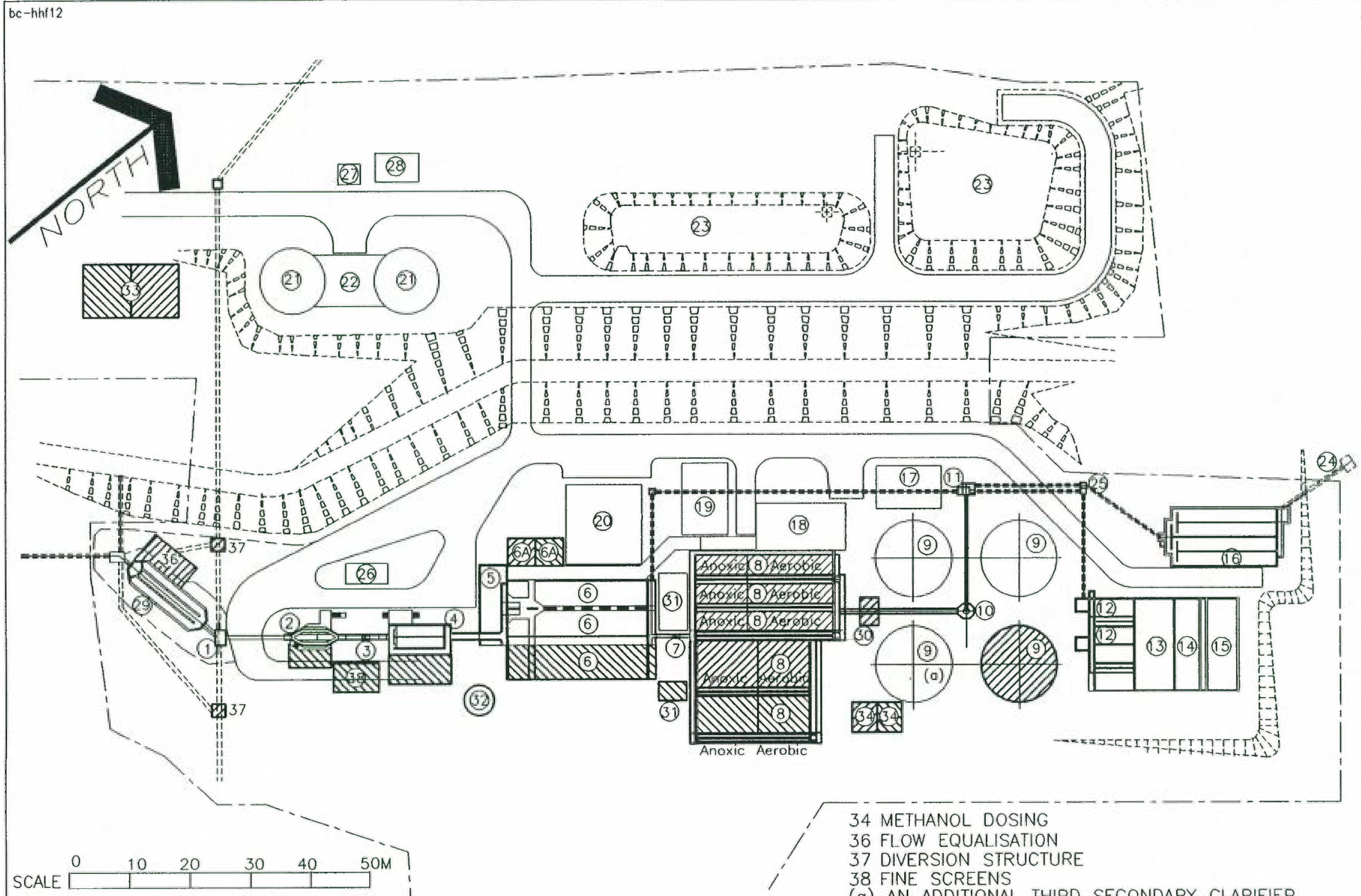
Other Facilities. Refer to Section 8, pages 8-9 and 8-10 for all other works required at the plant under this option.

Process Flow Diagram and Plant Layout. Refer to figures 9-9 and 9-10 for the proposed Stage 1 Upgrade facilities and process train.

Stage 2 Amplification (25,000 EP)

To handle additional flows, the following facilities are the minimum needed to continue to achieve Level 2 effluent targets.

Biological Reactor. In addition to the Stage 1 Upgrade, an additional HBMLE reactor will need to be provided and have a process volume of approximately 700 m^3. Both the Stage 1 Upgrade and Stage 2 Amplification will result in a total biological reactor volume of 3,300 m^3 as compared to Option 1 requirement of 4,300 m^3.



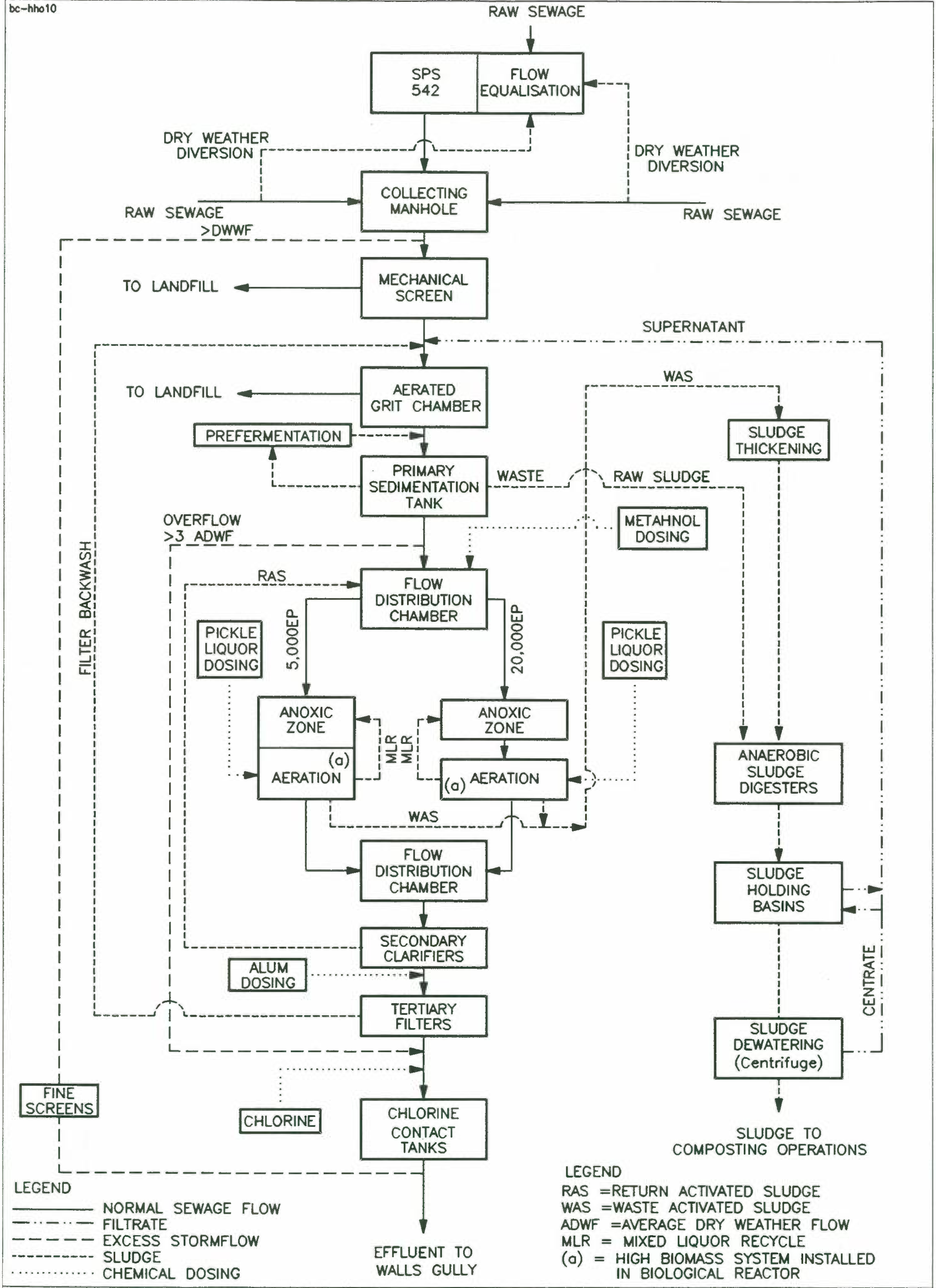
LEGEND
1 COLLECTING MANHOLE
2 MECH. RAKED BAR SCREENS
3 CUT-THROAT FLUME (RAW SEWAGE)
4 AERATED GRIT CHAMBER
5 PRIMARY CONTROL BUILDING
6 PRIMARY SEDIMENTATION TANKS
6A PREFERMENTATION
7 CUT-THROAT FLUME (SETTLED SEWAGE)
8 ANOXIC/AEROBIC REACTOR
9 SECONDARY SEDIMENTATION TANKS
10 MIXED LIQUOR DISTRIBUTION & EFFLEUNT COLLECTION CHAMBER
11 SECONDARY EFFLUENT DIVERSION STRUCTURE
12 DUAL MEDIA FILTERS
13 FILTER CONTROL BUILDING
14 BACKWASH WATER HOLDING TANK
15 BACKWASH EFFLUENT HOLDING TANK
16 CHLORINATION TANKS
17 CHLORINATION BUILDING
18 BLOWER HOUSE INCLUDING RETURN & WASTE ACTIVATED SLUDGE PUMPS
19 ELECTRICITY SUB-STATION
20 ADMINISTRATION BUILDING
21 DIGESTION TANKS
22 DIGESTION CONTROL BUILDING
23 SLUDGE LAGOONS (DISUSED)
24 OUTFALL TO CREEK
25 SECONDARY EFFLUENT MANHOLE
26 INFLAMMABLE LIQUID STORE
27 WASTE GAS BURNER
28 SLUDGE DEWATERING BUILDING
29 SPS 542
30 FLOW DISTRIBUTION CHAMBER
31 CHEMICAL STORAGE (PHOSPHORUS REMOVAL)
32 CHEMICAL STORAGE (ALKALINITY ADDITION)
33 SLUDGE HANDLING BUILDING (INCLUDES SLUDGE THICKENEING AND DEWATERING)
34 METHANOL DOSING
36 FLOW EQUALISATION
37 DIVERSION STRUCTURE
38 FINE SCREENS
(a) AN ADDITIONAL THIRD SECONDARY CLARIFIER IS CURRENTLY UNDER CONSTRUCTION
(b) HIGH BIOMASS SYSTEM INSTALLED IN BIOLOGICAL REACTOR

▨ STAGE 1 UPGRADE FOR 20,000EP
▨ STAGE 2 AMPLIFICATION TO 25,000EP

WATER BOARD
SYDNEY-ILLAWARRA-BLUE MOUNTAINS
WASTEWATER AND REUSE PLANNING

HORNSBY HEIGHTS S.T.P.
OPTION 2 - TREATMENT LEVEL 2 (10 mg/L TN)
GENERAL ARRANGEMENT FOR 20,000EP & 25,000EP MLE

Figure
9-9



WATER BOARD
SYDNEY–ILLAWARRA–BLUE MOUNTAINS
WASTEWATER AND REUSE PLANNING

HORNSBY HEIGHTS S.T.P.
PROCESS FLOW DIAGRAM
OPTION 2 – LEVEL 2 (10mg/L TN)
20,000EP & 25,000EP

Figure
9–10

Other Facilities. Table 9-4 summaries the works required to cater for 25,000 EP. These are similar to Option 1 facilities which are discussed in Section 8 page 8-10.

Process Flow Train and Plant Layout. Refer to figures 9-9 and 9-10 for the proposed facilities and process train.

Level 3 Treatment Requirements (Total Nitrogen of 5 mg/L)

The Level 2 facilities as discussed above plus post denitrification are required to achieve the Level 3 effluent quality target, especially with regard to a total nitrogen target of 5 mg/L. Tables 9-3 and 9-4 indicate the works required while figures 9-11 and 9-12 show the process layout and flow train.

Refer Appendix C for more details of the Level 3 facilities which are similar to Option 1 requirements. The only major variation involves the biological reactor size and the incorporation of Linpor C-N or alternate high biomass system (refer Level 2 discussion above).

SUMMARY OF ACTIONS REQUIRED

Table 9-3 and Table 9-4 summaries the actions required to achieve Level 1, 2 and 3 effluent quality goals for both the Stage 1 Upgrade and Stage 2 amplification. For more details of the additional facilities required refer to the above discussion for Hornsby Heights STP.

The major benefit of installing a high biomass system in this proposed future stage is the reduction in biological reactor volume. Based on the results of the full scale trial of the high biomass system at Hornsby Heights STP, the Linpor C/N process shall be adopted for further investigation. This, however, does not limit the use of alternate fixed media types and if this is option is adopted further detailed analysis will be undertaken during the detailed design phase.

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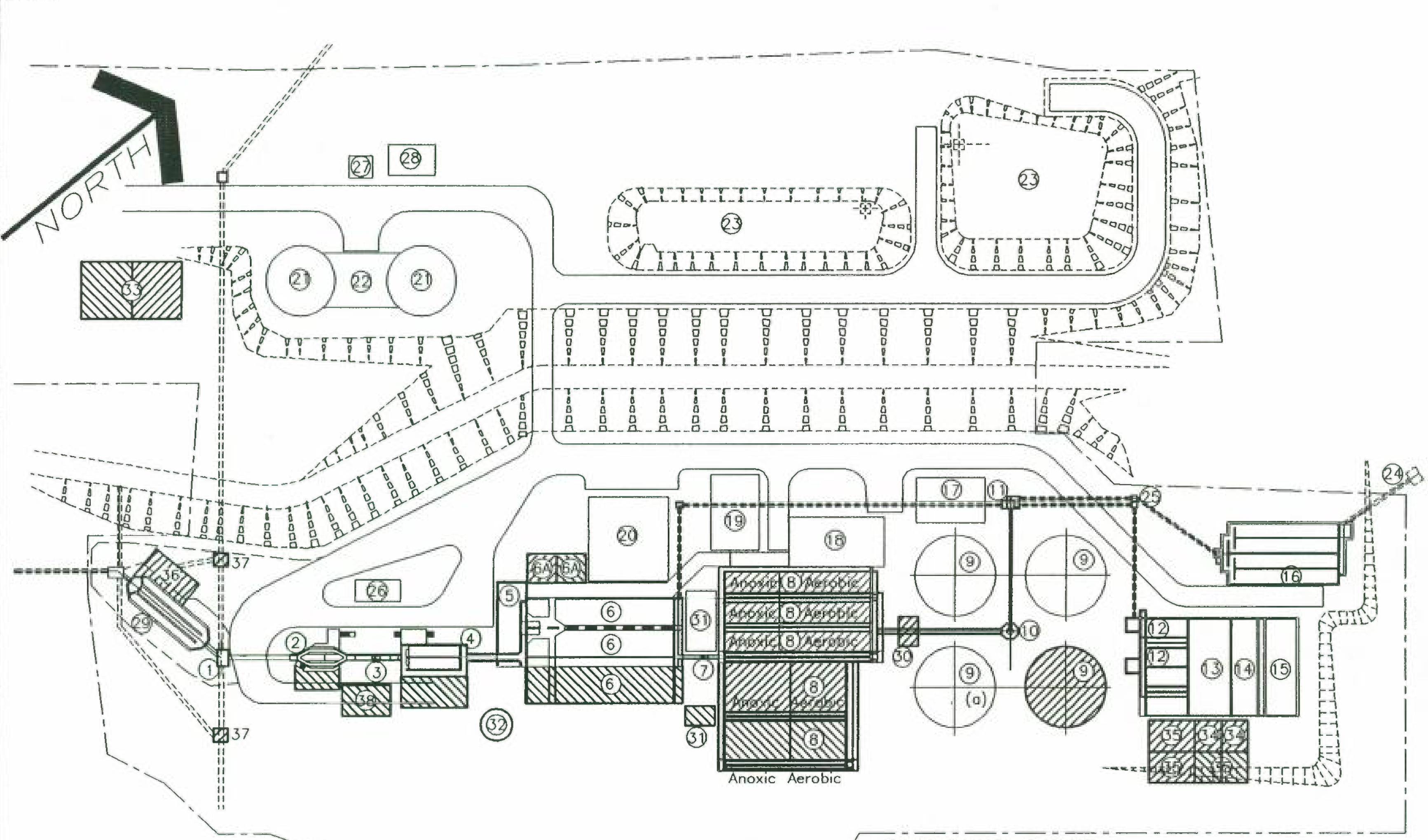


LEGEND
1 COLLECTING MANHOLE
2 MECH. RAKED BAR SCREENS
3 CUT-THROAT FLUME (RAW SEWAGE)
4 AERATED GRIT CHAMBER
5 PRIMARY CONTROL BUILDING
6 PRIMARY SEDIMENTATION TANKS
6A PREFERMENTATION
7 CUT-THROAT FLUME (SETTLED SEWAGE)
8 ANOXIC/AEROBIC REACTOR
9 SECONDARY SEDIMENTATION TANKS
10 MIXED LIQUOR DISTRIBUTION & EFFLEUNT COLLECTION CHAMBER
11 SECONDARY EFFLUENT DIVERSION STRUCTURE
12 DUAL MEDIA FILTERS
13 FILTER CONTROL BUILDING
14 BACKWASH WATER HOLDING TANK
15 BACKWASH EFFLUENT HOLDING TANK
16 CHLORINATION TANKS
17 CHLORINATION BUILDING
18 BLOWER HOUSE INCLUDING RETURN & WASTE ACTIVATED SLUDGE PUMPS
19 ELECTRICITY SUB-STATION
20 ADMINISTRATION BUILDING
21 DIGESTION TANKS
22 DIGESTION CONTROL BUILDING
23 SLUDGE LAGOONS (DISUSED)
24 OUTFALL TO CREEK
25 SECONDARY EFFLUENT MANHOLE
26 INFLAMMABLE LIQUID STORE
27 WASTE GAS BURNER
28 SLUDGE DEWATERING BUILDING
29 SPS 542
30 FLOW DISTRIBUTION CHAMBER
31 CHEMICAL STORAGE (PHOSPHORUS REMOVAL)
32 CHEMICAL STORAGE (ALKALINITY ADDITION)
33 SLUDGE HANDLING BUILDING (INCLUDES SLUDGE THICKENING AND DEWATERING)
34 METHANOL DOSING
35 POST DENITRIFICATION REACTOR
36 FLOW EQUALISATION
37 DIVERSION STRUCTURE
38 FINE SCREENS
(a) AN ADDITIONAL THIRD SECONDARY CLARIFIER IS CURRENTLY UNDER CONSTRUCTION
(b) HIGH BIOMASS SYSTEM INSTALLED IN BIOLOGICAL REACTOR

SCALE 0 10 20 30 40 50M

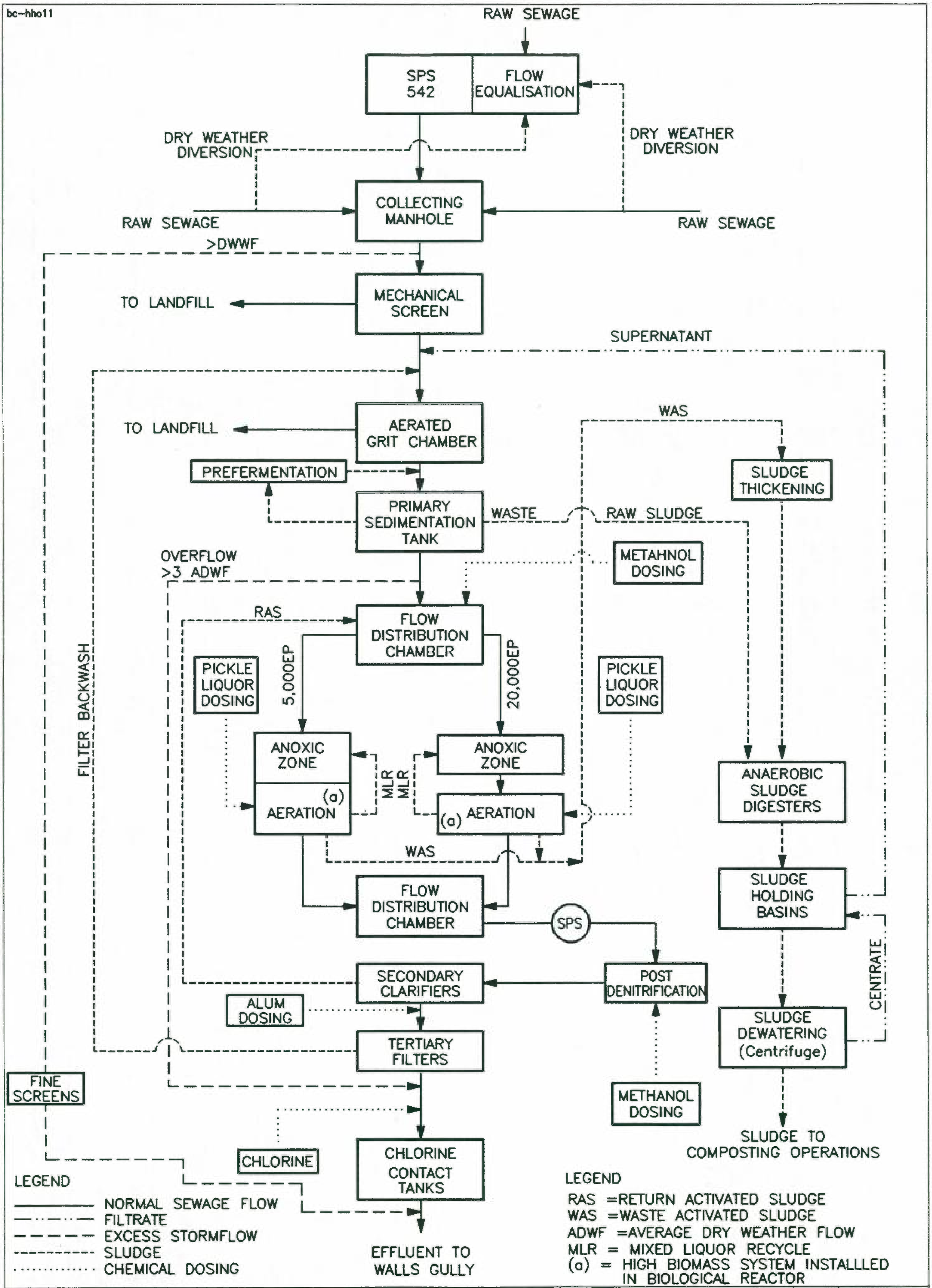
▨ STAGE 1 UPGRADE FOR 20,000EP

▨ STAGE 2 AMPLIFICATION TO 25,000EP

WATER BOARD
SYDNEY-ILLAWARRA-BLUE MOUNTAINS
WASTEWATER AND REUSE PLANNING

HORNSBY HEIGHTS S.T.P.
OPTION 2 - TREATMENT LEVEL 3 (5 mg/L TN) GENERAL ARRANGEMENT FOR 20,000EP & 25,000EP MLE

Figure
9-11



WATER BOARD
SYDNEY-ILLAWARRA-BLUE MOUNTAINS
WASTEWATER AND REUSE PLANNING

HORNSBY HEIGHTS S.T.P.
PROCESS FLOW DIAGRAM
OPTION 2 – LEVEL 3 (5mg/L TN)
20,000EP & 25,000EP

Figure
9–12

TABLE 9-3. SUMMARY OF OPTION 2 PROPOSED WORKS - HORNSBY HEIGHTS STP STAGE 1 UPGRADE 20,000 EP

Actions Proposed	**Treatment Level**		
	Level 1 (15 mg/L TN)	**Level 2 (10 mg/L TN)**	**Level 3 (5 mg/L TN)**
Upgrading of nitrogen removal facilities	Provide Diurnal Flow Equalisation. Provide anoxic/aerobic zones in existing 3 aeration tanks (55% anoxic volume). Provide MLR and mixers in anoxic zone Install High Biomass System in Aerobic Zone Relocate aeration system and optimise Provide Prefermentation and Waste Mixed Liquor Facility	Provide anoxic/aerobic zones in existing 3 aeration tanks (55% anoxic) plus addition reactor with 0.7 ML volume Relocate aeration system and upgrade Anoxic Zone 55% of Volume Install High Biomass system in Aerobic Zone MLR, Mixers, plus aeration in New Reactor Provide Diurnal Flow Equalisation Provide Prefermentation and Waste Mixed Liquor Facility	As per Level 2
Upgrading of phosphorus removal facilities	Optimise multi-point dosing system	Optimise multi-point dosing system	Optimise multi-point dosing system
Upgrading primary sedimentation	Install automatically controlled weirs for COD removal optimisation	Treat Raw Sewage and Retain PST for collection of COD and Storm Treatment	Treat Raw Sewage and Retain PSTS for collection of COD and Storm Treatment
External Carbon Source	-	Provide methanol dosing	Provide methanol dosing
Clarifiers	Provide one circular clarifier of 350 m^2 area (fourth clarifier)	Provide one circular clarifier of 350 m^2 area (fourth clarifier)	Provide one circular clarifier of 350 m^2 area (fourth clarifier)
Suspended Growth Post Denitrification	-	-	Provide post anoxic reactor 2.5 hr detention (including 1 hr aerobic)
Sludge Handling	Provide sludge thickening and sludge dewatering facilities	Provide sludge thickening and sludge dewatering facilities	Provide sludge thickening and sludge dewatering facilities
Capacity (EP)	20,000	20,000	20,000
MLE Type	Settled Sewage	Raw Sewage	Raw Sewage

TABLE 9-4. SUMMARY OF OPTION 2 PROPOSED WORKS - HORNSBY HEIGHTS STP STAGE 2 AMPLIFICATION 25,000 EP

Actions Proposed	**Treatment Level**		
	Level 1 (15 mg/L TN)	**Level 2 (10 mg/L TN)**	**Level 3 (5 mg/L TN)**
Amplification of nitrogen removal facilities	As per Level 1 Stage 1 Upgrade (Table 9-3) Amplification of aeration system Amplification of Prefermentation Unit Amplify facility for wasting mixed liquor	As per Level 2 Stage 1 Upgrade (Table 9-3) plus additional reactor of 0.7 ML Anoxic Zone 55% of Volume Install High Biomass System MLR and mixers plus aeration in new reactor Amplify aeration system Amplification of Prefermentation Unit Amplification of Waste Mixed Liquor	As per Level 2 Stage 2 Amplification
Flow Equalisation	No amplification required	No amplification required	No amplification required
Secondary Clarifiers	No additional clarifier required	No additional clarifier required	No additional clarifier required
Phosphorus Removal	Amplify system by 5,000 EP	Amplify system by 5,000 EP	Amplify system by 5,000 EP
Alkalinity Control	Amplify system by 5,000 EP	Amplify system by 5,000 EP	Amplify system by 5,000 EP
Tertiary Filtration	Fit out cells for 5,000 EP	Fit out cells for 5,000 EP	Fit out cells for 5,000 EP
Chlorination	Amplify system by 5,000 EP	Amplify system by 5,000 EP	Amplify system by 5,000 EP
Sludge Thickening/Dewatering	Amplify by 5,000 EP	Amplify by 5,000 EP	Amplify by 5,000 EP
Digestion	Operate in Primary Mode	Operate in Primary Mode	Operate in Primary Mode
Screens/Inlet Works/Grit Removal	Amplify by 5,000 EP	Amplify by 5,000 EP	Amplify by 5,000 EP
Primary Sedimentation Tanks	Amplify by 5,000 EP/Provide automatic Penstock	Amplify by 5,000 EP	Amplify by 5,000 EP
Methanol Dosing Facility	-	Amplify Methanol Dosing Facility by 5,000 EP	Amplify Methanol Dosing Facility by 5,000 EP
Suspended Growth Post Denitrification	-	-	Amplify Post Anoxic Reactor by 5,000 EP
MLE Type	Settled Sewage	Raw Sewage	Raw Sewage
Capacity (EP)	25,000	25,000	25,000

OPTION OVERVIEW

To allow an adequate comparison to be made between the options investigated, Option 2 which involves the retention, upgrade and amplification of the Hornsby STPs with the high biomass MLE has the following characteristics that are discussed below. An additional overview is provided in the Section discussing "comparison of options":

Capital and Operating Costs

Based on the Board's costing system the Order of Cost estimate for upgrading and amplifying Hornsby Heights STP and upgrading West Hornsby STP are summarised in Table 9-5 below.

TABLE 9-5. OPTION 2 - CAPITAL AND OPERATING COSTS

Effluent Total Nitrogen Target (90%ile Values)	Capital Cost $M			Operating Cost^a$M/Yr	
	West Hornsby STP	Hornsby Heights STP	Total	West Hornsby STP	Hornsby Heights STP
15	4.95	9.35	14.3	2.92	1.91
10	6.20	12.1	18.2	2.96	1.92
5	9.40	13.8	23.2	3.01	2.0

a) Operating cost based at Year 2000 EP load.

Expected Implementation Time Frame

If the environmental assessment and all necessary approvals are obtained by end 1995, Option 2 may be completed by 1998. While the augmentations are being carried out, the existing Hornsby STPs will continue to discharge high total nitrogens. At present West Hornsby STP is discharging an average effluent total nitrogen concentration of 30 mg/L, while, Hornsby Heights STP, has an average effluent total nitrogen of around 50 mg/L in the discharge. Although the Board is endeavouring to reduce effluent total nitrogens to around 25 mg/L on average, major works will be necessary to achieve lower levels.

Nitrogen Loading to Berowra Creek

The adoption of Option 2 will significantly reduce the Board's contribution of total nitrogen loads to the river. Table 9-6 shows the reductions in average yearly nitrogen loads to Berowra Creek that could be expected around year 2000 for the various effluent quality targets being examined.

TABLE 9-6. YEARLY TOTAL NITROGEN LOADS TO BEROWRA CREEK (YEAR 2000)

Effluent Quality Target	West Hornsby STP			Hornsby Heights STP			Expected Total
	Yr 2000 Flow	Average Effluent TN	Total Nitrogen kg/Yr	Yr 2000 Flow	Average Effluent TN	Total Nitrogen kg/Yr	Nitrogen Load/Yr from Hornsby STPs
Baseline[a]	11.05	30	121,000	5.8	50	105,850	226,850
Level 1	11.05	10	40,330	5.8	10	21,200	61,530
Level 2	11.05	7	28,250	5.8	7	14,800	43,050
Level 3	11.05	3	12,100	5.8	3	6,350	18,450

a. Baseline condition refers to maintaining the Hornsby STPs as nitrification plants.

Land Requirements

No additional lands will be required at the Hornsby STPs under Option 2 and all facilities proposed will be contained within the current plant boundaries. It must be stressed, however, that the standard 400 metre buffer zone generally applied to Board STPs does not exist at both West Hornsby and Hornsby Heights STPs. No further development should be allowed to encroach even closer.

Operational Aspects

The conversion of the existing nitrification plants to the proposed MLE process will not dramatically affect the current operation of the STPs. In fact, economic paybacks can be expected as reduction in oxygen and lime usage is inherent to biological nitrogen removal plants. Also, as the MLE process does not represent complex technology, no additional skills or increased staff numbers are necessary above the current operating level. Also, no major increases in odours, noise or energy consumption above the existing sewage treatment process is expected when converting to the MLE system.

As phosphorus removal shall continue to be removed by chemical means, a high degree of process reliability in achieving low effluent phosphorus levels is also expected. Current sludge handling and dewatering is also expected not to be adversely affected and will not need major modifications to process treatment philosophy.

Environmental Impacts

If adopted, Option 2 will improve the quality of effluent currently being discharged from the Hornsby plants to Berowra Creek. Without the benefit of an intensive environmental investigation and continual water quality monitoring within Berowra

Creek, the effluent quality target to be adopted to help endeavour to achieve the Berowra Creek goal of recreational and modified ecosystem water quality criteria is unknown. Other issues, including the control of diffuse source pollutant inputs from urban and bushland runoff and limiting development to the current Urban Development Programme will also play an important role in returning the creek to environmental health.

Additional impacts that may be expected in Option 2, include increased noise and truck movements during the construction phase of the scheme, but this is only for the short term. Minimum increases in truck movements can also be expected during the operational phase of the proposed MLE processes at both West Hornsby and Hornsby Heights STPs, and will have no major impact in increasing noise and odour levels.

Beneficial Reuse

With the Board's policy of maximising the beneficial use of effluent and sludges, Option 2 has limited potential for effluent reuse and can be maximised within the STPs only. External markets are limited to golf courses, nurseries and council parks and require large outlays from the community before their inception. Even if this is achieved, no guarantee to continual reuse can be given as it is generally dependant on weather conditions and is generally limited in quantity.

At present, all digested and dewatered sludges from the Hornsby STPs is used for composting at the ANL site. This will continue to occur provided the sludge produced is of good and consistent quality.

Grit and Screening products will also continue to be dewatered, bagged and disposed of in landfill sites.

SECTION 10

OPTION 3 - NEW TREATMENT PLANT

This option involves the decommissioning of West Hornsby and Hornsby Heights STPs and construction of a new biological nitrogen and chemical phosphorus removal plant at a greenfield site. The Level 1, 2 and 3 effluent quality targets as outlined in Table 7-1, will be achieved by using the IDAL process plus add-on facilities.

The proposed Berowra STP is to be located adjacent to a residential subdivision near Easton Road, Berowra (see Figure 10-1). The site is approximately 12.3 Ha with a 90 m buffer zone around proposed structures.

Option 3 would involve the construction of a new plant at Berowra. The plant would incorporate the IDAL process, multi-point dosing, tertiary treatment and disinfection. These treatment facilities would cater for the West Hornsby and Hornsby Heights sewage flows. All flows from the existing West Hornsby and Hornsby Heights STPs would be transferred to the new Berowra STP.

EFFLUENT QUALITY REQUIREMENTS

As the new plant will discharge to Berowra Creek via an unnamed creek, the treatment facilities are to be capable of meeting the effluent quality targets as summarised in Table 7-1.

NEW SEWAGE TREATMENT PLANT SITES

New sewage treatment plant sites have been investigated in the Berowra Creek catchment. Much of the catchment consists of steep sided, riverine gorges with existing development on narrow ridge tops. Suitable sites for establishment of a sewage treatment plant are rare due to restrictions such as:

- Insufficient land area with appropriate slope.
- Proximity of residential areas.
- Alienation of land for other purposes (parkland, special uses etc.).

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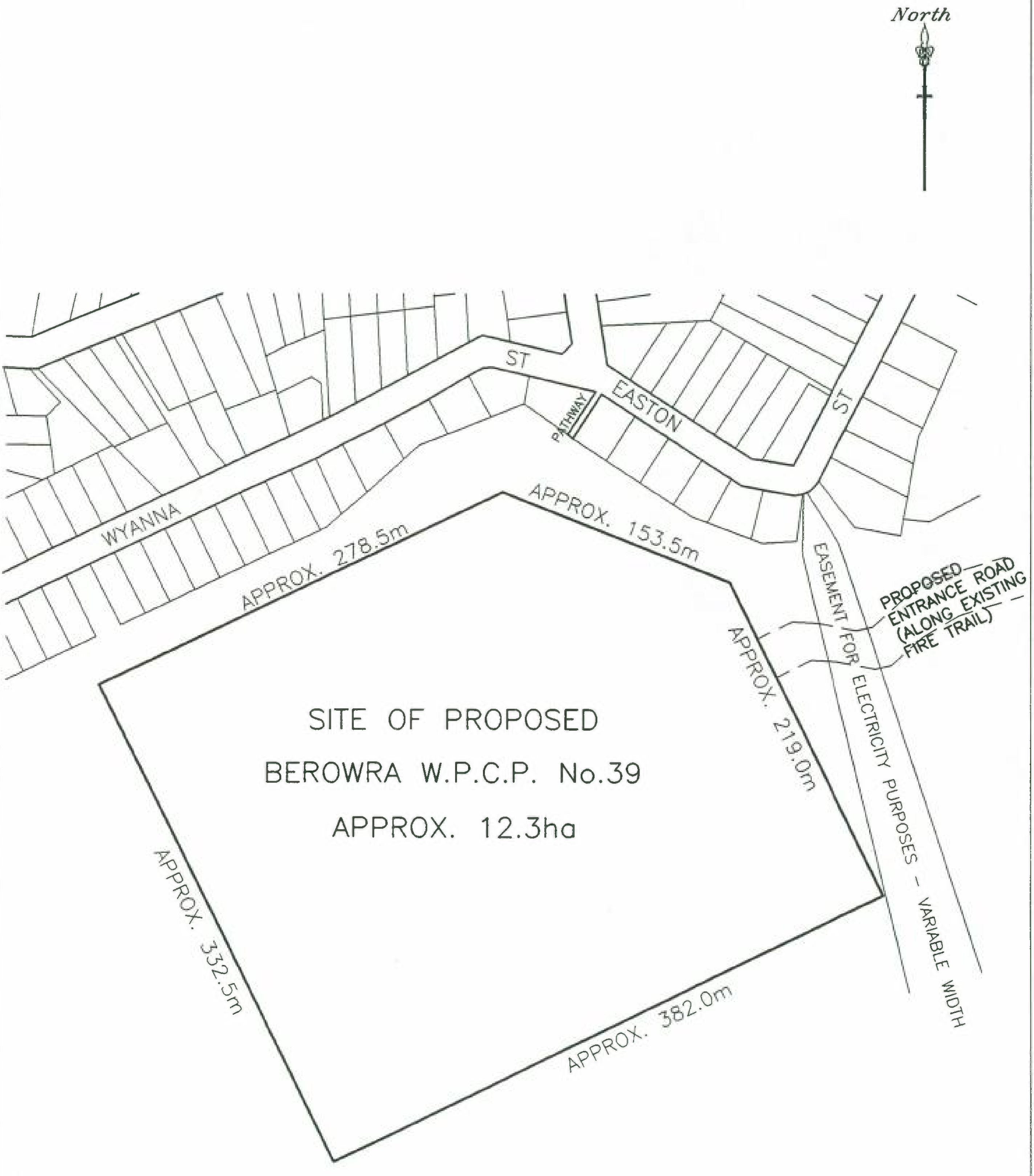

WATER BOARD
SYDNEY–ILLAWARRA–BLUE MOUNTAINS
WASTEWATER AND REUSE PLANNING

OPTION 3
SITE OF PROPOSED
NEW BEROWRA S.T.P.

Figure
10–1

- Appropriate sites but at an elevation which would require difficult and expensive pumping.

The new sites investigated are:

- Crosslands.
- Mt Kuring-gai industrial area.
- Berowra STP site near Easton Road, Berowra.

The new plant would incorporate biological nitrogen removal, chemical phosphorus removal, tertiary treatment and disinfection.

SITE SELECTION

Crosslands Site

The Crosslands site is currently zoned for Public Recreation and is large enough in area required for the ultimate Berowra STP. The use of the Crosslands site for this purpose, however, would alienate the land from its current use and severely degrade the amenity of the area. In addition, locating the STP at this site would incur significant expense in the construction of a sewer, with either tunnelling to the site or excavating in the Berowra Valley Bushland Park.

Therefore, this site will no longer be considered for the new Berowra STP.

Mt Kuring-gai Industrial Area

The Department of Planning's Employment Lands Development Programme specifies

55.4 Ha of vacant land for release in the Mt Kuring-gai industrial area. Time restraints for this project have prevented detailed investigation of suitable sites in this proposed area. If this option for diverting sewage to the Berowra area is adopted, however, more detailed investigation of suitable sites may be carried out.

Therefore, at this time, this site will not be considered for the new Berowra STP.

Site near Easton Road, Berowra

This site was previously identified during the investigations for the upgrading and amplification of the Hornsby Heights STP. That report stated that, if using conventional sewage treatment technology, the site would restrict a sewage treatment plant to 60,000 EP. Using deep tanks for either an IDAL or MLE process, however, the site would be sufficient for the ultimate EP of 75,000 EP from both existing sewage treatment plant catchments.

The site is sloping, but not excessively, and the existing slope would assist in maintaining a hydraulic gradient line through the STP. Residential zoned and developed land is adjacent within the Department of Planning's recommended 400 m buffer zone and the location of potentially odour producing treatment process units would be critical on this site. Therefore, appropriate odour control measures would be required if this site is adopted.

At this time, this site is the most suitable for the STP proposed in this option, therefore, transfer systems and costings will be evaluated for the Easton Road site. Subsequent investigations may determine a more suitable site if this option of diverting sewage to the Berowra area is adopted.

STRATEGIC PLANNING

The options developed in this study must link with the strategies being developed as part of the Clean Waterways Programme (CWP). Consequently, strategies being investigated are discussed briefly in the following section.

The wastewater strategies being developed for the CWP represent the broadest level at which the planning process occurs. Strategies are defined in terms of a very long planning horizon and at a low level of detail in terms of specific projects or non-structural methods. The strategies investigated are described in detail in Section 7.

A basic premise of the strategic plan is that there will be a degree of rationalisation between existing inland treatment plants before the plan is fully implemented. As discussed previously, the strategic plan aims to develop broad conceptual strategies with a long term planning horizon. This present report aims to investigate (in more detail) a range of suitable options which fit the context of the strategic plan.

FACILITIES TO BE PROVIDED

The previous Hornsby Heights STP Options Report stated that (using conventional sewage treatment technology) the Berowra site would restrict a sewage treatment plant to 60,000 EP. Using deep tanks with vertical walls for either an IDAL or MLE process, however, the site would be sufficient for the ultimate EP of 75,000 EP from both existing sewage treatment plant catchments.

Based on an ultimate site capacity of 75,000 EP, the following facilities would be provided to achieve Level 1 effluent quality target:

Screening and grit removal.
Chemical dosing for phosphorus removal (multi point dosing).
Biological nitrogen removal reactor.
Tertiary chemical dosing.
Tertiary filtration.
Disinfection.
Sludge stabilisation.
Sludge thickening/dewatering.

Level 2 effluent quality would also require carbon source substrate dosing (such as methanol) into the reactor and Level 3 would require the addition of an attached growth reactor with carbon source substrate dosing for post denitrification.

PROCESS SELECTION

There are a number of processes available which could be utilised to meet the effluent quality targets as summarised in Table 7-1. For the purposes of this investigation, due to the extreme time limitations and the discussion of process options in another part of this document, the IDAL process will be adopted for the new Berowra STP site. The design criteria shown in Tables 7-5 and 7-6 respectively will be used to size and cost the Level 1 IDAL. Additional facilities will be added to achieve the Level 2 and Level 3 targets.

DESCRIPTION OF OPTION

This option's basic assumption is that a new STP is required for the combined West Hornsby and Hornsby Heights STPs' flows to meet the requirements of the three treatment levels.

For this option:

- West Hornsby (WH) and Hornsby Heights (HH) STPs would be decommissioned.
- Inlet structure modification to existing WH and HH STPs.
- Pumping stations (SPS) and rising mains provided (as shown in Figure 10-2) from WH and HH STPs to Berowra STP.
- A new Berowra STP would be constructed to treat the diverted flow from West Hornsby and Hornsby Heights STPs.

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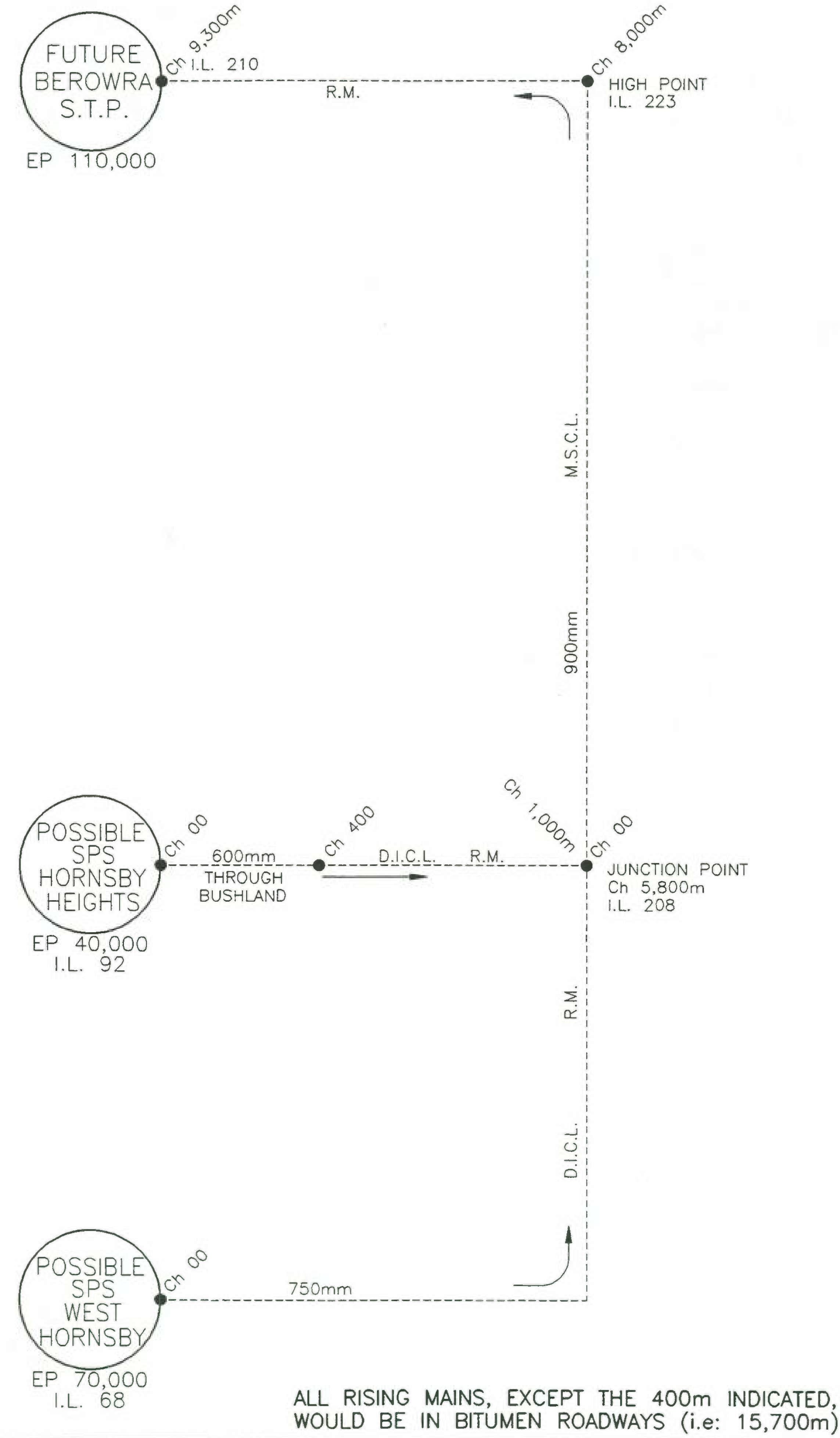


ALL RISING MAINS, EXCEPT THE 400m INDICATED, WOULD BE IN BITUMEN ROADWAYS (i.e: 15,700m)

WATER BOARD SYDNEY-ILLAWARRA-BLUE MOUNTAINS *WASTEWATER AND REUSE PLANNING*	DECOMMISSION WEST HORNSBY & HORNSBY HEIGHTS STPs & TRANSFER ALL FLOWS TO NEW BEROWRA STP	Figure 10-2

- Overflow from the inlet structure would be retained in a Wet Weather Holding Tank (WWHT) and pumped to Berowra STP when STP treatment capacity is available.

- Overflow from WWHT would receive fine screening and grit removal before discharge to local creek.

The following assumptions will apply to the option:

- Raw sewage flows of up to Design Wet Weather Flow (DWWF, ie. 4 x PDWF) for 75,000 EP would be transferred to Berowra STP for treatment and disposal.

- Flows greater than DWWF and WWHT capacity would receive fine screening and grit removal before discharge to the Berowra Creek catchment.

- Wet weather holding facilities would be provided to attenuate excessive storm flows and return them to the transfer system when treatment capacity is available.

The existing inlet structures of West Hornsby and Hornsby Heights STPs would be modified to enable all flows up to DWWF to be pumped to the new Berowra STP for treatment and disposal.

The modified inlet structure at each plant would have a facility to bypass storm flows greater than DWWF to a WWHT. The WWHT would have facilities to drain to the wet well of the transfer SPS to Berowra STP when there is treatment capacity at the STP. Overflow from the WWHT would receive fine screening and grit removal before discharge to the local creek.

The proposed routes and sizes of the rising mains to the new Berowra STP are shown in figure 10-2. Due to enviornmental concerns, laying pipes in the Berowra Valley Bushland Park is not considered acceptable. Therefore, a longer route laid under roads has been adopted for this option.

A new sewage treatment plant at Berowra would be constructed to treat the raw sewage transferred from West Hornsby and Hornsby Heights STPs.

SIZING OF FACILITIES

Flows and Population Projection

As discussed in previous sections of this report, the current and ultimate EP and flows of West Hornsby and Hornsby Heights STP catchments are summarised in Table 10-1.

TABLE 10-1. CURRENT AND ULTIMATE EP AND FLOWS OF WEST HORNSBY AND HORNSBY HEIGHTS STP CATCHMENTS

	EP		**Average Dry Weather Flow (ML/d)**	
	Current	**Ultimate**	**Current**	**Ultimate**
West Hornsby Hornsby Heights	35,000 EP 20,000 EP	50,000 EP 25,000 EP	9.5 ML/d 5.4 ML/d	13.5 ML/d 6.8 ML/d
TOTAL	55,000 EP	75,000 EP	14.9 ML/d	20.3 ML/d

For the purposes of this investigation, the DWWF is taken as 4 x PDWF.

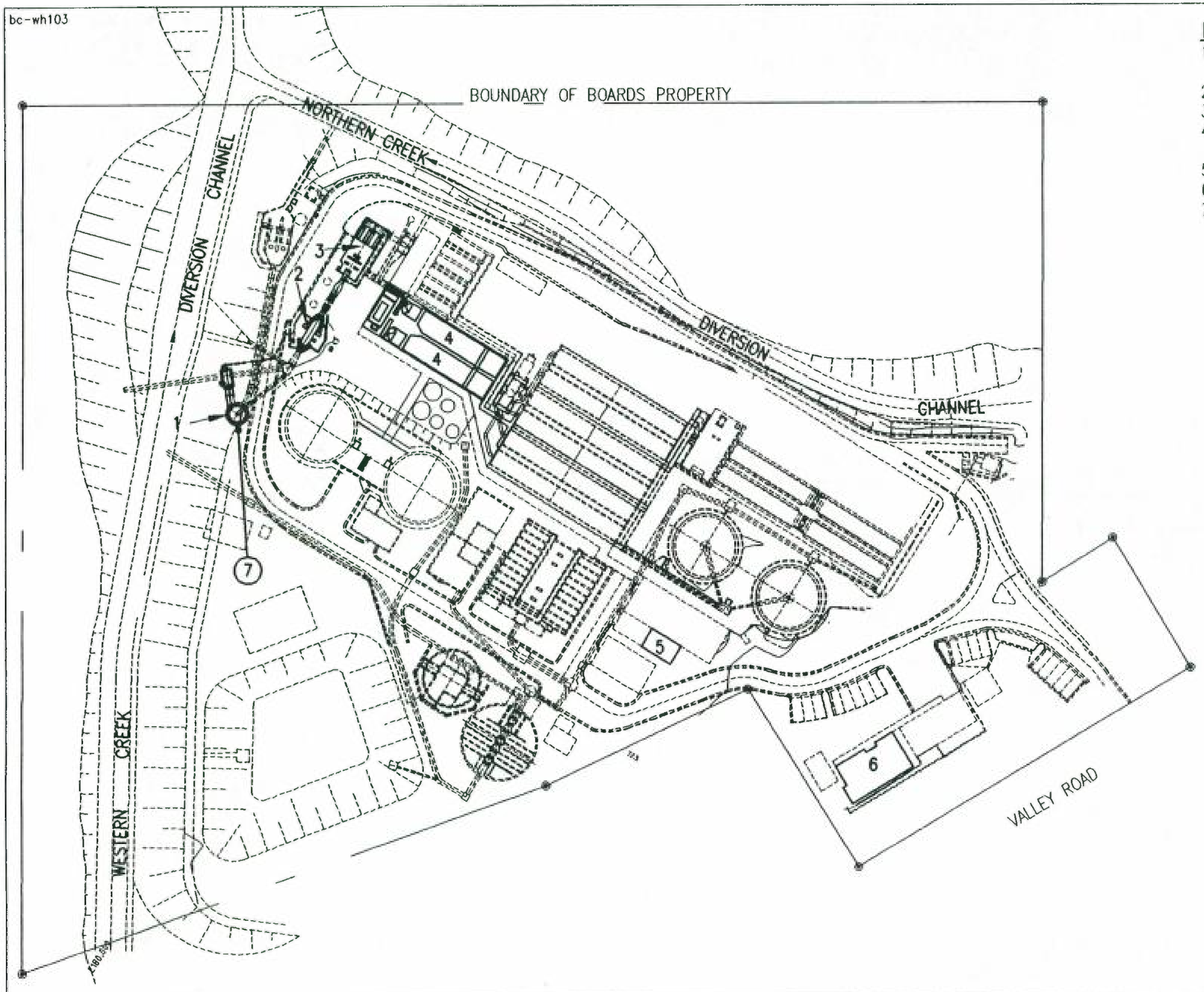
Modification to Existing STPs

West Hornsby and Hornsby Heights STPs would be decommissioned and modified to provide the following facilities:

- A new modified inlet structure, with bypass facility, to convey all flows to the transfer SPS.
- A Wet Weather Holding Tank (WWHT) to attenuate excessive storm flows and capable of having the volume being pumped into the transfer system after a wet weather event.
- A Screening Plant (with fine screening and grit removal facilities) would be used to treat any overflow from the WWHT before discharge to the local creek.

Figure 10-3 and figure 10-4 show the modified layout of the facilities at West Hornsby and Hornsby Heights STPs respectively.

With the new inlet structure, the flow will drain to the wet well of the transfer SPS, which will convey the flow to Berowra STP. The proposed SPS would have sufficient capacity to take all flows from the two catchments. As a safety measure, however, a WWHT and a screening plant will be provided. This may only be bc-wh103



LEGEND

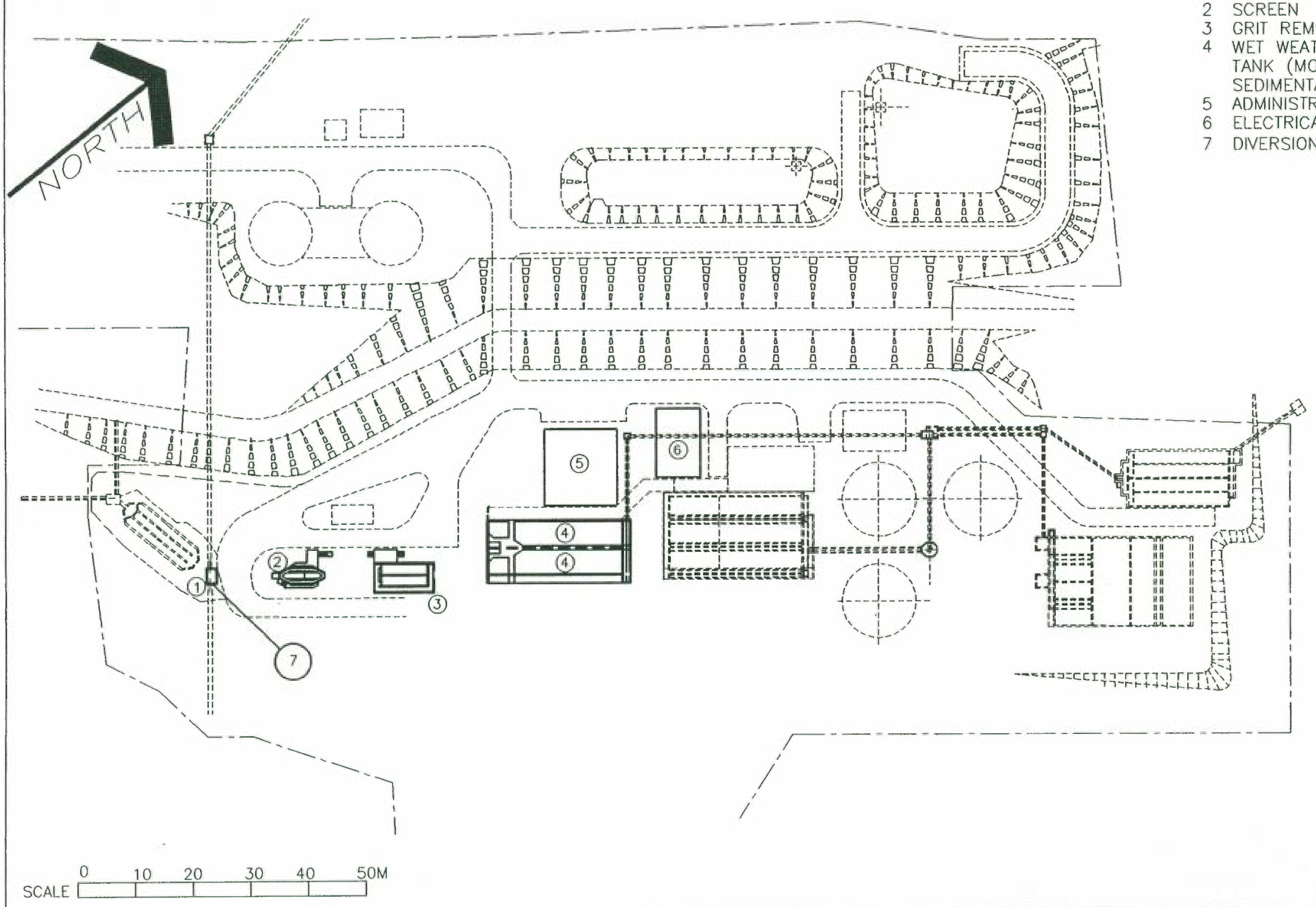
1 NEW INLET & DIVERSION STRUCTURE (MODIFIED FROM RAW SEWAGE FLOW SPLITTER)
2 SCREEN
3 GRIT REMOVAL
4 WET WEATHER HOLDING TANK (WWHT = MODIFIED PRIMARY SEDIMENTATION TANKS)
5 11kV SUBSTATION
6 ADMINISTRATION BUILDING
7 DIVERSION S.P.S.

WATER BOARD
SYDNEY–ILLAWARRA–BLUE MOUNTAINS
WASTEWATER AND REUSE PLANNING

WEST HORNSBY S.T.P.
GENERAL ARRANGEMENT OF
SCREENING PLANT (WITH WWHT) & DIVERSION S.P.S.

Figure
10–3

bc-hh104



LEGEND

1 NEW INLET & DIVERSIONS STRUCTURE
2 SCREEN
3 GRIT REMOVAL
4 WET WEATHER HOLDING TANK (MODIFIED PRIMARY SEDIMENTATION TANK)
5 ADMINISTRATION BUILDING
6 ELECTRICAL SUB-STATION
7 DIVERSION S.P.S.

WATER BOARD
SYDNEY-ILLAWARRA-BLUE MOUNTAINS
WASTEWATER AND REUSE PLANNING

HORNSBY HEIGHTS S.T.P.
GENERAL ARRANGEMENT OF
SCREENING PLANT (WITH WWHT)

Figure
10-4

required when major repair or major maintenance is conducted within the transfer system. The existing primary sedimentation tanks will be converted to the WWHTS.

Construction of an SPS and Rising Main

This part of the work comprises two separate SPSs and rising mains from West Hornsby and Hornsby Heights STPs merging into a common rising main which would run all the way to Berowra STP.

With a nominal rising main size of 750 mm MSCL, there would be sufficient capacity for the ultimate EP and flow, i.e. capable of delivering flows of up to DWWF of the ultimate catchment size of 75,000 EP.

Figure 10-2 shows the schematic route of rising mains.

BEROWRA STP

Introduction

Berowra STP would serve the combined sewage catchment areas of West Hornsby and Hornsby Heights STPs as described in Section 4. Future development in these areas shall also be serviced by Berowra STP. The ultimate development in this catchment area is estimated to be 75,000 EP (based on development of the "most-likely" physical catchment area capable of draining to the treatment plant). Berowra STP's likely ultimate catchment area, of about 40 square kilometres, is shown in figures 3-1, 3-9A and 3-9B.

Facilities to be provided at Berowra STP

The flow and load, currently of about 55,000 EP, when transferred would represent about 50 percent of the ultimate capacity of Berowra STP . Hence, a significant proportion of the ultimate capacity of Berowra STP is required from the initial stage.

Table 10-2 summarises the total EP projection for this Option:

TABLE 10-2. COMBINED EP PROJECTION FOR OPTION 3

	Year								
	1994	1996	1998	2000	2005	2010	2015	2019	Ultimate
West Hornsby	35,200	36,967	38,864	40,864	44,650	46,105	46,284	46,419	50,000
Hornsby Heights	18,800	20,048	20,859	21,638	23,480	24,705	24,794	24,836	25,000
TOTAL	54,000	57,015	59,726	62,502	68,130	70,810	71,078	71,255	75,000

As the plant effluent would discharge into a tributary of Berowra Creek the effluent must meet the effluent quality targets as summarised in Table 7-1.

A new nutrient removal plant would be constructed on the Berowra site. To provide sufficient capacity for the initial transfer and as approximately 90 per cent of the ultimate capacity will be required within 10 to 15 years the first and final stage of Berowra STP would be provided for the 75,000 EP ultimate load.

The following facilities for construction would be provided:

Level 1 Treatment

Screening and grit removal facilities.
IDAL tank to achieve carbonaceous oxidation, nitrification and denitrification.
Flow Equalisation.
Multi-point chemical dosing systems.
Tertiary Dual Media Filtration.
WAS thickener.
Sludge dewatering facilities.
Disinfection facilities (ultra-violet radiation with chlorination as a back-up).
Associated administration, control and maintenance facilities.

As in the previous options, Level 2 treatment would be achieved by the addition of methanol dosing facilities dosing an external carbon source into the biological reactor, while Level 3 would require the addition of an attached growth post denitrification facilities. As no distinct secondary clarifiers are provided (as is the case with the MLE process) the attached growth post denitrification option will need to be installed in lieu of the suspended growth system.

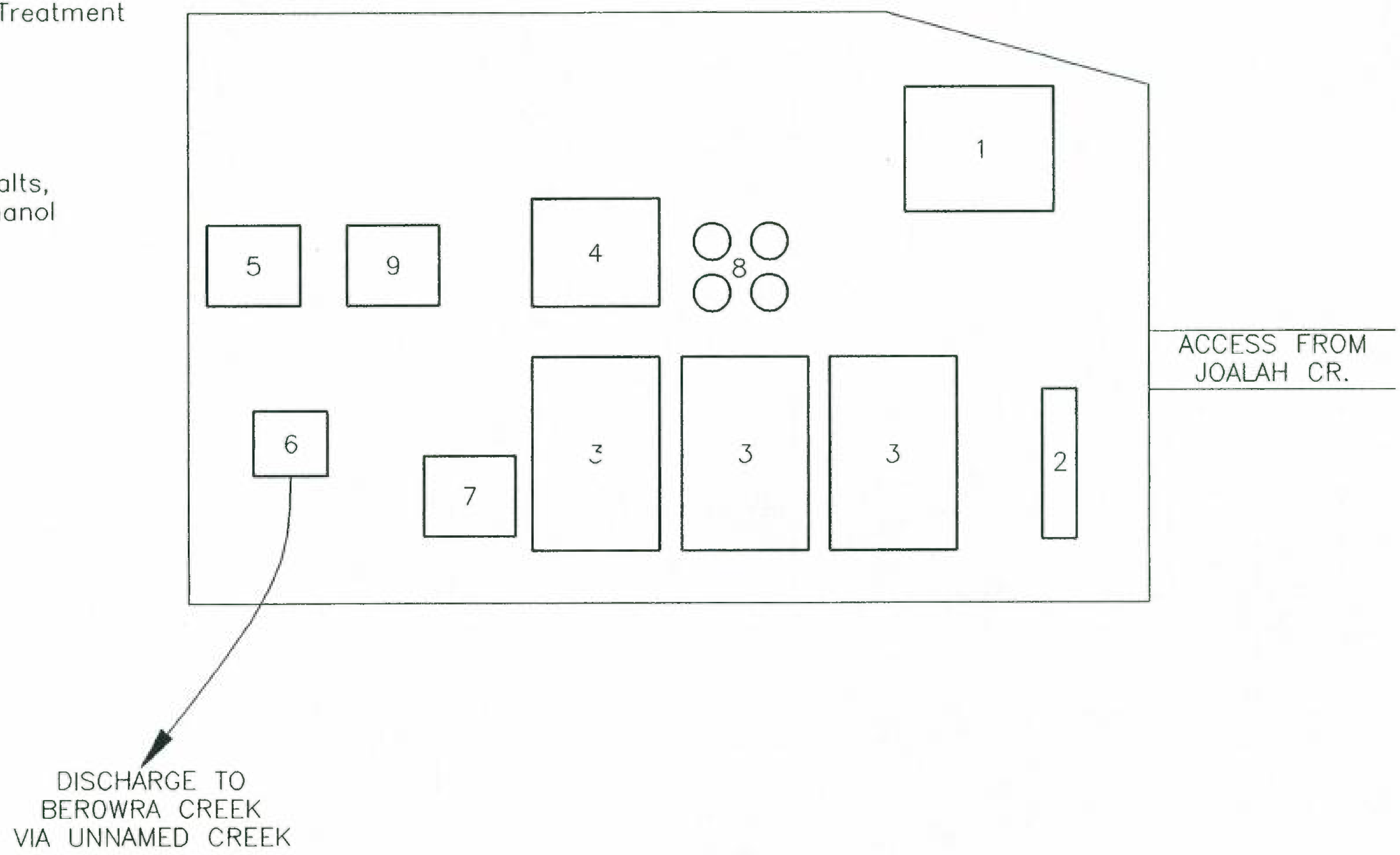
Figure 10-5 shows the Stage 1 and ultimate IDAL process layout for the proposed Berowra Creek STP. Figure 10-6 shows the process flow train. Tables 10-3, 10-4 and 10-5 indicate the works needed for this option.

bc-bc75

LEGEND

1. Adminstration Building
2. Inlet Works and Preliminary Treatment
3. IDALS for 75,000EP
4. Equalisation Basin
5. Tertiary Filtration
6. Disinfection
7. Sludge Processing
8. Chemical Storage for Iron Salts, Alum, Polymer, Lime & Methanol
9. Post Denitrification

▭ Stage 1 Facilities for 75,000EP

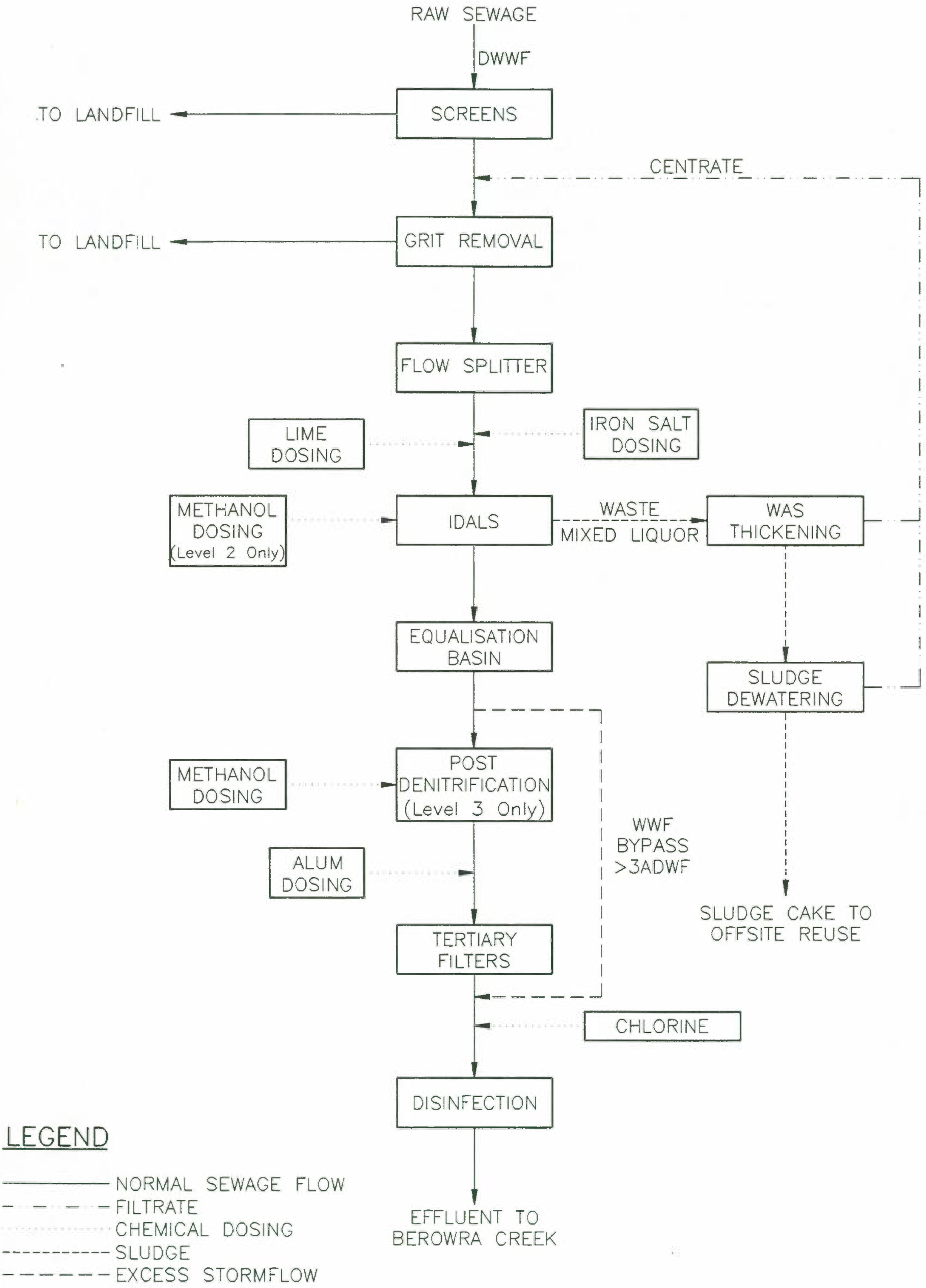


WATER BOARD
SYDNEY-ILLAWARRA-BLUE MOUNTAINS
WASTEWATER AND REUSE PLANNING

PROPOSED BEROWRA S.T.P.
OPTION 3

Figure
10-5

bc-bcpfd



WATER BOARD
SYDNEY-ILLAWARRA-BLUE MOUNTAINS
WASTEWATER AND REUSE PLANNING

OPTION 3
PROPOSED BEROWRA S.T.P.
PROCESS FLOW DIAGRAM

Figure
10-6

TABLE 10-3. SUMMARY OF OPTION 3 ACTIONS FOR WEST HORNSBY STP

Actions Proposed	**Treatment Level**		
	Level 1 (TN 15 mg/L)	**Level 2 (TN 10 mg/L)**	**Level 3 (TN 5 mg/L)**
Decommission West Hornsby STP	Decommission West Hornsby STP and modify and retain relevant facilities	As for Level 1	As for Level 1
Modify inlet structure and STP	Modify inlet structure and convert primary sedimentation tanks to WWHT	As for Level 1	As for Level 1
Pumping Station and Rising Main	Provide pumping station and rising main to Berowra STP	As for Level 1	As for Level 1

TABLE 10-4. SUMMARY OF OPTION 3 ACTIONS FOR HORNSBY HEIGHTS STP

Actions Proposed	**Treatment Level**		
	Level 1 (TN 15 mg/L)	**Level 2 (TN 10 mg/L)**	**Level 3 (TN 5 mg/L)**
Decommission Hornsby Heights STP	Decommission Hornsby Heights STP and modify and retain relevant facilities	As for Level 1	As for Level 1
Modify inlet structure and STP	Modify inlet structure and convert primary sedimentation tanks to WWHT	As for Level 1	As for Level 1
Pumping Station and Rising Main	Provide pumping station and rising main to Berowra STP	As for Level 1	As for Level 1

TABLE 10-5. SUMMARY OF OPTION 3 ACTIONS FOR BEROWRA STP

Actions Proposed	**Treatment Level**		
	Level 1 (TN 15 mg/L)	**Level 2 (TN 10 mg/L)**	**Level 3 (TN 5 mg/L)**
New STP at Berowra	Provide facilities for 75,000 EP at Berowra with: ▪ Screening and grit removal facilities ▪ IDAL tank to achieve carbonaceous oxidation, nitrification and denitrification ▪ Multi-point chemical dosing systems ▪ WAS thickener ▪ Sludge dewatering facilities ▪ Disinfection facilities ▪ Associated administration, control and maintenance facilities	As for Level 1 with methanol dosing facilities to the IDAL	As for Level 1 with post-denitrification and associated methanol dosing facilities

OPTION OVERVIEW

To allow an adequate comparison to be made between the options investigated, Option 3, which involves the decommissioning of West Hornsby and Hornsby Heights STPs and construction of a new biological nitrogen and chemical phosphorus removal plant at a greenfield site has the following characteristics. An additional overview is provided in the Section discussing "comparison of options".

Capital and Operating Costs

Based on the Board's costing system, the Order of Cost estimate for upgrading and amplifying Hornsby Heights STP and upgrading West Hornsby STP are summarised in Table 10-6 below.

TABLE 10-6. OPTION 3 - CAPITAL AND OPERATING COSTS

Effluent Total Nitrogen Target (90%ile Values)	Capital Cost $M					Operating Cost $M/Yr	
	West Hornsby STP	Hornsby Heights STP	Transfer Pumping Station & Rising Main	Berowra STP	Total	Transfer Pumping	Berowra STP
15	2.0	2.0	21.7	34.6	63.0	0.69	3.69
10	2.0	2.0	21.7	34.8	63.2	0.69	3.72
5	2.0	2.0	21.7	41.3	67.0	0.69	3.77

a) Operating cost based at Year 2000 EP load.

Expected Implementation Time Frame

If the environmental assessment and all necessary approvals are obtained by end 1995, Option 3 may be completed by 1998/1999. While the augmentations are being carried out, the existing Hornsby STPs will continue to discharge high total nitrogens. At present West Hornsby STP is discharging an average effluent total nitrogen concentration of 30 mg/L, while Hornsby Heights STP has an average effluent total nitrogen of around 50 mg/L in the discharge. Although the Board is endeavouring to reduce effluent total nitrogens to around 25 mg/L on average, major works will be necessary to achieve lower levels.

Nitrogen Loading to Berowra Creek

The adoption of Option 3 will significantly reduce the Board's contribution of total nitrogen loads to the river. Table 10-7 shows the reductions in average yearly nitrogen loads to Berowra Creek that could be expected around year 2000 for the various effluent quality targets being examined.

TABLE 10-7. YEARLY TOTAL NITROGEN LOADS FROM BEROWRA STP TO BEROWRA CREEK (YEAR 2000)

Effluent Quality Target	Yr 2000 Flow	Average Effluent TN	Total Nitrogen kg/Yr
Baseline[a]	16.85	30	226,850
Level 1	16.85	10	61,503
Level 2	16.85	7	43,052
Level 3	16.85	3	18,451

[a] Baseline condition refers to maintaining the Hornsby STPs as nitrification plants.

Land Requirements

No additional land will be required at the Hornsby STPs under Option 3 and all facilities proposed will be contained within the current plant boundaries. It must be stressed, however, that the standard 400 metre buffer zone generally applying to Board STPs does not exist at either West Hornsby and Hornsby Heights STPs. No further development should be allowed to encroach further on to the existing structures. The existing sites at West Hornsby and Hornsby Heights need to be retained to accommodate the diversion and WWF treatment facilities. Residential development exists within the 400 m buffer zone for the proposed new Berowra STP and, therefore, odour control measures would be required at the new site.

Operational Aspects

The conversion of the existing plants to the proposed storm treatment facilities will obviously affect the current operation of the STPs as these will effectively be decommissioned as continuously operating STPs. The proposed new Berowra STP would utilise the IDAL process as currently used elsewhere in the Board and therefore is a process familiar to Waste Water Inland North operations personnel. Economic paybacks can be expected as reduction in oxygen and lime usage are inherent to biological nitrogen removal plants. Also, as the IDAL process does not represent complex technology, no additional skills or increased staff numbers are necessary above the current operating level. Also no major increases in odours, noise or energy consumption above the existing sewage treatment process is expected when implementing to the IDAL system.

As phosphorus removal shall continue to be removed by chemical means, a high degree of process reliability in achieving low effluent phosphorus levels is also expected. Current sludge handling and dewatering is also expected not to be adversely affected and will not need major modifications to process treatment philosophy.

Environmental Impacts

If adopted, Option 3 will improve the quality of effluent currently being discharged from the Hornsby plants to Berowra Creek. Without the benefit of an intensive environmental investigation and continual water quality monitoring within Berowra Creek, the effluent quality target to be adopted to help endeavour to achieve the Berowra Creek goal of recreational and modified ecosystem water quality criteria is unknown. Other issues, including the control of diffuse source pollutant inputs from urban and bushland runoff and limiting development to the current Urban Development Programme, will also play an important role in returning the creek to environmental health.

This option would produce a single point source of effluent disposal to Berowra Creek. This has the potential of concentrated impact on the creek in the event of major process malfunction in the STP.

This option would have a major impact on the Berowra Valley Bushland Park as the proposed new STP would be located in this reserve. This would alienate more than 12 hectares of native bushland and require a major access road through approximately 500 m of bushland and residential streets in Berowra.

Additional impacts that may be expected in Option 3, include increased noise and truck movements during the construction phase of the scheme, but this is only for the short term. Minimum increases in truck movements can also be expected during the operational phase of the proposed MLE processes at both West Hornsby and Hornsby Heights STPs and will have no major impact in increasing noise and odour levels. Significant increases in truck movements at Berowra STP would also occur.

Beneficial Reuse

With the Board's policy of maximising the beneficial use of effluent and sludges, Option 3 has limited potential for effluent reuse and can be maximised within the STPs only. External markets are limited to golf courses, nurseries and council parks and require large outlays from the community before their inception. Even if this is achieved, no guarantee to continual reuse can be given as it is generally dependant on weather conditions and is generally limited in quantity.

At present, all digested and dewatered sludges from the Hornsby STPs are used for composting at the ANL site. This will continue to occur provided the sludge produced is of good and consistent quality.

Grit and screening products will also continue to be dewatered, bagged and disposed of in landfill sites.

SECTION 11

OPTION 4 - UPGRADED STPS AND NEW TREATMENT PLANT

This option involves retaining both West Hornsby and Hornsby Heights STPs at their present capacities and construction of a new nutrient removal plant at a greenfield site to provide treatment for all flows in excess of the capacities of the existing STPs.

The greenfield site for the new treatment plant has been the proposed Berowra STP site, although this may be subject to change. If this option is adopted more detailed investigations can be carried out during the environmental assessment stage. Alternate sites may be more amenable and may include a potential location within the Mt Kuring-gai industrial area.

Both the West Hornsby and Hornsby Heights STPs will be retained and upgraded to achieve the Level 1, 2 and 3 effluent quality targets for 45,000 and 20,000 EP respectively. This represents the West Hornsby STP Stage 2 Upgrade and Hornsby Heights STP Stage 1 Upgrade. Flows will need to be transferred from the Hornsby Heights catchment as a first priority to alleviate potential overloading after the year 2000.

OPTION 4

This option's basic assumption is that both West Hornsby and Hornsby Heights STPs can be upgraded to meet the requirements of the three treatment levels at their current capacities without major amplifications. This means that facilities at both existing sewage treatment plants can be utilised well into the next century. The plants' ultimate future can thus be assessed again, possibly after the strategic planning process (discussed in Section 1) has been finalised and is well into the implementation phase. A new STP would be constructed to treat the combined flows in excess of the current capacities of West Hornsby and Hornsby Heights STPs.

For this option:

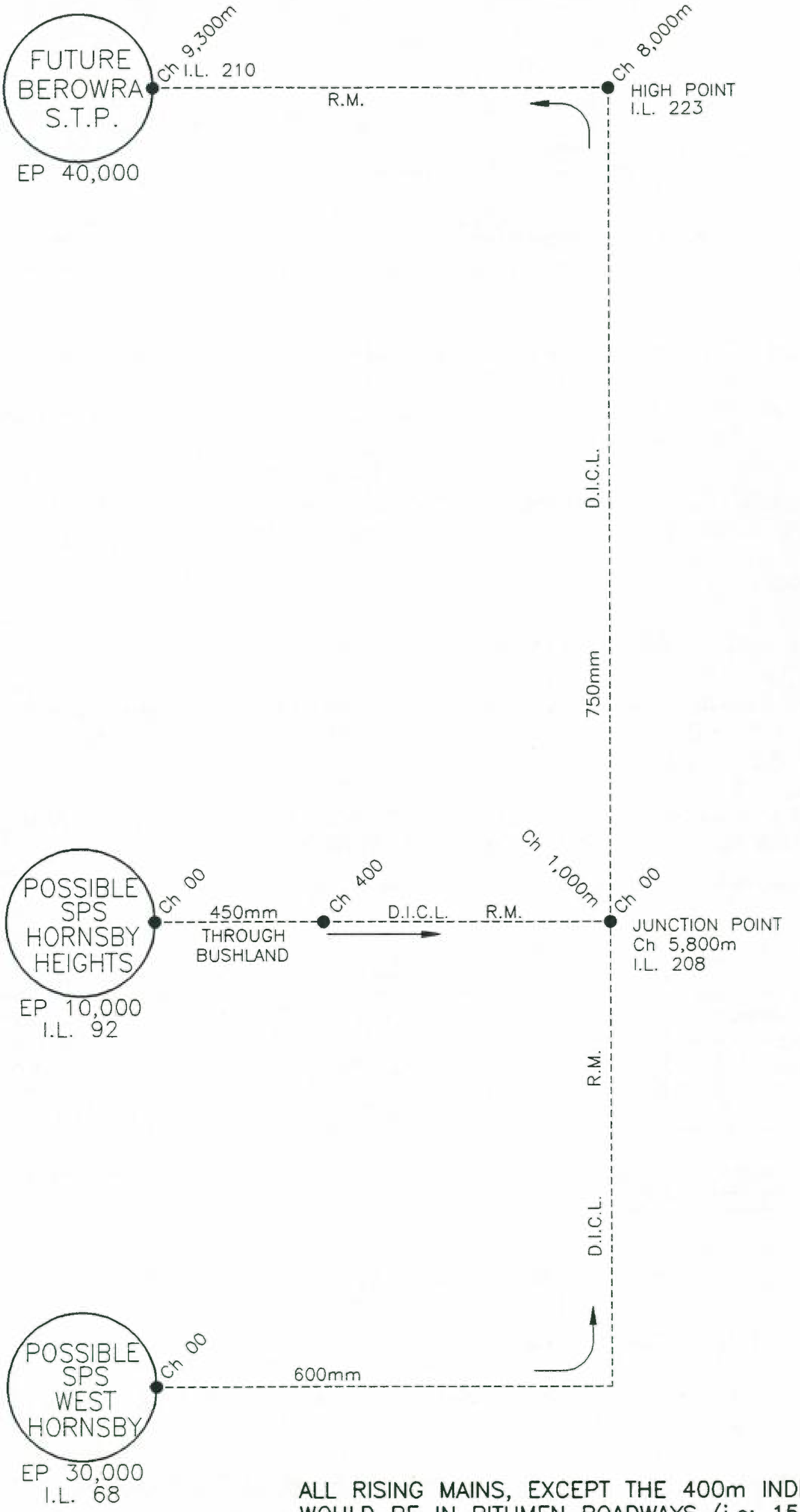
- West Hornsby (WH) and Hornsby Heights (HH) STPs would be retained at their current nominal capacities and upgraded to achieve the Levels 1, 2 and 3 effluent quality targets.
- Inlet structure modification to existing WH and HH STPs.
- Pumping stations (SPS) and rising mains provided (as shown in figure 11-1) from WH and HH STPs to Berowra STP.
- Diversion structure in the sewerage system located in the Berowra area to divert flows directly to the new Berowra STP when load on Hornsby Heights STP reaches that plant's capacity.
- A new Berowra STP would be constructed to treat the excess flow diverted from West Hornsby and Hornsby Heights STPs.
- Overflow from inlet structure would be retained in a Wet Weather Holding Tank (WWHT), and treated when STP capacity is available.
- Overflow from WWHT would receive fine screening and grit removal before discharge to local creek.

The following assumptions will apply to the option:

- Raw sewage flows of up to Design Wet Weather Flow (DWWF, ie. 4 x PDWF) for 10,000 EP would be transferred to Berowra STP for treatment and disposal;
- Flows greater than DWWF and WWHT capacity would receive fine screening and grit removal before discharge to the Berowra Creek catchment; and
- Wet Weather holding facilities would be provided to attenuate excessive storm flows and returned to the treatment facilities when capacity is available.

The existing inlet structures of West Hornsby and Hornsby Heights STPs would be modified to enable all flows in excess of the existing STP's capacity and up to DWWF (ie. 4 x PDWF) for 10,000 EP to be pumped to the new Berowra STP for treatment and disposal (5,000 EP from West Hornsby and 5,000 EP from Hornsby Heights STP catchments).

The modified inlet structure at each plant would have a facility to bypass storm flows greater than DWWF to a WWHT. The WWHT would have facilities to drain to either the originating STP or the wet well of the transfer SPS to Berowra STP



ALL RISING MAINS, EXCEPT THE 400m INDICATED,
WOULD BE IN BITUMEN ROADWAYS (i.e: 15,700m)

WATER BOARD
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WASTEWATER AND REUSE PLANNING

RETAIN WEST HORNSBY & HORNSBY HEIGHTS STPs & TRANSFER FLOWS IN EXCESS OF NOMINAL CAPACITY TO A NEW BEROWRA STP

Figure 11–1

depending on the available treatment capacity at the STP. Overflow from the WWHT would receive fine screening and grit removal before discharge to the local creek.

The proposed routes and sizes of the rising mains to the new Berowra STP are shown in figure 11-2. Due to environmental considerations of not laying sewer mains through the Berowra Valley Bushland Park an alternate route utilising main arterial roads has been adopted.

A new sewage treatment plant at Berowra would be constructed to treat the raw sewage transferred from West Hornsby and Hornsby Heights STPs.

SIZING OF FACILITIES

Flows and Population Projection

As discussed in previous sections of this report, the current and ultimate EP and flows of West Hornsby, Hornsby Heights and Berowra STP catchments are summarised in Table 11-1.

TABLE 11-1. CURRENT AND ULTIMATE EP AND FLOWS OF WEST HORNSBY AND HORNSBY HEIGHTS AND BEROWRA STP CATCHMENTS

	EP		**Average Dry Weather Flow (ML/d)**	
	Current	**Ultimate**	**Current**	**Ultimate**
West Hornsby	35,000 EP	45,000 EP	9.5 ML/d	12.2 ML/d
Hornsby Heights	20,000 EP	20,000 EP	5.4 ML/d	5.4 ML/d
Berowra	Nil	10,000 EP	Nil	2.7 ML/d
TOTAL	55,000 EP	75,000 EP	14.9 ML/d	20.3 ML/d

Notes:
1. The "catchment" of Berowra STP consists of the sewered area at Berowra and the flow diverted from West Hornsby and Hornsby Heights STPs in excess of those plants' individual capacities.

For the purposes of this investigation, the DWWF is taken as 4 x PDWF.

Modification to Existing STPs

Modification to existing facilities at West Hornsby and Hornsby Heights STPs would be significant.

West Hornsby and Hornsby Heights STPs would be upgraded and modified to provide the following facilities:

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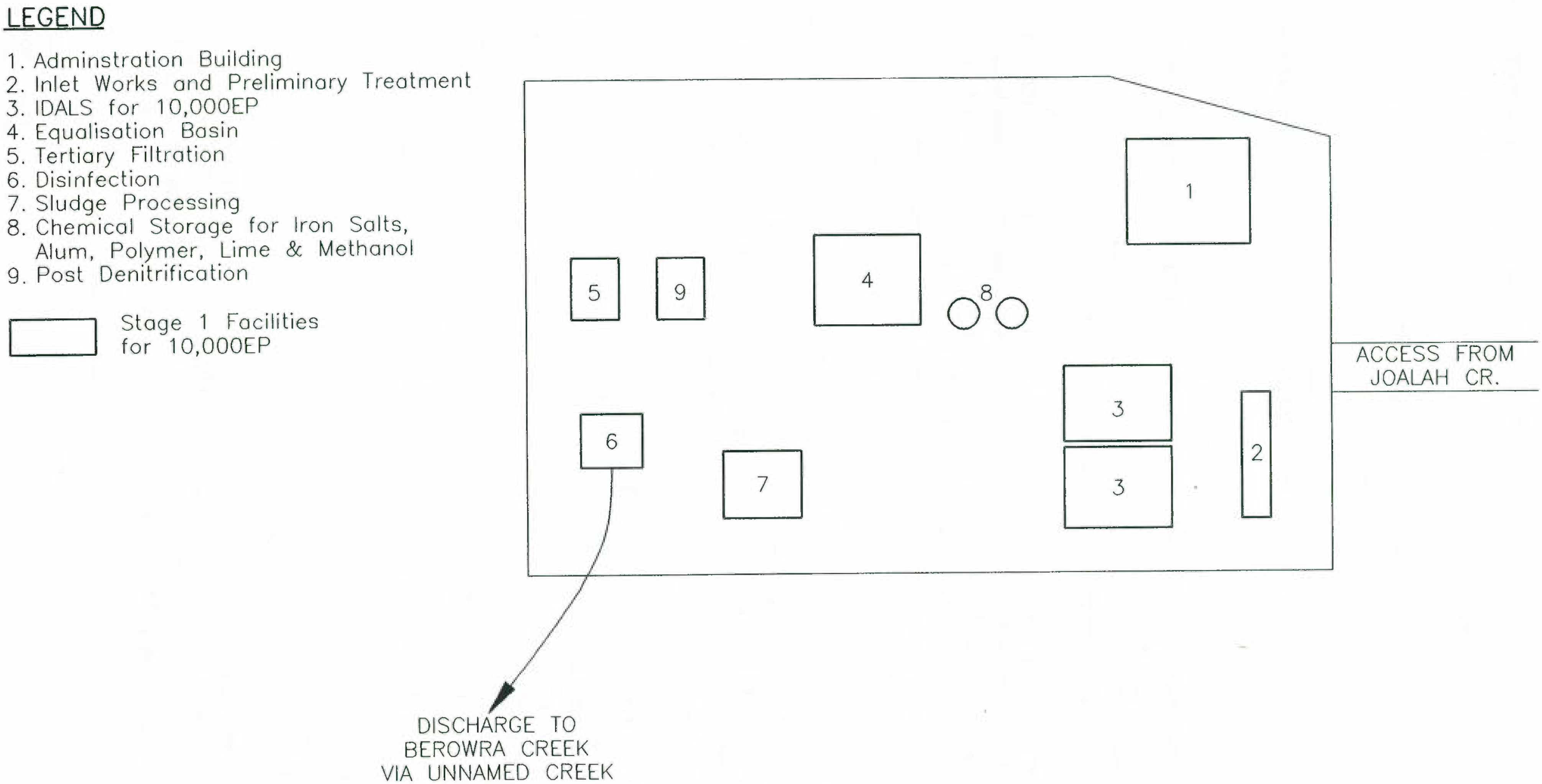


WATER BOARD
SYDNEY–ILLAWARRA–BLUE MOUNTAINS
WASTEWATER AND REUSE PLANNING

PROPOSED BEROWRA S.T.P.
OPTION 4

Figure
11–2

- A new modified Inlet structure, with bypass facility, to convey all flows greater than the current capacities to the transfer SPS.

- A Wet Weather Holding Tank (WWHT) to attenuate excessive storm flows, and capable of having the volume being pumped into the transfer system after a wet weather event.

- A Screening Plant (with fine screening and grit removal facilities) would be used to treat any overflow from the WWHT before discharge to the local creek.

Figure 11-3 and figure 11-4 show the modified layout of the facilities at West Hornsby and Hornsby Heights STPs respectively.

With the new inlet structure, the excess flow will drain to the wet well of the transfer SPS, which will convey the flow to Berowra STP. The proposed SPSs would have sufficient capacity to take all diverted flows from the two catchments. However, as a safety measure, a WWHT and a Screening Plant will be provided at the existing STPs. This may only be required when major repair or major maintenance is conducted within the transfer system.

Upgraded STPs

As the retained plants shall continue to discharge to Berowra Creek, both West Hornsby and Hornsby Heights STP shall be upgraded to their current stated nominal capacities. Section 8, contains more details of the facilities required to meet the proposed effluent quality goals, Level 1, 2 and 3 respectively.

Construction of an SPS and Rising Main

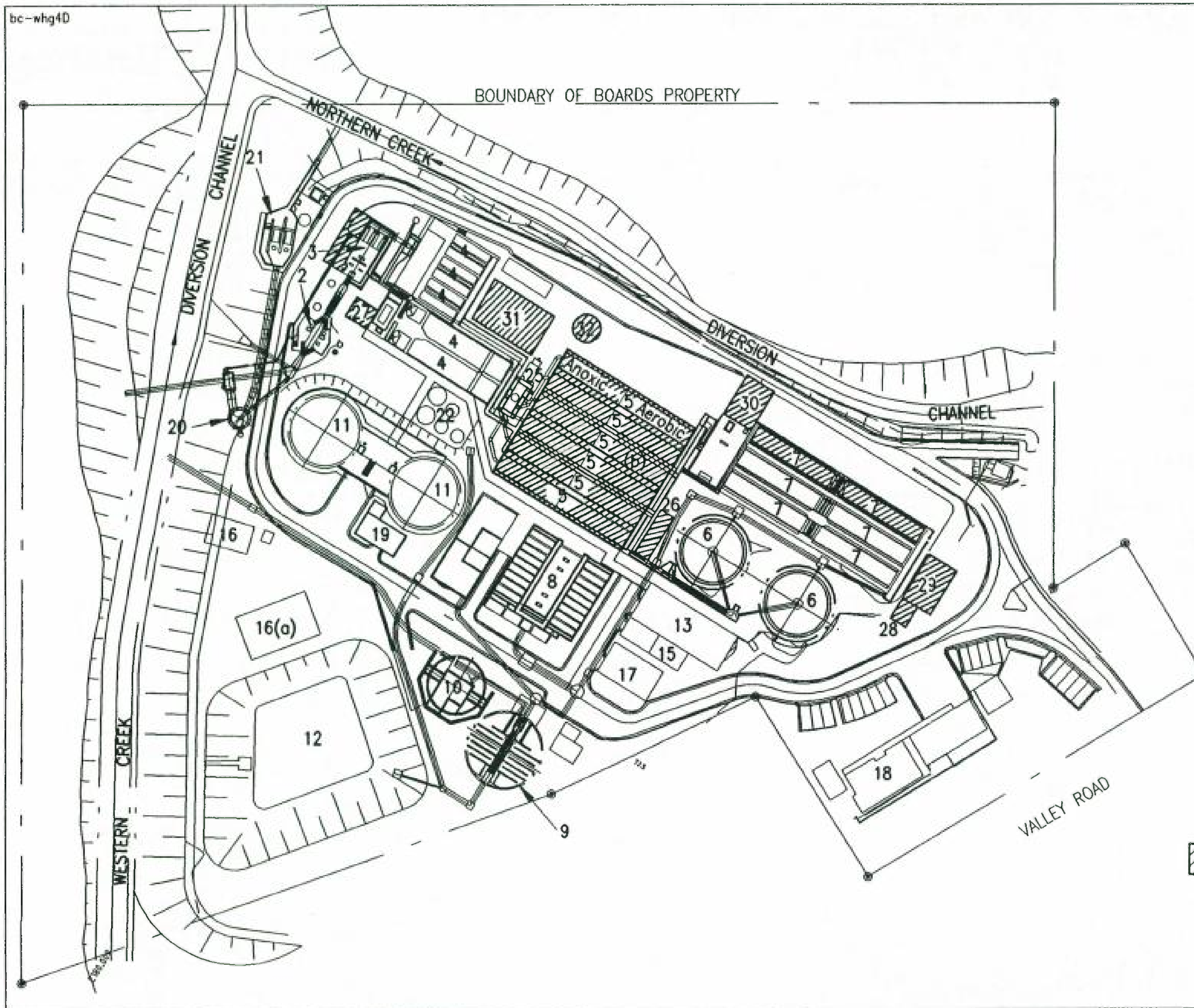
This part of the work comprises two separate SPSs and rising mains from West Hornsby and Hornsby Heights STPs merging into a common rising main which would run all the way to Berowra STP.

With a nominal size of 300 mm DICL for the combined rising main there would be sufficient capacity for the ultimate EP and flow, i.e. capable of delivering flows of up to DWWF of the ultimate diverted catchment size of 10,000 EP for Berowra STP.

BEROWRA STP

Introduction

Berowra STP would serve part of the combined sewage catchments areas of West Hornsby and Hornsby Heights STPs as described above in Section 4. Future development in these areas above the nominal capacities of the ultimate sizes of West Hornsby and Hornsby Heights STPs shall also be serviced by Berowra STP.



LEGEND

1 SPS 490
2 SCREEN
3 AERATED GRIT CHAMBER
4 PRIMARY SEDIMENTATION TANKS
5 ANOXIC / AERATION TANKS
6 CIRCULAR SECONDARY SEDIMENTATION TANKS
7 RECTANGULAR SEDONDARY SEDIMENTATION TANKS
8 DUAL MEDIA FILTERS
9 CHLORINE CONTACT TANK
10 EFFLEUNT PUMPING STATION
11 DIGESTERS
12 HOLDING BASIN
13 BLOWER HOUSE / RAS PUMPING STATION
14 RAS PUMPING STATION
15 11kV SUBSTATION
16 SLUDGE DEWATERING AREA
17 CHLORINATION BUILDING
18 ADMINSTRATION BUILDING
19 SLUDGE PUMPING STATION SPS 212
20 RAW SEWAGE FLOW SPLITTER
21 STORM FLOW FINE SCREENS
22 CHEMICAL DOSING FACILITIES (PHOSPHORUS REMOVAL) + ALKALINITY ADDITION
23 FILTERED WATER TANK
24 FOUL WATER TANK
25 FLOW SPLITTER
26 MIXED LIQUOR PUMPING STATION + MIXED LIQUOR RECYCLE
27 PREFERMENTATION
28 METHANOL DOSING FACILITY
29 POST DENITRIFICATION FACILITY
30 POST DENITRIFICATION PUMPING STATION
31 WET WEATHER HOLDING TANK
32 DIVERSION S.P.S.

(a) SLUDGE DEWATERING FACILITY CURRENTLY UNDER CONSTRUCTION (INCLUDES CENTRIFUGES).
(b) EXISTING AERATION TANKS MODIFIED TO ANOXIC / AEROBIC REACTOR (MLE).

▨ ADDITIONAL FACILITIES FOR 45,000EP

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SYDNEY-ILLAWARRA-BLUE MOUNTAINS
WASTEWATER AND REUSE PLANNING

WEST HORNSBY S.T.P.
OPTION 4
GENERAL ARRANGEMENT FOR 45,000EP MLE & DIVERSION S.P.S.

Figure
11-3

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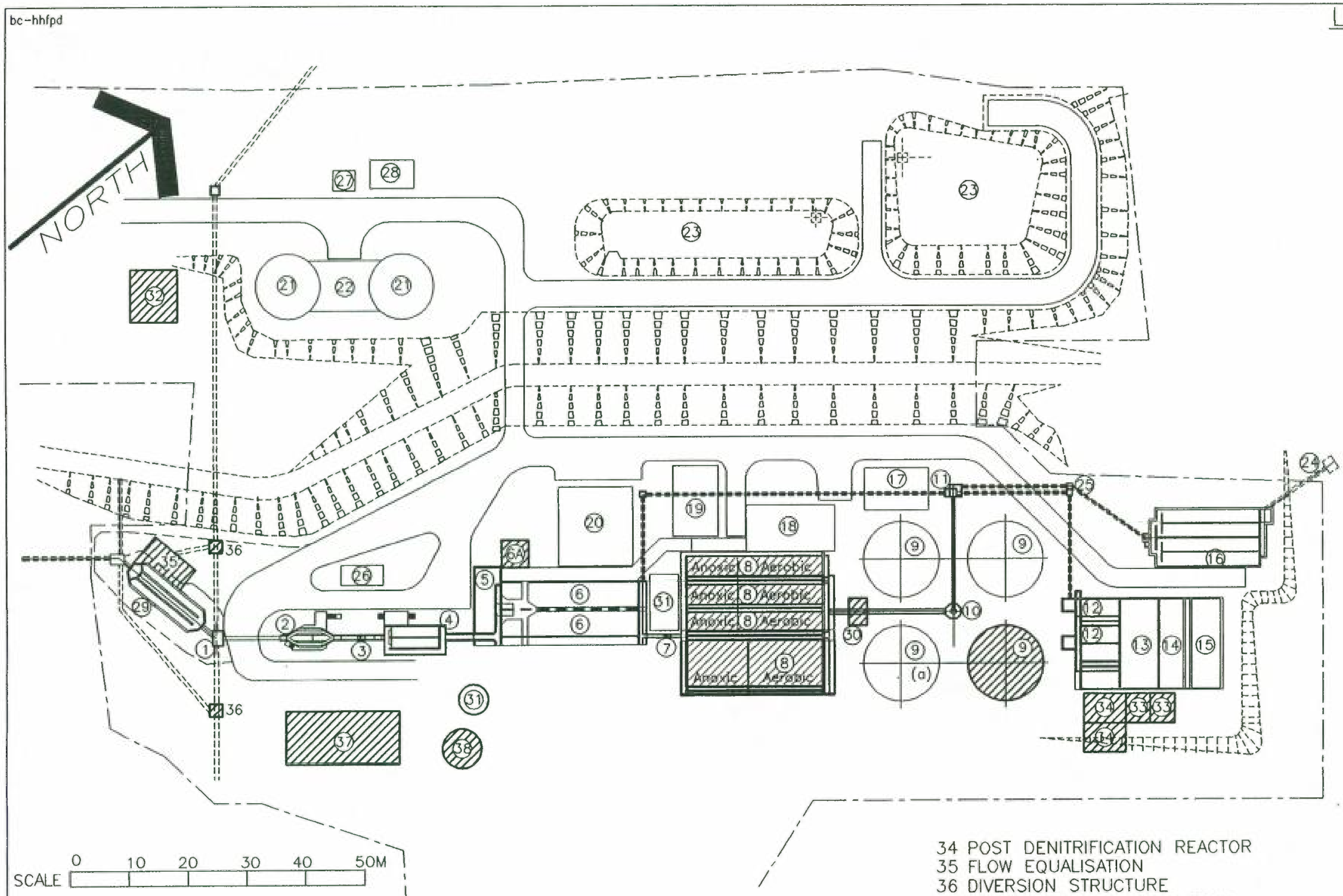


▨ STAGE 1 UPGRADE FOR 20,000EP

(a) AN ADDITIONAL THIRD SECONDARY CLARIFIER IS CURRENTLY UNDER CONSTRUCTION

LEGEND

1 COLLECTING MANHOLE
2 MECH. RAKED BAR SCREENS
3 CUT-THROAT FLUME (RAW SEWAGE)
4 AERATED GRIT CHAMBER
5 PRIMARY CONTROL BUILDING
6 PRIMARY SEDIMENTATION TANKS
6A PREFERMENTATION
7 CUT-THROAT FLUME (SETTLED SEWAGE)
8 ANOXIC/AEROBIC REACTOR
9 SECONDARY SEDIMENTATION TANKS
10 MIXED LIQUOR DISTRIBUTION & EFFLEUNT COLLECTION CHAMBER
11 SECONDARY EFFLUENT DIVERSION STRUCTURE
12 DUAL MEDIA FILTERS
13 FILTER CONTROL BUILDING
14 BACKWASH WATER HOLDING TANK
15 BACKWASH EFFLUENT HOLDING TANK
16 CHLORINATION TANKS
17 CHLORINATION BUILDING
18 BLOWER HOUSE INCLUDING RETURN & WASTE ACTIVATED SLUDGE PUMPS
19 ELECTRICITY SUB-STATION
20 ADMINISTRATION BUILDING
21 DIGESTION TANKS
22 DIGESTION CONTROL BUILDING
23 SLUDGE LAGOONS (DISUSED)
24 OUTFALL TO CREEK
25 SECONDARY EFFLUENT MANHOLE
26 INFLAMMABLE LIQUID STORE
27 WASTE GAS BURNER
28 SLUDGE DEWATERING BUILDING
29 SPS 542
30 FLOW DISTRIBUTION CHAMBER
31 CHEMICAL STORAGE (ALKALINITY ADDITION)
32 SLUDGE HANDLING BUILDING (INCLUDES SLUDGE THICKENING & DEWATERING)
33 METHANOL DOSING
34 POST DENITRIFICATION REACTOR
35 FLOW EQUALISATION
36 DIVERSION STRUCTURE
37 WET WEATHER HOLDING TANK
38 DIVERSION S.P.S.

WATER BOARD
SYDNEY-ILLAWARRA-BLUE MOUNTAINS
WASTEWATER AND REUSE PLANNING

HORNSBY HEIGHTS S.T.P.
OPTION 4
GENERAL ARRANGEMENT FOR 20,000EP MLE & DIVERSION S.P.S.

Figure
11-4

The ultimate development in this catchment area is estimated to be 10,000 EP (based on development of the "most-likely" physical catchment area capable of draining to the treatment plant). Berowra STP's likely ultimate catchment area is shown in figures 5-A, 5-B and 5-C.

Facilities to be provided at Berowra STP

The flow and load which would be required to be transferred initially would represent only a small proportion of the ultimate capacity of Berowra STP. However, the projected load will increase rapidly to greater than 60% of the ultimate capacity within 10 to 15 years, therefore, it is proposed to provide the ultimate capacity of the STP in the first and final stage.

Table 11-2 summarises the total EP projection for this Option:

TABLE 11-2. COMBINED EP PROJECTION FOR OPTION 4

	YEAR								
	1994	1996	1998	2000	2005	2010	2015	2019	Ultimate
West Hornsby	35,200	36,967	38,867	40,864	44,650	45,000	45,000	45,000	45,000
Hornsby Heights	18,880	20,048	20,000	20,000	20,000	20,000	20,000	20,000	20,000
Berowra	Nil	Nil	859	1,638	3,480	5,810	6,078	6,255	10,000
TOTAL	54,080	57,015	59,726	62,502	68,130	70,810	71,078	71,255	75,000

As the plant effluent would discharge into a tributary of Berowra Creek the effluent must meet the effluent quality targets as summarised in Table 7-1 above.

A new nutrient removal plant would be constructed on the Berowra site. To provide sufficient capacity for the initial transfer and subsequent increasing load the first and final stage of Berowra STP would be 10,000 EP capacity. The combined upgraded plants at West Hornsby and Hornsby Heights plus the Stage 1 10,000 EP Berowra STP will provide adequate capacity for the Berowra Creek Catchment to the ultimate load expected from the catchment. The following facilities would be provided for Level 1 Treatment:

Screening and grit removal facilities.
IDAL tank to achieve carbonaceous oxidation, nitrification and denitrification.
Flow Equalisation.
Multi-point chemical dosing systems.
Tertiary Dual Media Filtration.
WAS thickener.

Sludge dewatering facilities.
Disinfection facilities (Ultraviolet radiation).
Associated administration, control and maintenance facilities.

As in the previous options, Level 2 treatment would be achieved by the addition of methanol dosing facilities dosing external carbon source into the biological reactor, while Level 3 would require the addition of attached growth post denitrification facilities. As no distinct secondary clarifiers are provided (as is the case with the MLE process) the attached growth post denitrification option will need to be installed in lieu of the suspended growth system.

Figure 11-2 shows the Stage 1 IDAL process layout for the proposed Berowra Creek STP. Figure 10-6 shows the process flow train. Tables 11-3, 11-4 and 11-5 indicate the works needed for this option.

TABLE 11-3. SUMMARY OF OPTION 4 ACTIONS FOR WEST HORNSBY STP

Actions Proposed	**Treatment Level**		
	Level 1 (TN 15 mg/L)	**Level 2 (TN 10 mg/L)**	**Level 3 (TN 5 mg/L)**
Modify inlet structure and STP	Modify inlet structure, fine screens and provide WWHT	As for Level 1	As for Level 1
Upgrade STP	Provide upgraded treatment facilities to nominal capacity as described in Section 8 for Option 1	As for Level 1	As for Level 1
Pumping Station and Rising Main	Provide pumping station and rising main to Berowra STP	As for Level 1	As for Level 1

TABLE 11-4. SUMMARY OF OPTION 4 ACTIONS FOR HORNSBY HEIGHTS STP

Actions Proposed	**Treatment Level**		
	Level 1 (TN 15 mg/L)	**Level 2 (TN 10 mg/L)**	**Level 3 (TN 5 mg/L)**
Modify inlet structure and STP	Modify inlet structure and provide WWHT	As for Level 1	As for Level 1
Screening Plant	Provide fine screens and grit removal for WWHT overflow	As for Level 1	As for Level 1
Upgrade STP	Provide upgraded treatment facilities to nominal capacity as described in Section 8 for Option 1	As for Level 1	As for Level 1
Pumping Station and Rising Main	Provide pumping station and rising main to Berowra STP	As for Level 1	As for Level 1

TABLE 11-5. SUMMARY OF OPTION 4 ACTIONS FOR BEROWRA STP

Actions Proposed	**Treatment Level**		
	Level 1 (TN 15 mg/L)	**Level 2 (TN 10 mg/L)**	**Level 3 (TN 5 mg/L)**
New STP at Berowra	Provide facilities for 10,000 EP at Berowra with: ▪ Screening and grit removal facilities ▪ IDAL tank to achieve carbonaceous oxidation, nitrification and denitrification ▪ Multi-point chemical dosing systems ▪ WAS thickener ▪ Sludge dewatering facilities ▪ Disinfection facilities ▪ Associated administration, control and maintenance facilities	As for Level 1 with methanol dosing facilities to the IDAL	As for Level 1 with post-denitrification and associated methanol dosing facilities

OPTION OVERVIEW

To allow an adequate comparison to be made between the options investigated, Option 4, which involves the retention and upgrading of the existing Hornsby STPs at their current nominal capacities and the construction of a new biological nitrogen and chemical phosphorus removal plant at a greenfield site in Berowra, has the following characteristics. An additional overview is provided in the Section discussing "comparison of options".

Capital and Operating Costs

Based on the Board's costing system, the Order of Cost estimate for upgrading and amplifying Hornsby Heights STP and upgrading West Hornsby STP are summarised in Tables 11-6 and 11-7 below.

TABLE 11-6. OPTION 4 - CAPITAL COSTS

Effluent Total Nitrogen Target (90%ile Values)	Capital Cost $M				
	West Hornsby STP	Hornsby Heights STP	Transfer Pumping Station & Rising Main	Berowra STP	Total
15	3.6	3.9	8.5	11.0	27.0
10	6.1	6.2	8.5	11.1	31.9
5	7.0	7.0	8.5	12.8	35.3

TABLE 11-7. OPTION 4 - OPERATING COSTS

Effluent Total Nitrogen Target (90%ile Values)	Operating Cost $M[a]				
	West Hornsby STP	Hornsby Heights STP	Transfer Pumping Station & Rising Main	Berowra STP	Total
15	2.94	1.91	0.01	0.19	5.04
10	2.96	1.91	0.01	0.19	5.07
5	3.00	1.93	0.01	0.19	5.13

a Operating cost based at Year 2000 EP load.

Expected Implementation Time Frame

If the environmental assessment and all necessary approvals are obtained by end 1995, Option 4 may be completed by 1999. While the augmentations are being carried out, the existing Hornsby STPs will continue to discharge high total nitrogens. At present West Hornsby STP is discharging an average effluent total nitrogen concentration of 30 mg/L, while Hornsby Heights STP has an average effluent total nitrogen of around 50 mg/L in the discharge. Although the Board is endeavouring to reduce effluent total nitrogens to around 25 mg/L on average, major works will be necessary to achieve lower levels.

Nitrogen Loading to Berowra Creek

The adoption of Option 4 will significantly reduce the Board's contribution of total nitrogen loads to the river. Table 11-8 shows the reductions in average yearly nitrogen loads to Berowra Creek that could be expected around year 2000 for the various effluent quality targets being examined.

TABLE 11-8. YEARLY TOTAL NITROGEN LOADS FROM BEROWRA STPs TO BEROWRA CREEK (YEAR 2000)

Effluent Quality Target	Yr 2000 Flow	Average Effluent TN	Total Nitrogen kg/Yr
Baseline[a]	16.85	30	226,850
Level 1	16.85	10	61,503
Level 2	16.85	7	43,052
Level 3	16.85	3	18,451

a. Baseline condition refers to maintaining the Hornsby STPs as nitrification plants.

Land Requirements

No additional land will be required at the Hornsby STPs under Option 4 and all facilities proposed will be contained within the current plant boundaries. It must be stressed, however, that the standard 400 metre buffer zone generally applying to Board STPs does not exist at either West Hornsby and Hornsby Heights STPs. No further development should be allowed to encroach further on to the existing structures. The existing sites at West Hornsby and Hornsby Heights need to be retained for the upgraded STPs. Residential development exists within the 400 m buffer zone for the proposed new Berowra STP and, therefore, odour control measures would be required at the new site.

Operational Aspects

The addition of the proposed storm treatment facilities to the existing plants will affect the operation of the STPs to a limited extent as the plants will continue to operate as STPs at their current nominal capacities and excess flow will be diverted to the new plant. The existing plants will be upgraded to the MLE process as discussed in Section 8 - Option 1 and the operational aspects of that option apply to the existing plants in this option also. Full treatment will be provided for flows up to 3ADWF, primary treatment for all flows up to 6ADWF and preliminary treatment including fine screening for all flows.

The proposed new Berowra STP would utilise the IDAL process as currently used elsewhere in the Board and therefore is a process familiar to Waste Water Inland North operations personnel. Economic paybacks can be expected as reduction in oxygen and lime usage are inherent to biological nitrogen removal plants. As the IDAL process also does not represent complex technology, no additional skills or increased staff numbers are necessary above the current operating level. Also no major increases in odours, noise or energy consumption above the existing sewage treatment process is expected when implementing to the IDAL system.

As phosphorus removal shall continue to be removed by chemical means, a high degree of process reliability in achieving low effluent phosphorus levels is also expected.

Current sludge handling and dewatering is also expected not to be adversely affected and will not need major modifications to process treatment philosophy.

Environmental Impacts

If adopted, Option 4 will improve the quality of effluent currently being discharged from the Hornsby plants to Berowra Creek. Without the benefit of an intensive environmental investigation and continual water quality monitoring within Berowra Creek, the effluent quality target to be adopted to help endeavour to achieve the Berowra Creek goal of recreational and modified ecosystem water quality criteria is unknown. Other issues, including the control of diffuse source pollutant inputs from urban and bushland runoff and limiting development to the current Urban Development Programme, will also play an important role in returning the Creek to environmental health.

This option would produce three separate effluent disposal points to Berowra Creek. This has the potential to reduce the impact on the creek in the event of a major process malfunction at any of the STPs.

Additional impacts that may be expected in Option 4, include increased noise and truck movements during the construction phase of the scheme, but this is only for the short term. Minimum increases in truck movements can also be expected during the operational phase of the proposed MLE processes at both West Hornsby and Hornsby Heights STPs and will have no major impact in increasing noise and odour levels.

Beneficial Reuse

With the Board's policy of maximising the beneficial use of effluent and sludges, Option 4 has limited potential for effluent reuse and can be maximised within the STPs only. External markets are limited to golf courses, nurseries and council parks and require large outlays from the community before their inception. Even if this is achieved, no guarantee to continual reuse can be given as it is generally dependant on weather conditions and is generally limited in quantity.

At present, all digested and dewatered sludges from the Hornsby STPs are used for composting at the ANL site. This will continue to occur provided the sludge produced is of good and consistent quality.

Grit and screening products will also continue to be dewatered, bagged and disposed of in landfill sites.

SECTION 12

TRANSFER STRATEGY

The Board is currently carrying out strategic planning for wastewater for its area of operation and will include the Sydney, the Blue Mountains and the Illawarra Regions. Information is anticipated to be available in 1995 for community consultation.

A "Transfer Strategy" was requested to be investigated by the Berowra Creek Technical Working Party to achieve zero discharge of Total Nitrogen into Berowra Creek during dry and wet weather. The transfer routes adopted in this report may be modified in future wastewater plans as part of the "Choices for Clean Waterways" options. It is therefore possible that the "Transfer Strategy" considered here may not be the most cost-effective and/or environmentally effective, especially with regard to directing flows to North Head STP.

As a result, the outcome of this investigation will be specifically relevant to the Berowra catchments only, and include, for example, a "dedicated transfer system" for the "Transfer Strategy". Therefore benefits which may arise from a strategically planned transfer system can not be fully addressed here due to limited information on the options available for transfer to the ocean.

As discussed previously in the "Options for Investigation" (Section 7 of this report), one broad "Transfer Strategy" was considered for the options report. It is further divided into two main categories depending on the influent quantity. These include:

- Dry and wet weather transfer out of the inland catchment.
- Dry weather transfer out of the inland catchment.

The first category aims to relieve inland waterways of treatment plant effluent discharges during dry weather conditions and wet weather flows up to two year ARI (i.e. Average Recurrence Interval). For Hornsby Heights and West Hornsby STP, the two year ARI is equivalent to the Board's Design Wet Weather Flow (DWWF) or four times Peak Dry Weather Flows (PDWF). This is achieved by transporting all raw sewage or effluent to the ocean.

The second category aims to relieve inland waterways of sewage-origin pollutant loads during dry weather conditions by transporting dry weather flows, i.e. up to three times Average Dry Weather Flows (ADWF), to the ocean. When the flows to the STPs exceeded the "dry weather flow" regime (or up to 3 ADWF), however, the flows will be discharged into the local creek after primary treatment.

BEROWRA CREEK PROJECT

For the purposes of this investigation, the transfer strategy, will attempt to be compatible with the above-mentioned strategy and categories.

The following sub-sections will outline preliminary transfer routes to achieve flow transfers out of the Berowra catchment to the eastern seaboard. All specific transfer options will be elaborated in the following sections.

With reference to the above, the Board is investigating a number of strategies for the treatment and disposal of sewage within the Sydney Region. The strategies are scheduled to be released in 1995 for public comment as part of the government's Choices for Clean Waterways.

One of the strategies being investigated relates to the transfer of dry and wet weather sewage out of the inland catchments of Sydney to the coast. The Berowra Creek Technical Working Party has also specifically requested that the transfer of the Hornsby plant's sewage to the ocean be also investigated.

As detailed information on specific transfer routes is not yet available, this report's recommended transfer strategy may need to be reviewed following the "Choices for Clean Waterways" exhibition. The amount of work needed to determine firm details on specific pipelines, tunnel routes or upgrading the Northern Suburbs Ocean Outfall System (NSOOS) is extensive, so "dedicated tunnels" were considered applicable for this study for the transporting of sewage from Berowra Creek catchment to Warriewood and North Head STP's.

Warriewood Sewerage Catchment

As limited spare capacity is available in the existing Warriewood sewerage collection infrastructure, a "dedicated tunnel" was adopted as the most appropriate method for transporting flows from the Hornsby plants to Warriewood STP.

An above ground transfer system including rising mains and carriers was not considered feasible due to the high potential in disrupting the surrounding national parks and bushland. The impacts on the community would also be greater in terms of construction noise, traffic, acquisition of lands etc, if using an above ground transfer route.

North Head Sewerage Catchment

For the transfer of sewage flows to North Head STP, a number of transfer strategies may exist and include:

Dedicated Tunnel System to North Head STP. This transfer route is based on the premise that Berowra Creek catchment could be served by a dedicated tunnel independent of other sewage contributors along its length with the costs being totally attributable to the users.

As no up to date details are available on the proposed options to amplify the main Northern Suburbs Ocean Outfall Sewer (NSOOS), the "dedicated tunnel" transfer system was chosen for this study.

This "dedicated tunnel" route and costs may need to be reviewed in the light of work scheduled for exhibition in 1995.

Amplified and Upgraded Northern Suburbs Ocean Outfall Sewer (NSOOS). As previously indicated, a considerable amount of investigation is yet required, on the options to amplify and upgrade the NSOOS system. The Board is investigating a number of options to augment the capacity of the existing NSOOS, and to adequately serve current and future development for this catchment. This work is expected to be completed in 1995.

This transfer strategy therefore has not been considered further in this report. If the community, however, chooses the option of transfer of sewage to the ocean for further consideration, it is considered prudent that a decision be deferred until after the NSOOS options plan has been complete.

GENERAL TRANSFER ROUTE ALTERNATIVES

To help achieve the zero discharge of Total Nitrogen to Berowra Creek, one strategy is to transfer the flow (sewage or effluent) towards the nearest eastern seaboard STPs and then discharge to the ocean. Hence, the transfer route from the Berowra catchments are towards either Warriewood STP or North Head STPs. These two routes will be discussed further in following sub-sections.

Another possible route is to transfer to, and discharge into, the estuarine region of Hawkesbury River. In the case of raw sewage transfer, the existing West Hornsby and Hornsby Heights STPs will be decommissioned and a new "Brooklyn STP" will be required. In the case of plant effluent transfer, a pumping station may be required to receive the effluent (via a tunnel) and pump the effluent into the estuarine region of the river. In either case, a site is required in the Brooklyn area for the transfer scheme to work. Other considerations include the high effluent quality required for discharge and the proximity of oyster farming in the area. Hence, this transfer scheme will not be considered further.

Although timing for this investigation is limited, a range of transfer routes to the ocean were developed. These routes are preliminary only and would be subject to further review and change if one specific strategy/option is adopted for further consideration during the environmental assessment phase.

Two transfer routes were considered depending upon the destinations, viz transfer to Warriewood STP site or to North Head STP and deepwater ocean outfall.

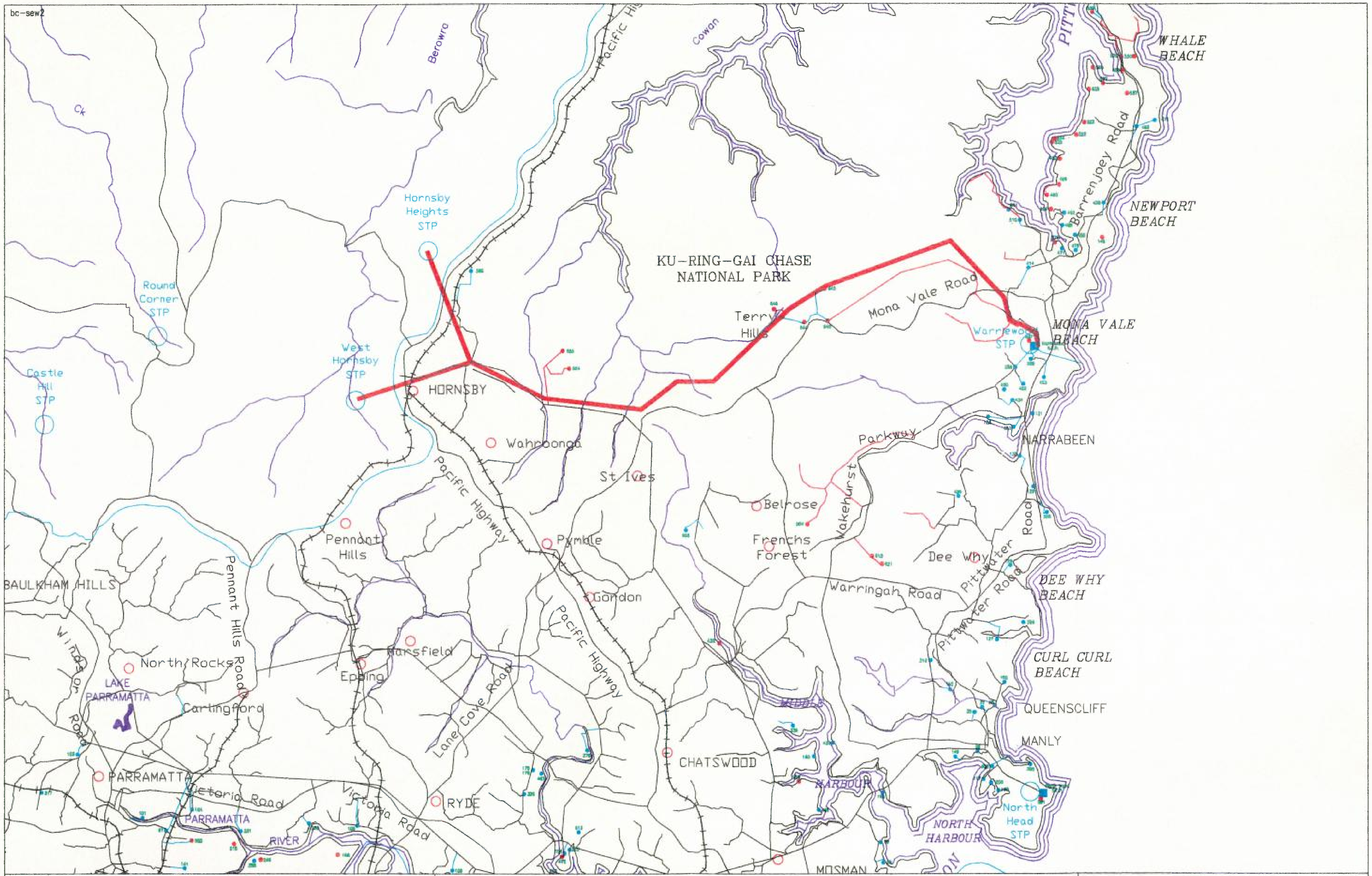
Transfer Route to Warriewood STP site - ROUTE A

A possible transfer route from the Hornsby Heights and West Hornsby STP catchments to Warriewood STP site is shown in Figure 12-1.

The existing sewer reticulation system to each STP will be retained. This will enable the use of existing infrastructure and have a single starting point for the tunnel. The existing inlet structure of the STP will be modified to satisfy the operation of the tunnel system.

As West Hornsby STP is at a lower elevation than Hornsby Heights STP, the elevation (or RL) of the tunnel's starting point from West Hornsby STP is a major design factor. After some consideration, the transfer strategy for Route A will consist of two equal length tunnels, which would collect flow from Hornsby Heights and West Hornsby STPs, and will meet at a common tunnel to transfer sewage towards the ocean. It is proposed that the two tunnels will meet in the vicinity of Curtin Avenue, Wahroonga, which is also in the vicinity of end of the existing West Middle Harbour Sub-main (WMHS). Due to the different depths of the tunnels, a vertical drop of about 6 m is required to merge the two tunnels into a common tunnel.

Based on the requirements of the National Parks and Wildlife Act, it will be quite likely that no major construction activity will be allowed in the National Park. In view of this, the common tunnel will not traverse the Ku-ring-gai Chase National Park as the possibility exists of having aqueducts (some quite long) and having a number of access shafts (for tunnel inspection and maintenance) located in inaccessible parts of the National Park. The proposed route, which follows the upper section of the West Middle Harbour Submain route, will circumvent the perimeter of the National Park as much as possible without causing undue inconvenience to the residents along the route. It will go through part of the undeveloped area of Duffys



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ROUTE A - TUNNEL SCHEME FROM
BEROWRA CATCHMENTS TO WARRIEWOOD S.T.P.

Figure
12-1

Forrest and Terry Hills on route to the Ingleside-Warriewood Valley area. The tunnel will terminate near the existing Warriewood Carrier, which is about 3 km from Warriewood STP. Due to the water charged soil conditions, in-trench gravity main will be required to convey the flow for the last stretch to Warriewood STP destination.

Although part of the route will be under National Park area, there will be no or minimal visible interruption on the land surface. Major access shafts to service and maintain the tunnel will be required along the route. The locations will be selected in order to have minimal environmental impact on both the local community and the natural environment.

For any tunnelling activity and construction, it would be ideal to utilise a tunnel-boring machine. The size of the cutting head of the tunnel-boring machine will determine the size of the tunnel and hence, the capacity of the tunnel. The size of the tunnel constructed for this route will be approximately 2.5 m x 1.5 m . It will have more than sufficient capacity for both the dry and wet weather flows for the Berowra catchments. As such, the route and costs associated with this tunnel will apply to both categories of the transfer strategy.

The total length of the tunnel section is about 25 km, whilst the gravity main for the last stretch to Warriewood STP site is about 3 km. A total of 12 major access shafts will be required along the transfer route for inspection and maintenance.

Construction cost estimates for this transfer route, including a total contingency of 30 percent is shown in Table 12-1:

TABLE 12-1. CAPITAL COST FOR TRANSFER ROUTE A

Item	Cost $M
Tunnel section (25 km)	62.0
Gravity mains (3 km)	4.9
12 Major Access Shafts	12.0
Removal/disposal of Spoil	5.5
Sub-total	84.4
Contingencies (30 %)	25.3
TOTAL Capital Cost is $ 109.7 m, say	$ 110 million

The operating and maintenance (O & M) costs for this transfer scheme are approximately $ 16,000 per annum. Adding an allowance for the scope contingency and head office management charge of 30 percent (which excludes environmental operating licence fee), the O & M cost will be approximately $ 21,000 per annum, say $ 25,000 per annum.

These costs will be used to provide the overall specific option's capital and operating costs and will be described in the following sections.

Transfer Route to North Head STP - ROUTE B

The route for the transfer of flows from Hornsby Heights and West Hornsby STPs to North Head STP is more complicated as it covers a range of terrain and soil conditions. At this stage and for the present scope of investigation, a dedicated carrier/tunnel will be assumed to be provided for the transfer.

A possible route to North Head STP is shown in Figure 12-2.

The first part of the transfer, i.e. individual tunnels from Hornsby Heights and West Hornsby STPs respectively, will emerge in a common tunnel in the vicinity of Curtin Avenue, Wahroonga. This will be similar to that described in Route A.

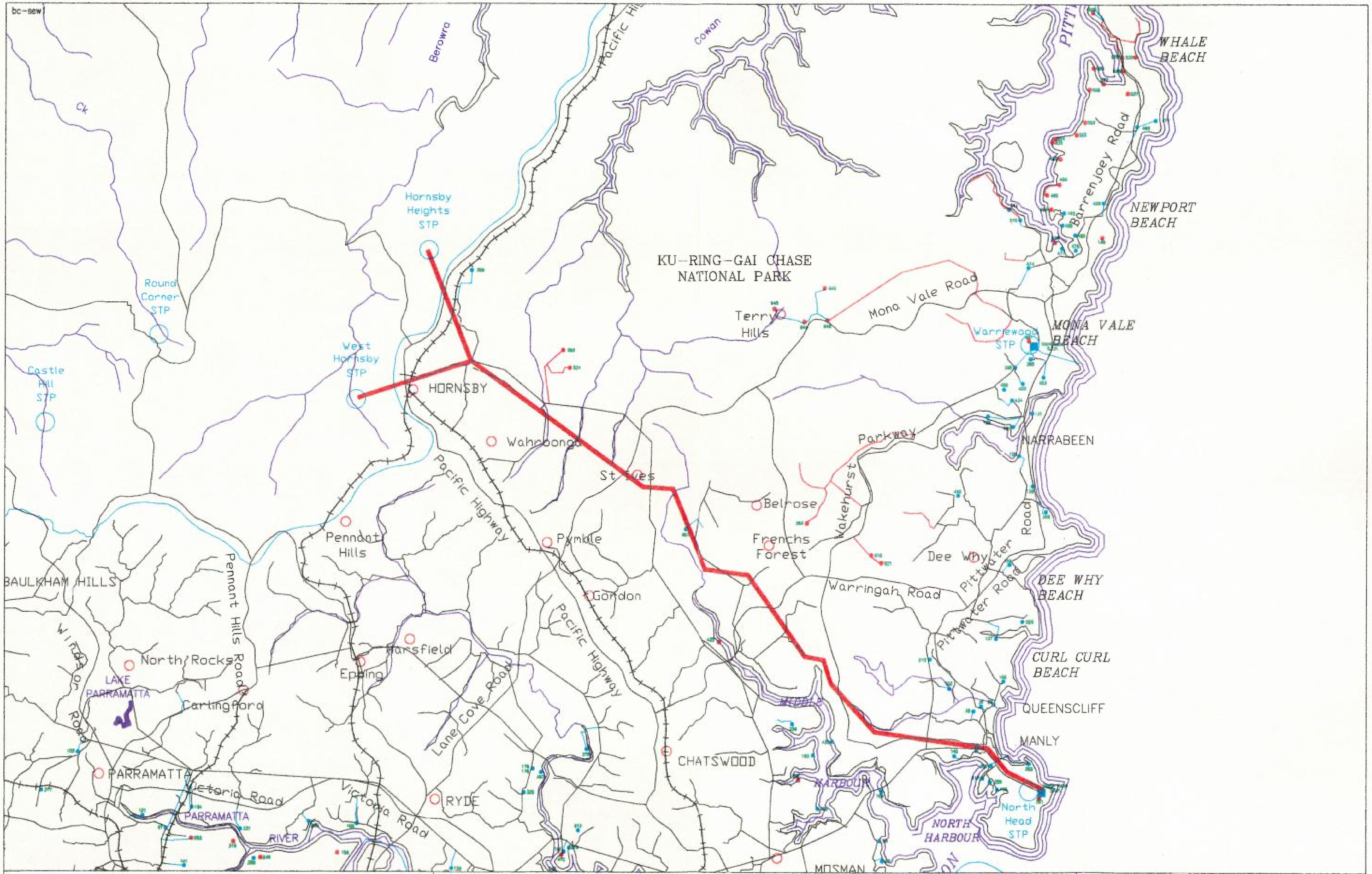
The common tunnel will be in the general direction towards North Head STP, i.e. Manly. It will be a straight tunnel until the crossing of the Middle Harbour Creek. The tunnel will go through the suburbs of Davidson, Forestville, North Seaforth, North Balgowlah and Balgowlah before reaching Manly. Due to the soil conditions in Manly, a conventional tunnel boring technique will not be feasible. A pipe-jacking and concrete tunnel forming (i.e. a small section at a time) method will need to be employed to complete the last stretch of the tunnel to North Head STP inlet.

Although part of the route will be under a number of National Park areas (i.e. Ku-ring-gai Chase National Park and Davidson State Recreation Area), there will be no or minimal visible interruption on the land surface. Major access shafts to service and maintain the tunnel will be required along the route and their locations will be selected to have minimal environmental impact to both the local community and to the natural environment.

As with Route A, a tunnel-boring machine will be employed and the size of the tunnel will be approximately 2.5 m x 1.5 m. It will have more than sufficient capacity for both the dry and wet weather flow for the Berowra catchments. As such, the route and costs associated with this tunnel will apply to all transfer options.

The total length of the transfer scheme is approximately 29 km. A total of 14 major access shafts will be required along the transfer route for inspection and maintenance.

Construction cost estimates for transfer Route B, including a total contingency of 30 percent is shown in Table 12-2.



WATER BOARD

SYDNEY-ILLAWARRA-BLUE MOUNTAINS

WASTEWATER AND REUSE PLANNING

ROUTE B – TUNNEL SCHEME FROM
BEROWRA CATCHMENTS TO NORTH HEAD S.T.P.

Figure
12-2

TABLE 12-2. CAPITAL COST FOR TRANSFER ROUTE B

Item	Cost $M
Tunnel section (28 km)	70.0
Pipe-jacking through Manly (1 km)	6.0
14 Major Access Shafts	9.8
Water cushioning Device	1.0
Removal/disposal of Spoil	5.8
Sub-total	92.6
Contingencies (30 %)	27.8
TOTAL Capital Cost is $ 120.4 m, say	$ 120 million

The operating and maintenance (O & M) costs for this transfer scheme are approximately $ 18,500 per annum. Adding an allowance for the scope contingency and head office management charge of 30 percent (which excludes environmental operating licence fee), the O & M cost will be approximately $ 24,000 per annum, say $ 30,000 per annum.

These costs will be used to provide the overall specific option's capital and operating costs and will be described in the following sections.

Amplified and Upgraded NSOOS

The Board is currently investigating the potential for augmenting the existing NSOOS system including West Middle Harbour Submain, to adequately transport current and future flows to North Head STP.

At present, certain sections of the NSOOS (i.e. West Middle Harbour Submain, the Spit and Lane Cove) are lacking in wet weather capacity for the existing catchment. The future options for augmenting the NSOOS, although not defined in detail at present, may be sized to handle future flows from the Hornsby STPs catchment.

As firm proposals for an amplified NSOOS are not yet available, the cost of using the NSOOS as an option has not been included in this report. However, the costs associated with this option are likely to be considerable.

Capital cost estimates, however, are provided to give the community some indication of the costs involved in connecting to a proposed amplified NSOOS and West Middle Harbour Submain. These costs are indicative only as details of the location and size of the proposed upsized NSOOS not yet available.

Table 12-3 details the indicative capital costs in connecting the Berowra Creek catchment to the NSOOS system, and includes:

- Provision of two distinct transfer tunnels from the Hornsby plants to a common connection point at the Upper Section of an amplified West Middle Harbour Submain.
- Lift Station to transfer flows from the common Hornsby STPs tunnel to the proposed amplified WMHS.
- Three access shafts.

Additional costs which include converting the Hornsby STPs to either storm or primary treatment plants, amplification of North Head STP and incremental charges for using an augmented NSOOS system will also need to be included for this transfer strategy.

TABLE 12-3. INDICATIVE COSTS FOR CONNECTING TO PROPOSED AUGMENTED NSOOS

Item	Capital Cost $M
Tunnel Section (8.5 km) Lift SPS 3 Access Shafts Removal/Disposal of Spoil	21.3 2.1 2.0 1.8
Sub Total	**27.2**
Contingencies (30%)	8.2
Total	**35.4**

1. Costs are rough costs only as location of proposed amplified NSOOS unknown.
2. Costs do not include incremental costs that can be attributed to Berowra Creek Catchment if using an augmenting NSOOS system.
3. Additional costs relating to amplifying North Head STP, and modifications to the Hornsby plants are not included.

As details of this potential alternate transfer route(s) are not available at this stage, it has not been investigated further in this report. If, however, the community requests that the transfer of sewage to North Head STP be considered, details of these transfer route(s) are scheduled to be exhibited in 1995.

TRANSFER ROUTE OVERVIEW

Capital and Operating costs

The capital costs for Route A and Route B are $ 110 m and $ 120 m respectively and the operating costs are $ 25,000 per year and $ 30,000 per year respectively.

As the estimates for the routes are on an Order-of-Cost basis and have an accuracy of approximately 20-25 percent, it can be assumed that the costs for the two routes are similar.

Land Requirements

The overall length of Route B is about 1 km longer than Route A. As tunnels are proposed, however, no additional land is required, outside that required for the access shafts along the route. The land requirement for the two routes will be minimal.

Operational aspects

The major operational difficulties will be associated with the actual construction phase of the tunnel and the removal and disposal of spoil.

At present, the Board has no formal guidelines for the managing for the removal and disposal of tunnelling spoil. Any activity, however, will need to take into account all relevant legislation, such as Environmental Planning and Assessment Act (regarding assessment of environmental impacts), Environmental Offences and Penalties Act, Clean Waters Act, Clean Air Act (regarding dust etc), Noise Control Act etc. In addition, recent amendments to Schedule 3, Part 4 of the Environmental Planning and Assessment Act have modified the list of activities classified as "Designated Development" which require an Environmental Impact Statement (EIS) and Development Application (DA) to a consent authority (e.g. local council). Relevant activities relating to tunnelling include crushing, removal of sand, gravel, rock and minerals, stockpiling, recycling and reuse of the above-mentioned material. The Board's Legal Services is presently considering the applicability of these new amendments for the Board.

For Route A, the last part of the transfer, i.e. at Warriewood, will pose some disruption to the local community because it is a pipe in trench system.

For Route B, the last stretch of tunnel in Manly will be the most difficult. A means of pipe-jacking and concrete tunnel forming (i.e. a small section at a time) will need to be employed. As the tunnel invert will be below the North Head STP inlet works, pumping will be required to transfer flow up for treatment. This will be confirmed during detailed design stage.

Environmental Impacts/Benefit

These routes are only two of a multitude of possible alternatives. They have been selected based upon the best information available to-date and on the limited time available for the investigation. Nevertheless, the broad strategy and direction of the routes are compatible with the strategic planning process.

The selection of the final route will be determined during the detailed design stage, after the final transfer scheme is adopted by the Board.

In the process of the determining the actual route of the tunnel, careful consideration will be given to minimise the impact on the local community and the natural environment.

In the case of local community, the actual location of the access shafts will be selected to be in undeveloped or less sensitive parts of the suburb. Landscaping and camouflage activities will be conducted to minimise the visual impact of the access shafts.

In the case of the natural environment, where the tunnel route involves location in any national park area, no construction activities will occur within the surface of the national park. Any interruption on the surface will be kept to a minimum. No aqueduct, pumping station or access portals will be constructed within the natural park area. Where ventilation of the tunnel system can occur, odour control equipment and mitigation measures will be employed.

The final route will only be selected after a period of public participation.

Potential for Future Connections

As discussed earlier, a dedicated tunnel was assumed within the scope of this investigation. This will, inevitably, limit the benefit of this scheme only to the Berowra catchment and not to the Northern Sydney catchment.

As the proposed tunnel cross a number of suburbs, there are some strategic benefits attached to their incorporation.

Some of the benefits include:

- Provide sewerage services to future release area.
- Provide sewerage services to backlog area.
- Relieve the hydraulic load on the WMHS and NSOOS.

- Reduce overflow incidences in the old WMHS and NSOOS.

All these benefits will become more apparent and will gain importance when assessing the findings of the strategic planning process. Nevertheless, it is important to point out the benefits for future consideration.

In the case of Route A, the following are identified:

- The tunnel can intercept the WMHS at Ku-ring-gai Creek. This will remove the flow upstream of the interception and relieve the hydraulic load on the lower part of WMHS and subsequently the Northern Suburbs Ocean Outfall Sewer (NSOOS). The area served by this transfer will be part of the suburbs of Hornsby, East Wahroonga, Wahroonga, West Wahroonga, Warrawee, Turramurra, North Turramurra, St. Ives Chase and North St. Ives.
- The proposed tunnel can provide sewerage connections from the future release and backlog areas of Duffys Forest and Terry Hills. These areas were planned to be connected to the Deep Creek Submain in around 2010.
- The tunnel can serve the future release areas in the Ingleside-Warriewood Valley Area.

In the case of Route B, the following are identified:

- The tunnel can intercept the WMHS in the vicinity of Killeaton Street, St. Ives. This may remove the flow upstream of the interception and relieve the hydraulic load on the lower part of WMHS and subsequently the Northern Suburbs Ocean Outfall Sewer (NSOOS). The area served by this transfer will be part of Hornsby, East Wahroonga, Wahroonga, West Wahroonga, Warrawee, Turramurra, North Turramurra, St. Ives Chase, North St. Ives and St. Ives.
- The tunnel will cross the Middle Harbour Creek and intercept the Davidson Park Carrier (DPC) at its junction with the Carol Creek Carrier in Forestville. This may remove the flow upstream of the interception and relieve the hydraulic load on the lower part of DPC and subsequently the lower part of WMHS and NSOOS. The area served by this transfer will be part of the suburbs of Davidson, Belrose, Frenchs Forest, Killarney Heights and Forestville.

- The tunnel may intercept the Narrabeen Submain in Balgowlah. This will remove the flow upstream of the interception point and relieve the hydraulic load on the lower part of NSOOS, especially the problems associated with this carrier when, during wet weather conditions, the NSOOS is placed under stress by additional flows for which it was not designed (i.e. as a result of I/Is). The area served by this transfer will be part of the suburbs of Narrabeen, Collaroy Plateau, Collaroy, Wheeler Heights, Cromer, Cromer Heights, Narraweena, Dee Why, Allambie Heights, Brookvale, Wingala, North Curl Curl, Curl Curl, Allambie, North Manly, Manly Vale, North Balgowlah and Balgowlah.

- The tunnel may relieve the stress on the NSOOS to avoid a majority of the overflows experienced in its upper reaches.

Other Assessments/Impacts

One important consideration is the duration in implementing the scheme. The initial phase will involve gaining the approvals for and location of the proposed tunnels, via the normal political and community assessment processes. It is anticipated that a decision will be made within two years. After the approval of the option, the duration for the implementation of the scheme, which includes surveying and detailed design, and finally construction and commissioning, is estimated at approximately five years. Hence, the overall time frame for commissioning may be about seven years, a situation which not considered favourable for Berowra Creek and the potential overloading of Hornsby Heights STP.

Another important factor will be the community acceptance of the scheme. The communities most affected by the transfer scheme will be those at the end of the tunnel, i.e. Warriewood and Manly. They will, inevitably, argue that they do not wish to get the sewage from other parts of Sydney and that the ocean is not a limitless "hole" for assimilation. Hence, a lengthy period of public discussion will be necessary for this strategy to be accepted by the overall community, which may delay the project even further.

SECTION 13

OPTION 5 - DRY AND WET WEATHER RAW SEWAGE TRANSFER TO WARRIEWOOD STP

This option aims to relieve the Berowra Creek waterways of all treatment plant effluent discharges during dry weather conditions and wet weather flows up to two year ARI (i.e. Average Recurrence Interval). For the purposes of this investigation, the two year ARI is assumed to be equivalent to the Board's Design Wet Weather Flow (DWWF) or 4 times Peak Dry Weather Flow (PDWF).

For this option, the following will be provided:

- West Hornsby (WH) and Hornsby Heights (HH) and STPs will be decommissioned.
- Inlet structure modification to existing WH and HH STPs.
- A transfer tunnel will be constructed (as per Route A described in Section 12) from the Hornsby STPs to Warriewood STP.
- Overflows from the inlet structure will be retained in a wet weather holding tank (WWHT) and pumping facilities to transfer WWHT's content back to tunnel when capacity is available.
- Any overflows from the WWHT will undergo fine screening and grit removal before being discharged to the local creek.
- Upgrading and amplification of Warriewood STP to treat all the transferred flows before discharge to the ocean via Warriewood ocean outfall.

The following assumptions apply to this option:

- Raw sewage flows of up to DWWF (i.e. 4 PDWF) will be transferred to Warriewood STP for treatment and disposal.
- Flows greater than DWWF will be stored in WWHT at the Hornsby STP sites. The WWHT will attenuate excessive storm flows and will be returned to the transfer system when able. If storm flows are to be discharged to the creek, they will receive fine screening and grit removal treatment.

DESCRIPTION OF OPTION 5

The existing inlet structures at West Hornsby (WH) and Hornsby Heights (HH) STPs will be modified to enable flows of up to DWWF to flow into the tunnel. As no pumping is proposed, raw sewage will gravitate to Warriewood STP for treatment and disposal.

The modified inlet structure will have a bypass facility to divert storm flows, greater than DWWF, to a Wet Weather Holding Tank (WWHT). Pumping facilities will be provided to pump the content of the WWHT back into the transfer tunnel whenever there is capacity in the tunnel or at the Warriewood STP. Overflows from the WWHT will receive fine screening and grit removal before discharge to the local creek.

As discussed in Section 12, Route A is proposed for the transfer of raw sewage from the Berowra catchment to Warriewood STP.

As the transferring of flow in this option is additional to the local Warriewood catchment, Warriewood STP will need to be amplified to cope with the additional hydraulic and pollutant load. Upgrading will also be required to produce a nitrified effluent.

A schematic diagram of this option is shown in figure 13-1. A process flow diagram of the proposed Screening and Grit Removal Plant (SP), which includes the proposed WWHT, is shown in figure 13-2.

FACILITIES REQUIRED

The following sections provide an overview of the facilities proposed for Option 5.

Flows and population projections

As discussed in previous sections of this report, the current and future design flows for the West Hornsby and Hornsby Heights STPs are summarised in Table 13-1. The maximum flow (ie. DWWF) for the transfer will be approximately 123 ML/d in the year 2019.

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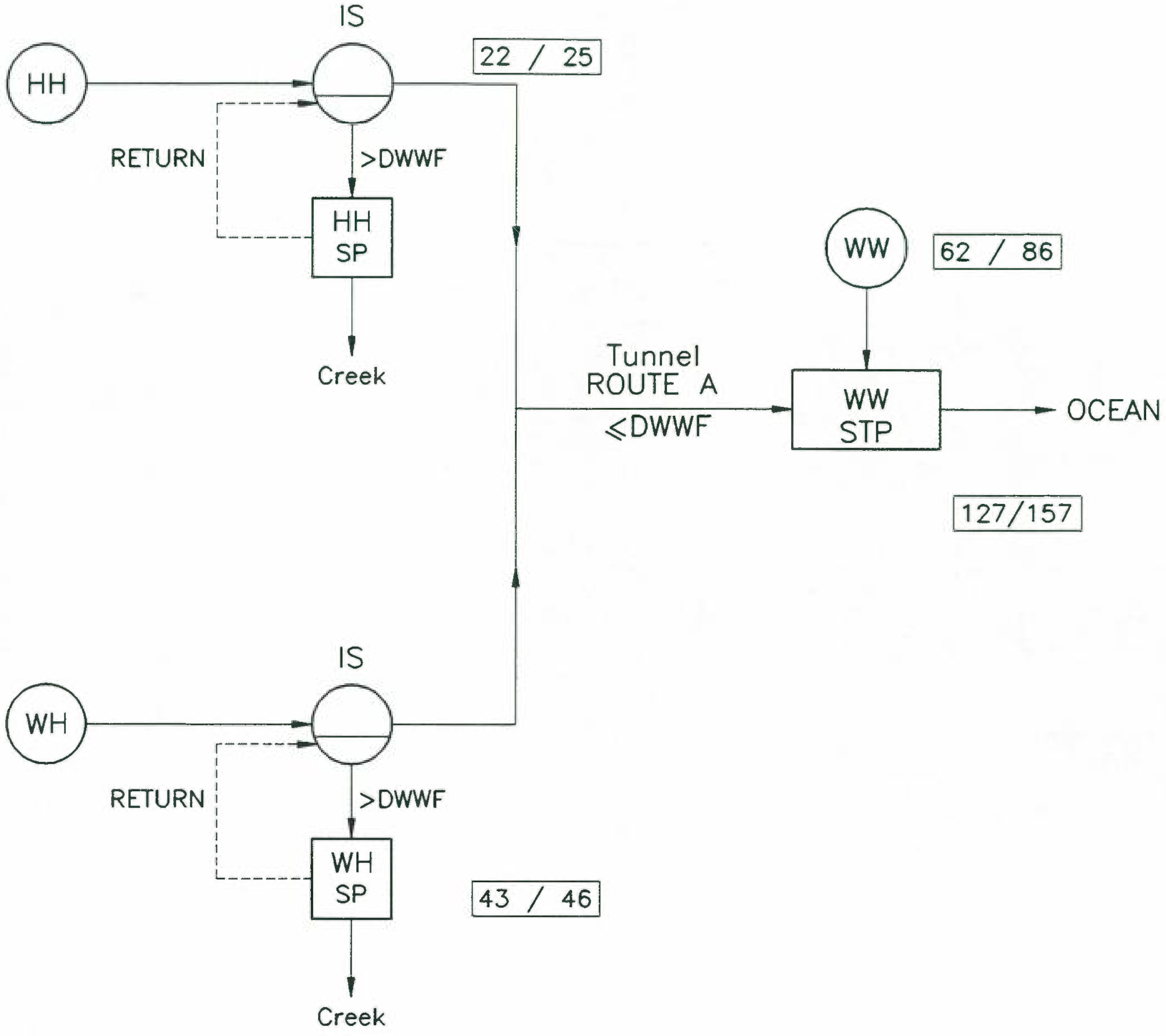


2002 / 2019 = Flows in thousand EP

☐ = Treatment Facility

○ = Catchment

SP = Screening Plant
STP = Sewage Treatment Plant

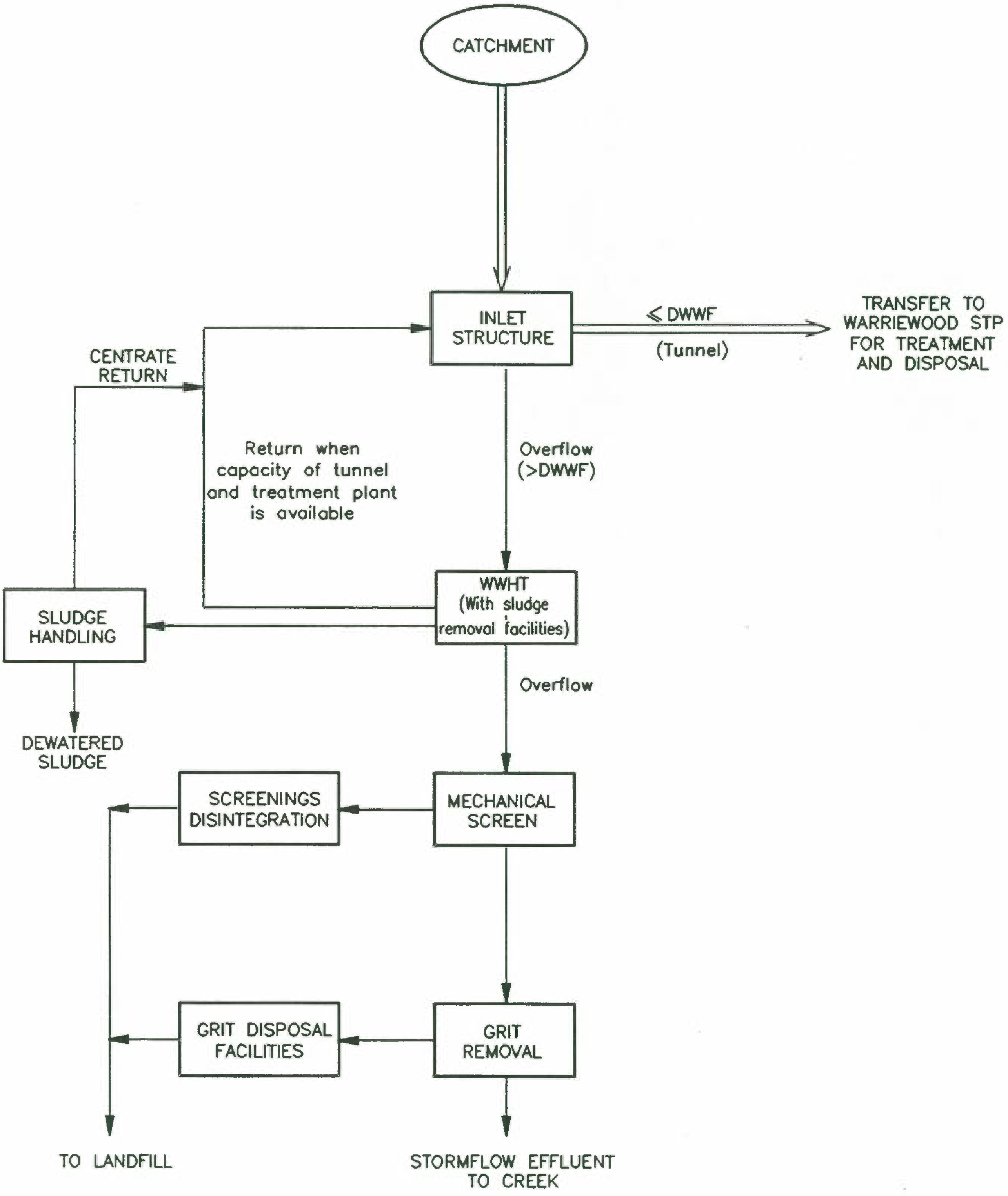
IS = Inlet Structure
HH = Hornsby Heights
WH = West Hornsby
WW = Warriewood
DWWF = Design Wet Weather Flow

WATER BOARD
SYDNEY–ILLAWARRA–BLUE MOUNTAINS
WASTEWATER AND REUSE PLANNING

OPTION 5
RAW SEWAGE TRANSFER SCHEME
FOR DRY & WET WEATHER

Figure
13–1

bc-scpl4



LEGEND

═══ NORMAL SEWAGE FLOW

WWHT = Wet Weather Holding Tank

WATER BOARD
SYDNEY-ILLAWARRA-BLUE MOUNTAINS
WASTEWATER AND REUSE PLANNING

OPTION 5
SCREENING PLANT
PROCESS FLOW DIAGRAM

Figure
13–2

TABLE 13-1. CURRENT AND PROJECTED ULTIMATE EP AND FLOWS FOR HORNSBY STPs

STP	EP ('000)/ ADWF-DWWF Flows (ML/d)			
	1994	2000	2005	2019
West Hornsby	35/9.5-62	41/11-71	45/12-77	46/12.5-80
Hornsby Hts	18.8/5.1-35	21.6/5.8-40	23.5/6.4-42	25/6.7-43

Modifications to Existing Hornsby STPs

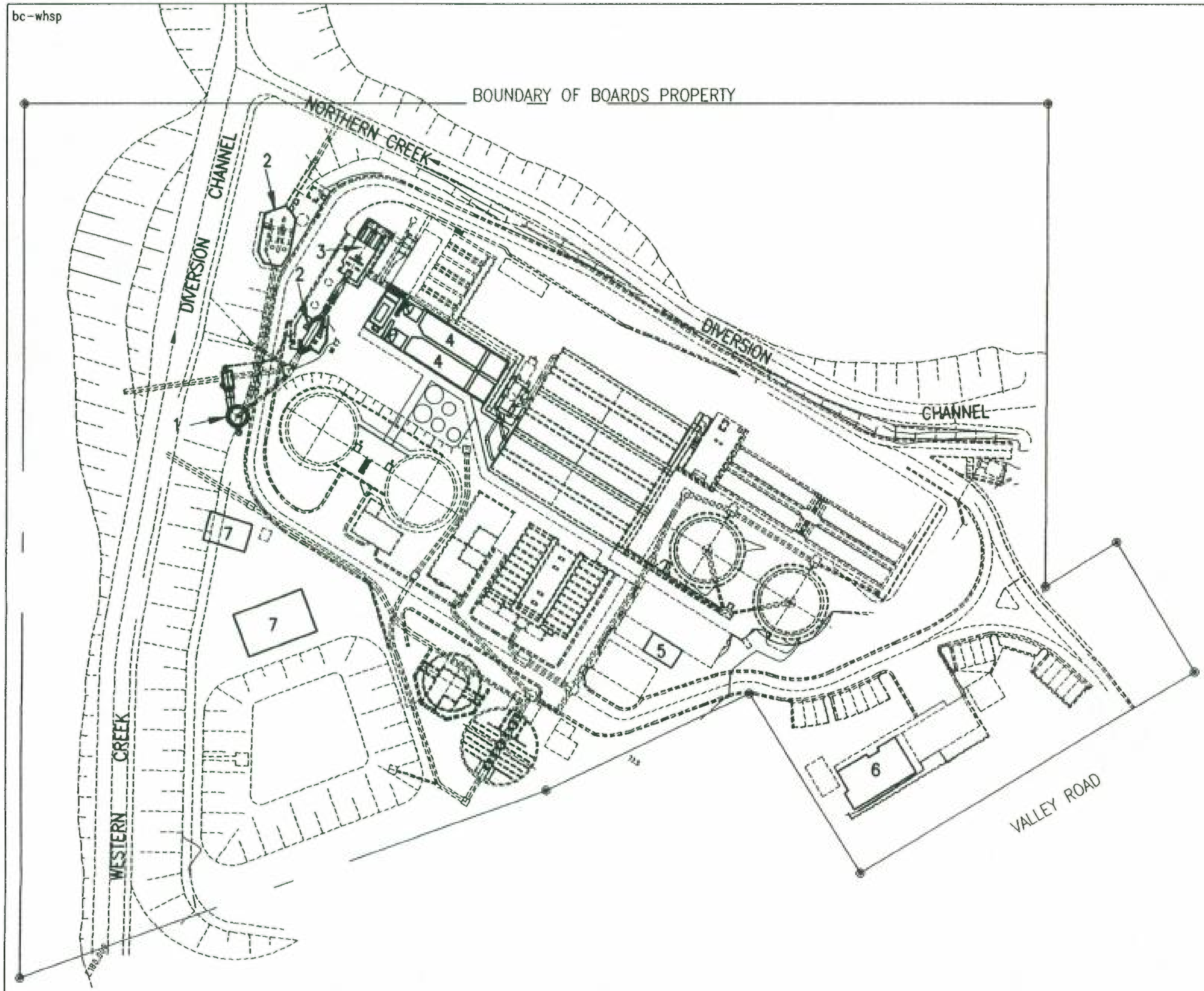
Modifications to existing facilities at the Hornsby STPs will be required to convert them to a flow transfer and screening plant.

West Hornsby and Hornsby Heights STPs will be decommissioned and modified to provide the following facilities:

- A new modified inlet structure, with bypass facility, to convey all flows to the transfer tunnel system.
- Wet Weather Holding Tank (WWHT) to attenuate excessive storm flows and capable of having the volume to be pumped into the transfer system after wet event.
- A Screening Plant (with fine screening and grit removal facilities) will be used to treat any overflow from the WWHT before discharged to the local creek.

Figures 13-3 and 13-4 show the modified layout of the facilities at West Hornsby and Hornsby Heights STPs respectively.

With the new inlet structure, the flow will drop into the proposed transfer tunnel, which will convey the flow to Warriewood STP. According to the proposed tunnel system, as described as Route A in Section 12, there will be sufficient capacity to take all flows from the two catchments. As a safety measure, however, a WWHT and a screening facility will be provided. This may only be required when major repair or major maintenance is conducted within the tunnel system or at Warriewood STP, or excessive storm flows are experienced in the Berowra catchment.



LEGEND

1 NEW INLET STRUCTURE (MODIFIED FROM RAW SEWAGE FLOW SPLITTER)
2 SCREEN
3 GRIT REMOVAL
4 WET WEATHER HOLDING TANK (WWHT = MODIFIED PRIMARY SEDIMENTATION TANKS)
5 11kV SUBSTATION
6 ADMINISTRATION BUILDING
7 SLUDGE HANDLING BUILDING

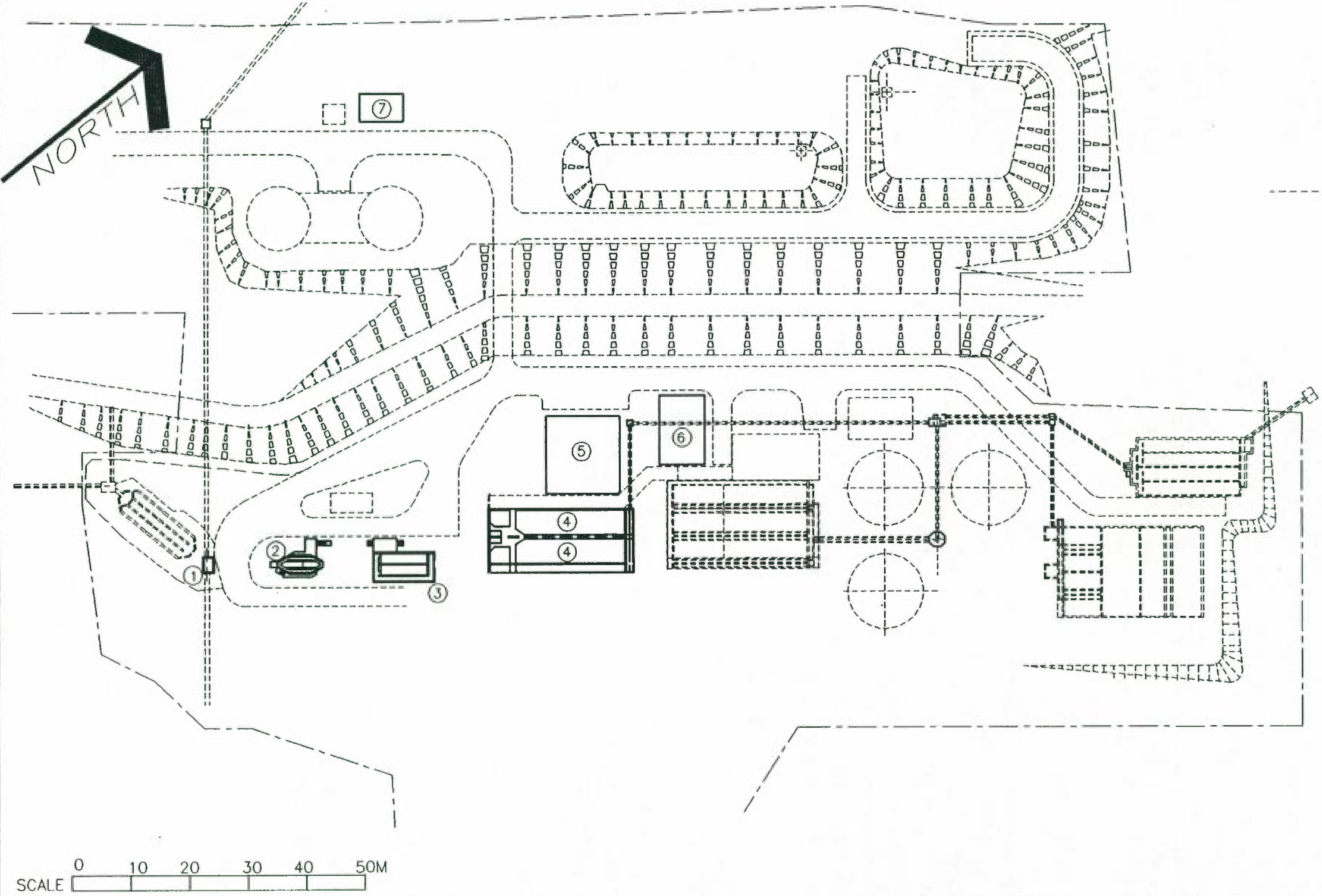
– – – – DECOMMISSIONED FACILITIES

WATER BOARD
SYDNEY–ILLAWARRA–BLUE MOUNTAINS
WASTEWATER AND REUSE PLANNING

WEST HORNSBY S.T.P.
GENERAL ARRANGEMENT OF
SCREENING PLANT (WITH WWHT)

Figure
13–3

bc-hhsp



LEGEND
1 NEW INLET STRUCTURE
2 SCREEN
3 GRIT REMOVAL
4 WET WEATHER HOLDING TANK (MODIFIED PRIMARY SEDIMENTATION TANK)
5 ADMINISTRATION BUILDING
6 ELECTRICAL SUB-STATION
7 SLUDGE HANDLING BUILDING

--------- DECOMMISSIONED FACILITIES

WATER BOARD
SYDNEY-ILLAWARRA-BLUE MOUNTAINS
WASTEWATER AND REUSE PLANNING

OPTION 5
HORNSBY HEIGHTS S.T.P.
GENERAL ARRANGEMENT OF
SCREENING PLANT (WITH WWHT)

Figure
13-4

Route A - Tunnel to Warriewood STP

As discussed in Section 12, Route A initially comprises of two individual tunnels, from Hornsby Heights and West Hornsby STPs, merging into a common tunnel to Warriewood STP. The last 3 km of the transfer scheme is by gravity mains due to the soil condition of Warriewood area.

With a nominal tunnel size of 2.5 m x 1.5 m, it will have more than sufficient capacity for the design flow adopted and will be capable of delivering flows of up to DWWF of the ultimate catchment size of 75,000 EP.

Warriewood STP

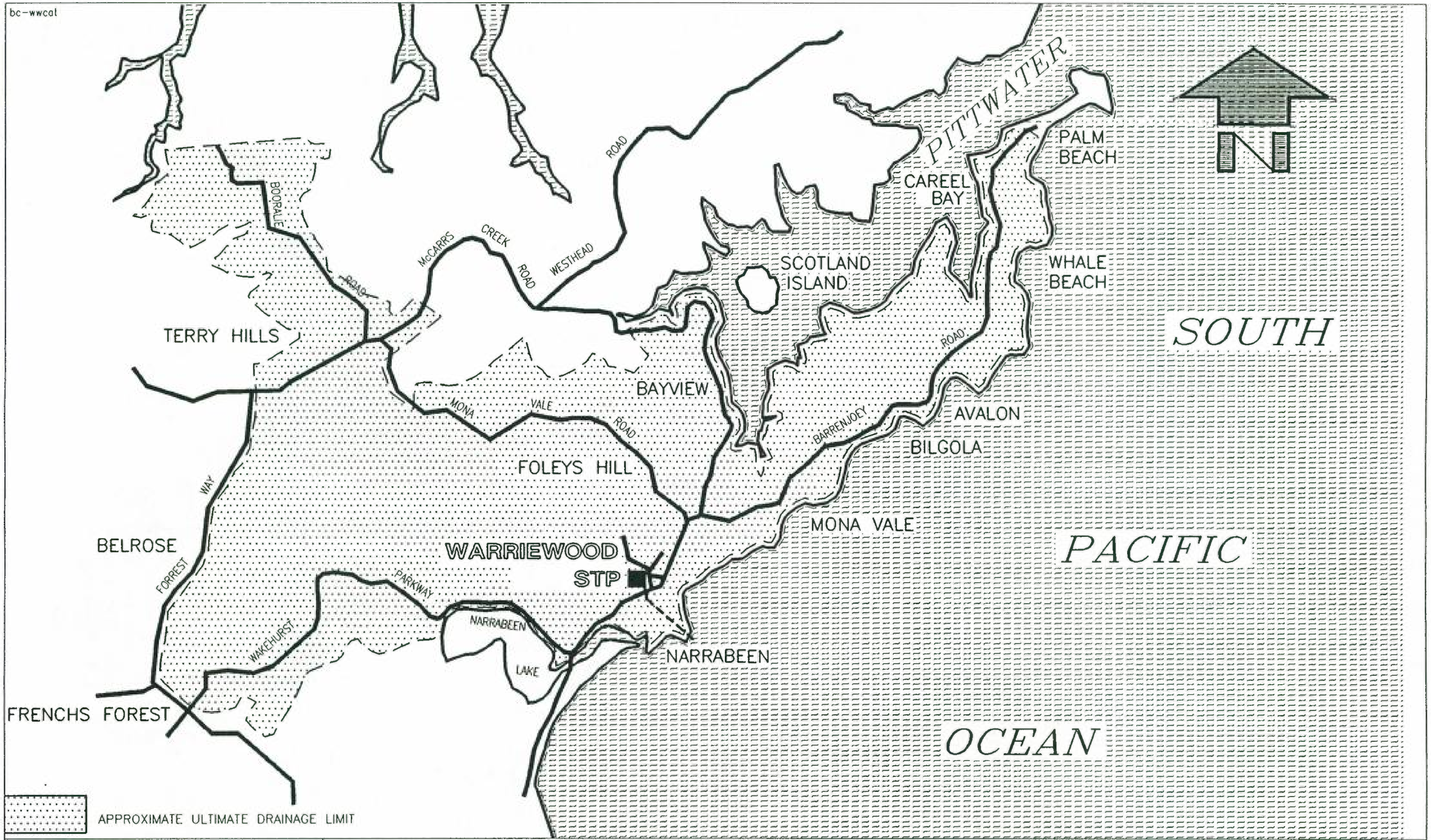
Introduction. Warriewood STP serves the existing residential and industrial areas of the major part of the Warringah Shire and Pittwater Council, extending westward to Duffys Forest, southward to Frenchs Forest and northward to Palm Beach. Future development in these areas shall also be serviced by Warriewood STP. The ultimate development in this catchment area is estimated to be 200,000 EP (based on development of the "most-likely" physical catchment area capable of draining to the treatment plant). Warriewood STP's likely ultimate catchment area, of about 25 square kilometres, is shown in the attached figure 13-5.

Warriewood STP, which was commissioned in January 1975, is located on Board's land off Warriewood Road, Warriewood as shown in figure 13-6. The existing site area is approximately 14.9 hectares.

Currently, Warriewood STP has a capacity of 80,000 EP and provides high rate secondary treatment for BOD and suspended solids removal with subsequent sludge digestion and dewatering of the solids. The treated effluent is currently disinfected by chlorination and then discharged into the ocean at Turimetta Head via a gravity main to a shoreline discharge as shown on attached figure 13-6. The dewatered digested sludge is trucked off-site for composting prior to beneficial uses, such as application to forest areas.

A current layout of the Warriewood STP is shown in figure 13-7. A process flow diagram for the existing facilities is shown in figure 13-8.

Table 13-2 contains a summary of existing treatment process capacities at Warriewood STP.



WATER BOARD
SYDNEY-ILLAWARRA-BLUE MOUNTAINS

WASTEWATER AND REUSE PLANNING

WARRIEWOOD S.T.P.
WARRIEWOOD CATCHMENT AREA

Figure
13-5

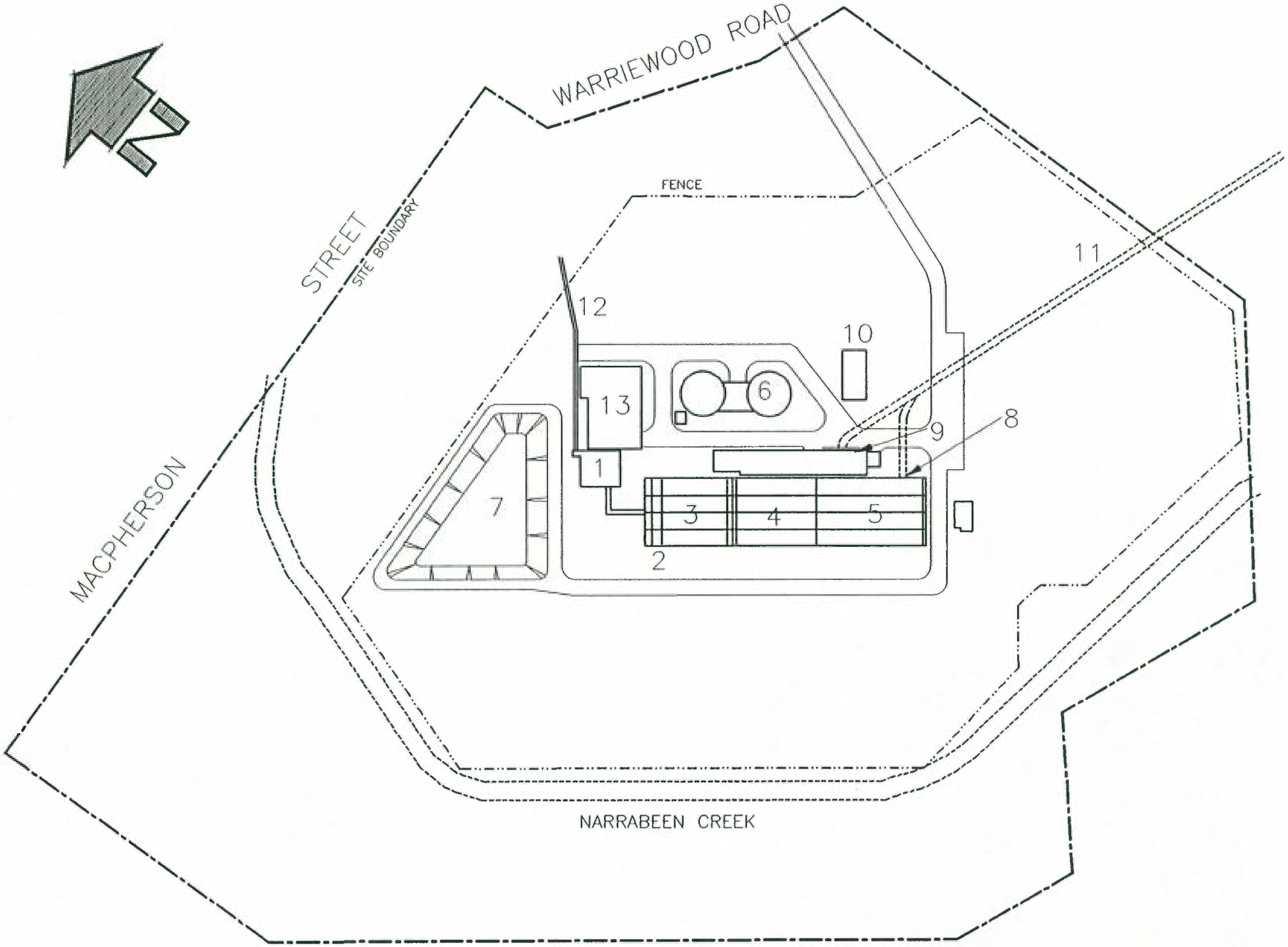
WATER BOARD
SYDNEY–ILLAWARRA–BLUE MOUNTAINS

WASTEWATER AND REUSE PLANNING

WARRIEWOOD S.T.P.
STP SITE AND OCEAN OUTFALL ROUTE

Figure
13–6

bc-wwga



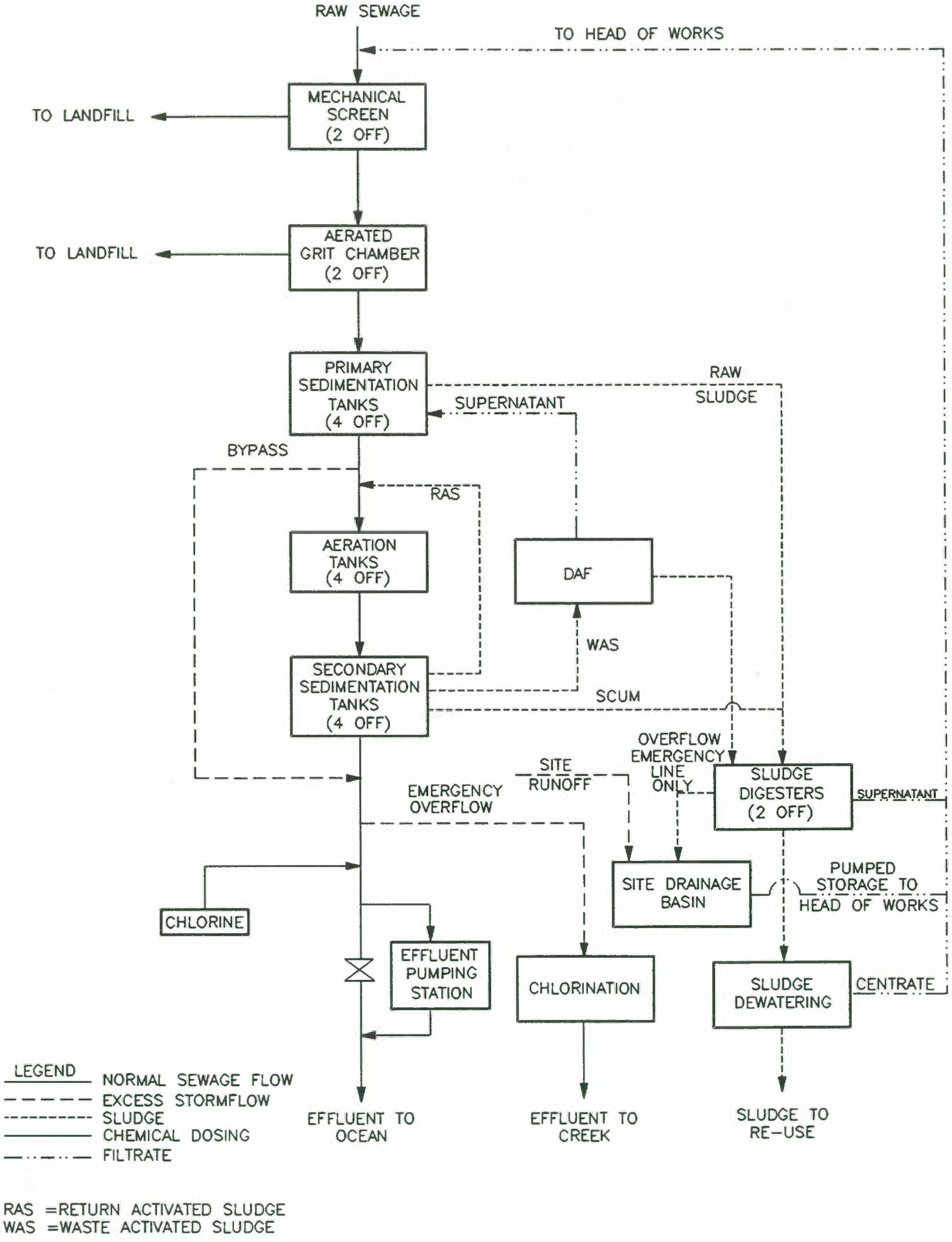
LEGEND.
1.BAR SCREENS.
2.PREAERATION & GRIT REMOVAL.
3.PRIMARY SEDIMENTATION TANKS.
4.AERATION TANKS.
5.SECONDARY SED. TANKS.
6.DIGESTION TANKS.
7.SITE DRAINAGE BASIN
8.CHLORINATION.
9.EFFLUENT PUMPING STATION.
10.ADMIN. BUILDING.
11.OCEAN OUTFALL.
12.R.S. INLET MAIN.
13.SLUDGE DEWATERING AND HANDLING BUILDING.

WATER BOARD
SYDNEY-ILLAWARRA-BLUE MOUNTAINS
WASTEWATER AND REUSE PLANNING

WARRIEWOOD S.T.P.
EXISTING PLANT
GENERAL ARRANGEMENT

Figure
13-7

bc-wwpfd



WATER BOARD
SYDNEY-ILLAWARRA-BLUE MOUNTAINS
WASTEWATER AND REUSE PLANNING

WARRIEWOOD S.T.P.
PROCESS FLOW DIAGRAM

Figure
13-8

TABLE 13-2. PRINCIPAL DIMENSIONS OF UNITS AT WARRIEWOOD STP

Unit Operation	Number of Units & Type	Dimensions (m)	Total Surface Area (m^2)	Total Volume (m^3)
Screens	2 Mechanically raked	1.5 x 1.8 18 mm spacing	5.4	
Grit Chambers	2 Aerated	12.4 m long 4 m wide 2.36 m Average Water Depth (AWD)	99	234
Primary Sedimentation Tank	4 Rectangular	30.5 m long 6.1 m wide 3.05 m AWD	744	2270
Biological Reactors	4 Rectangular	30.5 m long 6.1 m wide 3.85 AWD	-	2865
Secondary Sedimentation Tank	4 Rectangular	42.7 m long 6.1 m wide 3.51 m AWD	1042	3657
Anaerobic Digesters	2 Mixed Heated	9.45 m AWD 16.8 m diameter	-	4600
Sludge Dewatering Unit	2 Centrifuge	12-16 m^3/h	-	-
Chlorination Facility Pre & Post	No Chlorine Tank	For pre and post chlorination	-	-

Additional Facilities at Warriewood STP. As this option investigates the transferring of raw sewage from Hornsby Heights and West Hornsby STPs to Warriewood STP for treatment and disposal, the EP on Warriewood STP will be approximately 160,000 EP in 2019.

As discussed in "Equivalent Population Projections" (i.e. Section 4 of this Report), Warriewood STP will not need to amplify its works until around 2014. With the transfer scheme, as set out in this option, however, Warriewood STP would require amplification to coincide with the implementation of the transfer scheme.

TABLE 13-3. COMBINED EP PROJECTIONS FOR OPTION 5

Catchments	1994	2002	2005	2010	2015	2019
West Hornsby	35209	42705	44650	46105	46284	46419
Hornsby Hts	18821	21717	23480	24705	24794	24887
Warriewood	53300	62832	66872	73139	81293	86000
Total	107330	127254	135002	143949	152371	157306

When transferred, the current flow from the Hornsby STPs will represent about 70 per cent of the existing Warriewood STP capacity. Hence, a major amplification of Warriewood STP is required.

Additionally, as recommended in the EPA EG-1 document ("Environmental Guidelines for the Discharge of Wastes to Ocean Waters", refer Appendix A), discharge may need to be of a nitrified secondary quality, if the existing outfall is not extended to deeper waters.

As it is unlikely that an extended ocean outfall will be accepted favourably by the community, upgrading of the existing Warriewood treatment facilities has been assumed to produce a nitrified secondary effluent. Based on the current design criteria for nitrification plants, the existing facilities at Warriewood STP would be an equivalent 40,000 EP nitrification facility. In order to cope with the existing load from the Warriewood catchment, a new stage of 40,000 EP will be required immediately. Hence, a total capacity of 80,000 EP will be available.

To also accept the transferred hydraulic load from the Berowra catchment, another amplification stage of 80,000 EP is required for Warriewood STP. This will give Warriewood STP a total capacity of 160,000 EP. The following facilities, which will be capable of producing a nitrified secondary effluent, are planned to be provided:

Screening and grit removal facilities.
Primary treatment facilities.
Aeration tank to achieve carbonaceous oxidation and nitrification.
Secondary clarifiers.
Multi-point chemical dosing systems (include lime and iron salts).
WAS thickener.
Anaerobic digesters.
Sludge dewatering facilities.
Disinfection facilities.
Associated administration, control and maintenance facilities.

Figure 13-9 shows a general layout of the amplified Warriewood STP.

Warriewood STP Outfall. The existing Warriewood STP effluent main and cliff-face outfall at Turimetta Head has sufficient capacity. Hence, no amplification is required.

SUMMARY OF FACILITIES FOR OPTION 5

Table 13-4 summarises the costs, capacities and implementation timeframe for the various components of Option 5.

TABLE 13-4. OPTION 5 REQUIREMENTS

Item	Size/Capacity	Capital Cost	Implementation Timeframe	Operating Cost (per annum)
Modification of Hornsby Hts	25,000 EP	$2 M	1 years	$50,000
Modification of West Hornsby	46,500 EP	$2 M	1 years	$50,000
Tunnel System	2.5 m x 1.5 m	$110 M	5 years	$25,000
Warriewood STP Amplification and Upgrade	160,000 EP (80,000 EP for this Option)	$32 M	3 years	$3,520,000

OPTION OVERVIEW

Option 5 has the following characteristics that will help form part of the evaluation stage of this report.

Capital and Operating Costs

Based on preliminary assessment of the option, the Order-Of-Cost capital and operating costs are as follow:

Capital Cost is $ 146 million.
Operating Cost is $ 3.7 million/annum at year 2002.

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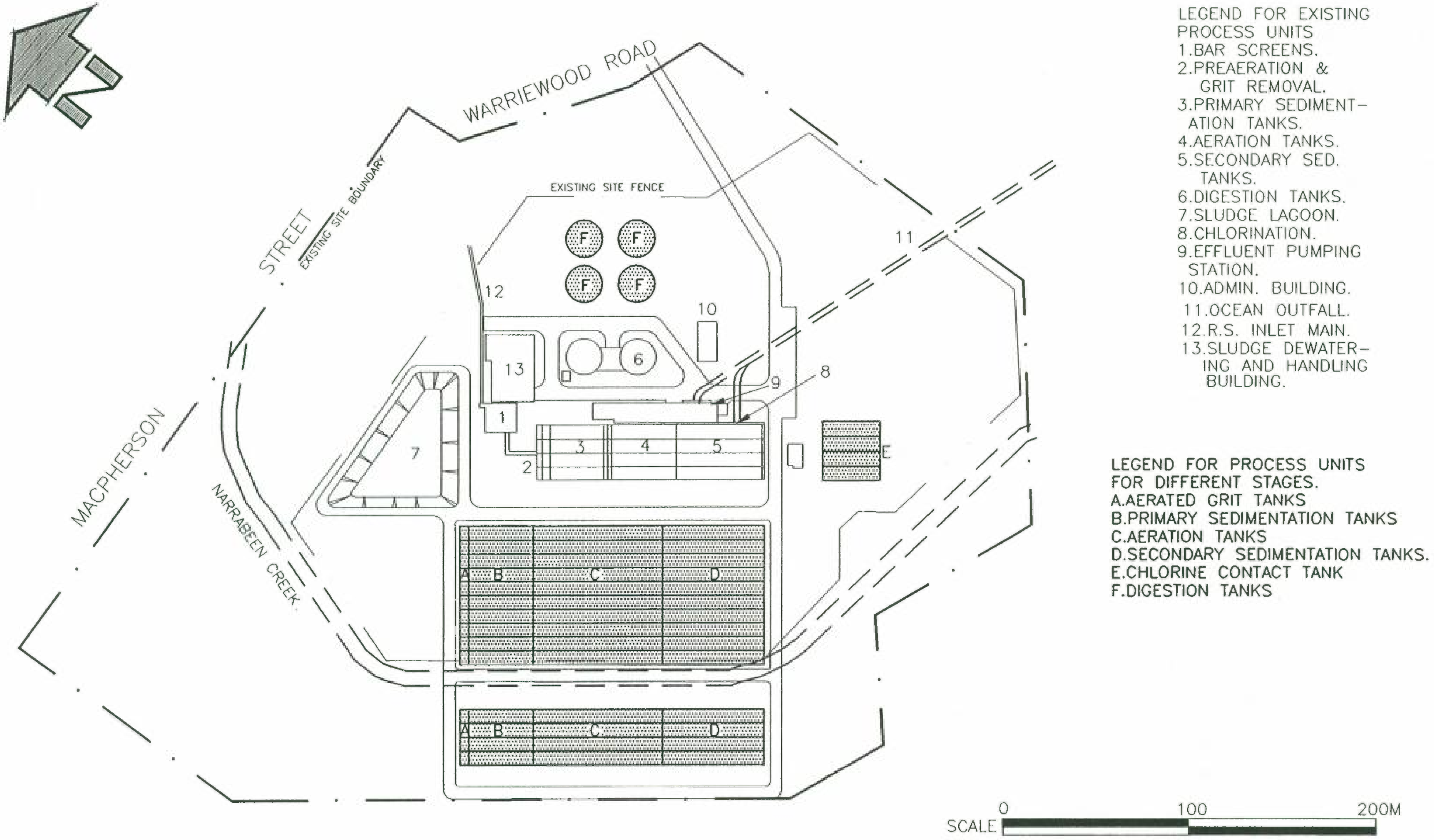


WATER BOARD
SYDNEY-ILLAWARRA-BLUE MOUNTAINS

WASTEWATER AND REUSE PLANNING

WARRIEWOOD S.T.P.
EXISTING AND ULTIMATE DEVELOPMENT
GENERAL ARRANGEMENT

Figure
13-9

Expected Implementation Timeframe

As discussed in Section 12 of this report and shown in Table 13-4, the timeframe for implementation of the tunnel scheme is the longest of all the component parts for Option 5; and is expected to be about 5 years.

Whilst the scheme is being constructed, the existing Hornsby Heights and West Hornsby STPs will continue to discharge their effluent into Berowra Creek. This will continue to have the present environmental impact on Berowra Creek and no improvement is expected to at least the year 2002.

Effluent Quality

This option will relieve Berowra Creek waterways of all treatment plant effluent discharges up to 100 per cent of the time. This is due to the ample capacity in the tunnel system.

The only time when there may be discharges to the local creek is when the tunnel system is undergoing major repair or major maintenance. One can assume, however, that this occurrence will be infrequent. Should the tunnel be taken off-line, the discharges will receive fine screening and grit removal treatment.

All flows transferred to Warriewood STP will receive secondary treatment and nitrification. The effluent when discharged to the ocean will be of secondary quality and also be low in ammonia concentration. This effluent quality will comply with the long-term goal of the EPA's EG-1 guidelines.

Land Requirements

As the proposed WWHT and Screening Plant will be located in the boundary of the Hornsby STPs; no additional land is required.

Additional land will, however, be required to accommodate the major access shafts along the route of the transfer tunnel. Each access shaft will be purposely located, wherever possible, in less sensitive areas. The area required for each shaft will be approximately 100 square metres.

The amplification of Warriewood STP may be contained within the Board's boundary, which is about 14.9 Ha. Hence, no additional land is required. Other activities, however, not related to the STP, such as the region's sewerage depot, will have to be relocated off the STP site. Additionally, with the buildup of additional facilities on-site, there will be negligible buffer zone between the plant facilities and the surrounding residential and commercial development.

Operational Aspects

With the decommissioning and conversion of the tertiary facilities at West Hornsby and Hornsby Heights STPs to a flow transfer/screening plant, the operational requirements (i.e. labour, and chemical) at the two facilities can be dramatically reduced. As discussed earlier, all flow will be diverted into the transfer tunnel system. Hence, no major operating cost will be incurred from the two sites with manpower required only to provide regular service and maintenance to the wet weather treatment facilities, i.e. pumping, screening and grit removal facilities.

Additional labour will be required to maintain and inspect the "transfer tunnel/carrier". Control and telemetry will be also required to ensure proper operation of the transfer system.

The main operating cost of this option will be associated with the operation of the amplified Warriewood STP. Although automatic control and telemetry system will be utilised at the amplified plant, it will require skilled labour to operate the STP efficiently. Other operating costs will occur and be associated with extra power and chemicals required and more regular servicing and maintaining of equipment.

Environmental Impacts/Benefit

The removal of effluent discharges from the Berowra Creek catchment will be assured with the adoption of Option 5. Nutrients, especially nitrogen, will be transferred to the ocean for disposal. Although this option may achieve zero discharges to Berowra Creek, the removal of plant effluent, and its dilution potential, may well have a negative impact on the creek in dry weather. Also reductions in the occurrence of algal blooms in the estuarine section of the creek can not be quantified and may well still eventuate.

The next major impact will be caused by the construction and maintenance of the transfer tunnel/carrier from the Berowra catchment to the Warriewood STP site. The selection of the route will have to be treated with extreme care and sensitivity. No possible overflow and discharge from the tunnel/carrier is allowable along the whole transfer route. Odour control will be performed along the route to mitigate odour complaint from the nearby residents.

Another major impact associated with Option 5 will be amplification of Warriewood STP. The amplification and upgrade of Warriewood STP will be a large addition of facilities on-site. The impact will be experienced mainly by the nearby residents especially during the construction phase, e.g. machinery and truck movements, noisy construction activities, etc.

During the operational phase, they will be associated increases in truck movements due to chemical deliveries, solid waste and sludge removal. There may be an increased impact associated with odour and noise generation (e.g. pumps, blowers etc.). With the addition of odour control and mitigation measures on-site, however, this impact will be reduced dramatically.

The impact of the receiving waters, i.e. ocean off Turimetta Head, will be minimal. In dry weather and normal operation of the STP facilities, nitrified secondary effluent will be discharged. In wet weather events, all discharges (i.e. flows greater than 3 ADWF) will undergo at least primary treatment, with at least 3 ADWF receiving secondary treatment.

Currently, the plant's effluent receives chlorination before discharge to the ocean. This will continue and will reduce effluent's faecal coliform numbers to acceptable levels, prior to discharge into the receiving waters.

Beneficial Reuse

With the Board's present policy in encouraging residual and effluent reuse, part of the flow treated will be retained for reuse. Effluent reuse within the STP will be maximised using the high quality effluent produced. Internal reuse applications include:

Flushing and sprays of screens.
Flushing of grit pumps.
Scum sprays in tanks.
Sprays in thickener and centrifuge.
Dilution water for chemical dosing.
Hosing down application throughout STP.
Onsite irrigation.

External markets will be sought to take up more effluent. These potential markets may include golf courses, nurseries, council parks and industrial applications.

At present, all digested and dewatered sludge from Warriewood STP is used for beneficial reuse, i.e. composting. This will continue to occur provided the sludge produced is of good and consistent quality.

Other Considerations

The community's acceptance of the scheme will be one of the most important considerations in the adoption of this option. This will be particularly true for the community living in the Warriewood area.

SECTION 14

OPTION 6 - DRY AND WET WEATHER RAW SEWAGE TRANSFER TO NORTH HEAD STP

Similar to Option 5, this option aims to relieve the Berowra Creek waterways of all treatment plant effluent discharges during dry weather conditions and wet weather flows up to two year ARI (i.e. Average Recurrence Interval). The destination of effluent for this option, however, is to North Head STP, where it will be treated and then disposed via the deepwater ocean outfall.

For Option 6, the following will be provided:

- West Hornsby (WH) and Hornsby Heights (HH) STPs will be decommissioned.
- Inlet structure modification to existing WH and HH STPs.
- A transfer tunnel will be constructed (as per Route B described in Section 12) from the Hornsby STPs to North Head STP.
- Overflows from inlet structure will be retained in a Wet Weather Holding Tank (WWHT), and pumping facilities to transfer WWHT's content back to tunnel when tunnel capacity is available.
- Any overflows from the WWHT will undergo fine screening and grit removal before discharge to local creek.
- Modification to North Head STP's inlet structure and new influent pumping station to receive transferred flows.

The following assumptions apply to this option:

- Raw sewage flows of up to DWWF (i.e. 4 PDWF) will be transferred to North Head STP for treatment prior to disposal via the deep ocean outfall.
- Flows greater than DWWF will be stored in WWHT at the Hornsby STPs' sites. The WWHT will attenuate excessive storm flows which will be returned to the transfer system when able. If storm flows are to be discharged to the creek, they will receive fine screening and grit removal treatment.

DESCRIPTION OF OPTION 6

The existing inlet structures at West Hornsby (WH) and Hornsby Heights (HH) STPs will be modified to enable all flows of up to DWWF to flow into the tunnel. As no pumping is proposed, raw sewage will gravitate to North Head STP for treatment and disposal via the deepwater ocean outfall.

The modified inlet structure will have a bypass facility to divert storm flows, greater than DWWF, to a Wet Weather Holding Tank (WWHT). Pumping facilities will be provided to pump the content of the WWHT back into the transfer tunnel whenever there is capacity in the tunnel. Overflows from the WWHT will receive fine screening and grit removal before discharge to the local creek.

As discussed in Section 12, Route B is proposed for the transfer of raw sewage from the Berowra catchment to North Head STP.

A schematic diagram of this option is shown in figure 14-1. A process flow diagram of the proposed Screening and Grit Removal Plant (SP), which includes the proposed WWHT, is shown in figure 14-2.

FACILITIES REQUIRED

The following paragraphs summarise the proposed works for Option 6.

Flows and population projections

The current and future design flows for the Hornsby Heights and West Hornsby catchments were previously discussed and are similar to that described in Option 5.

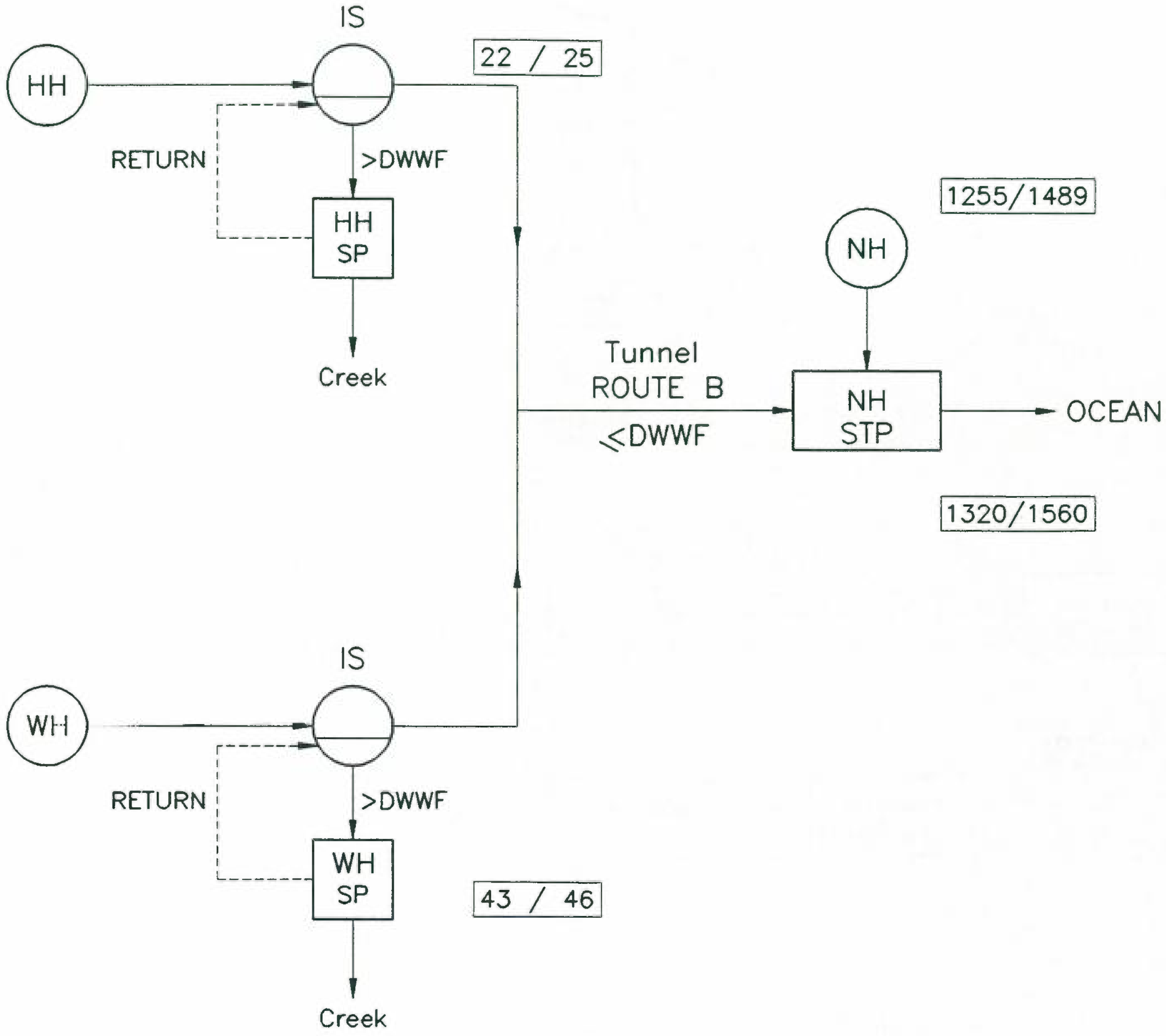
Modifications to existing STPs

Modifications to the existing facilities at Hornsby Heights and West Hornsby STPs will be similar to that described in Option 5 (i.e. Section 13 of this report).

Route B - Tunnel to North Head STP

As discussed in Section 12, Route B initially comprises two individual tunnels, from Hornsby Heights and West Hornsby STPs, merging into a common tunnel to North Head STP. The last 1 km of the transfer scheme is by pipe-jacking with concrete tunnel forming technique due to the soil conditions in the Manly area.

With a nominal tunnel size of 2.5 m x 1.5 m, it will have more than sufficient capacity for the design flows adopted, i.e. capable of delivering flows of up to DWWF for 75,000 EP.



2002 / 2019 = Flows in thousand EP

☐ = Treatment Facility

○ = Catchment

SP = Screening Plant
STP = Sewage Treatment Plant

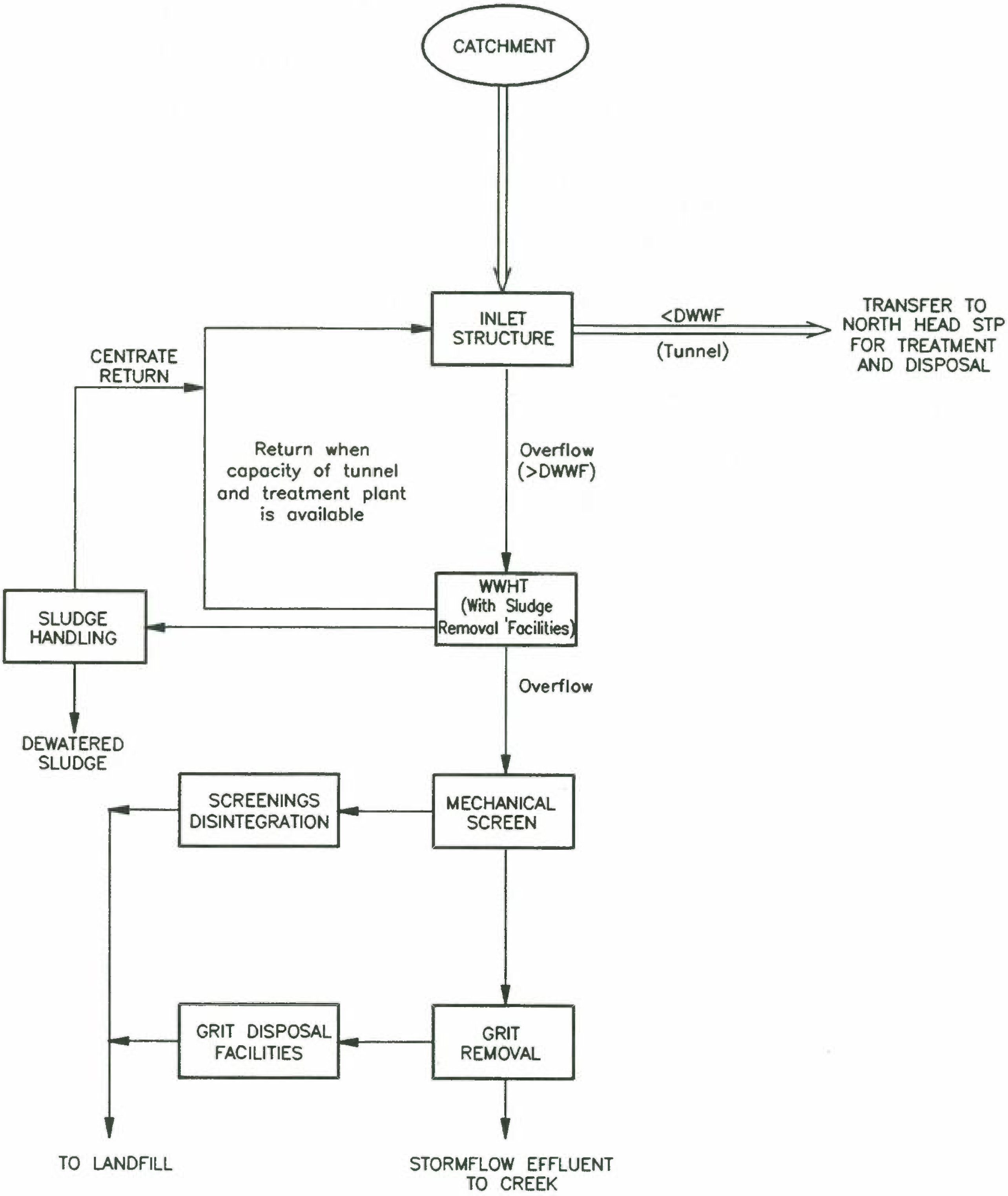
IS = Inlet Structure
HH = Hornsby Heights
WH = West Hornsby
NH = North Head
DWWF = Design Wet Weather Flow

WATER BOARD
SYDNEY–ILLAWARRA–BLUE MOUNTAINS
WASTEWATER AND REUSE PLANNING

OPTION 6
RAW SEWAGE TRANSFER SCHEME
FOR DRY & WET WEATHER

Figure
14–1

bc-scpl5



LEGEND

═══ NORMAL SEWAGE FLOW

WWHT = Wet Weather Holding Tank

WATER BOARD
SYDNEY-ILLAWARRA-BLUE MOUNTAINS
WASTEWATER AND REUSE PLANNING

OPTION 6
SCREENING PLANT
PROCESS FLOW DIAGRAM

Figure
14-2

North Head STP

Introduction. North Head STP currently provides high rate primary treatment to sewage flows from a catchment of approximately 416 square kilometres from the coast at North Head to Blacktown, bounded in the North by Narrabeen Lagoon, St. Ives and Hornsby and in the South by Sydney Harbour, Lidcombe, Yagoona and Merrylands. Figure 14-3 shows the catchment area served by North Head STP.

North Head STP is located on a 15.9 ha site which is owned by the Board. Since its commissioning in 1971, the facilities at North Head has been progressively expanded and upgraded to the present high rate primary treatment plant.

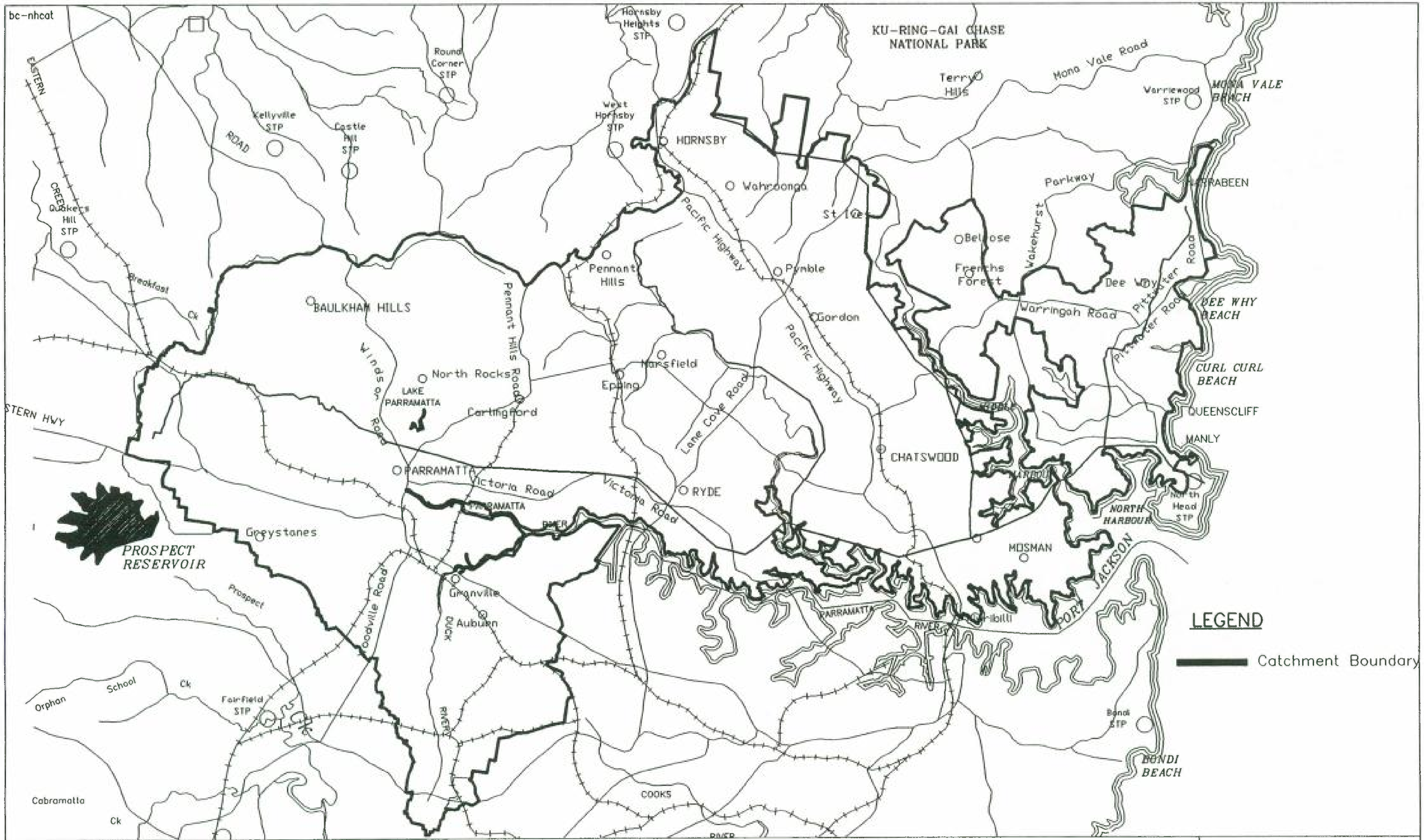
In addition, since December 1990, the treated effluent has been discharged through the 3.5 km long deepwater ocean outfall. The original cliff-face outfall is now used only for emergency discharge of untreated or partially treated wastewater. A general arrangement of North Head STP is shown in figure 14-4.

The capacity of North Head STP is 1,250,000 EP and it currently treats a load of approximately 1,100,000 EP.

A process flow diagram for the existing facilities at North Head STP is shown in figure 14-5; and comprises of the following facilities:

2 coarse mechanically raked bar screens and 5 fine rotary drum screens.
4 influent pumps.
2 aerated grit removal chambers.
4 rectangular high rate primary sedimentation tanks.
3 circular sludge thickeners.
3 sludge centrifuges.
3 solid incinerators (now decommissioned).
A stormflow degritting plant.
Chemical stabilisation of sludge, grit, screenings and scum.
Deepwater ocean outfall.

Table 14-1 contains a summary of existing treatment process capacities at North Head STP.

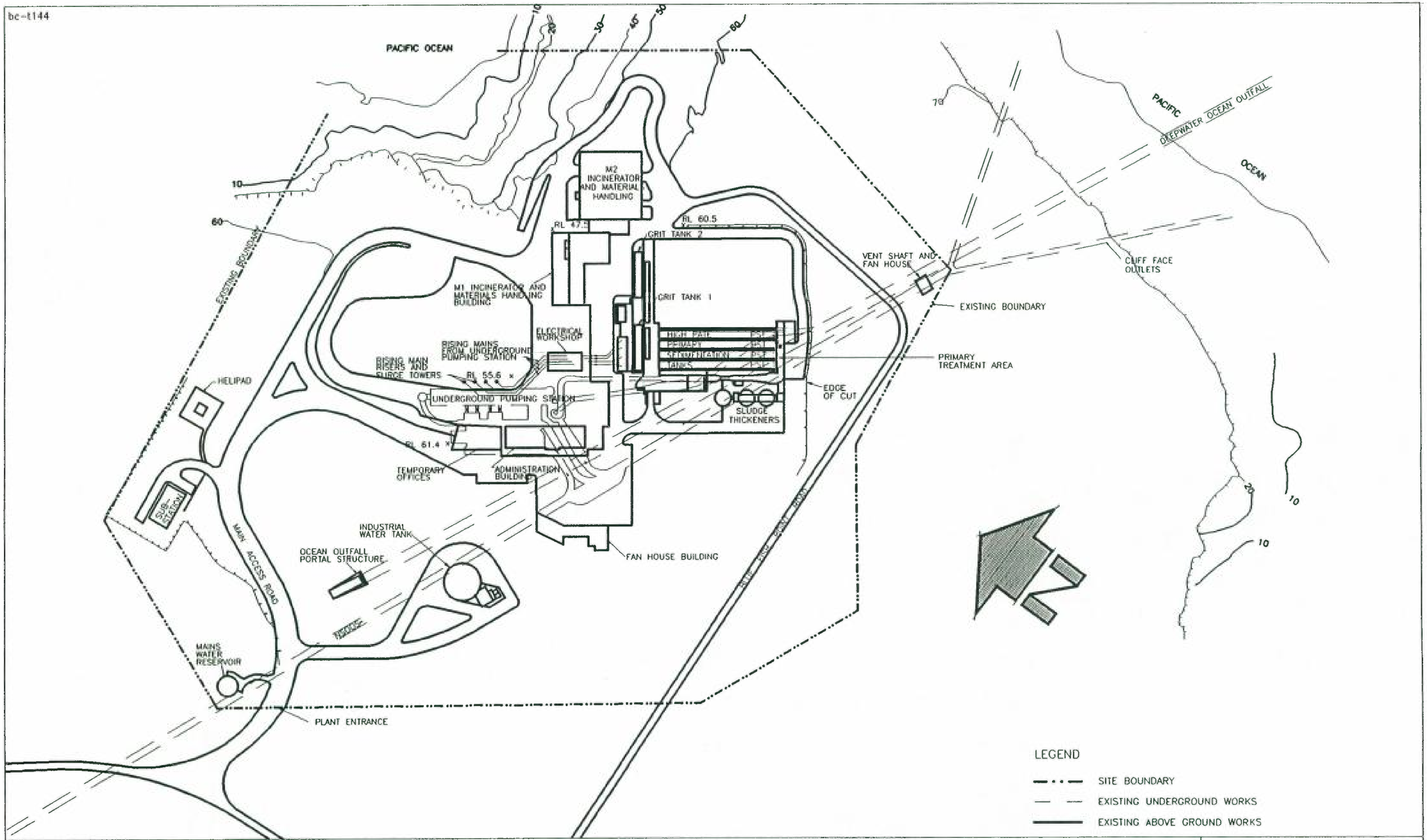


WATER BOARD
SYDNEY-ILLAWARRA-BLUE MOUNTAINS

WASTEWATER AND REUSE PLANNING

NORTH HEAD S.T.P.
CATCHMENT AREA

Figure
14–3

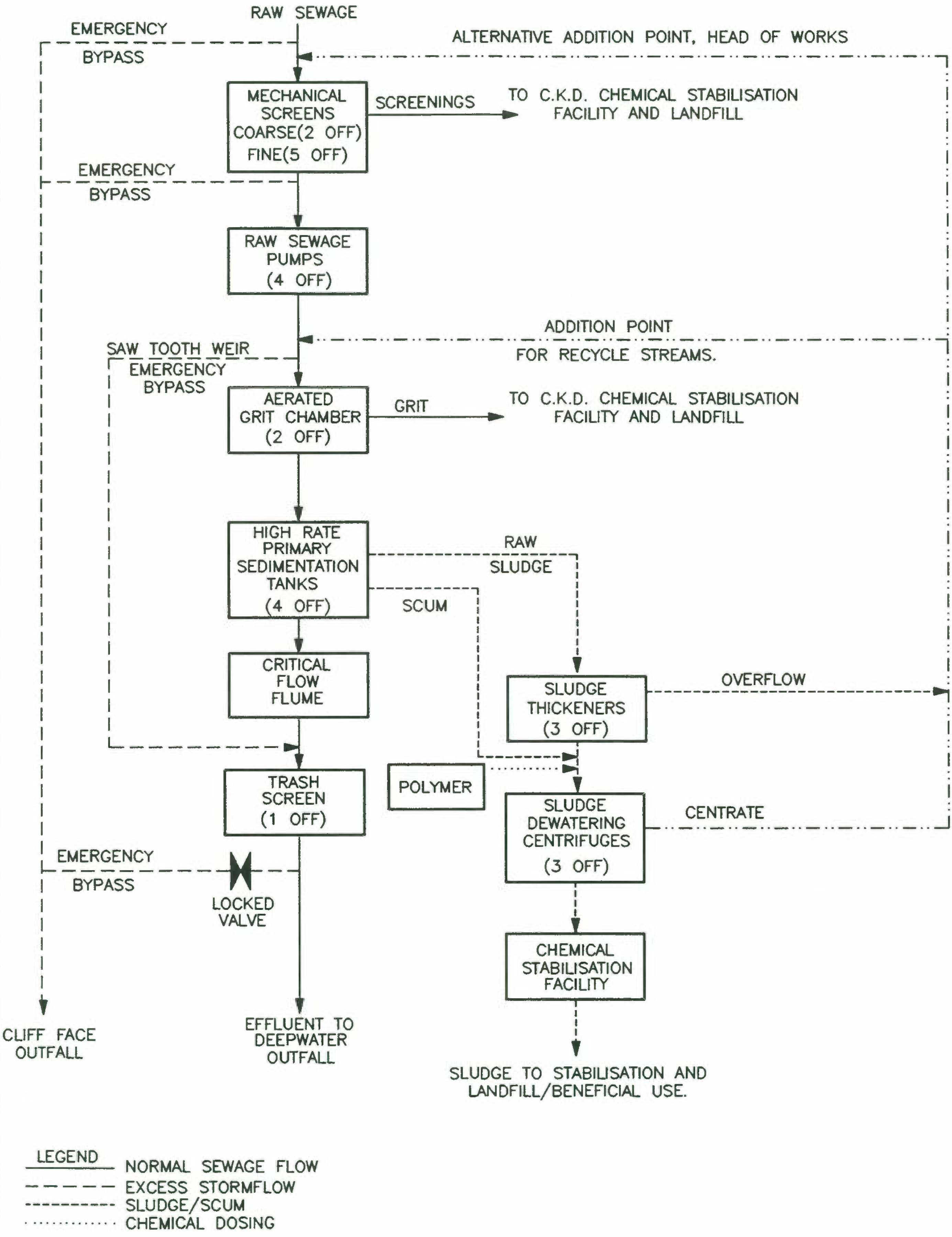


WATER BOARD
SYDNEY-ILLAWARRA-BLUE MOUNTAINS
WASTEWATER AND REUSE PLANNING

NORTH HEAD S.T.P.
EXISTING PLANT
GENERAL ARRANGEMENT

Figure
14-4

bc-t145



WATER BOARD
SYDNEY-ILLAWARRA-BLUE MOUNTAINS
WASTEWATER AND REUSE PLANNING

NORTH HEAD S.T.P.
PROCESS FLOW DIAGRAM

Figure
14-5

TABLE 14-1. PRINCIPAL DIMENSIONS OF UNITS AT NORTH HEAD STP

Unit Operation	Number of Units & Type	Dimensions (m)	Total Surface Area (m^2)	Total Volume (m^3)
Screens	2 Mechanical Raked + 5 Rotary Drums	1.83 m wide 1 x 13 mm & 1 x 19 mm openings + 5.96 m dia x 2.32 m 2 x 12 mm & 3 x 5 mm openings	-	-
Influent Pumps	4 Centrifugal Pumps	4.2 m^3/s @ 64 m head 485 rpm	-	-
Grit Chamber	2 Aerated	27.8 m long 7.18 m wide 3.98 m AWD	400	1760
Primary Sedimentation Tank	4 Rectangular	7.46 m long 6.1 m wide 3.1 m AWD	1760	5824
Sludge Thickener	3 Circular	7.5 m dia 3.0 m AWD	-	-
Sludge Dewatering	3 Centrifuges	3 x 70 m^3/h	-	-
Chemical Stabilisation	Lime and Kiln dust stabilisation			
Deepwater Ocean Outfall	1 Tunnel with Diffuser	3.3 km long 3.5 m dia 36 diffusers	-	-

Additional Facilities at North Head STP. This option investigates the transferring of raw sewage from West Hornsby and Hornsby Heights STPs to North Head STP for treatment and disposal. Based on the tunnel construction, the earliest time for the scheme to be commissioned is forecasted around 2002.

Table 14-2 summarises the combined EP projection for Option 6.

TABLE 14-2. COMBINED EP PROJECTIONS FOR OPTION 6

Catchments	1994	2002	2005	2010	2015	2019
West Hornsby	35,209	42,705	44,650	46,105	46,284	46,419
Hornsby Hts	18,821	21,717	23,480	24,705	24,794	24,887
North Head	1,137,000	1,255,000	1,296,000	1,370,000	1,444,000	1,489,000
Total	1,191,030	1,319,422	1,364,130	1,440,810	1,515,078	1,560,306

When transferred, the current flow from the Hornsby STPs will represent about 4.5 percent of the existing North Head STP capacity. Under this scenario, the EP on North Head STP will be approximately 1,560,000 EP in 2019.

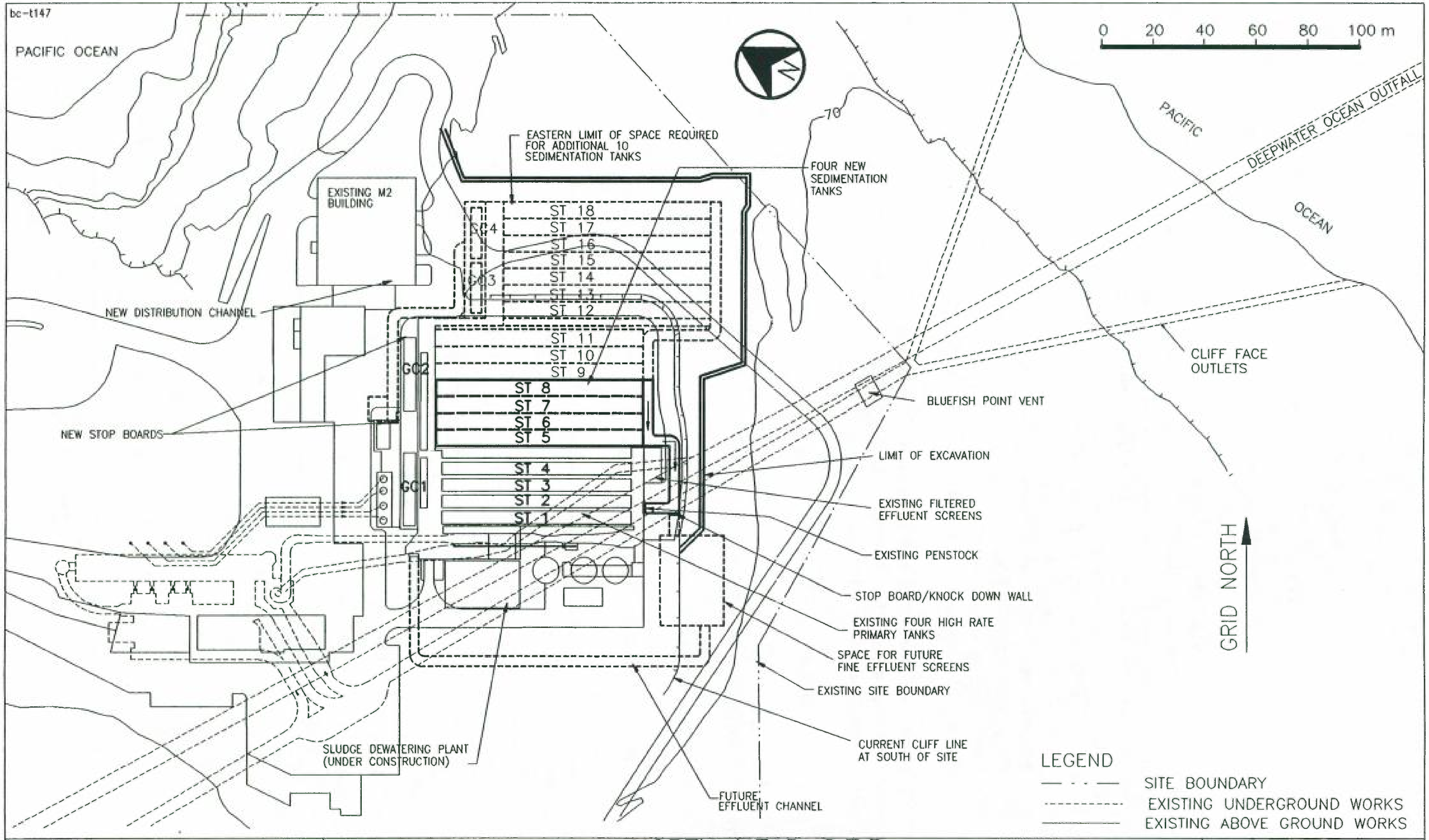
To help determine the facilities required to meet the requirements of NSW's EPA EG-1 document ("Environmental Guidelines for the Discharge of Wastes to Ocean Waters"), the Board had produced a draft "Facility Plan" for North Head STP, dated November 1992. The different stages of development proposed are:

- Interim improvement in grease capture and suspended solid removal.
- Stage A Upgrade, providing primary treatment (or 65 % suspended solid removal efficiency).

Since the completion of the draft "Facility Plan", its recommendations are being reviewed and will provide important information in the strategic planning for Sydney.

An Interim improvement project has, however, been approved and is undergoing the community consultation phase. Figure 14-6 shows a general layout of North Head STP with the interim grease capture improvement (i.e. the provision of 4 additional sedimentation tanks). It is expected to be implemented by 1998. At the present estimation, the earliest time for the implementation of Stage A Upgrade if approved may well be around year 2005.

Depending upon the outcomes of the strategic planning process, the community's expectation in ocean protection and the EPA licence requirements, the Board may have to expedite the implementation of Stage A Upgrade. This upgrade will not only serve the purpose of improving the effluent quality but also will enable the STP to serve a greater hydraulic load.



WATER BOARD
SYDNEY–ILLAWARRA–BLUE MOUNTAINS

WASTEWATER AND REUSE PLANNING

NORTH HEAD S.T.P.
INTERIM GREASE CAPTURE IMPROVEMENT
PROPOSED ALTERNATIVE ARRANGEMENT OF NEW
SEDIMENTATION TANKS 5 TO 8

Figure
14–6

The flows from Berowra Creek catchment are not expected to have a major impact on the performance of North Head STP after the implementation of the upgrade stages. For the purpose of this investigation, however, a minimal capital expenditure, i.e. one sedimentation tank and pumping facilities, will be assumed for the adoption of this scheme. In addition, an operating cost for a 65,000 EP process train using the following facilities will be assumed:

Screening and grit removal facilities.
Primary treatment facilities.
Drying and pelletiser facilities.
Associated administration, control and maintenance facilities.

North Head STP Deepwater Ocean Outfall. The existing North Head STP Deepwater Ocean Outfall has sufficient capacity for about 2,060,000 EP flow. Hence, no amplification is required.

SUMMARY OF FACILITIES FOR OPTION 6

Table 14-3 summarises the costs, capacities and implementation timeframe for the various components of Option 6.

TABLE 14-3. OPTION 6 REQUIREMENTS

Item	Size/Capacity	Capital Cost	Implementation Timeframe	Operating Cost (per annum)
Modification of Hornsby Hts	25,000 EP	$2 M	1 year	$50,000
Modification of West Hornsby	46,500 EP	$2 M	1 year	$50,000
Tunnel System	2.5 m x 1.5 m	$120 M	5 years	$30,000
North Head STP Amplification and Upgrade	One sed. Tank and inlet pumps	$7 M	1 year	$910,000

OPTION OVERVIEW

The following overview briefly lists the option's particular benefits which will be used later in this report's analysis phase.

Capital and operating costs

Based on preliminary assessment of the option, the Order-Of-Cost capital and operating costs are as follow:

Capital Cost is $ 131 million.
Operating Cost is $ 1.1 million per annum at Year 2002.

Expected Implementation Timeframe

As discussed previously in Section 12 and reinterated in Table 14-3, the timeframe for implementation of the tunnel scheme is the longest of all the component parts for Option 6; and is expected to be about 5 years.

Whilst the scheme is being constructed, the existing Hornsby Heights and West Hornsby STPs will continue to discharge its effluent into Berowra Creek. This will continue to have the present environmental impact on the Berowra Creek until the transfer is completed (i.e. around the year 2002).

Effluent Quality

This option will relieve Berowra Creek waterways of all treatment plant effluent discharges up to 100 % of the time. This is due to the ample capacity of the tunnel system.

The only time when there may be discharges to the local creek is when the tunnel system is undergoing major repair or major maintenance. One can assume, however, that this occurrence will be very limited. Should the tunnel be taken off-line, the discharges will receive preliminary treatment which includes fine screening and grit removal.

All flows, when transferred to North Head STP, will receive high rate primary treatment before discharged to the ocean via the deepwater ocean outfall.

At present effluent discharges for North Head STP comply with current licence conditions and the transfer of the Berowra Creek catchment flows are expected not to adversely effect the ocean plant's performance in dry weather. The provision of the interim grease capture improvements, however, will move suspended solids and grease and come closer to the long term goals set in the EPA's EG-1 guidelines.

The dilution provided by the deep ocean outfall will further minimise the impact on the receiving water environment.

Land Requirements

For this option, the existing facilities at West Hornsby and Hornsby Heights STPs will be modified to Wet Weather Holding Facilities and no major augmentation is required. The works will all be contained within the current site boundaries and hence, no additional lands are needed.

Additional land will, however, be required to accommodate the major access shafts along the route of the Transfer Tunnel. Each access shaft will be purposely located in non-sensitive areas wherever possible. The area required for each shaft will be approximately 100 square metres.

The amplification and upgrade of North Head STP will fit within the Board's boundary, which is about 15.9 Ha. Hence, no additional land is required.

Operational Aspects

As discussed in Section 13, comments regarding the modified storm plants at West Hornsby and Hornsby Heights STPs and the tunnel system will be valid for Option 6.

The main operating cost of this option will be associated with the operation of the amplified and upgraded North Head STP. Nevertheless, being a primary plant, the operating aspect will be less complex when compared to secondary treatment processes with no major need for highly skilled operators. More regular servicing and maintaining of equipment in the large STP will, however, be required.

Environmental Impacts/Benefit

As for Option 5, the removal of effluent disposal from the Berowra Creek catchment will be assured in Option 6. Nutrients, with special regard to nitrogen, will be transferred to the ocean for disposal. Although this option may achieve zero discharges to Berowra Creek the reduction in algal bloom occurrences in the estuarine section are unknown. The loss of effluent dilution in the receiving waters may also have a negative impact.

Other main impacts will be caused by the construction and maintenance of the transfer tunnel/carrier from the Berowra catchment to the North Head STP site and amplification at North Head STP. The selection of the route will have to be treated with extreme care and sensitivity. No possible overflow and discharge from the tunnel/carrier is allowable along the whole transfer route. Odour control will be performed along the route to mitigate odour complaint from the nearby residents.

During the operational phase, they will be only a marginal increased of truck movements due to chemical supplies, solid waste and sludge removal.

The impact of the receiving waters, i.e. ocean off Manly, will be minimal after the dilution from the deepwater ocean outfall. If the Stage A Upgrade is recommended and approved by the community after the public exhibition phase of the choices for Clean Waterways strategies, primary effluent will be discharged at the deepwater ocean outfall.

Beneficial Reuse

With the Board's present policy in encouraging residual and effluent reuse, part of the flow treated will be reused. Effluent reuse within the STP will occur using the effluent produced. This will reduce the use of potable water in the plant.

At present, all chemically-stabilised sludge from North Head STP is used for beneficial reuse, i.e. composting. This will continue to occur provided the sludge produced is of good and consistent quality.

Other Considerations

The community's acceptance of the scheme will be one of the most important considerations in the adoption of this option. This will be particularly true for the community living in the Manly area.

SECTION 15

OPTION 7 - DRY AND WET WEATHER PLANT EFFLUENT TRANSFER TO WARRIEWOOD STP OUTFALL

Similar to Option 5, this option aims to relieve the Berowra Creek waterways of all treatment plant effluent discharges during dry weather conditions and wet weather flows up to two year ARI (i.e. Average Recurrence Interval) or Board's Design Wet Weather Flow (DWWF). Instead of raw sewage being transferred, as in Option 5, Option 7 involves the transfer of treated effluent to the ocean for disposal.

In this option, the existing STPs of Hornsby Heights and West Hornsby will be retained; and the treated effluent transferred to Warriewood STP outfall for disposal.

For Option 7, the following will be provided:

- West Hornsby (WH) and Hornsby Heights (HH) STPs will be retained to produce nitrified secondary effluent.
- Flows greater than 3 ADWF will be retained in a Wet Weather Holding Tank (WWHT) after receiving primary treatment. Pumping facilities will be provided to transfer WWHT's content back to the secondary process train during dry weather period.
- Any overflows from the WWHT will undergo fine screening before discharged to local creek.
- A transfer tunnel will be constructed (as per Route A described in Section 12) from WH and HH STPs to Warriewood STP site.
- Transfer carrier system will be connected to the Warriewood STP outfall.

The following assumptions apply to this option:

- Raw sewage flows of up to DWWF (i.e. 4 PDWF) will receive preliminary and primary treatment.
- Flows up to 3 ADWF will receive secondary treatment (and ammonia reduction) before being transferred, via Route A tunnel system, to Warriewood STP outfall for disposal.

- Flows greater than 3 ADWF, after primary treatment, will be retained in the Wet Weather Holding Tank (WWHT). The WWHT content will be returned to the secondary treatment train when able (i.e. during dry weather period).

- Overflow from the WWHT will receive fine screening before discharge to the local creek.

DESCRIPTION OF OPTION 7

The existing West Hornsby (WH) and Hornsby Heights (HH) STPs will be retained. The treatment facilities will continue to operate in their current design mode and provide nitrified secondary quality (i.e. BOD reduction and nitrification) for flows up to 3 ADWF.

Flows greater than 3 ADWF will be stored in a Wet Weather Holding Tank (WWHT) after receiving preliminary and primary treatment. The content of the WWHT will be returned to the secondary treatment train whenever possible (i.e. after the wet weather event).

In a prolonged wet weather event, any overflows from the Wet Weather Holding Tank (WWHT) will receive fine screening before discharged to the local creek.

The nitrified secondary effluent will be discharged into the transfer tunnel. As discussed in Section 12, Route A is proposed for the transfer of the STPs' effluent from the Berowra catchment to Warriewood STP site. The transfer tunnel/carrier will be connected directly to the Warriewood STP outfall, where the effluent can be discharged into the ocean.

A schematic diagram of Option 7 is shown in figure 15-1. A process flow diagram of the proposed Secondary Plant (which include WWHT) is shown in figure 15-2.

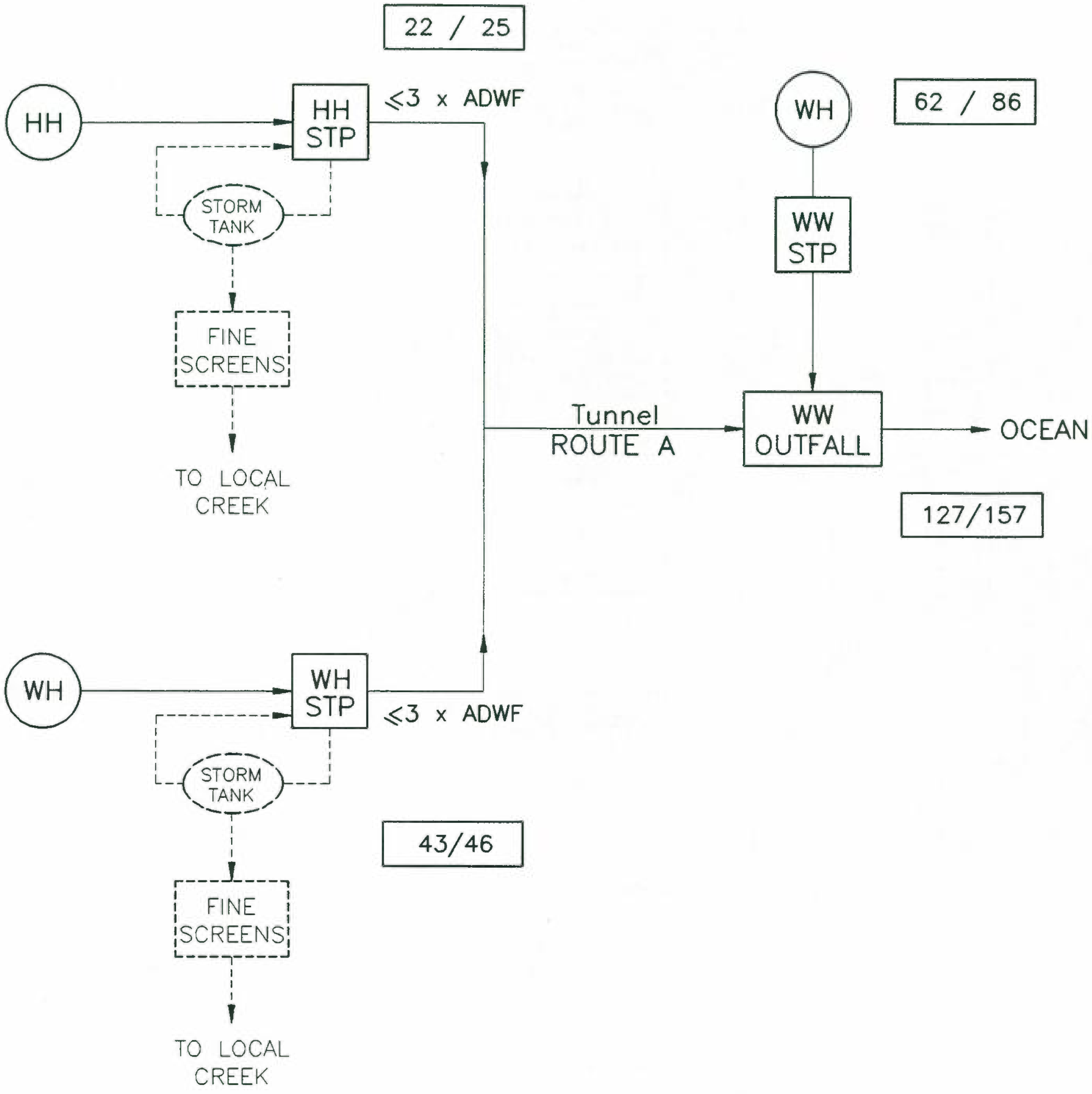
FACILITIES REQUIRED

The following facilities will be required under this option.

Flows and population projections

The current and future design flows adopted for the Hornsby plants have been previously discussed and are similar to that described in Option 5.

bc-dww



2002 / 2019 = Flows in Thousand EP

□ = Treatment Facility

○ = Catchment

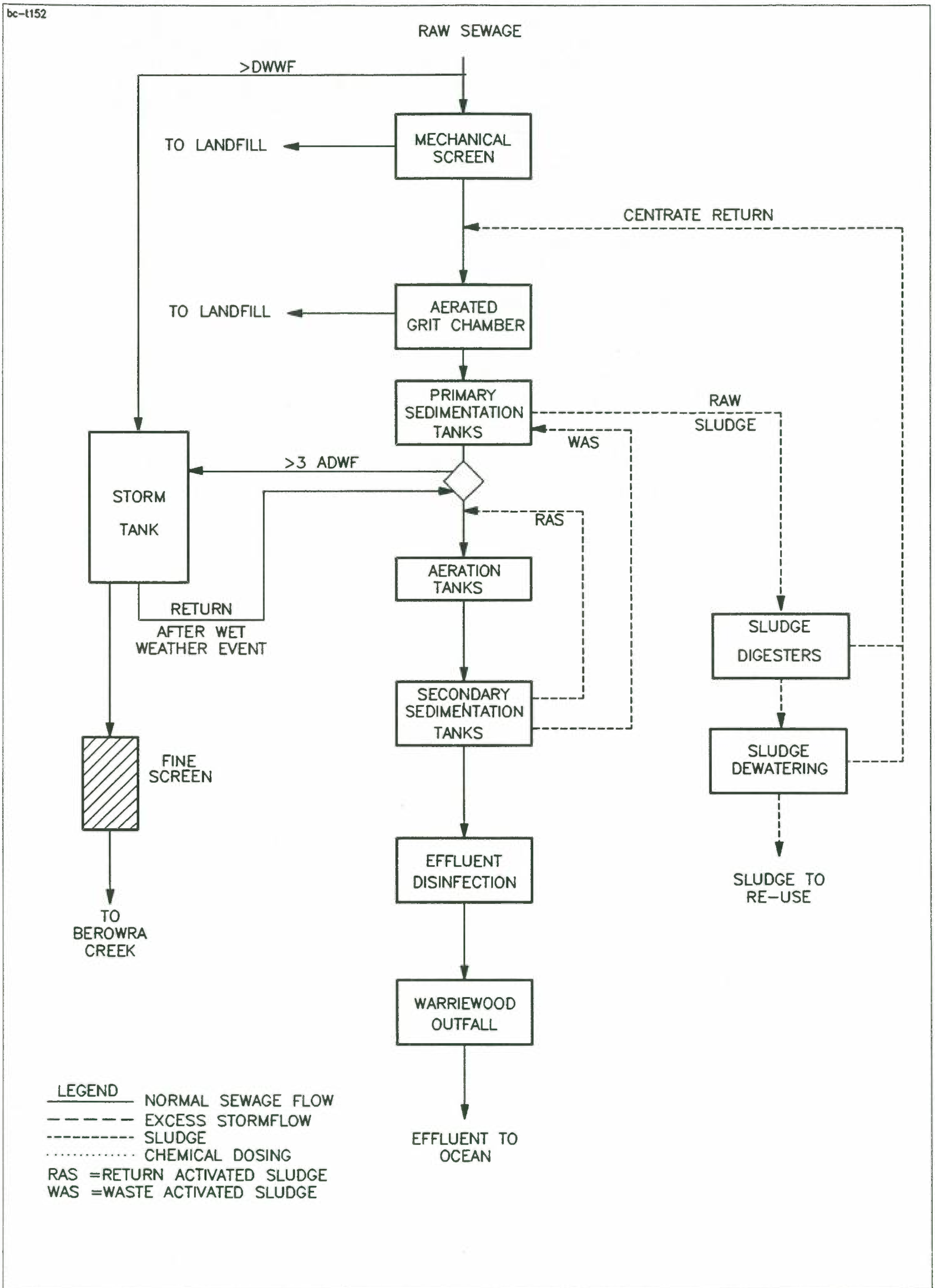
STP = Sewage Treatment Plant

HH = Hornsby Heights
WH = West Hornsby
WW = Warriewood
ADWF = Average Dry Weather Flow

WATER BOARD
SYDNEY-ILLAWARRA-BLUE MOUNTAINS
WASTEWATER AND REUSE PLANNING

OPTION 7
TREATED SEWAGE
TRANSFER SCHEME
FOR DRY & WET WEATHER

Figure
15-1



WATER BOARD
SYDNEY-ILLAWARRA-BLUE MOUNTAINS
WASTEWATER AND REUSE PLANNING

OPTION 7
SECONDARY STP (WITH NITRIFICATION)
PROCESS FLOW DIAGRAM
FOR DRY & WET WEATHER

Figure
15-2

Modifications to Existing STPs

West Hornsby and Hornsby Heights STPs will continue to operate as a secondary plants with nitrification (plus WWHT). The following facilities will be retained and operated on site. Additional structures will also be provided and are also indicated:

Screening and grit removal facilities.
Primary treatment facilities.
Aeration tank to achieve carbonaceous oxidation and nitrification.
Secondary clarifiers.
Multi-point chemical dosing systems.
Wet Weather Holding Tank (WWHT) with fine screening facilities.
WAS thickener.
Anaerobic digesters.
Sludge dewatering facilities.
Disinfection facilities.
Associated administration, control and maintenance facilities.
Existing tertiary filters decommissioned.

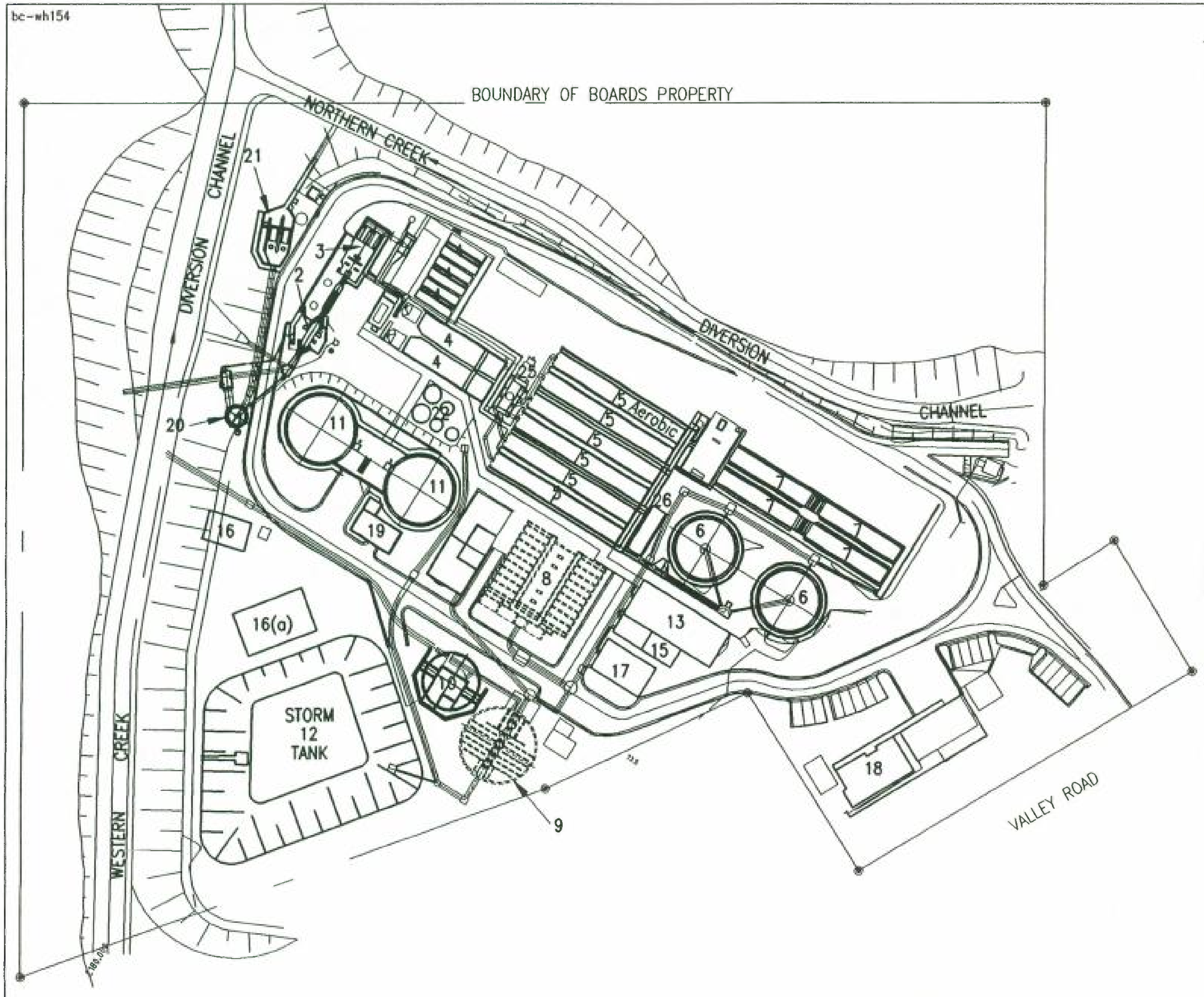
Figures 15-3 and 15-4 show the modified layout of the facilities at West Hornsby and Hornsby Heights STPs respectively.

The existing facilities at Hornsby Heights and West Hornsby STP were discussed in the previous sections of this report. The main modification to HH and WH STPs are:

- Construction of a WWHT, with pumping facilities to return content to the secondary treatment train.
- Fine screening to the WWHT overflow before discharged to creek.
- Connection to the transfer tunnel system.

The WWHT can be constructed by converting the sludge holding basins at West Hornsby and Hornsby Heights STPs. Control will be provided to return the content of WWHT to the secondary process train when treatment capacity is available (i.e. after wet weather events).

The nitrified secondary effluent will gravitate into the transfer tunnel, which will convey the effluent to Warriewood STP outfall for disposal.



LEGEND

1	SPS 490
2	SCREEN
3	AERATED GRIT CHAMBER
4	PRIMARY SEDIMENTATION TANKS
5	AERATION TANKS
6	CIRCULAR SECONDARY SEDIMENTATION TANKS
7	RECTANGULAR SECONDARY SEDIMENTATION TANKS
8	DUAL MEDIA FILTERS
9	CHLORINE CONTACT TANK
10	EFFLUENT PUMPING STATION
11	DIGESTERS
12	STORM TANK (MODIFIED HOLDING BASIN)
13	BLOWER HOUSE / RAS PUMPING STATION
14	RAS PUMPING STATION
15	11kV SUBSTATION
16	SLUDGE DEWATERING AREA
17	CHLORINATION BUILDING
18	ADMINSTRATION BUILDING
19	SLUDGE PUMPING STATION SPS 212
20	RAW SEWAGE FLOW SPLITTER
21	STORM FLOW FINE SCREENS
22	CHEMICAL DOSING FACILITIES (PHOSPHORUS REMOVAL) + ALKALINITY ADDITION
23	FILTERED WATER TANK
24	FOUL WATER TANK
25	FLOW SPLITTER
26	MIXED LIQUOR PUMPING STATION + MIXED LIQUOR RECYCLE

(a) SLUDGE DEWATERING FACILITY CURRENTLY UNDER CONSTRUCTION (INCLUDES CENTRIFUGES).

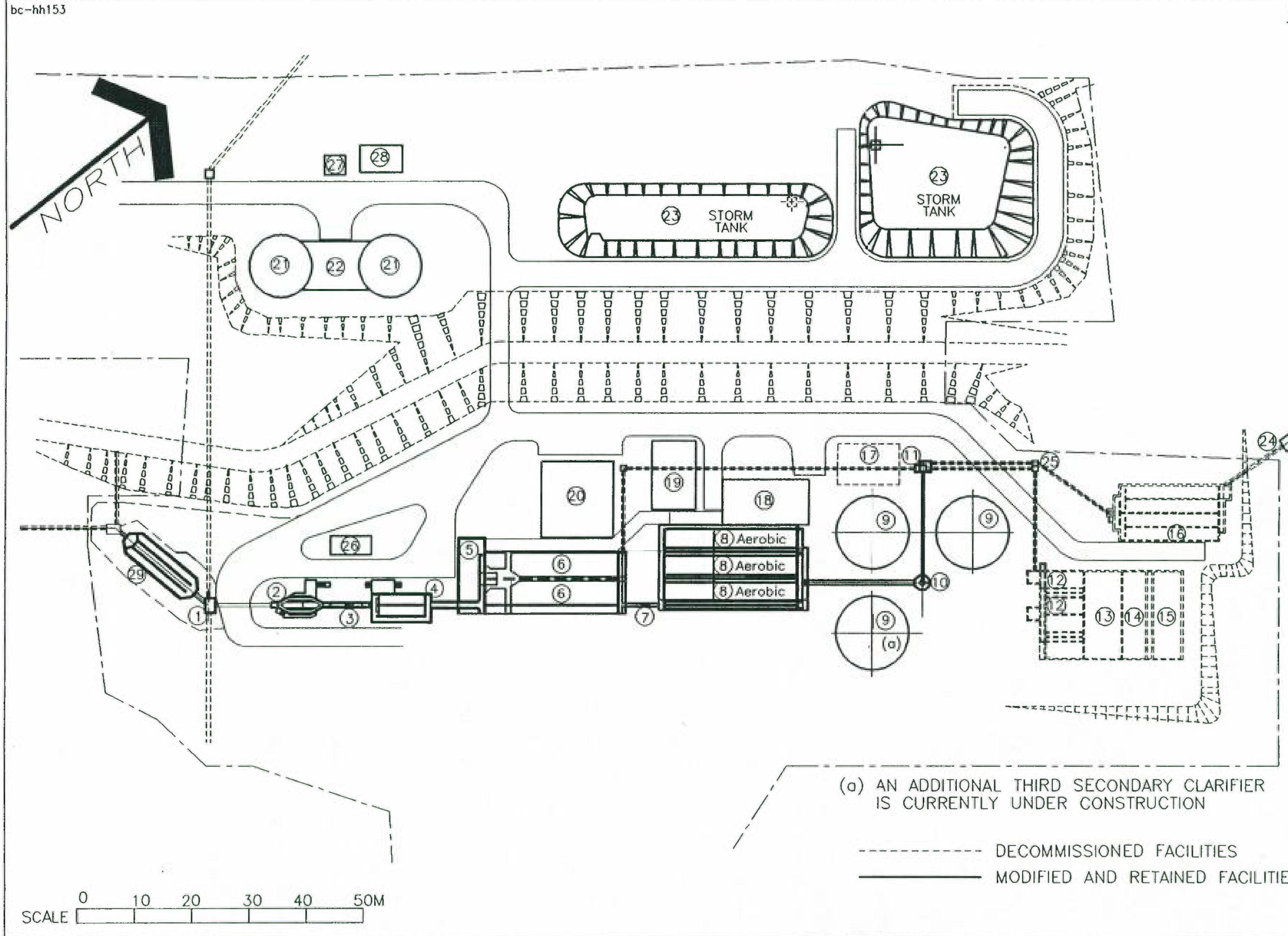
——— RETAINED/MODIFIED FACILITIES

– – – – – DECOMMISSIONED FACILITIES

WATER BOARD
SYDNEY–ILLAWARRA–BLUE MOUNTAINS
WASTEWATER AND REUSE PLANNING

OPTION 7
WEST HORNSBY S.T.P.
GENERAL ARRANGEMENT
SECONDARY PLANT (WITH NITRIFICATION AND STORM TANK)

Figure
15–3



(a) AN ADDITIONAL THIRD SECONDARY CLARIFIER IS CURRENTLY UNDER CONSTRUCTION

- - - - - - DECOMMISSIONED FACILITIES

——— MODIFIED AND RETAINED FACILITIES

LEGEND

1	COLLECTING MANHOLE
2	MECH. RAKED BAR SCREENS
3	CUT-THROAT FLUME (RAW SEWAGE)
4	AERATED GRIT CHAMBER
5	PRIMARY CONTROL BUILDING
6	PRIMARY SEDIMENTATION TANKS
7	CUT-THROAT FLUME (SETTLED SEWAGE)
8	AEROBIC REACTOR
9	SECONDARY SEDIMENTATION TANKS
10	MIXED LIQUOR DISTRIBUTION & EFFLUENT COLLECTION CHAMBER
11	SECONDARY EFFLUENT DIVERSION STRUCTURE
12	DUAL MEDIA FILTERS
13	FILTER CONTROL BUILDING
14	BACKWASH WATER HOLDING TANK
15	BACKWASH EFFLUENT HOLDING TANK
16	CHLORINATION TANKS
17	CHLORINATION BUILDING
18	BLOWER HOUSE INCLUDING RETURN & WASTE ACTIVATED SLUDGE PUMPS
19	ELECTRICITY SUB-STATION
20	ADMINISTRATION BUILDING
21	DIGESTION TANKS
22	DIGESTION CONTROL BUILDING
23	STORM TANK (MODIFIED ONE DISUSED SLUDGE LAGOON)
24	OUTFALL TO CREEK
25	SECONDARY EFFLUENT MANHOLE
26	INFLAMMABLE LIQUID STORE
27	WASTE GAS BURNER
28	SLUDGE DEWATERING BUILDING
29	SPS 542

WATER BOARD
SYDNEY-ILLAWARRA-BLUE MOUNTAINS
WASTEWATER AND REUSE PLANNING

OPTION 7
HORNSBY HEIGHTS S.T.P.
GENERAL ARRANGEMENT
SECONDARY PLANT (WITH NITRIFICATION AND STORM TANK)

Figure
15-4

Route A - Tunnel to Warriewood STP

As discussed in Section 12, the tunnel nominated as Route A will be used. Route A initially comprises two individual tunnels, from Hornsby Heights and West Hornsby STPs, merging into a common tunnel to Warriewood STP site. It will join up with the Warriewood STP outfall for the disposal of the transferred effluent directly into the ocean.

With a nominal tunnel size of 2.5 m x 1.5 m, the transfer tunnel will have more than sufficient capacity for the design flows and be, capable of delivering effluent produced from both Hornsby plants.

Warriewood STP Outfall

The existing Warriewood STP cliff-face outfall at Turimetta Head has sufficient capacity. Hence, no amplification is required.

SUMMARY OF FACILITIES FOR OPTION 7

Table 15-1 summarises the costs, capacities and implementation timeframe for the various components of Option 7.

TABLE 15-1. OPTION 7 REQUIREMENTS

Item	Size/Capacity	Capital Cost	Implementation Timeframe	Operating Cost (per annum)
Modification of Hornsby Hts	25,000 EP	$5 M	1 year	$1,578,000
Modification of West Hornsby	46,500 EP	$5 M	1 year	$2,572,000
Tunnel System	2.5 m x 1.5 m	$110 M	5 years	$25,000
Warriewood STP outfall connection		$1 M	1 year	$10,000

OPTION OVERVIEW

The following discussion provides a brief overview of Option 7.

Capital and Operating Costs

Based on preliminary assessment of the option, the Order-Of-Cost capital and operating costs are as follow:

Capital Cost is $ 121 million.
Operating Cost is $ 4.2 million (per annum Year 2002 cost).

Expected Implementation Timeframe

As discussed in Section 12 of this report and shown in Table 15-1, the timeframe for implementation of the tunnel scheme is the longest of all the component parts for Option 7 and is expected to be completed in about 5 years after construction starts.

Whilst the scheme is being constructed, the existing Hornsby Heights and West Hornsby STPs will continue to discharge its effluent into Berowra Creek. This will continue to have the present environmental impact on the Berowra Creek and no improvement is expected until the year 2002.

Effluent Quality

This option will relieve Berowra Creek waterways of all treatment plant effluent discharges substantially.

Based on flow data to the Hornsby plants over the past 3 years (refer Section 3), 98 per cent of the incoming flows are less than or equal to the 3 ADWF allowance. Similarly approximately 99 per cent of the flows are less than or equal to 3 ADWF. By providing properly sized WWHT facilities, the occurrence of storm water discharge to Berowra Creek can be dramatically reduced.

The only time when there may be discharges to the local creek is when the tunnel system is undergoing major repair or major maintenance, however, one can assume that this occurrence will be very limited. Should the tunnel be taken off-line and with proper operation of the system, all flows will receive primary and secondary treatment before discharges to the local creek.

The transferred plant effluent, when discharged to the ocean, will be of secondary quality and also low in ammonia concentration. This effluent quality will comply with the long-term goal of the EPA's EG-1 guidelines.

Land Requirements

For West Hornsby and Hornsby Heights STPs no additional lands beyond that already existing at the plants is required under Option 7.

Additional land will, however, be required to accommodate the major access shafts along the route of the Transfer Tunnel. The area for each shaft will be approximately 100 square metres.

Operational Aspects

With the conversion of the tertiary facilities at Hornsby Heights and West Hornsby STPs to a secondary treatment process (with nitrification), the operational requirements (i.e. labour, power and chemical) at the two facilities can be reduced slightly. Present skill level of the current operators will still be required to run the modified facilities.

Additional labour will be required to maintain and inspect the "transfer tunnel/carrier" with control and telemetry being provided to ensure proper operation of the transfer system.

Environmental Impacts/Benefit

As for Options 5, the removal of effluent disposal from the Berowra Creek catchment will be assured in Option 6. Nutrients, will special regard to nitrogen, will be transferred to the ocean for disposal. Although this option may achieve zero discharges to Berowra Creek, the reduction in algal bloom occurrences in the estuarine section are unknown. The lost of effluent dilution in the receiving waters may also have a negative impact.

An additional major impact will be caused by the construction and maintenance of the transfer tunnel/carrier from the Berowra catchment to the Warriewood STP site. The selection of the route will have to be treated with extreme care and sensitivity. No possible overflow and discharge from the tunnel/carrier is allowable along the whole transfer route. Odour will not be a problem because of its secondary quality effluent. Odour control, however, will be performed along the route to mitigate odour complaints from the nearby residents if it eventuates.

There will be some impact associated with the connection of the transfer scheme to the Warriewood STP outfall. The impact will be experienced by the residents especially during the construction phase, e.g. machinery and truck movements, noisy construction activities, etc.

During the operational phase of the two Hornsby STPs, there will be increased of truck movements due to chemical supplies, solid waste and sludge removal when compared to the Options 1, 2 and 4.

The impact of the receiving waters, i.e. ocean off Turimetta Head, will be minimal. In dry weather, nitrified secondary effluent from the Hornsby plants will be discharged.

Beneficial Reuse

With the Board's present policy in encouraging residual and effluent reuse, part of the flow treated will be retained for reuse. Effluent reuse within the STPs will occur using the high quality effluent produced. The majority of effluent, however, will be transferred out of the Berowra catchment and will be discharged into the ocean.

In the future, if there are external markets (e.g. nurseries, golf courses etc) available along the route, it may be possible to tap into the tunnel to extract the treated effluent for reuse. This will, however, be quite expensive and the cost will need to be borne by the user.

At present, all digested and dewatered sludge from Hornsby Heights and West Hornsby STPs are used for beneficial reuse, i.e. composting. This will continue to occur provided the sludge produced is of good and consistent quality.

Other Considerations

The community's acceptance of the scheme will be one of the most important considerations in the adoption of this option. This will be particularly true for the community living in the Warriewood area.

SECTION 16

OPTION 8 - DRY WEATHER RAW SEWAGE TRANSFER TO WARRIEWOOD STP

This option aims to relieve the Berowra Creek waterways of sewage-origin pollutant loads during dry weather conditions by transporting dry weather flows (i.e. up to 3 ADWF) to the ocean. For this option, raw sewage flows will be transferred to Warriewood STP, where it will be treated prior to disposal via the existing cliff-face outfall.

For Option 8, the following will be provided:

- West Hornsby (WH) and Hornsby Heights (HH) STPs will be modified into storm STPs or SSTP (as per Fairfield SSTP) and wet weather flows after treatment being discharged into the local creek.
- Inlet structure modification to WH and HH SSTPs.
- A transfer tunnel will be constructed (as per Route A described in Section 12) from WH and HH SSTPs to Warriewood STP.
- Amplification of Warriewood STP to treat and dispose all the transferred flows and load.

The following assumptions apply to this option:

- Raw sewage flows of up to 3 ADWF will be transferred to Warriewood STP for treatment and disposal,
- Flows greater than 3 ADWF will be treated in the SSTP at the Hornsby plants being discharged into Berowra Creek, and
- Flows greater than DWWF will be bypassed and will receive fine screening before discharged to the local creek.

DESCRIPTION OF OPTION 8

The existing inlet structures at West Hornsby (WH) and Hornsby Heights (HH) STPs will be modified to enable flows of up to 3 ADWF to flow into the transfer tunnel. As no pumping is proposed, raw sewage will gravitate to Warriewood STP for treatment and disposal.

The modified inlet structure will have a bypass facility for wet weather flows greater than 3 x ADWF to divert flows to a Storm STP (SSTP). The treated effluent from the SSTP will be discharged into the local creek. The SSTP is comonly referred to as the chemical assisted sedimentation (CAS) process.

Flows greater than DWWF will be bypassed from the inlet structure and discharged to the local creek after receiving fine screening.

Unlike Option 5, no Wet Weather Holding Tank (WWHT) will be provided for this option.

As discussed in Section 12, Route A is proposed for the transfer of raw sewage from the Berowra catchment to Warriewood STP.

As the transferring of flow in this option is in addition to the local Warriewood catchment, Warriewood STP will need to be amplified to cope with the additional hydraulic and pollutant load.

A schematic diagram of this option is shown in figure 16-1. A process flow diagram of the proposed Storm STP (SSTP) is also shown in figure 16-2.

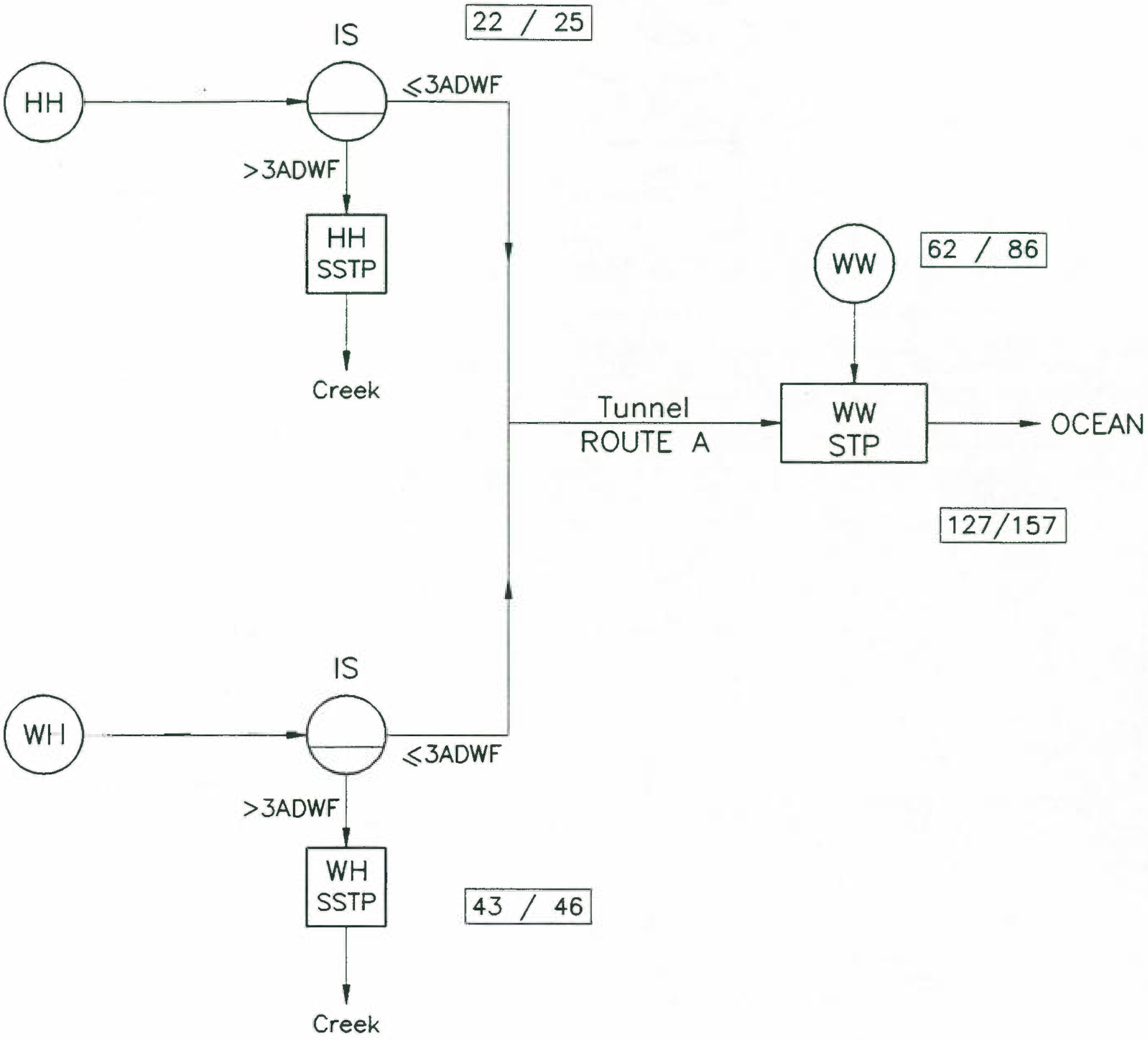
FACILITIES REQUIRED

Option 8 proposes the installation of the following facilities at the Hornsby plants and Warriewood STP.

Flows and Population Projections

The current and design flows adopted for the West Hornsby and Hornsby Heights catchments were previously discussed and are similar to that described in Option 5. The only difference is the transfer of flows of up to 3 ADWF, rather than DWWF. Table 16-1 shows the EP and flow projections for the two catchments.

bc-t161



2002 / 2019 = Flows in thousand EP

☐ = Treatment Facility

○ = Catchment

SSTP = Storm Sewage Treatment Plant

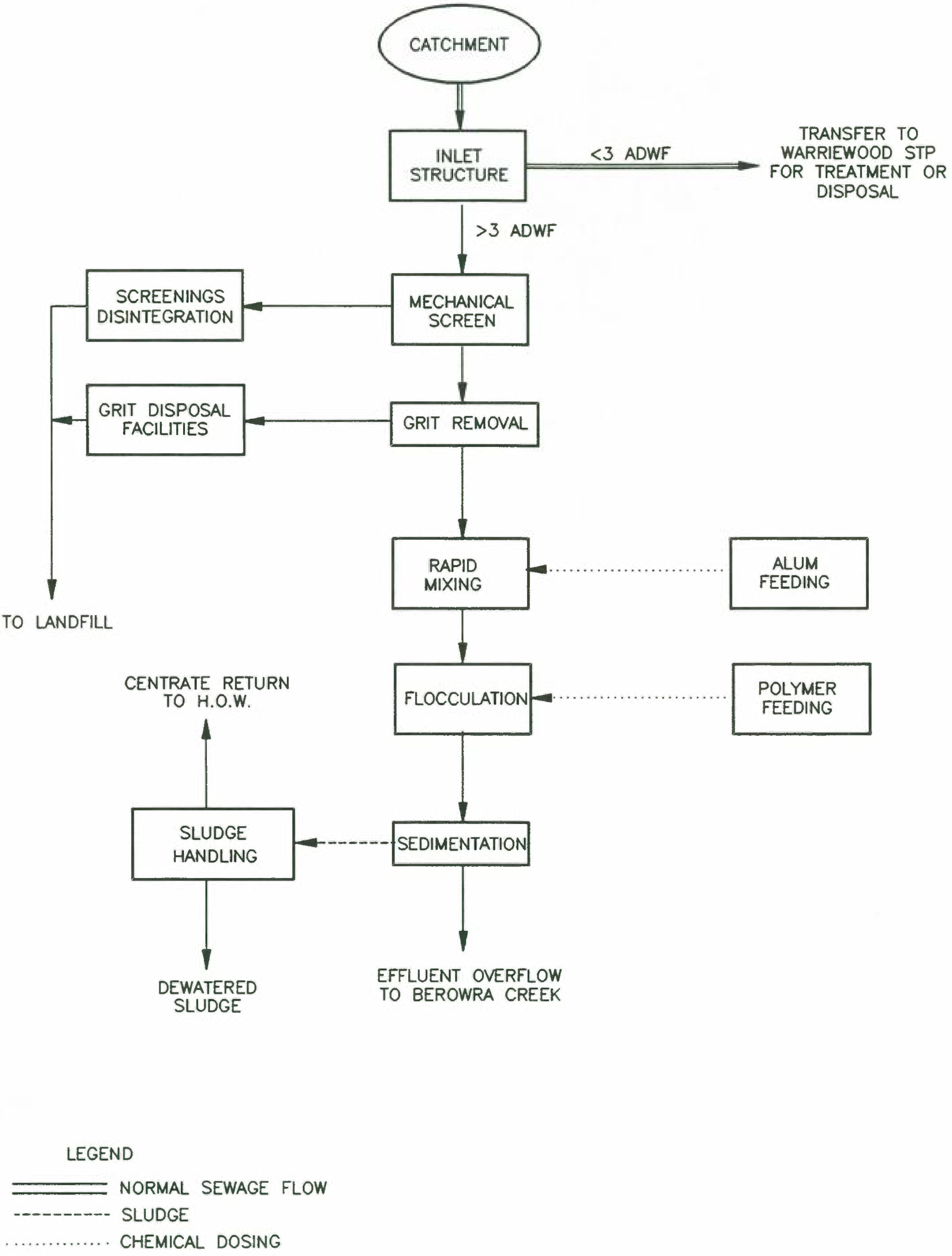
STP = Sewage Treatment Plant
IS = Inlet Structure
HH = Hornsby Heights
WH = West Hornsby
WW = Warriewood
ADWF = Average Dry Weather Flow

WATER BOARD
SYDNEY-ILLAWARRA-BLUE MOUNTAINS
WASTEWATER AND REUSE PLANNING

OPTION 8
RAW SEWAGE TRANSFER SCHEME
FOR DRY WEATHER ONLY

Figure
16-1

bc-t162



WATER BOARD
SYDNEY-ILLAWARRA-BLUE MOUNTAINS
WASTEWATER AND REUSE PLANNING

OPTION 8
STORM S.T.P.
PROCESS FLOW DIAGRAM

Figure
16-2

TABLE 16-1. CURRENT AND PROJECTED DESIGN EP FLOWS FOR HORNSBY STPs

STP	EP ('000)/ ADWF-3xADWF Flows (ML/d)			
	1994	2000	2005	2019
West Hornsby	18.8/5.1-15	21.6/5.8-17	23.5/6.4-19	25/6.7-20
Hornsby Hts	35/9.5-28	41/11-33	45/12-36	46/12.5-38

Modifications to Existing STPs

Modification to the existing facilities at Hornsby Heights and West Hornsby STPs will be required to convert them to a Flow Transfer/Storm Plant facility.

West Hornsby and Hornsby Heights STPs will be modified to provide the following facilities:

A new modified inlet structure, with bypass facilities.
Screening and grit removal facilities.
Rapid mixing and flocculation facilities.
Primary treatment facilities.
Chemical dosing systems.
Fine screening facility on the bypass stream.
Sludge thickening and dewatering.

Figures 16-3 and 16-4 show the modified layout of the facilities at West Hornsby and Hornsby Heights SSTPs respectively.

With the new inlet structure, the flow will gravitate into the proposed transfer tunnel which will convey the flow to Warriewood STP.

Route A - Tunnel to Warriewood STP

According to the proposed tunnel system, as described in Section 12, Route A will be used and it will have sufficient capacity to take all flows from the two catchments. Route A initially comprises of two individual tunnels, from Hornsby Heights and West Hornsby STPs, merging into a common tunnel to Warriewood STP. The last 3 km of the transfer scheme is by gravity mains due to the sandy soil conditions experienced in the Warriewood area.

With a nominal tunnel size of 2.5 m x 1.5 m, the tunnel will have more than sufficient capacity for the design flow and will be capable of delivering flows of up to 3 ADWF for 75,000 EP.

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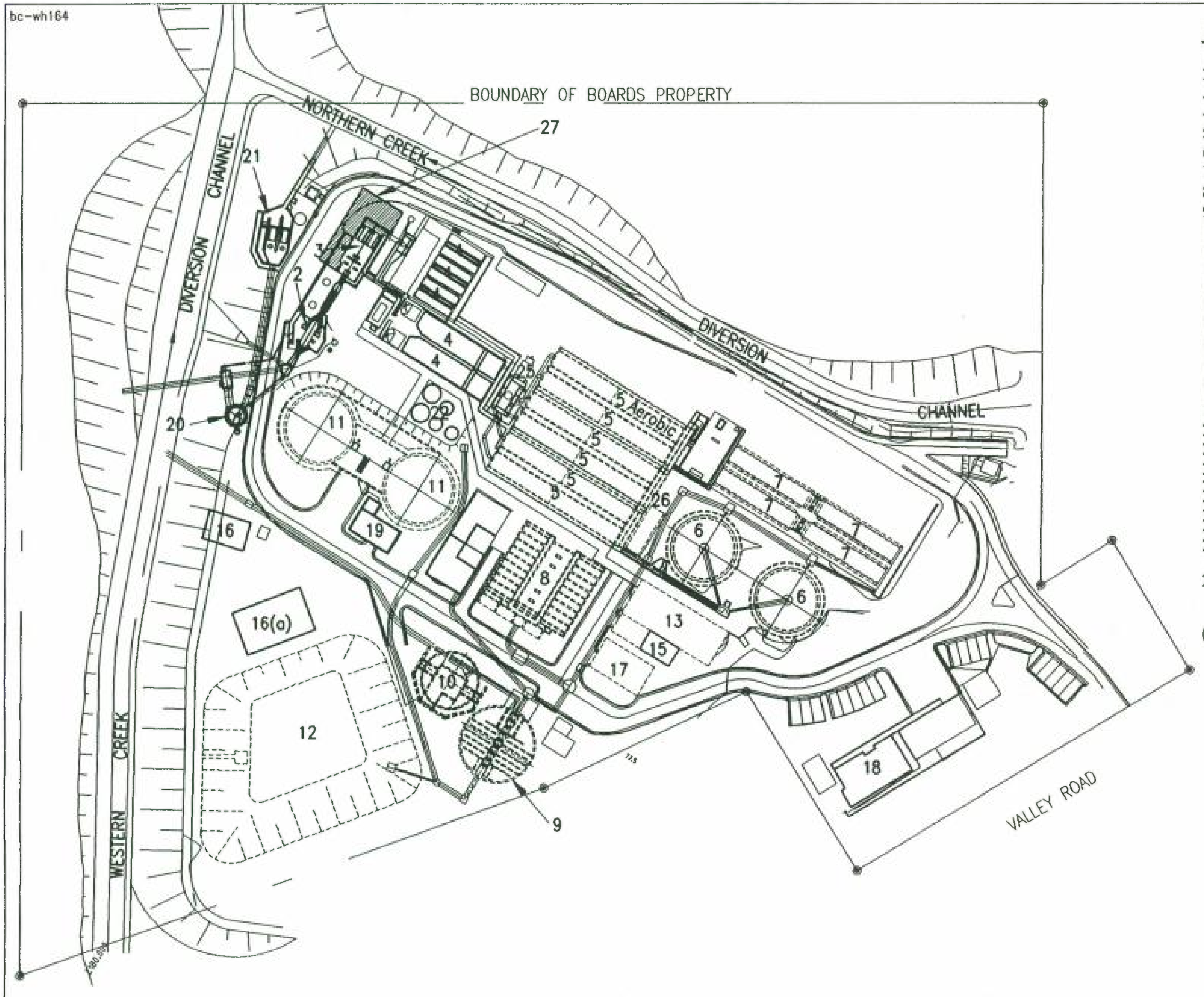


LEGEND
1 SPS 490
2 SCREEN
3 AERATED GRIT CHAMBER
4 PRIMARY SEDIMENTATION TANKS
5 AERATION TANKS
6 CIRCULAR SECONDARY SEDIMENTATION TANKS
7 RECTANGULAR SECONDARY SEDIMENTATION TANKS
8 DUAL MEDIA FILTERS
9 CHLORINE CONTACT TANK
10 EFFLUENT PUMPING STATION
11 DIGESTERS
12 HOLDING BASIN
13 BLOWER HOUSE / RAS PUMPING STATION
14 RAS PUMPING STATION
15 11kV SUBSTATION
16 SLUDGE DEWATERING AREA
17 CHLORINATION BUILDING
18 ADMINSTRATION BUILDING
19 SLUDGE PUMPING STATION SPS 212
20 RAW SEWAGE FLOW SPLITTER
21 STORM FLOW FINE SCREENS
22 CHEMICAL DOSING FACILITIES
23 FILTERED WATER TANK
24 FOUL WATER TANK
25 FLOW SPLITTER
26 MIXED LIQUOR PUMPING STATION + MIXED LIQUOR RECYCLE
27 RAPID MIXING AND FLOCCULATION

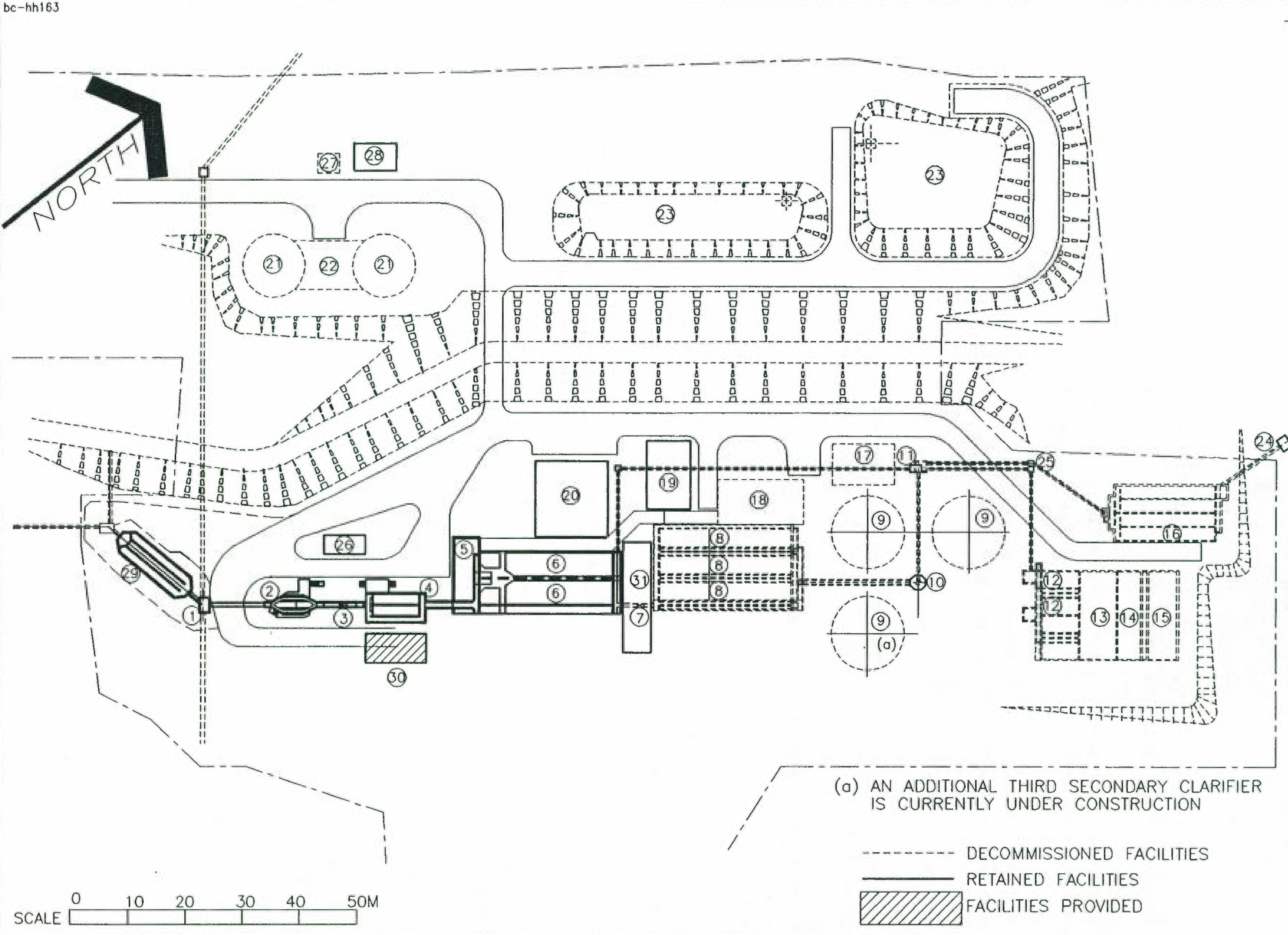
(a) SLUDGE DEWATERING FACILITY CURRENTLY

- - - - - DECOMMISSIONED FACILITIES
——— RETAINED/MODIFIED FACILITIES
▨ FACILITIES PROVIDED

WATER BOARD
SYDNEY–ILLAWARRA–BLUE MOUNTAINS
WASTEWATER AND REUSE PLANNING

WEST HORNSBY S.T.P.
GENERAL ARRANGEMENT
STORM PLANT

Figure
16–3



(a) AN ADDITIONAL THIRD SECONDARY CLARIFIER IS CURRENTLY UNDER CONSTRUCTION

LEGEND

1 COLLECTING MANHOLE
2 MECH. RAKED BAR SCREENS
3 CUT-THROAT FLUME (RAW SEWAGE)
4 AERATED GRIT CHAMBER
5 PRIMARY CONTROL BUILDING
6 PRIMARY SEDIMENTATION TANKS
7 CUT-THROAT FLUME (SETTLED SEWAGE)
8 ANOXIC/AEROBIC REACTOR
9 SECONDARY SEDIMENTATION TANKS
10 MIXED LIQUOR DISTRIBUTION & EFFLUENT COLLECTION CHAMBER
11 SECONDARY EFFLUENT DIVERSION STRUCTURE
12 DUAL MEDIA FILTERS
13 FILTER CONTROL BUILDING
14 BACKWASH WATER HOLDING TANK
15 BACKWASH EFFLUENT HOLDING TANK
16 CHLORINATION TANKS
17 CHLORINATION BUILDING
18 BLOWER HOUSE INCLUDING RETURN & WASTE ACTIVATED SLUDGE PUMPS
19 ELECTRICITY SUB-STATION
20 ADMINISTRATION BUILDING
21 DIGESTION TANKS
22 DIGESTION CONTROL BUILDING
23 SLUDGE LAGOONS (DISUSED)
24 OUTFALL TO CREEK
25 SECONDARY EFFLUENT MANHOLE
26 INFLAMMABLE LIQUID STORE
27 WASTE GAS BURNER
28 SLUDGE DEWATERING BUILDING
29 SPS 542
30 RAPID MIXING/FLOCCULATION
31 CHEMICAL DOSING

WATER BOARD
SYDNEY-ILLAWARRA-BLUE MOUNTAINS
WASTEWATER AND REUSE PLANNING

HORNSBY HEIGHTS S.T.P.
GENERAL ARRANGEMENT
STORM PLANT

Figure
16-4

Warriewood STP

As discussed in Section 13 regarding the implementation of staging and the effluent requirement, Warriewood STP would also require amplification and upgrade to coincide with the implementation of the transfer scheme.

Similarly to Option 5, Warriewood STP will need to be amplified and upgraded to cope with additional loads and of produce a nitrified secondary effluent.

Unlike Option 5, however, the facilities provided can be sized to treat pollutant loads and flows of up to 3 ADWF from the Berowra Catchment.

Although the actual size of tanks would be slightly smaller, the layout of the amplified Warriewood STP would be similar to that of figure 13-9.

Warriewood STP Outfall

The existing Warriewood STP effluent main and cliff-face outfall at Turimetta Head has sufficient capacity. Hence, no amplification is required.

SUMMARY OF FACILITIES FOR OPTION 8

Table 16-2 summarises the costs, capacities and implementation timeframe for the various components of Option 8.

TABLE 16-2. OPTION 8 REQUIREMENTS

Item	Size/Capacity	Capital Cost	Implementation Timeframe	Operating Cost (per annum)
Modification of Hornsby Hts	25,000 EP	$4 M	1 years	$290,000
Modification of West Hornsby	46,500 EP	$4 M	1 years	$390,000
Tunnel System	2.5 m x 1.5 m	$110 M	5 years	$25,000
Warriewood STP Amplification and Upgrade	160,000 EP (80,000 EP for this Option)	$30 M	3 years	$3,520,000

OPTION OVERVIEW

The following paragraphs briefly summarise the particular characteristics of Option 8.

Capital and operating costs

Based on preliminary assessment of the option, the Order-Of-Cost capital and operating costs are as follow:

Capital Cost is $ 148 million.
Operating Cost is $ 4.2 million per annum at Year 2002.

Expected Implementation Timeframe

As discussed in Section 12 of this report and shown in Table 16-2, the timeframe for implementation of the tunnel scheme is the longest of all the component parts for Option 8 and is expected to be completed in about 5 years after construction starts.

Whilst the scheme is being constructed, the existing Hornsby Heights and West Hornsby STPs will continue to discharge their effluent into Berowra Creek. This will continue to have the current environmental impact on the Berowra Creek and no improvement is expected until the year 2002.

Effluent Quality

This option will relieve Berowra Creek waterways of sewage-origin pollutant substantially in dry weather. Wet weather flows greater than 3 ADWF, however, will be discharged after receiving physical chemical treatment.

Discharges of storm treated flows to the local creek may also occur when the tunnel system is undergoing major repair or major maintenance. One can assume, however, that this occurrence will be very limited. Should the tunnel be taken off-line flows would receive CAS treatment (for flows up to DWWF) before discharging to the local creek.

All flows transferred to Warriewood STP will receive secondary treatment and nitrification. This effluent quality will comply with the long-term goal of the EPA's EG-1 guidelines for ammonia and other pollutants.

Land Requirements

No additional land is required at West Hornsby or Hornsby Heights STP under this option.

Additional land would be required, however, to accommodate the major access shafts along the route of the Transfer Tunnel. The location of each access shaft will be purposely chosen to not have any major impact on bushland areas as discussed in Section 12. The area for each shaft will be approximately 100 square metres.

Like Option 5, the amplification and upgrade of Warriewood STP will be contained within the Board's boundary, which is about 14.9 Ha. Hence, no additional land is required.

Operational Aspects

With the conversion of the tertiary facilities to Hornsby Heights and West Hornsby STPs to storm CAS treatment plants the operational requirements (i.e. labour, and chemical) at the two facilities can be reduced. As discussed earlier, flow greater than 3 ADWF will be treated at the two sites. It is considered less complex to operate a SSTP compared with a tertiary treatment plant. Hence, slightly skilled operators can be deployed for the SSTP. Because the facilities will be used only during wet event, manpower will be required only to provide regular service and maintenance to all the facilities, i.e. pumping, screening and grit removal, chemical dosing and storage facilities.

Additional labour will be required to maintain and inspect the "transfer tunnel/carrier". Control and telemetry will be required to ensure proper operation of the transfer system.

Like Option 5, the main operating consideration of this option will be associated with the operation of the amplified Warriewood STP. This will include automatic control and telemetry system within the STP, skilled labour, power, and chemicals; and more regular servicing and maintaining of equipment.

Unlike Option 5, this option requires the operation of three major treatment facilities.

Environmental Impacts/Benefit

Under Option 8 dry weather flows will be removed from Berowra Creek. The impact on the creek cannot be ascentained at this stage since the removal of effluent flows may not only have a major impact on dilution, but the occurrence of algal blooms may not be reduced significantly.

During the implementation phase, impacts will also be associated with the modification of the existing facilities at Hornsby Heights and West Hornsby STPs. These include the modification of the inlet structure and modifying to a SSTP set-up.

An additional impact will be caused by the construction and maintenance of the transfer tunnel/carrier from the Berowra catchment to the Warriewood STP site.

The next major impact will be that associated with a major amplification of Warriewood STP. The amplification and upgrade (i.e. to provide nitrification capability) of Warriewood STP will be a large addition of facilities on-site. The impact will be experienced by the residents especially during the construction phase, e.g. machinery and truck movements, noisy construction activities, etc.

During the operational phase at all the facilities, there will be a decrease in truck movements due to lower chemical supplies, solid waste and sludge removal.

The impact of the receiving waters, i.e. ocean off Turimetta Head, will be minimal. In dry weather and normal operation of the STP facilities, nitrified secondary effluent will be discharged. In addition, the plant's effluent receives chlorination before discharges to the ocean. This will dramatically reduce effluent's faecal coliform numbers to acceptable levels prior to discharge into the receiving waters.

In wet weather events, however, flows greater than 3 ADWF will be treated at the proposed CAS plants at West Hornsby and Hornsby Heights STPs respectively. The flow will undergo chemical treatment before discharge into the local creek. This will have some environmental impact on the creek's receiving water.

Beneficial Reuse

With the Board's present policy of encouraging residual and effluent reuse, part of the flow treated will be reused. Effluent reuse within the STP will occur using the high quality effluent produced. External markets will be sought to take up more effluent. These potential markets may include golf courses, nurseries, council parks and industrial applications.

At present, all digested and dewatered sludge from Warriewood STP is used for beneficial reuse, i.e. composting. This will continue to occur provided the sludge produced is of good and consistent quality.

Other Considerations

The community's acceptance of the scheme will be one of the most important considerations in the adoption of this option. This will be particularly true for the community living in the Warriewood area.

SECTION 17

OPTION 9 - DRY WEATHER RAW SEWAGE TRANSFER TO NORTH HEAD STP

Like Option 8, this option aims to relieve the Berowra Creek waterways of sewage-origin pollutant loads during dry weather conditions by transporting dry weather flows (i.e. up to 3 ADWF) to the ocean. For this option, the destination of the transfer is North Head STP, where the raw sewage is treated and disposed via the deepwater ocean outfall.

Option 9 is a variation of Option 6 and the facilities previously specified are similar.

For Option 9, the following will be provided :-

- West Hornsby (WH) and Hornsby Heights (HH) STPs will be modified into Storm STPs or SSTP (as per Fairfield SSTP) and effluent discharged into the local creek.
- Inlet structure modification to WH and HH SSTPs.
- A transfer tunnel will be constructed (as per Route B described in Section 12) from WH and HH SSTPs to North Head STP.
- Modification to North Head STP's inlet and new influent pumping station.

The following assumptions will be applied to the option:

- Raw sewage flows of up to 3 ADWF will be transferred to North Head STP for treatment and disposal.
- Flows greater than 3 ADWF will be treated in the SSTP before discharge to Berowra Creek.
- Flows greater than DWWF will be bypassed and will receive fine screening before discharged to the local creek.

DESCRIPTION OF OPTION 9

The existing inlet structures at Hornsby Heights (HH) and West Hornsby (WH) STPs will be modified to enable flows of up to 3 ADWF to flow into the transfer tunnel. As no pumping is proposed, raw sewage will gravitate to North Head STP for treatment and disposal via the deepwater ocean outfall.

The modified inlet structure will have a bypass facility for wet weather flows greater than 3 ADWF to divert the flows to a Storm STP (SSTP). The treated effluent from the SSTP will be discharged into the local creek. The SSTP is a CAS process and will rely on physical/chemical treatment to remove pollutants.

Flows greater than DWWF will be bypassed from the inlet structure and discharged to the local creek after receiving fine screening.

As discussed in Section 12, Route A is proposed for the transfer of raw sewage from the Berowra catchment to North Head STP.

A schematic diagram of this option is shown in figure 17-1. A process flow diagram of the proposed Storm STP (SSTP) is shown in figure 17-2.

FACILITIES REQUIRED

The facilities discussed below are proposed to be provided in Option 9.

Flows and population projections

The current and design flows adopted for the Hornsby plants have been detailed previously and are similar to those described in Option 8 (i.e. Table 16-1).

Modification to existing STPs

The modifications required to convert the existing facilities at West Hornsby and Hornsby Heights STPs into Storm STPs will be the similar to those proposed in Option 8 (Section 16 of this report). Like Option 8, no wet weather holding tank (WWHT) will be provided for this Option.

Figures 16-3 and 16-4 (shown in Section 16) show the modified layout of the facilities at Hornsby Heights and West Hornsby SSTPs respectively.

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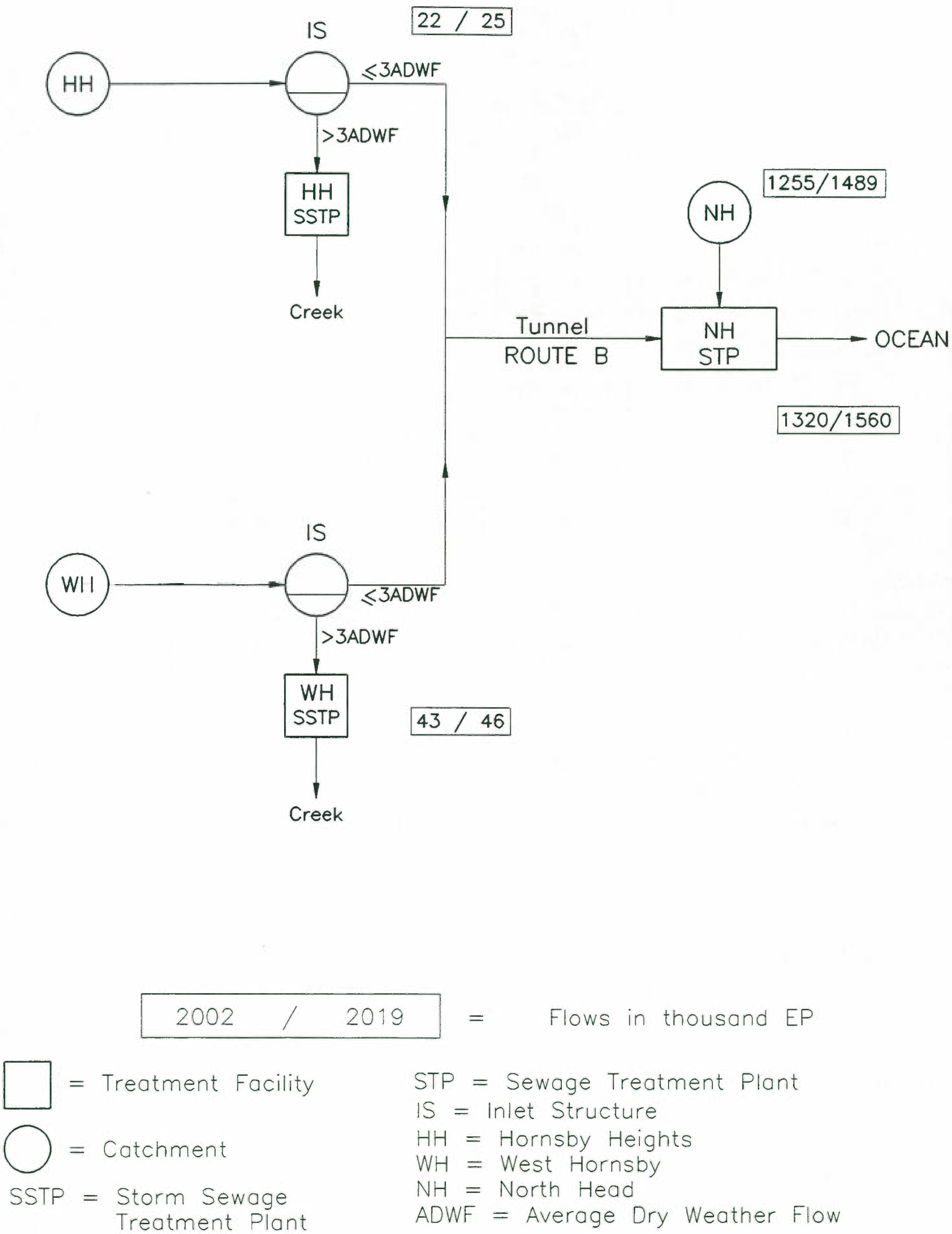
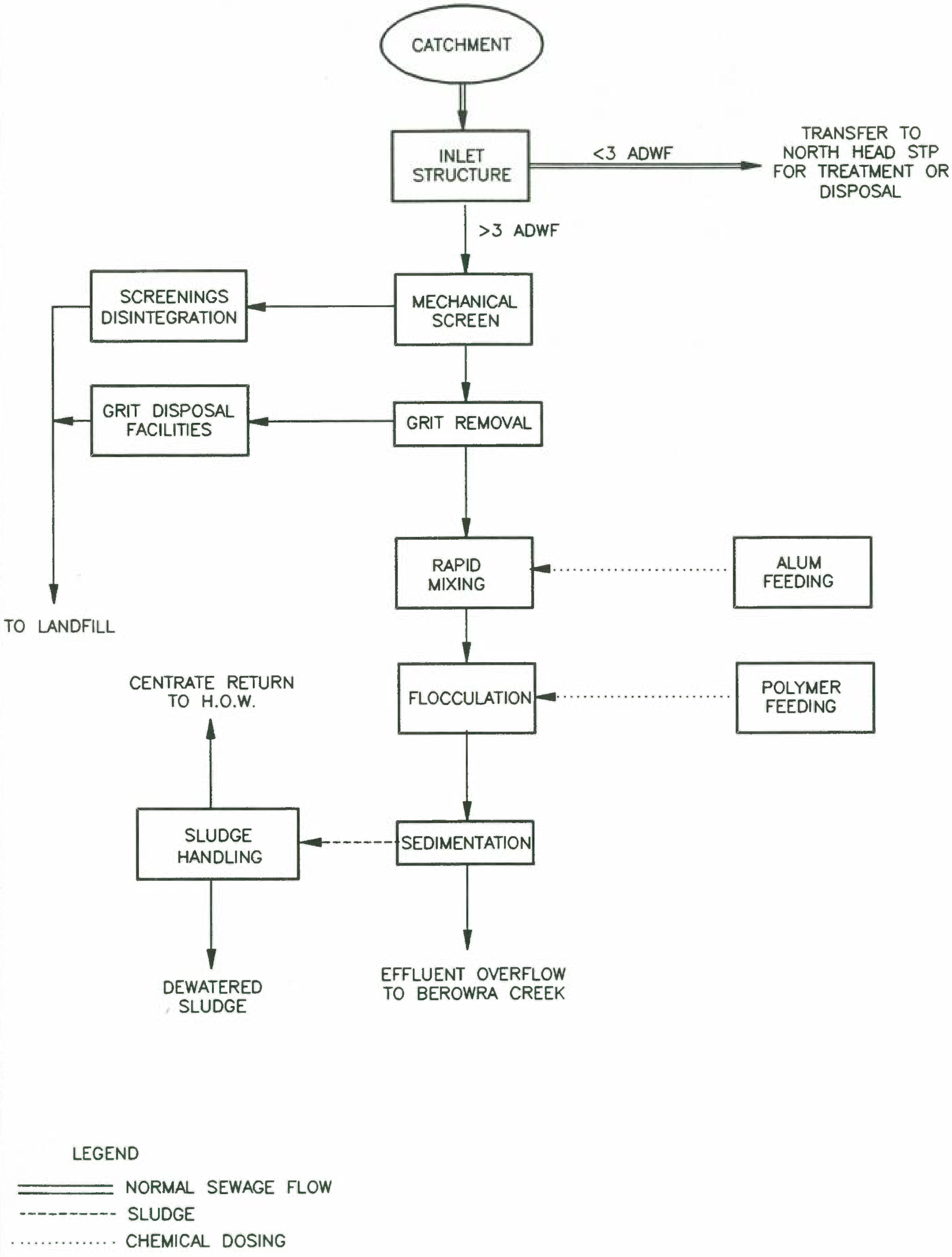


WATER BOARD
SYDNEY-ILLAWARRA-BLUE MOUNTAINS
WASTEWATER AND REUSE PLANNING

OPTION 9
RAW SEWAGE TRANSFER SCHEME
FOR DRY WEATHER ONLY

Figure
17-1

bc-t172



WATER BOARD
SYDNEY–ILLAWARRA–BLUE MOUNTAINS
WASTEWATER AND REUSE PLANNING

OPTION 9
STORM S.T.P.
PROCESS FLOW DIAGRAM

Figure
17–2

Route B - Tunnel to North Head STP

According to the proposed tunnel system, as described in Section 12, Route B will be used and it will have sufficient capacity to take all flows from the two catchments. Route B initially comprises two individual tunnels, from Hornsby Heights and West Hornsby STPs, merging into a common tunnel to North Head STP.

With a nominal tunnel size of 2.5 m x 1.5 m, it will have more than sufficient capacity to accept the proposed flows for the Hornsby plants.

North Head STP

Refer to Section 14 for a detailed summary of existing facilities at North Head STP.

Based on the information provided in Section 14, and regarding the implementation of staging, North Head STP will require minimal modification to suit this option. Like Option 6, new influent pumping station and one sedimentation tank is assumed as the capital expenditure for this option.

Unlike Option 6, the facilities provided can be sized to treat pollutant loads and flows of up to 3 ADWF. This flow regime will give rise to slightly smaller pumps and tank. For this investigation, however, the facility will be assumed to be similar to that of Option 6; and the layout as per Figure 14-7.

North Head STP Deepwater Ocean Outfall

The existing North Head STP deepwater ocean outfall has sufficient capacity for about 2,060,000 EP flow. Hence, no amplification is required.

SUMMARY OF FACILITIES FOR OPTION 9

Table 17-1 summarises the costs, capacities and implementation timeframe of the various components of Option 9.

TABLE 17-1. OPTION 9 REQUIREMENTS

Item	Size/Capacity	Capital Cost	Implementation Timeframe	Operating Cost (per annum)
Modification of Hornsby Hts	25,000 EP	$4 M	1 year	$290,000
Modification of West Hornsby	46,500 EP	$4 M	1 year	$390,000
Tunnel System	2.5 m x 1.5 m	$120 M	5 years	$30,000
North Head STP Amplification and Upgrade	One sed. Tank and inlet pumps	$7 M	1 year	$910,000

OPTION OVERVIEW

The following overview is provided for Option 9. It is not exhaustive as further comparision will be undertaken later in the report.

Capital and Operating Costs

Based on preliminary assessment of the option, the Order-Of-Cost capital and operating costs are as follow:

> Capital Cost is $ 135 million.
> Operating Cost is $ 1.6 million per annum at Year 2002.

Expected Implementation Timeframe

As discussed in Section 12 of this report and shown in Table 17-1, the timeframe for implementation of the tunnel scheme is the longest of all the component parts for Option 9 and is expected to be completed about 5 years after construction begins.

Whilst the scheme is being constructed, the existing Hornsby Heights and West Hornsby STPs will continue to discharge their effluent into Berowra Creek. This will continue to have the current environmental impact on the Berowra Creek; and no improvement is expected until the year 2002.

Effluent Quality

This option will relieve Berowra Creek waterways of sewage-origin pollutant substantially in dry weather.

Flow greater than 3 ADWF will have received physical/chemical treatment by the CAS process, before discharge to the local creek.

Discharges to the local creek may also occur when the tunnel system is undergoing major repair or major maintenance. Should the tunnel be taken off-line and with proper operation of the system, all flows will receive physical/chemical treatment (for flows up to DWWF) before being discharged to the local creek.

All flows, when transferred to North Head STP, will receive high rate primary treatment before discharge to the ocean via the deepwater ocean outfall.

At present effluent discharges for North Head STP comply with current licence conditions and the transfer of the Berowra Creek catchments flows are not expected to adversely effect the ocean plant's performance in dry weather. The provision of the interim grease capture improvements, however, will move suspended solids and grease and come closer to the long term goals set in the EPA's EG-1 guidelines. The dilution provided by the deep ocean outfall will further minimise the impact on the receiving water environment.

Land Requirements

No additional land is required at the Hornsby plants for Option 9.

Additional land would be required to accommodate the major access shafts along the route of the Transfer Tunnel. The location of each access shafts will be in non-sensitive area wherever possible. The area for each shaft will be approximately 100 square metres.

Like Option 6, the amplification and upgrade of North Head STP will be contained within the Board's boundary, which is about 15.9 Ha. Hence, no additional land is required.

Operational Aspects

As previously discussed in Section 15, comments regarding the operation of the proposed Hornsby Heights and West Hornsby SSTPs, and the tunnel system, will be similar for Option 9.

Like Option 6, the main operating consideration of this option will be associated with the operation of the amplified and upgraded North Head STP. This will include an automatic control and telemetry system within the STP, labour, power, and chemicals and more regular servicing and maintaining of equipment.

Like Option 8, this option requires the operation of three major treatment facilities.

Environmental Impacts/Benefit

Option 9 will remove dry weather effluent flows from Berowra Creek. The environmental impact or benefit in transferring out of the catchment is unknown and the impacts that may relate to reduced dilution and occurrence of algal blooms in the Berowra Creek catchment is also difficult to predict. A detailed environmental assessment will need to be undertaken to determine whether they are negative or positive impacts.

During the implementation phase, like Option 8, the first impact will be associated with the modification of the existing facilities at Hornsby Heights and West Hornsby STPs.

The second impact will be caused by the construction and maintenance of the transfer tunnel/carrier from the Berowra catchment to North Head STP.

During the operational phase at all the facilities, there will be proportional increase in truck movements due to chemical supplies, solid waste and sludge removal.

The impact of the receiving waters, i.e. ocean off Manly, will be minimal, after the dilution via the deepwater ocean outfall. After the Stage A Upgrade, primary effluent will be discharged.

In wet weather events, however, flows greater than 3 ADWF will be treated at Hornsby Heights and West Hornsby SSTPs. The flows will undergo chemical treatment before discharge into the local creek. This will have some environmental impact on the creek's receiving water.

Beneficial Reuse

With the Board's present policy of encouraging residual and effluent reuse, part of the flow treated will be reused. Effluent reuse within the storm treatment plants and North Head STP will occur using the effluent produced. This will reduce the use of potable water in the plant.

At present, all chemically-stabilised sludge from North Head STP is used for beneficial reuse, i.e. composting. This will continue to occur provided the sludge produced is of good and consistent quality.

Other Considerations

The community's acceptance of the scheme will be one of the most important considerations in the adoption of this option. This will be particularly true for the community living in the Manly area.

SECTION 18

OPTION 10 - DRY WEATHER PLANT EFFLUENT TRANSFER TO WARRIEWOOD STP OUTFALL

Similar to Option 8, this option aims to relieve the Berowra Creek waterways of sewage-origin pollutant loads during dry weather conditions by transporting dry weather flows (i.e. up to 3 ADWF) to the ocean.

For Option 10, the raw sewage will be treated on-site by the modified West Hornsby and Hornsby Heights STPs and the treated effluent transferred to Warriewood STP outfall for disposal. Option 10 is similar to Option 7, except that no Wet Weather Holding Tank (WWHT) is provided.

For Option 10, the following will be provided:

- West Hornsby (WH) and Hornsby Heights (HH) STPs will be retained to produce nitrified secondary effluent.
- A transfer tunnel will be constructed (as per Route A described in Section 12) from WH and HH STPs to Warriewood STP site.
- Transfer system will be connected to the Warriewood STP outfall.

The following assumptions apply to this option:

- Raw sewage flows of up to DWWF (i.e. 4 PDWF) will receive preliminary and primary treatment.
- Flows up to 3 ADWF will receive secondary treatment before being transferred, via Route A tunnel system, to Warriewood STP outfall for disposal.
- Flows greater than 3 ADWF, after primary treatment, will be discharge to the local creek.
- Flows greater than DWWF will receive fine screening before discharge to the local creek.

DESCRIPTION OF OPTION 10

The existing West Hornsby (WH) and Hornsby Heights (HH) STPs will be retained. The treatment facilities will be retained to provide nitrified secondary quality (i.e. BOD reduction and nitrification) for flows up to 3 ADWF.

The facilities will be exactly as that proposed in Option 7 with the exception of the Wet Weather Holding Tank (WWHT). No WWHT will be provided for this option.

The nitrified secondary effluent will be discharged into the transfer tunnel. As discussed in Section 12, Route A is proposed for the transfer of the Hornsby plants' effluent from the Berowra catchment to Warriewood STP site. The transfer scheme will be connected directly to the Warriewood STP outfall, where the effluent can be discharged into the ocean.

A schematic diagram of Option 10 is shown in figure 18-1. A process flow diagram of the proposed Secondary Plant is shown in figure 18-2.

FACILITIES REQUIRED

Option 10 involves the following:

Flows and Population Projections

Refer to Table 16-1 for design flow adopted in Option 10.

Modifications to Existing STPs

West Hornsby and Hornsby Heights STPs will continue to operate as a secondary plants with nitrification. With the exclusion of the WWHT, the facilities provided are exactly the same as those described in Option 7.

Figures 15-3 and 15-4 (in Section 15 of this report) show the modified layout of the facilities at Hornsby Heights and West Hornsby STPs respectively.

The nitrified secondary effluent will gravitate into the transfer tunnel, which will convey the effluent to Warriewood STP outfall for disposal.

Route A - Tunnel to Warriewood STP

As discussed in Section 12, the tunnel nominated as Route A will be used. Route A initially comprises of two individual tunnels, from Hornsby Heights and West Hornsby STPs, merging into a common tunnel to Warriewood STP site. It will join

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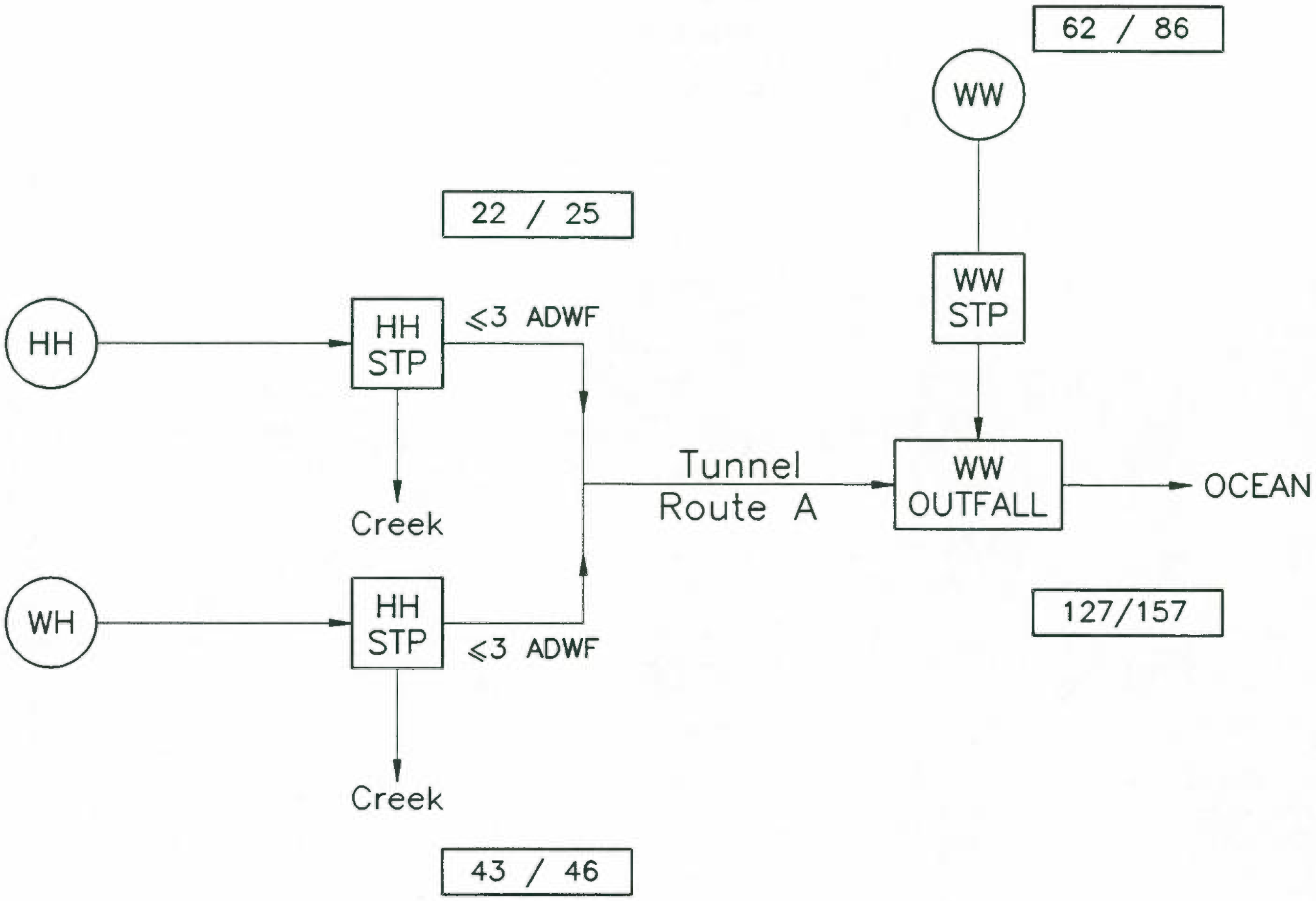


2002 / 2019 = Flows in Thousand EP

☐ = Treatment Facility

○ = Catchment

STP = Sewage Treatment Plant

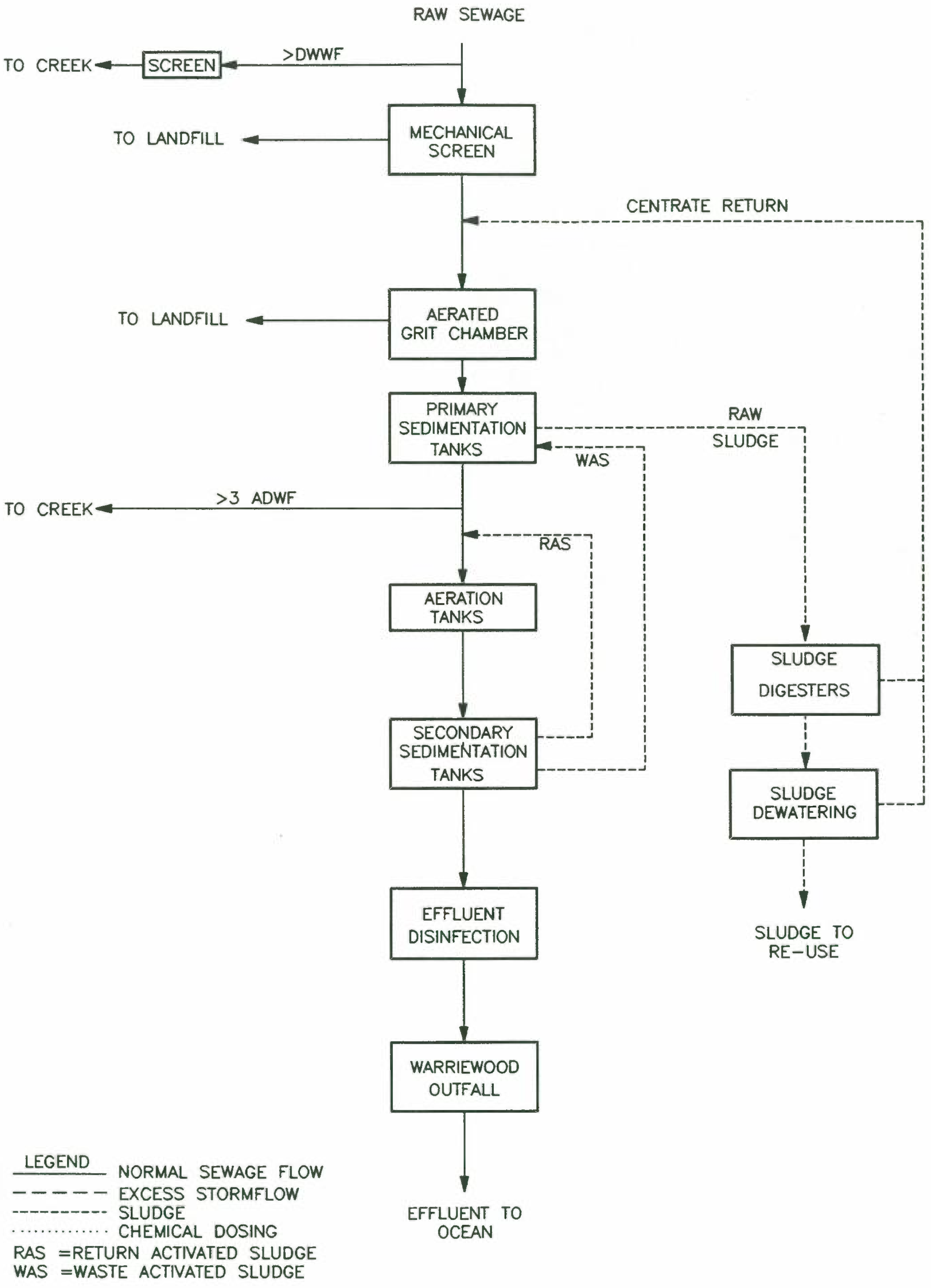
HH = Hornsby Heights
WH = West Hornsby
WW = Warriewood
ADWF = Average Dry Weather Flow

WATER BOARD
SYDNEY–ILLAWARRA–BLUE MOUNTAINS
WASTEWATER AND REUSE PLANNING

OPTION 10
TREATED SEWAGE
TRANSFER SCHEME
FOR DRY WEATHER ONLY

Figure
18–1

bc-t182



WATER BOARD
SYDNEY-ILLAWARRA-BLUE MOUNTAINS
WASTEWATER AND REUSE PLANNING

OPTION 10
SECONDARY STP (WITH NITRIFICATION)
PROCESS FLOW DIAGRAM
FOR DRY WEATHER ONLY

Figure
18-2

up with the Warriewood STP outfall for the disposal of the transferred effluent directly into the ocean.

The transfer tunnel proposed will have adequate capacity to transfer the Hornsby plants design flows.

Warriewood STP Outfall

The existing Warriewood STP cliff-face outfall at Turimetta Head has sufficient capacity. Hence, no amplification is required.

SUMMARY OF FACILITIES FOR OPTION 10

Table 18-1 summarises the costs, capacities and implementation timeframe for the various components of Option 10.

TABLE 18-1. OPTION 10 REQUIREMENTS

Item	Size/Capacity	Capital Cost	Implementation Timeframe	Operating Cost (per annum)
Modification of Hornsby Hts	25,000 EP	$4.5 M	1 year	$1,578,000
Modification of West Hornsby	46,500 EP	$4.5 M	1 year	$2,572,000
Tunnel System	2.5 m x 1.5 m	$110 M	5 years	$25,000
Warriewood STP outfall connection		$1 M	1 year	$10,000

OPTION OVERVIEW

A brief overview of Option 10 is provided below.

Capital and operating costs

Based on preliminary assessment of the option, the Order-Of-Cost capital and operating costs are as follow:

Capital Cost is $ 120 million.
Operating Cost is $ 4.2 million per annum at Year 2002.

Expected Implementation Timeframe

As discussed in Section 12 of this report and as shown in Table 18-1, the timeframe for implementation of the tunnel scheme is the longest of all the component parts for Option 10 and is expected to be completed about 5 years after construction commences.

Whilst the scheme is being constructed, the existing Hornsby Heights and West Hornsby STPs will continue to discharge their effluent into the local creek, and subsequently into Berowra Creek. This will continue to have the current environmental impact on Berowra Creek and no improvement is expected until the year 2002.

Effluent Quality

This option will relieve Berowra Creek waterways of all dry weather flows.

From the flow information available for the past three years (refer Section 3 of this report), only about 1 per cent of the time does the incoming flow exceed the 3 ADWF for Hornsby Heights STP. Similarly, for West Hornsby STP, the corresponding figure is only about 2 per cent of the time.

When these flows (greater than 3 ADWF) are discharged, they would have received preliminary and primary treatment.

Discharges to the local creek may also occur when the tunnel system is undergoing major repair or major maintenance. Should the tunnel be taken off-line and with proper operation of the system, all flow would have received nitrified secondary treatment (for flows up to 3 ADWF) and primary treatment (for flows up to DWWF) before discharges to the local creek.

The transferred plant effluent, when discharged to the ocean, will be of secondary quality and also low in ammonia concentration. This effluent quality will comply with the long-term goal of the EPA's EG-1 guidelines.

Land Requirements

No additional land is required at the Hornsby STPs under this option.

Additional land would, however, be required to accommodate the major access shafts along the route of the Transfer Tunnel. The area for each shaft will be approximately 100 square metres.

Operational Aspects

With the conversion of the tertiary facilities at West Hornsby and Hornsby Heights STPs to a secondary plant (with nitrification), the operational requirements (i.e. labour, power and chemical) at the two facilities can be reduced slightly. The present skill level of existing operators will also be required to run the modified facilities.

Additional labour will be required to maintain and inspect the "transfer tunnel/carrier". Control and telemetry will be required to ensure proper operation of the transfer system.

Environmental Impacts/Benefit

As for Options 5, the removal of effluent disposal from the Berowra Creek catchment will be assured in Option 6. Nutrients, with special regard to nitrogen, will be transferred to the ocean for disposal. Although this option may achieve zero discharges to Berowra Creek the reduction in algal bloom occurrences in the estuarine section are unknown. The lost of effluent dilution in the receiving waters may also have a negative impact.

An additional major impact will be caused by the construction and maintenance of the transfer tunnel/carrier from the Berowra catchment to the Warriewood STP site. The selection of the route will have to be treated with extreme care.

No possible overflow and discharge from the tunnel/carrier is allowable along the whole transfer route. Odour will not be a problem because of its secondary quality effluent. Odour control, however, will be performed along the route to mitigate odour complaint from the nearby residents if it eventuates.

There will be some impact associated with the connection of the transfer scheme to the Warriewood STP outfall. The impact will be experienced by the residents especially during the construction phase, e.g. machineries and truck movements, noisy construction activities, etc.

During the operational phase of the two Hornsby STPs, there will be associated increased truck movements due to chemical supplies, solid waste and sludge removal.

The impact of the receiving waters, i.e. ocean off Turimetta Head, will be minimal. In dry weather and normal operation of the STP facilities, nitrified secondary effluent will be discharged.

Wet weather flows will receive primary treatment before discharge to Berowra Creek during storm conditions. The combination of effluent dilution and larger flows in the creek should minimise the effect of wet weather flow discharge.

Beneficial Reuse

With the Board's present policy in encouraging residual and effluent reuse, part of the flow treated will be retained for reuse. Effluent reuse within the STP will occur using the high quality effluent produced. Effluent being transferred out, however, will discharge into the ocean.

In the future, if there are external markets (e.g. nurseries, golf courses etc) available along the route, it may be possible to tap into the tunnel to extract the treated effluent for reuse.

At present, all digested and dewatered sludge from Hornsby Heights and West Hornsby STPs are used for beneficial reuse, i.e. composting. This will continue to occur provided the sludge produced is of good and consistent quality.

Other Considerations

The community's acceptance of the scheme will be the most important consideration in the adoption of this option. This will be particularly true for the community living in the Warriewood area.

SECTION 19

OPTION 11 - INDIRECT POTABLE WATER REUSE

This option involves the treatment of sewage from West Hornsby and Hornsby Heights STPs to a potable water standard and its return to the Berowra Creek Potable Water Supply.

This will essentially ensure no discharge of effluent in dry weather to the receiving waters.

Current NSW Government and Water Board policy is to encourage the use of recycled water wherever feasible. The EPA also requires that adequate consideration is given to potential effluent reuse scheme alternatives before it will approve the discharge of effluent to surface waters. Consequently, suitable investigation of the implications and advantages for potential effluent reuse schemes need to be examined.

QUALITY REQUIREMENTS

There are three general areas of effluent reuse, each of which have different quality requirements. These areas are land application, industrial and urban/residential reuse. There are no official quality guidelines for industrial uses, rather these are determined on a case by case basis depending upon each industry's own process water quality requirements.

For land application and urban/residential reuse schemes the EPA and NSW Recycled Water Co-ordination Committee have produced specific quality guidelines and these are briefly discussed in the following sections.

Land Application

In November 1992, the EPA issued draft guidelines for the Utilisation of Treated Wastewater on Land[1]. The guidelines were produced to consolidate and update the previous design guides of:

WP-6 Design Guide for the Disposal of Wastewaters by Land Application.
WP-7 Water Conservation by Reuse.

The EPA's document provides basic guidelines on effluent quality requirements for various parameters but the EPA will decide on the acceptability of any effluent quality based on detailed information regarding the type of irrigation, proposed loading rates, soil characteristics, proximity and use of any surface waters etc.

Urban/Residential Guidelines

The NSW Guidelines for Urban and Residential Use of Reclaimed Water[2] detail quality requirements for treated sewage effluent suitable for most non-potable uses in urban residential areas with open public access and for general distribution through a dual reticulation system.

A dual reticulation system requires the construction of a distribution network of pipes dedicated exclusively to supplying non-potable water, with a service connection at each individual home. This network of pipes would be parallel to but separated from the potable distribution system.

Recycled Water Guidelines Summary

Based on these established guidelines, the Board has developed water quality criteria for various reuse applications as part of its strategic planning for effluent reuse[3]. Four water quality categories were developed according to the reuse applications as shown in Table 19-1.

EXISTING REUSE SITUATION

Current effluent reuse is essentially limited to on-site use around the STPs for hosing down areas contaminated by sewage or sludge, watering of existing landscaped and lawn areas, backwashing of the dual media filters and minor process uses. The latter use for backwashing is effectively within the treatment process and is an internal recycle stream. Therefore it will not be considered further in this section.

There is no monitoring of the volumes of effluent used although there is clearly a greater demand for effluent during the drier summer months, with demand for watering tapering off to virtually nil during the wetter months.

TABLE 19-1. RECYCLED WATER QUALITY CRITERIA

Parameter	Level A	Level B	Level C	Level D
BOD_5	20 [c]	10	5	ND
SS	30	10	5	ND
Ammonia	25	5	1	ND
Total N	40	40	15	0.5
Total P	3	3	0.3	0.05
Faecal Coliforms (org/100 mL)	300 [d]	200	5 [a]	ND
TDS	500	500	500 [g]	25
Turbidity (NTU)	15	10	5 [a]	0.1
Sulphate	100	100	100	0.5
Silicate	12	12	12	0.1
Chloride	175	175	175 [g]	10
Calcium	70	70	70	0.3
Magnesium	10	10	10	ND
Potassium	20	20	20	1
Sodium	120	120	120	7
Heavy Metals	ND	ND	ND	ND
TYPICAL USES	agricultural irrigation[e], dust suppression, quenching	urban irrigation[e]	residential, rec. lakes[f], cooling towers[g]	indirect potable, boiler feed[b]

Notes: All units mg/L unless otherwise specified.

a. New South Wales Recycled Water Co-ordination Committee (NSWRWCC) Guidelines (turbidity limit is 95 percentile value).

b. Further treatment may be required by customers on-site.

c. Clean Waterways Programme (CWP) STP effluent target.

d. NSW EPA - draft guidelines for Land Irrigation, May 1993

e. Nutrient removal may not be required

f. Primary contact

g. Currently under review

ND Not Detectable

POTENTIAL USES FOR EFFLUENT

The Environmental Impact Statement (EIS) for the Rouse Hill STP[4] indicated that a comprehensive package of water management strategies would be required to protect existing water quality in the Hawkesbury-Nepean. Part of this package included utilisation of as much effluent as possible for irrigating open spaces and the provision of a dual water supply system.

Land with a potential to be irrigated with recycled water includes open space, public parks, playing fields, golf courses etc. Such irrigation demand would obviously be seasonal, peaking in hot, dry periods in spring and summer.

The potential uses for recycled water include lawn and garden watering, car washing and toilet flushing. Recycled water for these purposes could be provided using very highly treated sewage effluent from the STPs.

Estimated demands for the system are based on some limited gaugings of domestic water usage in Sydney's northern suburbs which indicated that an average daily recycled water demand of about 300 L/per dwelling could be expected. This is approximately 45 per cent of the average sewage flow generated daily per dwelling.

Treated effluent supply from an STP will follow a diurnal pattern which does not necessarily coincide with the estimated recycled water demand pattern. Figure 19-1 shows the assumed supply and demand patterns for the recycled water scheme of a typical catchment. Examination of figure 19-1 indicates that supply will be adequate for daily maximum demand, but as the timing of peak supply and demand do not coincide, storage of recycled water is required.

An integral part of the operational requirements of the dual water system will be a one way interconnection between the potable water system and recycled water system. This interconnection is required to guarantee the recycled supply in the event of a system failure on the trunk delivery side or when treated effluent does not meet recycled water specifications. This interconnection will also be utilised to supplement flows when non-potable demand exceeds the recycled water supply.

Cost estimates carried out by the Board's North Western Systems Planning, indicate that the cost of a dual reticulation system additional to the potable supply network is $1,500 per lot. This figure includes the savings associated with the reduced supply cost (approximately $350/lot). The land purchasers costs for plumbing and equipment amounts to an additional $750 bringing the total cost of provision to approximately $2,250/lot.

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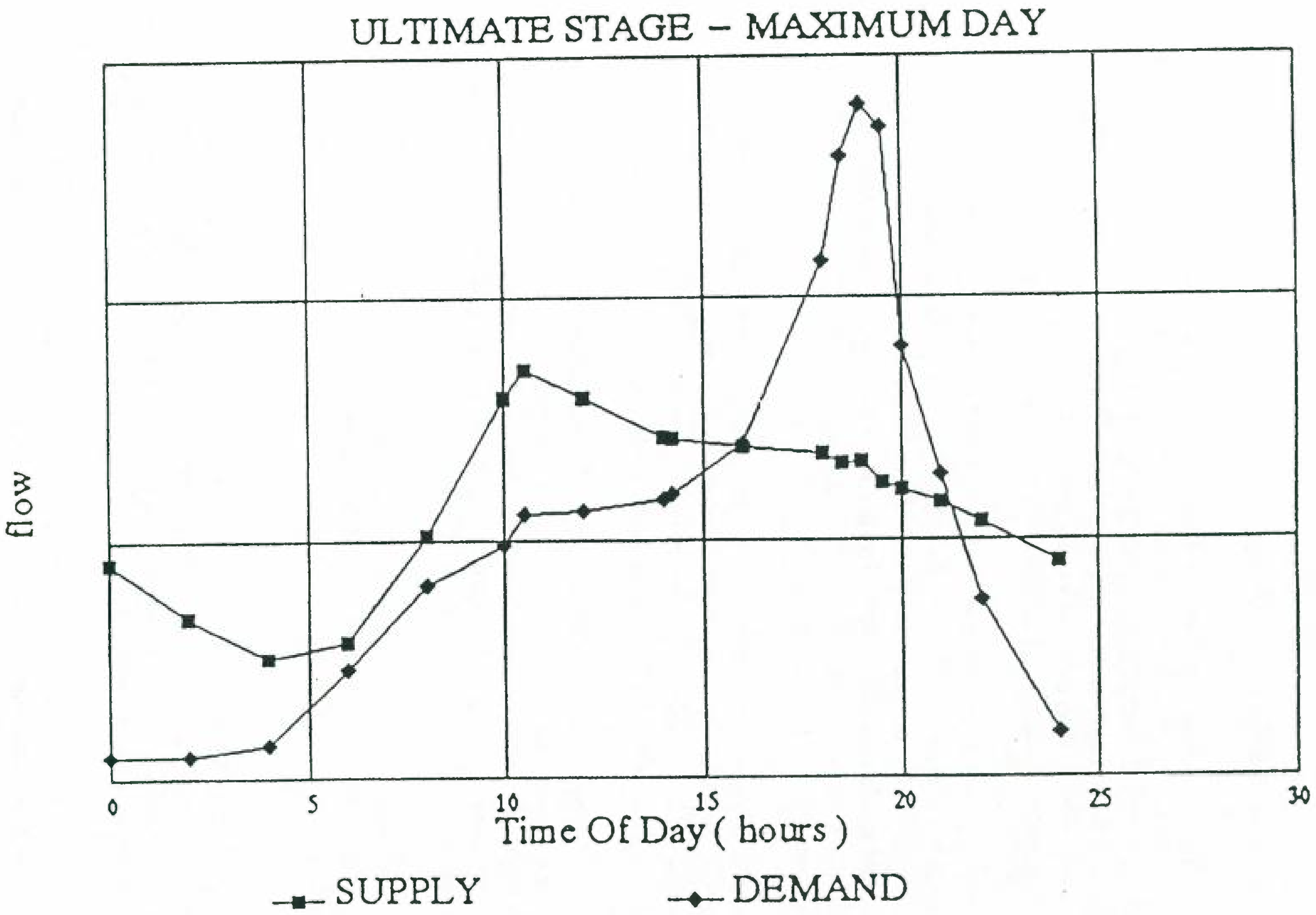

WATER BOARD
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WASTEWATER AND REUSE PLANNING

TYPICAL WATER DEMAND AND EFFLUENT SUPPLY CURVES
DUAL WATER SUPPLY SCHEME

Figure
19–1

DUAL WATER SUPPLIES

Dual water supply systems use a high quality potable water for all plumbing services inside properties and residences and a lower quality water (non potable) for toilets and external uses (such as garden watering).

In the reticulation of reclaimed effluent, the protection of public health is of paramount importance. The risk of cross connection, of effluent polluting the potable supply, together with the overall costs of such a system have historically been considered too high to justify implementation. Ass a result of potential impacts on the water quality of the Hawkesbury-Nepean system, however, the Board has endorsed the concept of dual water supplies for the Rouse Hill Development Area[5].

Dual water supplies which are utilised for external non-potable uses enable the low quality water to meet peak summer demands (approximately 20 per cent of average dry weather flows). For most of the time (periods of low demand), however, there is minimal demand for low quality water. During these periods, the effluent must be discharged to the waterways, indicating critical management of nutrient removal at the treatment plant would be required.

The maximum benefit of a dual water supply scheme would be gained if the low quality supply were used for both external and toilet flushing purposes. Toilet flushing provides a base load of demand (about 10 per cent to 20 per cent of average dry weather flows) irrespective of weather conditions.

Hence, dual water supply systems have the potential to reduce the amount of effluent flowing to the receiving waters and can be important in conserving water resources and in deferral of headworks for potable water supply. The reduction in effluent discharge quantity may be up to 40 percent in dry weather but, during low demand and wet weather conditions, the reduction would likely be less than 20 percent.

Tertiary treated effluent with adequate disinfection and nutrient reduction is considered by the NSW Recycled Water Coordination Committee to be the minimum required for dual water supply systems. This effluent standard is shown in Table 19-1.

The feasibility of **significant** use of dual water supply in a developed catchment is questionable. A dual water system is generally only economical in newly developed areas (eg. the Rouse Hill development area) and it would be difficult and costly to extend the system to existing developed areas.

Irrespective of the quantity of effluent supplied for dual water usage, the remainder of flow from the treatment plant would still need to be disposed to surface waters, and would require at least Level A treatment.

ISSUES ASSOCIATED WITH DISINFECTION

There are many issues associated with the disinfection of sewage effluent. Some of these are:

Effluent disposal/reuse method.
Flow.
Degree of treatment upstream of disinfection unit.
Formation of undesirable by products.
Residual disinfection.

Effluent Disposal/Reuse Methods

At present, most effluent from the Board's inland STPs is discharged to surface waters. In the future, more effluent will be reused for irrigation and industrial purposes. A summary of the disinfection requirements for different disposal/reuse methods are given in Appendix B, Table B-1.

TABLE 19-2. EFFLUENT DISPOSAL METHOD AND DISINFECTION REQUIREMENTS

	Discharge to Creek	**Urban/Residential reuse**	**General Irrigation**	**Irrigation of Specialised Crops**
Faecal Coliform	< 200 per 100 mL	< 1 per 100 mL	< 2000 per 100 mL	< 10 per 100 mL < 20 per 100 mL (80%ile)
Coliform	NA	< 10 per 100 mL (90%ile)	NA	NA
Virus	NA	< 2 per 50 L	NA	NA
Parasites	NA	< 1 per 50 L	NA	NA

NA = Not applicable

Flow

Flow to the STP during dry weather varies between a minimum of 0.5 ADWF in the night and a maximum of 2 ADWF in the morning. During wet weather, flows to the STP could reach higher than 6 ADWF. The current practise provides adequate effluent disinfection to flows up to 3 ADWF. The disinfection requirements in wet weather will be very high due to excessive flows and higher pollutant loads that may be present. The effectiveness of disinfection will be impaired by the presence of organic and inorganic substances in the storm flows. Further, it is not cost effective to provide effective disinfection to storm flows.

Degree of Treatment Upstream of Disinfection

Most disinfection processes practiced in sewage treatment require contact with the organism to be neutralised. Presence of suspended solids will generally hinder effective disinfection due to shielding effects. Presence of substances that consume or react with the disinfectant will reduce the availability of the disinfectant for pathogen kill. For example, the presence of ammonia will combine with chlorine when used for disinfection. One gram of ammonia nitrogen will require about 10 grams of chlorine for complete oxidation.

STRATEGIC PLANNING

Water Reuse is a component part of the Clean Waterways Programme. Its objective is the preparation of medium and long term plans for water reuse within the Water Board Service Area. The planning process aims to identify and develop a series of projects for the Water Board to implement in order to effectively and efficiently use reclaimed water. The resulting strategies will form the basis for water reuse and will be incorporated into the 20 and 60 year planning horizons of the strategic plan.

The planning approach adopted divides the project into eight distinct tasks or work packages. These tasks are as follows:

- Resources Evaluation; identifies the existing baseline and projected water resources available in the study area. Its main focus was to categorise all of the wastewater treatment facilities by location and effluent quality and quantity.
- Market Survey; consisted of preparation of an inventory of potential reuse markets. Concentration was placed on large water users.
- Identify Potential Projects; combines tasks 1 and 2 to match potential users with available resources and allow development of a list of potential projects.
- Develop Reuse Goals; this task will establish the philosophical goals for water reuse and detail the involvement of the Board on each particular project.
- Develop Reuse Guidelines; this task will establish the guidelines for water reuse ranging from the planning criteria to operating protocols.
- Evaluate Alternatives and Costs; a thorough analysis and evaluation of potential projects will be undertaken, leading to a ranking of projects on a cost per megalitre basis.

- Formulate Implementation Plan; this task will identify those projects for combination into a comprehensive water reuse master plan, outlining system layouts configurations and an implementation plan.

- Community Consultation; a programme of community consultation and education will be conducted to gain public acceptance of the plan.

POTENTIAL PROJECTS

Agricultural Irrigation. As indicated previously, strategic planning for wastewater reuse involves development of potential projects for implementation in the long term. Within the area of treatment plants under consideration in this report, the strategic planning process identifies only a single reuse scheme[5] (apart from the potential of a dual water supply system such as at Rouse Hill).

This scheme involves the provision of a recycled effluent pipeline extending from West Hornsby STP across the Berowra Valley Bushland Park and along Quarry Road to Round Corner and then along Kenthurst, Old Northern and Dural Roads. This route may present major environmental difficulties, however, an alternate route along Pennant Hills and New Line Roads to Round Corner would be several times longer.

About one third of the Board's total supply of reticulated water for agriculture is used for intensive horticulture in the Hills District of Baulkham Hills and Hornsby. The scheme is therefore based upon supplying the nurseries and market gardens in the Dural area with reclaimed water for irrigation purposes. Approximately 150 potential customers were identified with a combined annual average reuse potential of up to 2.5 ML/d. Swane Brothers Nursery in Galston Road is the biggest user of reticulated water in the area (150 kL/d) and is currently experiencing supply problems.

This scheme has the advantage of providing relief from peak season domestic water supply problems in the Dural area whilst serving a stable market. Demand, however, will be highly seasonal.

Economic evaluation of this scheme has not yet been completed, however, on a simplistic level, it is quite apparent that the infrastructure costs associated with supplying these markets will be quite high by virtue of the significant length of delivery main required. These costs may make this scheme unattractive.

Indirect Potable Reuse

This project would involve treating waste water to level D standard as indicated in Table 19-1 and pumping the reclaimed water to a storage reservoir, such as Prospect or Thornleigh Reservoirs.

The Water Reclamation Plant (WRP) process train would include chemical flocculation/coagulation and molecular membrane filtration, in this case reverse osmosis (RO), to reduce total dissolved solids (TDS) to ambient source levels and for the removal of total chlorinated organics. The reclaimed water would then be mixed in the reservoir with fresh potable water to cause a loss of identity.

Other pretreatment prior to RO, including lower levels of nutrient removal and coarser membranes, have been suggested to lower the cost of RO, however, the most efficient process configuration would be determined during preliminary project design and this level of detail is beyond the scope of this study.

ADDITIONAL SMALLER SCALE POTENTIAL PROJECTS

There are few additional opportunities for effluent reuse in relatively close proximity to either West Hornsby or Hornsby Heights STPs which appear viable. The following sections, however, detail possible reuse schemes within the area.

Pennant Hills and Muirfield Golf Courses

The Board has recently received inquires from the Pennant Hills Golf Course regarding the feasibility of tapping into a sewer main passing through its land, treating the sewage and using the effluent to irrigate the course. The Board, currently, will not allow such a proposal to proceed. An alternative to this scheme is to receive treated effluent from one of the Board's STPs. West Hornsby STP is the closer of the two Berowra Creek plants to this course and, potentially, could supply the Club with effluent. Within the general area of the Pennant Hills Golf Course is also Muirfield Golf Course which may also benefit from supply of an additional cheap water source. These two courses are amongst the highest ten golf courses in terms of their yearly consumption of potable water (Pennant Hills has the highest consumption). Table 19-2 shows the average daily potable water consumption at each of these courses.

TABLE 19-3. GOLF COURSE WATER USAGE

Club	Area	Water Use kL/d
Pennant Hills	32	262
Muirfield	30	150
Total		412

Source:
Water Reclamation and Reuse, Market Analysis June 1992.

Water demand at golf courses is, however, highly seasonal and the majority of demand can be expected during the hotter, drier summer months. During this period, the peak daily water use could be expected to be well in excess of those values listed in Table 19-2. Conversely, during the wetter winter months demand could be expected to be very small or non existent. This large variation between average and peak daily demand means that the delivery infrastructure (which needs to be sized for peak demand) will often be oversized and not fully utilised.

A rising main to supply these two courses would need to be approximately 15 km in length (11 km to Baulkham Hills, an additional 4.25 km to Muirfield). The route to these two courses may, however, pass through some significant high points which would necessitate considerable pumping.

Given the length of the required delivery main and size of pumping station required, it is very unlikely that this scheme would currently be attractive to these courses. The potential average volume of effluent that could be reused at these two sites is not extremely large in comparison to Castle Hill STP's daily flow and therefore offers little real benefit to the Board to set up.

The only additional potential user in the catchment would be the Cumberland state forest but the cost of providing irrigation facilities to this area would be prohibitive and offer no real advantage. Furthermore, as a native forest an increase in water supply and nutrient levels may be detrimental to the health of the vegetation.

Market Gardens

The potential project identified in the strategic planning process for effluent reuse, (to supply market gardens etc in the Baulkham Hills and Hornsby area from Rouse Hill STP, was conceived on the basis that the Round Corner plant would be decommissioned in the short term. Should the Round Corner plant be retained into the future, then supply of these markets from Round Corner would be more cost effective. Infrastructure costs, however, would be quite high for the volumes of effluent expected to be utilised and may still make this scheme unattractive.

Dual Water Supply

The feasibility of significant effluent reuse through a dual water supply system in the West Hornsby or Hornsby Heights catchments is questionable. The dual system is generally only economic in newly developed areas (eg. Rouse Hill) and for this reason, it would probably be impracticable to extend a system into the existing developed areas of each catchment on a large scale.

The future development of small housing estates in relatively close proximity to either treatment plant may, however, offer the potential to create small scale dual water supply schemes. There are insufficient potential new areas in the Hornsby Heights catchment to make a dual water supply economically attractive. There could be adequate potential development in the western part of the West Hornsby STP catchment, however, to provide such an opportunity. There is approximately 200 Ha remaining to be developed within this area but it may not be fully developed for some decades. Based on the usage rate adopted for the Rouse Hill system (300 L/day/dwelling) this would represent only a 700 kL/day average demand on the treatment plant. At this scale and timing such a system could only be practicably considered as a pilot scheme study. Given the commitment to large scale dual water supply in the Rouse Hill Development area an additional pilot scheme in the Berowra Creek catchment would prove to be of little value. The Rouse Hill experience would provide all necessary information for decisions on other possible schemes.

OPTIONS

Sub-Option A - Non Potable Agricultural Reuse

This option involves the provision of a recycled effluent pipeline extending from West Hornsby STP across the Berowra Valley Bushland Park and along Quarry Road to Round Corner, and then along Kenthurst, Old Northern and Dural Roads. The sewage treatment plant effluent would be treated to Level A and pumped to a storage reservoir in the Dural area.

The option is based on supplying the nurseries and market gardens in the Dural area with reclaimed water for irrigation purposes. Approximately 150 potential customers were identified with a combined annual average reuse potential of up to 2.5 ML/d.

This scheme has the advantage of providing relief from peak season domestic water supply problems in the Dural area whilst serving a stable market. Demand, however, will be highly seasonal.

The pipeline route may present major environmental difficulties, however, an alternate route along Pennant Hills and New Line Roads to Round Corner would be several times longer.

Economic evaluation of this scheme has not yet been completed, however, on a simplistic level it is quite apparent that the infrastructure costs associated with supplying these markets will be quite high because of the significant length of delivery main required. These costs may make this scheme unattractive.

Advantages/Disadvantages

The advantages of the option are as follows:

- Avoidance of nutrient removal costs for the flow that is pumped to Dural
- Relief of peak season domestic water supply problems in the Dural area.
- The market is stable compared to other agricultural districts in the Sydney Basin.
- Semi rural environment means low unit transport costs.

Disadvantages of this option are:

- Variable hydraulic and pollutant loads could cause variable effluent quality leading to customer dissatisfaction and subsequent disuse of effluent.
- Demand would be highly seasonal.

The reuse of effluent in this area could be further evaluated by considering effluent from Round Corner STP or from possible future STPs in the Galston/Glenorie area as these are developed, however, this is not within the scope of this report.

Sub-Option B - Non Potable Domestic Reuse - Dual Water Supply

This option involves the provision of a recycled effluent pipeline extending from West Hornsby STP across the Berowra Valley Bushland Park and along Quarry Road to Round Corner, and then along New Line Road. The sewage treatment plant effluent would be treated to Level C and pumped to a storage reservoir in the Round Corner area.

The option is based on supplying the new urban release areas between New Line and Old Northern Roads and along Quarry Road in the Round Corner/South Dural area with reclaimed water for non-potable domestic purposes.

A dual reticulation system would require the construction of a distribution network of pipes dedicated exclusively to supplying non-potable water, with a service connection at each individual home. This network of pipes would be parallel to but separated from the potable distribution system. The potential uses for recycled water would be lawn and garden watering, car washing and toilet flushing.

Estimated demands for the system are based on some limited gauging of domestic water usage in Sydney's northern suburbs which indicated that an average daily recycled water demand of about 300 L/per dwelling could be expected. This is approximately 45 per cent of the average sewage flow generated daily per dwelling.

There is approximately 200 Ha remaining to be developed within the western area of the catchment but this may not be fully developed for some decades. Based on the usage rate adopted for the Rouse Hill system (300 L/day/dwelling) this would represent a 700 kL/day average demand on West Hornsby STP.

The pipeline route may present major environmental difficulties, however, an alternate route along Pennant Hills and New Line Roads to Round Corner would be several times longer. This option would require a dedicated pumping station to be constructed in or near West Hornsby STP to pump the reclaimed effluent to Round Corner.

Sub-Option C - Indirect Potable Reuse

This project would involve treating waste water to level D standard as indicated in Table 19-1 and pumping the reclaimed water to a storage reservoir, such as Thornleigh Reservoir.

The Water Reclamation Plant (WRP) process train would include chemical flocculation/coagulation and molecular membrane filtration, in this case, reverse osmosis (RO), to reduce total dissolved solids (TDS) to ambient source levels and for the removal of total chlorinated organics. The WRP would treat effluent of a high quality with a very low level of nutrients from both West Hornsby and Hornsby Heights STPs. The reclaimed water would then be mixed in the reservoir with fresh potable water to cause a loss of identity.

Other pretreatment prior to RO, including lower levels of nutrient removal and coarser membranes, have been suggested to lower the cost of RO, however, the most efficient process configuration would be determined during preliminary project design and this level of detail is beyond the scope of this study.

The present total flow of 14.7 ML/d from both West Hornsby and Hornsby Heights STPs represents sufficient potable water supply for 44,000 EP based on a per capita water consumption of 300 L/EP.d, allowing for 10% bleed off of unusable RO waste stream containing the salts, nutrients and organic substances removed from the effluent by the RO process. The ultimate total flow of 18.2 ML/d from both STPs represents sufficient potable water supply for 61,000 EP. This means there would be a 19% shortfall of potable water in the catchment/supply area ie. 19% of the potable water requirements would need to be drawn from the Sydney supply. This also means that 81% of the Berowra Creek catchment areas potable water supply could be provided by this option.

DISCUSSION

The use of effluent in the non-potable options described in this section are an appropriate use of a scarce resource, however, it is considered that the non-potable options are not viable due to the relatively small proportion of effluent that could be reused and the long distances to the reuse areas. Significant volumes of effluent would still need to treated to an acceptable level and discharged to Berowra Creek. Therefore, the reuse of effluent by these methods, with the destinations of effluent split in this way, would not be economically viable.

The potable reuse option has the advantage of significantly reducing water demand in the Hornsby area from Sydney's major supply dams and eventually, if applied over a much larger area, would reduce Sydney's dependence on an irregular and increasingly insufficient rainfall. There would still be significant resistance to the potable reuse of effluent amongst consumers, however, and this will disadvantage this option.

Overall, Sub-option C - Indirect Potable Reuse is considered the most viable of the effluent reuse options, is therefore recommended and has been costed on this basis.

The indirect potable reuse option proposed in this section requires sewage effluent to be treated to Level 3 as described for Option 1 in Section 8 and then passed through a Reverse Osmosis unit to produce potable water. This water would then be pumped to Thornleigh Reservoir.

FACILITIES REQUIRED

For this option, the following will be provided:

- West Hornsby and Hornsby Heights STPs will be upgraded and amplified (if required) to Level 3 effluent quality requirements as detailed in Section 8. Refer Table 8-1 to 8-3 for a summary of the works required.
- A transfer SPS and rising main to transfer tertiary effluent from Hornsby Heights STP to West Hornsby STP site.
- Flows up to 3 ADWF for 25,000 EP.
- Installation of Reverse Osmosis facilities at West Hornsby STP (the plant will be converted to a Water Reclamation plant).
- Provide Ultra Violet Radiation (UV) facilities for 75,000 EP and optimise existing chlorination facilities for dual disinfection purposes.
- Provide waste brine pumping station and rising main from West Hornsby STP to NSOOS.

- Provide potable water pumping station and rising main from West Hornsby Water Reclamation Plant to Thornleigh Reservoir for mixing with Berowra Creek catchment and Thornleigh Reservoir's water distribution system.

The following design assumptions apply to this option:

- All flows up to 3 ADWF will be treated at both the Hornsby Heights and West Hornsby STPs to Level 3 effluent quality targets. All flows (up to 3 ADWF) are then transferred to the Water Reclamation Plant situated at West Hornsby site.

- Flows in excess of 3 ADWF and up to DWWF will receive preliminary and primary treatment prior to discharge to the Berowra Creek Catchment.

- All flows treated at the Water Reclamation plant will be transferred to the Thornleigh Reservoir for potable water supply.

Upgrade of West Hornsby STP

With reference to Section 8, facilities recommended to achieve Level 3 effluent quality targets shall be provided at West Hornsby STP in Option 11. The treatment process adopted includes the MLE process plus post denitrification facilities (with methanol dosing). Table 8-1 summarises the work required while a detailed discussion is provided in Section 8 and Appendix C. The plant will have adequate capacity for 46,500 EP.

Upgrade and Amplify Hornsby Heights STP

In Option 11, Hornsby Heights STP will be upgraded to treatment Level 3, and amplified to 25,000 EP to cater for future additional loads. The facilities to be provided are summarised in Table 8-2 and 8-3 respectively and are discussed in more detail in Section 8 and Appendix C. Figure 8-11 and 8-12 detail the proposed plant layout and process train for the Hornsby Heights plant.

Transfer SPS and Rising Main

A 500 mm diameter rising main and associated effluent pumping station will be constructed from Hornsby Heights STP to the West Hornsby STP site. The approximate length of the route is 7 kilometres, of which 0.5 kms is through the Berowra Valley Bushland park. The remaining length of the proposed rising main will be within the Pacific Highway and minor streets to the plant. Figure 19-2 shows a schematic of the proposed transfer line. The rising main will be designed to be able to transfer all flows up to 3ADWF allowance to the proposed Water Reclamation Plant (WRP) at West Hornsby (refer below).

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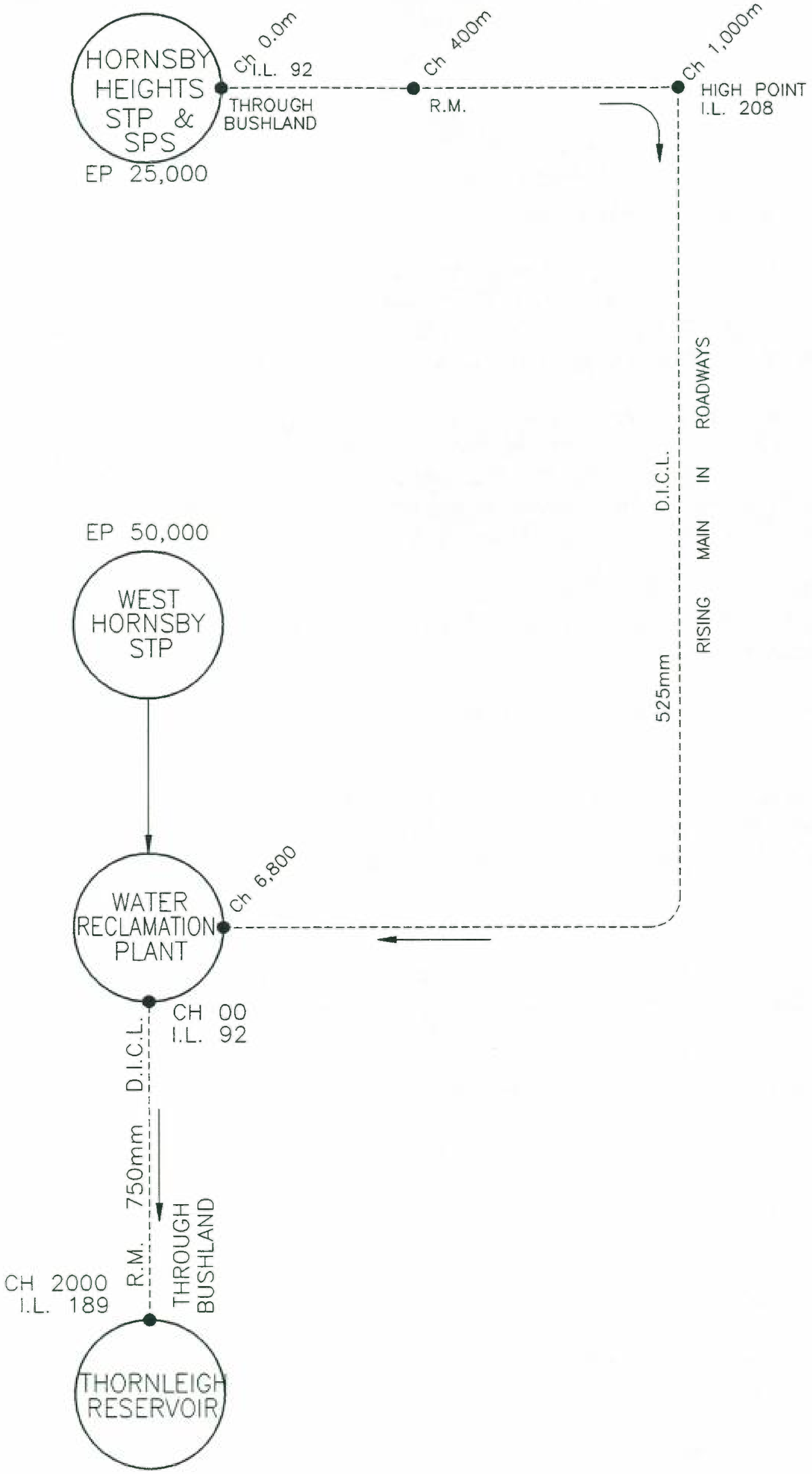


WATER BOARD
SYDNEY-ILLAWARRA-BLUE MOUNTAINS
WASTEWATER AND REUSE PLANNING

ALL TREATED EFFLUENT TO
NEW WEST HORNSBY
WATER RECLAMATION PLANT

Figure
19-2

Water Reclamation Plant

A reverse osmosis facility and associated equipment will be provided at the West Hornsby STP site to treat tertiary effluent from both the West Hornsby and Hornsby Heights STPs. The WRP will also disinfect the potable water produced by ultra violet radiation followed by chlorination.

As the WRP will generate a brine waste stream, a dedicated SPS and rising main of 150 mm diameter will be installed from West Hornsby STP to the North Suburbs Ocean Outfall Sewer (NSOOS). The brine solution, which represents approximately 10 to 15 per cent of the incoming tertiary effluent flow from the Hornsby STPs, will be treated by the North Head STP and deep ocean outfall sewer.

The Water Reclamation Plant at West Hornsby STP which includes the reverse osmosis facility is shown on figure 19-3 and a schematic of the process is provided on figure 19-4.

Indirect Potable Water Transfer Line

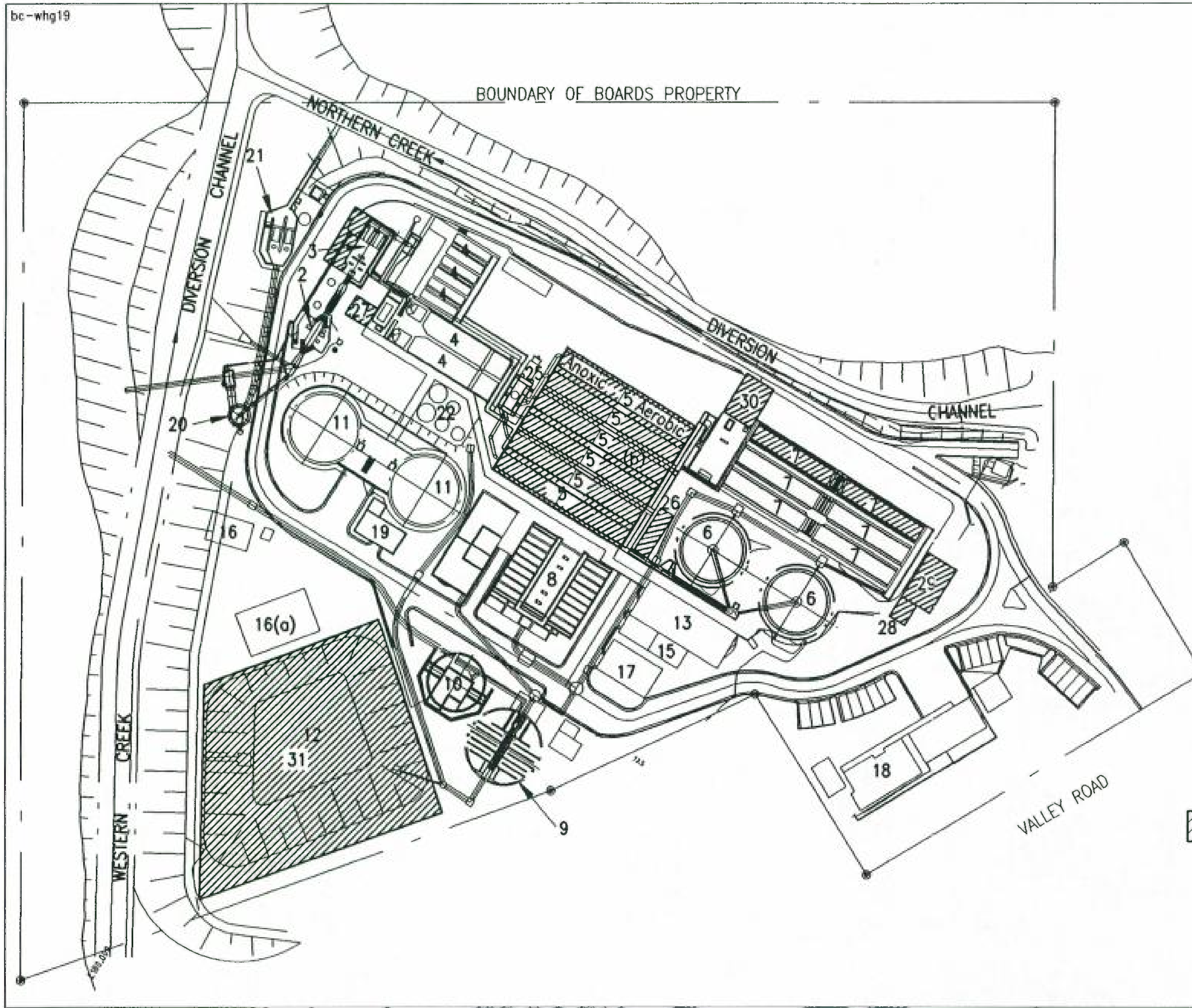
A dedicated transfer system shall be provided in Option 11 to deliver the indirect potable water generated at the West Hornsby Water Reclamation Plant to the Thornleigh Reservoir. A rising main of approximately 750 mm diameter and length of up to 3 kilometres will traverse through public reserve to the reservoir.

Figure 19-2 also details the overall schematic flow train for Option 11.

The conversion of wastewater to indirect potable water at the Hornsby STPs will not only have the potential to benefit the Berowra Creek catchment, but all the areas served by the Thornleigh reservoir system.

Thornleigh Reservoir is a major service reservoir in Sydney's northern suburbs usually supplying several smaller service reservoirs to the north and west. The service reservoirs supplied by Thornleigh include:

Wahroonga.
West Pennant Hills.
Rogans Hill.
Baulkham Hills.
Beecroft.
Dural and Dural South.
Castle Hill.
Berowra.
Hornsby and Hornsby Heights.
Cowan.
The Brooklyn Area.



LEGEND

1	SPS 490
2	SCREEN
3	AERATED GRIT CHAMBER
4	PRIMARY SEDIMENTATION TANKS
5	ANOXIC / AERATION TANKS
6	CIRCULAR SECONDARY SEDIMENTATION TANKS
7	RECTANGULAR SEDONDARY SEDIMENTATION TANKS
8	DUAL MEDIA FILTERS
9	CHLORINE CONTACT TANK
10	EFFLEUNT PUMPING STATION
11	DIGESTERS
12	HOLDING BASIN
13	BLOWER HOUSE / RAS PUMPING STATION
14	RAS PUMPING STATION
15	11kV SUBSTATION
16	SLUDGE DEWATERING AREA
17	CHLORINATION BUILDING
18	ADMINSTRATION BUILDING
19	SLUDGE PUMPING STATION SPS 212
20	RAW SEWAGE FLOW SPLITTER
21	STORM FLOW FINE SCREENS
22	CHEMICAL DOSING FACILITIES (PHOSPHORUS REMOVAL) + ALKALINITY ADDITION
23	FILTERED WATER TANK
24	FOUL WATER TANK
25	FLOW SPLITTER
26	MIXED LIQUOR PUMPING STATION + MIXED LIQUOR RECYCLE
27	PREFERMENTATION
28	METHANOL DOSING FACILITY
29	POST DENITRIFICATION FACILITY
30	POST DENITRIFICATION PUMPING STATION
31	REVERSE OSMOSIS BUILDING
(a)	SLUDGE DEWATERING FACILITY CURRENTLY UNDER CONSTRUCTION (INCLUDES CENTRIFUGES).
(b)	EXISTING AERATION TANKS MODIFIED TO ANOXIC / AERDBIC REACTOR (MLE).
▨	ADDITIONAL FACILITIES FOR 46,500EP

WATER BOARD
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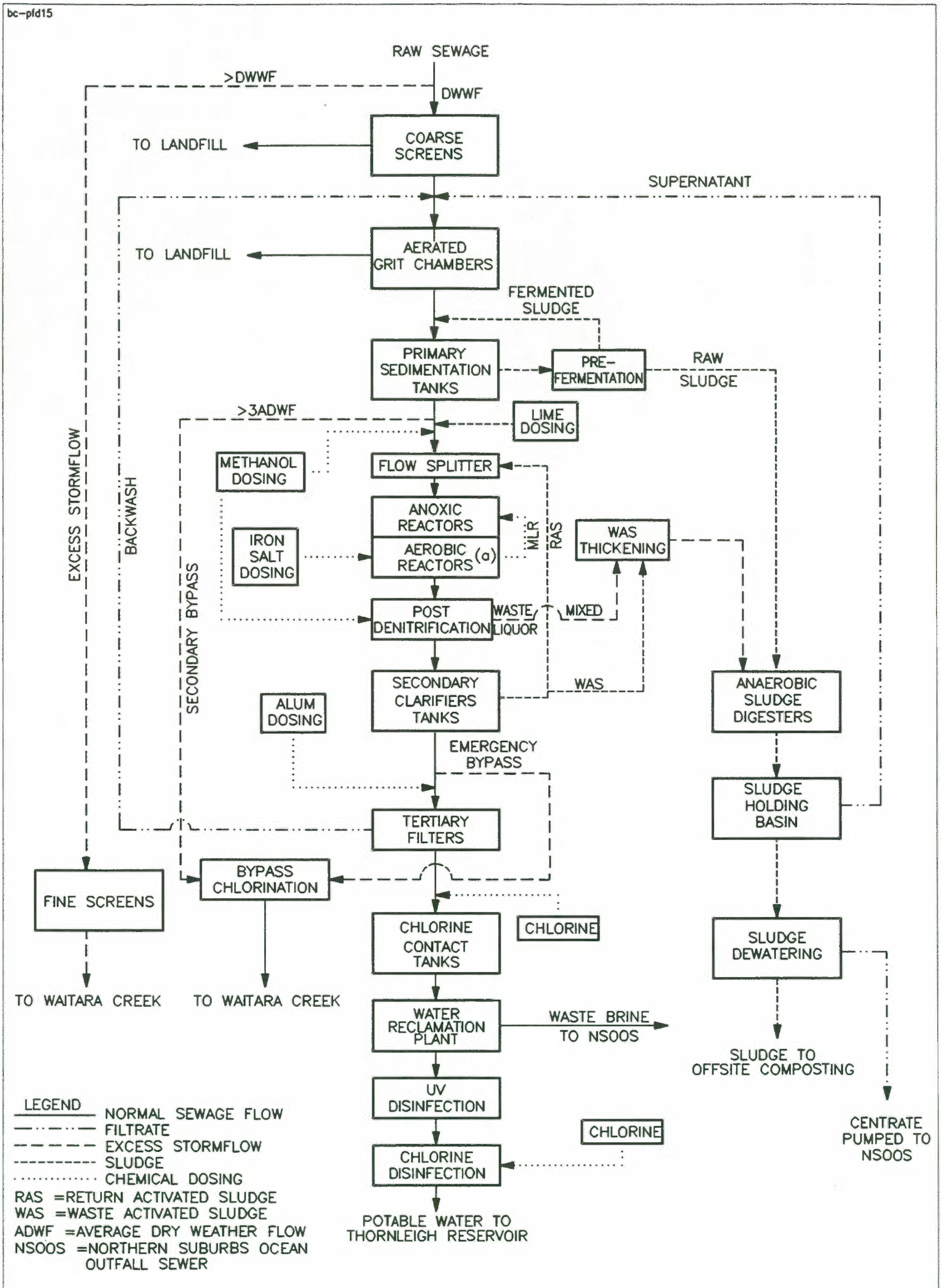
WASTEWATER AND REUSE PLANNING

WEST HORNSBY S.T.P. & W.R.P.
OPTION 11 – POTABLE REUSE
GENERAL ARRANGEMENT FOR 46,500EP MLE AND WATER RECLAMATION PLANT

Figure
19–3



WATER BOARD
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WASTEWATER AND REUSE PLANNING

WEST HORNSBY S.T.P. & W.R.P.
PROCESS FLOW DIAGRAM
FOR OPTION 11 – 0.05mg/L TN

Figure
19–4

The estimated population served by the Thornleigh system is approximately 270,000 persons. The average day flow is approximately 200 ML/d with a projected maximum day of 356 ML/d. The present total flow of 14.7 ML/d of potable water reclaimed from the STPs represents 7.5 per cent of the current average day flow through Thornleigh Reservoir. The Pymble Reservoir water supply system can also be supplied from Thornleigh and this system has an estimated population served of approximately 290,000 persons. Also, the Northern Suburbs water supply system is networked such that water from Thornleigh Reservoir can supply to the northern beaches of Sydney and therefore the total estimated population which can be served with water from Thornleigh Reservoir is in excess of 800,000 persons.

SUMMARY OF FACILITIES FOR OPTION 11

The summary of Option 11 actions are shown in Table 19-4 below.

TABLE 19-4. SUMMARY OF OPTION 11 ACTIONS

Actions Proposed	Treatment Level Potable Water Standard
Modify West Hornsby STP	Modify West Hornsby STP as in Option 1 and modify and retain relevant facilities
Modify Hornsby Heights STP	Modify Hornsby Heights STP as in Option 1 and modify and retain relevant facilities
Hornsby Heights STP Pumping Station and Rising Main	Provide pumping station and rising main from Hornsby Heights STP to West Hornsby STP
Provide Reverse Osmosis Facilities	Provide Reverse Osmosis facilities at West Hornsby STP
West Hornsby STP Waste Brine Pumping Station and Rising Main	Provide waste brine pumping station and rising main from West Hornsby STP to NSOOS
West Hornsby STP Potable Water Pumping Station and Rising Main	Provide potable water pumping station and rising main from West Hornsby STP to Thornleigh Reservoir

OPTION OVERVIEW

To allow for adequate analysis between options investigated, the following paragraphs discuss the important characteristics of Option 11. An additional overview is provided in Section 21 "Comparison of Options".

TABLE 19-5. CAPITAL AND OPERATING COSTS

Item	Capacity	Capital Cost $M	Operating Cost $M/annum @ Year 2000
Hornsby Heights STP Upgrade Amplification (Level 3 target)	25,000 EP	13.7	1.9
West Hornsby STP Upgrade (Level 3 target)	46,500 EP	9.3	3.0
Hornsby Heights STP Pumping Station and Rising Main	25,000 EP	6.4	0.22
West Hornsby Water Reclamation Plant	75,000 EP	31.5	2.4
West Hornsby Water Reclamation Plant Pumping Station and Rising Main	75,000 EP	7.0	0.58
Waste Brine Pumping Station & Rising Main	75,000 EP	1.8	0.02
Total		59	8.12

Expected Implementation Time Frame

If the environmental assessment and all necessary approvals are obtained by end 1995, Option 11 may be completed by 1998/99. While the augmentations are being carried out, the existing Hornsby STPs will continue to discharge high total nitrogens. At present, West Hornsby STP is discharging an average effluent total nitrogen concentration of 30 mg/L, while Hornsby Heights STP has an average effluent total nitrogen of around 50 mg/L in the discharge. Although the Board is endeavouring to reduce effluent total nitrogens to around 25 mg/L on average, major works will be necessary to achieve lower levels. Once the facilities are completed no discharge to Berowra Creek is expected if all indirect potable water is used.

Nitrogen Loading to Berowra Creek

The adoption of Option 11 will significantly reduce the Board's contribution of total nitrogen loads to the river. In fact zero effluent discharges should result if the produced potable water is reused. If discharges are to occur, an effluent total nitrogen concentration of 0.5 mg/L will be obtained in dry weather. Table 19-6 shows the reductions in average yearly nitrogen loads to Berowra Creek that could be expected around year 2000 for the various effluent quality targets being examined in Options 1 to 4 and compared to Option 11.

TABLE 19-6. YEARLY TOTAL NITROGEN LOADS TO BEROWRA CREEK (YEAR 2000)

Option	Effluent Quality Target	West Hornsby STP			Hornsby Heights STP			Expected Total
		Yr 2000 Flow	Average Effluent TN	Total Nitrogen kg/Yr	Yr 2000 Flow	Average Effluent TN	Total Nitrogen kg/Yr	Nitrogen Load/Yr from Hornsby STPs
1 to 4	Baseline[a]	11.05	30	121,000	5.8	50	105,850	226,850
	Level 1	11.05	10	40,330	5.8	10	21,200	61,530
	Level 2	11.05	7	28,250	5.8	7	14,800	43,050
	Level 3	11.05	3	12,100	5.8	3	6,350	18,450
11	TN 0.5 mg/L	11.25	0.25	1,027	5.7	0.25	520	1,547

a. Baseline condition refers to maintaining the Homsby STPs as nitrification plants.

Therefore, if Option 11 is adopted a dramatic reduction in effluent total nitrogen (as well as other pollutants) will occur.

Land Requirements

No additional lands will be required at the Homsby STPs under Option 11 and all facilities proposed will be contained within the current plant boundaries. It must be stressed, however, that the standard 400 metre buffer zone generally applying to Board STPs does not exist at either West Homsby and Homsby Heights STPs. No further development should be allowed to encroach even closer. Additional land is required at the Thomleigh Reservoir as no major construction is expected.

Easements will need to be obtained, however, for the proposed rising mains from Homsby Heights STP and the Water Reclamation Plant (at West Homsby STP) to Thomleigh.

Operational Aspects

The conversion of the existing nitrification plants at the Homsby STPs to the proposed MLE process will not dramatically affect the current operation of the STPs. In fact, economic paybacks can be expected as reduction in oxygen and lime usage are inherent to biological nitrogen removal plants. As the MLE process also does not represent complex technology, no additional skills or increased staff numbers are necessary above the current operating level. Also no major increases in odours, noise or energy consumption above the existing sewage treatment process is expected when converting to the MLE system.

For the Water Reclamation plant at the West Homsby STP site, the reverse osmosis facility will increase operating costs dramatically due to the inherent design of the high pressure membrane filtration process. The membranes require frequent chemical cleaning and the process as a whole needs skilled supervision.

At present the Board has no operational experience with RO facilities and a full scale trial will need to be undertaken to ascertain its long term viability and operational requirements.

As phosphorus shall continue to be removed by chemical means, a high degree of process reliability in achieving low effluent phosphorus levels is also expected. Current sludge handling and dewatering is also expected not to be adversely affected and will not need major modifications to process treatment philosophy.

Additional labour will be required to maintain and inspect the various transfer lines planned in Option 11. Control and telemetry will be needed to ensure proper operational of the indirect potable water transfer scheme to prevent overflows at the Thornleigh reservoir.

Environmental Impacts

If adopted, Option 11 will dramatically reduce the discharge of tertiary effluent to Berowra Creek. If all the treated flows are used for indirect potable water supply, zero discharges to Berowra Creek will occur during dry weather. The effect of no dry weather STP flows in Berowra Creek are unknown but the existing high dilution provided by STP flows would be removed.

The brine solution produced by the RO plant may have a high concentration of solids, organics and restricted substances. Although a potential problem may occur, the high dilution and assimilative capacity offered by the deep ocean outfall off North Head STP, plus the fact that the Berowra Creek catchment sewage is mainly domestic in origin should alleviate concerns.

If adopted, Option 11 will improve the quality of effluent currently being discharged from the Hornsby plants to Berowra Creek. Without the benefit of an intensive environmental investigation and continual water quality monitoring within Berowra Creek, the effluent quality target to be adopted to achieve the Berowra Creek goal of recreational and modified ecosystem water quality criteria is unknown. Other issues, including the control of diffuse source pollutant inputs from urban and bushland runoff and limiting development to the current Urban Development Programme will also play an important role in returning the creek to environmental health.

Additional impacts that may be expected in Option 11 include increased noise and truck movements during the construction phase of the scheme, but this is only for the short term. Minimum increases in truck movements can also be expected during the operational phase of the proposed MLE processes at both West Hornsby and Hornsby Heights STPs, the transfer SPS and rising mains and Water Reclamation plant at

West Hornsby STP and will have no major impact in increasing noise and odour levels.

Beneficial Reuse

With the Board's policy of maximising the beneficial use of effluent and sludges, Option 11 has maximum potential for effluent reuse. The external market involves the supplementation of the potable water supply but requires large outlays from the community before their inception.

At present, all digested and dewatered sludges from the Hornsby STPs are used for composting at the ANL site. This will continue to occur provided the sludge produced is of good and consistent quality.

Grit and Screening products will also continue to be dewatered, bagged and disposed of in landfill sites.

REFERENCES

1. Environment Protection Authority, *Draft Guidelines for the Utilisation of Treated Wastewater on Land*, November 1992.

2. NSW Recycled Water Co-ordination Committee, *NSW Guidelines for Urban and Residential Use of Reclaimed Water*, May 1993.

3. Water Board, *Water Reclamation and Reuse Guidelines Preliminary Draft*, August 1992.

4. Manidis Roberts Consultants, *West Hornsby STP Proposed Interim Upgrading REF*, January 1991.

5. Water Board, *Water Reclamation and Reuse Project Identification*, November 1992.

SECTION 20

RESIDUALS MANAGEMENT

Residuals management is generally defined as the collection, handling, treatment and subsequent beneficial use or disposal of the residuals from sewage collection and treatment, water treatment or stormwater systems. The residuals from sewage treatment are typically screenings, grit, scum and sludge.

One of the Board's corporate objectives is to manage these residuals for safe, beneficial use or environmentally acceptable disposal.

It is important to stress that the development of the options for this study is being driven by the effluent quality objectives and not the residual/biosolids objectives. Although the residual/biosolids objectives present some emerging issues regarding on their usage and/or disposal, the Board is currently formulating a preferred corporate direction in the Residual Management Planning. It will address all the strategic issues. Ideally, the effluent quality and biosolids' objectives should be optimally satisfied in the formulation of any option.

This section provides an overview of residuals management issues; and the specific residual issues that are applicable to the options considered in this study.

PRESENT RESIDUALS MANAGEMENT PRACTICE

This section outlines the existing arrangements for collection and beneficial use and disposal of residuals from the Board's West Hornsby, Hornsby Heights, Warriewood and North Head STPs.

Sludge

At West Hornsby, Hornsby Heights and Warriewood STPs, anaerobic digesters are used to stabilise sludge from the liquid treatment process. Stabilised sludge from the digester is dewatered on-site using centrifuges before being transported off-site.

All dewatered sludge from the three STPs is transported to the Australian Native Landscapes (ANL) compost site at Badgerys Creek. The dewatered sludge undergoes further processing at ANL which ensures the quality is suitable for the compost market.

At North Head STP, sludge from the primary tanks is chemically stabilised using lime and Cement Kiln Dust (CKD). This is referred to as the "N-Viro process". The stabilised sludge product or "N-Viro soil" is trucked to the compost facility at Badgerys Creek. About 30 per cent of the product is used in grazing, orchards, vineyards or turf farms; whilst the rest is used as landfill cover or disposed as landfill.

Screenings

West Hornsby, Hornsby Heights and Warriewood STPs have mechanically raked screens which deliver collected screenings into Otto bins. The plant also operates manually raked bypass screens, with screenings also stored in Otto bins. Screenings from these bins are transferred to the Board's collection truck and transported to Eastern Creek landfill site for burial.

The North Head STP has 5 rotary drum (fine) screens and 2 bar (coarse) screens. Screenings are automatically removed, dewatered in screw presses and then pneumatically conveyed to ground level for further processing. The dewatered screenings undergoes the "N-Viro process" before being trucked off-site to a designated tip (e.g. Belrose landfill site) for burial.

Grit

West Hornsby, Hornsby Heights and Warriewood STPs operate aerated grit chambers. The grit is periodically collected from the chamber and concentrated using grit classifiers. The grit separated is collected in Otto bins prior to transport and disposal at the Eastern Creek landfill depot.

North Head STP uses two spiral-flow aerated grit removal tanks. Grit is pumped from the hoppers as slurry to the solids handling building. The grit is dewatered and undergoes the "N-Viro Process". Like screening, grit can be collected in a skip and trucked to landfill for burial.

Scum

Any scum collected at an STP is generally incorporated with that STP's sludge for stabilisation and subsequent use. Separate handling of scum as a minor residual requiring use or disposal is therefore not required.

For West Hornsby, Hornsby Heights and Warriewood STPs, scum is mixed with sludge which is digested, dewatered prior to use as compost. For North Head STP, scum is mixed with raw sludge which is further treated to became "N-Viro soil".

SLUDGE QUANTITIES

This section presents the estimated sludge quantities from the West Hornsby, Hornsby Heights, Warriewood and North Head STPs for their existing catchments.

Table 20-1 summarises the best current estimation of average and peak sludge production at these plants.

TABLE 20-1. CURRENT AND PREDICTED RAW SLUDGE QUANTITIES

STP	Average Raw Sludge Production[a] (DT/d)			Peak Dry Raw Sludge Production[b] (DT/d)		
	1994	2005	2011	1994	2005	2011
West Hornsby	3.9	4.8	4.8	6.3	7.6	7.6
Hornsby Heights	2.0	2.3	2.4	3.2	3.7	3.8
Warriewood	6.1	7.6	8.4	9.7	12.2	13.4
North Head	34.7	39.6	42.4	55.6	63.4	67.9

a. Based on 1994 average dry weather sewage flows, adjusted from 1993 flow in Volume 5C (referenced below).

b. Based on 1.6 peaking factor for raw sludge.

Sources :
Strategic Plan for Wastewater and Stormwater, Volume 5A, Residuals Management Planning Baseline Information, March 1993; and

Waste Water and Reuse Branch, Volume 5C, Residuals Management Planning, Biosolids Options Costs and Product Quality Assessment, August 1994.

EXISTING SLUDGE QUALITY

Sludge quality is described in terms of the concentrations of chemical substances such as metals and organochlorines (OC's), pathogens, nutrients, aesthetic characteristics such as odours and insect attractants and leachate results.

There are large numbers of inorganic and organic pollutants in sewage sludges which may be harmful to humans, animals and plants. Levels of many of these pollutants have been decreasing during the last few years as a result of more stringent trade waste control, changing industrial manufacturing processes and changing consumer habits. Although chemical constituents in raw sewage are most frequently very low, the increased concentration in the sludge makes their presence in sludge of more concern. Despite this, possibly more important is the ability of certain pollutants to bioaccumulate, their potential toxicity and the total amount of pollutant applied per unit area of land.

As most beneficial applications of sludge will involve placement on land for some agricultural or soil amelioration purpose, known sludge quality data from the West Hornsby, Hornsby Heights, Warriewood and North Head STPs are compared against "Contamination Grade" and "Stabilisation Grade" in the NSW EPA's "Interim Code of Practice for Use and Disposal of Biosolids Products" (June 1994) for sludge application to land in Tables 20-2, 20-3, 20-4 and 20-5 respectively. In the case of North Head STP, no organochlorine pesticides data is available.

TABLE 20-2. WEST HORNSBY STP - DIGESTED SLUDGE QUALITY[a]

Pollutant	Concentration (mg/kg) in Digested Sludge[a]		
	50 Percentile	90 Percentile	Biosolids Code Contamination Grade C (for Agriculture)
Metals			
Arsenic	4.2	5.9	20
Cadmium	3.0	4.1	20
Chromium	65	75	500
Copper	1087	1244	2000
Lead	113	187	420
Mercury	3.7	4.9	15
Nickel	20	29	270
Selenium	8	13	50
Zinc	658	851	2500
Based on 88 Samples			
Organochlorine Pesticides			
Aldrin	0.04	0.05	0.5
Dieldrin	0.04	0.17	0.5
Chlordane	0.04	0.20	0.5
Heptachlor	0.04	0.05	0.5
Lindane	0.04	0.05	0.5
Hexachlorobenzene	0.04	0.05	0.5
BHC	0.04	0.05	0.5
PCB	0.07	0.23	1.0
DDT/DDE/DDD	0.13	0.20	1.0
Based on 70 Samples			

a. Raw sludge data is not available.

Sources :-
Strategic Plan for Wastewater and Stormwater Volume 5A Residuals Management Planning Baseline Information March 1993; and
Interim Code of Practice for Use and Disposal of Biosolids Products, June 1994, NSW EPA.

TABLE 20-3. HORNSBY HEIGHTS STP - DIGESTED SLUDGE QUALITY[a]

Pollutant	**Concentration (mg/kg) in Digested Sludge[a]**		
	50 Percentile	**90 Percentile**	**Biosolids Code Contamination Grade C (for Agriculture)**
Metals			
Arsenic	5.0	6.6	20
Cadmium	3.3	4.2	20
Chromium	65	73	500
Copper	1239	1455	2000
Lead	109	142	420
Mercury	4.6	6.3	15
Nickel	24	33	270
Selenium	15	19	50
Zinc	978	1178	2500
Based on 40 Samples			
Organochlorine Pesticides			
Aldrin	0.04	0.04	0.5
Dieldrin	0.04	0.11	0.5
Chlordane	0.04	0.16	0.5
Heptachlor	0.04	0.04	0.5
Lindane	0.04	0.04	0.5
Hexachlorobenzene	0.04	0.04	0.5
BHC	0.04	0.04	0.5
PCB	0.04	0.21	1.0
DDT/DDE/DDD	0.20	0.20	1.0
Based on 30 Samples			

a. Raw sludge data is not available.

Sources :-
Strategic Plan for Wastewater and Stormwater, Volume 5A Residuals Management Planning Baseline Information March 1993; and
Interim Code of Practice for Use and Disposal of Biosolids Products, June 1994, NSW EPA.

TABLE 20-4. WARRIEWOOD STP - DIGESTED SLUDGE QUALITY[a]

Pollutant	Concentration (mg/kg) in Digested Sludge[a]		
	50 Percentile	90 Percentile	Biosolids Code Contamination Grade C (for Agriculture)
Metals			
Arsenic	6.3	9.4	20
Cadmium	4.4	6.6	20
Chromium	52	57	500
Copper	2010	2677	2000
Lead	134	196	420
Mercury	4.7	6.6	15
Nickel	19	24	270
Selenium	12	15	50
Zinc	1053	1553	2500
Based on 58 Samples			
Organochlorine Pesticides			
Aldrin	0.05	0.06	0.5
Dieldrin	0.08	0.30	0.5
Chlordane	0.19	0.41	0.5
Heptachlor	0.05	0.05	0.5
Lindane	0.05	0.05	0.5
Hexachlorobenzene	0.05	0.06	0.5
BHC	0.05	0.05	0.5
PCB	0.22	0.26	1.0
DDT/DDE/DDD	0.15	0.33	1.0
Based on 40 Samples			

a. Raw sludge data is not available.

Sources :-
Strategic Plan for Wastewater and Stormwater Volume 5A Residuals Management Planning Baseline Information March 1993; and
Interim Code of Practice for Use and Disposal of Biosolids Products, June 1994, NSW EPA.

TABLE 20-5. NORTH HEAD STP - RAW SLUDGE QUALITY[a]

Pollutant	Concentration (mg/kg) in Raw Sludge[a]		
	50 Percentile	90 Percentile	Biosolids Code Contamination Grade C (for Agriculture)
Metals			
Arsenic	1.6	2.5	20
Cadmium	1.9	3.3	20
Chromium	32	59	500
Copper	320	450	2000
Lead	60	120	420
Mercury	2.2	4.4	15
Nickel	15	31	270
Selenium	3.6	5.1	50
Zinc	360	500	2500
Based on 26 Samples			
Organochlorine Pesticides			
Aldrin	NM	NM	0.5
Dieldrin	NM	NM	0.5
Chlordane	NM	NM	0.5
Heptachlor	NM	NM	0.5
Lindane	NM	NM	0.5
Hexachlorobenzene	NM	NM	0.5
BHC	NM	NM	0.5
PCB	NM	NM	1.0
DDT/DDE/DDD	NM	NM	1.0
Based on 15 Samples			

a. NM is "Not Measured".

Sources :-
Strategic Plan for Wastewater and Stormwater, Volume 5A Residuals Management Planning Baseline Information March 1993; and
Interim Code of Practice for Use and Disposal of Biosolids Products, June 1994, NSW EPA.

Assuming that the 90 percentile concentrations approximate the code requirement of mean plus two standard deviations (m + 2s), the above data shows that the dewatered sludge produced at West Hornsby and Hornsby Heights is suitable and is currently being used in agricultural applications. Although the copper content in the Warriewood's dewatered sludge is higher than "Code's Contamination Grade C limits", it is currently undergoing further treatment and being diluted with other sludges at the "Composter" making it suitable for agricultural applications. North Head's sludge, after undergoing chemical stabilisation, will be suitable for beneficial reuse in agriculture. This leads to the conclusion that with further processing noted, sludges produced at all the plants under investigation would be acceptable for use in a beneficial reuse application to agricultural land.

Compliance on a batch basis may, however, lead to some batches failing to meet the "Contamination Grade" required for agriculture use.

Another important aspect of sludge quality and potential beneficial reuse applications is the nutrient value of the sludge. Sewage sludge can be rich in nitrogen, phosphorus and essential trace elements. It can supply some of the nitrogen and phosphorus needs of pasture and some growing crops as well as improving soil structure and provide some micro-nutrients.

Table 20-6 illustrates average nutrient concentrations in sludges from the West Hornsby, Hornsby Heights, Warriewood and North Head STPs.

TABLE 20-6. AVERAGE SLUDGE NUTRIENT CONCENTRATIONS FOR WEST HORNSBY, HORNSBY HEIGHTS, WARRIEWOOD AND NORTH HEAD STPs

Constituent	West Hornsby[a] (digested)	Hornsby Heights[a] (digested)	Warriewood (digested)	North Head (undigested)
Ammonia	5343	6692	5840	11580
TKN	38822	37643	44855	31640
Nitrate	141	-	136	11
Nitrite	6	-	21	6
Total Nitrogen	38969	(37643)[b]	45012	31657
Total Phosphorus	40905	44820	21954	5380
Sodium	563	526	701	737
Potassium	954	677	1177	896
Calcium	13659	16378	22418	8700
Magnesium	2572	2826	3395	1200
Aluminium	-	8434	-	-

a. Units are mg/kg (dry).

b. Values in parenthesis indicate missing nitrate and nitrite data.

Source:
Strategic Plan for Wastewater and Stormwater, Volume 5A Residuals Management Planning Baseline Information March 1993.

FUTURE SLUDGE QUALITY

Concentrations of heavy metals and organochlorines in raw sewage generated in the Board's area of operations have decreased in recent years. Reductions in these contaminants provide benefits in terms of reduced sewage and sludge treatment costs and increased potential for beneficial uses of sewage sludge and other residuals.

There are several factors which have resulted in reductions in these contaminants to date, mainly increased public awareness and the Board's Trade Waste Policy. These are likely to continue contributing to reductions in sewage strengths. In the future other factors such as rationalisation of STPs, effluent reuse, greater public awareness and treatment upgrades using metals salts for phosphorus removal will also influence sludge quality. Some of these factors will tend to increase contaminant concentrations, whereas other factors will have the opposite effect.

When considering maximisation of the beneficial use of sludge (a Water Board goal), it is essential to understand the variety of sewage treatment liquid processes used by the Board, both currently and proposed, which produce sludges of varying nutrient value and chemical content. Furthermore, maximising beneficial use potential may involve adopting processes which produce higher, rather than lower nutrient values in the resulting sludges.

Because of the impact on sludge nutrient levels of certain liquid process options, the Board needs to make holistic decisions with respect to wastewater management. Until the introduction of beneficial use of sludge objectives, most of the wastewater management decision-making revolved around liquid stream/water quality objectives, with sludge being the resulting waste product to be disposed of. This concentration on the liquid stream/water quality objectives does not adequately address the implications on the solids handling side. Nearly every major liquid stream/water quality decision has an impact on the quantity and/or quality of the resulting sludge and hence impacts on disposal/use options. Accordingly, liquid stream/water quality process and management decisions must consider the implications of residuals management.

The goal of residuals management is to beneficially use all sludge or alternatively dispose of it in an environmentally acceptable manner. A measure of the Board's success will be to achieve the highest level of beneficial use available for the maximum amount of sludge.

Some of the residuals management issues that are relevant to the selection of preferred treatment options for the various options are discussed below:

- **Alum or Ferric Salts Dosing.** Alum and ferric salts are currently used to precipitate phosphorus at West Hornsby and Hornsby Heights STPs' treatment process. Both of these salts bind phosphorus very effectively and it is removed from the effluent and is deposited in the sludge. Unfortunately, both alum and ferric salts bind phosphorus so effectively that when the resulting sludge is applied to land, the phosphorus remains bound and is in a form that is not immediately available to plants as a phosphorus fertiliser.

The addition of alum has been shown to cause deterioration in dewaterability of alum sludges compared with no chemical addition. However, in comparison with iron sludges, no greater dewatering difficulty has been clearly distinguished. Dewatering of alum sewage sludge from plants without primary sedimentation will probably experience some difficulty in achieving 20 per cent cake solids which is a general goal for dewatered sludge.

- **Metal Impurities in Metal Salt Coagulants.** Ferric chloride and spent pickle liquor often contain significant levels of heavy metal contamination[2]. When these contaminant metals are concentrated in the sludge, some sludges may not meet guidelines for beneficial use or for landfilling. This may develop at plants if ferric chloride or spent pickle liquor are used and they are contaminated with high levels of heavy metals. By contrast, alum is relatively contaminant free.

- **Lime.** Many Australian soils are not only characteristically low in pH (4.5 to 6.0), they have little buffering capacity, so agricultural lime (calcium carbonate) is frequently added to commercial agricultural land. If sludge contained lime then this would significantly increase its value above its nutrient value. The use of lime, in the treatment process would be an excellent opportunity to promote high beneficial use of sludge nutrients and increase soil buffers and pH. At plants where supplemental alkalinity is required or if lime were used in lieu of iron or aluminium salts, lime can provide this additional function. Lime binds phosphorus via a different mechanism than alum or ferric salts and unlike dosing with alum or ferric salts, the phosphorus remains available to plants when lime sludge is applied to land. Both West Hornsby and Hornsby Heights STP's currently utilise lime for alkalinity control.

- **Primary Sludge and Digestion.** Raw primary sludge derived directly from primary sedimentation provides nearly the most ideal form of nitrogen for agricultural use. Digestion significantly hydrolyses organic nitrogen producing soluble ammonia which is then lost from the sludge in supernatant or the dewatering process. Digestion, therefore, reduces the nitrogen content and hence the value of the sludge.

  Anaerobic sludge digestion reduces the total solids content of raw sludge resulting in higher concentrations of pollutants. Digested sludge pollutant concentrations are approximately 50 per cent higher than corresponding raw sludge concentrations depending on the degree of stabilisation achieved by the digestion process. This concentration of heavy metals could disqualify the sludge for agricultural use.

- **BNR, IDAL and MLE Secondary Plants.** Different schools of thought prevail within the Board as to whether future activated sludge plants should be biological nutrient removal (BNR) or intermittent decanted aerated lagoon (IDAL) or MLE plants. Neither school of thought has fully considered the implications on beneficial use of sludge. Both types of plant will require chemical additions (Fe or Al salts will probably be used) to remove phosphorus. Providing the BNR design is effective, it will require a lower amount of chemical than the MLE or IDAL (which are not specifically designed to remove phosphorus). The IDAL and MLE processes with their greater chemical requirement to achieve suitable phosphorus removal produce sludge that contains phosphorus in the highly bound chemical form as well as larger quantities of metal hydroxides. This sludge will therefore be of significantly lower agricultural phosphorus value than the BNR sludge.

  Recently, with the operation of the Penrith STP BNR process it has been found that the plant has extreme difficulty in achieving 20 per cent solids for its dewatered sludge (actually achieving around 16-17 per cent). These values are generally below the contracted minimum of 20 percent solids delivered to a contractor.

MINOR RESIDUALS

Minor residuals collected at the Board's sewage treatment plants include screenings and grit. Though quantities of these residuals are considerably less than those of sludge, these materials require on-going management because of their significant impact on plant operations and equipment.

Screenings and Grit Quantities

Screenings quantities vary from plant to plant depending on the size of the plant and on the efficiency of capture. Efficiency is affected by screen type, flow through velocity, aperture size and sewerage catchment characteristics.

A variety of screening systems are utilised by the Board, from fine rotosieves to coarse bar screens with capture rates typically 2-10 mg/L (dry weight per litre of sewage).

Like screenings, grit quantities vary because of plant size and efficiency of capture. Efficiency of grit capture is dependent on type of grit tank, flow velocities and sewerage catchment characteristics.

Capture rates for grit typically lie in the range of 2 to 20 dry mg per litre of raw sewage. However, grit loads increase enormously in wet weather. This is largely due to the accumulation of grit within the sewer reticulation systems and their flushing out during high flow periods.

Table 20-7 shows estimates of average daily quantities of screenings and grit collected at the Board's West Hornsby, Hornsby Heights, Warriewood and North Head STPs in 1994.

TABLE 20-7. ESTIMATED SCREENINGS AND GRIT QUANTITIES 1994 (dry kg/day)

Plant	Screenings	Grit
West Hornsby	93	139
Hornsby Heights	50	75
Warriewood	72	15
North Head	3070	1535

a. Capture rate of screenings : - West Hornsby, Hornsby Heights and North Head (10 mg/L); and Warriewood (5 mg/L).

b. Capture rate of grit :- West Hornsby and Hornsby Heights (15 mg/L); Warriewood (10 mg/L); and North Head (5 mg/L).

Source : Strategic Plan for Wastewater and Stormwater, Volume 5B, Residuals Management Planning, Preliminary Evaluation of Baseline Information, September 1993.

FUTURE RESIDUALS MANAGEMENT PRACTICE

Strategic Planning

The Board's is carrying out the planning effort to identify future residuals management strategies for the Board's STPs.

Part of the strategic planning for residuals management had been accomplished in four distinct steps. Step one is the preparation of Volume 5A - Residuals Management Planning Baseline Data[3]. Volume 5B presents broad environmental and technical analyses of residual processing centres and market applications. Volume 5C presents cost and quality analyses of residuals management options and strategies. The final step involves further development and evaluation of comprehensive residuals management alternatives. This final step involves the integration of residuals management data and preferred alternatives into the overall strategic wastewater planning process which also considers and integrates water reclamation, water quality goals, collection systems and dry/wet weather flow management. Interaction with other elements of the planning process involves providing baseline residuals information about costs, typical facilities and constraints.

SLUDGE MANAGEMENT ISSUES RELATED TO EFFLUENT OPTIONS

As discussed earlier, the options of this study are developed on the basis of effluent objectives and not the residual objectives. The following sub-section will present the sludge management issues encountered by the various effluent options.

Option 1 and 2

These options involve retaining and upgrading the West Hornsby and Hornsby Heights STPs. Although they utilise different processes, it is expected that the sludge management processes currently in use at each plant will continue in the short to medium term until the strategic planning outcomes are known; and can be progressively implemented.

The existing method of trucking dewatered sludge from existing STPs; and final composting at ANL may pose potential problems in the future. With increasing urban development in the catchment and improved treatment processes sludge quantities will increase, necessitating additional truck movements. The existing route is expected to suffer further encroachment from residential developments. Given the experience in other areas of the Board's operations where sludge trucking through residential areas was strongly opposed by the local community, it is reasonable to expect that community opposition in some form may arise in the future. Concerns regarding road safety, noise, odours and potential road damage are most likely to be raised.

Should this situation eventuate, consideration will need to be given to modifying the current sludge management practice. Alternatives may include the provision of drying facilities to reduce the number and frequency of truck movements, or a sludge transfer pipeline (to other STPs or other regional sludge processing centre).

The current use for the dewatered sludge from West Hornsby and Hornsby Heights STPs will continue. Given that the Berowra catchment will be predominantly residential in nature, it is expected that the sludge quality which results from the treatment process will continue to be suitable for composting and agricultural use.

Option 3

This option involves the decommissioning of West Hornsby and Hornsby STPs; and constructing a new nutrient removal plant at the proposed Berowra STP site. Under this scenario, all sewage treatment and hence sludge processing will take place at Berowra STP. The process design adopted at Berowra STP incorporates IDAL process with chemical removal of phosphorus. In terms of beneficial reuse applications, this process produces a chemical sludge which is slightly low in quality, but will still be suitable for agricultural use in terms of the nutrient levels.

The current application as in Option 1 and 2 will be applicable to the sludge produced in Option 3.

Option 4

This option involves the upgrading of West Hornsby and Hornsby Heights STP to their current stated treatment plant capacity; and flows in excess of this capacity are to be transferred to a new proposed Berowra STP.

For this option, three STPs will be producing sludges; and three STPs will continue to have the impact from associated difficulties with sludge treatment and disposal. The sludge produced will continue to be suitable for the current applications.

Option 5

This option consists of transferring all flows to Warriewood STP for treatment and disposal. For this option, the existing Hornsby STPs can be considered as decommissioned; and all the sludge will be produced in Warriewood STP. As a nitrified secondary STP, sludge produced will be suitable for the current application of composting and agricultural usage. The impact of sludge and its transportation will be limited to one STP, i.e. Warriewood STP.

Option 6

This option consists of transferring all flows to North Head STP for treatment and disposal. For this option, the existing Hornsby STPs can be considered as decommissioned; and all the sludge will be produced in North Head STP. Sludge produced will need to be chemically stabilised by lime and CKD. The application will be limited to the current applications of composting and landfill covering material. Like Option 5, the impact of sludge and its transportation will be limited to one STP, i.e. North Head STP.

Option 7

This option consists of treating all flows at the local STPs but only to secondary standard; and transferred the effluent to Warriewood STP outfall for disposal. For this option, the existing Hornsby STPs will be retained and modified to produce secondary effluent quality.

As a nitrified secondary STP, sludge produced will be suitable for the current application of composting and agricultural usage. The impact of sludge and its transportation will be experienced by three STPs, including Warriewood STP producing sludge from its own catchment.

Option 8

This option is similar to Option 5, except that the sewage flow is limited to 3 ADWF. Flows transferred will be treated at Warriewood STP and disposed via the outfall. For this option, the existing Hornsby STPs can be considered as decommissioned; and all the sludge will be produced in Warriewood STP. As a nitrified secondary STP, sludge produced will be suitable for the current application of composting and agricultural usage. The impact of sludge and its transportation will be limited to one STP, i.e. Warriewood STP.

Option 9

Like Options 6 and 8, this option consists of transferring flows of up to 3 ADWF to North Head STP for treatment and disposal. For this option, the existing Berowra STPs can be considered as decommissioned; and all the sludge will be produced in North Head STP. Sludge produced will need to be chemically stabilised by lime and CKD. The application will be limited to the current applications of composting and landfill covering material. The impact of sludge and its transportation will be limited to one STP, i.e. North Head STP.

Option 10

This option consists of treating flows of up to 3 ADWF at the local STPs but only to secondary standard; and transferred the effluent to Warriewood STP outfall for disposal. Flows greater than 3 ADWF will be discharged into the local creek after primary treatment. Like Option 7, the existing West Hornsby and Hornsby heights STPs will be retained and modified to produce secondary effluent quality.

As a nitrified secondary STP, sludge produced will be suitable for the current application of composting and agricultural usage. The impact of sludge and its transportation will be experienced by three STPs, including Warriewood STP producing sludge from its own catchment.

Option 11

Like Option 1, this option involves the retaining and upgrading of West Hornsby and Hornsby Heights STPs to their future requirement. However, unlike Option 1, all dry weather effluent will be further treated to produce an effluent suitable for potable water reuse.

For this option, two STPs will be producing sludges; and they will continue to have the impact from associated difficulties with sludge treatment and disposal. The sludge produced will continue to be suitable for the current applications.

MINOR RESIDUALS MANAGEMENT ISSUES RELATING TO EFFLUENT OPTIONS

Currently, screenings and grit from all the plants in this study are ultimately disposed of by burial at the Eastern Creek landfill depot. Irrespective of which option is being considered it is expected that this method of disposal will continue at least in the short term. The only variations being the number of plants from which the screenings and grit must be collected before transport to the Eastern Creek landfill site.

At present no stabilisation of the screenings or grit is required before burial, it is likely however that at sometime in the future, minor residuals processing will require some means of chemical (or other) stabilisation. Potential regulatory requirements may require a stabilised product prior to landfilling or burial. It is not clear if bagging of these minor residuals would be adequate.

REFERENCES

1. Water Board, *Investigation of Aluminium Sulphate for Phosphorus Removal*, January 1992.

2. Water Board, *Review of the Potential Environmental Effects of Dosing Sewage with Spent Pickle Liquor*, May 1991.

3. Water Board, *Strategic Plan for Wastewater and Stormwater, Volume 5A - Residuals Management Planning Baseline Information*, March 1993.

4. Water Board, *Strategic Plan for Wastewater and Stormwater, Volume 5B - Residuals Management Planning, Preliminary Evaluation of Baseline Information*, September 1993.

5. NSW Environment Protection Authority (EPA), *Interim Code of Practice for the Use and Disposal of Biosolids Products*, June 1994.

6. Water Board, *Waste Water and Reuse Planning, Volume 5C - Residuals Management Planning, Biosolids Options Costs and Product Quality Assessment*, August 1994.

SECTION 21

COMPARISON OF OPTIONS

The following criteria were used to compare options for the achievement of effluent total nitrogen of 15, 10 and 5 mg/L at West Hornsby and Hornsby Heights STPs. Zero discharge options were also considered and compared to treatment and discharge plants in the Berowra Creek Catchment.

The criteria adopted includes:

Capital and operating costs (economic appraisal).
Ability to meet treatment level requirements.
Operational considerations.
Impacts on receiving streams.
Plant and transfer scheme malfunctions.
Odour and noise potential.
Residuals management.
Effluent reuse.
Environmental considerations.

CAPITAL AND OPERATING COSTS

As a means of differentiating options in terms of economics, two appraisal methods have been adopted as outlined in the Board's Economic Appraisal Guidelines[1]. These methods are as follows:

Net Present Value (NPV).
Net Present Value Per Unit of Investment (NPVI).

The following details should be noted concerning the compilation of capital and operating costs and NPVs:

- Cost basis is July 1993.
- Capital and operating costs for the STPs investigated were based on the Cost Estimating Manual - Planning dated July 1993.
- Operating costs do not include yearly licence fees.

- An allowance has been made for operational redundancy for equipment in the costs however all available treatment structures on site are utilised to their maximum capability.

- Upgrading and amplification options investigated orientate facilities to prevent major disruption to current operation during construction and minimise loss of process capacity during routine or major maintenance/breakdown situations.

- Costings and NPV analysis are based on the high population growth summarised in Section 4 for the Hornsby STPs. Adoption of the medium population growth will only slightly decrease the process sizing and will have no major impact on the NPV analysis.

- The dedicated transfer routes to the ocean were costed by Systems Planning Northern. The transfer routes adopted in this report may be modified when the Choices for Clean Waterways strategies are released.

- NPVs are calculated over a 25 year period at a discount rate of 7 per cent. NPV analyses at 4 and 10 per cent discount rates have also been included and are highlighted in Table 21-1 for the various treatment goals specified by the Technical Working Party.

- The following asset lives have been adopted for the NPVs:

  Sewer tunnels, 150 years.
  Sewage pumping stations, 30 years.
  Sewage treatment plants, 25 years.
  Sewage rising mains, 80 years.

- Capital costs for treatment plants and transfer scheme components are based on contract rates with Board's supervision.

- Capital and operating cost estimates are based on an order of accuracy of ± 25 per cent.

- In all NPV analyses a residual value is assumed for all capital scheme components based on their remaining service lives at the end of the 25 year analysis period.

- Although in Option 3, both the West Hornsby and Hornsby Heights STPs are to be decommissioned, no allowance has been made for potential gains from a land sale. Transfer facilities and wet weather storage limit their potential for development.

- When comparing the costs provided in Table 21-1 for Options 1 to 11, the following is to be considered:

    - As options 1 to 4 involve the permanent retention of STPs and continuous discharge of effluent to Berowra Creek, facilities have been costed for effluent total nitrogen targets of 15, 10 and 5 mg/L respectively. In wet weather, flows greater than three times average dry weather flow receive primary treatment only, and are discharged in conjunction with fully treated effluent (maximum of 3 ADWF).

    - The facilities proposed in Options 5 to 10, for the ocean transfer strategies, will result in the zero discharge of effluent to Berowra Creek catchment during dry weather (that is, a total nitrogen effluent level of zero mg/L). In wet weather, however, a number of options may result in local stream discharges, if excessive storm flows are experienced.

      The infrastructure proposed in Option 11 will also result in zero effluent discharges to Berowra Creek if all treated flows are returned to the Thornleigh water supply reservoir. If dry weather discharges are necessary, a total effluent nitrogen level of 0.5 mg/L can be expected. Also during wet weather, flows that do not receive full treatment, will be transferred to the creek.

- Treatment facility design has been based, wherever possible, on site specific raw sewage and known biological characteristics. When this has not been available, however, theoretical Water Board design values have been used. Due to the importance in maximising the use of facilities, actual biological wastewater characteristics are being measured. When they become available, the sizing and costing of facilities provided in this report may need to be revised.

Net Present Values

A summary of estimated capital and operating costs and net present values for Options 1 to 11 and for each of the three treatment levels is shown in Table 21-1.

Table 21-1 also shows the sensitivity of the NPV results to a changing discount rate of 4, 7 and 10 per cent. Figure 21-1 also summarises the NPV results of the 7 per cent discount rate. Ranking of all options will also be based on the seven percent discount rate.

Table 21-1 clearly illustrates that Options 1 and 2 are relatively close in terms of their overall NPVs and are the lowest cost options. Option 4 is the third ranking option. An increasing discount rate naturally reduces the NPV for each option, however, there is little change to the relative order of options under all treatment levels. This indicates a low sensitivity to a changing discount rate.

It should be noted that facilities for options 1 to 4 have been costed to reduce nitrogen in the effluent to 15, 10 and 5 mg/L respectively.

Option 3 (New treatment plant at Berowra) is generally ranked fourth, although a slight change in ranking occurs at lower discount rates.

TABLE 21-1. SUMMARY OF COSTS AND NPVS

Option	Treatment Level	Capital Cost ($M)	Operating Cost ($M/yr)		NPV[a] over 25 years			Option Ranking[c]
			2000	2019	4%	7%	10%	
Option 1	1 (15)	14.6	4.8	5.4	88.9	67.3	53.0	1
	2 (10)	18.1	4.9	5.4	92.1	70.2	55.6	
	3 (5)	23.1	5.0	5.5	96.8	74.3	59.2	
Option 2	1 (15)	14.3	4.8	5.4	90.3	68.2	53.6	2
	2 (10)	18.2	4.9	5.4	94.1	71.6	56.6	
	3 (5)	23.2	5.0	5.5	98.7	75.6	60.0	
Option 3	1 (15)	63.0	4.3	4.8	116.2	94.9	79.0	4
	2 (10)	63.2	4.4	4.9	116.8	95.3	79.4	
	3 (5)	67.0	4.5	5.0	121.0	98.8	82.3	
Option 4	1 (15)	27.0	5.0	5.8	100.7	77.5	61.9	3
	2 (10)	31.9	5.1	5.9	104.8	81.2	65.1	
	3 (5)	35.3	5.1	6.0	108.3	84.2	67.7	
Option 5	b	145.9	4.9	3.9	141.2	126.0	110.0	9
Option 6	b	131.0	4.9	1.1	109.4	103.6	94.0	5
Option 7	b	121.0	4.9	4.5	131.6	116.0	100.5	8
Option 8	b	148.0	4.9	4.5	147.9	130.5	113.0	10
Option 9	b	135.0	4.9	1.7	114.8	107.9	97.0	6
Option 10	b	120.0	4.9	4.5	130.8	115.4	100.0	7
Option 11	Potable Water	69.8	8.1	9.1	169.1	131.8	106.0	11

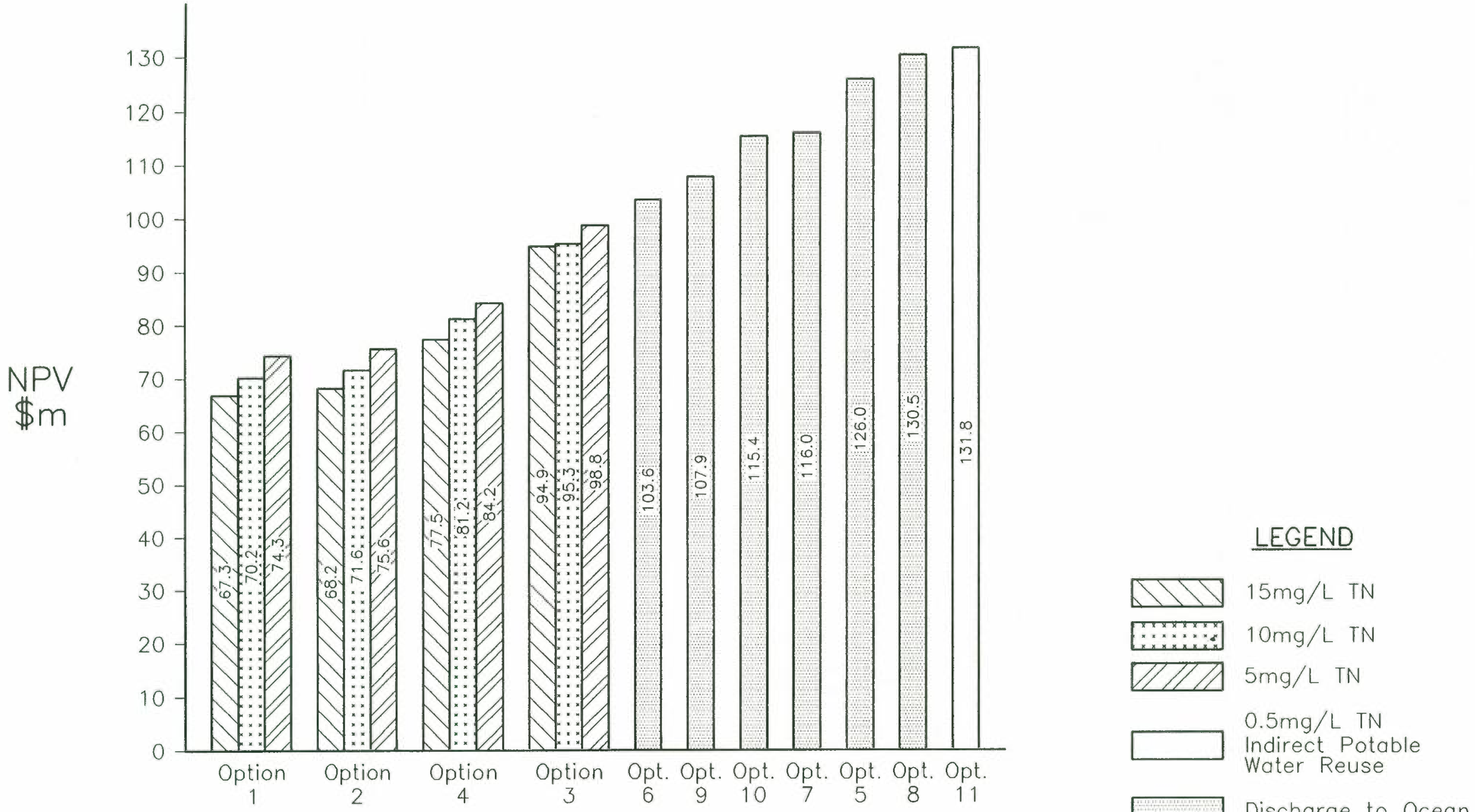
Values in brackets refer to effluent Total nitrogen 90 percentile values

a. NPV analysis is over period 1994 to 2019.
b. Zero discharge to Berowra Creek during dry weather as sewage is transferred to the ocean STPs at either Warriewood or North Head.
c. Options ranking on NPVs at 7 percent discount rate.

Although the standard MLE process (Option 1) is equal in cost to Option 2, it is recommended above Option 2 at this stage until further full scale trials are available on a high biomass MLE process. If it proves to be successful it should be introduced in future Stages at Hornsby Heights STP. Also, as minimum redundancy or spare capacity has been provided for in these options, the treatment process biological reactors have been purposely oriented in parallel operation mode rather than series. This will allow more flexibility in operation and when undertaking maintenance without loss of full treatment.

The next cheapest option is Option 4 followed by Options 3 and 6.

bc-grp3



WATER BOARD
SYDNEY–ILLAWARRA–BLUE MOUNTAINS
WASTEWATER AND REUSE PLANNING

WEST HORSNBY & HORNSBY HEIGHTS S.T.P'S
SEWAGE TREATMENT AND DISPOSAL OPTIONS
NET PRESENT VALUE (7% DISCOUNT RATE)

Figure
21–1

Whether upgrading West Hornsby and Hornsby Heights STP to their current nominal capacity, with the transfer of flows above this size to a new Berowra STP (Option 4), or decommissioning the Hornsby STPs entirely with their sewage catchments transferred to a new STP (Option 3), both options involve the extensive provision of sewage treatment and transport infrastructure. This results in no major overall benefit when compared to the retention of West Hornsby and Hornsby Heights STPs at their current location. Also for Option 4, odour and corrosion due to low flows in the transfer pipeline may occur initially. Operational problems could be expected at the new treatment plant as well when commissioning due to initial low flows below design capacity. Both options 3 and 4 will also require the acquisition of land at Berowra which will have a dramatic impact on the community.

The transfer of both West Hornsby and Hornsby Heights raw sewage to North Head STP for treatment and subsequent disposal via the deep ocean outfall is, by economic analysis only, the fifth ranking option (Option 6).

As the differences in physical, social and environmental impacts between the transfer options and retained treatment in Berowra Creek may be major, one of the determining factors is cost. Here the differences in the strategies are significant. It should be appreciated that transfer schemes often require the provision of facilities sized for ultimate wet weather conditions or construction tunnel equipment available to undertake the work, which will result in the under-utilisation of the dedicated tunnel in the initial years and a high capital cost up front. As the Board is undertaking a major strategic planning exercise, planned for completion and public review in 1995, the adoption of ocean transfer options is considered premature and may well result in significant costs to the community. Although no detailed findings are available at present, it may well be more prudent for the short to medium term to retain and treat sewage within Berowra Creek.

From Table 21-1, the remaining transfer options to the ocean are also dear in terms of capital expenditure and net present values. The transfer options are ranked (in order of lowest to highest cost) as follows; Option 6, Option 9, Option 10, Option 7, Option 5 and Option 8.

The transfer options to the ocean (options 5 to 10) do not include the provision of nutrient removal facilities as their effluent will be discharged to the ocean after either receiving primary treatment at North Head STP, or secondary treatment at either Warriewood STP or the Berowra Creek catchment STPs. The overall effect of the transfer, however, will result in no discharges to Berowra Creek (except under excessive wet weather conditions) and can be related to zero discharges of total nitrogen to the Berowra catchment. These nutrient loads, however, are discharged into the ocean since the ocean treatment facilities proposed make no provision for phosphorus and nitrogen removal. Also the transfer of effluent out of the Berowra Creek catchment will result in a major reduction in creek flow and diluting influence in dry weather periods. This may have a major impact on the creek and would need to be investigated if ocean transfer was adopted for review in the environmental assessment stage.

Option 11 (which is ranked last in the economic analysis) involves producing a potable water from sewage entering both the existing Hornsby STPs, with its redistribution back into the Berowra drinking water supply. The wastewater treatment facilities provided will need to consistently achieve a very strict effluent quality target, and result in no major adverse impact to the community especially with regard to public health. The option is also reliant on the disposal of a brine solution to the ocean which may have high concentrations of salts and trace metals.

Net Present Value Per Unit of Investment

The net present value per unit of investment (NPVI) is the ratio of the net present value of the option to the net present value of the capital investment required. This criterion attempts to take into account capital funding constraints and seeks to maximise aggregate net present value from the available funds by choosing the projects with the highest net present value per dollar of investment.

Table 21-2 illustrates for each option its net present value per unit of capital expenditure. The analysis directly indicates that capital funding restraints favour both the incorporation of Options 1 and 2, the retention, upgrade and amplification of West Hornsby and Hornsby Heights STPs. Option 4 (Upgraded STPs and new treatment plant) is ranked third as in the NPV analysis above. Option 3 (new treatment plants), however, on an NPVI analysis is superceded in fourth position by Option 11 (indirect potable water reuse). This is due to the fact that less capital outlay is required in Option 11 as it maximises the use of existing facilities. However, the indirect potable water reuse option has the highest operating cost of all the options investigated which is due to the use of advanced waste water facilities at the water reclamation plant, and transferring brine solution to the NSOOS. It is considered at this stage that indirect potable water reuse in the Berowra Creek catchment should be investigated on a strategic level, rather than site specific, so as to maximise potential benefits for the whole of Sydney. Figure 21-2 summarises Table 21-2 results for the seven per cent discount rate.

TABLE 21-2. SUMMARY OF COSTS NET PRESENT VALUE PER UNIT OF INVESTMENT

Option	Treatment Level	NPVI[a] (over 25 years)		
		4%	7%	10%
Option 1	1 (15)	8.2	6.9	6.1
	2 (10)	6.8	5.7	5.0
	3 (5)	5.6	4.7	4.2
Option 2	1 (15)	8.4	7.0	6.2
	2 (10)	6.9	5.7	5.1
	3 (5)	5.7	4.8	4.2
Option 3	1 (15)	2.7	2.3	2.1
	2 (10)	2.7	2.3	2.1
	3 (5)	2.6	2.3	2.1
Option 4	1 (15)	5.3	4.4	3.9
	2 (10)	4.6	3.9	3.4
	3 (5)	4.3	3.6	3.2
Option 5	b	1.9	1.6	1.6
Option 6	b	1.6	1.5	1.4
Option 7	b	2.2	1.8	1.7
Option 8	b	1.9	1.7	1.6
Option 9	b	1.7	1.5	1.5
Option 10	b	2.2	1.8	1.7
Option 11	Potable Water	3.3	2.8	2.5

Values in brackets refer to effluent Total nitrogen 90 percentile values

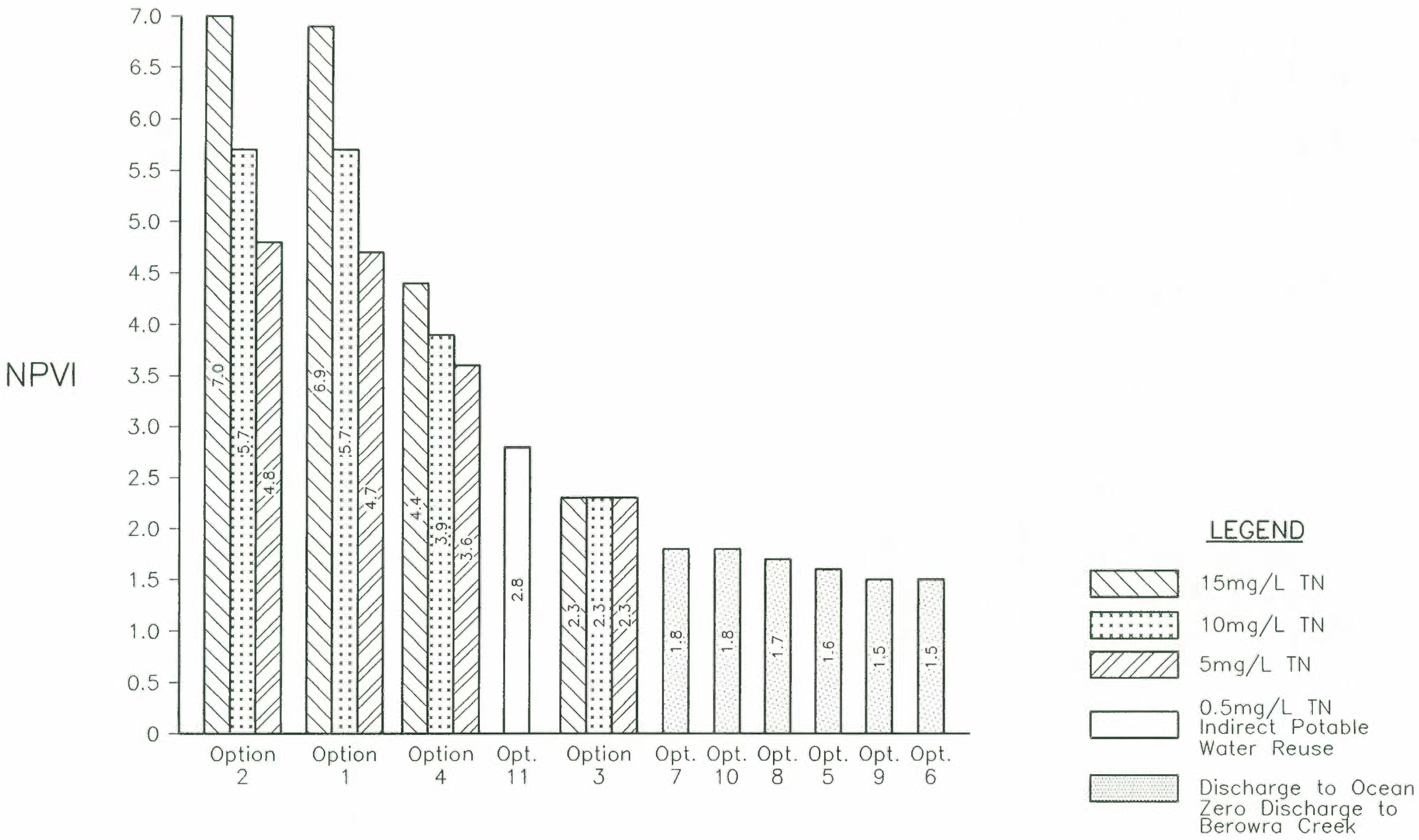
a. NPV analysis is over period 1994 to 2019.
b. Zero discharge to Berowra Creek during dry weather.

Sensitivity Analysis

To determine the sensitivity of the options to variations in capital and operating costs additional NPV and NPVI analyses were carried out. These analyses involved inflation of the estimated capital costs by 25 per cent and the operating cost by 10 per cent.

A summary of the inflated capital and operating costs and NPV's for options 1 to 11 and for each of the three treatment levels is shown in Table 21-3.

bc-grp4



WATER BOARD
SYDNEY–ILLAWARRA–BLUE MOUNTAINS

WASTEWATER AND REUSE PLANNING

WEST HORSNBY & HORNSBY HEIGHTS S.T.P'S
SEWAGE TREATMENT AND DISPOSAL OPTIONS
SUMMARY OF NET PRESENT VALUE PER UNIT OF INVESTMENT

Figure
21–2

TABLE 21-3. SUMMARY OF INFLATED COSTS AND NPVS

Option	Treatment Level	Capital Cost $M	Operating Cost $M/yr		NPV[a] over 25 years			Option[c] Ranking
			2000	2019	4%	7%	10%	
Option 1	1 (15)	18.2	5.3	5.9	99.41	75.5	59.6	1
	2 (10)	22.6	5.4	5.9	103.4	79.1	62.8	
	3 (5)	28.9	5.4	6.1	109.1	84.1	67.2	
Option 2	1 (15)	17.9	5.3	5.9	100.9	76.5	60.3	2
	2 (10)	22.8	5.4	5.9	105.6	80.6	63.9	
	3 (5)	29.0	5.4	6.1	111.1	85.5	68.2	
Option 3	1 (15)	78.8	4.7	5.3	134.3	110.5	92.5	4
	2 (10)	79.0	4.8	5.4	135.0	111.0	93.0	
	3 (5)	83.8	5.0	5.5	140.2	115.3	96.5	
Option 4	1 (15)	33.8	5.5	6.4	113.6	88.0	70.5	3
	2 (10)	39.9	5.6	6.5	118.7	92.5	75.0	
	3 (5)	44.1	5.6	6.6	122.9	96.1	77.6	
Option 5	b	182.4	5.4	4.3	166.8	150.1	131.5	9
Option 6	b	163.8	5.4	1.2	130.6	124.4	112.8	5
Option 7	b	151.3	5.4	4.9	154.0	137.1	119.5	8
Option 8	b	185.0	5.4	4.9	174.4	155.3	135.1	11
Option 9	b	168.8	5.4	1.9	136.6	129.3	116.8	6
Option 10	b	150.0	5.4	4.9	152.9	136.3	118.9	7
Option 11	Potable Water	87.2	8.9	10.0	193.7	152.1	123.1	10

Values in brackets refer to effluent Total nitrogen 90 percentile values

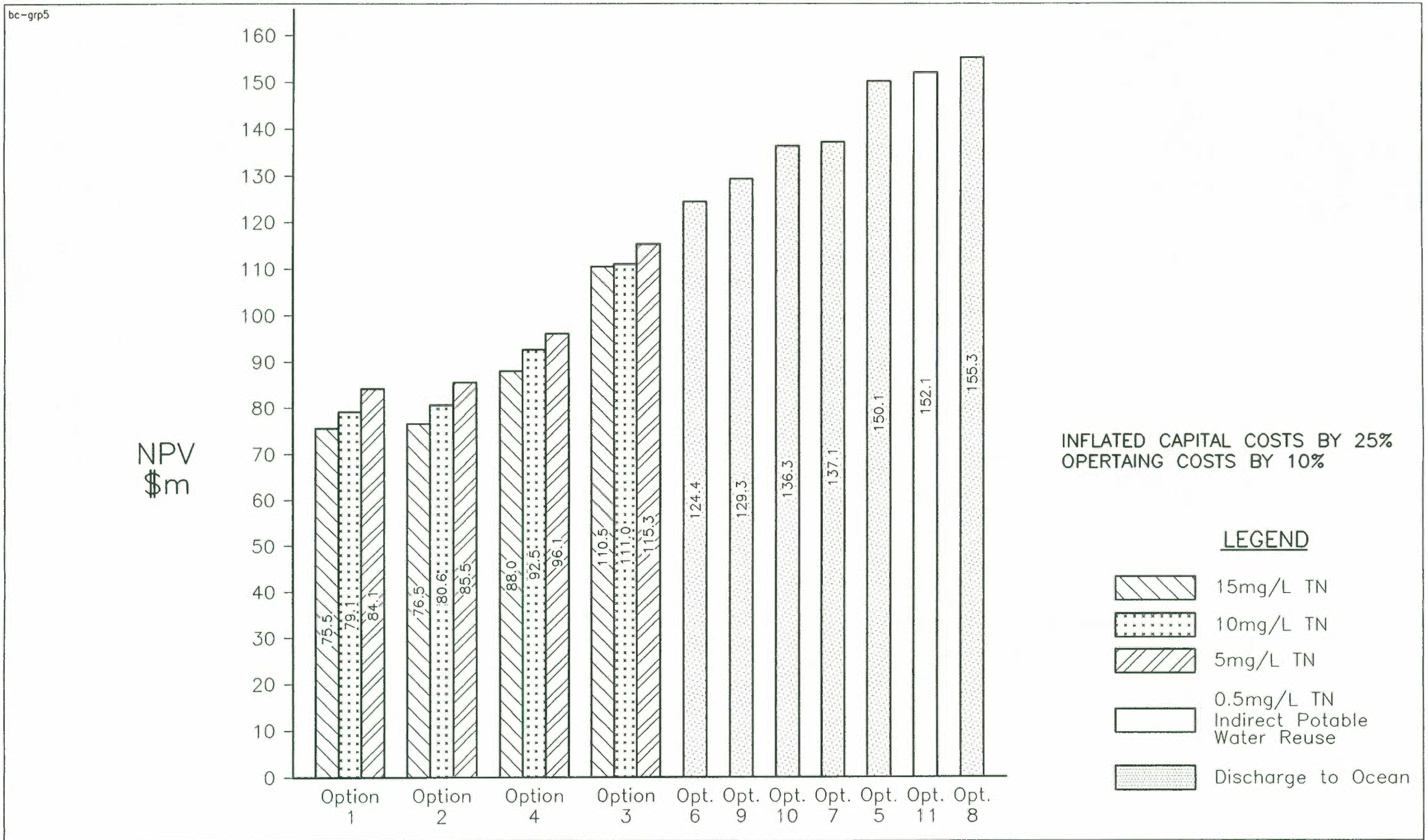
a. NPV analysis over the period 1994 to 2019.

b. Zero discharge to Berowra Creek during dry weather as sewage is transferred to the ocean STPs at either Warriewood or North Head.

c. Ranking of Options based on NPV analysis at 7 per cent discount rate.

Figure 21-3 graphically illustrates in ranking order the inflated net present value at 7 per cent discount rate for each of the options investigated.

This analysis shows that in terms of overall life cycle costing (NPV) there is no change in the relative ranking of the options except in the case of Option 11. This change is relatively insignificant as the options ranking moves only from eleventh to tenth.



INFLATED CAPITAL COSTS BY 25%
OPERTAING COSTS BY 10%

WATER BOARD
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WASTEWATER AND REUSE PLANNING

WEST HORNSBY & HORNSBY HEIGHTS S.T.P.'s
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NET PRESENT VALUE (7% DISCOUNT RATE)
SENSITIVITY ANALYSIS ON INFLATED COSTS

Figure
21-3

Table 21-4 illustrates the inflated NPVI for each option and treatment level, while figure 21-4 graphically illustrates these values in ranking order at a 7 per cent discount rate.

TABLE 21-4. SUMMARY OF INFLATED NET PRESENT VALUE PER UNIT OF INVESTMENT

Option	Treatment Level	NPVI (over 25 years)		
		4%	7%	10%
Option 1	1 (15) 2 (10) 3 (5)	7.3 6.1 5.0	6.2 5.1 4.3	5.5 4.5 3.8
Option 2	1 (15) 2 (10) 3 (5)	7.5 6.2 5.1	6.3 5.2 4.3	5.5 4.6 3.9
Option 3	1 (15) 2 (10) 3 (5)	2.5 2.5 2.4	2.2 2.2 2.1	2.0 2.0 2.0
Option 4	1 (15) 2 (10) 3 (5)	4.8 4.2 3.9	4.0 3.5 3.3	3.5 3.1 3.0
Option 5	a	1.8	1.6	1.5
Option 6	a	1.5	1.4	1.4
Option 7	a	2.0	1.7	1.6
Option 8	a	1.8	1.6	1.5
Option 9	a	1.6	1.5	1.4
Option 10	a	2.0	1.7	1.6
Option 11	Potable water TN 0.5 mg/L	3.0	2.6	2.3

Notes:
Values in brackets refer to effluent total nitrogen 90 percentile values

a. Zero discharge to Berowra Creek during dry weather

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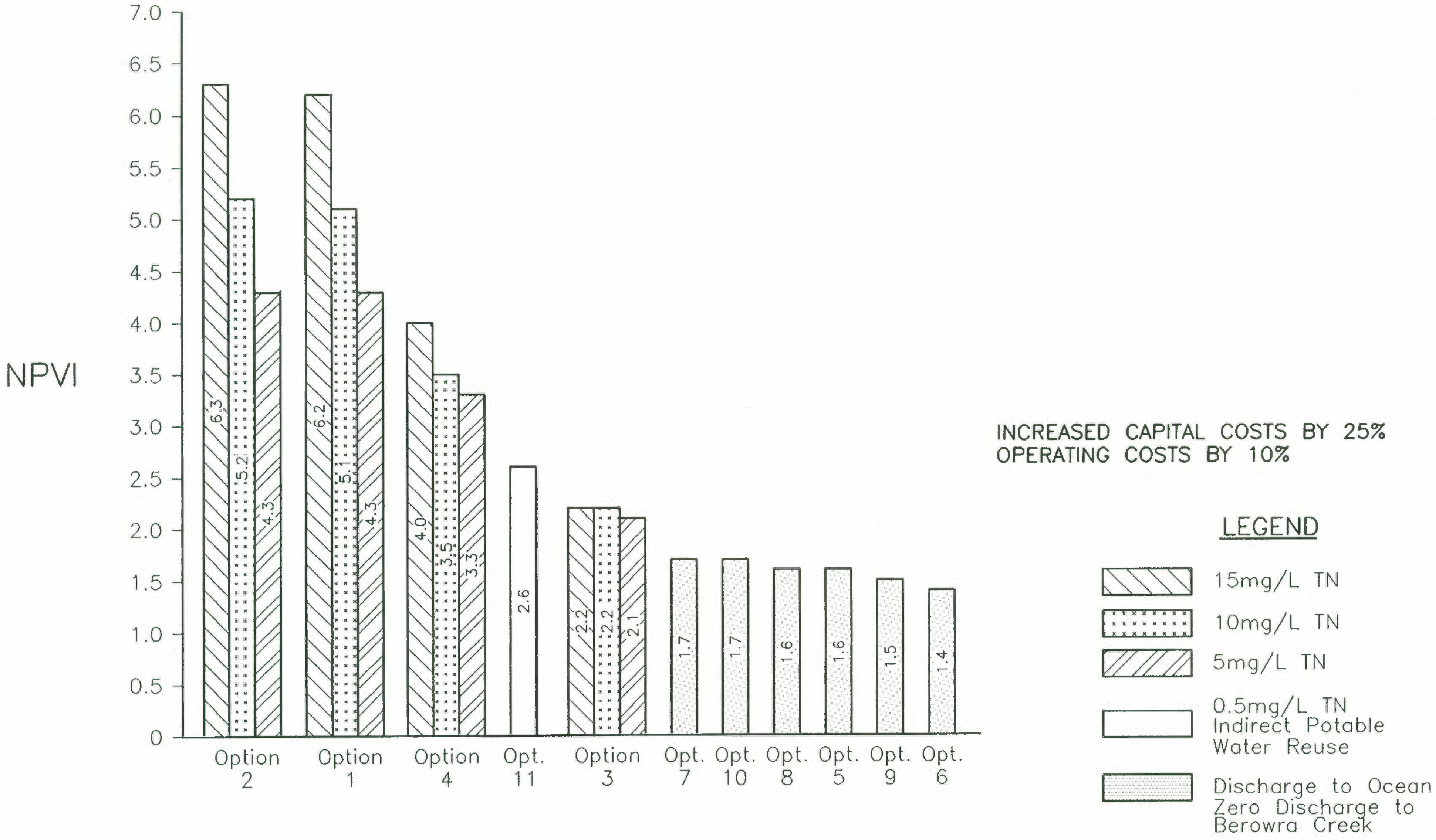

INCREASED CAPITAL COSTS BY 25%
OPERATING COSTS BY 10%

WATER BOARD
SYDNEY–ILLAWARRA–BLUE MOUNTAINS

WASTEWATER AND REUSE PLANNING

WEST HORNSBY & HORNSBY HEIGHTS S.T.P.'s SEWAGE TREATMENT AND DISPOSAL OPTIONS SUMMARY OF NET PRESENT VALUE PER UNIT OF INVESTMENT SENSITIVITY ANALYSIS ON INFLATED COSTS

Figure
21–4

The results of this NPVI analysis show that there is little change in the relative ranking of options with increased capital and operating costs. Options 1, 2, 4 and 3 are still favoured on a capital funding constraint basis as well as Option 11.

TREATMENT LEVEL REQUIREMENTS FOR BEROWRA STP's

Ability to Meet Level 1 Treatment (Total Nitrogen of 15 mg/L)

The MLE process considered in this report for options 1, 2, 4, and the intermittent activated sludge system for the proposed new treatment plant (options 3 and 4) all have the ability to meet Level 1 effluent quality. The advanced wastewater treatment plant in Option 11 will easily meet Level 1 requirements.

Ability to Meet Levels 2 and 3 Treatment

In order to meet Levels 2 and 3 criteria, 'add-on' facilities (methanol dosing and post-denitrification) would be required. As the same "add-ons" apply to each option, the ability of the options to meet the Levels 2 and 3 target is effectively the same.

Ability to Meet Standards Beyond Level 3 Treatment

The long term effluent quality criteria for the Hornsby STPs are uncertain. The EPA is considering receiving water criteria in the Hawkesbury/Nepean basin of 0.5 mg/L nitrogen and 0.05 mg/L phosphorus and, given that in dry weather the STP effluents may comprise the major flow in tributary streams, its possible that the targets could apply to STP effluents.

None of the options under consideration (except Option 11) could be directly modified to meet such low limits. The only way that such limits could be met would be by provision of additional facilities which might include:

Ion exchange.
Reverse osmosis.
Activated carbon adsorption.

In terms of meeting such stringent criteria all options (excluding Options 5 to 10) are considered to be equal. It is considered, however, that such facilities would require further investigation since disposal of concentrated brine streams could pose significant problems. Appendix B provides information of the processes in more detail.

If Options 5 to 10 are adopted (transfer of flows to ocean discharge) no upgrading of existing facilities would be required at West Hornsby and Hornsby Heights.

Treatment of Wet Weather Flows

For all options, it is proposed to limit the flow to be treated within the plant to the DWWF value previously discussed in Section 3.

Treatment of wet weather flow within the plant will vary, depending on the option chosen.

In the IDAL system (options 3 and 4), the full DWWF would pass through the normal treatment facilities, except for tertiary facilities where flow would be limited to 3 ADWF. At flows greater than 3 ADWF, the normal cycle of operation of the IDAL would be replaced by a storm cycle. In the storm cycle aeration period would be reduced and the decant period increased to cater for the greater than normal flow. This is the normal mode of operation of all intermittent treatment systems of this type.

With the continuous flow systems (Options 1, 2 and 11), flows through the biological reactor/clarifier (as well as through the tertiary facilities) would be limited to 3 ADWF. Flows greater than 3 ADWF would receive screening, grit removal and primary sedimentation facilities (which would be designed to treat the full DWWF) and would then by-pass to the disinfection facilities. This arrangement is typical for continuous flow systems and is aimed at preventing "wash-out" of the biological solids in the secondary treatment system.

As far as overall treatment efficiency of wet weather flows is concerned, the IDAL system probably has the potential to produce a slightly better effluent that the continuous flow systems. Although at DWWF, the IDAL would act mainly as a sedimentation tank, the presence of biological solids would undoubtedly provide some additional treatment. As the dilution of sewage will be high at sewage flows greater than 3 ADWF, however, the difference in overall treatment efficiencies between the two systems would be relatively minor.

Options 5, 6, 8 and 9 consider transferring all flows (up to DWWF) to either Warriewood or North Head STP for treatment and effluent disposal to the ocean. Under these options full treatment will be provided for 3 ADWF at Warriewood STP with flows greater than this allowance being given primary treatment.

All flows transferred to North Head will receive primary treatment prior to discharge to the ocean via the deep water outfall.

Flow in excess of DWWF will be stored at the transfer stations in Berowra and if in the eventuality of no spare capacity, will be discharged after preliminary treatment to the local creeks.

For Options 7 and 10, flows up to 3 ADWF, after secondary treatment at both Hornsby Heights and West Hornsby STPs will be transferred to the Warriewood STP for disposal. Flows in excess of this amount will receive primary treatment at least before potential discharge to the Berowra Creek catchment. All storm flows potentially discharged to Berowra Creek will be very dilute.

Under all options, adequate storm treatment shall be provided and is considered adequate when higher dilutions are being experienced within the receiving waters.

PROCESS RELIABILITY, OPERABILITY AND FLEXIBILITY

There is adequate experience in the operation of the standard processes under consideration within this report. The IDAL system at Quakers Hill STP is performing extremely well at present, producing effluent nitrogen, ammonia and phosphorus levels within its design criteria (to Level 2) requirements.

The Board has some experience with the MLE process at Riverstone and Castle Hill STPs. Recent modifications to both plants have resulted in both STPs achieving Level 2 total nitrogen levels. The Board has also commissioned an MLE facility at West Camden which is approaching the Level 1 effluent quality goals. If properly designed and operated, the MLE system should be capable of reliably meeting the required nutrient removal performance. Further experience with a high biomass MLE is also required to ensure its successful performance.

Because of the generally simpler arrangement of the IDAL system (and less mechanical equipment) in comparison with the continuous flow systems, the IDAL is undoubtedly the easier process to operate, however, it requires considerably more land area than a continuous flow process.

The existing secondary treatment process at Warriewood STP should pose no major problems in operation, and the proposed upgrading to a nitrification plant to meet ammonia removal requirements should improve hydraulic constraints currently being experienced during wet weather. The existing shoreline ocean outfall has also adequate capacity to handle increased loads from the Berowra catchment.

In considering the North Head STP, the proposed augmentation under Options 5 and 8, should adequately address the treatment of additional flows for the Hornsby catchment, however, further works may be needed in the future to adequately address the community expectations for acceptable ocean discharge.

Sludge Settleability

All biological processes (particularly those operating at relatively long sludge ages) have a potential sludge settleability problem, however, this problem has been observed to be reduced with chemical dosing.

As the MLE and IDAL systems are dependant on chemical dosing for phosphorus removal, poor settleability should not be a significant factor with options involving that system.

Sludge Production

Because of both the MLE and IDAL dependence on chemical dosing for phosphorus removal, the quantity of sludge produced may be as much as 15% by volume and 30% by weight greater than that produced in the non-chemical treatment systems. (This is based on the chemical dosing trials carried out some years ago at Glenfield STP[1]).

Sludges from many of the Water Board's sewage treatment plants are suitable to be applied to agricultural land in accordance with the EPA's code of practice for biosolids [2]. Not covered by the EPA's code are the concentrations of iron and aluminium in the sludge and the resulting impact on available phosphorus. Iron and aluminium salts are added to sewage to lock up phosphorus and prevent its discharge in the effluent. The chemically bound phosphorus ends up in the sludge.

Discussion with NSW Agriculture reveal that when high Fe and Al sewage sludges are applied to land any of the following may occur, depending on the circumstances:

- Phosphorus may not be available to plants.
- Available phosphorus in the soil may be depleted.
- Additional superphosphate may need to be applied to overcome any negative fertiliser value of the applied sludge.

NSW Agriculture is currently assessing its research and development projects to determine the occurrence of the above possible scenarios. Their assessment will lead, it is hoped, to the defining of the circumstances under which the application of chemical sludges to the land is and is not beneficial with respect to phosphorus. The NSW Agriculture findings will probably have implications on the Board's beneficial use programme.

For high Fe and/or Al sludge their effects may be mitigated by blending with non chemical organic sludges, utilising them in compost material or other means where the phosphorus content in the sludge is not important to its use.

IMPACTS ON RECEIVING STREAMS

Though West Hornsby and Hornsby Heights plants discharge effluent to Berowra Creek and ultimately to the estuarine section of the Hawkesbury River, the immediate waterways to which they discharge vary.

Effluent from Hornsby Heights STP enters Calna Creek and flows some 5 kms through predominantly bushlands areas before joining Berowra Creek. Both the West Hornsby and Hornsby Heights effluent makes up the majority of creek flow particularly in dry weather.

Effluent from West Hornsby STP is effectively discharged into Berowra Creek (after a short run in Waitara Creek) close to, Fishponds Waterhole.

The impacts of effluent discharges on these waterways are characterised by increased nutrient and coliform levels close to the point at which effluent enters the streams. In the case of Hornsby Heights STP, however, Calna Creek offers a significant zone of pollutant assimilation up to its confluence with Berowra Creek.

The West Hornsby plant represents the most significant discharge to the Berowra Creek system in dry weather. Although the creek experiences an initial pollutant load from West Hornsby, by the time the Creek reaches Crosslands Reserve an effective assimilation is provided for the conventional pollutants as well as total phosphorus and ammonia. Total nitrogen levels, however, exceed upstream STP levels by 5 to 1.

For options 1, 2 and 4, in which all STPs are developed separately, the benefit of nutrient assimilation in existing streams would be retained.

For Option 3, which involves the decommissioning of both West Hornsby and Hornsby Heights STPs with transfer of flows to a new STP, the existing effluent discharge points will be concentrated into one. As a result, there will be a loss of significant assimilative capacity both in the upper section of Calna Creek and in Waitara Creek.

Removal of effluent from the upper section of Waitara and Berowra Creeks, however, would be expected to lead to some improvement in stream, nutrient and coliform levels, although the effects of a resulting lower stream flow may offset this benefit due to less available dilution of urban and rural runoff. The provision of pollutant reduction mitigative measures within the whole of the Berowra Creek catchment, such as artificial wetlands and riffle zones, may, however, help to minimise these impacts of urban and rural runoff. The instream study being undertaken by Hornsby Council to alleviate storm water overflow pollution will also be effective in dry weather situations and should be seriously considered for implementation.

The potable water reuse and transfer to the ocean options (option 11 and options 5 to 10) will have a dramatic impact on Berowra Creek in terms of no major dry weather flow discharges and subsequent loadings. The transfer options may offer a long term solution for Berowra Creek. This is further strengthened by the fact that no nutrient removal is required for ocean discharges.

The issue of water quality effects resulting from these options examined in this study is a complex one which cannot be adequately assessed in the absence of water quality modelling. It is imperative that such modelling be initiated whether or not an environmental impact assessment of the proposals is undertaken.

PLANT AND TRANSFER SCHEME MALFUNCTIONS

Malfunctions at sewage treatment plants can occur due to biological process upsets and failures of electrical and mechanical equipment.

Biological process upsets may result from components of sewage which are toxic to the micro-organisms involved in treatment. Toxic loads are more likely where the sewage has an industrial component. The Hornsby sewerage catchments under consideration in this study, however, are predominantly residential in nature with only relatively small areas of light industrial/commercial zonings. As a result, there is little likelihood of severe toxic loads from any catchment.

Malfunctions due to electrical/mechanical failures occur in all plants and can only be adequately guarded against by duplicate/back-up facilities or storage of wastewaters until the fault is rectified. All Options under consideration do provide some form of storage or partial back-up facilities.

In Options 5 to 10 the transfer of flows to the ocean will put these plants into the category of having all the "eggs in one basket". In addition, the transfer system is also subject to failure and this could lead to discharge of raw sewage. To minimise this danger, routine maintenance will be provided on all facilities in the transfer schemes to contain raw sewage overflows during periods of equipment or tunnel malfunction. Further storage is also to be provided with the use of existing treatment units at West Hornsby and Hornsby Heights STPs.

Mechanical and electrical equipment at the proposed new STP will be newly installed and will not be expected to be subject to the same frequency of breakdown as equipment at West Hornsby and Hornsby Heights. Preventative maintenance and equipment renewal programmes at these older plants should, however, substantially eliminate any advantage gained by a new facility. Programmes will, however, need to be implemented and form part of the operational cost for the STPs.

Options 1, 2, 4 and 11 provide some insurance against disruptive impacts from malfunctions by dispersing the potential for failure between the various plants. Preventative maintenance and/or equipment renewals must be vigorously undertaken to ensure the integrity of the treatment processes as equipment continues to age.

ODOUR AND NOISE POTENTIAL

For new greenfield STP sites, a 400 metre buffer between itself and any future residential development is now considered essential. Generally new plants will also utilise modern equipment designed to reduce noise and will also incorporate odour collection and scrubbing equipment on those process units which generate significant odours (inlet works, screens, primary sedimentation etc). These measures, in combination with the surrounding buffer zone and compatible land use zonings will typically minimise any odour or noise impact from this plant.

West Hornsby and Hornsby Heights STPs on the other hand is situated close to existing residential developments (less than 300 metres) with development encroaching near the plants boundary. The plants have in the past, suffered considerably from odour complaints and work has recently been completed to reduce the impact of odorous air from the screens, grit removal and primary sedimentation tanks. Improved house keeping has been successful in reducing the incidence of odour complaints but the close proximity of houses may still mean irregular occurrences of odour nuisance, particularly during times of maintenance.

The closure (or semi-closure) of the Hornsby plants (Option 3 and 5 to 10) would eliminate any odour or noise problems at this plant, although, some noise and odour release (during maintenance) would still occur with the operation of the required pumping station and wet weather holding facilities. It is not considered likely that the level of these nuisances will effect any surrounding residential areas. The community may believe that there is obvious benefit in closing the plants from the viewpoint of removing an industrial type operation which is sited uncomfortably close to residential areas. The options involving transfer to the ocean or to a new STP site, however, will only transfer this potential problem to other STPs surrounded by development as well.

RESIDUALS MANAGEMENT

The sludge produced currently at West Hornsby and Hornsby Heights STPs complies with the EPA Interim Code of Practice for Biosolids and therefore does not pose an identifiable threat to the food chain and human health. At present, sludges from both West Hornsby and Hornsby Heights STPs are used for blending with composting materials at ANL. Options 1 to 4 and Option 11, will have no major impact on this current strategy.

For the transfer options, (Options 5 to 10) sludge will be collected, and stabilised at either Warriewood or North Head STPs. If Berowra sewage flows are directed to Warriewood STP, no major change to the current sludge management strategy is envisaged, except in sludge quantities to process. The stabilised and dewatered sludge will continue to be outloaded for composting and beneficial use.

At North Head STP sludges are stabilised using lime treatment and cement kiln dust prior to being outloaded to agricultural and landfill sites within the Sydney Region. This current practice will not be dramatically impacted on if, either Options 5 and 9 are adopted.

Sludges that may be collected in the processing facilities at West Hornsby and Hornsby Heights STPs also should not pose any problems for disposal.

EFFLUENT REUSE

Opportunities for effluent reuse were investigated (Option 11) and potential exists for major reuse via indirect potable water supply. Other reuse projects may include dual water supply in new development areas and irrigation of golf clubs, and intensive horticulture but to a lesser degree in terms of quantity and continual use during the whole year. Also, if Options 1 or 2 are adopted by the community for the short to medium term, the facilities installed could be modified to produce potable water if the strategic wastewater plan recommends development of potential projects for implementation in the long term.

The adoption of the transfer options on the other hand will concentrate potential reuse products at either Warriewood or North Head STP. From a recent survey undertaken for the major ocean outfall, limited reuse potential exists at and around the treatment plants within the 3 kilometre radius. At present, a maximum demand of around 4 ML/d is forecast for the North Head STP and represents a very small percentage of current influent flows.

The concentration of flows at either North Head and Warriewood STPs will limit the potential for effluent reuse in the Berowra Catchment if the transfer options are adopted. Sewer mining along the dedicated tunnels may need to be employed if the Board's Corporate Directions to increase beneficial reuse of sewage effluent is a major objective in the long term planning for Sydney's water cycle.

ENVIRONMENTAL CONSIDERATIONS

Environmental objectives and criteria applicable to the Berowra Creek catchment were discussed in Section 6. The objectives and criteria are summarised under the categories protection of public health, protection of public amenity, protection of receiving waters and resource conservation. Each option investigated is assessed against the above objectives and criteria.

A preliminary assessment is made and tentative conclusions are drawn regarding the likelihood of compliance with the objectives and criteria.

Protection of Public Health

Protection of Public Health to Maintain the Quality of Primary and Secondary Recreational Waters. For Options 1, 2, 3 and 4 which involve discharge to Berowra Creek, compliance with primary and secondary recreational microbiological criteria is considered achievable with proper optimisation of chlorination facilities at the existing plants and proper design and optimisation at the proposed Berowra Creek STP (Options 3 and 4). The Technical Working Party has linked non compliance with the ANZECC primary and secondary water quality faecal coliform goals of 150 cfu/100 mL and 1000 cfu/100 mL respectively to other diffuse sources within the catchment. By ensuring consistent and reliable operation of disinfection facilities at the Berowra STPs, an improved compliance with microbiological criteria is therefore expected and should result in no direct adverse impact on public health. The diffuse source inputs of potentially harmful pathogens, however, will need to be identified and managed to ensure recreational waters are not polluted and public health is protected.

Discharges to the ocean, via the Warriewood or North Head sewerage systems should not dramatically influence the current situation at either Warriewood or North Head STPs. There are relatively few instances of non compliance with beach microbiological criteria, and most of these non-compliances can be linked with stormwater effects on the beaches. As no major upgrades are planned at the ocean plants under these options, no major improvement in compliance with microbiological criteria can be envisaged beyond the present level.

Protect Public from Emissions of Deleterious Substances. None of the options proposed are likely to result in the emission of substances to the air which could effect human health. On this basis, all options comply with the objective.

Prevent Bio Accumulation in Receiving Waters Organisms. Both Tables 5-3 and 5-4 in Section 5 indicate that the concentration of heavy metals measured in the receiving waters of Berowra Creek generally exceeded the guidelines concentration for primary contact recreation and ecosystem protection. Guideline concentrations for a number of heavy metals were exceeded across the whole catchment, decreasing with dilution in the tributaries. Lower concentrations found downstream of the STPs indicated that sewage effluent is diluting the concentrations in the catchment rather than increasing them. The removal of treatment flows from the Creek (Option 5 to 11) may well result in higher concentrations of heavy metals and be more available for biota accumulation.

No toxic organic compounds, with the exception of THM's, were detected above 5 μg/L. Based on guideline concentrations for drinking water compliance of THMs, the concentrations found in Berowra Creek are of little concern. Therefore, Options 1, 2, 3 and 4 are considered not to have a major impact on Berowra Creek, while Options 5 to 11 will remove the potential input of restricted substances (heavy metals plus organic compounds) from the Berowra Catchment and transfer them to the ocean where high dilution and assimilative capacity is available.

Fish associated with the shoreline outfalls showed evidence of bioaccumulation, in some instances to levels in excess of the NHMRC criteria. Since the deepwater outfalls have begun operation, field experiments have shown that monitoring organisms around the deepwater outfalls has the potential to accumulate restricted substances, but there is no evidence yet available that the operation of the deepwater outfalls adversely affects resident species. More evidence is required from the EMP reports due at end of 1994, but the current compliance of effluent from North Head and Warriewood with EG-1 guidelines for restricted substances suggests there is no direct threat to human health from the current plants effluent through bioaccumulation in the food chain. On this basis, the transfer options should not aggravate the current situation and should comply with this objective, especially with regard to Warriewood STP which affords a higher standard of treatment than the primary facilities at North Head STP.

A potential problem may exist for Option 11 which involves potable water reuse and ocean disposal of brine. In Option 11, this waste stream is planned to be transferred to the North Head STP via the NSOOS system. Primary treatment plus disposal via the deep ocean outfall, and the fact that the Hornsby sewerage catchments have a predominantly domestic sewage, should alleviate some of the concern.

Alternatives for brine treatment such as evaporation ponds and distillation are not considered feasible as they are expensive, require substantial land areas, and are energy intensive.

Ensure Sludge Does Not Impact Upon Food Chain. The sludge produced currently at the Hornsby and ocean STPs comply with current guidelines for agricultural, composting and/or landfill disposal. The options investigated are believed not to compromise this existing position, but more beneficial use can be afforded to ocean sludges which have no chemical addition. Despite this, all options proposed should comply with this criteria.

Community Expectation

While the public accepts the need for STPs, they frequently exhibit the NIMBY (not in my back yard) syndrome. Where communities do not have a choice with regard to plant location, they seek to minimise disturbance and nuisance from the STP. Also, they may perceive that these STPs are best suited in other locations where public health and the environment will be least affected.

The ideal situation would be for the operations and presence of the STP to be transparent to the community, although this is difficult where plants, such as North Head, have a high profile in the community. Proper zoning, screening and augmentation of an STP may not be enough to alleviate doubts that the STPs can meet public health and environmental protection. It may well be accepted that the existing Berowra Creek Catchment plants are best suited to treat sewage in their own catchment to standards acceptable by the local residents rather than transfer their impact in an easterly direction.

Protection of Public Amenity

Surface Waters Visually Free from Grease, Oil, Solids and Settleable Matter. The continuation of tertiary treatment in Options 1 to 4, and Option 11, will ensure a high standard of treatment and result in negligible visibility of grease, oil and solids in the receiving waters of Berowra Creek.

For Options 5, 7, 8 and 10 which involve raw or secondary effluent transfer to Warriewood, the ocean receiving waters should continue to be visually free from grease, oil and settleable matter on the majority of dry weather days. The options involving transfer to North Head STP (Options 6 and 9) may impact on the visibility of floatables in the ocean waters. The installation of additional primary sedimentation tanks, as proposed in the North Head STP Grease Capture Improvement - Needs Specification, November 1993, would result in partial achievement of this goal in that floatables, solids and settleable matter would not appear on the water surface. The tendency for the plume to surface from time to time, however, and for the plume to still have grease and oil associated with it resulting from primary treatment, would mean that the objective may not be fully achieved.

Site Facilities Not to Cause Unacceptable Visual Impacts. All new structures and works (except the tunnels) would be located above ground, and visual impacts of all options would be no worse than at present. Adequate measures shall be undertaken to continue to screen new facilities from existing residential development.

Control Odours from STP and Sewerage Systems. All options make provision for improved odour control to minimise the potential for odour nuisance from the plants. If proper housekeeping measures are not adequate, further consideration may need to be given to the installation of odour control facilities which will increase the overall costs for each option investigated. When considering Option 4, there may be problems with odours in the influent to the new STP due to low flows in the transfer pipeline initially.

Restrict Operational and Construction Traffic Noise to Acceptable Levels. Operational traffic noise would mainly be related to the transport of chemicals to the site and sludge and other residuals from the site. It is unlikely that any of these options would create a significant impact on residential amenity, as the road traffic noise level would probably not exceed current practice. The public perception, however, of the effects of increased sludge trucks through residential streets as experienced at North Head, may not be favourable received.

Construction traffic generation effects would be related to the amount of excavation required. The amount of spoil to be removed at the treatment plants would not be extensive and would probably be tolerated by the community. The tunnels would, however, require extensive excavation and spoil removal. It is likely that such truck numbers would be much less acceptable to the community especially near the National Park areas.

Restrict Operational and Construction Noise to Acceptable Levels. Most construction would occur aboveground and noise would need to be controlled. When excavation is required from the surface, and given the nearness of residential development, it is unlikely that the EPA noise guidelines would be able to be adhered to when major earthworks are being undertaken. A more detailed assessment is required during the EIS stages for the selected options.

Given that all facilities will be designed to reduce noise levels, operational noise would not be significant at any stage of the development for each option.

Minimise Impacts on Adjacent Land Uses. Surface land acquisition is required for the proposed new treatment plant site, rising mains and tunnel accesses in a number of the options investigated. This is considered to a major impact on the community and may be sufficient to dispel the practicality of Options 3, 4 and Options 5 to 10.

Protection of the Receiving Waters Environment

Prevent Direct Physical Effects on Marine Organisms and Community Structure. There is no detailed evidence yet available to suggest that the current operation of the deepwater ocean outfalls are having direct physical effects on marine organisms. Preliminary data and observations suggest that the marine community is not directly impacted upon by the effluent from the outfall, but the results of the EMP in 1994 will be needed to provide conclusive evidence. Options 6, 9 and 11 should have no major impact on the marine environment.

Transfer Options to Warriewood should also have no major impact on the marine environment as secondary effluent plus ocean discharge via a short ocean outfall shall be utilised.

Prevent Bioaccumulation of Restricted Substances in Receiving Waters Organisms. Although there was direct evidence of bioaccumulation in marine organisms in the vicinity of the shoreline outfalls, there is no direct evidence yet available for such occurrences in organisms associated with the deepwater outfalls. The potential for this to occur, however, has been demonstrated. It is unlikely that accumulation in organisms would be to a level which would affect the health or longevity of the organisms, or the structure of the communities in which they live.

Definitive assessment of this will need the results of the EMP reports in 1994.

The concentrations of restricted substances in the effluent currently comply with the criteria of EG 1 and on that basis it is assessed that Options 5 to 10 will not influence the current situation.

For Options involving discharges to Berowra Creek, current investigations indicate that restricted substances from STP effluent are of little concern, and provided that trade waste control is continued, should have no major long term impact on the biota in Berowra Creek.

OVERVIEW OF STRATEGIES

This section provides a summary of the potential advantages and disadvantages of each option. These statements are qualitative in nature and represent outcomes which are considered likely to be demonstrated when implemented.

Options 1 and 2 - Upgrading and Amplification of West Hornsby and Hornsby Heights STPs

The potential advantages of Options 1 and 2 are considered as follows:

- Maximises use of current assets especially with regard to West Hornsby which has recently been upgraded.
- Minimises change to existing surface water flow regime in Berowra Creek, allowing current flows to provide dilution.
- Facilitates local catchment wastewater management through decentralised development and tends towards a distinct water quality management strategy for Berowra Creek.
- Facilitates future reuse of effluent in areas adjacent to the treatment plants, if available, or provide future reuse in new development areas.
- Facilitates construction of major works in response to local growth and needs.
- Substantial reduction in total nitrogen and other pollutants to Berowra Creek.

The potential disadvantages of Options 1 and 2, are:

- Reduces economy of scale in treatment facility construction and operation if that potential exists.

- The upgrading of treatment facilities to either Levels 1, 2 and 3, will not meet proposed stringent water quality targets that may be enforced in the future by the EPA. It is also doubtful whether the removal of all effluent from Berowra will achieve the EPA's water quality goals of 0.5 mg/L total nitrogen and 0.05 mg/L total phosphorus in Berowra Creek. It is recommended that implementation of improvements be done in stages and be reliant on water quality monitoring.

Options 3 and 4 - New Treatment Plant

Options 3 and 4 involve either the transport of all flows (Options 3) or excess flows above existing West Hornsby and Hornsby Heights STPs capacity (Option 4) to a proposed new treatment plant in the Berowra Catchment. The major advantages include:

- Provides the opportunity for a new treatment process to be purpose built to achieve a high degree of nutrient reduction as is the case with the Rouse Hill STP, and be more reliable than upgraded facilities.

- Provides economy of scale in constructing regional treatment facilities (Option 3 only). Option 4 will still result in three treatment plants in the Berowra Catchment.

The potential disadvantages are:

- Concentration of assets at one treatment plant location (Option 3 only).

- Continual reliance of successful operation of transfer infrastructure from existing STP catchments to proposed Berowra STP.

- Current assets at West Hornsby and Hornsby Heights STP not utilised to their full potential (Option 3 only).

- No additional benefit in nutrient reduction over options 1 and 2.

- Acquisition of additional land at a cost of over $ 3M is required for the new treatment plant. The potential site(s) nominated also may have an adverse effect on the public as an inadequate buffer is available to screen the plant's functions from residential and commercial development.

- Major disruption to traffic in Hornsby Council will be experienced with the construction of proposed rising mains from both the West Hornsby and Hornsby Heights STPs.

- The site nominated for the proposed new treatment plant is located in Berowra Valley Bushland Park

Option 5 and Option 6 - Dry and Wet Weather Flows to Ocean STPs

Options 5 and 6 consist of transporting all flows to either Warriewood or North Head STPs respectively for treatment and disposal. The potential advantages of Option 5 and 6 are:

- Significantly reduces the nutrient loading on Berowra Creek under both dry and wet weather conditions.
- Increases economy of scale in treatment facility construction and operation (Option 6 only). For Option 5, Warriewood STP will need substantial augmentation to treat additional Berowra Creek catchment sewage flows.
- Reduces the levels of treatment and associated operating costs in Berowra Creek Catchment. The existing West Hornsby and Hornsby Heights treatment plants will be modified to screening and sewage transferral plants.
- Reduces demand for highly skilled O & M services in multiple locations.
- May allow potential cost savings on coastal wet weather overflow control by diverting the discharge from trunk overflows to the effluent transfer tunnel.

The potential disadvantages are:

- Removes the contribution of treated effluent from the dry weather base flow of Berowra Creek and it's tributaries. In our case, the majority of dry weather flow in Berowra is contributed by the treatment plant flows.
- May exacerbate the extent of saline intrusion in Berowra Creek.
- Does not support effluent reuse in areas where demand may exist. To facilitate future reuse, sewer mining would need to be employed (at a high cost) along the alignment of the transfer pipelines.
- Reduces flexibility for future strategies and concentrates resources in one location. Although malfunctions may not be frequent, the risk of major plant disruption would have a more obviously negative effect at centralised facilities than if operating a number of dispersed STPs.
- Commits large capital expenditures well in excess of demand.

- Requires co-ordination of local catchment growth in Berowra Creek with regional system development needs in either North Head or Warriewood STP catchment.

Options 8 and 9 - Dry Weather Raw Sewage to Ocean

These options involve the transfer of dry weather flows to either Warriewood STP (Option 8) or North Head (Option 9). Flows in excess of the 3 ADWF will receive storm treatment at the Hornsby STPs before discharge to Berowra Creek. The potential advantages include:

- Eliminates effluent discharge to Berowra waterways during dry weather periods.

- Eliminates need for influent wastewater storage systems at West Hornsby and Hornsby Heights STPs. These plants, however, will need to be converted to storm plants.

- Reduces the levels of treatment and associated costs at the Hornsby STPs; and reduces demand of highly skilled services at the Berowra STPs.

The potential disadvantages for these options are similar to Options 6 and 10 discussed above as well as:

- Increasing need for regulatory management of multiple wet weather discharge locations.

- Economics of scale are not improved as three treatment plants are still required.

- Process modification required at both West Hornsby and Hornsby Heights STPs respectively (i.e. storm treatment plants similar to Fairfield STPs).

Options 7 and 10 - Treated Effluent to Warriewood Outfall

The advantages of Options 7 and 10 are:

- Reduce treatment level at both West Hornsby and Hornsby Heights STPs from tertiary to secondary treatment.

- No need for amplifying Warriewood STP to cater for increasing flows.

- Warriewood STP Ocean Outfall has adequate capacity for additional loads from the Hornsby STPs.

- Amplify Hornsby Heights STP to secondary treatment standard only.
- No need for nutrient removal facilities except for nitrification.
- Facilitates future reuse of effluent along the alignment of the effluent transfer pipeline.

Disadvantages are similar to Option 8 except treatment is provided in the Berowra Catchment rather than at Warriewood STP.

Option 11 - Indirect Potable Water Reuse

The potential advantages of Option 11 are:

- Effluent discharge to sensitive inland waterways is minimised.
- Berowra Creek catchment would be the first major region in Sydney to achieve indirect potable water reuse, as distinct from Rouse Hill dual water supply.
- Multi levels of treatment would minimise public health risk.
- Reduces need to augment water supplies in the future.
- Allows catchment management of wastewater treatment and reuse/disposal.
- If flow needs to re-enter Berowra Creek discharge of nutrients approaches proposed EPA background water quality targets.

The potential disadvantages of Option 11 are:

- Difficult to fully assess all construction, operation and public health issues.
- Increases complexity of treatment technology and associated operating costs.
- Creates demand for very highly skilled O & M services.
- Requires public education and acceptance of reuse strategy and that it is safe to public health.
- Increases importance of public health aspects of regulatory management.
- Brine disposal will add to the total flow treated at North Head STP and may increase salt and restricted substance concentrations discharged to the ocean.

SUMMARY

Options 1, 2, 4 and 11 involve maintaining the existing plants and improving the effluent quality discharged to Berowra Creek. Whether Level 1, 2 or 3 quality is adopted is subject to EIS recommendations, however, any improvement of the treatment provided over current practise will have a beneficial impact on the existing water quality in Berowra Creek.

With respect to air quality, studies[3] have concluded that the existing plants could be amplified to their next planned stages with low risk of odour nuisance to present residential properties.

Options 3, 4 and 11 have the potential for environmental damage associated with the construction of a transfer scheme through some non-urbanised and native bushland areas within the Hornsby Council area. Although the transfer route will be purposely located within roadways in most circumstances, they will need to travel through bushland. Costs required to minimise impact on the bushland and restore the area to its natural state after construction have not been quantified, however, they may be substantial. The EIS would need to address these issues if these options are considered further.

For both Options 3 or 4, a new IDAL plant would need to be constructed on suitable land in the Berowra catchment. The proposed site will range from 10,000 EP to 75,000 EP capacity. The acquisition of land and the building of a new plant at Berowra (refer figure 10-5) is considered to have a greater impact on the surrounding environment (where residential developments are close to the proposed plant site) than to upgrade the existing West Hornsby and Hornsby Heights plants.

Despite the higher dilution and assimilation capacity of the ocean compared to Berowra Creek, the schemes involving the transfer of sewage to the eastern seaboard (Options 5 to 10 respectively) will involve extensive capital outlay and take a number of years to construct. The adoption of the ocean transfer options will necessitate the discharge of high total nitrogen levels until the transfer infrastructure and corresponding amplification works at the ocean plants are completed. Based on best construction practices and necessary approval, the earliest commissioning date for these options is expected around the year 2001.

The ocean transfer options may not be compatible with the Choices for Clean Waterways strategies which are currently being prepared by the Board. Extensive community consultation will need to follow before any major consideration and approval is given to the easterly transfer of inland sewerage systems.

The adoption of the transfer options will also have major social and physical impacts which may include:

- Strong resistance to the transfer of sewage to North Head or Warriewood sewerage catchments.
- Considerable impact to the community via the physical construction of the transfer tunnels and gravity mains, spoil removal and access chambers near the Kuring-gai Chase National Park.
- Lack of perceived improvements when comparing ocean to inland discharges.

Overall, it is considered that the acceptance of the transfer options would not only take a long period of time but would need to guarantee no adverse impact of the ocean waters.

REFERENCES

1. I. Lim, T. Nguyen, *Phosphorus Precipitation with Pickle Liquor at Glenfield WPCP,* Water (Journal of the Australian Water and Wastewater Association), March 1987.

2. Pollution Control Branch, *Investigation of Aluminium Sulphate for Phosphorus Removal*, Water Board, Sydney, 1992.

3. Design Branch, *Odour Potential Study at Hornsby Heights STP*, Water Board, Sydney, 1990.

SECTION 22

EVALUATION OF OPTIONS

As outlined in Section 21, Options 1 and 2 (followed by Option 4) have a significant advantage in economic terms over the remaining options. As a number of the options either achieve higher effluent quality standards or transfer effluent out of the Berowra Catchment, selection of a apparent best option(s) will also depend upon the relative importance of other evaluation criteria. This is largely a **subjective judgement** which will vary depending on the particular person or organisation making the judgement.

In order to establish a apparent best option from the Board's point of view, a weighted factor analysis was carried out as discussed below. This is a procedure often adopted in value management as it allows the views of all interested parties to be taken into account. It is important to realise, however, that the procedure is only a tool which can assist in coming to a decision.

The method adopted comprises three major steps as follows:

- Ranking and weighting of perceived important evaluation criteria to reflect their relative importance.
- Rating of the options on their relative performance in terms of the evaluation criteria. This is very subjective and may vary from person to person.
- Combining the weighting and rating values to yield a suitability score for each option.

WEIGHTING OF THE EVALUATION CRITERIA

The technique used for ranking and weighting the evaluation criteria was a paired comparison method and is described below.

Each major evaluation criterion (as detailed in Section 21) is progressively paired with another and the perceived importance of one criterion compared with another is reflected in a score which is established on the following basis:

Criteria 'A' slightly more important than 'B', score A = 1 (ie 1A).

Criteria 'A' more important than 'B', score A = 2 (ie. 2A).
Criteria 'A' very much more important than 'B' score A = 3 (ie. 3A).

or alternatively if:

Criteria 'B' is slightly more important than 'A', score B = 1 (ie. 1B).
Criteria 'B' is more important than 'A', score B = 2 (ie 2B).
Criteria 'B' very much more important than 'A' score B = 3 (ie 3B).

and so on:

A against C.
A against D.
etc.

then:

B against C.
B against D.
etc.

RATING OF OPTIONS

The next phase of the evaluation process is to assess each option on its ability to meet each of the evaluation criteria. This can be achieved by rating each option based on a numeric scale of 1 to 4, as a measure of how well the option performs on the evaluation criteria relative to other options.

The numeric scale used was as follows for perceived ability potential or improvements.

4 = Very Good or Very high improvement
3 = Good or High improvement
2 = Fair or Medium improvement
1 = Poor or Low improvement

A numerical scale for economic comparison was also used in the analysis and is as follows:

1 = Very high costs
2 = High costs
3. = Medium costs
4. = Low costs

Personnel from Inland Wastewater, Systems Planning and Sewage Treatment Planning completed this paired comparison for the Rouse Hill Rationalisation study and Table 22-1 indicates the results.

As other evaluation criteria have been discussed in this report, Table 22-1 has been adjusted by Wastewater and Reuse Planning to include additional criteria. This revised weighting analysis as shown in Table 22-2 is by no means fixed and may be varied to suit other criteria if the community requires. It does provide an initial assessment, however, that will direct the community in choosing the most appropriate sewage treatment and effluent disposal option (s) for the Hornsby STPs, that may be considered further in the environmental impact assessment phase.

TABLE 22-1. RANKING AND WEIGHTING OF EVALUATION CRITERIA (ROUSE HILL RATIONALISATION STUDY)

Evaluation Criteria		Score	Ranking	Weighting (%)
A	Ability to meet Level 1,2 & 3 requirements	55	1	27
B	Capital and Operating Costs	39	2	19
C	Impact on Receiving Waters	31	3	15
D	Odour and Noise Potential	26	4	13
E	Effluent Reuse	19	5	9
F	Operational Considerations	16	6	8
G	Residuals Management	13	7	6
H	Plant and Transfer Scheme Malfunctions	7	8	3
Total		206		100%

TABLE 22-2. REVISED RANKING AND WEIGHTING OF EVALUATION CRITERIA FOR OPTIONS

	Evaluation Criteria	**Ranking**	**Perceived Weighting**
A	Ability to meet Levels 1, 2 & 3 requirements	1	23
B	Capital and Operating Costs	2	16
C	Receiving Water Improvement	3	13
D	Odour and Noise Potential	4	11
E	Effluent Reuse	5	8
F	Community Expectation	6	7
G	Strategic Planning Compatibility	7	7
H	Operational Considerations	8	6
I	Residuals Management	9	5
J	Plant and Transfer Malfunctions	10	4
	Total		100%

NB: Community Expectations and Strategic Planning Compatibility was assumed equal to Effluent Reuse raw score in Table 22-1. This may be subject to change.

SELECTION OF FAVOURED OPTION

Having established the weightings for each evaluation criterion and the rating of each option, the total suitability scores for the options are determined by summing the product of the weightings and rating values for each of the evaluation criterion. The results are summarised in Table 22-3.

When transfer of effluent or raw sewage out of the catchment is considered (options 5 to 10) a low rating was applied to Criterion A in Table 22-3. This is based on the following:

- The transfer infrastructure and proposed treatment facilities are not capable of removing phosphorus and nitrogen.
- Although the ocean transfer schemes remove effluent from Berowra Creek and, in effect, provide zero total nitrogen discharge, the nutrients are transported to the ocean for disposal.
- The impact of zero effluent discharges due to options 5 to 10 respectively, is taken into consideration in Criterion C, 'Improvements to Receiving Waters'.

- Despite the unlikely opportunity for failure of the transfer infrastructure, there is still a possibility of discharging high nutrient levels to Berowra Creek when the above facilities malfunction.

Table 22-3 shows that based on the adopted selection criteria, the 3 apparent best options from the economic analysis in Section 21 remain unchanged in this evaluation matrix and are as follows (in order of ranking).

▪ Option 1	-	Retain, upgrade and amplify Hornsby Heights STP and Retain and upgrade West Hornsby STP with standard MLE.
▪ Option 2	-	Retain, upgrade and amplify Hornsby Heights STP with standard MLE and retain and upgrade West Hornsby STP with high biomass MLE.
▪ Option 4	-	Retain, upgrade West Hornsby and Hornsby Heights STPs and transfer excesses flows to new Berowra Treatment Plant.

From Table 22-3, the fourth ranked option remains Option 3 (new treatment plant at Berowra) followed by Option 11 (indirect potable water reuse).

Although Option 11 has a perceived improved ranking position it does not warrant further investigation out of the context of the strategic plan which may maximise indirect potable water reuse for the Sydney Region overall.

The options involves transfer to the ocean (i.e. options 5 to 10) have the lowest scores and do not warrant further consideration.

TABLE 22-3. PRELIMINARY EVALUATION MATRIX FOR WEST HORNSBY AND HORNSBY HEIGHTS SEWAGE TREATMENT AND DISPOSAL OPTIONS

Evaluation Criteria	**Option 1**		**Option 2**		**Option 3**		**Option 4**		**Option 5**		**Option 6**		**Option 7**		**Option 8**		**Option 9**		**Option 10**		**Option 11**	
	R	**S**	**R**	**S**	**R**	**S**	**R**	**S**	**R**	**S**	**R**	**S**	**R**	**S**	**R**	**S**	**R**	**S**	**R**	**S**	**R**	**S**
A. Ability to meet Levels 1, 2 & 3	4	92	3.5	81	3.5	81	4	92	1	23	1	23	1	23	1	23	1	23	1	23	4	92
B. Capital costs Operating costs NPVs	4 3 4	59	4 3 4	59	2 3 2	37	3 3 2	43	1 3 1	27	1 3 2	32	1 3 1	27	1 3 1	27	1 3 1	27	1 3 1	27	2 1 1	22
C. Impact on receiving waters . Berowra Creek . Ocean	3 4	46	3 4	46	2.5 4	42	4 4	52	4 3	46	4 2	39	4 3	46	4 3	46	4 2	39	4 3	46	4 2	39
D. Odour and Noise potential	2	22	2	22	3	33	2	22	3	33	3	33	3	33	3	33	3	33	3	33	3	33
E. Effluent reuse	2	16	2	16	2	16	2	16	1	8	1	8	1	8	1	8	1	8	1	8	4	32
F. Protection of public health - community expectation	3	21	3	21	2	14	3	21	2	14	2	14	3	21	2	14	1	7	3	21	2	14
G. Compatibility with Strategic Plan	3	21	3	21	2	14	2	14	1	7	1	7	1	7	1	7	1	7	1	7	2	14
H. Operational Consideration	3	18	3	18	4	24	2	12	33	18	2	12	3	18	2	12	3	18	3	18	3	18
I. Residual Management	3	15	3	15	4	20	3	15	3	15	4	20	3	15	3	15	4	20	3	15	2	10
J. Plant and Transfer Malfunction	2	8	2	8	4	16	3	12	2	8	2	8	2	8	2	8	2	8	2	8	3	12
Total	-	318	-	307	-	294	-	297	-	199	-	196	-	206	-	199	-	184	-	206	-	286
Ranking	1		2		4		3		7A		8		6A		7B		9		6B		5	
Note: R - denotes Rating S - denotes Score																						

SECTION 23

RECOMMENDATIONS

This Section summaries the findings of this report, in terms of the economic and subjective ranking of options investigated, indicative costs per lot, incremental improvements and recommendation. The community will play an important role in selecting the option(s) for further consideration in the environmental assessment phase planned to be completed by June 1995.

ECONOMIC RANKING

On an economic basis, the treatment and disposal of sewage in Berowra Creek for the short to medium term is the more favourable strategy when compared to ocean transfer and effluent reuse. From Table 21-1, the net present values favour Option 1, Option 2, Option 4 and Option 3. The remaining options involve substantial transfer of flows to the ocean and, in the short term, will require significant capital expenditure in excess of that required for retained facilities in the study area. The above ranking is not changed by the sensitivity analysis summarised in Table 21-3.

All options involving discharge to Berowra Creek provide for improved sewage treatment to meet more stringent effluent quality requirements and to cater for projected additional loads. The ocean transfer options, however, do not achieve nutrient reduction as such and convey the phosphorus and nitrogen to the ocean. With reference to figures 21-1 and 21-2 respectively, this would be expensive if it involves large outlays of capital related to dedicated tunnel transfer systems. Other concerns which arise with the ocean transfer options are the maintenance of existing flow regimes (albeit influenced by effluent discharges) in the creek system, and the acceptability of transferring flows to another catchment.

Therefore, ocean transfers are not recommended at this stage for the Berowra Creek catchment. If the community however, requests that transfer of sewage from Berowra to the ocean should be considered further, then Option 6 and Option 9, which involve dry and wet weather flow transfer to North Head STP are recommended. Although dedicated transfer systems have made these options economically unattractive at this stage, the future potential of an amplified NSOOS may subsequently make Options 6 and Option 9 economically viable. At this stage however this viability is not quantifiable.

As specific details on options for augmenting the North Suburbs Ocean Outfall Sewer are planned to be available in 1995, the recommendations contained in this report may need to be modified.

As the opportunities for major effluent reuse in Berowra Creek is limited to indirect potable water reuse, Option 11 is not recommended at this stage for Berowra and should only be considered on a strategic level as discussed previously.

SUBJECTIVE EVALUATION

The detailed process of evaluating all the options investigated in this report, via an evaluation matrix, was adopted to incorporate the influence of a number of major criteria as discussed in Sections 21 and 22.

This analysis attempted to evaluate options against a number of priorities to arrive at a consensus on the option(s) from the Board's point of view. For each level of effluent quality the relative ranking of options is unchanged and was as follows (in ranking order):

Option 1	Retention and Upgrade with MLE process.
Option 2	Retention and Upgrade with high biomass MLE process.
Option 4	Retention of Upgraded Plants and New STP.
Option 3	New treatment plant.

Although the weighted factor analysis is only useful as a general guide, it is considered to be a reasonable basis for selection of apparent best option(s). Accordingly, Option 1 is recommended as the sewage treatment and effluent disposal strategy for West Hornsby and Hornsby Heights STPs respectively.

If a full scale trial of a proposed high biomass MLE process is implemented and proven successful in achieving the proposed effluent total nitrogen levels, then it is recommended that Option 2 be adopted for Hornsby plants.

As detailed costs of a proposed amplified NSOOS system, are not available at this stage, Option 1 (or Option 2) is favoured based on the preliminary engineering, economic, operational capability and environmental investigations undertaken for this report. A further detailed study of the social, economic, and environmental impacts of the recommended scheme, however, along with community involvement and consultation, is required to determine the final option to be implemented.

INDICATIVE COST PER LOT

Implementation of any further works will result in costs due to amplification (i.e. growth in catchment) and higher standard of nutrient reduction (upgrades).

The Board's objectives are to maintain financial viability of the business with services being cost effective, value for money and achieving a competitive rate of return.

It is therefore the Board's policy that all amplification costs be charged against developers as these works are specifically required for the additional development.

To provide the community with some indication of the costs for treatment improvement and amplification of plant capacity, Table 23-1 sets out an indicative implementation cost per lot that may be equated if Option 1 is adopted. The adoption of other options examined within this report would equate to a higher cost per lot.

These costs are indicative only and provide a comparison for different levels of improvement as well as the proposed costs for new development (refer Appendix D for more details).

TABLE 23-1. INDICATIVE COST PER LOT FOR OPTION 1

Total Effluent Total Nitrogen Target (90 percentile)	$ Per Lot	
	Existing Lots	New Development Lots
15	242	2750
10	369	2865
5	551	3050

In an endeavour to return Berowra Creek to environmental health, the inclusion of indicative costs per lot enables the community to compare various means of improvement and allows effective decision making.

INCREMENTAL IMPROVEMENTS

Organisations of the Berowra Creek Technical Working Party are committed to support the ecologically sustainable development of Berowra Creek catchment and improve the environmental health of the creek. The initial goal shall be consistent with the pursuit of recreational activities such as swimming, and that fishing with confidence and protection of the shellfish industry are longer term goals. The ecologically sustainable development objectives are to be guided by the National Water Quality Management Strategy Policies and Principles - A Draft Reference Document published by ANZECC.

The TWP has agreed to the staged or incremental improvement of Berowra Creek, with a Water Quality Management Strategy and a Plan of Management being prepared and implemented progressively to achieve the above goals.

The principle of Incremental Improvement recognises that in many circumstances water quality is already insufficient to support the environmental values of the community. Under these circumstances it may be technologically impossible or financially prohibitive to return water quality to that required to meet objectives in one step. Furthermore, environmental uncertainty can lead to a counterproductive over-investment if unsubstantiated and somewhat arbitrary water quality criteria are seen as criteria which must be satisfied.

With millions of dollars at stake over the next 20 years for nitrogen reduction, it is financially prudent to invest in scientific research to establish site specific nutrient targets rather than aim for precautionary principles.

The fundamental principle of ANZECC is to classify waters according to the environmental value requested by the community. Before relevant targets and thence improvement strategies can be effectively conducted, the community's requirements in terms of river usage must be established. In doing so the community must be made aware of the financial implications of their choices.

This total catchment management philosophy, however, cannot be sustained without continuous instream monitoring.

Whilst incremental improvement occurs, instream monitoring should continue to refine the long term targets. As the quality of the river approaches the objectives, it will be easier to establish appropriate targets until, at some point, the river quality matches the environmental value requirements.

RECOMMENDATION

Based on the available information to date, the incremental improvement philosophy of ANZECC, and the economic evaluation carried out in accordance with NSW Treasury Guidelines; the adoption of Option 1 (or Option 2), retention of the existing STPs and upgrade with the MLE process to achieve a total nitrogen concentration in the discharged effluent of 15 mg/L is the least cost option. If adopted, this would result in the significant reduction from the present effluent total nitrogen concentrations of approximately 227,000 kg/year down to 62,000 kg/year (at year 2000 projected EP growth).

At this stage however, it is recommended that future works at the Hornsby plants proceed on clear evidence of environmental benefit, and direction from the EPA on the levels of treatment required and submission to the government's pricing tribunal for consideration. It should be noted that the Board has invested considerable capital and operating funds over the last 4 years to significantly improve levels of treatment in terms of disinfection, ammonia removal, phosphorus and some nitrogen removal. It is suggested that the environmental benefit of this work be scientifically evaluated together with Hornsby Council's initiatives prior to committing to further works so that the community can be assured that their funds are being spent to best effect. The environmental benefit should be determined via an environmental assessment process and environmental monitoring of the receiving waters.

In conjunction with other projects being carried out by other parties within the Berowra Creek Community Contract, this initial step may provide one of the key components in the progressive improvement to the receiving waters.

Ongoing monitoring, which has been agreed to by the members of the TWP to be co-operatively undertaken, will ensure a firm basis for evaluating further remedial steps that may be required towards meeting the community goals of recreational water quality of the Berowra Creek Waterways.

APPENDIX A

OCEAN DISCHARGE REQUIREMENTS

Due to the complex nature of marine discharges within the Sydney Region, Appendix A identifies the main enviromental requirements/guidelines to be considered if discharging to the ocean. A summary of the Effluent Quality Criteria applicable to Sewage Treatment Plants discharging to the ocean off Sydney is provided below.

This section presents the receiving water quality legislation and criteria relevant to the performance of ocean STPs that set the standards for beach and ocean water quality.

LEGISLATION

Ocean water pollution is managed under the following legislation:

- The Clean Waters Act (1970), which sets forth the basic framework for a comprehensive water pollution control programme for New South Wales, provides for the classification of waters of NSW, and regulates the discharge of polluted waters and the provisions for enforcement of those regulations.
- The Pollution Control Act (1970). Under section 17K of the Act, pollution control approvals for new works, or augmentations of existing works, involving the discharge of wastes into waters are required. A licence, renewed annually, must subsequently be obtained in accordance with section 17(i) of the Act. Conditions set in approvals and licences are based on guidelines contained in the environmental guideline EG1 -Water, prepared by the EPA.

Clean Waters Regulation (1972) - Class "O" Ocean Outfall Waters. The Clean Waters Regulation (1972) establishs a classification of riverine, estuarine and marine waters in the State into a number of categories. When the NSW Government announced the Clean Waterways Programme in December 1989, it gave a commitment to adopt the Class "O" Ocean Outfall Waters classification of the Clean Waters Regulation (1972) for ocean waters.

This classification prescribes the level of protection required for ocean waters to preserve their natural quality or, if this is not feasible, a quality consistent with the needs of users. Class "O" Ocean Outfall Waters are defined in Regulation 8 of the

Clean Waters Regulation (1972).

None of the NSW coastal ocean waters are classified Class O or otherwise.

The requirements of the Clean Waters Act (1970), as it applies to Ocean Outfall Waters, comprise a series of general statements to the effect that effluent discharge is to have minimal impact on beaches, ocean water quality and marine life. The requirements set out in the existing Class "O" classification are generally qualitative and the EPA intends to strengthen the classification by closer definition of terms such as "adversely affected" and "abnormal concentrations" in the context of impacts to beaches and the aquatic environment.

Environmental Guideline - Discharge of Wastes to Ocean Waters (EG1 - Water)

The Environmental Guideline - Discharge of Wastes to Ocean Waters provides designers of ocean discharge outfalls a framework to assist them to meet the environmental protection levels given in the Class "O" classification. Originally issued in 1974 as WP-1, and modified in 1993, the guideline presents criteria to be used in the design of ocean outfalls for waste discharges, lists minimum receiving water quality objectives and presents the method for calculation of effluent limits. The EPA has indicated its intention to revise the Guideline every three years as further scientific data on environmental effects become available. The treatment plants will need to be upgraded to meet statutory requirements which will be largely determined by the guidelines.

In February 1993, EG-1 Design Guide[1] for Discharge of Wastes to Ocean Waters was published. This guideline includes effluent quality requirements for suspended solids, and oil and grease in receiving waters. The guideline also requires that the bioaccumulation of specific restricted substances does not result in adverse impacts on marine organisms or pose a threat to human health. The criteria considered include:

MICROBIOLOGICAL

The bacteriological criteria provide for public health protection for inshore waters, ie. those waters within a zone bounded by the shoreline and a distance of 300 m from the shoreline. The criteria refer to faecal coliforms.

- For Primary Contact Recreational Waters (ie. where body is immersed in the ocean and ingestion of some water is likely).
    - Monthly 50th percentile < 150 CFU per 100 mL.
    - Monthly 80th percentile < 600 CFU per 100 mL.

- For Secondary Contact Recreational Waters (i.e. where there is some direct contact with water but where the probability of swallowing water is low).
    - Monthly 50th percentile < 1,000 CFU per 100 mL.
    - Monthly 80th percentile < 4,000 CFU per 100 mL.

Sampling frequencies for ocean outfall performance monitoring may be specified in the licence and conditions.

(NB: In comparison to the WP-1 1974 guidelines currently in place and the Department of Health limits, those limits are slightly different. Department of Health Guidelines for Bacteriological Quality of Bathing Waters are that water should be considered to be unsuitable for bathing where the faecal coliform count, calculated as the geometric mean of the number of organisms in three water samples taken at one time from the area being examined, exceeds 300/100 mL or the number of faecal coliforms in any one sample exceeds 2000/100 mL).

Disinfection

Where disinfection is necessary to meet the microbiological criteria, methods other than chlorination are preferred (eg. ozone or ultraviolet disinfection).

PHYSICAL CHARACTERISTICS

This section includes aesthetic criteria which by their nature, are subjective. The following conditions shall apply to receiving waters before and after initial dilution is complete:

Visual Impact

Treatment must be provided to wastes before discharge so that the receiving water remains visually free of particulate grease or other gross floatable matter. If colour changes are likely to occur, limits for colour of effluent may be applied through licences.

Odour Impact

As a result of effluent discharges the receiving waters shall be free from objectionable odours.

Settleable Solids

The discharge of settleable solids will be such that no significant accumulation occurs and that benthic and intertidal communities will not be degraded. The term "degraded" refers to gross changes in species, population density or growth anomalies.

SUSPENDED SOLIDS, OIL & GREASE

The environmental guidelines include the following conditions for effluent quality:

Suspended Solids

The 50th percentile value for suspended solids in the effluent shall not exceed 50 mg/L, although the general aim for sewage treatment works will be 85 percent removal.

Oil & Grease

The 50th percentile total oil and grease concentration of 25 mg/L will apply to sewage effluents discharged from extended ocean outfalls. Oil and grease limits for industrial effluents and proposed shoreline sewage discharges will usually be considerably lower and specified in licence conditions.

CHEMICAL CHARACTERISTICS

The following conditions shall apply to receiving waters outside the mixing zone:

Dissolved Oxygen

The discharge of oxygen demanding materials shall not cause the dissolved oxygen concentration to fall by more than 10 per cent of background levels.

pH

The effluent discharge shall not cause the pH to vary by more than 0.1 units from ambient levels.

Nutrients

Nutrients discharged shall not cause excessive aquatic plant growth or degrade indigenous biota.

Restricted Substances

The discharge shall not result in the concentration of restricted substances at the completion of initial dilution exceeding the water quality criteria set out in Table A-1. Table A-1 gives water quality criteria limits, together with the allowable concentrations of these contaminants in effluent if it is diluted 10.5 times as would be expected for a cliff face outfall, and 150 times (as is the case of a deep ocean outfall such as the North Head STP ocean outfall). Allowable concentrations of contaminants in the effluent have been calculated using the equation given in Table A-1 and the background levels given in Table A-2.

The discharge of effluent shall be such that bioaccumulation of restricted substances, resulting in adverse impacts on marine organisms or posing a health risk to human consumers of seafood, does not occur. Table A-3 lists the National Health and Medical Research Council's (NHMRC) recommended concentration limits for organochlorines and trace metals in the edible portion of fish and shellfish required to safeguard human health.

Biological Characteristics

The discharge of wastes shall not result in the bioaccumulation of pollutants in marine organisms to levels where marine organisms are degraded or where consumption of seafood presents a health risk.

Areas of Speical Significance

This section covers wastes discharged into areas of special biological interest (e.g. marine parks) or waters used for commercial harvesting of bivalve molluscs. Wastewater discharged into shellfish harvesting areas is required not to exceed a median faecal coliform density of 14 MPN (most probable number) per 100 mL with no more than 10 per cent of samples exceeding 43 MPN per 100 mL. The initial dilution process or the defined mixing zone of waste discharge must not overlap commercial harvesting areas.

Radioactivity

Radioactivity of discharged effluent should not exceed the individual or collective dose limits set by the International Atomic Energy Agency. It is the intent of the guidelines to restrict all discharges to a radioactive nature except for very low level wastes, such as those discharged from some hospitals. The Board's Trade Waste Policy prohibits the discharge of radioactive wastes, except those discharged from some hospitals, so this condition is always met.

TABLE A-1. OCEAN WATER QUALITY CRITERIA FOR RESTRICTED SUBSTANCES

Substance	**Water Quality Criteria (ug/L) WP-1 1974**	**Water Quality Criteria[a] (Cc)(ug/L) (EG1)**	**Allowable conc in Effluent with 10.5:1 Dilution (Ce) (ug/L) (to meet (EG1)**	**Allowable conc in Effluent with 150:1 Dilution (Ce) (ug/L) (to meet EG1)**
Arsenic [a]	100	8	74	1051
Cadmium	200	4.7	48.8	696.1
Chromium	20	25.0[b]	260.4	3717.2
Copper[a]	200	3	29	405
Lead	100	2.8	26.6	375.3
Mercury[a]	1	0.04	0.12	3.02
Nickel	100	4.1	29.3	480.9
Selenium[a]		15	105	1650
Silver[a]	20	0.7	7.3	103.5
Zinc	300	43.0	443.9	6330.8
Cyanide[a]	200	1	11	150
Phenolic Compounds[a]	500	30	315	4500
Chlorinated Phenolic Compounds[a]		1	11	150
Total Chlorine Residual[a]	1000	2	21	300
Ammonia - N[a]	5000	600	6300	90000
Hexachlorocyclohexane (isomers)[a]	Sum total identifiable chlorinated hydrocarbons = 2	0.004	0.042	0.6
Endrin		0.0012	0.013	0.18

[a] Concentrations are derived from USEPA 1986 Quality Criteria for Water. Where chronic toxicity is not reported, values of substances marked* have been taken from the California Ocean Plan, 1990.

[b] Hexavalent Chromium

Concentration limits for constituents of effluent discharges (Ce) can be calculated using the factored chronic criteria values for receiving waters (Cc), the background seawater concentration (Cb) and the calculated minimum initial dilution of the average dry weather effluent stream (D), using the dilution equation: $Ce = Cb + D (Cc - Cb)$
where Ce = pollutant concentration in effluent (Calculated), Cb = pollutant concentration in background seawater (Given in EG1), Cc = pollutant concentration at the completion of initial dilution (Given in EG1), D = design initial dilution ratio. The background concentrations of restricted substances in sea water (Cb), to be used in this calculation, are detailed in the environmental guidelines EG1 - Water or in Table A-2 below.

TABLE A-2. BACKGROUND CONCENTRATIONS OF REGISTRATIONS OF RESTRICTED SUBSTANCES (Cb)

Substance	Concentration (ug/L)
Arsenic 3+	1
Cadmium	.06
Hexavalent Chromium	.22
Copper	.3
Lead	.3
Mercury	.02
Nickel	.9
Silver	.01
Zinc	.8

[a] If background information is available for any substance not specified at the time of application for approval of works this is to be supplied with the application.

[b] Where substances are not specified and no further data are available, assume a background concentration of zero.

[c] Data are for NSW Coastal Waters, sources: CSIRO and Environmental Monitoring Programme.

TABLE A-3. 1989 NHMRC CONCENTRATION LIMITS FOR ORGANOCHLORINES AND TRACE METALS IN THE EDIBLE PORTION OF FISH AND SHELLFISH

Organochlorines	**Fish and Shellfish (mg/kd wet weight)**	
BHC	.01	
Chlordane	.05	
Dieldrin	.1	
DDD	1	
DDE	1	
DDT	1	
Heptachlor	.05	
Heptachlor - epoxide	.05	
Lindane	1	
Trace Metals	**Fish (mg/kg wet weight)**	**Shellfish (mg/kg) wet weight**
Arsenic	1 (inorganic)	1 (inorganic)
Cadmium	.2	.2
Copper	10	70
Lead	1.5	2.5
Mercury	.5	.5
Selenium	1	1

TREATMENT PLANT BYPASSES

In addition to the water quality objectives and design criteria, the environmental guidelines list the circumstances under which normal effluent treatment processes may be bypassed. These circumstances might include:

- When a treatment unit is unavailable because it is undergoing modifications or refurbishment approved by the EPA.
- When a decision not to bypass treatment processes would put the health and safety of treatment plant workers at risk or put at risk the long term performance of the treatment plant or outfall.
- Power failure that was unavoidable at the plant.
- Failure or malfunction of essential equipment provided that the cumulative duration of all such events over the term of the licence did not exceed a limit specified in the licence.

ANZECC GUIDELINES FOR OCEAN WATERS

As part of a national water quality management strategy that seeks to manage the nation's water resources on a sustainable basis, the Australian and New Zealand Environment and Conservation Council (ANZECC) developed a set of *Australian Water Quality Guidelines for Fresh and Marine Waters, 1992*[2]. For each environmental value of a waterbody, specific guidelines have been formulated in terms of the key indicators. The environmental values (of relevance to the ocean plants) for which indicator guidelines are provided are the protection of aquatic ecosystems, and recreational water quality and aesthetics, and protection of human consumers of fish and other aquatic organisms.

The primary and secondary contact guidelines for bacterial content (faecal coliforms) in marine waters is essentially the same as described above for EG1-Water. The guidelines also require that nuisance organisms should not be present in excessive amounts - for algae this represents 15 - 20,000 cells/ml. They also specify the range of pH levels in the receiving waters, the absence of oil films, and chemical levels such that skin irritation would not occur.

To protect the aesthetic quality of the waterway, ANZECC guidelines recommend no more than 20 per cent reduction in water clarity and specific levels of change for hue and natural reflection.

The guidelines for restricted substances are too numerous to specify here. In general, the EPA guidelines for restricted substances at the edge of the mixing zone are similar to (but slightly lower than) ANZECC guidelines for ocean waters.

It should be noted, however, that these are guidelines only and the relevance of various criteria levels to the ecosystem in question needs to be determined by monitoring and research programmes. The onus on justifying less strict guidelines for particular waterbodies lies with the community and authority seeking to discharge into that waterbody.

Criteria not listed in EG1-Water include those for nitrogen and phosphorus. The ANZECC guidelines indicate it is not possible to recommend a single set of nitrogen and phosphorus concentrations which will prevent nuisance algal problems in marine waters because many other factors can also limit algal growth. The guidelines (indicative concentrations or ranges) for N and P in coastal waters are:

PO_4 - P	1 - 10 ug/L
NO_3 - N	10 - 60 ug/L
NH_4 - N	< 5 ug/L
Chlorophyll A	< 1 ug/L

These are provided only as levels above which problems have been known to occur. It should be noted that site specific studies are needed to determine the appropriate concentrations for the system offshore from Sydney.

ANZECC/AWRC TREATMENT LEVELS

In association with ANZECC, the Australian Water Resources Council has devised guidelines for the discharge of effluent from wastewater treatment plants to inland and coastal waters (*Draft Guidelines for Sewerage Systems, Effluent Management, 1992*)[3]. The guidelines recommend specific levels of wastewater treatment, depending on environmental values or beneficial uses of receiving waters and the nature of discharge sites. The guidelines for ocean discharge indicate that, despite the ability of the ocean to assimilate a suitable effluent, the maintenance of marine ecosystems is important, and effluent controls are needed to minimise effects on the environment and on human health. ANZECC/AWRC guidelines for treatment levels and ocean discharges are shown in Table A-4 while typical effluent quality for these various levels of treatment are shown in Table A-5.

TABLE A-4. ANZECC/AWRC GUIDELINES FOR DISCHARGE TO OCEAN AND MARINE WATERS

Ocean Discharge Options	Limiting Environmental Values Applying to Each Discharge Option	Effluent Parameters of Major Concern	Guideline Treatment Level	Higher Level Treatment Site Specific
Ocean Open or Unpopulated	Maintenance of Aquatic Ecosystems	Toxicants, Floatables, Colour, Turbidity, Suspended Solids	A	B
Ocean High Tidal Range	Maintenance of Aquatic Ecosystems Recreation - Secondary contact	Pathogens, Toxicants, Floatables, Colour, Turbidity, Suspended Solids	A,B	C
Ocean Nearshore or Populated	Maintenance of Aquatic Ecosystems, Recreation - Primary Contact, Aesthetic Enjoyment	Pathogens, Toxicants, Floatables, Colour, Turbidity, Suspended Solids, Salinity, Nutrient impact	C	E
Open Bays and Estuaries	Maintenance of Aquatic Ecosystems, Recreation - Primary Contact, Aesthetic Enjoyment	Nutrients, Pathogens, Toxicants, Floatables, Colour, Turbidity, Salinity, Suspended Solids, BOD, Heavy Metals	C	E
Enclosed Bays and Estuaries (Narrow inlet/outlet)	Maintenance of Aquatic Ecosystems, Recreation - Primary Contact, Aesthetic Enjoyment	Nutrients, Pathogens, Toxicants, Salinity, Floatables, Colour, Turbidity, pH, Suspended Solids, BOD, Heavy metals	C,D	D,E,F

Notes : Plant type - "typical" treatment process
: Please refer to Table A-5 for typical quality criteria.

A	Removal of gross solids plus some of the readily settleable solids eg. microscreening
B	Removal of gross solids plus readily settleable solids eg. primary sedimentation
C	Removal of most solids, BOD, eg. biological treatment, microfiltration, chemical treatment, lagoons
E	Disinfection, after removal of solids eg. lagooning, ultraviolet, chlorination
F	Advanced Wastewater Treatment eg. sand filtration, ion exchange, microfiltration

Abbreviations:

TSS	Total Suspended Solids
BOD	Biochemical Oxygen Demand

TABLE A-5. TYPICAL EFFLUENT QUALITY FOR VARIOUS LEVELS OF TREATMENT (ANZECC GUIDELINES)

(Effluent qualities outside this range occur, for a variety of reasons)

Treatment	**BOD mg/L**	**Suspended Solids mg/L**	**Total Nitrogen mg/L**	**Total Phosphorus mg/L**	**E Coli Org/100 ml**	**Anionic Surfactants mg/L**	**Oil and Grease mg/L**
Wastewater	150-400	150-450	35-60	6-16	10^7-10^8	5-10	50-100
A	140-350 (<25%)	140-350 (<25%)	35-60 (<25%)	6-16 (<25%)	10^7-10^8	5-10 (<25%)	50-100
B	120-250 (25-50%)	80-150 (25-50%)	30-55 (<25%)	6-14 (<25%)	10^6-10^7		30-70 (50-75%)
C	20-30 (75-95%)	25-40 (75-95%)	20-50 (<25%)	6-12 (<25%)	10^5-10^6 (50-75%)	< 5 (50-100%)	< 10 (80-100%)
D	5-20 (90-100%)	5-20 (90-100%)	2-20 (70-95%)	< 2 (75-100%)			< 5 (90-100%)
E					< 10^3 (>99.9%)		
F	2-5 (95-100%)	2-5 (95-100%)	< 5 (85-100%)	< 1 (85-100%)	< 10^2 (>99.9%)		< 5 (90-100%)

Note:

1. The figures in brackets indicate the percentage reduction from raw wastewater values for the nominated level of treatment.

2. A blank in the table indicates "not applicable".

Notes: Plant type - "typical" treatment process

A	Removal of gross solids plus some of the readily settleable solids eg. microscreening
B	Removal of gross solids plus readily settleable solids eg. primary sedimentation
C	Removal of most solids, BOD, eg. biological treatment, microfiltration, chemical treatment, lagoons
E	Disinfection, after removal of solids eg. lagooning, ultraviolet, chlorination
F	Advanced Wastewater Treatment eg. sand filtration, ion exchange, microfiltration

Abbreviations:

TSS	Total Suspended Solids
BOD	Biochemical Oxygen Demand

REFERENCES

1. EPA, *Environmental Guidelines, Discharge of Wastes of Ocean Waters*, February 1993.
2. ANZECC, *Australian Water Quality Guidelines for Fresh and Marine Waters*, November 1992.
3. ANZECC/AWRC, *Draft Guidelines for Sewerage Systems, Effluent Management*, 1992.

APPENDIX B

TREATMENT PROCESS SELECTION

Appendix B details the treatment processes selected for further examination in Options 1 to 11 of this report. The Appendix is to be read in conjunction with Section 7, entitled "Options for Investigation", especially with regard to treatment processes selected.

The treatment process and effluent disposal methods adopted for detailed investigation will need to meet the effluent and water quality criteria specified in Table 7-1 to 7-3 in Section 7. The treatment selected will, therefore, differ and be based on the strategies listed below:

- Treatment and Discharge to Berowra Creek.
- Transfer of Sewage or Effluent to the Ocean.
- Effluent Reuse in Berowra Creek Catchment.

The following paragraphs provide an in depth discussion of treatment processes selected for Options 1 to 11.

TREATMENT AND DISCHARGE TO BEROWRA CREEK

For sewage treatment plants discharging to Berowra Creek, or its tributaries, a number of biological and chemical treatment processes have been investigated to meet the three effluent quality levels as outlined in Table 7-1, with particular emphasis on total nitrogen and phosphorus reduction[1]. The following sections discuss the process options for the removal of nitrogen and phosphorus as well as BOD_5 and suspended solids.

Nutrient removal must be achieved at the treatment plants if the effluent total nitrogen levels of 15 mg/L, 10 mg/L and 5 mg/L and 0.3 mg/L phosphorus (90 percentile limits) are to be met (refer Table 7-1). Nutrient reduction methods investigated and adopted for further consideration are discussed below.

NITROGEN REMOVAL

Nitrogen exists in inorganic (as free and saline ammonia) and organic forms in a wastewater and it is, therefore, essential that the process selected for optimum nitrogen removal be able to process these different forms. Nitrogen may be removed from wastewaters by chemical or biological means.

The chemical methods that have found application in the removal of nitrogen are breakpoint chlorination, ammonia stripping and ion exchange, while biological nitrogen removal involves the nitrification/denitrification principle.

The biological removal alternatives involves the conversion of the inorganic and most of the organic fractions to one predominant species (nitrates), which are then removed through denitrification. The latter system can, therefore, be expected to achieve a greater overall nitrogen removal.

Nitrification/Denitrification. The biological removal of nitrogen involves the biological oxidation of ammonia nitrogen, free and saline, and the biological conversion of organic nitrogen to ammonia and then to nitrite and nitrate (Nitrification), followed by the biological reduction of nitrites and nitrates to nitrogen gas (Denitrification). There are many sewage treatment applications around the world which are achieving high efficiencies for nitrogen removal using this biological process[2].

The theory of nitrification (which occurs under aerobic conditions) is well documented, however, selection of retention time, pH and level of dissolved oxygen and possible inhibition by toxic or metal contaminants are important design considerations.

Denitrification is achieved by contacting the nitrified effluent with a carbon source in the absence of oxygen in an anoxic zone. Under these conditions the organisms in the wastewater will use oxygen from the nitrite and nitrate for metabolism using the carbon source. Systems configured for nitrification/denitrification provide operational cost savings over those which may only nitrify as denitrification returns both oxygen and alkalinity to the process, resulting in lower or equivalent running costs.

Earlier activated sludge plants designed for denitrification utilised an external carbon source such as methanol or molasses. Generally, these have been superseded by designs that utilise the influent sewage or carbon feedback from endogenous respiration and cell lysis as the necessary carbon source on grounds of cost effectiveness.

The advantages of biological nitrogen removal are:

- The process is well established with a high nitrogen removal efficiency (if influent sewage is favourable).
- The process does not add residual contamination to the wastewater.
- In conjunction with associated biological processes, organic nitrogen is converted and removed.
- Average nitrogen concentrations in effluents from correctly designed and operated biological nitrogen removal plants would generally lie in the range of 5 to 15 mg/L, with 90 percentile values around 10 to 20 mg/L.

The range of values is often due to the nature and characteristics of the incoming wastewater rather than design deficiencies. Biological nitrification/denitrification is, therefore, able to achieve the nitrogen reduction required for effluent levels 1 and 2.

The disadvantages of biological nitrogen removal include:

- Possible inhibition by toxic or metal contaminants in raw sewage. As the Hornsby plants treat mainly domestic strength sewage this should not be a major concern.
- Use of influent sewage as the food source for biological denitrification may not achieve low enough levels of nitrate reduction and an external carbon source such as methanol or acetate may be required to supplement the biological process. World wide experience, however, indicates that use of influent sewage and a limited external carbon source would not be cost inhibitive compared to alternate chemical systems.
- Level 3 effluent nitrogen target of 5 mg/L may not to be consistently achieved by this process and additional processes will need to be added (refer below).

Due to the relative ease of incorporating biological nitrification/denitrification facilities at the Hornsby plants it shall be considered further.

Post-Denitrification. Post-denitrification involves removal of residual nitrate in a biological reactor located at the downstream end of the treatment process. The reactor may be either a suspended growth or fixed bed type and is operated anoxically to stimulate the biomass to use nitrate as its oxygen source rather than free dissolved oxygen. The nitrate is reduced to nitrogen gas which is lost to the atmosphere.

The most widely used supplementary carbon source is methanol, a very readily available food source. There is also a potential danger of gross pollution occurring in the receiving waters in the event of over dosing. Measures will need to be put in place to prevent this.

The advantages of post-denitrification are:

- May be readily added to biological nitrification/denitrification processes to achieve low effluent total nitrogen levels (below 10 mg/L 90%ile values).
- With proper optimisation of upstream biological nitrogen removal processes, external carbon source dosing may be reduced by a considerable amount.
- The infrastructure required is generally smaller in size to alternate chemical nitrogen removal facilities and can be readily accommodated on sites which have limited room for augmentation

Disadvantages include:

- Dependence on external carbon source to continue the process. Cheaper food sources may, however, be available to methanol and can readily be applied to the process.
- Higher operating costs if carbon source over dosed.
- Potential organic pollution of receiving waters if over dosing occurs. Strict measures to prevent over dosing can be put in place to eliminate this potential.

High Biomass Systems. There are several methods of increasing the amount of biomass present in an activated sludge system[3]. These include proprietary processes, such as Linpor and Ringlace, as well as activated carbon. The aim of all of these is to provide media for the growth of micro-organisms so that the total active biomass is greater than would otherwise be the case.

Effectively these systems increase the solids retention time of the process and, as a result, should enable a higher degree of nitrification to be achieved than by conventional systems (provided adequate aeration is available). The systems seem to have greatest application in the upgrading of plants not originally designed for nitrification or which are deficient in the physical sizes of the reactor and/or clarifiers. Full scale trials of the Linpor process have been undertaken at Hornsby Heights STP in an effort to increase its nitrification capacity (refer Section 4).

Section 4 discusses the results of the study at Hornsby Heights STP and highlights the increase in nitrification potential at plants not designed for ammonia conversion.

The advantages of the high biomass system are similar to the biological nitrification/denitrification process plus the fact that reduced biological reactor volume is required when compared to standard biological nitrogen removal processes.

The disadvantages of the high biomass system are similar to the biological nitrification/denitrification process discussed previously plus the need to replenish the high biomass every 5 to 7 years.

Due to the added benefits of high biomass systems in terms of reduced process volume, it will be considered further.

Ammonia Stripping[4,5]. Ammonia can be stripped from the effluent by raising the effluent to pH 11, generally with lime, and passing the effluent through a stripping tower (somewhat similar to a cooling tower), while forcing ammonia-free air upwards through the tower. As the effluent drops from one layer of closely spaced slats to another within the tower, ammonia gas passes from the liquid to the air stream in order to approach equilibrium between the ammonia partial pressures in the liquid and air streams. Resulting effluent ammonia concentration is, however, usually greater than 2 mg/L.

The major advantage of the Ammonia Stripping Process is that there is no need to rely on the conversion of ammonia to nitrates for removal of total nitrogen. The disadvantages of Ammonia Stripping, however, are numerous and include:

- Only free ammonia is stripped, organic nitrogen passes through unchanged.
- Off-gas scrubbing, to remove the ammonia, would be required.
- High maintenance and operating costs, in particular additional pumping is usually required to elevated the liquid to the top of the tower and high chemical costs are incurred for pH adjustment.
- Very temperature dependent and may not consistently achieve ammonia removal during winter.
- Less reliable and less energy efficient than other processes.
- It has been replaced in many locations throughout the USA with biological nitrification as the latter is more reliable and cost effective.
- Problems can result from scale formation from precipitation in the tower.

Based on the above, this process will not be considered further.

Breakpoint Chlorination[4,5]. Breakpoint chlorination removes ammonia by oxidation to nitrogen gas. With proper control and flow equalisation, the ammonia -nitrogen present in wastewater could be reduced to zero. An added advantage of this process is that disinfection of wastewater is achieved at the same time. High total nitrogen removal facilities cannot generally be achieved, however, without the inclusion of biological nitrification/denitrification upstream of the process.

Other disadvantages include:

- The presence of other organic and inorganic compounds which exert chlorine demand will lead to a higher actual chlorine dose rate.
- There will be no reduction in organic nitrogen, nitrite and nitrate concentrations.
- High operating costs due to the high level of chlorination.
- Potential for formation of THM's (trihalomethanes) and other chlorinated organics.
- Increased dissolved solids.
- Removal of wastewater alkalinity.
- Dechlorination will be required, further adding to cost.

The high chlorine dose rate required makes breakpoint chlorination prohibitively expensive for removal of all but trace concentrations of ammonia. Based on the above discussion, breakpoint chlorination will not be considered further.

Selective Ion Exchange[4,5]. The inorganic nitrogen fraction may be removed from a wastewater through ion exchange using the naturally occurring zeolite clinoptilolite. The media may be regenerated and the ammonia either recovered as ammonium sulphate or discharged to the atmosphere as a gas.

This process has not found wide application and suffers from high capital and operating costs. It has consequently not be considered further for West Hornsby and Hornsby Heights STPs.

Conclusion. On the basis of the above discussion, only biological nitrogen removal processes will been considered further. For the Berowra Creek Catchment plants ammonia stripping, breakpoint chlorination and ion exchange are not considered viable alternatives for effluent total nitrogen target quality levels 1 and 2.

Post denitrification and methanol dosing facilities, however, will need to be added to the biological nitrogen process to achieve the 5 mg/L total nitrogen target.

PHOSPHORUS (P) REMOVAL

Phosphorus may be removed from wastewater by chemical, biological or combined chemical/biological means. At present, phosphorus removal at both West Hornsby and Hornsby Heights STPs is achieved by chemical means.

Chemical Phosphorus Removal. Chemical removal of phosphorus involves the formation of insoluble phosphate compounds which precipitate out of solution. Lime, alum and iron salts have all been found to be effective. Chemical addition can be made at a various points within the treatment process with differing results depending on the chemical used[5,6,7].

The degree of phosphorus removal which can be achieved by pre-precipitation (i.e. chemical addition to raw sewage upstream of the primary sedimentation tank and biological reactor) is limited because a significant portion of the influent phosphorus is in organic and polyphosphate forms which do not readily precipitate. Simultaneous precipitation (i.e. chemical addition to the biological reactor) should give rise to effluent phosphorus levels of 1 mg/L while post precipitation (i.e. chemical additional downstream of secondary sedimentation) followed by a filtration step can give rise to phosphorus levels as low as 0.1 - 0.3 mg/L.

The advantage of chemical phosphorus removal is:

- Relatively low capital cost.
- Greater reliability than the purely biological removal alternative.
- Ability to consistently achieve very low phosphorus levels.
- No major distribution to process expected if dosing optimised.

The disadvantages of chemical phosphorus removal is:

- Chemical addition will result in increased sludge volumes (up to 35 per cent on a dry mass basis for addition of Spent Pickle Liquor (iron salt) and 30 to 35 per cent for addition of alum.

- High recurring cost of chemical addition.

- Possible lower sludge dewatering efficiencies, particularly for aluminium sludges, although dewatering of biological phosphorus sludges at Penrith STP are also proving difficult.

- Alkalinity reduction (due to the addition of Fe and Al salts).

- Increase effluent dissolved solids.

Biological Phosphorus Removal. Some removal of phosphorus occurs in all biological treatment systems, however, the enhanced biological removal of phosphorus has, to date, only been achieved in modifications of the activated sludge process. It is with this process that much research effort has been expended in order to understand just how the process operates and what are the conditions for enhanced biological removal of phosphorus to occur.

While a portion of the phosphorus in the sewage will be used for organism growth in the activated sludge process, enhanced biological removal of phosphorus is achieved by inducing the organisms to incorporate phosphorus, in the form of polyphosphate, at rates far in excess of that required for normal growth.

The exact mechanism for this "luxury" uptake of phosphorus is still under investigation although the operational parameters required to induce this phenomenon are becoming more known. In general, it is required that the mixed liquor suspended solids be exposed to an anaerobic condition in the absence of nitrates. An alternating sequence of anaerobic/anoxic zones and aerobic zones in a wastewater treatment process selectively encourages the growth of facultative bacteria that are able to store phosphorus in excess of their metabolic needs as polyphosphates within the bacterial cell. In an anaerobic environment, phosphorus is released to the mixed liquor while organic substrate is simultaneously being absorbed. Upon subsequent exposure to an aerobic zone, the facultative bacteria will replicate and take up the phosphorus at enhanced levels.

A crucial factor in the success of a biological phosphorus plant is the nature of the incoming sewage[8] and lack of this understanding has been the main reason for the failure of the early plants. Nowadays a "fermentation" reactor is included in the design to modify the nature of the sewage to ensure that the inflow to the biological reactor contains sufficient short chain organic material to promote the growth of the organisms that are responsible for the enhanced uptake of phosphorus.

There are examples of this design principle in many plants around the world including Canada, South Africa (Johannesburg and others), Zimbabwe (Bulawayo) and Australia (Penrith and St Marys STPs).

A plant incorporating raw sewage "fermentation" and biological P removal processes would be expected to produce an effluent phosphorus concentration of around 2 mg/L on a reasonably consistent basis. These levels, however, have still not been achieved at Penrith STP biological phosphorus and nitrogen removal plant. Therefore, the biological phosphorus removal process alone without chemical support is considered unsuitable for West Hornsby and Hornsby Heights STPs. Also the activated sludge process requires considerable modification to incorporate biological phosphorus removal and includes anaerobic zones, RAS denitrification, larger clarifiers and aerobic sludge handling facilities.

Biological Phosphorus removal does, however, have the following reported advantages:

- Chemical costs are reduced if the system is operated correctly.
- The process does not add residual contaminants to the wastewater if re-release of phosphorus does not occur.

Disadvantages include:

- Higher capital cost due to larger process requirements.
- Less reliability and subject to favourable biological conditions.
- Using biological phosphorus removal tends to limit nitrogen removal in combined biological nitrogen and phosphorus removal plants.
- Sludges are more difficult to treat.
- More complex technology and requires highly skilled personnel to operate.

Combined Biological and Chemical Phosphorus Removal. In a number of countries throughout the world, combined biological and chemical removal steps have been employed to ensure a consistent degree of phosphorus removal is achieved. The Water Board has also employed combined biological and chemical phosphorus removal processes at Penrith, St Marys and Rouse Hill biological nutrient removal plants. These plants have been designed to remove nitrogen and phosphorus biologically with chemical dosing to achieve lower phosphorus levels. The continuous flow biological nutrient removal systems at the above STPs consists of a number of zones and separate clarification. The system is designed to maximise biological phosphorus removal and to utilise the chemicals as both a "backup" and as a"top up".

Advantages and disadvantages of the combined biological and chemical phosphorus removal plants are similar to the distinct chemical and biological systems. Another major advantage that may occur is lower chemical costs if the combined system can be operated reliably. The outlay of additional capital for this process, however, may well outweigh its practicality at existing treatment plants, such as West Hornsby and Hornsby Heights STPs. As the biological phosphorus removal process is also sensitive to incoming sewage characteristics, this may well lead to a stronger reliance on chemical phosphorus removal than originally believed. This is currently being experienced at Penrith STP.

Crystallisation. A recent development in the chemical removal of phosphorus is a crystallisation process where calcium phosphate is crystallised on to seed crystals. Such systems are being developed in Japan and, while being fairly complex in nature, they do have the benefit of a negligible sludge production. Workers in the Netherlands have recently reported on the removal of phosphorus through crystallisation of calcium phosphate in a fluidised bed. An advantage claimed for this process is that no waste sludge is produced, but rather a small quantity of dewatered phosphate pellets that can be reused in the phosphate industry. This technology is still considered to be in the development stage and the long term operability and reliability are yet to be established. It has not, therefore, not been considered further for West Hornsby and Hornsby Heights STPs. Pretreatment requirements for this process are considerable.

Conclusion. On the basis of the above, only chemical and combined chemical/biological phosphorus removal processes will be considered further for the Berowra Creek Catchment plants. Biological phosphorus removal and crystallisation are not considered viable alternatives to achieve the low effluent phosphorus target of 0.3 mg/L (90 percentile value).

TREATMENT PROCESS SHORT LISTING

A number of different liquid process options have been considered for meeting Effluent Target Levels 1, 2 and 3 as specified in Table 7-1.

The options considered fall into two groups and are based on being the removal of nitrogen by biological means. Chemical phosphorus removal facilities are also considered more applicable in removing phosphorus in the influent:

- Suspended Growth Activated Sludge Systems.
- Attached Growth Activated Sludge Systems.

Treatment options have been broadly evaluated for short-listing to meet target Levels 1, 2 and 3 based on demonstrated performance, ability to be constructed on a limited site(s) and the opportunity to maximise existing treatment facilities on-site.

Suspended Growth Activated Sludge Systems

Activated sludge systems that achieve biological nitrogen removal and that operate on the suspended media principle may be divided into two types; the normal continuous flow/continuous aeration types and the continuous inflow/intermittent outflow/intermittently aerated alternative.

Continuous Flow Process. The continuous flow/continuous aeration activated sludge system may be readily modified to achieve biological nitrogen removal through the incorporation of an anoxic zone while phosphorus removal can be achieved, in these plants by chemical addition to the biological reactor and tertiary filters. Phosphorus removal STPs may also be achieved biologically, through the incorporation of an anaerobic zone and in conjunction with chemical addition.

Continuous flow activated sludge processes can be operated at a range of solids retention times (SRT). Due to existing sludge processing facilities the low SRT process (15 day SRT) would be more suitable for West Hornsby and Hornsby Heights STPs. The extended aeration process (20 days or more SRT) would require more process volume and area requirement as well as the oxygenation costs are higher than for the 15 day SRT process.

There are many examples of continuously aerated nutrient removal plants in Australia, all generally incorporating biological nitrogen removal with phosphorus being removed by biological, chemical or combined biological/chemical means.

The Water Board has the following examples of the continuous flow activated sludge process plants with nutrient removal:

- Continuous flow biological nutrient removal systems consisting of a number of zones (anaerobic, anoxic, aeration and re-aeration) and separate clarification. The system is designed for nitrification, denitrification and biological phosphorus removal (with chemical backup). Prefermentation (to increase the readily biodegradable component of the raw sewage) is also provided. For the purpose of this study, this process will be referred to as a 'BNR' process although, strictly speaking BNR does not necessarily have to include biological phosphorus removal. Examples of the BNR can be found at Penrith, St Marys and Rouse Hill STPs.

- Continuous flow biological nitrogen removal system consisting of three zones (anoxic, aeration and re-aeration) and separate clarification. This system, sometimes referred to as the Modified Ludzack Ettinger[2] (MLE) process, is designed for nitrification, denitrification and chemical precipitation of phosphorus. Castle Hill, Round Corner and West Camden STPs are typical examples of this type of process.

Intermittent Process. The intermittently aerated alternative can take several forms[5] as indicated below:

- The IDEAS (intermittently decanted extended aeration system) or IDAL (intermittently decanted aerated lagoon) in which aeration and settlement occur on a cyclic basis in a single biological reactor. Many of these types of plant have been installed in Australia, particularly by the NSW Public Works Department.

- The SBR (sequencing batch reactor) system is gaining acceptance in Australia. It has a process advantage over the single reactor system (treatment phases are more distinct and short circuiting is avoided) but tends to be more expensive. The principal difference between the SBR and IDAL systems is that in the former each reactor received intermittent inflow where as in the latter case inflow is continuous. The SBR system consequently requires a minimum of two reactors and has a greater land requirement.

At present the Board has a number of IDALs in operation, with large plants found at Quakers Hill STP and Winmalee STP. An IDAL system is also planned to be incorporated at the proposed Picton STP.

Both of the above intermittent processes are able to achieve high degrees of biological nitrogen removal. Biological phosphorus removal has been reported at some of these plants but its efficiency is very variable and, while research is currently underway into means of maximising biological phosphorus removal in these intermittent systems, phosphorus removal is mainly achieved through the use of chemicals.

The intermittent system has the advantage that aeration and settlement take place within the same structure, making provision of separate clarifiers unnecessary. Also due to process kinetics the intermittent systems can be also configured to receive up to 4 PDWF, whereas secondary treatment within continuous flow systems is generally limited to 3 ADWF. The treatment efficiency of IDALS decreases, however, at high flow rates. For example, at 4 PDWF the IDAL acts principally as a sedimentation tank with some solids contact. At some locations, further capital cost savings can be achieved by forming the aeration lagoons with concrete lined earth embankments. Earth lagoons are, however, most economic when site topography allows earthworks cut and fill volumes to be balanced, when site crossfall is limited such that the maximum embankment height does not become excessive, and when site excavated materials are suitable for formation of water retaining embankments. At West Hornsby and Hornsby Heights STPs, however, much of the site is limited and is surrounded by steep terrain.

As additional treatment is required downstream of the aeration tank/lagoon, the intermittent process is further disadvantaged by flow balancing requirements. Flow out of the aeration system is concentrated within the decant period. Typically under dry weather conditions the decant phase occupies less than 25 per cent of the cycle duration. Outflow rate during decant consequently typically exceeds four times the average inflow rate over the cycle. Flow balancing is, therefore, required to avoid the cost of increasing downstream treatment process capacity to match high short-term flow peaks.

If, as at Quakers Hill, flow were to be pumped from the balance tank to downstream treatment units, then operating costs would increase as a result of pump power and maintenance expenses.

Based on the need to maximise the use of existing continuous flow facilities at the Hornsby STPs, surrounding site topography and site specific ground conditions the intermittent process is considered unsuitable for adoption for upgrading both West Hornsby and Hornsby Heights STPs. For a green field site, however, the IDAL system may well be an appropriate process for adoption, if the site area is available.

Pure Oxygen Activated Sludge. The use of pure oxygen activated sludge systems is gaining increasing acceptance for secondary treatment, due to its ability to maintain high dissolved oxygen levels. It is particularly suitable to conventional activated sludge systems when only carbonaceous BOD removal is required.

While the system could be used for nitrification/denitrification requirements, there are a number of disadvantages, in particular:

- The need for a relatively high SRT means that process volume reduction (one of the main benefits of the oxygen system) is less significant.
- The high D.O. in recycled mixed liquor and return sludge would inhibit denitrification and probably require much larger anoxic zones than air activated sludge systems.
- CO_2 is not stripped out, BOD reduction reduces pH which in turn reduces nitrification rates.

One of the features of the OAS process is that hydraulic retention time in the reactor tank is reduced to approximately 1.5 hours and sludge age is less than conventional Activated Sludge. For this reason OAS is a little use for nitrification/denitrification although additional facilities could be installed downstream if necessary.

This process shall not be considered further for biological nitrogen removal as it has no major advantage over the MLE or IDAL.

Attached Media Biological Treatment. Attached media biological treatment comprises systems that utilise a medium on which the organisms attach and grow. Sewage passes either through or over the medium and by so doing is purified by the attached organisms. Examples include:

Biologically Aerated Filters (BASF).
Biocarbone.
Membio.
Artificial Wetlands.

Trickling Filter/Solids Contact (TF/SC) Process. This process was first developed in 1979 and consists of a trickling filter, an aerobic solids contact tank and secondary sedimentation tanks.

Distinguishing characteristics of the process are listed below.

- The primary function of the aerated solids contact tank is to increase solids capture and flocculation and reduce particulate BOD.
- The majority of soluble BOD removal occurs in the trickling filter. Additional levels of treatment may be achieved by increasing the detention time of the aeration zone.
- Return sludge solids are mixed with trickling filter effluent.
- The aerated solids contact tank is not designed to nitrify, although partial nitrification may occur in the trickling filter.
- The aerated solids contact time is 1 hour or less (however this is variable) based on total flow, including recycle.
- The solids retention time (SRT) of the aerated solids contact tank is less than 2 days (again this may vary).

As noted, the TF/SC process is an economical method of upgrading old or overloaded trickling filter plants. Although the process could be modified to achieving nutrient removal, by incorporating biological nitrification / denitrification and chemical phosphorus removal, this would involve a considerable increase in the size of the solids contact stage above that normally adopted and there does not appear to be any significant advantage of the process (over a more conventional activated sludge biological nitrification / denitrification system) for upgrading of an existing activated sludge plant or for a new plant.

A variation of the TF/SC process, used at Olifantsfontein in South Africa, involves splitting the sewage inflow between a trickling filter and an activated sludge biological phosphorus removal system. The effluent from the trickling filter feeds directly into the aeration zone of the activated sludge plant. This variation depends on the use of surface aeration in the aeration zone (and the development of anoxic 'pockets' used for denitrification) and was developed specifically to upgrade an existing trickling filter plant. There are no advantages in using this process where filters do not already exist.

From the above, TF/SC process does not warrant further investigation.

Biological Aerated Submerged Filters (BASF). BASF is a biological process which combines oxidation and removal of stabilised suspended matter in the one reactor. Its compact size together with absence of secondary clarifiers makes it particularly suitable for sites with restricted area.

The process consists of an aerobic fixed film reactor operating with a submerged, granular bed. The granular media provides a matrix on which a high concentration of biomass can grow. Process air is added through injection pipes located near the bottom of the granular bed. The BASF serves as a final filter, thus eliminating the need for secondary clarifiers. In physical construction, each BASF cell resembles a conventional rapid gravity sand filter.

Like rapid gravity sand filters, BASF cells require periodic backwashing. Typically, this takes place every 18-36 hours (depending on the plant load), taking 25 to 55 minutes for each cell. Sludge from the backwash water is usually settled in a special-purpose sedimentation tank, the overflow of which is recycled through the BASF plant. Backwash water is reported to account for 8 to 10 per cent of the plant flowrate.

There are several versions of the BASF. In the BIOFOR process (licensed from Infilco Degremont by Sepa Pty Ltd), sewage flows in an upwards direction through the filter bed. In the BIOCARBONE process (licence from OTV by Aquatec Maxcon Pty Ltd), sewage flows in a downwards direction through the bed. The bioreactor of the MEMBIO process is another downflow version of the BASF.

BASF is always preceded by primary sedimentation (sometimes with chemical assistance). The BIOFOR process also requires a 2 mm screen to be installed downstream of the sedimentation tanks to prevent large solids from entering the granular bed.

If nitrification is required, it would be necessary to install a 2 stage BASF plant.

The first stage would achieve removal of carbonaceous material with a bed depth of 3 m and would operate at loading rates of 3 to 6 m/h (maximum hydraulic loading 10 m/h). The second stage would be designed for nitrification with a bed depth of 4 m and would operate at loading rates of 5 to 9 m/h (maximum hydraulic loading 12 m/h).

Also, if denitrification is required, a pre-denitrification stage prior to the 2-stage BASF plant is also required.

As additional stages for nitrification and denitrification are required to be added to the standard BASF processes, the original concept that the BASF is a very compact plant would not hold for the Hornsby STPs. Also as a large degree of retrofitting would need to be undertaken on-site, the process will not be considered further. From a new greenfield site, however, the BASF system modified for nitrogen and phosphorus removal may have potential.

Artificial Wetlands. Studies carried out some years ago at Richmond[9] showed the ability of artificial wetlands to remove large amounts of residual ammonia, nitrogen, BOD, SS and pathogens from secondary sewage effluent. Those results indicate that there is the potential for artificial wetlands to polish the effluent from the biological and chemical treatment processes at Berowra to Level 3 requirements.

There are, however, a number of uncertainties. The Richmond studies were carried out on effluent from conventional treatment (ie. total nitrogen of the order of 50 mg/L, most of which was in the form of ammonia). Under these conditions about 90% removal was achieved by nitrification/denitrification in certain of the wetland trial plots. In the case of Hornsby Heights, however, the requirement is for substantial nitrogen removal from an influent flow containing less than 10 mg/L total nitrogen very little of which would be ammonia. Whether the design parameters developed at Richmond could be extrapolated to this situation is by no means certain.

Another disadvantage is the area of land required. On the basis of the Richmond results (involving horizontal flow methods) a design parameter of 0.5 ML/ha/d would be indicative. Recent research into vertical flow artificial wetlands has indicated that higher loading rates are possible for those systems. Even if vertical flow systems were used, however, the area requirements would still be substantial.

Based on the above therefore, this process will not be considered further.

TREATMENT OPTIONS ADOPTED

Based on the above discussion and the Board's current operational experience with inland treatment plants, to consistently achieve the Level 1 and 2 effluent quality targets stipulated to be examined by the Berowra Creek Community Contract, viable treatment options for Options 1 and 2 involve the removal of nitrogen by biological means and phosphorus by chemical precipitation.

Level 1 and 2 Effluent Quality Targets

As the existing plants at both West Hornsby and Hornsby Heights STPs are continuous flow activated sludge systems incorporating nitrification and chemical phosphorus removal, the standard biological nitrogen and chemical phosphorus treatment plant, (which is sometimes referred to as the Modified Ludzack Ettinger (MLE) process shall be adopted for detailed investigation in Option 1. The MLE is designed for nitrification, denitrification and chemical precipitation of phosphorus. Castle Hill, Round Corner and West Camden STPs are typical examples of this treatment type. Also a modification of the MLE process involving the use of a high biomass system shall be considered. As Hornsby Heights STP has a full scale trial high biomass nitrification process in operation, it shall be examined in Option 2.

In Option 4, the retained and upgraded STPs shall also be achieved by using the MLE process.

A combined biological and chemical phosphorus removal process is considered not viable for Options 1 to 4. For Option 1 and 2, limited space is available for its incorporation at the Hornsby plants as additional BNR process requirements will limit the STPs capacity to treat their catchment flows now and in the future.

For Options 3 and 4 which both involve building a new treatment plant on a greenfield site, the combined biological and chemical phosphorus removal process was also not considered further at this stage either. This is based on the premise of current operational problems being experienced at Penrith STP where biological phosphorus and chemical dosing is not achieving low effluent phosphorus levels. This decision, however, may need to be reviewed during the environmental assessment phase if both Options 3 and 4 are to be examined in more detail, and when more favourable phosphorus reduction is obtained at both the recently commissioned Stage 3 St Marys and Stage 1 Rouse Hill STPs.

Therefore, for the proposed greenfield sites in Options 3 and 4, biological nitrogen and chemical phosphorus removal processes are considered to be more applicable. Alternate treatment systems that are viable include the MLE, the intermittent process and biological aerated submerged filters (BASF).

For the purposes of this report and based on actual operational experience gained by the Board at the Quakers Hill intermittently decanted aerated lagoon (IDAL) plant, the IDAL process shall be adopted as the treatment process for the proposed greenfield sites. A number of factors have led to its adoption and include:

- The current IDAL process at Quakers Hill STP has consistently achieved an effluent total nitrogen of 7 mg/L (90%ile value) for the 1993/1994 licence year.
- The nominated site for the proposed new plant has room to accommodate such a treatment system.
- The Board has no full scale operational experience with the BASF system including biological nitrification and denitrification in attached growth columns.
- Operation of the BASF may be adversely affected by the direct additional of chemicals in the attached growth media and trials would need to be undertaken before the Board could make a firm recommendation.
- The IDAL process is considered to be less complex to operate than the MLE process, reduces the need for secondary clarifiers and has the ability to provide partial biological treatment to stormflows which is an inherent design advantage over other processes.
- The intermittent process has gained extensive operational service throughout NSW and is a proven technology.
- At this stage, limited experience has been gained from Rouse Hill and St Marys STPs to the successful operation of the combined biological and chemical phosphorus removal process (in conjunction with biological nitrogen removal) for the Sydney Region. Also, recent results from Penrith STP are not conducive to favour the installation of this type of treatment process over the MLE or IDAL system.

Level 3 Effluent Quality Target (Total Nitrogen of 5 mg/L)

Both the MLE and IDAL process options selected for further investigation are considered capable of achieving the Level 1 and Level 2 effluent quality targets including the total nitrogen levels of 15 mg/L and 10 mg/L respectively. To achieve the total nitrogen level of 5 mg/L, however, the facilities required to meet this target include the Level 2 process plus post-denitrification for residual nitrogen removal. Post denitrification would comprise a post anoxic reactor using a supplementary carbon source (e.g. methanol) to sustain denitrification.

Phosphorus Reduction to 0.3 mg/L. To achieve consistent reduction in effluent phosphorus to 0.3 mg/L, phosphorus removal by addition of mineral salts (such as iron and alum) to the biological reactor plus secondary effluent (multi-point dosing) are considered to be the most appropriate process option for the Berowra Creek catchment sewage treatment plants (Options 1 to 4). Alternatives involving chemical dosing to primary sedimentation tanks are undesirable as the organics in the sewage will be immobilised and not made available for downstream processes, particularly denitrification.

The current practise of multi-point dosing in the Water Board involves the dosing of chemicals prior to the biological reactor (simultaneous precipitation) and direct to the deep bed tertiary filtration units (post precipitation). This will be incorporated in Options 1 to 4.

TRANSFER OF SEWAGE TO OCEAN

In Options 5 to 10 raw sewage or treated secondary effluent will be transferred from the Hornsby STPs to ocean plants located in the Warriewood and North Head catchment. The transfers will achieve in the majority of cases a zero effluent total nitrogen discharge at Berowra Creek. The nutrient loads that would have entered the creek will be transferred to less sensitive waters off the Sydney Coast.

The following section details the treatment processes examined to meet the effluent quality targets found in Table 7-2, especially with regard to the EPA's EG-1.

For ocean shoreline discharges such as Warriewood STP, the EPA EG-1 water quality criteria specifies at the initial dilution zone an ammonia concentration of 600 µg/L. Based on an initial dilution of 10:1 for Warriewood ocean outfall the maximum concentration of ammonia discharged from the Warriewood STP is approximately 6 mg/L. Therefore all options involving either treatment at Warriewood STP or secondary effluent disposal through the Warriewood ocean outfall will consider the production of a nitrified effluent.

For Options 5 and 8, raw sewage is planned for transfer from the Hornsby STPs to Warriewood STP for treatment and disposal via the shoreline ocean outfall. To adequately address the water quality criteria, Warriewood STP will need to be upgraded to remove ammonia. The plant, however, continues to meet the remaining water quality bacteriological requirements in the receiving waters. The transfer of the Hornsby STPs will not alter this situation.

Transfer of Raw Sewage to Warriewood STP

Based on the above discussion, Warriewood STP will need to be upgraded to achieve a nitrified effluent as well as augmented for handling increased flows from the Hornsby plants catchment. A number of activated sludge processes were examined for treatment at Warriewood and include:

Nitrification Activated Sludge (NAS). NAS is an activated sludge process which is capable of removing 90 to 95 percent of carbonaceous BOD_5, suspended solids and oil and grease. The process is also designed to achieve nitrification (ie convert ammonia to nitrates and nitrites) and is an extension of the conventional activated sludge system (refer below).

Conventional Activated Sludge (CONVAS). The conventional activated sludge is the standard suspended growth activated sludge process which is capable of removing 85 to 95 percent BOD_5, suspended solids and oil/grease. The plants are generally run at a solids retention time (SRT) between 4 and 8 days and they do provide for some partial nitrification (or ammonia removal). A variation to the CONVAS is the high rate activated sludge (HRAS) system which is also capable of removing 80 to 90 precent of conventional pollutants. The present Warriewood STP has been designed as a high rate activated sludge system. As the process is designed to operate around 3 to 4 days SRT they are unable to nitrify consistently to the low levels required. The HRAS system therefore will not be considered further.

Modified Ludzack-Ettinger (MLE). The MLE process is intended for biological nitrogen removal which is not a requirement for ocean discharge (refer Table 7-2). As the process is considered unnecessarily sophisticated for installation at Warriewood STP, it will not be investigated further.

Intermittently Decanted Aerated Lagoon (IDAL). The IDAL is a single tank process in which aeration, settling and effluent withdrawal takes place intermittently in a cyclical manner. Raw sewage is normally fed directly into the IDAL without primary sedimentation. The process is designed for nitrification and denitrification and is able to achieve low levels of ammonia, nitrogen, BOD_5 and suspended solids. As with the MLE process, the IDAL is considered inappropriate for installation at Warriewood STP.

Other Processes. The Trickling Filter/Solids Contact, Pure Oxygen Activated Sludge and BASF are also alternate processes which may be utilised for conventional pollutant reduction. Modifications to their standard design, however, will be required to achieve ammonia reduction.

Conclusion. Based on the above, the nitrification activated sludge process shall be adopted for upgrading Warriewood STP in options 5 and 8.

Transfer of Secondary Effluent to Warriewood STP Ocean Outfall.

In Options 7 and 10 nitrified secondary effluent is to be transferred form the Hornsby STPs to the Warriewood ocean outfall. Both the plants at West Hornsby and Hornsby Heights STP will continue to operate as nitrification plants and no major upgrading is required. Both the chemical phosphorus removal and tertiary filtration facilities are to be decommissioned.

Transfer of Raw Sewage to North Head STP.

For Options 6 and 9 which involves transferring raw sewage to North Head STP, minor amplification of the existing primary treatment process at the ocean plant plus discharge through the deep ocean outfall will provide adequate treatment to meet the water quality criteria in Table 7-2, and continue to meet current licence conditions.

As the flow to North Head STP from the Hornsby STPs will represent only approximately five per cent of the existing North Head plant flow, the transfer will have no major impact on the performance of the ocean plant. Also if the Clean Waterways Programme requests additional works at North Head STP, the Berowra Creek Catchment transfer will have even lesser impact.

Storm Treatment Plants at West Hornsby and Hornsby Heights

Options 5 to 10, transfer either raw sewage or effluent to the ocean plants at Warriewood and North Head STPs. Various storm treatment processes will be incorporated at the Hornsby STPs as listed below.

Option 5 and 6. In Options 5 and 6 all flows up to DWWF shall be transferred to ocean plants. Flows in excess of the DWWF will be stored on-site at the Hornsby STPs which will be converted to wet weather holding facilities. Although the occurrence of wet weather discharge to Berowra Creek shall be remote, all excessive storm flows shall still receive screening and grit removal.

Options 8 and 9. For Options 8 and 9, however, the existing Hornsby plants will be converted to storm treatment STPs. A number of alternate processes were examined and are discussed below:

Chemically-Assisted Sedimentation (CAS). CAS involves the dosing of ferric chloride coagulant and polyelectrolyte flocculant into the sewage influent. Based on proving treatment process trials at Malabar STP, CAS is generally capable of removing 80 to 85 percent of total suspended solids. The process relies on both physical and chemical methods such as primary sedimentation and chemical dosing for separating waste substances and does not utilise biological micro-organisms. It can be readily installed at West Hornsby and Hornsby Heights STPs which have both primary sedimentation and chemical dosing facilities. The existing Fairfield Storm treatment plant is based on a CAS system and has proven to be effective in reducing conventional pollutants under storm conditions. The CAS system, like all physical chemical systems, has minimal effect in reducing nitrogen.

Primary Sedimentation. At present the majority of the Board's plants provide storm treatment by treating all flows up to DWWF in primary sedimentation tanks. Although reasonable suspended solids removal has been reported during storm conditions the PSTs are still not as efficient in removing solids as physical/chemical systems such as CAS.

Swedish F.A.S.T. System. F.A.S.T. means "primary separation of suspended solids by use of triple doses". The process has been used successfully in Sweden but produced inconclusive results when trials were undertaken at North Head STP. As the F.A.S.T. process remains unproven under Australian conditions, it will not be considered further.

Sirofloc Process. Sirofloc is an Australian process developed by the CSIRO which relies on alum and magnetite dosing as well as magnetite separation. The Sirofloc plant, generally, would consist of three parallel treatment streams and two regeneration trains installed downstream of primary sedimentation tanks (which would operate in a non-CAS mode). Although the Sirofloc process is capable of solids removal to very low levels, it will not be considered further as the system represents a complex process, expensive to install, and would involve major retrofitting at the existing Hornsby STPs.

Dissolved Air Flotation (DAF). This process is similar to the CAS system except solids are removed in a DAF tank after they are forced to the surface by diffuse air injection. The system still relies on chemicals to coagulate and flocculate solids before being removed. The system is also more expensive to operate when compared to CAS.

Conclusion. From the above paragraphs, the storm treatment process to be adopted at the Hornsby STPs, for Options 8 and 9, shall be the chemically assisted sedimentation (CAS) process. The CAS system can be readily economically installed on-site by utilisation of existing structures. Although primary treatment is generally acceptable for the treatment of storm flows, the CAS facility is still recommended as it also provides a higher standard of treatment in the unlikely (but preferable) event that raw sewage could not be transferred to the ocean plants in dry weather.

Options 7 and 10. As these options transfer secondary effluent to the ocean, standard primary treatment consisting of preliminary screening and grit removal plus primary sedimentation is adequate for stormflows and represents current practise.

EFFLUENT REUSE IN BEROWRA CREEK CATCHMENT

To ensure the maximum beneficial reuse of effluent within Berowra Creek and its environs, Option 11 considers treating both the West Hornsby and Hornsby Heights STPs' effluent to potable water standard. For the purposes of this report, the treatment process recommended to achieve this high quality water consists of the Level 3 MLE system of Option 1 plus the provision of advanced wastewater facilities such as reverse osmosis (RO). The process shall also be referred to as the Water Reclamation Plant (WRP).

Other pretreatment prior to RO, including activated carbon and coarser membranes such in memtec or nanafiltration, may be possible to reduce the cost of the RO facility, however, the most efficient process configuration would be determined, if adopted for further investigation during the environmental assessment stage.

The reverse osmosis facility will also produce a concentrated brine solution as a waste by-product. As the catchment is mainly of domestic sewage origin, the restricted substances in the brine may not pose a major concern but further analysis will need to be undertaken. At this stage, the brine solution shall be discharged to the NSOOS via a dedicated rising main in Option 11.

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5. Metcaff and Eddy, Inc., *Wastewater Engineering, Treatment, Disposal, Reuse*, 19

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7. USEPA, *Design Manual for Phosphorus Removal*, 1987

8. Water Research Commission of South Africa, *Enhancement of Biological Phosphate Removal by Altering Process Feed Composition*, 1986

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APPENDIX C

RETENTION AND UPGRADE OF WEST HORNSBY AND HORNSBY HEIGHTS STPS

Appendix C provides a detailed discussion of the facilities required to upgrade West Hornsby STP and upgrade and amplify Hornsby Heights STP to achieve the Level 1, 2 and 3 effluent quality targets summarised in Table 7-1, and is to be read in conjunction with Section 8 Option 1. It also has relevance for Option 2. The effluent quality targets examined have been requested by the Berowra Creek Technical Working Party in the Joint Letter of Intent.

OPTION 1 FOR WEST HORNSBY STP

West Hornsby STP is located on a well developed site with over three-quarters of its available land being utilised. The site is surrounded by residential development to such an extent that houses are less than 90 metres away from the plant's eastern boundary. It is imperative that no further development is allowed to encroach nearer to the plant and all lands zoned non-residential remain as a buffer. The plant is currently designed to achieve NFR and BOD removal, full nitrification and partial denitrification (during summer only). Phosphorus removal is achieved principally by chemical dosing of spent pickle liquor into the biological reactor. Tertiary phosphorus removal facilities have recently been installed to dose alum into the clarified effluent prior to tertiary filtration. Tertiary filtration is carried out by upflow sand filters and the effluent is chlorinated prior to discharge. Sludge treatment is via the anaerobic sludge digester with all stabilised sludge being taken off-site after being dewatered.

Performance Data. An assessment of the current process performance at the West Hornsby STP was carried out to determine the capability of the existing facilities to meet different effluent quality levels.

Table 3-5 shows recent 1993/94 EPA compliance data for major nutrients, NFR and BOD, as well as compliance data for the year 92/93. As a result of the continuing process optimisation programme at the plant there has been some significant improvements in effluent quality.

The EPA licence compliance data proposed indicates that the plant is currently capable of achieving compliance with the proposed Levels 1, 2 and 3 conventional pollutants, ammonia and phosphorus effluent quality goals summarised in Table 7-1.

The Total Nitrogen requirements, however, are unattainable with the current plant configuration.

LEVEL 1 TREATMENT REQUIREMENTS (Total Nitrogen of 15 mg/L)

West Hornsby STP has a current nominal design capacity of 45,000 EP based on the nitrification capacity of the biological reactor. Detailed process modelling based on more realistic sewage characteristics, however, has shown that the plant could achieve and maintain the Level 1 treatment level and a Total Nitrogen effluent quality of
15 mg/L for 45,000 EP, if the existing process facilities are modified and configured to a biological nitrogen removal system or MLE.

The Stage 1 interim upgrade that has recently been completed at West Hornsby STP has included some allowance for nitrogen removal and could possibly achieve 45,000 EP load with an effluent Total Nitrogen of 20 mg/L (50 percentile) with its current process arrangement. Based on current plant performance at Castle Hill STP, which is similar to the existing West Hornsby works, a Total Nitrogen in the effluent of around 25 to 30 mg/L would be expected for a 90 percentile value if the process is optimised and adequate food source is available.

By undertaking further modifications, as indicated below, the West Hornsby plant can also attain a Total Nitrogen Level of 15 mg/L (90 percentile) for 46,500 EP (Stage 2 Upgrade):

- Continue to operate the plant in a settled sewage mode (i.e primary sedimentation tanks continue to operate to remove some portion of organic load before entering the biological reactor).
- Modify the size of the anoxic and aerobic process volume in the existing 6 biological reactor tanks and ensure anoxic/aerobic dividing walls are water tight to prevent backflow from aerobic section.
- Provide a mixed liquor recycle from downstream of the aerobic reactor to the influent anoxic zone upstream.
- Provide for adequate mixing of the modified anoxic zones.
- Redistribute existing aeration distribution system within the aeration tanks to ensure adequate air is delivered to proposed modified aerobic volume.
- Provide an additional secondary clarifier.

Table C-1 indicates the adopted design criteria for the proposed settled sewage MLE for Level 1 treatment. This may be subject to change during the detailed design phases if this option is adopted or more site specific information becomes available.

The ability of the existing plant to provide treatment to Level 1 standard for 46,500 EP will mean that no major amplification or upgrading works, beyond that discussed in more detail below, will be required at the plant for some time after 2019.

It should be noted that this assessment does not take into account a detailed assessment of the plant's hydraulics, which is beyond the scope of this report. On examination of the hydraulic design undertaken by Sinclair Knight and Partners for the Interim Upgrade the proposed modification should not hinder the plant's capability to treat flows for 45,000 EP. Accordingly, while no serious hydraulic restrictions are anticipated, an assessment of the ability of the plant to pass flows equivalent to 46,500 EP or more is recommended.

The following sections outline the modifications required, in more detail, to upgrade the plant's capacity to 46,500 EP (Stage 2 Upgrade) and to Level 1 standard.

Nitrification

The required ammonia level of 5 mg/L (90 percentile) is being achieved consistently by the current plant configuration. Assuming no more tankage, enlarging the anoxic zones would mean decreasing the overall size of the aerobic zones. As a consequence, a suitable modification of the air diffuser installation would be required to ensure nitrification still proceeds effectively.

TABLE C-1. WEST HORNSBY STP OPTION 1 TREATMENT LEVEL 1 - PROPOSED DESIGN CRITERIA (15 mg/L TN)

Item	Design Value
CAPACITY EP	46,500
AVERAGE DRY WEATHER FLOW (ML/d)	12.60
MAX DESIGN FLOW - 3 ADWF (ML/d)	37.8
SEWAGE CHARACTERISTICS	
Raw Sewage COD (mg/L)	630
Raw Sewage TKN (mg/L)	46
Raw Sewage TP (mg/L)	10
Temperature (Winter)	15°C
REMOVAL EFFICIENCY OF PRIMARY SEDIMENTATION	
COD (%)	45
TKN (%)	10
TP (%)	10
VSS/TSS	0.6
PREFERMENTATION	PROVIDED[d]
BIOLOGICAL REACTOR (CONTINUOUS FLOW)	
Min Winter Solids Retention Time (days)	15
Process Volume (ML)	
Anoxic	1.90
Aeration	2.56
Total	4.46
Anoxic Sludge Mass Fraction[a]	0.42
Peak Oxygen Demand (kg/d)	6,600
SECONDARY CLARIFIERS[b]	
• Total Surface Area Requirement (m^2)	1,255
• Additional Area (m^2)	180

a. Anoxic sludge mass fraction is derived from the ratio of the total anoxic volume to the total reactor volume.

b. The option assumes all four existing clarifiers will be utilised in the process.

c. Although flow equalisation would be advantageous at West Homsby STP for smoothing out peak loads in dry weather, no room exists on-site to adequately locate a flow equalisation facility without major use of existing land and pumping resources.

d. Refer to main text for further details.

As the peak oxygen demand for the 46,500 EP MLE plant has been calculated at 6,600 kg/d (or 0.13 kg 0_2/EP.d), the Stage 1 Interim Upgrade has ample oxygen capacity provided negating the need to amplify the existing blower system. The existing system is capable of delivering over 9,000 kg 0_2/d (or 0.2 kg 0_2/EP.d).

Nitrogen Removal

The total nitrogen level requirement for Level 1 of 15 mg/L on a 90 percentile basis is not being met by the current plant layout and the following process modifications will be required to meet this goal.

Mixed Liquor Recycle (MLR). In a conventional biological Nitrification/Denitrification process it is essential to supply nitrate rich mixed liquor and RAS to the anoxic zone for enhancing denitrification. In the case of West Hornsby STP, however, only RAS is returned to the anoxic zone, thus limiting potential denitrification. As a consequence, mixed liquor recycle facilities will be required at West Hornsby STP for this option. A MLR system capable of returning up to 5 ADWF for 46,500 EP is to be provided.

Modification to Biological Reactors. The existing anoxic zones at West Hornsby STP are too small to achieve substantial denitrification and need to be significantly enlarged. This would involve converting approximately 42 per cent of each reactor's volume into an anoxic zone (currently it is approximately 16 per cent) by relocating the existing dividing walls and installing additional mixers. Activated sludge would continue to be drawn from the underflow of the secondary clarifiers and returned to the upstream of the biological reactor. Waste activated sludge will not continue to be extracted from the existing secondary clarifiers but will be wasted from the biological reactor prior to being thickened and directed to anaerobic sludge digesters for further stabilisation.

Increasing Biodegradability of Feed. The nature of the sewage entering the anoxic zone of the biological reactor can strongly influence the degree of denitrification. A feed sewage high in readily biodegradable material will promote good denitrification. There are several methods that can be used to modify the feed to increase the readily biodegradable component. These are shown diagrammatically in figure 8-1 and include:

- Prefermentation tanks, in which sewage or sludge is held for a period to promote fermentation of organic material and the consequent production of readily biodegradable material.
- Activated primary sedimentation, in which primary sludge is recycled around the sedimentation tank to increase the solids in the tank (and, again, to promote fermentation).

- Primary sludge "bleed", whereby sludge which has undergone some fermentation in the sludge hoppers is introduced directly into the anoxic zone of the biological reactor.

All of these methods should theoretically improve denitrification performance. Their impact on performance, however, is difficult to predict and, in the case of the first system listed, would be difficult to justify for the Level 1 total nitrogen requirement. The raw sludge "bleed" option, although a relatively simple system to introduce, cannot be recommended for implementation as no major trials have been undertaken.

For this Level, either activated primaries or prefermentation may be adopted. For this report perfermentation shall be used.

Modified Primary Sedimentation Tanks (PSTs) Removal Efficiency

On examination of the current performance of the existing primary sedimentation tanks at West Hornsby STP during dry weather, Chemical Oxygen Demand removal rates can vary dramatically between 30 and 70 per cent and this has been confirmed by operational staff. To ensure the successful operation of the settled sewage MLE process, excessive COD removals are to be avoided so as to allow the entry of adequate food sources for biological denitrification. Controls are, therefore, recommended to ensure that during the day to day operation of the PSTs the removal efficiencies for COD range between 30 and 45 percent. This should ensure an adequate food source for the biological nitrogen removal reactor without resulting in increased reactor volume and clarifier requirements.

The control system installed shall allow the use of any of the five existing tanks, during dry weather, via an automatic hydraulic penstock control to each tanks inlet. When storm flows are experienced, all PSTs are to be used, with a flow measurement level in the inlet works automatically opening the proposed penstocks to each PST.

Phosphorus Removal

The total phosphorus requirement of 0.3 mg/L on 90 percentile basis has not been achieved as yet (Table 3-5). As a result, further optimisation of the existing phosphorus facilities will be required to achieve this requirement.

The chemical dosing facility has recently been upgraded to provide additional tertiary phosphorus removal. This new system involves alum "post" dosing into the secondary effluent stream upstream of the tertiary filters to supplement the existing pickle liquor dosing located upstream of the biological reactor.

There has been a number of preliminary trials carried out at the plant to assess the broad capabilities of this process. These results tend to indicate that the upgraded system has the potential to achieve 0.3 mg/L phosphorus on a 90 percentile basis consistently after further optimisation.

Other Pollutants

The plant routinely meets the Level 1 requirements for BOD and NFR and, as a result, no upgrading of the process to meet improved effluent levels of these pollutants is required. The monitoring results in Table 3-5, however, show a failure to achieve the 90 percentile faecal coliform requirement. The present chlorine dosing system has a capacity of 80,000 EP and the plant is producing low levels of NFR due to the efficient operation of the tertiary filters. This indicates that the plant should be able to consistently obtain the faecal coliform levels required. No upgrading of the disinfection system is proposed, however, these deficiencies need to be eliminated to ensure the faecal coliform limits can be met. (Currently, operational staff at West Hornsby STP are investigating the options available to improve disinfection).

Other Facilities to be Provided

No additional facilities other than those discussed above will be required under this option. To accommodate the settled sewage MLE process at West Hornsby STP, it is expected some hydraulic modification works will be required and an estimate of its costing will be included in the economic analysis.

Process Flow Diagram and Plant Layout

Figures 8-2 and 8-3 show the additional facilities required at the plant and the new process flow train under the Level 1 treatment requirements for treatment of settled sewage in the biological reactor.

LEVEL 2 TREATMENT REQUIREMENTS (TOTAL NITROGEN 10 mg/L)

Modifications will need to be undertaken at West Hornsby STP to achieve the total nitrogen effluent requirement of 10 mg/L (90 percentile) for 46,500 EP.

Preliminary investigations indicate that the 10 mg/L total nitrogen target can be met by treating settled sewage and modifying raw sewage characteristics using prefermentation. An alternative to this may involve the dosing of an external carbon source, such as methanol, directly to the biological reactor, but full scale trials are required to verify its potential in consistently achieving the stated objective. Although flow equalisation may be employed to attenuate flow and mass loadings on the downstream treatment facilities, the stringent total nitrogen effluent quality goal still may not be met, as it may eliminate the opportunity to utilise or condition the incoming food source for enhanced nitrogen removal. Flow equalisation and external carbon source with a settled sewage flow, however, warrants full scale investigation and is recommended to be considered as an urgent priority for the Board to examine.

Although prefermentation was originally not provided with the MLE design, experience with biological nutrient removal plants in South Africa indicates that an ideal sewage feed, containing adequate concentrations of readily biodegradable COD (RBCOD) enhances denitrification. Prefermentation increases RBCOD and is considered to be a essential enhancement of this process type, particularly for Levels 2 and 3 treatment.

To achieve the 10 mg/L total nitrogen level, therefore, a settled sewage MLE process with controlled conditioning of the incoming food source has been adopted as the most appropriate process for West Hornsby STP.

The following section discusses the facilities required to meet Level 2 effluent equality targets while Table C-2 also shows the adopted design criteria.

TABLE C-2. WEST HORNSBY STP: OPTION 1 TREATMENT LEVEL 2 - PROPOSED DESIGN CRITERIA (10 mg/L TN)

Item	Design Value
Capacity EP	46,500
ADWF (ML/d)	12.60
MAX DESIGN FLOW - 3 ADWF (ML/d)	37.8
SEWAGE CHARACTERISTICS	
• Raw Sewage COD (mg/l)	630
• Raw Sewage TKN (mg/l)	46
• Raw Sewage TP (mg/l)	10
• Temperature (winter)	15
REMOVAL EFFICIENCY OF PRIMARY SEDIMENTATION	
COD (%) (Optimum)	20 to 40
TKN (%)	10
TP(%)	10
VSS/TSS	0.6
PREFERMENTATION AND METHANOL DOSING	PROVIDED[c]
BIOLOGICAL REACTOR (CONTINUOUS FLOW)	
Min Winter Solids Retention Time (days)	15
Process Volume ML (at ADWF)	
Anoxic	1.90
Aeration	2.56
Total	4.46
Anoxic Sludge Mass Fraction[a]	0.42
Peak Oxygen Demand kg/d	6,800
SECONDARY CLARIFIERS[b]	
• Total Surface Area Required (m^2)	1,450
• Additional Surface Area (m^2)	375

a. Anoxic sludge mass fraction is derived from the ratio of the total anoxic volume to the total reactor volume.
b. The option requires all existing four clarifiers plus 1 additional clarifier to be utilised in the process.
c. Refer to main text for further details.

Nitrification

The required ammonia level of 1 mg/L on a 90 percentile basis and 0.5 mg/L on a 50 percentile basis for Level 2 effluent quality is close to being achieved by the current plant configuration (refer to Table 3-5).

The incorporation of the settled sewage MLE plus process optimisation will ensure compliance with the effluent ammonia concentration target. The increase in size of the anoxic zone from 16 to 42 percent within the existing biological reactor, however, will result in decreasing the overall size of the aerobic zones and, as a consequence, a suitable variation of the existing diffuser installation will be necessary to ensure nitrification still proceeds effectively within the modified aerobic volume.

The existing aeration blowers need not be amplified as adequate aeration capacity above a peak oxygen demand of 6,800 kg/d exists.

Nitrogen Removal

Modification to Primary Sedimentation Tanks. To improve denitrification performance, the MLE process will include primary sedimentation for the collection of sludge and prefermentation. The fermented sludge would be returned to upstream of the primary sedimentation tanks to elutriate volatile fatty acids into the settled wastewater. During storm conditions, the primary sedimentation tanks will continue to be used for the treatment of wet weather flows.

To control COD removal and RBCOD production, the flow into the PSTs shall also be controlled by automatic penstocks, so as to allow individual tank isolation. This will permit the control of COD removal efficiencies during dry weather as well as allow for the reduction in size of downstream facilities.

Methanol Dosing. To not limit the potential for biological denitrification, an external carbon source such as methanol is considered prudent to be dosed in the biological reactor. For the Level 2 effluent quality target, a 46,500 EP methanol dosing facility is recommended to be provided at West Hornsby STP for full scale trial purposes in order to examine the effect of direct dosing into the anoxic reactor. Dosing shall be optimised and run in conjunction with the proposed prefermentation facilities. On-line sensor equipment shall be installed to regulate methanol dosing.

Modification of Biological Reactor. The existing anoxic zones at West Hornsby STP are currently too small to achieve a high level of denitrification, as mentioned in the Level 1 discussion. Therefore, up to 42 percent of the biological reactor will need to be converted into an anoxic zone. In addition, mixed liquor recycle facilities will be required to return flows up to 5 ADWF from downstream of the aerobic reactor to the anoxic zones. The existing RAS system will also need to be upgraded to ensure a flow return capability of up to 2 ADWF from the underflow of the clarifier system. Wasting of mixed liquor directly from the biological reactor will also be provided for proper SRT control.

Secondary Clarifiers. To minimise the cost of the proposed upgrade, an additional rectangular secondary clarifier shall be provided rather than augmenting the existing biological reactor. The clarifier will be similar to the two existing rectangular tanks and will be located between tank 3504 and the northern access road.

Phosphorus Removal

As previously discussed in the Level 1 summary multi-point dosing has been considered acceptable in achieving an effluent phosphorus concentration of 0.3mg/L (90 percentile).

Other Pollutants Reduction

West Hornsby STP currently meets the Level 2 requirements for BOD and NFR and as such no upgrading of the process to achieve further conventional pollutant reduction is necessary. Optimisation of the current chlorine effluent disinfection system is required, however, to ensure compliance with the 90 percentile target of 200 cfu/100 ml.

Other Facilities to be Provided

As is the case for Level 1 effluent quality targets, no additional facilities are required, other than those listed above.

Process Flow Diagram and Plant Layout

The proposed modified settled sewage MLE facilities and its process train are detailed on figures 8-4 and 8-5.

LEVEL 3 TREATMENT REQUIREMENTS (TOTAL NITROGEN OF 5 mg/L)

To achieve the total nitrogen level of 5 mg/L (90 percentile) consistently, additional treatment facilities will need to be added to the Level 2 treatment process. The need for an external carbon food source, such as methanol, to supplement the readily degradable food source in sewage is considered essential to achieve the Level 3 total nitrogen requirement and it is recommended that this extended food source be dosed out in a separate structure located between the MLE biological reactor and tertiary filtration.

This is commonly referred to as post denitrification and involves the removal of residual nitrate in a biological reactor located at the downstream end of the treatment process. The reactor may be either a suspended growth or fixed bed type and is operated anoxically to stimulate this biomass to use nitrate as its oxygen source rather than free dissolved oxygen. The nitrate is reduced to nitrogen gas which is lost to the atmosphere.

Post denitrification is very effective and has been installed at a number of treatment plants overseas as well as at the Lower Molonglo in the ACT. For the purpose of this investigation, methanol shall be adopted as the external carbon source and the post denitrification facility will consist of a separate suspended growth reactor located downstream of the proposed Level 2 settled sewage MLE biological reactor. To reduce the potential of gross organic pollution occurring in the receiving waters, in the event of failure of the methanol dosing system, a re-aeration zone shall be installed downstream of the post anoxic tank. Flows from the post denitrification facility will be directed to the clarifiers for further treatment.

Post Denitrification Facility

To achieve the Level 3 effluent quality goals, a post denitrification facility will be installed in addition to the Level 2 facilities to reduce total nitrogen levels to 5 mg/L. A nominal hydraulic detention time of 2.5 hour is required for the post anoxic reactor (including the re-aeration zone). For a 46,500 EP flow a process volume of approximately 1.5 ML shall be provided. A methanol dosing system shall also be installed for 46,500 EP and be capable of dosing methanol ranging between 15 and 30 milligrams of methanol per litre of sewage.

Figures 8-6 and 8-7 detail the Level 3 facilities required and its process train respectively.

SUMMARY OF PROPOSED WORKS

A summary of works required in Option 1 to obtain the Level 1, 2 and 3 effluent quality goals stipulated by the Berowra Creek Technical Working Party, is shown in Table C-3. Table C-3 proposed works will upgrade the West Hornsby STP to a 46,500 EP biological nitrogen and chemical phosphorus removal process (operated in the settled sewage MLE mode) and should have adequate capacity well beyond the year 2019 (refer Section 4).

TABLE C-3. SUMMARY OF OPTION 1 PROPOSED WORKS - WEST HORNSBY STP FOR 46,500 EP

Actions Proposed	**Treatment Level**		
	Level 1 (15 mg/L TN)	**Level 2 (10 mg/L TN)**	**Level 3 (5 mg/L TN)**
Upgrading of nitrogen removal facilities	Enlarge anoxic zones in existing 6 aeration tanks (42% anoxic). Relocate aeration system in aerobic zone. Provide activated primaries recycle system. Provide additional mixers in anoxic zone Install mixed liquor recycle	Install mixed liquor recycle Provide prefermentation system Increase size of anoxic area to at least 42% in existing 6 aeration tanks Provide additional mixers in anoxic zone Relocate aeration system	Install mixed liquor recycle Relocate aeration system in aerobic zone Provide additional mixers in anoxic zone Increase size of anoxic area to 42% in existing 6 aeration tanks Provide prefermentation tank
Upgrading of phosphorus removal facilities	Optimise multi-point dosing system	Optimise multi-point dosing system	Optimise multi-point dosing system
Upgrading primary sedimentation	Install automatically controlled penstocks for COD removal optimisation	Install automatically controlled penstocks for COD removal optimisation	Install automatically controlled penstocks for COD removal optimisation
External Carbon Source	-	Provide methanol dosing facility	Provide methanol dosing facility
Clarifiers	Provide one rectangular clarifier of 180m^2	Provide one rectangular clarifier of 375 m^2	Provide one rectangular clarifier of 375 m^2 area
Suspended Growth Post Denitrification	-	-	Provide post anoxic reactor (1.5 hr anoxic detention plus 1 hr aerobic)
Process Type	Settled Sewage MLE	Settled Sewage MLE	Settled Sewage MLE
Estimated minimum capacity (EP)	46,500	46,500	46,500

FUTURE PLANT SIZE

To ascertain the viability of permanently retaining the West Hornsby STP, a preliminary investigation was undertaken to determine the site's suitability to cater for the projected ultimate catchment potential. Based on the revised population projection for West Hornsby, found in Section 4, the plant's facilities were sized for a expected ultimate of 50,000 EP. An additional Stage of approximately 5,000 EP capacity was considered reasonable to be added to the Stage 2 Upgrade to provide facilities to treat the future catchment.

Although the site is restricted, adequate room exists to site facilities for 50,000 EP.

If stricter effluent quality targets (such as TN of 0.5 mg/L and P of 0.05 mg/L) are to be achieved additional land may need to be utilised to site advanced wastewater treatment facilities.

Land, south east of the STP has potential for utilisation although it is opposite existing residential development. This land is located off Valley Road, is currently zoned for recreational use and is currently under the control of Hornsby Council.

As the existing plant's boundary is near to residential developments, appropriate measures should be undertaken during the environmental assessment stage to determine what facilities or actions are required to reduce the impact of odours.

OPTION 1 FOR HORNSBY HEIGHTS STP

Hornsby Heights is located on a well developed site with over half of its available level land being utilised. Further augmentation of the STP will need to occur on the remaining level and sloped areas on the south eastern side. The site is surrounded by residential development on two sides (south western and north eastern) with the closest houses being approximately 200 m from the boundary of the plant. The site is also split in two by Calna Creek, with the creek and plant surrounded by bushland for a maximum of 200 m. This existing buffer zone (which is less than the Board's standard 400 m buffer) is considered inadequate and has resulted in a number of complaints from surrounding residents. Due consideration will need to be given to improved house keeping and other odour masking techniques to reduce odour generation and detection. No further development within the buffer zone must be ensured by Council and the Department of Planning.

The plant is currently designed to achieve NFR and BOD removal and full nitrification but has no capacity for denitrification. Phosphorus removal is achieved principally by chemical dosing of spent pickle liquor into the biological reactor and alum dosing prior to tertiary filters. The tertiary phosphorus removal facilities have only recently been installed. Tertiary filtration is carried out by dual media filters and the tertiary effluent is chlorinated prior to discharge. Sludge treatment is via the anaerobic sludge digester with all stabilised sludge being pumped to the sludge holding basins. This stored sludge is dewatered by a temporary dewatering unit when required and transport off-site for beneficial use.

Performance Data. An assessment of the current process performance of the Hornsby Heights plant is required to enable determination of the facilities which will be required to meet the different effluent quality levels.

Table 3-11 (Section 3) shows recent 93/94 and earlier 92/93 EPA compliance data for major nutrients, NFR and BOD. As a result of a continuing process optimisation programme and replacement of old equipment, there has been some significant improvements in effluent quality.

The EPA licence compliance data indicates that the plant is currently capable of achieving compliance with the Levels 1, 2 and 3 BOD, suspended solids, ammonia and phosphorus effluent quality goal. Total nitrogen requirements, however, are unattainable due to the lack of nitrogen removal process facilities.

STP Potential. Hornsby Heights STP has a current nominal design capacity of 20,000 EP based on its nitrification capacity. To achieve the Level 1 total nitrogen limit of 15 mg/L, it is estimated that a biological nitrogen removal process will have a downrated capacity of 14,000 EP. This capacity assessment is based on the utilisation of all processes on-site, provision of mixed liquor recycle and an adequate food source.

As the current load on Hornsby Heights STP is 18,800 EP, the proposed biological nitrogen removal plant (MLE) will also need to undergo immediate amplification. To cater for future growth in the catchment, amplification to 25,000 EP is considered necessary.

To maximise the use of existing structures, this option involves:

- Modifying the existing Stage 1 plant for biological nitrification/denitrification and chemical phosphorus removal for 20,000 EP This will provide capacity to the year 1998.
- A further amplification of 5,000 EP (Stage 2) with a continuous flow biological nitrogen removal system (MLE).

The Stage 1 upgrade would involve the modification of the exiting continuous flow, activated sludge system to provide denitrification in addition to providing BOD removal and nitrification. Chemical dosing for the removal of phosphorus currently exists and would continue to be used in the upgraded Stage 1 plant. Facilities required to meet all the prepared effluent quality levels are also discussed in more detail below.

The Stage 2 amplification of the plant is also based on a continuous flow biological nitrogen removal system combined with chemical P removal, tertiary filtration and disinfection.

The Stage 2 amplification will need to be implemented before the year 2000 and will provide adequate capacity in conjunction with the Stage 1 upgrade beyond the year 2018.

LEVEL 1 TREATMENT REQUIREMENTS (Total Nitrogen of 15 mg/L)

Stage 1 Upgrade (20,000 EP)

The following sections outline the works required to upgrade Hornsby Heights STP to 20,000 EP with Table C-4 providing details of the adopted design criteria. A settled sewage MLE process is considered adequate to achieve a total nitrogen effluent quality of 15 mg/L (90 percentile value).

Flow Equalisation. Facilities at Hornsby Heights STP Inlet Sewage Pumping Station (SPS 542) can be readily modified and augmented to provide for dry weather flow equalisation. To reduce the effect of daily peaks, the existing SPS will be augmented to incorporate additional volume plus mixers for the flow equalisation structure. Dry weather flows from the plant's main gravity lines shall also be directed to the flow equalisation structure to attenuate peak loads (refer figures 8-8 and 8-9).

Inlet Works and Grit Removal. No upgrading of the existing 20,000 EP inlet works and grit removal facilities will be required.

Primary Sedimentation/Prefermentation. The primary sedimentation tanks have been sized to cater for the full Stage 1 flow (20,000 EP). Modification of the plant for biological nitrification/denitrification may require raw sewage conditioning which could be achieved in two ways. The first method would involve the provision of a prefermentation tank constructed upstream of the biological reactor, having a maximum hydraulic retention time (SRT) of 6 days (normal operating SRT would be 3 days). Sludge collected in the primary sedimentation tanks would be pumped into the prefermentation tank, conditioned and returned to the flow entering the biological reactor.

An alternative method for conditioning the raw sewage would be to convert the existing primary sedimentation tanks to activated primary tanks. This involves recirculation of the sludge to the inlet of the tanks to build up a 'sludge blanket' where fermentation of sludge could occur. Conditioned sludge would then be wasted into the biological reactor. Odour control measures would have to be taken with this form of sludge conditioning as the process can be a major odour generator.

Based on the current raw sewage characteristics, prefermentation will be adopted to maximise the production of RBCOD.

To ensure optimum COD collection and removal, automated weirs shall be provided to regulate flows to the PSTs as discussed in the West Hornsby STP case. During storm conditions all flows shall be directed to both tanks for treatment.

TABLE C-4. HORNSBY HEIGHTS STP OPTION 1 TREATMENT LEVEL 1 - PROPOSED DESIGN CRITERIA (15 mg/L TN)

Item	Design Value for Stage 1 Upgrade	Design Value for Stages 1 and 2
CAPACITY EP	20,000	25,000
AVERAGE DRY WEATHER FLOW (ML/d)	5.4	6.75
MAX DESIGN FLOW - 3 ADWF (ML/d)	16.2	20.25
SEWAGE CHARACTERISTICS		
Raw Sewage COD (mg/L)	540	540
Raw Sewage TKN (mg/L)	56	56
Raw Sewage TP (mg/L)	12.5	12.5
PREFERMENTATION	PROVIDED[b]	PROVIDED[b]
REMOVAL EFFICIENCY OF PRIMARY SEDIMENTATION		
COD (%) (optimum))	20	20
TKN (%)	10	10
TP (%)	10	10
VSS/TSS	0.55	0.55
BIOLOGICAL REACTOR (CONTINUOUS FLOW)		
Min Winter Solids Retention Time (days)	15	15
Process volume of ADWF (ML)		
Anoxic	0.8	1.1
Aeration	1.10	1.4
Total	1.90	2.5
Anoxic Sludge Mass Fraction[a]	0.42	0.42
Peak Oxygen Demand (kg/d)	3,700	4,520
SECONDARY CLARIFIERS		
• Clarifier Area Required (m^2)	965	1,100
• Additional Clarifier area (m^2)	350	-

a. Anoxic sludge mass fraction is derived from the ratio of the total anoxic volume to the total reactor volume. At this level, no increase of the existing anoxic volume is proposed.

b. Refer to main text of further description.

To minimise the size of downstream biological treatment facilities and still ensure an adequate food source for denitrification, the primary sedimentation tank's COD removal efficiency will be controlled during dry weather and range between 20 and 40 per cent.

Automated weirs are to be installed to direct flows to either PST during dry weather with both PSTs brought into operation during wet weather conditions.

The raw sludge wastage to the existing anaerobic digesters shall also remain in service and will be optimised between RBCOD generation and biological nitrogen removal for settled sewage flows.

Biological Reactor. The existing aeration tanks will be modified to achieve biological nitrification/denitrification and BOD removal, with chemical phosphorus removal.

The proposed arrangement for upgrading the Stage 1 plant, to provide nitrification and denitrification, would involve conversion of the existing aeration tanks into anoxic and aerobic zones. Approximately forty two percent of the present aeration volume would be modified to an anoxic zone (low in dissolved oxygen) by installing mechanical stirrers and separation walls. In order to provide flexibility in varying the anoxic zone detention time, provision may be made for the downstream end of the anoxic zone to be aerated. The proposed parallel operation will ensure some redundancy when work needs to be undertaken in the reactors for maintenance and will allow minimum disruption to process operation during construction.

Facilities would be provided for recycling nitrate rich mixed liquor from the aerobic zone to the anoxic zone. The mixed liquor recycle will be sized for up to 5 ADWF capacity return. Activated sludge would be drawn from the clarifier underflow and directed upstream of the biological reactor. Waste Activated Sludge will not continue to be wasted from the underflow of the secondary clarifiers but will be withdrawn direct from the biological reactor and thickened prior to being stabilised in the anaerobic digesters. This will ensure adequate SRT process control and will not overload the anaerobic digesters.

The existing Linpor C/N system in two of the aeration tanks will be removed under Option 1. In Option 2, however, they will be utilised. For further details refer Section 3.

Secondary Clarification. An additional circular clarifier with a surface area of 350 m^2 will need to be provided as part of the Stage 1 upgrade. A total clarifier surface area of 1,100 m^2 is required to ensure adequate clarification and sludge thickening for 25,000 EP (refer Table C-4).

Tertiary Filtration. No upgrade of existing dual media filters is required.

Alkalinity Control. The existing lime dosing facilities on-site will be retained, operated and have adequate capacity for 25,000 EP if optimised.

Phosphorus Removal. The total phosphorus level of 0.3 mg/L on a 90 percentile basis has not been achieved to date as shown by licence compliance data in Table 3-11. An alum tertiary dosing system has recently been installed at Hornsby Heights, however, the results of this are not reflected in the compliance data. Based on Castle Hill STP results, where a total phosphorus level of 0.3 mg/L on a 90 percentile basis was achieved, it is considered that the effluent phosphorus level will likely be achieved with the multi-point dosing system.

Disinfection. Current disinfection of plant effluent is achieved by chlorination and has adequate capacity for 20,000 EP.

Sludge Digestion. The design criteria for the modified biological reactor requires a 15 day minimum winter SRT which would require waste activated sludge to be stabilised by further digestion. As chemical (rather than biological) phosphorous removal would be provided in the upgrading of the existing plant, sludge stabilisation could be achieved by either aerobic or anaerobic digestion. Present anaerobic digestion capacity is adequate (design capacity is 40,000 EP), and would continue to be used for sludge stabilisation for both primary and waste activated sludge.

Sludge Thickening/Dewatering. To ensure proper control of the process solid retention time, waste activated sludge will be removed directly from the biological reactor and thickened prior to wasting to the anaerobic digestion tanks. Raw sludge wasted from the PSTS will also be thickened prior to entry. Permanent dewatering facilities would also be provided for the digested sludge.

Process Flow Diagram and Plant Layout. Figures 8-8 and 8-9 show the additional facilities required at the plant and the new process flow train under the Level 1 treatment requirements.

Stage 2 Amplification (25,000 EP)

In addition to the Stage 1 20,000 EP Upgrade, the biological nitrogen removal plant would still require a Stage 2 Amplification of 5,000 EP. Refer Table C-4 for adopted design criteria.

Inlet Works/Screens/Grit Removal. A 5,000 EP amplification of the existing inlet works to provide for Stage 2 screening and grit removal capacity of 25,000 EP will be provided. Fine screens as proposed in Stage 1 upgrade will also be amplified.

Primary Sedimentation/Prefermentation. Amplification of the primary sedimentation tanks from 20,000 EP to 25,000 EP would be required. As discussed previously, prefermentation tanks would also be amplified from 20,000 to 25,000 EP and will also include automated flow control to each tank.

Biological Reactor. The Stage 1 and 2 biological reactor would be of 25,000 EP capacity and would provide nitrification, denitrification and phosphorus removal by chemical means. A number of zones would be provided within the biological reactor and would operate as follows:

- Anoxic Zone - denitrification and oxidation of organic matter.
- Aeration Zone - oxidation of organic matter, nitrification and excess phosphorus uptake.
- Re-aeration Zone - raising DO of mixed liquor. (which may or may not be physically separated from the aeration zone)

The current aeration system at Hornsby Heights STP is designed to nitrification system for 20,000 EP and has a capacity in delivering 4,000 kg/d of oxygen at peak loadings.

In Stage 1 the peak oxygen demand will be 3700 kg/d and after Stage 2 is added, 4,500 kg/d. Therefore, in Stage 2 the biological reactor aeration system will need to be amplified to cater for the increasing demand. In the Stage 1 upgrade no amplification of the blower system is considered necessary although it would need to be operated at its full design capacity. The diffuser delivery system will need to be modified to direct flow into the new aerobic zones generated.

A mixed liquor recycle would be provided to return mixed liquor from the downstream end of the aeration zone to the inlet of the anoxic zone.

Flow to the biological reactor and secondary sedimentation tanks would be limited to 3 ADWF. Flows greater than 3 ADWF would be by-passed after primary sedimentation to the disinfection facilities and effluent discharge point. Excess activated sludge would be wasted from the aeration or re-aeration zone and discharged to sludge processing facilities.

To facilitate maximum use of existing facilities plus provision for future amplifications, the Stage 1 and Stage 2 biological reactor requirements should be integrated as much as possible. For this option, the 3 existing aeration tanks will be converted to anoxic and aerobic zones, with an additional fourth biological reactor provided for the Stage 2 amplification (refer figure 8-8).

Secondary Clarification. No additional amplification is required as the Stage 1 Upgrade provides adequate clarifier capacity for 25,000 EP with the proposed biological reactor process volume.

Tertiary Filtration. Civil works for Stage 2 filtration facilities have been provided in Stage 1. These will need to be fitted out to provide 25,000 EP filtration capacity.

Phosphorus Removal (and Alkalinity Control). The multi-point chemical dosing facilities would be amplified to 25,000 EP for phosphorus removal. The alkalinity control system will also need to be optimised to achieve 25,000 EP capacity.

Sludge Thickening/Dewatering. The Stage 1 sludge thickening and dewatering facilities will need to be amplified to 25,000 EP.

Sludge Digestion. The existing two anaerobic digesters at Hornsby Heights STP have a nominal capacity of 40,000 EP and need not be amplified when operated in the primary mode and sludge is thickened prior to entry.

Chlorination Facilities. The design capacity of the existing chlorination dosing system is 20,000 EP. This is insufficient to provide capacity beyond the year 2000 and will be amplified to 25,000 EP. Also the additional chlorination tank on site and will be commissioned to increase chlorination facility capacity beyond 25,000 EP.

Process Flow Diagram and Plant Layout. Figures 8-8 and 8-9 show the additional facilities required for Stage 2 and the proposed process flow train to achieve the Level 1 treatment requirements.

LEVEL 2 TREATMENT REQUIREMENTS (Total Nitrogen of 10 mg/L)

Process examination using site specific sewage characteristics indicates that there will be considerable difficulty in achieving the total nitrogen requirement of 10 mg/L (90 percentile) at Hornsby Heights STP if settled sewage continues to be treated in the biological process downstream.

Based on the current effluent total nitrogen discharges from Penrith STP, to achieve the total nitrogen requirement of 10 mg/L, the raw sewage MLE process with sludge conditioning via prefermentation is considered the most appropriate process configuration. Methanol dosing facilities (or equivalent) shall also be provided and optimise with the prefermentation facilities. The primary sedimentation tanks will, however, be retained to collect COD and provide storm treatment.

The raw sewage MLE will be equivalent to raw sewage entering the biological reactor as no solids are wasted from the primary sedimentation tanks. Under this scenario the modelling indicates that the existing facilities have only 8,000 EP capacity if modified to this raw sewage MLE configuration.

Stage 1 Upgrade (20,000 EP)

Table C-5 details the adopted process design criteria for the proposed Stage 1 raw sewage MLE treatment plant. This, however, may be subject to change when more up-to-date information becomes available on the site specific process kinetics. The works required for this option are discussed below in more detail, with figures 8-10 and 8-11 showing plant layout and process train respectively.

The total nitrogen level requirement for Level 2 of 10 mg/L on a 90 percentile basis is to be achieved by providing the following facilities:

Biological Reactor. At present, the current biological reactor provides only aeration for nitrification and a distinct anoxic zone is required to facilitate the denitrification process. To ensure the upgrade will provide maximum operational flexibility, each existing aeration tank will be converted to anoxic/aerobic reactors.

The existing full scale Linpor C/N system trial facilities shall be removed from the two aeration tanks.

An additional biological reactor (1.2 ML) will also be provided with anoxic and aerobic zones and operate in parallel to the modified aeration tanks. This will allow minimum disruption during construction and will ensure some redundancy when major maintenance is to be carried out on-site.

The existing blower aeration system will need to be amplified from 4,000 kg/d capacity to 4,500 kg/d to cater for the increased peak oxygen demand when treating raw sewage.

As the present aeration tanks will be modified into anoxic/aerobic zones, the existing air diffuser delivery facilities will need to undergo modifications. The aeration system will also need to be extended to the new proposed anoxic/aerobic tank as detailed in figure 8-10.

As no raw sludge wasting will be undertaken from the modified PST, WAS will be directed to sludge thickeners prior to entry to the anaerobic sludge digesters. The WAS will be mixed liquor direct from the biological reactor which will ensure improved control of the process SRT.

As for Level 1, mixed liquor recycle facilities will be provided for the modified and new biological reactor and be capable of returning a flow up to 5 ADWF from the downstream end of the aerobic reactor to upstream of the anoxic zone.

Primary Sedimentation and RBCOD Generation. As for Level 1, the sedimentation tanks will be capable of collecting and transferring sludge to a prefermentation tank for RBCOD generation. As all collected sludge is directed to the biological reactor, PSTs do not require automated penstocks as is the case for the settled sewage MLE.

Methanol Dosing. Facilities shall be provided for the dosing of RBCOD and will supplement food source for denitrification. The dosing system shall have a capacity of 20,000 EP.

TABLE C-5. HORNSBY HEIGHTS STP OPTION 1 TREATMENT LEVEL 2 - PROPOSED DESIGN CRITERIA (10 mg/L TN)

Item	**Design Value**	
	Stage 1 Upgrade	**Stage 1 and 2**
CAPACITY EP	20,000	25,000
AVERAGE DRY WEATHER FLOW (ML/d)	5.4	6.75
MAX DESIGN FLOW - 3 ADWF (ML/d)	16.2	20.25
SEWAGE CHARACTERISTICS		
Raw Sewage COD (mg/L)	540	540
Raw Sewage TKN (mg/L)	56	56
Raw Sewage TP (mg/L)	12.5	12.5
PREFERMENTATION AND METHANOL DOSING	PROVIDED[c]	PROVIDED[c]
VSS/TSS	0.55	0.55
RAW SEWAGE TREATMENT	Raw Sewage MLE	Raw Sewage MLE
BIOLOGICAL REACTOR (CONTINUOUS FLOW)		
Min Winter Solids Retention Time (days)	16	16
Process Volume (ML)		
Anoxic	1.40	2
Aeration	1.70	2.3
Total	3.10	4.3
Anoxic Sludge Mass Fraction[a]	0.45	0.45
Peak Oxygen Demand (kg/d)	4,500	5,200
SECONDARY CLARIFIERS[b]		
• Surface Area Required (m^2)	1,100	1,100
• Addition of Surface Area (m^2)	350	-

a. Anoxic sludge mass fraction is derived from the ratio of the total anoxic volume to the total reactor volume. At this level, no increase of the existing anoxic volume is proposed.

b. The option assumes all three existing clarifiers will be utilised in the process plus additional clarifiers if required.

c. Refer to main text for further details.

Nitrification. As for Level 1, the required ammonia limit of 1 mg/L (90 percentile) will be achievable by the raw sewage process. The aeration system delivery will, however, need to be redirected into the various aerobic zones being provided.

Sludge Digestion. The existing two anaerobic digesters will be modified and operated in the primary treatment mode. All sludges will be thickened prior to entry and stabilisation.

Sludge Thickening/Dewatering. Permanent sludge thickening and dewatering facilities shall be provided to maximise the use of the existing digesters and ensure an acceptable product for beneficial use or landfill.

Phosphorus Removal. The required total phosphorus limit of 0.3 mg/L (90 percentile) is considered capable of being met by the newly installed post alum dosing facilities and iron salt dosing, after optimisation of this system. This is based on results from Castle Hill STP that has similar phosphorus removal facilities.

Alkalinity Control. The existing lime dosing facilities shall be operated to control pH and have adequate capacity for 20,000 EP.

Flow Equalisation. Flow equalisation shall be provided and be similar to the facility described in the Level 1 discussion.

Secondary Clarification. An additional secondary clarifier with a surface area of 350 m^2 is required due to the upgrading and consequential increase in the process volume of the biological reactor. It is proposed that the additional clarifier will be similar in size to the third clarifier presently under construction. This will provide a more than adequate clarification capacity for 20,000 EP.

Other Facilities to be Provided. The plant is presently rated at a nominal 20,000 EP capacity and, consequently, the remaining structures including the inlet works, screens, tertiary treatment and chlorination do not require to be upsized.

Process Flow Diagram and Plant Layout. Figures 8-10 and 8-11 show the additional facilities required at the plant and the new process flow train under Level 2 treatment requirements for treatment of raw sewage in the biological reactor.

Stage 2 Amplification (25,000 EP)

The following discussion outlines the additional structures required to amplify the plant from a 20,000 EP raw sewage MLE to 25,000 EP and meet Level 2 requirements. Table C-5 shows the adopted design criteria for the proposed amplification.

Biological Reactor. In addition to the Stage 1 Upgrade, amplification of the biological reactor to 25,000 EP capacity will involve adding a new separate unit containing an aeration zone and an anoxic zone with mixed liquor recycle. A total volume of approximately 1.2 ML is to be provided. This unit will be fed with sewage from a new flow diversion chamber. This Stage 2 will operate independently of the Stage 1 Upgrade, however, mixed liquor will be combined and directed to the secondary clarifiers.

A mixed liquor recycle system will be provided for the Stage 2 biological reactor for the return of nitrate rich mixed liquor. The existing RAS system shall also be amplified to return active biomass upstream of the new biological reactor. Mixed liquor shall also be wasted directly from the biological reactor to control process SRT rather than drawing off waste activated sludge from the clarifier underflow.

Secondary Clarification. The provision of a fourth secondary clarifier in Stage 1 Upgrade will provide adequate capacity for up to 25,000 EP flows. Therefore, no additional clarifiers will be required in the Stage 2 amplification.

Other Facilities to be Provided. The amplification of inlet works, screens, grit tanks, primary sedimentation, chemical dosing facilities (including methanol and chemical phosphorus facilities), tertiary filters and chlorination facilities will be required. They will all need amplification from their nominal 20,000 EP capacity to 25,000 EP. Adequate room is available next to the existing facilities for the amplification to be undertaken without major disruption.

Refer to figures 8-10 and 8-11 for the Process Flow Diagram and Plant Layout for the 25,000 EP Raw Sewage MLE.

LEVEL 3 TREATMENT REQUIREMENTS (Total Nitrogen of 5 mg/L)

In addition to installing the proposed Level 2 structures at Hornsby Heights STP, post denitrification facilities would be required to reduce total nitrogen levels to 5 mg/L (Level 3 effluent quality target).

In Stage 1, a post suspended growth denitrification reactor, with a nominal detention time of 2.5 hours, will be provided for the residual removal of nitrates by biological means. Methanol will be dosed into the incoming mixed liquor, adequately mixed and distributed throughout the reactor to simulate denitrification.

The suspended growth post anoxic reactor will be located downstream of the biological reactor and will utilise the secondary clarifiers for thickening and suspended solids removal. A process volume of approximately 560 m^3 is required.

For the Stage 2 amplification, the Stage 1 post anoxic reactor is to be amplified to cater for 25,000 EP and a additional volume of 190 m^3 is envisaged.

Figures 8-12 and 8-13 show the Level 3 process train and plant layout for both the Stage 1 and 2 MLE processes and add- on facilities needed to comply with the proposed Level 3 effluent quality target, especially with regard to a total nitrogen requirement of 5 mg/L in the discharged effluent.

SUMMARY OF PROPOSED WORKS

Tables C-6 and C-7 detail the works necessary to be undertaken at the Hornsby Heights STP site to achieve a total effluent nitrogen discharge of 15, 10 and 5 mg/L respectively for the Stage 1 Upgrade and Stage 2 Amplification. The necessary works have been split up so flexibility exists to delay Stage 2 amplification if the population growth within the catchment is not realised as detailed in Section 5.

FUTURE PLANT SIZE

Based on a revised assessment of the Hornsby Heights STP ultimate catchment potential, the maximum contribution from population and industry is projected not to exceed 25,000 EP.

To ascertain the viability of permanently retaining the treatment plant, a preliminary investigation was undertaken to determine the site suitability to cater for 25,000 EP and achieve an effluent quality target equal to Level 3 (refer Table 7-1).

On examination, the Hornsby Heights plant has the potential to easily accommodate a 25,000 EP MLE plant.

As the existing STP's buffer zone falls short of the recommended 400 metre exclusion zone from residential development, appropriate measures should be undertaken on site to quantify and determine the most appropriate strategy for odour emission control. This is recommended to be undertaken during the environmental assessment phase, to determine if additional facilities such as structure covers, odour scrubbers or masking agents are to be incorporated for the retained plants.

TABLE C-6. SUMMARY OF OPTION 1 PROPOSED WORKS - HORNSBY HEIGHTS STP STAGE 1 UPGRADE 20,000 EP

Actions Proposed	**Treatment Level**		
	Level 1 (15 mg/L TN)	**Level 2 (10 mg/L TN)**	**Level 3 (5 mg/L TN)**
Upgrading of nitrogen removal facilities	Provide Diurnal Flow Equalisation. Provide anoxic/aerobic zones in existing 3 aeration tanks (42% anoxic). Provide MLR and mixers in anoxic zone Relocate aeration system Provide aeration system and optimise Provide Prefermentation and Waste Mixed Liquor Facility	Provide anoxic/aerobic zones in existing 3 aeration tanks (45% anoxic) plus additional reactor with 1.2 ML volume Relocate aeration system and upgrade Anoxic Zone 45% of Volume MLR, Mixers, plus aeration in New Reactor Provide Diurnal Flow Equalisation Provide Prefermentation and Waste Mixed Liquor Facility	As per Level 2
Upgrading of phosphorus removal facilities	Optimise multi-point dosing system	Optimise multi-point dosing system	Optimise multi-point dosing system
Upgrading primary sedimentation	Install automatically controlled weirs for COD removal optimisation	Treat Raw Sewage and Retain PST for collection of COD and Storm Treatment	Treat Raw Sewage and Retain PSTS for collection of COD and Storm Treatment
External Carbon Source	-	Provide methanol dosing	Provide methanol dosing
Clarifiers	Provide one circular clarifier of 350 m^2 area (fourth clarifier)	Provide one circular clarifier of 350 m^2 area (fourth clarifier)	Provide one circular clarifier of 350 m^2 area (fourth clarifier)
Suspended Growth Post Denitrification	-	-	Provide post anoxic reactor 2.5 hr detention (including 1 hr aerobic)
Sludge Handling	Provide sludge thickening and sludge dewatering facilities	Provide sludge thickening and sludge dewatering facilities	Provide sludge thickening and sludge dewatering facilities
Capacity (EP)	20,000	20,000	20,000
MLE Type	Settled Sewage	Raw Sewage	Raw Sewage

TABLE C-7. SUMMARY OF OPTION 1 PROPOSED WORKS - HORNSBY HEIGHTS STP STAGE 2 AMPLIFICATION 25,000 EP

Actions Proposed	**Treatment Level**		
	Level 1 (15 mg/L TN)	**Level 2 (10 mg/L TN)**	**Level 3 (5 mg/L TN)**
Amplification of nitrogen removal facilities	As per Level 1 Stage 1 Upgrade (Table C-6) plus provision of new biological reactor 0.6 ML (42% anoxic zone) Provision of MLR and anoxic zone mixers. Amplification of aeration system Amplification of Prefermentation Unit Amplify facility for wasting mixed liquor	As per Level 2 Stage 1 Upgrade (Table C-6) plus additional reactor of 1.2 ML Anoxic Zone 45% of Volume MLR and mixers plus aeration in new reactor Amplification of aeration system Amplification of Prefermentation Unit Amplification of Waste Mixed Liquor	As per Level 2 Stage 2 Amplification
Flow Equalisation	No amplification required	No amplification required	No amplification required
Secondary Clarifiers	No additional clarifier required	No additional clarifier required	No additional clarifier required
Phosphorus Removal	Amplify system by 5,000 EP	Amplify system by 5,000 EP	Amplify system by 5,000 EP
Alkalinity Control	Amplify system by 5,000 EP	Amplify system by 5,000 EP	Amplify system by 5,000 EP
Tertiary Filtration	Fit out cells for 5,000 EP	Fit out cells for 5,000 EP	Fit out cells for 5,000 EP
Chlorination	Amplify system by 5,000 EP	Amplify system by 5,000 EP	Amplify system by 5,000 EP
Sludge Thickening/Dewatering	Amplify by 5,000 EP	Amplify by 5,000 EP	Amplify by 5,000 EP
Digestion	Operate in Primary Mode	Operate in Primary Mode	Operate in Primary Mode
Screens/Inlet Works/Grit Removal	Amplify by 5,000 EP	Amplify by 5,000 EP	Amplify by 5,000 EP
Primary Sedimentation Tanks	Amplify by 5,000 EP/Provide automatic weir	Amplify by 5,000 EP	Amplify by 5,000 EP
Methanol Dosing Facility	-	Amplify Methanol Dosing Facility by 5,000 EP	Amplify Methanol Dosing Facility by 5,000 EP
Suspended Growth Post Denitrification	-	-	Amplify Post Anoxic Reactor by 5,000 EP
MLE Type	Settled Sewage	Raw Sewage	Raw Sewage

APPENDIX D

INDICATIVE COST PER LOT FOR OPTION 1

As the Board's objectives are to maintain financial viability of the business with services being cost effective and achieving a competitive rate of return, the pricing system should reflect the cost of providing the services and encourage the most efficient use of resources.

To give the Berowra Creek Catchment community an indication of the costs for treatment improvement and extension of plant capacity, Appendix D provides an indicative cost per lot if Option 1, the least cost option, is adopted. The remaining options (Options 2 to 11) if chosen, will result in a higher cost per lot if implemented.

It must be stressed that the costs provided are preliminary only, have an order of cost accuracy of ±25 per cent.

MAINTENANCE OF CURRENT LEVEL OF SERVICE

To compare the current level of service with the proposed upgrades discussed in this report, both the West Hornsby and Hornsby Heights STPs will be considered to operate as activated sludge plants with nitrification. Phosphorus removal will continue to be undertaken by chemical dosing. This is currently the operational capability for both plants.

West Hornsby STP

To retain the current level of service at West Hornsby STP for 46,500 EP only minor hydraulic modifications are required, prior to the primary sedimentation tanks and the mixed liquor distribution chamber. Optimisation of the phosphorus removal and chlorination facilities will also be needed to improve reliability in achieving current licence conditions.

Hornsby Heights STP

At Hornsby Heights STP the current Linpor process will be retained and optimised to ensure that full nitrification continues to be achieved for 20,000 EP. Optimisation of the phosphorus removal and chlorination system will also be needed to meet current licence conditions consistently.

To cater for additional population loads, Hornsby Heights STP will also be augmented by a 5,000 EP stage taking the total capacity of the plant to 25,000 EP.

INDICATIVE COST PER LOT FOR OPTION 1

Table D-1 summarises the Net Present Value (NPV) for maintaining the current level of treatment scenario for both the Hornsby plants. This information can be used to give an indication of the contribution that needs to be provided from new development areas which instigate the upsizing of treatment facilities plus the cost per lot for improved level of treatment. If Option 1 (retention, upgrade and amplification of the Hornsby STPs with MLE process) is adopted for implementation, Table D-1 provides an indicative cost per lot that can be related to the proposed upgrades and additional development.

TABLE D-1. INDICATIVE COST PER LOT FOR OPTION 1

Option	NPV on Total Annual Costs ($M)	NPV on Capital Costs ($M)
Option 1 TN15	67.32	9.83
Option 1 TN10	70.20	12.36
Option 1 TN5	74.30	15.78
Option 0-A	61.85	4.42
Option 0-B	55.86	0
Differential Costs ($M)		
Upgrading to TN15	5.47	5.41
Upgrading to TN10	8.35	7.94
Upgrading to TN5	12.45	11.36
Amplification	5.99	4.42
Cost Per Lot ($ per lot)		
Upgrading to TN15	242	239
Upgrading to TN10	369	351
Upgrading to TN5	551	503
Amplification	2496	1842

TN - Total Nitrogen

Option 1 TN 15 to TN 5 include upgrade plus amplification costs for the proposed augmentation.

Option 0-A refers to maintaining the current level of service and amplifying the plants when required

Option 0-B refers to the do nothing option and is used as a base case.

The above costs are indicative only and have an order of accuracy of ±25 per cent.

The provision of Option 1 may equate to an indicative implementation cost per lot of:

Total Effluent Nitrogen (mg/L)	15	10	5
Cost/Lot ($)	242	369	551

for upgrades plus an additional $2,496/lot base charge for new Berowra Creek developments. The above upgrade costs will also need to be added to the amplification cost of $2,496/lot, to cater for the various treatment level upgrades.

As the number of lots in the catchment are based on equivalent population projections shown in Section 4, the above costs are approximate and would need to be revisited based on the option(s) adopted for implementation.

GLOSSARY

- **Activated Sludge (Process)**

  A biological treatment process in which a mixed mass of micro-organisms is kept in suspension together with the sewage being treated.

- **Advanced Treatment**

  A general term applied to treatment processes which go beyond normal primary, secondary and tertiary treatment. Advanced treatment includes nutrient removal methods.

- **Aerobic (Zone)**

  A zone where there is a measurable concentration of dissolved oxygen present.

- **Alkalinity**

  A measure of the ability of a water to neutralise acids. It is a measure of the "buffer capacity" of a water (i.e. the ability of a water to resist a drop in pH as a result of acid addition).

- **Ammonia Stripping**

  The removal of ammonia from sewage by passing the sewage flow through a tower where it is brought in contact with a counter current of air. Gaseous ammonia is released to the atmosphere.

- **Anaerobic (Zone)**

  A zone of near zero concentrations of both dissolved oxygen and oxidised nitrogen (ie. nitrogen in the form of nitrate or nitrite).

- **Anoxic (Zone)**

  A zone of near zero concentration of dissolved oxygen.

- **Assimilation**

  The utilisation by various organisms (including vegetation) of organic matter and nutrients in a watercourse as food for biological growth.

- **Assimilation Capacity**

  The ability to a watercourse to accept inputs of polluting materials.

- **Assimilation Zone**

  That section of a stream in which the concentrations of various pollutants (such as organic matter and nutrients) are greater than normal "background" values; the zone in which recovery from the effects of pollution occurs.

- **Background Concentration (of pollutants)**

  The concentrations of organic matter, nutrients, etc., that would occur in watercourses in the absence of inputs from sewage treatment plants and from urban development.

- **Biocarbone (Process)**

  A proprietary biological sewage treatment process in which sewage is brought into contact with micro-organisms growing on a fixed media. Excess solids are removed by reversing flow at a high rate to was solids from the media.

- **Biochemical Oxygen Demand**

  The amount of oxygen utilised in a specified time period (usually 5 days at 20°C) by organisms in a water sample. It is a measure of the amount of organic pollutants.

- **Biological Reactor**

  A vessel in which the waste to be treated is brought into contact with a mixed population of micro-organisms under environmental conditions favourable to biological growth.

- **Biological Treatment**

  The removal of organic pollutants from a waste water by use of micro-organisms to oxidise the organic material to simple end products.

- **Blue-Green Algae (Cyanobacteria)**

  Aquatic photosynthetic bacteria which are able to obtain their nitrogen requirements directly from the atmosphere (nitrogen fixation).

- **BNR (Biological Nutrient Removal)**

  An activated sludge sewage treatment process for the removal of a large percentage of nitrogen and phosphorus from sewage using biological (rather than chemical) means. The process uses a combination of anaerobic, anoxic and aerobic zones.

- **BOD_5**

  See "Biochemical Oxygen Demand".

- **Breakpoint Chlorination**

  The addition of chlorine to an effluent in sufficient quantity that all ammonia present is oxidised to nitrogen gas and other stable compounds. Breakpoint chlorination results in a residual concentration in the effluent of free (uncombined) chlorine.

- **Capacity (of a treatment plant)**

  The nominal load (in terms of equivalent population) that can be treated at a sewage treatment plant. In some cases where plants were not originally designed for nutrient removal, the hydraulic capacity of the plant may exceed the nutrient removal capacity.

- **Carbon Absorption**

  The use of carbon powder or granules with high porosity ("activated" carbon) as a medium to absorb organic impurities in a wastewater. The wastewater to be treated is passed through a column of the carbon medium.

- **Chemical Oxygen Demand**

  The amount of oxygen utilised in the oxidation of a waste by a strong oxidising agent (potassium dichromate). It is a measure of the amount of organic pollutants but, unlike biochemical oxygen demand, it cannot distinguish between biodegradable and non-biodegradable organic matter.

- **Chemical Precipitation (of Phosphorus)**

  A phosphorus removal process in which chemicals (usually lime or salts of iron or aluminium) react with phosphorus in a wastewater to form an insoluble precipitate which can be removed from the waste by sedimentation.

- **Clarification**

  See "Sedimentation".

- **Continuous Flow Biological Reactor**

  A reactor in which the sewage inflow and outflow occur continuously (see also IDAL).

- **COD**

  See "Chemical Oxygen Demand".

- **DAF**

  See "Dissolved Air Flotation"

- **Dechlorination**

  The removal of residual chlorine from a wastewater. This may be carried out by adding chemicals (eg. sulphur dioxide) or by carbon adsorption.

- **Denitrification**

  The biological conversion of nitrogen in the form of nitrate to gaseous nitrogen. Nitrification is a pre-requisite for denitrification which is a nutrient removal process (because the gases are lost to the atmosphere).

- **Diffuse (sources of pollutants)**

  A term used to describe inputs to streams from catchment runoff as distinct from concentrated inputs from sewage treatment plants.

- **Digestion (of sludge)**

  The stabilisation of sludge by the use of micro-organisms which use organic matter in the sludge for their growth. The resultant sludge is relatively inoffensive. Digestion may be carried out either anaerobically or aerobically (the latter being similar in principle to the activated sludge process).

- **Dissolved Air Flotation**

  A process in which solids are removed from a liquid by releasing fine bubbles of air at the bottom of a vessel. The air bubbles attach to solid particles and float them to the surface where they can be removed by scraping mechanisms.

- **Dissolved Oxygen**

  The concentration of uncombined oxygen present in a water sample.

- **DO**

  See "Dissolved Oxygen".

- **Effluent**

  The liquid discharged after sewage treatment.

- **Electroldialysis**

  The separation of dissolved minerals for a water using a semi-permeable membrane under the influence of an electrical potential.

- **EP**

  See "Equivalent Population".

- **EPA**

  See "Environment Protection Authority".

- **Equalisation Basin**

  A basin used to regulate the flow from an intermittent activated sludge process to prevent hydraulic overload of downstream treatment processes.

- **Equivalent Population**

  A flow-based unit of measurement used to indicate sewage load. A flow of 270 litres per day is defined as 1 EP.

- **Environmental Protection Authority**

  The government agency responsible for administration of pollution control legislation (see also State Pollution Control Commission).

- **Faecal Coliforms**

  A group of bacteria, the presence of which in water indicates the possibility of contamination by warm blooded animals.

- **Filamentous Organisms**

  Multi-cell micro-organisms which occur in long filaments. These are undesirable in activated sludge treatment as they produce a poorly settling sludge (resulting in excessive suspended solids in the effluent) and also cause excessive scum on the surface of biological reactors and clarifiers.

- **Flocculation**

  A process in which a liquid is held in a vessel where gentle stirring is applied. The aim is to provide contact between solid particles so that they combine into larger particles which will settle more easily in subsequent sedimentation tanks.

- **High Biomass System**

  Processes designed to increase the number of micro-organisms in an activated sludge process by providing fixed support for their growth.

- **Hocutt (quadrant)**

  A method of analysing data on biological diversity to assess whether a watercourse is in a healthy state or is under stress from toxic or organic pollution.

- **Humas Tanks**

  Secondary sedimentation tanks used in conjunction with the trickling filter process.

- **IDAL (Intermittently Decanted and Aerated Lagoon)**

  An activated sludge sewage treatment process in which biological treatment and settlement of solids (clarification) are combined in the one reactor. Sewage inflow occurs continuously but effluent outflow occurs intermittently (at a higher flowrate) after a period of quiescent conditions.

- **Ion Exchange**

  A process in which specific ions held by electrostatic forces on the surface of a solid material are exchanged for ions in a solution. The water to be treated is usually passed through a bed of the exchange material.

- **Microfiltration**

  The use of a semi-permeable membrane to remove very small solid particles (from about 0.5 to 10 microns) from a water.

- **Mixed Liquor**

  The liquid within the biological reactor of an activated sludge system comprising a mixture of micro-organisms and sewage being treated.

- **MLE (Modified Ludzack - Ettinger) Process**

  An activated sludge sewage treatment process aimed at removal of a large percentage of nitrogen from sewage. The process uses a combination of anoxic and aerobic zones.

- **Nitrification**

  The biological oxidation of ammonia to nitrite and then to nitrate. Nitrification is carried out by a selective group of micro-organisms and it results in the conversion of nitrogen from one chemical form to another. Nitrification is not a nutrient removal process.

- **Nitrifies**

  The micro-organisms responsible for nitrification.

- **Nitrogen Limitation**

  Concentrations of nitrogen which are low enough (in comparison with other plant nutrients such as phosphorus) to cause restrictions on the growth of organisms. Nitrogen limitation favours the growth or organisms able to "fix" nitrogen directly from the atmosphere (see "Blue-green Algae").

- **Nocardia**

  A genus of filamentous organisms often associated with excessive scum in activated sludge systems.

- **NPV (Net Present Value) Analysis)**

  An method of economic analysis of engineering options in which future anticipated expenditures and incomes are 'discounted' to present values to enable economic comparisons to be made.

- **Nutrients**

  Chemical elements used by living organisms for their growth. When available in excessive amount in waterways, nutrients may lead to large growths of vegetation and/or algae. In sewage treatment the term usually refers to nitrogen and phosphorus.

- **Nutrient Removal**

  A general term used for sewage treatment processes which reduce the concentration of nitrogen and/or phosphorus in treatment plant effluents. Biological or chemical methods may be used.

- **pH**

  A measure of the concentration of hydrogen ions in a solution. pH is expressed on a scale of 1 to 14 with low numbers indicating "acidic" conditions and high numbers "basic" conditions. A pH of 7 is neutral.

- **Pickle Liquor**

  A waste product from metal finishing processes containing a significant concentration of ferrous or ferric ions which may be used in the chemical precipitation of phosphorus.

- **Post-Dosing**

  Dosing of chemicals for phosphorus removal as an additional treatment stage after secondary treatment.

- **Preliminary Treatment**

  Basic sewage treatment aimed at removal of course solids and floating material (rags, plastics etc) and fine inorganic material (grit, sand).

- **Prefermentation**

  Preconditioning of sewage prior to biological treatment to increase the concentration of soluble organic (readily biodegradable) matter. Sewage solids are retained for a time under anaerobic conditions to encourage fermentation of the solids to occur.

- **Primary Effluent**

  The outflow from primary treatment (also called "settled sewage").

- **Primary Treatment**

  A sewage treatment process in which readily settleable solids are removed as a liquid sludge. Primary treatment reduces the suspended solids concentration by about 60% and BOD by about 30%.

- **Pure Oxygen (systems)**

  The use of pure oxygen as a substitute for air in the activated sludge process. The advantage is improved transfer efficiency of oxygen to the mixed liquor resulting in reduced size of the biological reactor (which must be covered to prevent loss of oxygen to the atmosphere).

- **Re-aeration**

  An increase in the dissolved oxygen concentration of the mixed liquor in an activated sludge system. This is sometimes used to improve the efficiency of downstream treatment processes.

- **Receiving Waters**

  Streams into which sewage effluents are discharged.

- **Reverse Osmosis**

  The separation of dissolved minerals from a water by filtering through a semi-permeable membrane under applied pressure.

- **Rising Main**

  A pipeline through which a liquid is pumped (rather than flowing under the influence of gravity).

- **RBCOD (Readily Biodegradable COD)**

  Soluble organic matter which can be taken up by micro-organisms directly without first having to be broken down into smaller molecules by enzymes.

- **Secondary Sedimentation**

  The removal by settling of solids generated in secondary biological treatment. May also be called "Secondary Clarification".

- **Secondary Treatment**

  A term generally applied to sewage treatment processes involving the use of micro-organisms for the removal of organic impurities. Secondary treatment removes up to 90% of BOD and SS and may or may not be preceded by primary treatment.

- **Sedimentation**

  The separation of suspended particles from a wastewater by gravity settling.

- **Selector (compartment)**

  A section of the biological reactor of an activated sludge system which is designed to favour the growth of non-filamentous types of micro-organisms (filamentous types produce a poorly settling sludge).

- **Secondary Effluent**

  The outflow from the secondary sedimentation tanks following biological secondary treatment.

- **Sewage**

  The waste conveyed in sewers, comprising 99.9% water.

- **Sewage Treatment**

  The processes involved in physically removing or biologically oxidising the 0.1% impurities in sewage such that the resulting effluent can be satisfactorily assimilated by the receiving waters.

- **Sewerage (system)**

  The infrastructure used to convey sewage.

- **Simultaneous Dosing**

  Dosing of chemicals for phosphorus removal to an activated sludge system so that the precipitated phosphorus can be removed in the secondary sedimentation tanks. Phosphorus precipitation occurs "simultaneously" with the removal of organic material by biological activity.

- **Sludge**

  The waste stream from sewage treatment containing the bulk of the solid particles.

- **Sludge Thickening**

  The processing of liquid sludge to increase its solids concentration. Thickened sludge is still a liquid and can be pumped.

- **Sludge Dewatering**

  The processing of liquid sludge to increase its solids concentration to about 20% at which stage it can be regarded as a moist solid able to be moved by trucks.

- **Solids Contact**

  The bringing together of a wastewater and biological solids (micro-organisms) to enable waste treatment to occur.

- **Solids Retention Time**

  The average age of the micro-organisms in an activated sludge system; the average time that micro-organisms are retained within the system before being removed in the waste sludge. Also known as "sludge age".

- **SPCC**

  State Pollution Control Commission.

- **SRT**

  See "Solids Retention Time".

- **State Pollution Control Commission**

  The government agency formerly responsible for administration of pollution control legislation; absorbed into the EPA on 1 March 1992.

- **Suspended Solids (SS)**

  A measure of the concentration of those particles in water which will not pass through a standard filter; also known as non-filterable residue (NFR).

- **Tertiary Treatment**

  A term generally applied to treatment processes which "polish" an effluent to reduce the concentrations of organic and inorganic solids to lower levels than those obtained with primary and secondary treatment.

- **TKN (Total Kjeldahl Nitrogen)**

  The amount of nitrogen present in sewage in the form of ammonia plus organic nitrogen compounds.

- **"Trickling" Filtration**

  A biological treatment process in which the sewage to be treated "trickles" downward through a coarse medium (eg. river stones) where it comes in contact with a mixed mass of micro-organisms. Also called "Biological Filtration".

- **Ultimate (EP or Load)**

  The development of a sewerage catchment to its full potential (ie. when all available land has been developed for residential or industrial uses).