NIWA
Taihoro Nukurangi

Memorandum

To:	Stephanie Grogan – Department of Conservation	Date:	9 June 2009
From:	Sue Clearwater – NIWA	Our Ref:	DOC09208
Copy:			
Subject:	*Peer review of "Assessment of Offshore Acid Mine Drainage Effluent Disposal"*		

Peer review of "Assessment of Offshore Acid Mine Drainage Effluent Disposal" by C. Conwell, P. Barter, D. Clement (2008). Cawthron Report No. 1537 prepared for Hydro Developments Ltd.

I have reviewed the Cawthron report described above (referred to below as Cawthron 2008), and been provided with the supporting documentation listed below:

- Hydro Developments LTD (HDL) Resource consent application and assessment of effects on the environment for the Stockton Plateau Hydro Scheme.
- Stockton Plateau Hydro Scheme S92 Request for Additional Information
- GHD 2008. Report for proposed hydro power scheme - Stockton Plateau: Assessment of effects aquatic ecology. September 2008.
- URS 2008. Stockton Plateau Hydro Project - Water quality and hydrological modelling. Prepared for Hydro Development Limited. URS Report Reference 42167967/01/03.
- Holman 2007 ARD Disposal to Ocean. Preliminary laboratory based evaluation of the effects of mixing Stockton ARD with seawater. Stockton Coal Mine Buller. Prepared by Joe Holman for Phil Lindsay SENZ. Appendix C in URS (2008).

It was beyond the agreed scope of the contract to fully review the reports GHD (2008), Holman (2007) and URS (2008), however some use of them was made to provide further background for assessment of the Cawthron report.

The stated scope for the Cawthron report was: "The Cawthron Institute was contracted by HDL to undertake an ecological assessment of acid rock drainage disposal to the ocean. The assessment is focused on the effects of discharging AMD [Acid Mine Drainage] through a proposed ocean outfall off the Granity shoreline". The scope of the review focussed on ecological effects, but also examined the relationship between concentrations of contaminants in the effluent and the dilution required to meet relevant water quality guidelines.

The outfall would be constructed as a part of a proposed "off-river" hydro development that will abstract AMD from the upper catchments of the Ngakawau River initially through two proposed power stations.

General description of the scope and nature of the report.

- The report is based mostly on previously existing information and provides a brief description of the proposed activity, the volumes and characteristics of effluent likely to be produced, and a "desktop" evaluation of the marine environment likely to be affected by the discharge, with some mention of the freshwater environment that the AMD currently enters.
- A framework for assessing the effects of the discharge on the marine environment is described and the key stressors are identified as changes in: pH; total suspended solids; and trace metals.

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- Potential impacts of the discharge and pipeline construction are described in general terms, along with the potential impact of removing the AMD from the freshwater waterways.
- A narrative is provided of the results of a 99.9% (or 1000-fold) dilution of a modelled representative AMD sample by seawater provided in URS (2008, Table 5-6), compared to ANZECC guidelines for Cu, Ni and Zn (pp. 25-26).
- The likely effects of the discharge on pH and clarity are discussed based on the results of seawater dilution of two AMD samples—one probably by the authors and the other provided in URS (2008). Based on dilution of a single uncharacterised sample, the authors suggest that clarity guidelines are likely to be met by a 10:1 dilution of AMD discharge, while further testing is recommended to assess likely effects AMD on pH in the receiving environment, particularly for AMD with an initial pH ≤3 (p. 29).
- Potential effects of AMD on subtidal and intertidal habitats, plankton, invertebrates, and vertebrates are discussed in general terms and the effects are described as either "negligible", "localised" or "unknown" (pp 30-32).
- The extent of potential dispersion of a plume and precipitated iron and aluminium from the outfall is described as "beyond the scope of the report" (p. 32). The authors note that the potential for formation of a visual plume of iron precipitates warrants further investigation (p 33).

The report's final recommendations are that (pp. 35-36):

- the low pH of the AMD is the parameter most likely to cause adverse environmental effects, therefore more laboratory investigations are recommended to develop the dilution thresholds required to meet discharge guidelines;
- more receiving environment monitoring is conducted (pre- and post-construction) once the final outfall design and location is decided;
- more benthic fauna and sediment chemistry monitoring should be conducted pre- and post-outfall construction;
- a one-off effluent dispersion study is undertaken once the outfall is commissioned to validate predictive studies;
- ongoing water quality monitoring should then be focussed on effluent quality rather than receiving environment monitoring.

General comments

1. The report provides a description of the marine receiving environment based on existing literature which I consider appropriate for the assessment at this stage of the project.
2. The level of assessment of the freshwater environment is also sufficient given that the focus of the report is the potential impact of the ocean outfall and that some consideration should be given to the reduction of impact in the freshwater environment.
3. A framework for discharge effects assessment is based on ANZECC (1992 & 2000) water quality guidelines and other relevant information described. I would consider this to be appropriate for this project, if it was critically applied to an adequately characterised effluent and for higher discharge flow scenarios. More use could be made of "low reliability" guidelines (e.g. for Mn) and CORMIX modelling of low and high volume discharges must be completed to fully assess the potential impact of the outfall. These issues are addressed further below.

<u>Description of the proposed activity and underlying assumptions of the assessment</u>

4. Minimal description of the proposed activity was provided with an unduly heavy reliance on knowledge of preceding reports, which made it difficult to evaluate the assumptions made in this assessment of outfall effects. A full description of the hydro scheme is not required, but the assumptions of the analysis should have been provided in the report,

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particularly in the context of providing recommendations on a proposed activity that may change in scope as the project develops. For example, there was no description of whether the AMD inputs to the Hydro Scheme will continue to be treated in the upper catchments (i.e., settling ponds and lime neutralisation) or if this treatment will cease—a factor that will have a large impact on effluent water quality. The proposal that sediment capture structures will be installed in the reservoirs (URS 2008 p.5-14), was not mentioned in the Cawthron report, and basic information such as the proposed outfall length (described as 650 m in the AEE) was not provided in the introduction to the report (found later in the table describing CORMIX parameters).

Description of the effluent

5. Most importantly, insufficient information was provided in the report to characterise the AMD effluent and use this characterisation throughout the report in a consistent manner.
6. Modelled "worst-case" water quality of the AMD was provided (Table 1) (from Appendix D, URS 2008), although the underlying assumptions (i.e. widespread failure of the AMD treatment systems) were not stated, along with a justification for using this extreme-case data and not providing an "expected" effluent composition based on the upper percentile of the proposed operational reservoir.
7. Two reports, URS (2008) and Holman (2007), provide a reasonable basis to analyse the likelihood of the effluent meeting/exceeding water quality guidelines, when combined with predictive dilution data from the CORMIX diffuser modelling. The authors did not, however, use the available data, which included a range of dilutions encompassing those predicted by the CORMIX model (e.g., Figure 5-2, Table 5-6 in URS 2008 and Tables 2-8 in Holman 2007) to good effect.
8. No concentration data were provided for key trace metals which have the potential to bioaccumulate in aquatic food-chains, such as mercury (Hg) and cadmium (Cd). If this information is not available, it should be acknowledged as a data gap, alternatively if concentrations of these key metals are known to be low in the AMD, (i.e., at or approaching analytical detection limits), this is important information that indicates that the risks of adverse effects are low. I note that some information on Hg and Cd concentrations is available in Holman (2007) indicating concentrations are low.
9. No information on local seawater composition was provided in the Cawthron report, although some information was provided in Holman (2007). If this information was not considered representative of local conditions, then standard seawater composition could have been used to allow preliminary calculations of initial mixing concentrations for guideline comparisons.
10. Contradictory information on AMD sample dilution and precipitation rates from URS (2007) (report not examined by S. Clearwater) and Holman (2007) was presented (p. 5), with no attempt to explain the discrepancies. Examination of Holman (2007) suggests that to some extent the data can be reconciled, once testing conditions are taken into account (e.g., variable AMD composition).
11. Discussion of water quality guidelines compliance and CORMIX dilution modelling was based only on a single discharge volume of 4.5 $m^3 s^{-1}$. However the authors stated that scheme has a proposed discharge capacity of 9 $m^3 s^{-1}$. **This is a major shortcoming of the risk assessment for potential marine effects.** Effluent dilution should also be modelled at low and maximum discharge volumes. A higher rate of discharge may result in lower or higher dilution (e.g., due to higher velocity output from the diffuser) but modelling is required to determine this. Equally the effects of a low volume discharge aren't easy to predict and should be modelled.
12. CORMIX modelling data was presented that suggests under current design criteria, a discharge of 4.5 $m^3 s^{-1}$ will achieve an initial dilution of 45:1, gradually increasing to

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80:1 approximately 800 m from the diffuser. The subsequent discussion of seawater dilution modelling by URS (2008), and discharge guidelines compliance was based on a 99.9% dilution (Table 6, Cawthron 2008), which is equivalent to a 1000-fold dilution, which, according to the CORMIX results will not be achieved within 800 m modelled distance from outfall. Also, the justification for the initial composition of AMD used by URS (2008) in this model was not explained, even though it differed significantly from the worst-case modelling provided in Table 1 (Cawthron 2008).

13. Examination of URS (2008) shows that the undiluted AMD composition used in the modelled seawater dilution is based on modelling of the "most probable" outfall conditions of the hydro scheme (Table 5-6, URS 2008), and thereby represents the best available information on the average composition of the effluent at the outfall. Also, information on contaminant concentrations in 98% seawater (~ 45-fold) dilution and a 99% seawater (100-fold) dilution was presented (Table 5-6, URS 2008). This information is more relevant for Cawthron (2008) to demonstrate whether guideline exceedance is likely within a reasonable mixing zone under the discharge conditions predicted by CORMIX, than a 1000-fold dilution (>800 m from the outfall).
14. Similarly the data provided for the "worst case" discharge scenario (URS 2008, Appendix D) and/or high flow conditions (e.g., URS 2008, Table 5-4) could have been applied to address likely upper range (e.g., 95%ile) concentrations for contaminants. This information should have been used with reference to the CORMIX modelling (e.g., even by simply applying a 45-fold or 60-fold dilution) to discuss whether contaminant concentrations would be likely to exceed trigger values at the edge of a reasonable mixing zone.

<u>Potential to form a visible plume</u>

15. Assessment of the potential for the discharge to form a visible plume was partly based on changes in pH and clarity in a single sample of AMD (pH 4.5), diluted with filtered seawater (section 4.7.2). No information was given on how this sample was obtained and why it might be representative of the range of discharge from the scheme. Minimal information was given on methods used, for example equilibration times used in the dilution series –aluminium and iron precipitates will not form immediately, so these data do not necessarily rule out formation of visible plumes in this type of effluent. Use of data from a single sample is not considered adequate.
16. Holman (2007) and URS (2008) provide useful data on the likely formation of precipitates, and both state that formation of precipitates is likely, although no attempt was made to predict the extent and impact at the outfall due to the complexity of the issue.
17. In section 4.7.4 the issue of a visible plume of Fe precipitate is addressed with reference to exceedance of the loading threshold provided by Younger (2008) of a daily discharge of 200 kg/d at a marine outfall. This threshold is based on a range of case studies of discharges of ferruginous mine water that suggest that a discharge of 200 kg Fe/d or less at a marine outfall is unlikely to cause a visible plume even under calm conditions. As noted by the authors of the Cawthron report, both examples of the AMD provided in the report (i.e., worst-case and probable composition) will exceed the Fe loading threshold at a discharge of 4.5 $m^3 s^{-1}$. The authors fail to take into account higher discharge rates (e.g. proposed scheme capacity of 9 $m^3 s^{-1}$). Daily Fe discharges of the different AMD described in this report at two flow rates are provided in Table A below. These data suggest that under the criteria provided by Younger (2008), the "worst-case" AMD described in the report is highly likely to cause a visible discharge plume, whereas the modelled "most probable" AMD composition is less likely to cause a visible discharge plume.

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Table A: Quantities of iron (kg/d) to be discharged in different types of AMD. AMD composition described in Table 1 Cawthron (2008, p. 5) is "worst case".

Effluent	Effluent concentration [Fe] (mg/L)	Discharge mass load of Fe (kg/d) 4.5 m^3/s	9 m^3/s
Weka Reservoir (Worst-case outfall) Table 1 (Cawthron 2008)	27.1	10 536	21 072
Table 6 (Cawthron 2008) pH 3.7 AMD	0.6	233	466

18. URS (2008) states that the data provided by Younger (2008) are discharges to estuarine environments and therefore not relevant to the proposed Granity outfall, however the majority of the outfalls discussed in the publication are direct to marine environments (*P.L. Younger, Pers. Comm. email to S. Clearwater 4/6/09*).
19. As recommended by Cawthron, formation of a visible plume should be assessed against a 33-50% change from the highly variable background conditions at the outfall location. At times tannin-stained freshwater, as well as suspended solids may alter the background clarity and colour of the coastal waters. Munsell colour charts may be used to compare the colour of the background seawater to the discharge.

Effects of low pH

20. A dilution series of a single sample of AMD (pH 3.3) provided by URS (2008) was used to illustrate that the stated pH guideline (0.2 pH unit change, ANZECC 1992), would not be met without substantial dilution (approximately 1000-fold). This level of dilution is not predicted to be available within 800 m of the outfall at a discharge of 4.5 $m^3 s^{-1}$. (Cawthron 2008).
21. The criterion of a no more than 0.2 unit pH change recommended by Cawthron (2008) is appropriate because of background water quality in the nearshore West Coast. Surface water classes defined in the 3rd schedule of the Resource Management Act do not prescribe limits on pH shift in surface waters although class AE would permit no pH change that is injurious to aquatic organisms. Consenting authorities may impose an explicit limit on pH change as a separate consent condition. Estuarine and near-shore ecologies are attuned to pH changes greater than 0.2 units, and that an adequately protective condition would be to limit pH changes to 0.2 units from the local ambient pH at the edge of the mixing zone.

Discussion of other potential effects of the outfall

22. Open ocean environments are iron-limited, thus iron addition can cause algal blooms. Nearshore marine waters are not usually iron-limited therefore the AMD discharge is not expected to cause algal blooms in the region of the outfall.
23. I agree with the conclusion that outfall construction as described is likely to have minimal long-term effect on the receiving environment.

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Minor points

24. Table 3 –Density data should be used along with taxonomic proportion information to describe the marine benthos.
25. Eleven references cited in the report are missing from the reference list.
26. The formatting in three out of six tables in the report needs to be aligned.

Summary

27. The likely Hydro Scheme specifications used as the basis for this assessment of the AMD outfall are inadequately described within the Cawthron report, making it difficult to evaluate the assumptions of the report and how it will relate to the Scheme as it progresses.
28. The potential environmental impacts of an oceanic discharge of AMD at this location are described and discussed in general terms, however, this report does not make best use of the information available on AMD composition to provide preliminary guidelines for the discharge, and thereby allow preliminary specification of dilution rates required for compliance with accepted water quality guidelines at the edge of the outfall diffuser mixing zone.
29. The guidelines applied by Cawthron to effluent quality at the outfall were appropriate for the type of discharge and the receiving environment, although more use could be made of "low reliability" guidelines (e.g., Mn, As).
30. The general recommendations provided by the Cawthron report regarding the likely impacts (or lack of them) of the outfall on the marine environment are valid, with the exceptions that current information suggests a visible plume of Fe and Al precipitates is likely upon discharge of worst-case effluent, the issue of suspended solids (excluding precipitates) does not appear to have been considered, and insufficient information has been provided regarding concentrations of key trace metals such as mercury (Hg) and cadmium (Cd) which have the potential to bioaccumulate in aquatic food-chains.

Recommendations

31. CORMIX modelling and the parameters used, were appropriate to determine likely dilution of this discharge and take into account the different densities of the effluent and seawater, however further CORMIX modelling **must** be completed to understand likely effluent dilutions at minimum and maximum acceptable flows with the proposed diffuser and alternate configurations.
32. Although the issue of AMD composition at the scheme outfall is complex, better use could be made of existing data along with a critical analysis of the information to provide the applicant with parameters for the AMD discharge and diffuser design, particularly now that a mixing zone of 300 m radius has been suggested by the applicant in the "SPHP S92 Request for Additional Information".
33. The proposed mixing zone of 300 m is reasonable and appropriate to the discharge described.
34. According to the available CORMIX modelling and URS (2008) modelling of the most likely composition of the effluent (not worst-case scenario) at flows of 4.5 $m^3 s^{-1}$ the current diffuser specifications are likely to result in an exceedance of pH guidelines beyond a 300 m radius mixing zone, and beyond 800 m from the outfall. It may be possible to alter the diffuser design and thereby increase the initial dilution and/or treat the effluent in the Weka reservoir (e.g., adjust pH to 4.0) prior to discharge and thereby meet pH guidelines. This exercise should also be completed for low and high volume discharges.

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35. As recommended by URS (2008) comprehensive data should be collected on the composition of AMD under a variety of conditions (e.g., high and low flows and a range of locations throughout the catchment). This data should include information on acidity[1] (not just pH) to enable prediction of pH changes after seawater dilution, and to allow the project applicant (HDL) to determine whether effluent treatment prior to discharge is required and feasible.
36. At 300 m the CORMIX model predicts approximately 60:1 dilution, which is equivalent to approximately 98.3% seawater. Data presented by URS (2008) suggests that at this dilution various guidelines for Zn, Pb, Ni, and Mn will be met by the modelled most probable (but not necessarily worst-case) AMD.
37. Limited information suggests that concentrations of Hg, Cr and Cd in AMD are low and unlikely to exceed water quality guidelines in the diluted discharge, however future analysis of AMD composition (which is very variable) should include a suite of elements (e.g., including those listed above and As, Ag, B, and Se) at least until it can be demonstrated that concentrations are low enough to not be of concern. Particular attention should be given to elements that could bioaccumulate in biota around the outfall (i.e., Hg, As and Cd).
38. Data provided by URS (2008) and Holman (2007) on As concentrations in AMD is compromised by analytical problems and needs to be supplemented with further sampling to resolve these issues.
39. Sediment loads (e.g., coal fines) were not addressed in this report, however, other documents state that sediment traps will be installed in both reservoirs in order to reduce sediment loads through the turbines. More information on this issue relative to discharge guidelines (i.e., separate to formation of precipitates) would be useful.
40. The AMD discharge as currently described, is likely to cause a visible plume of Fe and Al precipitate at least within the mixing zone, although as recommended by Cawthron (2008) this is only significant if it causes a 33-50% change from background conditions, outside the mixing zone. As explained by Cawthron, Fe and Al precipitates produced at the marine outfall will have minimal ecological impact –their potential impact will be on aesthetic values, and perception of the receiving environment and associated fishery.
41. The recommendations in the Cawthron report for further site-specific marine and freshwater monitoring would provide useful additional baseline information to further refine the risk assessments. ANZECC sediment quality guidelines provide a basis to determine whether current discharges from the Ngakawau river and Granity stream have elevated trace metal concentrations in sediments. Similarly more information on trace metal concentrations in sessile biota exposed to the current discharges will help establish if significant impacts from the proposed outfall are likely.
42. It is beyond the scope of the Cawthron report, but some consideration should be given to the risk to waterfowl and other wildlife by creating reservoirs of AMD.
43. An integrated risk assessment should take into account that:
    a) the proposed marine discharge in some regards, represents a shift of an existing freshwater discharge from (mostly) the Ngakawau river outlet and Granity stream;
    b) if the effluent meets the 95% ANZECC trigger values and a <0.2 pH unit change (e.g., by liming, diffuser design for high dilution, managing rate of discharge to meet pH guidelines) the discharge will potentially represent an improvement

[1] The pH is a measure of the concentration of protons in a solution, whereas acidity gives an indication of the buffering of the solution and how much diluent (e.g., seawater) will be required to bring the pH up to the required value (e.g., pH 4.0) prior to discharge. Different solutions may have the same pH but have a different acidity and thereby require addition of different amounts of base to increase the pH by 1.0 unit.

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over the existing conditions both in the upstream freshwater environments and at the marine/river outlet interface;

c) discharge of the AMD to an exposed and turbulent marine environment will be highly diluted compared to the existing multiple discharges to small waterways;
d) discharge of the contaminants to a marine receiving environment will have reduced toxicity compared to discharge in a freshwater receiving environment.

Please contact me if you would like to discuss this review.

Regards,

Susan Clearwater

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Memorandum

To:	Stephanie Grogan – Department of Conservation	Date:	23 June 2009
From:	Sue Clearwater – NIWA	Our Ref:	DOC09208
Copy:			
Subject:	*Review of "Hydro Developments Ltd –Stockton Plateau Hydro Scheme Draft Conditions*		

Review of "Hydro Developments Ltd –Stockton Plateau Hydro Scheme Draft Conditions (26 May).

Draft Resource Consent Conditions
COASTAL PERMIT RC08149/5

1) A mixing zone of 300 m from the outfall and the ANZECC (2000) contaminant Trigger Values for 95% protection are appropriate for the receiving environment.

2) Routinely obtaining samples and measurements at the edge of the mixing zone will be operationally difficult due to weather conditions on the West Coast, locating the edge of the mixing zone, and predicting the exact location of the plume at the time of sample collection - potentially producing unreliable data. For this reason compliance conditions must be stated primarily in terms that can be monitored by measuring the effluent composition as it leaves Weka Reservoir (hereafter referred to as the Weka discharge), rather than at the edge of the mixing zone. For example, the current CORMIX model predicts that at a flow of 4.5 $m^3 s^{-1}$, a 60-fold dilution will be achieved 300 m from the outfall. Under these conditions an effluent composition meeting ANZECC contaminant 95% Trigger Values multiplied by a dilution factor of 60 would be acceptable at the Weka discharge. More data is required to establish dilutions that will be achieved under low and high flow conditions. If a lower dilution is achieved at higher (or lower) effluent flows this dilution factor will be applied to the Trigger Values, instead of 60-fold, in order to ensure compliance under all operating conditions.
   Recommendation
   a) Compliance conditions must be stated in terms of effluent composition at the Weka discharge, under a stated flow and using the lowest modelled dilution factor achieved at the edge of the 300 m mixing zone;
   b) The dilution factor(s) can only be applied to the Trigger Value if the applicant has demonstrated the regulator's satisfaction, that the dilution (or a higher dilution) will be achieved at the edge of the mixing zone, by the final diffuser design and operating conditions (e.g., flow);
   c) In order to ensure compliance under all operating conditions, the lowest dilution factor achieved by the final diffuser design under the permitted range of operating conditions will be the one applied to the ANZECC Trigger Values for effluent composition at Weka discharge.

3) The ANZECC (2000) 95% Trigger Values for Ag, As, B, Cu, Cd, Cr, Hg, Mn, Ni, Pb, Se and Zn should be applied to the discharge as described in 2) above. After a comprehensive study of AMD composition is completed, contaminants that may exceed Trigger Values in the discharge at the edge of the mixing zone may be added to the conditions, conversely there may be justification to remove some contaminants from the list of compliance conditions. Low reliability trigger values will be used for As, B, and Hg. The units for the ANZECC trigger values are given in g/m^3.

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Recommendation

a) The Trigger Values listed in Table 3-1 should be applied to the effluent with a dilution factor to be applied for the composition at the Weka discharge as described in item 2) above;

b) On an ongoing basis the effluent should be measured at least 4 times a year to ensure compliance with metal and metalloid Trigger Values at the edge of the mixing zone;

c) Effluent samples should be taken from the Weka discharge.

Table 3-1: The 95% ANZECC (2000) Trigger Values to which the dilution factor can be applied.

Contaminant	Ag	As III[a]	As V[a]	B	Cu	Cd	Cr III	Cr VI	Hg[b] (inorganic)	Hg[b,c] (methyl)
95% Trigger Value (g/m^3)	0.0014	0.0023	0.0045	5.1	0.0013	0.0055	0.010	0.0044	0.0004	0.0001

[a]Low reliability trigger value.
[b]These trigger values do not take into account bioaccumulation or biomagnification risks.
[c]This trigger value is derived from the high reliability trigger value for inorganic Hg with a safety factor of 4 allowing for the greater toxicity of methyl Hg.

Table 3-1(cont):

Contaminant	Mn[a,b]	Ni	Pb	Se[a,b]	Zn
95% Trigger Value (g/m^3)	0.080	0.070	0.0044	0.003	0.015

4) The mercury (Hg), manganese (Mn), and selenium (Se) ANZECC trigger values do not take into account bioaccumulation or biomagnification. Currently there is insufficient information about the effluent composition to determine whether these metals/metalloids are in sufficient concentrations to present a risk to the receiving environment and for human consumption of seafood. It is possible that methylation of Hg could occur in the sediments of the scheme reservoirs.

Recommendation

a) Prior to commissioning the outfall, samples of sessile benthic biota (e.g., mussels) should be taken just outside the mixing zone and measured to establish baseline metal and metalloid concentrations. Following commissioning of the outfall on-going sampling should be undertaken to determine whether bioaccumulation is occurring in the receiving environment.

5) **Recommendation**

Once the outfall is commissioned a "one-off" dye dilution, and dispersal study must be undertaken during a range of operating conditions in calm, still weather, at slack tide, to verify that the CORMIX-modelled dilution factors are being achieved at the edge of the mixing zone. This study will need to assess dilution for a range of discharge flows, depending on the proposed final operating regime. If predicted dilution factors are not being achieved, the compliance Trigger Values and conditions for all parameters monitored in the Weka discharge will be adjusted accordingly by the actual dilution factors.

6) In order to ensure compliance with pH guidelines the applicant must establish a relationship between i) the acidity and pH of the discharge, and ii) the seawater dilution required to achieve a change in receiving water pH by not more than 0.2 pH units. This relationship will be used to establish the compliance acidity and pH values required at the Weka discharge. The seawater samples for background pH comparison will be taken 1000 m from the midpoint of the diffuser, in a direction perpendicular to the movement of the plume. Note that a range of salinity and pH measurements of the receiving waters under different weather and current conditions are required, in order to establish background conditions. If, for example, the coastal area around the discharge point is strongly influenced by freshwater inputs from Granity Creek and Ngakawau River, the buffering capacity (and acidity) of the background water will be reduced –equally the pH will be reduced from 8.2 and thus the target pH for the discharge will be affected.

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Recommendations

a) Prior to commencing discharge the applicant will establish a relationship between pH and acidity of the discharge and the seawater dilution required at the edge of the mixing zone to achieve a change in receiving water pH by not more than 0.2 pH units. Using this acidity-pH relationship and the minimum dilution achieved at the edge of the mixing zone by the final diffuser and operating specifications, a compliance acidity and pH will be set for the Weka discharge.

b) Once the outfall is commissioned a "one-off" study must be undertaken to verify that the compliance pH and acidity values are achieving the predicted <0.2 pH unit change at the edge of the mixing zone. This would ideally be undertaken in conjunction with the dye dispersion study so that the location of the plume and dilutions were well defined.

c) Quarterly measurements will be made of acidity to ensure ongoing compliance with the originally derived pH relationship.

7) It is straightforward to continuously monitor pH in effluent, and this will provide information about ongoing effluent composition and compliance with discharge conditions.

Recommendation.

a) As well as flow, the Consent Holder shall maintain a continuous record (being 15 min recordings) of the pH of the Weka discharge to ensure the pH does not fall below the minimum value derived in item 5) above. Such records shall be retained by the Consent Holder and made available to the WCRC upon request.

8) The proposed conditions for clarity (no more than 50% change from background) are appropriate for the receiving environment.

Recommendation

a) The applicant must establish a relationship between measured dissolved Fe and Al concentrations in the discharge, and precipitation, clarity (black disc measurement) and colour changes following the minimum predicted seawater dilution at the edge of the mixing zone. Maximum Fe and Al concentrations can be derived for the Weka discharge that will ensure compliance with the clarity conditions at the edge of the mixing zone.

b) Initially Fe and Al concentrations should be monitored weekly in the effluent and the results compared with those used to derive the precipitation threshold in 8(a). There monitoring results should be reviewed after one year, and if compliance with clarity conditions has been achieved, monitoring can be reduced to quarterly monitoring.

c) Quarterly receiving water clarity monitoring (black disc) should be undertaken to provide a basis for clarity effects assessment.

Proposed Ocean Outfall Management Plan.

The proposed plan for outfall management is relatively comprehensive and includes the elements required to establish pre-development conditions in the receiving environment, as well as more accurately characterise the probable composition of the effluent under best-to-worst case conditions.

<u>Recommended additions to the Plan</u>

Taking into consideration recommendations from my review of the Cawthron report (Conwell et al. 2008) which assessed the potential impact of the marine outfall I recommend that the proposed Plan should explicitly include the following:

1. To verify predictions of actual water quality "Water quality modelling studies" should include a mix of field, modelling <u>and</u> laboratory studies. The chemical composition of AMD effluent from a wide range of localities under a wide range of flow conditions should be determined.
2. Analysis of the probable acidity (i.e., not just the pH) of the effluent in Weka Reservoir should be undertaken, in order to determine likely pH changes at the edge of the mixing zone and

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operational constraints (i.e., quantities of lime required) on pH adjustment of the effluent prior to discharge.

3. Modelling studies of the outfall should include analysis of dilution at expected low, medium and high flows. This information can be used to assess whether the effluent will meet water quality guidelines, particularly for pH (no greater than 0.2 pH units from background) at the edge of a 300 m mixing zone under all flow conditions.
4. Description of effluent management activities (e.g., liming, flow management), not just monitoring, to be undertaken to ensure compliance with discharge conditions.

For consideration in the Plan preparation

Regarding item 16 d), establishing a marine baseline survey -it would be informative to obtain some data to establish a baseline for the historical effect of the AMD on the marine benthic environment around the Ngakawau River outlet, prior to commissioning the SPHP. Site location choices should take into account that freshwater inputs alone will affect the marine fauna and this will be minimally affected by commissioning of the SPHP, while contaminant accumulation is of more interest in this context. For this reason, site choice should focus on areas potentially affected by the AMD, but outside the zone significantly affected by decreased salinity. This may help the applicant track mitigation of environmental impacts by AMD-affected Ngakawau River and predict likely effects (or lack of them) of the SPHP outfall.

Conclusion

The draft consent conditions suggested by the applicant are discussed and some modifications/changes are listed above. The proposed Ocean Outfall Management Plan with the additions recommended above will provide a comprehensive basis with which to regulate and monitor the SPHP discharge. Allowance should be made for adjustments to the consent conditions once comprehensive information is available on the composition of the AMD under a range of flow conditions, using the final proposed diffuser design and operational specifications of the scheme.

Regards,

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