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## **Hydro Developments Ltd**

**Report for Proposed Hydro Power  
Scheme - Stockton Plateau**

**Assessment of Effects  
Aquatic Ecology**

**September 2008**



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## Executive Summary

Hydro Developments Ltd (HDL) is proposing to develop a run-of-the-river hydroelectric power generation scheme using sub-catchments which drain the Stockton Plateau. Currently, these catchments drain to the Ngakawau River and into the Tasman Sea.

A review of the existing information on the four potentially affected sub-catchments was undertaken with the purpose of:

- ▶ Identifying existing aquatic ecology values within the Ngakawau River catchment and the sub-catchments that may be impacted by the proposed project, based on existing reports prepared for the area;
- ▶ Assessing the likely impact of the proposed project on the aquatic ecological values within the impacted sub-catchments; and
- ▶ Providing recommendations to mitigate potential negative impacts on the aquatic ecological values.

Historic and current coal mining on the Stockton Plateau impacts numerous tributaries / sub-catchments of the Ngakawau River and the Ngakawau River itself. Increased suspended sediments, low pH water and heavy metal contamination are the principal causes of the impacts on the tributaries and the river.

The Stockton Plateau and its immediate surrounds do not currently support diverse or abundant aquatic ecological values, with very limited significant macroinvertebrate, plant or fish species identified in studies conducted to date. This paucity in diversity and value is considered to be caused by historical and current coal mining activity, resulting in highly acidic and conductive water, and in some cases, the smothering of habitat by precipitated metal hydroxides and / or sediments.

The proposed scheme will impact upon the existing aquatic ecology of the affected streams by significantly reducing flows in each of the sub-catchments; this is particularly true of the lower Mangatini St Patrick Streams. In light of the absence of significant aquatic ecological values, the reduction of the flows in these streams is not considered to be significant from an aquatic ecological perspective.

Furthermore, one of the key objectives of the proposed scheme is to restore the water quality in the Ngakawau River and Estuary to the natural state typical of the river system before mining commenced. It is considered that the proposed scheme may in fact enhance environmental values within the general area, by reducing the rates of sedimentation and acidification in Plateau streams flowing into the Ngakawau River. This benefit is potentially substantial.

We therefore suggest that the overall ecosystem consequences of the proposed scheme will be slight, particularly in light of the potential ecological benefits.

The improvement in water quality in the Ngakawau River resulting from the reduction of mine-affected water entering the river system is likely to be a significant part of the total mitigation package. Although it is considered that the impacts of the proposed scheme (through reduced flows) on existing aquatic ecological values in the Ngakawau catchment are likely to be minor, they still need to be mitigated where possible. Some effects, such as habitat loss for the rare moss and liverwort species identified in several of the streams could be offset by ensuring that the remaining locations on the Stockton Plateau river system where these species are present are protected.

Further recommendations are provided in section 6.



# 1. Introduction

## 1.1 Background

Hydro Developments Ltd (HDL, the Client) is proposing to develop a run-of-the-river hydroelectric power generation scheme using water sub-catchments which drain the Stockton Plateau, Buller (herein after referred to as the Stockton Plateau Hydro Scheme). Currently, these catchments drain to the Ngakawau River and into the Tasman Sea.

Historic and current coal mining on the Stockton Plateau impacts numerous tributaries / sub-catchments of the Ngakawau River and the Ngakawau River itself. Increased suspended sediments, low pH water and heavy metal contamination are the principal causes of the impacts on the tributaries and the river. A number of measures have been adopted by Solid Energy New Zealand (SENZ, the site owner) to manage and control impacts on the Ngakawau River as a result of mining operations on the Plateau. These include the construction and maintenance of numerous sediment containment and settling ponds, lime-dosing in the Mangatini Stream to raise the pH, and removal of heavy metals by a flocculation process.

The Stockton Plateau Hydro Scheme has four principal aims:

1. To capture and discharge to sea acid mine drainage (AMD) from the sub-catchments of the Ngakawau River affected by historical and current mining activities;
2. Dilute low flow AMD with less contaminated runoff from storm events in storage reservoirs to achieve levels of chemical contamination that can be discharged to sea;
3. Generate hydroelectricity from the discharge of mine affected water to sea; and
4. Restore the water quality in the Ngakawau River and Estuary to the natural state typical of the river system before mining commenced.

## 1.2 Scope of Work

GHD has been engaged by HDL to carry out a review of the existing aquatic ecology information against the proposed project and compile an environmental impact assessment (aquatic ecology only) for consenting purposes. In order to complete this work, the following tasks were undertaken:

- Site familiarisation tour;
- Sourcing and collation of available information regarding the aquatic ecological values within streams and creeks that are likely to be affected by the proposed project, as well as the Ngakawau River;
- Identification of information gaps (if any);
- Review of relevant aquatic ecology information against the proposed project; and
- Provision of recommendations for the life of the project to ensure that aquatic ecology values are protected, improved and/or appropriately managed.



### **1.3 Purpose**

The purpose of this report is to:

- ▶ Present a description of the existing aquatic ecology values within the Ngakawau River catchment and the sub-catchments that may be impacted by the proposed project, based on existing reports prepared for the area;
- ▶ Assess the likely impact of the proposed project on the aquatic ecological values within the impacted sub-catchments; and
- ▶ Provide recommendations to mitigate potential negative impacts on the aquatic ecological values.



## 2. Description of Proposed Scheme<sup>1</sup>

The following section defines the location of the scheme and its physical position in relation to the main geographical, hydrological and mine-related features of the area. Also defined are the key elements of the proposed scheme.

### 2.1 Location

The Stockton Plateau Hydro Scheme is located amongst the coal mining areas above Ngakawau and Hector Townships on the West Coast of the South Island. The area is 30 km northeast of Westport.

Mining in this area generally takes place on the Stockton Plateau, an area of elevated ground above Ngakawau and Hector and it is on this plateau that the majority of the proposed project infrastructure will be located. This area forms the southern most portion of the Ngakawau River catchment.

### 2.2 Proposed Scheme Details

The Stockton Plateau Hydro Scheme is based around a core scheme, which covers the main water collection, hydro-electric power and outfall structure. Also included within the scheme are several optional elements which capture mine affected runoff from areas for which the cost of collection cannot be offset by revenue from the generation of electricity. These areas are considered to make a smaller contribution to the overall degraded quality of the Ngakawau River. These elements have been assessed as desirable add-ons to the main proposals, with their ultimate inclusion being dependant on an assessment of their costs versus their benefits.

#### 2.2.1 Core Elements

The core elements of the scheme are as follows:

1. Mt William Impoundment;
2. Mt William Reservoir to Weka Creek Reservoir conduit;
3. Weka Creek Power Station Penstock;
4. Weka Creek Power Station;
5. Weka Creek Impoundment;
6. Mangatini Stream Weir;
7. Mangatini diversion conduit;
8. Weka Creek Reservoir to Granity Power Station conduit;
9. Granity Power Station Penstock;
10. Granity Power Station; and
11. Granity Sea Outfall.

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<sup>1</sup> Taken from Stockton Plateau Hydro Project – Water Quality and Hydrological Modelling, Prepared for HDL, URS 13 August 2008



### 2.2.2 Optional Elements

The optional elements of the scheme are as follows:

1. Darcy Stream Weir;
2. Darcy Transfer Conduit;
3. Mine Creek Weir; and
4. Mine Creek transfer conduit.

### 2.3 Effects of the Scheme on Flows

URS were engaged by HDL to carry out water quality and hydrological modelling for the Stockton Plateau Hydro Project. URS have drawn the following conclusions regarding the effect of the scheme on flows:

**Table 1 Modelled Effects of the Scheme on Flows<sup>2</sup>**

Watercourse	Natural flow (m <sup>3</sup> /s) 95% time exceeded	Modelled Flow with Optional Elements Included (m <sup>3</sup> /s)	% Reduction from natural flow	Modelled Flow with Optional Elements Excluded (m <sup>3</sup> /s)	% Reduction from natural flow
St. Patrick Stream	1	0.5	50%	0.6	40%
Mangatini Stream	0.4	0.1	75%	0.1	75%
Mine Creek	0.11	0.07	36%	0.11	0%
Ngakawau River	2.3	1.6	30%	1.7	26%

Flows in the lower Mangatini and St Patrick Stream, below the proposed impoundments, were identified as being significantly reduced. This is particularly true in low flow periods. Whilst it is critical to capture the low and medium flows to improve water quality, the removal of such flows from the watercourses will result in a noticeable reduction in flows, including over the Mangatini Falls.

The loss of base flow in headwaters and the reduction of flow rates within the Ngakawau River must be balanced with the significant water quality improvements which the scheme presents.

### 2.4 Effects of the Scheme on Water Quality

In their August 2008 report, URS drew the following conclusions on the modelled effect of the scheme on water quality:

- ▶ There are significant limitations used to derive some of the data used in water quality modelling. A programme of intensive water quality modelling is recommended in order to gain more confidence in the predictions stated here;

<sup>2</sup> Taken from Stockton Plateau Hydro Project – Water Quality and Hydrological Modelling, Prepared for HDL, URS 13 August 2008



- ▶ At the rehabilitated mine following closure, prolonged periods of low flows result in poorer modelled scheme water quality due to the reservoir water being dominated by poorer quality seepage;
- ▶ Scheme options (Darcy Headwaters, T35 Streams and Upper Mine Creek) have little impact on the overall water quality of the scheme water, but their inclusion in the scheme helps to improve the water quality in the Ngakawau River;
- ▶ The scheme will have a significant positive effect on the water quality in the Ngakawau River by removing mine affected waters;
- ▶ Water quality consent conditions at the Ngakawau River are likely to be met with the scheme in place. Without the scheme, exceedances are possible under low and median flow conditions;
- ▶ When scheme water is discharged into the ocean, Fe precipitation is likely. No attempt to assess the impact on the marine environment in terms of visual and amenity values, ecological or water quality impacts, and the fate of the impact of other detriments have been considered in this report;
- ▶ Although modelling takes no account of the natural variance in Total Suspended Solids (TSS) across the wider Ngakawau catchment, there is a strong indication that the proposed scheme contributes significantly to meeting the consent conditions at (water quality monitoring point) NR.



## 3. Environmental Setting and Existing Ecological Values

### 3.1 Environmental Overview

The proposed location for the Stockton Plateau Hydro Scheme is the Stockton Plateau which lies within the Ngakawau Ecological District. The Plateau is in the westernmost ranges of the Southern Alps, sits between 400 and 1100m above sea level (asl), and is a large, uplifted, faulted and distorted tableland of Brunner coal measures. Drainage from the Plateau is highly variable, with the most common drainage being angulate, where controlled by joints or faults, or contorted (Overmars *et al.*, 1998). The climate of the Plateau is characterized by a high orographic rainfall (6.3m annually), due to the condensation of moisture in westerly and north-westerly wind as it ascends and cools over the ranges (Suren & McKerchar, 2001). Extreme rainfall events occur sporadically, with peak rainfall recorded in spring.

Streams draining the Plateau have high flows and frequent flood events. The density of stream channels is high, the vegetation is sparse and soil depths over basement rock are minimal. Soil moisture variation is a minor component in the water balance (NIWA - Suren & McKerchar, 2001).

A number of watercourses flow through the main mining area on the Plateau; the main ones being St Patrick Stream and Mangatini Stream. Other smaller streams include T35, T31, Mine Creek, Sandy Creek, and Weka Creek. Most of the waterways draining the Plateau into the Ngakawau River are affected by coal mining related influences through three mechanisms:

1. Direct physiological effects through low pH and high metal concentrations;
2. Smothering of habitat by precipitated metal hydroxides or coal fines; and
3. Affecting in-stream food supplies and predator-prey relationships (NIWA - Suren & McKerchar, 2001).

Although the water draining the Plateau is naturally acidic, historical and current mining activity has inflated the natural acidity through exposing underlying pyritic bedrock to oxidation; a by-product of this oxidation process is hydrogen sulphide.

The resulting low pH in the mine affected watercourses, and the Ngakawau River, have reduced the presence and abundance of aquatic ecology values. Interestingly, surveys of West Coast streams conducted by Collier & Winterbourn (1987) have found benthic macroinvertebrates to be relatively tolerant of lower pH conditions, indicating that acidity is not a primary factor influencing the taxonomic composition of macroinvertebrate communities. However, low pH does have the potential to increase the solubilisation of metals (namely zinc, lead and aluminium) that occur in the water and hence increase their bio-reactivity.

The depauperate nature of the macroinvertebrate communities present in mine impacted water appears to be the result of elevated concentrations of trace metals. Additionally, the Ngakawau River is impacted through the process of aluminium hydrolysis. Products that precipitate through this process below the confluence of a mine impacted stream (such as Mine Creek) with non-acidic waters decrease the abundance of periphyton and macroinvertebrates (Herrmann *et al.*, 1992).

Several studies have been undertaken of the macroinvertebrate communities of the Ngakawau River catchment and associated tributaries over the years. These studies provide a useful summary of the



existing communities within the waterways in the subject catchment and include NIWA (Boubee *et al.* 1999, Suren & McKerchar 2001), Boubee – Cypress Mine expert evidence, Harbrow (2001), KMA (1995, 1996, 1997) and the Cypress Mine Resource Consent application and AEE (Solid Energy, December 2003). Generally, the invertebrate communities in these mine-affected streams are dominated by chironomids, oligochaetes and ceretopogonid midges, reflective of the relatively poor water quality, low pH, elevated concentrations of metals, and variations in flow regimes.

Two components of the aquatic flora (algae and aquatic bryophytes) have been studied in streams draining the Stockton Plateau and the Ngakawau River itself. Two reports by NIWA (Suren & McKerchar 2001, Suren & Glenny 2002) have been undertaken for the Stockton Plateau streams and Upper Waimangaroa Valley respectively. The 2001 NIWA study included several sites on Mine Creek, one site on the Mangatini River and several sites on the Ngakawau River itself, whilst the 2002 NIWA study included St Patrick Stream. The Cypress Mine Resource Consent application and associated AEE (Solid Energy, December 2003) also summarises these studies. However, in general the information on aquatic flora within the Ngakawau catchment is limited.

A number of fish surveys of the scheme-relevant watercourses draining the Plateau have been undertaken. These include:

- ▶ Strickland (1995) – upper Ngakawau River;
- ▶ NIWA (1998) – Plateau area and lower Ngakawau River; and
- ▶ DoC Surveys contained in Freshwater Fisheries Data – Plateau area and Ngakawau River.

Freshwater fish distributions appear to have been severely reduced by the acidic mine drainage. There are also physical barriers to migratory fish populations in the Ngakawau catchment such as the waterfall at the confluence with the Mangatini Stream and the steep topography of the catchment in general. Additionally, regular flooding likely contributes to the absence of migratory fish.

This section of the report presents information on each of the Ngakawau River sub-catchments (Appendix A) relevant to the scheme, and provides:

1. A description of the sub-catchment;
2. Existing water quality and quantity;
3. Detailed ecological information, including values present; and
4. A gap analysis with regard to further field investigations required (if applicable).

### **3.2 Mangatini Stream/Sandy Creek/Weka Creek Sub-Catchment**

#### **3.2.1 Description of Sub-Catchment**

The smaller catchments of Sandy Creek and Weka Creek flow into the Mangatini Stream and for the purpose of this report are discussed together. The Mangatini Stream sub-catchment comprises tributaries draining from the central Stockton Plateau mining area to the confluence with the Ngakawau River at Mangatini Falls. The Mangatini sub-catchment comprises an area of approximately 2040ha. The Mangatini Stream and its associated tributaries are arguably the most affected by mining activity in the region. Land cover in the Mangatini sub-catchment is generally highly modified by mining activity, especially in the upper region of the sub-catchment.

**Figure 1 Aerial Photograph of Lower Mangatini Sub-Catchment**



The Mangatini Stream is currently dosed with lime by Solid Energy in an effort to improve water quality, by raising the pH in the Lower Mangatini Stream.

### **3.2.2 Water Quality and Quantity**

Water quality in the Mangatini Stream is generally poor. A number of water quality monitoring points exist on the Stockton Plateau area, predominantly operated by Solid Energy. Data from these monitoring points was used by URS in their geochemical modelling assessment report (URS, 2008). It is this data that is used as the basis for discussion on water quality in the Mangatini Stream.

A comparison between the untreated and treated water quality in the Upper Mangatini shows that median pH is recorded as 2.8 (monitoring point S14C), rising to 5.6 (monitoring point S14B) after treatment. Reductions in concentrations of dissolved aluminium, iron, copper and zinc are also noted after treatment in the Upper Mangatini. It should be noted that the pH of the water in the Mangatini Stream is lower than the recommended 6.5-9.0 for the protection of aquatic ecosystems (ANZECC, 2000).

Natural flows in the Mangatini Stream (recorded primarily at monitoring point S14) compared to flows in the Ngakawau River (monitoring point NR) are given in Table 2.



**Table 2 Natural Flows in the Mangatini Stream Compared to Ngakawau River Flows<sup>3</sup>**

% Time Exceeded	Natural Flow - Mangatini (m <sup>3</sup> /s)	Natural Flow - Ngakawau (m <sup>3</sup> /s)	% Flow contribution of Mangatini Stream to Ngakawau River
95	0.4	2.3	17%
90	0.5	2.8	18%
80	0.6	3.4	18%
50	1.1	6.4	17%
30	2.2	14.4	15%
10	9.2	47.1	20%

### 3.2.3 Ecological Description and Values Present

NIWA studies (Suren & McKerchar 2001; Suren & Glennly 2002) have concluded that depauperate macroinvertebrate communities exist in the Mangatini Stream, probably resulting from low pH, elevated concentrations of metals, and variation in flow regimes, which limit primary production.

NIWA found that of the four streams draining the Stockton Plateau mine area that they surveyed (Mine Creek, Miller Stream, Granity Stream and Mangatini Stream), the Mangatini Stream had the lowest species richness of just four taxa (taxa range, 4 –28). Species richness was also poor in the upstream reaches of the Mangatini Stream. Ephemeroptera (mayflies), Plecoptera (stoneflies) and Trichoptera (caddisflies) (EPT) taxa were absent in the Mangatini, indicating that this sub-catchment supports a species poor community. The invertebrate communities in the mine-affected Sandy Creek and Weka Creek are dominated by chironomids, oligochaetes and ceretopogonid midges, reflective of the relatively poor water quality, low pH, sedimentation and variable flow of these waterways.

Only one type of green algae was found in Mangatini Stream where it formed thick mucus like clumps and covered up to 40% of the stream-bed in places. No aquatic bryophytes were observed in Mangatini Stream, presumably reflecting the unstable substrate during high flows. However, the rare moss *Blindia lewinskyae* was found in Weka Creek. This observation is noted as a *pers obs* siting in NWA 2001 therefore we are unable to determine whether the site was above or below the area that will be impacted by the proposed scheme.

Freshwater fish distributions have been severely reduced by the acidification of the Mangatini Stream, and the poor water quality forming a “chemical barrier” to fish migration. Additionally, the Mangatini waterfall at the confluence with the Ngakawau River presents a physical barrier to migratory fish populations, as does the steep topography of the sub-catchment in general.

<sup>3</sup> Taken from Stockton Plateau Hydro Project – Water Quality and Hydrological Modelling, Prepared for HDL, URS 13 August 2008

### Ecological Values

From the existing data available, there are no macroinvertebrate, fish or aquatic fauna species of significant value within the Mangatini Stream/Sandy Creek/Weka Creek sub-catchment.

However, the rare moss *Blindia lewinskyae* was found in Weka Creek (site unknown). This moss is not threatened but is listed, as it is naturally uncommon. It is found only on the West Coast of New Zealand. The restricted range of this species suggests that it may be of considerable conservation interest.

### 3.2.4 Gap Analysis

It is considered that sufficient information is available on the aquatic ecology in this sub-catchment to adequately assess potential impacts from the proposed scheme. However, we suggest that comprehensive baseline surveys be conducted prior to scheme construction. Should the scheme proceed, this baseline survey will provide robust information against which changes in sub-catchment ecological values can be measured.

## 3.3 Mine Creek Sub-Catchment

### 3.3.1 Description of Sub-Catchment

The Mine Creek sub-catchment is located to the north of the Mangatini Stream sub-catchment. The tributaries of Mine Creek collect water from the northern part of the Stockton Plateau. Mine Creek flows generally in a northern direction, under Stockton Road towards a confluence with the Ngakawau River. The Mine Creek sub-catchment comprises an area of approximately 960ha.

**Figure 2** Photograph of the Headwaters of Mine Creek



*From Suren, A. & McKerchar, A. (2001)*



### 3.3.2 Water Quality and Quantity

Water quality data for the upper reaches of Mine Creek (monitoring point UM1), indicates elevated concentrations of dissolved aluminium, iron, zinc and nickel. In addition, the pH level is low (3.1 average) which again, is below the recommended 6.5-9.0 for the protection of aquatic ecosystems (ANZECC, 2000).

Natural flows in Mine Creek compared to flows in the Ngakawau River (monitoring point NR) are given in Table 3.

**Table 3 Natural Flows in Mine Creek Compared to Ngakawau River Flows<sup>4</sup>**

% Time Exceeded	Natural Flow - Mine Creek (m <sup>3</sup> /s)	Natural Flow - Ngakawau (m <sup>3</sup> /s)	% Flow contribution of Mine Creek to Ngakawau River
95	0.11	2.3	5%
90	0.14	2.8	5%
80	0.17	3.4	5%
50	0.33	6.4	5%
30	0.67	14.4	5%
10	2.75	47.1	6%

### 3.3.3 Ecological Description and Values Present

NIWA (Suren & McKerchar 2001) indicated that the macroinvertebrate community composition found in Mine Creek was similar to that of the Mangatini Stream, being dominated by chironomid (orthoclid) midges. *Oxyethira albeiceps* (algal piercing caddisfly) was common in the mid reaches of Mine Creek, which could be reflective of the algal communities present in this stretch of the creek. The invertebrate communities in the mine-affected Mine Creek are dominated by chironomids, oligochaetes and ceretopogonid midges, reflective of the relatively poor water quality, low pH, sedimentation and variable flow of these waterways.

NIWA (Suren & McKerchar 2001) also noted that caddisflies were found in all Plateau streams sampled and stoneflies were found at all sites except for the headwaters of Mine Creek. In addition, it was noted that although the mayfly, *Deleatidium*, was found in some of the Plateau streams, it became less common or was absent at the downstream end of Mine Creek suggesting that in-stream conditions were unsuitable. NIWA (Suren & McKerchar 2001) attributed this lack of species downstream to either downstream drift being negligible or survivability in the streams being low.

It has also been observed that no algae were present on the west branch of Mine Creek. However other sites on Mine Creek supported several taxa of algae. Bryophyte cover was recorded as 50% of the streambed at one site on mid Mine Creek and this waterway supported more species of liverworts than mosses. Lower Mine Creek and the west branch of Mine Creek also support high bryophyte cover – up to 40%.

<sup>4</sup> Taken from Stockton Plateau Hydro Project – Water Quality and Hydrological Modelling, Prepared for HDL, URS 13 August 2008



Rowe (2006) notes that there is no recruitment of fish from the Ngakawau River into the mine-affected streams such as Mine Creek due to poor water quality forming a “chemical barrier”. Harding *et al.* (2006) also note that no fish were observed in Mine Creek throughout their surveying of the area.

Boubee (2006) does note that there is one fish record from 1964 – a banded kokopu in Mine Creek. However, no further records have been observed of fish species in Mine Creek since that time.

#### **Ecological Values**

From the existing data available, there are no macroinvertebrate or fish species of significant value within this sub-catchment.

#### **3.3.4 Gap Analysis**

It is considered that sufficient information is available on the aquatic ecology in this sub-catchment to adequately assess potential impacts from the proposed scheme. However, we suggest that comprehensive baseline surveys be conducted prior to scheme construction. Should the scheme proceed, this baseline survey will provide robust information against which changes in sub-catchment ecological values can be measured.

### **3.4 St Patrick Stream Sub-Catchment**

#### **3.4.1 Description of Sub-Catchment**

The St Patrick Stream catchment is located to the south and east of the Upper Mangatini Stream, and comprises an area of approximately 4490ha. The St Patrick Stream sub-catchment includes water draining from the southern part of the Stockton Plateau and includes tributaries of Fly Creek, Plover Stream, T31 and T35 Streams.

St Patrick Dam is located at on the southern side of the Stockton Plateau and is noted to be non-operational. In high flows, water collects behind the dam, but is not retained and during normal flows, there is no reservoir behind the dam. Channels within the dam consist mainly of barren bedrock with no riparian cover; above the dam the channels are stable with good growths of aquatic mosses and riparian vegetation. Below the dam, the stream disappears underground. Within this reach the gradient is shallow with non-turbulent flows (NIWA – Boubee *et al.*, 1999). Below the confluence with the T31 Stream, St Patrick Stream changes its substrate composition to pure bedrock (NIWA, 1999).

#### **3.4.2 Water Quality and Quantity**

In a report entitled Water Quality of the Upper Waimangaroa CMP prepared by Kingett Mitchell and Associates (KMA, 1997), water quality was measured at St Patrick Stream Bridge. St Patrick Stream had the lowest pH of all the sites investigated during all flow regimes (average 3.3 +/- 0.3).

The acidity of these waters (waters in the lower St Patrick Stream) means they have increased potential to solubilise metals. St Patrick Stream is known to contain elevated concentrations of aluminium, lead, zinc and copper that, in combination with low alkalinity and hardness, do not meet the USEPA (1986) chronic criteria for the protection of aquatic ecosystems.



Natural flows in St Patrick Stream compared to flows in the Ngakawau River (monitoring point NR) are given in Table 4.

**Table 4 Natural Flows in St Patrick Stream Compared to Ngakawau River Flows<sup>5</sup>**

% Time Exceeded	Natural Flow - St. Patrick Stream (m <sup>3</sup> /s)	Natural Flow - Ngakawau (m <sup>3</sup> /s)	% Flow contribution of St. Patrick Stream to Ngakawau River
95	1	2.3	43%
90	1.1	2.8	39%
80	1.4	3.4	41%
50	2.6	6.4	41%
30	5.9	14.4	41%
10	17.6	47.1	37%

### 3.4.3 Ecological Description and Values Present

There have been several studies undertaken in the upper St Patrick Stream sub-catchment area for Cypress Mine consenting purposes. Additional studies have been conducted on the Waimangaroa River catchment, including KMA (1995), KMA (1997) and Cypress Mine – Resource Consent Application and Assessment of Environmental Effects (Solid Energy 2003).

The KMA (1997) report focussed on macroinvertebrate communities and identified that the upper St Patrick Stream contained high relative numbers of the environmentally sensitive Ephemeroptera and several species of Plecoptera. This indicates that the in-stream habitat above St Pat’s Dam is of quite high quality. Boubee (2006) confirms this finding and notes that with the exception of Plover Stream, the benthic communities in the upper St Patrick Stream catchment are indicative of high water quality and habitat containing a diverse range of fauna. The upper St Patrick Stream is not affected by acid mine drainage and as such can provide a source of recruitment to the lower channels.

Boubee (2006) noted that one sampling period of T31 Stream, just before the stream entered St Patrick Stream, showed that, although the stream was acidic (pH 3.1), it supported a high macroinvertebrate population. However, this sampling time occurred when filamentous algae was abundant in the river indicating periods of stable flow which is unusual in this sub-catchment. In subsequent surveys, algae abundance has been low as has invertebrate diversity and abundance.

The lower St Patrick Stream and Plover Stream macroinvertebrate communities are characteristic of poor water quality (Boubee, 2006). Macro-invertebrate abundance and diversity is low and a low percentage of the more environmentally sensitive species such as EPT taxa and overall support a poor macro-invertebrate community. NIWA (Boubee *et al.* 1999) also noted that Plover Stream and the lower St Patrick Stream were characterised by low macroinvertebrate abundance. Taxa richness was poor and low EPT taxa were present. Both these streams are influenced by acid mine runoff, characterised by low

<sup>5</sup> Taken from Stockton Plateau Hydro Project – Water Quality and Hydrological Modelling, Prepared for HDL, URS 13 August 2008



pH and elevated levels of some metals, often over guideline values for protection of aquatic ecosystems (ANZECC 2000).

NIWA (Suren & Glenny, 2002) observed that the rare moss *Blindia lewinskyae* was found in mid St Patrick Stream (above the dam) and NIWA (Suren & McKerchar 2001) also notes (pers obs) it was observed in T35. This moss species is obviously tolerant of acidic conditions and the variable flow conditions that characterise this St Patrick Stream site. Percentage stream-bed cover of bryophytes in the upper and mid St Patrick Stream (both sites above the existing dam) was relatively high. Over 50% bryophytic cover, comprised of eight different species, was observed at both these sites. This high cover could be reflective of high substrate stability, primarily bedrock, in this upper catchment area.

NIWA have also observed that the rare liverwort, *Allisoniella scottii*, was found in the upper St Patrick Stream site (above the dam). This species is known only from streams flowing from the Tin Range on Stewart Island, and from Mt Euclid in the Paparoa Range (Suren & Glenny 2002).

In the KMA (1995) report on fish species present in the St Patrick Stream, only freshwater crayfish (koura) were found upstream of St Pat's Dam. It was noted that this was not surprising given that the existing dam limits fish access upstream from the Ngakawau River catchment, as does the Mangatini Falls.

Boubee (2006) surveyed fish communities in the St Patrick Stream in 1998 and noted that no fish species were found at any sites sampled. This is consistent with the Harding *et al.* (2006) report which noted that the stream was fishless, and Strickland (1995) who reported that only freshwater crayfish (koura) were present. Koura have subsequently been found in St Patrick Stream and several other streams draining the Plateau.

#### **Ecological Values**

There are no macro-invertebrate or fish species of significant value within the St Patrick Stream sub-catchment.

However, there is:

- ▶ A rare aquatic moss, *Blindia lewinskyae*, present in mid St Patrick Stream (above the existing dam) and T35. It is found only on the West Coast of New Zealand. The restricted range of this species suggests that it may be of considerable conservation interest; and
- ▶ A rare liverwort, *Allisoniella scottii*, present in the upper St Patrick Stream (above the dam). This species is known only from streams flowing from the Tin Range on Stewart Island, and from Mt Euclid in the Paparoa Range. The restricted range of this species suggests that it may be of conservation interest.

#### **3.4.4 Gap Analysis**

It is considered that sufficient information is available on the aquatic ecology in this sub-catchment to adequately assess potential impacts from the proposed scheme. However, we suggest that comprehensive baseline surveys be conducted prior to scheme construction. Should the scheme proceed, this baseline survey will provide robust information against which changes in sub-catchment ecological values can be measured.

### 3.5 Ngakawau River Sub-Catchment

#### 3.5.1 Description of Sub-Catchment

The Ngakawau River flows generally east to west, towards the Tasman Sea. The river flows through the Ngakawau Gorge to the confluence with Charming Creek and Mangatini Stream. Beyond the confluence with the Mangatini Stream, the river widens to c. 30m and becomes estuarine as it flows out to the Tasman Sea. The Ngakawau River sub-catchment comprises an area of approximately 610ha.

Most of the catchment is dominated by bedrock, and is covered with a thin layer of soil. Dominant catchment vegetation consists of a mixture of native shrubs and low ground cover, although some small podocarp trees occur in sheltered valleys. Introduced plants such as gorse are common in the area (NIWA – Suren & McKerchar, 2001).

Boulders, ranging from 50 % at the most upstream site to 80 % at the second most upstream site, dominated the riffle substrate of the Ngakawau River. Large and small cobbles make up most of the remaining substrate at these sites, with the lowest site having the finest substrate. At the confluence, small cobbles and gravels dominate the substrate (30 % each), followed by boulders and large cobbles (15 % each) (NIWA, 2001).

**Figure 3 Photograph of the Ngakawau River above the Mine Creek Confluence**



*From Suren, A. & McKerchar, A. (2001)*

#### 3.5.2 Water Quality and Quantity

Stream pH in the Ngakawau River is higher than that of the small streams draining the Millerton mine area, and is above pH 4 at all sites except for immediately below the confluence on the river's true left. Stream pH is relatively constant across the river at both upstream sites, and at the site opposite Mine Creek, but drops considerably on the true left of the river just below Mine Creek (NIWA, 2001).



Natural flows in the Ngakawau River are presented in Table 5.

**Table 5 Natural Flows in Ngakawau River<sup>6</sup>**

% Time Exceeded	Natural Flow - Ngakawau (m <sup>3</sup> /s)
95	2.3
90	2.8
80	3.4
50	6.4
30	14.4
10	47.1

### 3.5.3 Ecological Description and Values Present

In the NIWA (Suren & McKerchar 2001) study, four sites on the Ngakawau River were surveyed, two sites above the confluence with Mine Creek, one opposite the confluence and one site below the confluence. Both species richness and (Ephemeroptera, Plecoptera and Trichoptera) EPT richness were highest at the upper most site as well as the site directly opposite the confluence with Mine Creek. Species richness and EPT richness were lowest at the site below the Mine Creek confluence.

Unlike the tributaries within the sub-catchments described above, the mayfly *Deleatidium* was found at all Ngakawau River sites and in relative abundance at the sites opposite or upstream of the Mine Creek confluence. Ostracods, copepods and chironomid midges were also found in all Ngakawau River samples at the lower sites but were largely absent from the tributaries. NIWA (Suren & McKerchar 2001) noted that these differences in species composition are more likely attributed to the influence of tidal salt water as opposed to acidic waters. NIWA (2001) also suggests that the discharge of acidic freshwater from tributaries such as Mine Creek may in fact ameliorate the influence of the salt water wedge and that the invertebrate communities may be responding to changes in salinity in the river rather than the discharge of acidic waters from Mine Creek. It is noted that the dominance of the mayfly was largely replaced by the bivalve *Sphaerium* at the two sites at and below the Mine Creek confluence.

Overall the macroinvertebrate fauna in the Ngakawau River was sparse, most likely reflective of a combination of the flood-prone flow regime of the river, coupled with the low pH.

No aquatic bryophytes or algae were observed in any of the Ngakawau River sites except for large growths of filamentous green algae covering boulders on the edges of the river (NIWA, 2001). NIWA noted that the lack of aquatic bryophytes is presumably a reflection of the unstable substrate in the river during times of high flow.

From the available reports it would seem that the Ngakawau is currently primarily a koaro river with minimal habitat available for other Galaxiid (whitebait) species such as inanga and banded kokopu. Harding *et al.* (2006) note that longfinned eels and koaro were the only migratory species found above the Ngakawau River Gorge.

<sup>6</sup> Taken from Stockton Plateau Hydro Project – Water Quality and Hydrological Modelling, Prepared for HDL, URS 13 August 2008



Boubee (2006) observed that few fish were present in the lower main stem of the Ngakawau River or in its tributaries, and stated that this is likely a factor of the acidic nature of the water. However migration past this point and up onto the Plateau is hindered by the physical features such as waterfalls and fast rapids. It is likely that, although migratory species do enter the Ngakawau River, unsuitable water quality, both in terms of acidity and sediment loading, prevents fish from actually residing in the main stem.

No brown trout or rainbow trout have been found in the Ngakawau River system in any of the studies carried out. NIWA (1999) observed that white-baiting does occur within the lower stretches of the Ngakawau River. However local white-baiters have observed that catches are typically made only at high flows when dilution of the mine affected tributaries occurs. Water quality improvement initiatives have been implemented by Solid Energy since October 2007. Since this time, there have been anecdotal reports of increased white-bait running the Ngakawau River.

The poor fish communities present in the middle and upper reaches of the Ngakawau River are uncommon to other streams and rivers in the area which are not subject to acid runoff and have no physical barriers to fish migration and support a diverse and abundant fish community.

#### **Ecological Values**

There are no macroinvertebrate or plant species of significant value within the Ngakawau River.

However:

- ▶ Longfinned eels have been observed in the middle reaches by Harding *et al.* (2006); and
- ▶ This River is used by white-baiters and, following Solid Energy's water quality improvement initiatives since 2007, white-bait numbers in the Ngakawau River have anecdotally increased.

#### **3.5.4 Gap Analysis**

Solid Energy water quality improvement initiatives have been significantly increased since 2007. However, to our knowledge, no further studies have been undertaken on the potential changes in ecological values in the Ngakawau River as a result of the reported improvements in the water quality.

It is suggested that a baseline survey be conducted of the current freshwater fish species (migratory and non-migratory) in the Ngakawau River below the Mangatini waterfall. Should the scheme proceed, this baseline survey will provide robust information against which changes in Ngakawau River ecological values can be measured.



## 4. Potential Impacts of Proposed Scheme on Existing Ecological Values

### 4.1 Impacts on Mangatini Stream/Sandy Creek/Weka Creek Sub-Catchment

Hydrological modelling conducted by URS (2008) to evaluate the reduction in flows resulting from the proposed scheme indicates that the flows in the Mangatini Stream will be reduced by 75%. This is a significant reduction, particularly in low flow periods, and will result in a noticeable reduction in flows including over the Mangatini Falls.

The proposed scheme will capture the mine-affected low and medium flows in the Mangatini Stream above the main intake site. However, during some peak high flows the component of the Stream that is not captured will continue down its natural flow channel and discharge at the Mangatini Falls into the Ngakawau River. The quality of this high peak flow will continue to be impacted by mining activity. However, Solid Energy is responsible for the treatment of water draining the mine-impacted areas of the Plateau. Existing and planned water quality treatment includes lime dosing to increase water pH and sediment containment and settlement ponds to reduce suspended solids. The proposed scheme also includes a sediment retention pond at the intake site, and it is intended that low flow AMD will be diluted with less contaminated runoff from storm events in storage reservoirs to achieve reduced levels of chemical contamination. Additionally, it is anticipated that loss from the Mangatini intake will occur only infrequently. Post-scheme water flows in the Mangatini Stream will be fed from Repo Stream (unaffected by AMD or the proposed scheme) in the reduced catchment below the Mangatini intake.

Thus, the significant capture of mine-impacted water from the Mangatini Stream will result in improved water quality. There will likely be an adjustment phase whereby existing ecology within the Mangatini Stream adapts to improved water quality, but reduced flow. However, there will be significant benefit to the water quality of the main stem of the Ngakawau River.

Currently, the Mangatini Stream/Sandy Creek/Weka Creek sub-catchment does not support a diverse ecology. However, it is known that the rare aquatic bryophyte *Blindia lewinskyae* is present in Weka Creek. Site specific details of this bryophyte in the waterway are unknown. Because this bryophyte currently exists in mine-impacted waters, it is thought that it is tolerant of acidic conditions, and able to deal with the often large, frequent floods that characterise the Plateau streams. However, any diversion of water from Weka Creek may have an adverse effect on the resident *B. lewinskyae* population, as aquatic bryophytes are generally intolerant of drying (Suren & McKerchar, 2001).

With the exception of *B. lewinskyae*, it is not considered that the proposed scheme's impact on the resident aquatic ecology of the Mangatini Stream will be of significance. Additionally, it is worth noting that *B. Lewinskyae* is present in other streams draining the Stockton Plateau, which are currently affected by mining activities and not subject to the affects of this proposed scheme.

### 4.2 Impacts on Mine Creek Sub-Catchment

Hydrological modelling conducted by URS (2008) to evaluate the reduction in flows resulting from the proposed scheme indicates that the natural flows in Mine Creek will be reduced by a maximum of 36%. This is an optional component of the proposed scheme. However, it will mostly be implemented.



Current water quality in Mine Creek is severely compromised by mining activity. This has significantly impacted upon the aquatic ecology of the system. As such there are limited ecological values present and the impact of the proposed scheme is not expected to result in further adverse effects.

The removal of the acidic water will benefit the remaining Mine Creek catchment below the intake and is also likely to improve the water quality of the Ngakawau River, at and below the confluence with Mine Creek.

However, it is important to note that NIWA (2001) suggested that the discharge of acidic freshwater from Mine Creek may ameliorate the influence of the salt water wedge in the Ngakawau River. Invertebrate communities at the confluence with Mine Creek may be affected as a result of the reduction in freshwater discharging into the Ngakawau River at this site. This may result in an increase in salt-tolerant species at and above the Mine Creek confluence.

### **4.3 Impacts on St Patrick Stream Sub-Catchment**

Hydrological modelling conducted by URS (2008) to evaluate the reduction in flows resulting from the proposed scheme indicates that the natural flows in St Patrick Stream will be reduced by a maximum of 50%. If the optional elements of the scheme are not included, then the flow will be reduced by 40%.

The upper St Patrick Stream catchment, with the exception of Plover Stream, contains water of relatively high quality and a relatively diverse macroinvertebrate community. The rare moss, *Blindia lewinskyae*, and the liverwort, *Allisoniella scottii*, have been recorded in the upper reaches of this catchment. However, observations of these rare species are only from sites upstream of the proposed scheme area and as such will not be affected.

Below the proposed intake, located below St Patrick Stream Bridge, water quality and associated ecology is of a much poorer quality. Currently, the average pH of St Patrick Stream, as measured at St Patrick Stream Bridge, is 3.3 +/- 0.3 (KMA, 1997), as a result of historical mining-related AMD.

In the lower St Patrick Stream, which will be affected by the proposed scheme, no macroinvertebrate or fish species of any significant value were identified in any of the studies carried out to date. The removal of the acidic water will benefit the remaining St Patrick Stream catchment below the intake and is also likely to improve the water quality of the Ngakawau River.

### **4.4 Impacts on Ngakawau River Sub-Catchment**

Hydrological modelling conducted by URS (2008) to evaluate the reduction in flows resulting from the proposed scheme indicates that the natural flows in the Ngakawau River will be reduced by a maximum of 30%. If the optional elements of the scheme are not included, then the flow will be reduced by 26%.

The risk of water abstraction decreasing available habitat is known to depend on stream size and the species present in the stream, with higher risks of deleterious effects in small streams than in larger streams and rivers (MfE, 2008). The proposed 30% maximum reduction of flow is not considered of significant impact due to the large flow that will remain in the main stem of the river, and the limited ecological values currently known to occur there.

The quality of the water (pH, metal concentrations, sediment loads) in the Ngakawau River will be significantly improved as a result of the capture of significant volumes of mine-affected water from the Mangatini and St Patrick Streams, as well as the likely capture and removal of Mine Creek AMD. Current



ecological values in the Ngakawau River appear to be minimal, with the exception of whitebait species and the longfinned eel. This is most likely reflective of a combination of the flood-prone flow regime of the river, coupled with the low pH, metal concentrations, and sediment loads.

In the presence of improved water quality, it is considered likely that macroinvertebrate, plant and fish species diversity and abundance will improve. The longfinned eel is gradually declining hence it has obtained a threatened species status. However, this eel is a migratory species and does not lay its eggs within New Zealand river systems. The glass eels return to the river systems from the sea at a later stage in life and they prefer clean waters. Therefore it could be expected that with improved water quality within the Ngakawau River as a result of the proposed scheme, migration of eels into this system may increase over time.

Harding *et al.*, 2006, predicted that, using a Migratory Galaxiid Distribution Model, the shortjaw kokopu and koaro should be widespread in the Ngakawau River catchment in the absence of poor water quality. In comparison to the Ngakawau River, the pristine Mokihinui River, which lies approximately 12 km to the north of the Ngakawau River, currently contains a highly diverse river ecology and supports a significant whitebait fishery. For example, twelve native and one introduced species of freshwater fish are known to exist in the Mokihinui River catchment including eight endemic and four “threatened” species (Bonnett *et al.*, 2007). It is possible that the improvement in the Ngakawau River’s water quality will eventually result in the recruitment of a similar range and abundance of freshwater fish to that currently seen in the Mokihinui River.



## 5. Conclusions

### 5.1 Water Quality Impacts

The Stockton Plateau and its immediate surrounds do not currently support diverse or abundant aquatic ecological values, with very limited significant macroinvertebrate, plant or fish species identified in studies conducted to date. This paucity in diversity and value is considered to be caused by historical and current coal mining activity, resulting in highly acidic and conductive water, and in some cases, the smothering of habitat by precipitated metal hydroxides and / or sediments. Studies worldwide have shown an overwhelming negative response of invertebrate communities to low pH, with taxa such as mayflies, crustaceans and molluscs being very sensitive to low pH (Suren & McKerchar, 2001).

NIWA (Suren & McKerchar 2001) found significant correlations between taxonomic richness and EPT richness and stream pH and conductivity, suggesting that invertebrate communities may be constrained by very low pH and in-stream metal concentrations. The proposed scheme, by capturing significant volumes of mine-affected water and removing it from the freshwater systems, is likely to result in improved water quality in each of the sub-catchments affected by the scheme. Models (developed by NIWA and the University of Canterbury) have predicted that by improving water quality, a more diverse macroinvertebrate community, reflective of surrounding catchments that are unaffected by acidic waters, such as the Mokihinui, could over time be expected to inhabit the Ngakawau River catchment. This predicted increase in macroinvertebrate community richness and abundance is in turn likely to support the migration of fish species, including whitebait species, back into the Ngakawau River main stem and associated tributaries.

Additionally, the extreme rainfall events experienced on the Plateau, and the resulting high flows and frequent flood events often result in sediment-laden water discharging from the Plateau. It is known that aquatic bryophytes tend to trap waterborne sediments, and so sediment-laden waters may smother these plants with time (NIWA - Suren & McKerchar, 2001). In the absence of sediment-laden water discharging from the Plateau as a result of the proposed scheme, bryophyte communities may increase in presence and abundance.

Much of the area of the proposed development has already been modified by mining activity and is affected by acidic discharge from the mine. One of the key objectives of the proposed scheme is to restore the water quality in the Ngakawau River and Estuary to the natural state typical of the river system before mining commenced. It is considered that the proposed scheme may in fact enhance environmental values within the general area, by reducing the rates of sedimentation and acidification in Plateau streams flowing into the Ngakawau River. This benefit is potentially substantial.

### 5.2 Water Quantity Impacts

The proposed scheme will impact upon the existing aquatic ecology of the affected streams by significantly reducing flows in each of the sub-catchments, this is particularly true of the lower Mangatini Stream and St Patrick Stream. However, the reduction of the flows in these streams is unlikely to have a major impact on the diversity of the macroinvertebrate, plant and fish populations in the greater Ngakawau catchment. We suggest that the overall ecosystem consequences of this will be slight.



The diversion of flows from the affected sub-catchments may result in certain streams drying up, or becoming ephemeral for periods of time. This may not be problematic for many invertebrates capable of moving into isolated pools and slow flowing trickles during times of low flow.

The aquatic fauna present in the catchment is limited. However, two species of considerable value have been identified, the liverwort, *Allisoniella scottii* and the rare moss, *Blindia lewinskyae*. Any diversion of water from the catchment may be problematic for the resident populations of these aquatic bryophytes as they are generally not tolerant to desiccation (Suren, 1996; Suren & McKerchar, 2001). However, both species are relatively common within the Plateau streams and the majority of sites where they are known to be present are outside of the area to be affected by the proposed scheme.

In addition, the fact that rainfall events are so regular on the Plateau may minimise any potential effects of desiccation, except for dry spells that last for more than 1 – 2 weeks (Suren & McKerchar, 2001).

**Overall, the impact of the proposed Stockton Plateau Hydro Scheme on the affected aquatic ecology is considered to be beneficial.**



## 6. Recommendations

Although it is considered that the impacts of the proposed scheme on existing aquatic ecological values in the Ngakawau catchment are likely to be beneficial overall, adverse impacts, where they exist, still need to be carefully managed and, wherever possible, mitigated. This includes mitigation during the commissioning, operation and decommissioning of the proposed scheme.

It is acknowledged that the improvement in water quality in the Ngakawau River and Estuary resulting from the reduction of AMD entering the river system is likely to be a significant part of the total mitigation package. However, there are a number of additional ways that the potential adverse impacts of the proposed scheme can be avoided, remedied, or mitigated.

### 6.1 Proposed Management Measures

#### 6.1.1 Aquatic Environment Protection

Measures to carefully manage and reduce adverse effects of the proposed scheme on the existing aquatic ecosystem are proposed below. We acknowledge that consultation for such measures would be required with the West Coast Regional Council, and interested parties such as the Department of Conservation, Fish and Game, Te Runanga O Ngati Waewae and other local iwi:

- ▶ Prior to construction commencing, undertake comprehensive baseline surveys in each of the affected sub-catchments for monitoring purposes following scheme commissioning. Focus should be on rare bryophyte and liverwort species and distribution, and the migratory and non-migratory freshwater fish species present in the Ngakawau River below the Mangatini Falls;
- ▶ If these baseline surveys identify rare or significant bryophyte and liverwort populations within the proposed impact zone, then loss of these populations and their habitats could be offset by ensuring that remaining locations on the Stockton Plateau where these species are present are protected;
- ▶ Additionally, a representative sample from each rare or significant population known to be affected by the proposed scheme could be collected and relocated to an appropriate similar habitat in an area not affected by the scheme;
- ▶ Ensure that adequate water depths and velocities are retained within the Ngakawau River to maintain and encourage the return of critical ecological values;
- ▶ In each of the affected streams, ensure that some flushing flows are maintained to eliminate large accumulations of sediment and also filamentous algae;
- ▶ All disturbed areas (as a result of construction activity) within 10 metres (and all steep faces) of each affected waterway should be stabilized and planted with suitable riparian vegetation as soon as practicable following completion of works;
- ▶ Until impacted riparian margins have been stabilised, erosion control mechanisms, such as silt fencing and straw mulching, may be required to limit sedimentation of waterways arising from the works;
- ▶ Although fish populations are absent or very limited in the scheme-affected streams discharging from the Plateau, care should still be taken to ensure that works do not affect the passage of fish or cause



stranding of fish in pools or channels. Additionally, works in flowing water should not be undertaken during the period 1 April to 30 September inclusive to avoid sedimentation impacts on fish spawning in the lower catchment.

The above recommendations should be collated in an **Aquatic Ecology Management Plan** (prepared by an appropriately qualified person).

In addition to the above, we suggest the inclusion of an **Aquatic Ecology Monitoring Plan** (prepared by an appropriately qualified person). This should include:

- ▶ Results of the baseline surveys conducted;
- ▶ A monitoring programme of water quality, flow, macroinvertebrates, aquatic plants, and fish, including the timing and frequency of the sampling programme; and
- ▶ Control reference sites and sites to be included in the scheme area, with representative upstream and downstream sites.

### 6.1.2 General Protection

Measures to reduce sedimentation and other adverse effects on the aquatic environment as a result of the construction and on-going maintenance of the proposed scheme include:

- ▶ A **Construction Management Plan** outlining the timing of works, construction practices and procedures to be adopted should be developed to ensure that the effects of construction activities are minimised to the greatest extent practicable. This should, as a minimum, include:
  - A programme of works, which includes, but is not limited to, a proposed timeframe for the works;
  - A locality map showing planned construction activity, waterways in the vicinity, and known ecological values;
  - Specific management plans for the ecological values that will be impacted by the construction activity;
  - Detailed drawings showing the type and location of erosion and sediment control measures; and
  - Measures to be undertaken should environmental management mechanisms fail and result in contamination of any watercourse or water body.
- ▶ All practicable measures should be undertaken to prevent oil and fuel leaks from vehicles and machinery. There should be no storage of fuel or refuelling of vehicles and machinery in areas that could result in a discharge to a waterway should a spill occur. Fuel should be stored securely or removed from the construction site overnight; and
- ▶ All spoil and other waste material from the works should be removed from the site upon completion of works.



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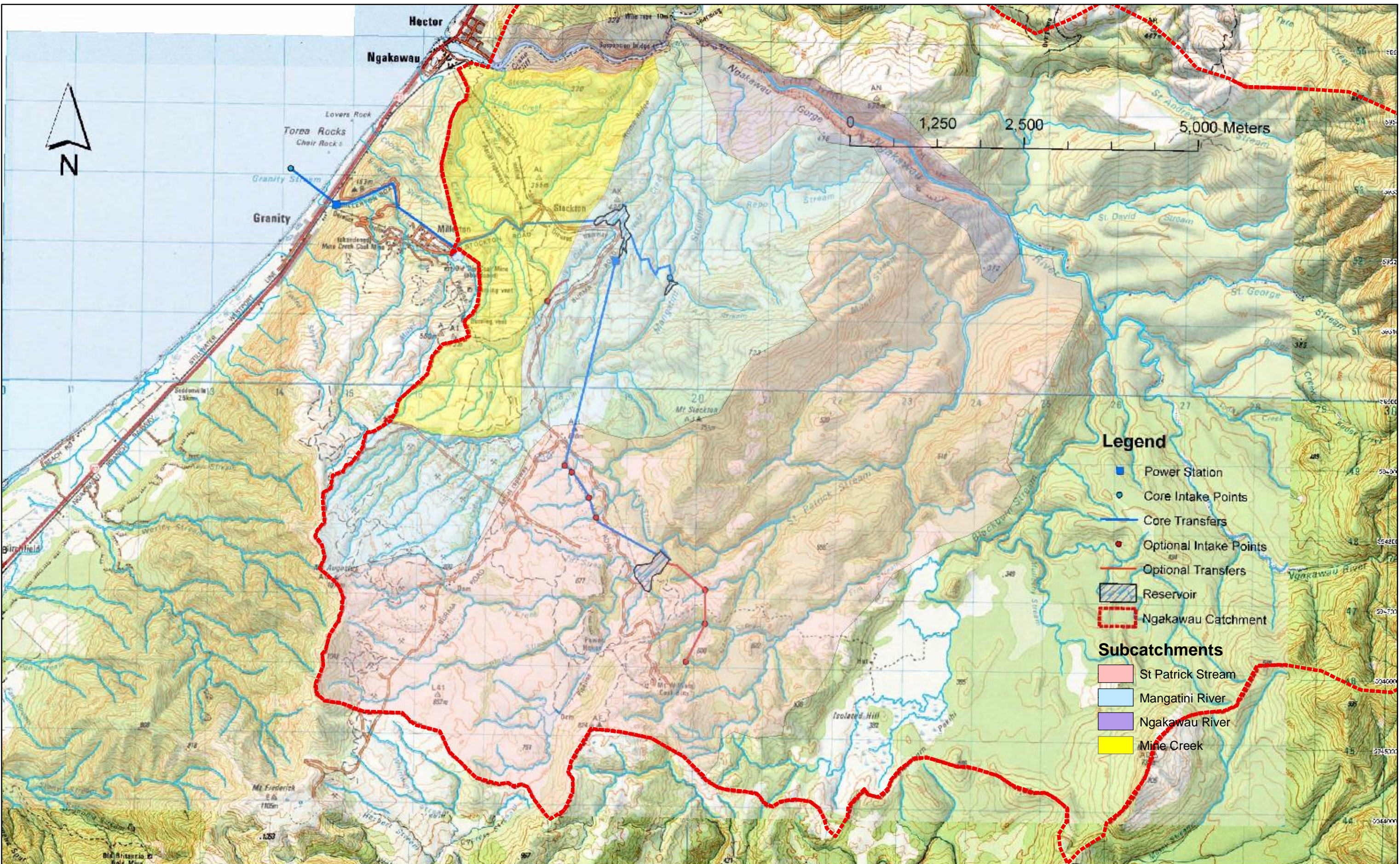
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Appendix A

# Sub-Catchment Boundaries and Proposed Scheme

GIS Map



**Legend**


- Power Station
- Core Intake Points
- Core Transfers
- Optional Intake Points
- Optional Transfers
- Reservoir
- Ngakawau Catchment

**Subcatchments**

- St Patrick Stream
- Mangatini River
- Ngakawau River
- Mine Creek

Issue	Description	Date	Approved	Designed:	Name	Date
DRAFT		08/09/08		S BRATTLE		08/09/08
				H PIPE		08/09/08
				Checked:		
				Approved:		
				Scale @ A3	1:50,000	
				Coordinate System:	N/A	

Client:  
**HYDRO DEVELOPMENT LIMITED**



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Project: **STOCKTON PLATEAU HYDRO SCHEME  
 PROPOSED SCHEME CORE & OPTIONAL ELEMENTS  
 CATCHMENT BOUNDARIES OVERLAIN**

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**Document Status**

Rev No.	Author	Reviewer		Approved for Issue		
		Name	Signature	Name	Signature	Date
Draft	Melissa Anthony	Jemma Sargent		Peter Forrest		11/09/08
Rev 0	Melissa Anthony	Jemma Sargent		Bob Penter		17/9/08