Sustainable Energy Ltd

Nadarivatu Hydro Power Scheme

SUPPLEMENTARY REPORT 2 TO THE EIA

- Environmental Impact Assessment
- Final
- September 2006

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Executive Summary

The Nadarivatu Hydropower Project is part of a programme of renewable energy developments being undertaken by Sustainable Energy Limited, a joint venture company between the Fiji Electricity Authority and Pacific Hydro Limited.

The original Nadarivatu scheme was granted an Environmental Approval in July 2005 by the Department of Environment (now Ministry of the Environment). The scheme has now been changed and this EIA report provides the supporting information for Sustainable Energy Limited to apply for a change to the original Environmental Approval.

The project still involves diverting headwaters from the Sigatoka River to the Ba River, within the upland Nadrau Plateau of Viti Levu. The previous scheme included a 60m high dam in the Qaliwana and Nadala Creeks and a weir in the Nukunuku Creek, providing water to two power stations with a combined capacity of 54 megawatts (MW). The proposed scheme includes one weir at the confluence of the Qaliwana and Nukunuku Creeks providing up to $15m^3/s$ to a single power house at the Buya Buya Village on the banks of the Ba River with a 41MW maximum capacity.

The development of this renewable energy source has a number of benefits for Fiji, these include:

The project represents an opportunity for Fiji to reduce its reliance on imported fossil fuels and develop a more sustainable long-term power generation strategy

- The replacement of diesel fuel and reduction in carbon dioxide (CO_2) emissions.
- Industry and other development in Fiji will benefit by ensuring power supplies are more consistent.
- Employment will be created in the project area during the construction period for unskilled and skilled labour.

A reassessment of the original baseline data was carried out on the revised scheme. The studies covered:

- Terrestrial species and habitats.
- Community consultation and impacts.
- Hydrological modelling of modified flows in the Sigatoka and Ba Rivers.
- Archaeological sites and impacts.

An additional round of water quality and instream biomonitoring was carried out in July 2006.

This process has identified a number of potential impacts of the proposed scheme and compared those to the original scheme. Overall, the nature of the effects would be similar, although the scale has reduced in many cases. The key points to note are:

- Sedimentation effects on aquatic ecology as a result of sediment discharges from earthworks in and around the rivers will remain, but will be reduced in scale due to the reduction in work areas and duration of construction period.
- Disturbance and loss of terrestrial ecology under the Nadarivatu Dam and Lake is no longer an impact.
- The diversion of water from the Qaliwana and Nukunuku Creeks will create uniformly low river flows downstream in the Sigatoka River, similar in scale to the previous scheme.
- Changes to downstream ecosystems and fish populations in the Sigatoka River as a result of the change in flow and the weir structure will be similar in scale to the previous scheme.
- Changes to Ba River flow during some scenarios, affecting fording and other river uses downstream, but providing improved fish habitat, will be similar in scale to the previous scheme.
- Disturbance to traditional village life, and in particular to Buya Buya Village, during construction as a result of the works and influx of workers to the district. These effects are likely to be reduced in scale overall due to the reduced construction period and the reduction in the number of workers and workers' camps but will still require pro-active management by the Contractor and Sustainable Energy Limited.
- Displacement of approximately 22,000 tonnes (T) of diesel per annum, based on a mean annual output of 101 gigawatt hours (GWh), at a relative diesel consumption rate of 0.22T/ megawatt hour (MWh). This compares to approximately 26,000T of diesel per annum for the original scheme.
- Displacement of approximately 66,000T of CO_2 per annum, based on the conversion of 0.656T CO_2 / MWh for diesel generators in Fiji. This compares to approximately 78,000T of CO_2 per annum for the original scheme.

Mitigation and management to address these issues has not changed significantly from the original EIA, as the nature of the effects would be similar and the scale of effects in most cases reduced. It is considered that if the actions in Section 5 are implemented then the adverse effects of the project will be minimised. The measures outlined in the EIA should ensure that the development could proceed and provide a significant benefit to Fiji's power supply and future economic development.

Minor changes to the Environmental Approval are recommended to account for the change in scheme design and impacts.

1. Introduction

This report is an Environmental Impact Assessment (EIA) to support an application to change an Environmental Approval for the Nadarivatu Hydropower Scheme, issued by the Department of Environment (now the Ministry for the Environment or MOE) dated 25 July 2005 (Appendix A). This process is in accordance with the Environment Management Act 2005.

1.1 Background and Overview of the Proposed Hydropower Scheme

In 2005, Sustainable Energy Limited (SEL), a joint venture between the Fiji Electricity Authority (FEA) and Pacific Hydro Limited, developed the Nadarivatu Hydropower Scheme. The scheme involved diverting water from the Qaliwana, Nadala and Nukunuku tributaries of the Sigatoka River via a tunnel to Nadarivatu Power Station 1 located near Lewa and then through a second tunnel to Nadarivatu Power Station 2 on the banks of the Ba River. The scheme included a 60m high dam at the confluence of the Qaliwana and Nadala creeks and a weir on the Nukunuku creek.

Subsequent to the Environmental Approval granted in July 2005, further design optimisation has occurred, and led to specific changes to the layout of the scheme, the size and location of the dam in the Sigatoka catchment and to the output and operation of the power station at the Ba River.

SEL now propose to construct and operate a 41 megawatt (MW) hydropower scheme in the Nadarivatu district. The scheme involves taking water from a 21.5m weir in the Sigatoka River catchment at the confluence of the Qaliwana and Nukunuku Creeks, through a tunnel and penstock to a power station on the banks of the Ba River. The weir will have the capacity to store up to 244,000 cubic metres (m^3) of water which, at the maximum scheme discharge of $15m^3/s$, is 4.5 hours storage.

1.2 EIA Process

An EIA was lodged with the Department of Environment in May 2005 for the original Nadarivatu Hydropower Scheme followed by Supplementary Report 1 to the EIA in July 2005. These reports are:

- SKM. 2005. Nadarivatu Hydropower Project EIA (Final).
- SKM. 2005. Nadarivatu Hydropower Project Appendices. (Final).
- SKM. 2005. Nadarivatu Hydropower Project Supplementary Report 1 to the EIA.

An Environmental Approval was issued to SEL on 25 July 2005[1].

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[1] A copy of the Environmental Approval is provided in Appendix A.

At a meeting between SEL (represented by FEA), SKM and MOE on 9 February 2006, it was agreed that a Supplementary Report No. 2 to the EIA was to be lodged with MOE to document and address all of the changes to environmental and social impacts from the proposed scheme changes. The MOE would consider the information in the Supplementary Report No. 2 to the EIA and amend the original Environmental Approval to address the changes. It was considered at the time that although the Government Stakeholder Group would be involved in the processing of the change to the Environmental Approval, the application would not require public notification through the Environment Management Act 2005 process.

1.3 Report Format

The report format is similar to the original EIA[2]. Within the report, the previous scheme will be called the 'original' scheme and the new scheme subject to this report will be called the 'proposed' scheme.

The proposed scheme is described in Section 2 followed by new baseline environmental information not included in the original EIA in Section 3. The impacts and management controls of the proposed scheme are detailed in Section 4. This section describes the changes to the nature and scale of impacts and management controls compared to the original scheme and includes new impacts and management controls where relevant. It has been noted in Section 4 where impacts will remain similar to the original scheme and where impacts will be reduced or eliminated as a result of the proposal.

Mitigation measures are prescribed in Section 5, where they are different to those prescribed in the original EIA. The specific changes proposed for the Environmental Approval are noted in Section 0, and Section 7 provides a summary and conclusion to the Supplementary Report.

1.4 Acknowledgements

SKM acknowledge MWH for the drawings and details of the scheme as provided in this report, and thank Peter Robinson for this input.

SKM thank the representatives of the government agencies for attending and contributing to the stakeholder group meeting on 6 September 2006 (minutes attached in Appendix E).

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[2] SKM 2005a.

SKM

2. Description of the Hydropower Scheme

2.1 Introduction

SEL have revised the Nadarivatu Hydropower Scheme. This section details the proposed scheme. Location Plans are included in Appendix B and Design Plans are included in Appendix C.

The key components of the proposed scheme are listed in Table 2-1, along with a comparison of similar components of the original scheme.

Table 2-1 Summary of Scheme Components

Component	Proposed Scheme	Original Scheme
Location	Nadarivatu	Nadarivatu
Maximum Output (MW)	41MW	54MW
Mean Annual Output (gigawatt hours (gWh) / annum)	101GWh	140GWh
Dams and Weirs	Korolevu weir – 19m high with 2.5m high crest gate Located at the confluence of the Nukunuku Creek and Qaliwana Creek 1.6ha holding pond	1 weir – on the Nukunuku Creek 1 dam – 60m high located at the confluence of the Nadala and Qaliwana Creeks 9ha holding pond
Live storage	244,000m^3 4.5 hours	6,000,000m^3 Approximately 4 days
Tunnels and penstocks	1 x 2km tunnel from weir to penstock near Buya Buya 1 x 1450m penstock from tunnel to power station at the Ba River.	1 x 2km tunnel from dam to weir 1 x 2km tunnel from weir to penstock near Buya Buya 1 x 1400m penstock from tunnel to power station at the Ba River
Power Stations	1 x 41MW power station at Buya Buya	2 power stations 1 x 10MW at Lewa 1 x 44MW at Buya Buya
Maximum discharge	15m^3/s	15m^3/s
Approximate mean annual diesel replacement	22,000T	26,000T

2.2 Location

The proposed scheme remains in the Nadarivatu district at the head waters of both the Sigatoka and Ba Rivers, as per the original scheme. A location map is provided on Scheme Plan SK000 in Appendix B. The new weir will be located at the confluence of the Qaliwana River and Nukunuku Creek, approximately 5km downstream of the previously proposed dam site and 1km downstream of the previously proposed weir site.

2.3 Proposed Scheme Layout and Design

As described in the introduction, the proposed scheme involves a weir located in the Sigatoka catchment, a tunnel to convey water from the weir to a power station on the Ba River, and the discharge of water to the Ba River.

In this section the following components are described:

- Korolevu Weir.
- Tunnel and Penstock.
- Power house.
- Mechanical and Electrical Plant.

2.3.1 Korolevu Weir

The Korolevu Weir will be located approximately 50m downstream of the Qaliwana and Nukunuku Creek confluence. The weir will impound a maximum live storage volume of approximately 244,000m^3 which, when based on a peak 15m^3/s generation flow, equates to 0.188 days or 4.5 hours storage at peak operation. Drawings are provided in Appendix C.

Details of the weir include following:

- A reinforced concrete buttress weir approximately 75m wide and estimated to be 19m high (structural crest level RL519) in the centre of the river.
- Consolidation grouting to foundations.
- A flood crest 36m wide over the weir.
- A 2.5m high bottom-hinged crest spillway gate across the full width of the spillway crest (36m). This creates a 21.5m high impoundment structure.
- Wing walls to approximately 7m above the structural weir crest.
- A plunge pool immediately downstream of the weir crest approximately 55m wide and 25m long.
- Twin 4.2m x 4.2m sluice culverts and gates through the base of the weir for regular reservoir sluicing and flushing to remove trapped sediments and clear material from around the submerged tunnel intake.
- A Tunnel Intake approximately 60m upstream of the weir crest including a gate tower approximately 30m high.

2.3.2 Tunnel and Penstock

The tunnel length, from the weir to the Ba power house is approximately 1950m. It will be 3m diameter and D shaped. The penstock from the tunnel to the Ba power house is approximately

1400m long and 2.25m in diameter. It will be buried along the full length, except in the immediate vicinity of the tunnel portal.

The penstock passes to the north of the Buya Buya Village, avoiding the areas that are in crops at present. It then passes down a steep gulley to the south the slope with the access road to the power house.

2.3.3 Power House

The power house will be located at the same site as the original scheme, on the bank of the Ba River. Drawings are provided in Appendix C. It will house 4 Pelton wheel turbines with individual generators in a tanked reinforced concrete structure approximately 7m deep and 18m wide x 50m long. Beneath the turbine tail race the power house is 11m deep. A loading bay 15m long x 18m will be provided. The superstructure will be approx 15m high x 18m wide x 65m long. Cladding will be galvanised steel sheeting.

The flood level is expected to be 7m to 9m above riverbed level. Foundations for the power house shaft are on rock while the rest of the platform will be on engineered fill using material excavated from the shaft and road construction. The river face of the platform will be faced with heavy rock protection won from the Ba River and adjacent slopes. The top of the concrete structure will be above the expected Probable Maximum Flood level.

A two storey control and office annex will be provided within the main building, adjacent to the loading dock. This will house the controls, 415 volt (V) electrical panels, operator stations, office accommodation, communication equipment and standby generator. In addition, sleeping accommodation and cooking facilities will be provided for operating personnel and maintenance staff.

2.3.4 Roads

New roads are needed to be constructed as follows:

- Access to the Korolevu intake will be obtained off the Lewa Road. It will pass the original Lewa intake and pass along the right bank of the Nukunuku Creek.
- Access to the Ba Power house and the downstream tunnel portal will be obtained from the Lewa Road above the Buya Buya Village. The road will also provide access to the Buya Buya Village.
- The access road to the Buya Buya Village will also be extended to provide road access to the high voltage substation near to the Buya Buya Village.

2.3.5 Mechanical and Electrical Plant

- Four Pelton turbine generators at the power station.
- Power house equipment and cranes.

- Controls and communications.
- Two 132KV lines from the Power house to the substation adjacent to the Buya Buya Village.
- A 132kV substation adjacent to the village.
- A 132kV 5.4km dual circuit transmission line from the substation to the existing Vuda / Wailoa transmission line.
- Upgrade of communication and electrical protection systems between Vuda and Wailoa power station.

2.4 Proposed Scheme Operation

Under normal operation water is drawn from the reservoir behind the Korolevu intake. The weir height allows for particles and sediment to drop out where they can be sluiced downstream through operation of the sluice culverts at the base of the weir during time of high flow. The intake will draw water continuously so long as the water exceeds the minimum flow amount of 0.2m^3/s. A gate or valve will be used to maintain this residual flow downstream of the weir. However, it should be noted that the natural flow can be less than 0.2m^3/s on occasions during the dry season.

The spillway crest gate at the intake will pass the initial flood flows up to approximately 150m^3/s, which corresponds to about the annual flood. The sluice gates have a capacity of 600m^3/s. This means that a 1:10 year flood can be passed without increasing the reservoir water level. The spillway has been designed to pass a flow of between 1,200 and 1,500m^3/s, which correspond to 70 to 100 year events. The probable maximum flood in the river of 3,900m^3/s would result in the structure being overtopped without leading to failure.

The tunnel and penstock are provided with drain valves to allow the tunnels to be inspected and maintained. A valve will be provided at the exit of the Korolevu to Ba tunnel. The valve will be operated by the penstock leak detection system that detects any mismatch in the flow between the top and bottom of the penstock. If a small mismatch is detected the scheme will be shut down. It will also allow the tunnel to be inspected without draining the penstock.

The entire scheme will be fully automatic and can be remote controlled from either the Vuda control centre or the Wailoa power station. It is expected that the station will be manned permanently for maintenance purposes.

The generators at the Ba Power House will operate at 11 kilovolts (kV). The output needs to be stepped up to 132kV to allow the power to be exported to the high voltage grid. Two 11kV /132kV transformers will be provided at the power house while the high voltage switchgear would be located in the switchyard at the top of the steep descent into the Ba River towards the Buya Buya Village.

2.5 Layout and Design Features Removed From the Scheme

The following features are **no longer part of the scheme** and should not be considered for the Environmental Approval:

- A rollcrete dam on the Qaliwana Creek at the confluence with the Nadala Creek.
- Nadarivatu Weir intake structure on the Nukunuku Creek.
- Desanders on the Nadarivatu Intake 1.
- 1.93km of 3m diameter tunnel from Nadarivatu Dam to Nadarivatu Power Station 1 and Intake.
- 70m long 2.45m diameter penstock from the outlet portal of the Nadarivatu Tunnel 1 to the Nadarivatu Power Station 1.
- 2.05km of 3m diameter tunnel from Nadarivatu Intake 1 to the Nadarivatu Penstock 2.
- Nadarivatu Power Station 1 at Lewa on the bank of the Nukunuku Creek.
- A 33kV line from the Nadarivatu Power Station 1 to the Vatukoula / Tavua substation at Tavua, along existing transmission line route.

2.6 Construction

Construction methodologies will be similar to those described in the original EIA (SKM 2005a). Construction methods are currently conceptual and will be further developed with the Contractor. The current construction programme is planned to start in February 2007 and commissioning to occur in mid 2008.

2.6.1 Weir and Tunnel Portal

The following outlines the envisaged construction sequence for the weir and tunnel intake portal:

- Complete bulk excavations for the weir and tunnel intake portal on the right bank of the river including the diversion channel bench upstream of the weir and temporary access tracks as shown on the layout plan in Appendix B.
- Construct the first three buttress walls (including foundation grouting), right bank wing wall and sluice channel slab and sluice gate frames (above normal river level).
- Construct the plunge pool slab and walls on the right bank (above normal river level).
- Install temporary walls to contain the diversion channel upstream and downstream of the weir and install temporary bridges across the diversion channel both upstream and downstream of the weir.
- Construct an upstream cofferdam at the narrowest section of river approximately 12m high within the narrow channel to divert flow into the diversion channel. It is envisaged that the cofferdam would be constructed using a sheetpile wall keyed to rock and including heavy steel support structure and backfilled upstream using excavated material from the right bank

excavations to provide additional support to the cofferdam wall, reduce leakage and to provide a working platform and access ramp.

- Construct a downstream cofferdam approximately 7-8m high to protect the works from downstream river flows encroaching back into the working area. It is envisaged that the cofferdam would be of similar construction to the upstream cofferdam.
- Complete foundation grouting and the construction of the weir and plunge pool and other works.
- Install the sluice gates and associated hydraulics using a mobile crane (20ton capacity) access through the diversion channel (at low river flows).
- Upon completion the cofferdams and other temporary works would be removed and the reservoir would then be filled.

It is assumed that a diversion capacity equivalent to a one year return interval full season event (185m^3/s) will provide sufficient protection although further risk assessment is required to confirm this assumption.

2.6.2 Construction Materials

Table 2-2 provides some of the major excavation and material quantities associated with this option. Quantities are estimated based on available information only and subject to change.

Table 2-2 Quantities of Spoil and Concrete

Item	Approximate Quantity (estimates only)
Cofferdams for temporary diversions 12m high upstream	11,000m^3
Excavation of soft material	10,000m^3
Excavation of rock	67,000m^3
Reinforced concrete	19,100m^3

The types of materials and potential sources are discussed below, however these are details that will be confirmed closer to the time of construction.

Aggregate Sands and Road Metal

In the immediate project area, deposits of natural sand and gravel are scarce. Most of the alluvium is composed of coarse gravels, cobbles and large boulders. Where present, sands and gravels occur as small, isolated deposits scattered throughout the beds and banks of rivers and large creeks.

Potential extraction sites for alluvial sands and aggregates have been identified at the following sites:

- **Qalimaca Creek**, located approximately 3km from the proposed dam site along the access road. The available quantity of material is yet to be confirmed however it is expected that the usable quantity will be limited.
- **Nadala and Nukunuku Creek Floodplains –** extraction of alluvial deposits around the villages of Navai and Nadrevutuka are currently being carried out by others. The deposits are located approximately 3 to 6km upstream of the Qaliwana and Lewa sites. In these areas, the creeks have a relatively flat gradient and meander through floodplains, wetlands and alluvial terraces. The alluvial deposits are most likely composed of silts and fine to medium sands with interbedded gravels, suitable for filter, drain and concrete aggregate. The available quantity of material is yet to be confirmed however it is possible that sufficient quantities of sand and gravel could be obtained from these areas.

Extraction of the alluvial deposits, if found to be viable, would be by conventional excavation along the creek bed and carted by large trucks to the sites where the material would be crushed and stockpiled. The rate of extraction may be limited by access in the smaller creek beds. However for the larger deposits the extraction rate is likely to be in the order of 8 to 10 trucks per hour.

Sand and gravel aggregates could also be obtained from excavated and/or quarried basalts and sandstone/siltstone. At the present time the only confirmed sources of aggregate local to the power scheme for reinforced concrete for the structures is the Monasavu Quarry which is owned by FEA.

Some potential quarry sites have been identified and these are indicated on the Plans in Appendix B. However, the final selected quarry sites will be subject to confirmation of suitable rock types and test quarries.

It is expected that conventional quarrying methods would be used on the existing slopes of the valley using the following method:

- Stripping of bush/trees and overburden material.
- Excavation of weathered surface rock to expose fresh bedrock.
- Drilling and blasting of the exposed rock to extract material and to form benches for access and stability.

The size and number of quarries would subject to availability of suitable material however an indicative size of quarry would be 50 to 100m in plan and 20 to 30m deep. Access roads will be necessary to allow large truck access for the removal of the quarried rock.

At suitable locations test quarries would be formed using drilling and blasting methods to expose the bedrock material to confirm the suitability of potential quarry locations.

Earthfill Material

Overburden soils are widespread throughout the project area as deposits of colluvial and residual soils, derived from volcanic and sedimentary bedrock, and ranging in thickness from less than 1m to nearly 15m. The soils are predominantly a light reddish-orange silty clay with relatively high plasticity and occasional gravel and cobble-sized particles, could potentially be used as impervious material.

Limited quantities of earthfill are required for the project and it is expected to be available as surplus material from cut excavations for access roads and other structures required for the project. The soils would be carted by truck and stockpiled at the required sites as necessary.

Rock Fill Materials

Materials suitable for rock fill are abundant throughout the entire project area. For river protection, rock is available as basalt boulders located throughout the adjacent river and creek channels.

2.6.3 Workers Camp

It is expected that a single workers camp will be required which covers all work sites. It would be sited to the north of Buya Buya Village on the Lewa ridge adjacent to the Lewa Road.

The camp will provide accommodation for up to 180 people along with kitchen, entertainment, washing facilities, workshops, store houses, vehicle garages, fuel and oil storage and diesel generators. The camps will be designed and operated in a similar manner as described in the original scheme.

2.6.4 Work Areas

Work areas are necessary at:

- Korolevu intake and power house.
- Korolevu/Ba tunnel downstream portal.
- Ba penstock at the top of the steel section immediately above the power house.
- Ba power house.

These areas are shown on the plans in Appendix B. They will be used for storage, concrete batching plants, site huts, toilets, diesel generators etc.

2.7 Operation

The proposed generation profile from Nadarivatu power scheme is aimed at meeting the demand between 8:30AM and 10:30PM, particularly on weekdays. The mean annual generation capacity is 101GWh, and depends primarily on the rainfall in any particular year, since there is little storage.

The operational hydraulics associated with this arrangement are summarised as follows:

- The tunnel intake is located approximately 50m upstream of the weir crest and the invert of the tunnel is set at 10.5m below the weir crest (based on 4m operating range + 3.5m water above tunnel soffit at minimum operating level + 3m tunnel height).
- The reservoir water level would be maintained within a 4m operating range. Detailed operational guidelines would be established to optimise the energy production for the scheme once all necessary parameters are known.
- The spillway gate would be partially lowered during smaller flood events and lowered completely during larger flood events. In all flood events greater than $40m^3/s$ it is expected that the sluice gates would be opened to maximise reservoir flushing and reduce the flood rise over the weir during large flood events.

The expected accumulation of sediment at the Korolevu Intake will be managed by a combination of in river sluicing through spillway crest gate and the low level sluice gates in the weir structure. Sluicing will be carried out during floods to simulate natural river sediment flows as closely as possible.

At flows in excess of the station rating, the spillway crest gate will be opened. The water level will be drawn down to pull material that is deposited in the upper reaches of the reservoir. This will improve the efficiency of flushing using the low level sluice gates when they are opened at higher river flows.

During major floods, the sluice gates will be used actively as the first means of passing all floods in order to minimise the build up of silt in the reservoir. The scheme operators may need to remove the silt by more active measures. These would include lowering the reservoir with the sluice gates open in order to create high water velocities in the area where the silt has been deposited.

At very rare intervals it will be necessary to drain the reservoir to check whether there is nay movement of major boulders in the reservoir. If there is, they may need to be blasted.

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3. Description of the Environment

3.1 Introduction

In this section, any new information regarding the existing environmental setting is described where relevant to the revised scheme.

Please note that the following sections of the original EIA remain relevant:

Section 3.2: Topography and Geomorphology

Section 3.3: Climate

Section 3.5: Land uses and land cover

Section 3.6: Hydrology

Section 3.7: Terrestrial ecology

Section 3.9: Noise

Section 3.10: Air Quality

Section 3.11: Visual Amenity

Section 3.12: Archaeological and Historic Values

Section 3.13: Economic Context

Section 3.14: Settlements and Social Environment

Section 3.15: Access and Vehicle Use

3.2 Surface Water Quality and Ecology

A third round of water quality and instream ecology was carried out in July 2006. The data is presented in Appendix D. The streams investigated in this baseline assessment are presented in Table 3-1. The sampling sites have been revised to reflect the new scheme. Some sites are no longer valid, and a new site (Site 9) has been added to address the impacts at the new weir location.

▪ **Table 3-1 Location of macroinvertebrate and water quality sampling sites**

Area	Site	Description	Study	
			2005	2006
Ba River	1	Marou Village (above proposed power station)	√	√
	2	Drala Village (below proposed power station)	√	√
Nukunuku Creek	3	Above hydrological station (approximately 1km above proposed weir and intake)	√	√
	4	50m below hydrological station	√	*
Nadala Creek	5	Nadala village	√	*
Qaliwana Creek	6	Nabuyasa village	√	*

Area	Site	Description	Study	
			2005	2006
	7	50m above hydrological recording station (approximately 1km above proposed weir and intake)	√	√
	9	Below confluence with Nukunuku Creek (approximately 200m below proposed weir and intake)	*	√
Savatu Creek	8	Savatu Creek access from Drala Village (control site)	√	√

Notes: * = Sites not sampled

The data shows that similar conditions exist as those described in the original EIA. Site 9 has similar characteristics and water quality to others in the Sigatoka catchment. Further details are provided in Appendix D.

3.3 Geology at the Weir Site

The following summarises the geological conditions as determined from the preliminary mapping of the weir site by MWH during a period from March to July 2006 (MWH 2006).

- The river channel is heavily incised with bluffs up to 6m high on the river bank and high cliff faces downstream of the proposed site.
- Exposed rock in the river bed and banks appears to range from massive columnar Basalts near the confluence to Pillow Basalts downstream with discontinuous layers of Breccia / Agglomerate, possibly rubble material at the top/base of the predominant rock mass layers.
- The exposed rock becomes more predominantly Breccia / Agglomerate towards the downstream bend in the river.

There do not appear to be any faults or significant discontinuities at this site although further ground work is required to confirm this.

4. Potential Impacts and Management Controls

4.1 Introduction

The changes to impacts from the original scheme are discussed in this section. The most significant change is the reduction in the inundation zone behind the dam, which will no longer occur. Overall the hydrological impacts are the most relevant changes compared to the original scheme, which in turn impacts on water quality, instream ecology and in stream uses.

4.2 Hydrology

This section covers the hydrological (flow) implications of the revised hydropower scheme on the Sigatoka River (combined Qaliwana and Nukunuku Streams) and the Ba River below the proposed Ba Power house discharge point.

The 1990 to 1999 flow information from the Qaliwana and Nukunuku Streams has been used in conjunction with a calibrated hydrological model provided by MWH to estimate inflow to the proposed weir/lake for scheme utilisation.

4.2.1 Summary of Changes to Hydraulic Impacts

Under the current scheme proposal there are some changes to the hydrological regime compared to the original scheme. These changes include:

- Creation of a smaller weir and holding pond immediately below the Qaliwana and Nukunuku Creeks, leading to a greatly reduced inundation zone behind the weir, compared to the dam.
- A catchment area 13.5ha greater in extent than that under the original proposal.
- Maintenance of a base flow (residual flow) downstream of the weir of $0.2m^3/s$. This compares to $0.1m^3/s$ from the Nadarivatu Dam and $0.1m^3/s$ from the Nadarivatu Weir from the previous scheme.
- Twin low level sluice culverts incorporating minimum flow gates, proposed to enable residual flow releases.
- A decrease in the combined discharge of the Qaliwana and Nukunuku Streams to the Sigatoka River and an increase in the mean flow for the Ba River downstream of the proposed Ba Power house.
- An increase in the use of moderate freshes for flushing flows to clear the weir/lake of sediment and debris compared to the original dam.

4.2.2 Effect on Flow From Qaliwana / Nukunuku Creek Catchments

Figure 4-1 illustrates the impact of the proposed scheme on the combined discharge from the Qaliwana and Nukunuku catchments downstream of the proposed weir utilising data from 1994 to

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1995. The dark hydrograph shows the natural river flow without the weir, and the light hydrograph shows the downstream flow once the weir is in place and the water diverted to the power scheme.

- **Figure 4-1 Mean Daily Qaliwana And Nukunuku Creek Inflows To The Weir/Lake And Resulting Spillway And Residual Flow To The Sigatoka River For The Period Of 1 January 1994 To 31 December 1995.**

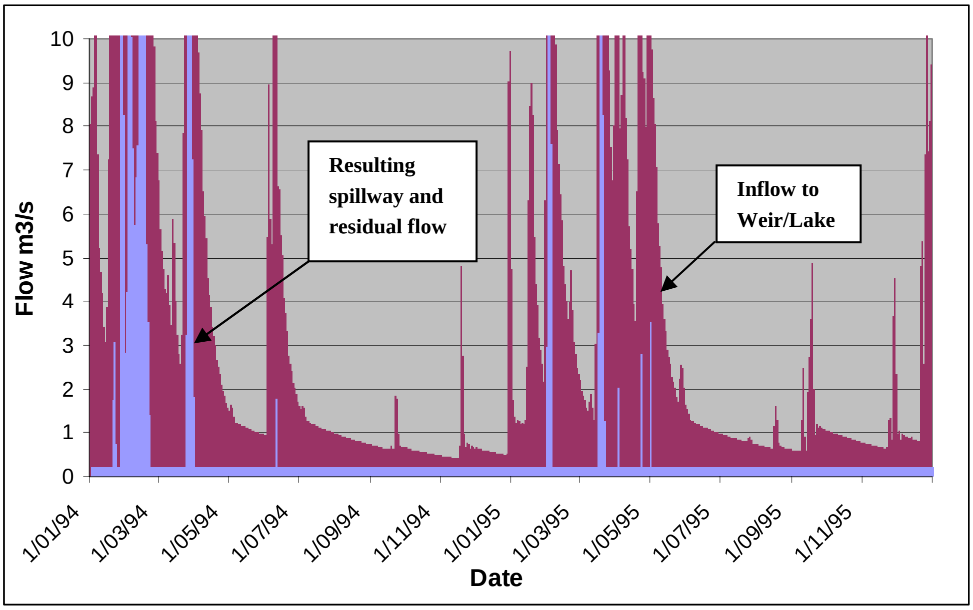

Figure 4-1 shows some difference in the shape of the resulting hydrographs to that of the original scheme (refer to SKM 2005a), due to combined Qaliwana and Nukunuku catchment flows (rather than just the Qaliwana flows used in SKM 2005a) and a reduced storage of the weir/lake compared to the original dam, resulting in greater frequency and magnitude of medium to high flows.

Due to the small storage capacity of the proposed scheme, there will be a relatively minor impact on medium to high flood flows.

Flow statistics for natural and modified flow from the confluence of the Qaliwana and Nukunuku Creeks are shown in Table 4-1, along with the original scheme design flows for comparison.

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▪ Table 4-1 Flow Statistics For The Qaliwana And Nukunuku Creek Flows At The Confluence.

Statistic	Natural flow (m^3/s)	Modified weir flow (m^3/s)	Modified original scheme flow (m^3/s)
Mean flow	5.93	1.74	1.62
Median flow	1.96	0.20	0.47
Min daily flow	0.41	0.20	0.23
Max daily flow	268.30	253.30	236.28
Mean Annual Low Flow (MALF)	0.69	0.20	0.14 – 0.23
Q7 10	0.46	0.20	0.12 – 0.22
5%ile	0.65	0.20	0.29

It should be noted that whilst a greater proportion of upper Sigatoka River catchment water is proposed to be diverted through the Ba power house for the Nadarivatu scheme, there is a greater proportion of higher flow that bypasses the Korolevu Weir than would have occurred under the original scheme design. This results in a much decreased and stable lower flow range with minimal modification to the upper flow range in the Sigatoka River headwaters. This decreased modification to higher flows biases the flow duration and results in a greater mean flow downstream of the Nadarivatu Weir than was calculated for in the previous scheme design. However, the resulting mean flow from upper Sigatoka catchments is relatively similar under both scheme proposals.

The residual flow of $0.2m^3/s$ will dominate the downstream base flow. This flow of $0.2m^3/s$ represents a modified base flow contribution to the Sigatoka River with the utilisation of a slightly greater catchment area (+13.54 ha) than that of the original scheme. This change to low flow hydrology is illustrated in Figure 4-1 as an example of what this may look like over any year and as a percentage of flow duration as shown in Figure 4-2.

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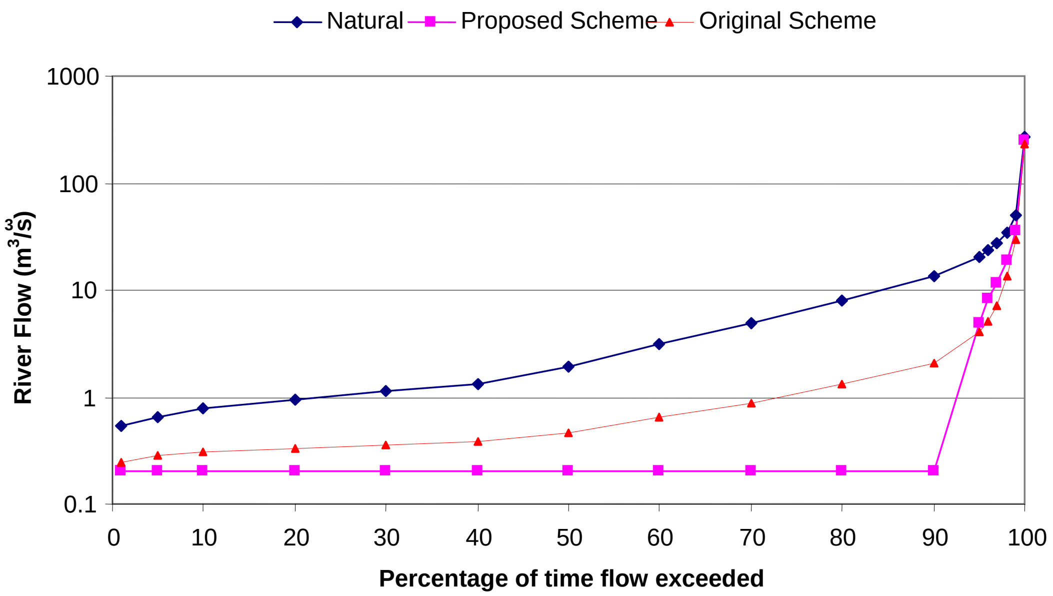
- **Figure 4-2 Flow Duration Curve For Qaliwana And Nukunuku Creek Combined Flow At Confluence.**



Differences in resulting river flows downstream of the proposed weir are mainly at the low flow portion of the duration curve (up to the 90 percentile). The proposed scheme will maintain a lower residual flow of 0.2m^3/s for a longer duration than the previously designed scheme. This is due to the greater magnitude of take from the Qaliwana and Nukunuku catchments at lower flows. Higher flows result in less modification to the natural flow due to the limited storage capacity of the proposed weir.

Flows up to the 50th percentile are similar for the current and previous scheme designs. Beyond the 70th percentile flow to the 90th percentile flow, differences in residual flow are approximately one order of magnitude for the Nadarivatu Scheme compared to that of the previous scheme design. The magnitude flushing flows will not be significantly altered by the scheme from those occurring under the natural flow regime.

In summary, the proposed Nadarivatu scheme will significantly modify the natural flow regime in the upper Sigatoka catchment. In theory, operation of the proposed scheme will result in extended periods of stable, low flow (at or near the residual flow of 0.2m^3/s) punctuated by flushing flows resulting from periods of high rainfall. In reality, operation of the station is likely to impart some diurnal variation on flows as generation is adjusted to meet demand and inflows refill the small operating storage.

4.2.3 Effect on Sigatoka River Catchment

The main effects of the proposed Nadarivatu scheme on the Sigatoka River are the reduced buffering of high flows from reduced live storage in the weir and greater duration of residual flows in the river, compared to the original scheme.

To illustrate the overall impact of the operation of the Nadarivatu scheme on cumulative river flows estimates of catchment, specific discharge were derived from an assessment of sub-catchment area and mean annual rainfall depth. These estimates were used to derive the percentage reduction in median flow resulting from the current Nadarivatu scheme at various locations downstream from the weir outlined in Table 4-2 below. Estimates of the flow reduction resulting from the original scheme are included for comparison.

- **Table 4-2 Percentage Of Modified Median Flow Contribution To Sigatoka River Of Headwater Catchments For Proposed Nadarivatu Scheme Compared To Previous Scheme.**

River location	Distance downstream (km)	Median flow (m^3/s)	Resulting median flow for Proposed / Original Scheme (m^3/s)	Resulting percentage of natural median flow remaining in-stream for Proposed Scheme (%)	Resulting percentage of natural median flow remaining in-stream for Original Scheme (%)
Qaliwana and Nukunuku confluence	0	1.96	0.20/0.47	10.2	24.0
Sigatoka at Naidraeu	7.15	2.34	0.58/0.85	24.8	36.3
Sigatoka at Jauvakarua	21.13	4.84	3.08/3.35	63.6	69.2
Sigatoka at Namoli	29.35	6.71	4.95/5.22	73.8	77.8
Sigatoka at Nukulau	35.60	9.03	7.27/7.54	80.5	83.5
Sigatoka at Lote Ck confluence	43.32	10.21	8.40/8.72	82.8	85.4
Sigatoka at Korovau	49.41	12.17	10.2/10.6	83.9	87.1
Sigatoka upstream of Kelyas	57.68	17.50	15.7/16.0	89.9	91.4
Sigatoka at Sigatoka	126.17	25.79	24.0/24.3	93.2	94.2

The estimates of residual flow show a significant impact on river flows immediately downstream of the weir. At this point the residual flow remaining in the river represents approximately 10 percent of natural discharge at median flow. Further downstream the impact on the river progressively decreases due to input from tributary catchments. At Sigatoka the diversion for the proposed scheme accounts for less than 7% of median river flow.

Comparison of impacts on residual flows resulting from the proposed and original schemes indicates a greater reduction in median discharge immediately below the weir resulting from the proposed scheme. However, below Naidraeu (21km downstream of the weir) the impact on river flows is comparable between the two schemes.

4.2.4 Impact on Riparian Groundwater Levels in Sigatoka Catchment

Inspection of the 1:250,000 topographical map of Fiji has shown potential riparian aquifers located adjacent to the Sigatoka River downstream of Kelyas (57.7km downstream of the Qaliwana and Nukunuku confluence). These riparian aquifers are likely to show effects of any long-term reduction in flow by a maximum corresponding decline in the water table level adjacent to the river. This maximum decline in water table level also assumes a direct connection between the aquifer and the river.

Changes to flow contribution for the Nadarivatu scheme (Table 4-2) at Kelyas is for a reduction in median flow of approximately 1.8m^3/s to 15.7m^3/s. Allowing for an estimated cross section width of approximately 50m and average velocity of flow of 1 m/s, the maximum decline in adjacent riparian water tables is estimated to be of the order of 70 mm downstream of Kelyas, based on the estimated reduction in median flow reduction. This decline is unlikely to have any significant impacts on existing groundwater users.

4.2.5 Effect on Ba River Catchment

The power house is located in the same position on the left bank of the Ba River as that previously designed and approved. A peak discharge of 15m^3/s is proposed from the power station to the Ba River. This discharge is identical to that for the original scheme. Provision for scheme discharge flow ramping is envisaged to be similar to the previous proposal, to provide adequate protection downstream for aquatic habitat and recreational/village uses. It is proposed under the previous assessment for Ba River discharges for a 15 minute ramping of the full 15m^3/s i.e. 1 minute/m^3/s ramping.

Figure 4-3 shows the natural Ba River flows and modified river flows as a result of the proposed scheme discharge utilising data from 1994 to 1995[3]. The changes in the discharge regime of the proposed scheme compared to the original scheme is primarily an increase the flow in the Ba River at low to medium flow ranges, with no significant increase in flood flows, and a reduction in daily “pulses”.

[3] Estimated from rainfall data and correlation to Sigatoka catchment flow data.

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- **Figure 4-3 Mean Daily Ba River Flow And Modified Flow As A Result Of The Proposed Nadarivatu Scheme Discharge For The Period Of 1 January 1994 To 31 December 1995.**

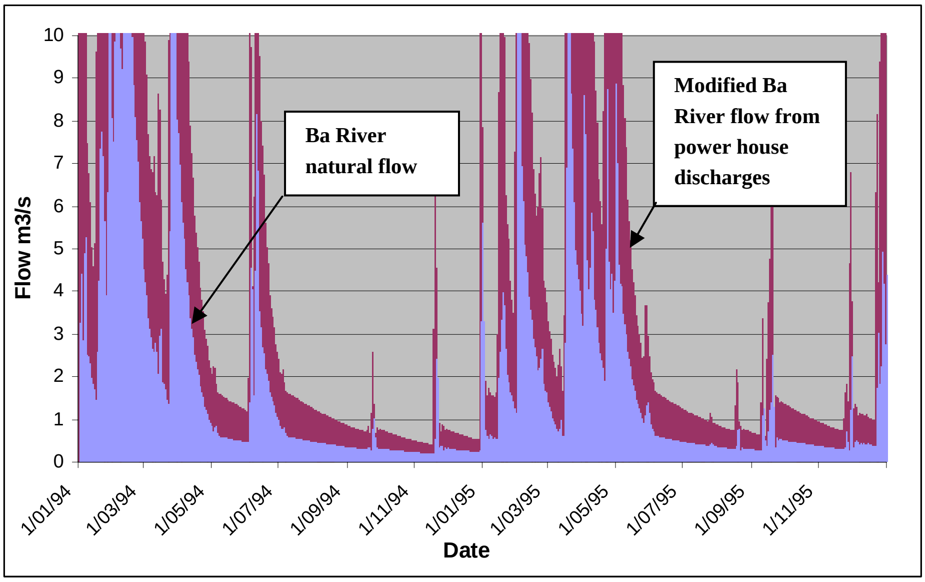

Figure 4-3 shows that the modified flow for the Ba River (the dark hydrograph) is in most cases not excessive over and above the natural flow regime (the light hydrograph). This is due to the limited water storage in the proposed weir. As such, a 'run of river' generation pattern results in a mirrored hydrograph of Ba River flows rather than a spiked peak generation pattern regime.

Estimates of Ba River flow statistics for natural and modified flows are given in Table 4-3.

- **Table 4-3 Flow Statistics For Ba River Flow At Below Power House 1990 – 1999[4]**

Statistic	Natural flow (m^3/s)	Modified weir flow (m^3/s)	Modified original scheme flow (m^3/s)
Mean flow	2.81	6.99	7.11
Median flow	1.03	2.82	2.52
Min daily flow	0.19	0.40	0.37
Max daily flow	126.98	141.98	159.00
MALF	0.33	0.82	0.71
Q7 10	0.21	0.48	0.42
5%ile	0.30	0.76	0.66

[4] Modelled data, excluding 1998 due to lack of accurate data.

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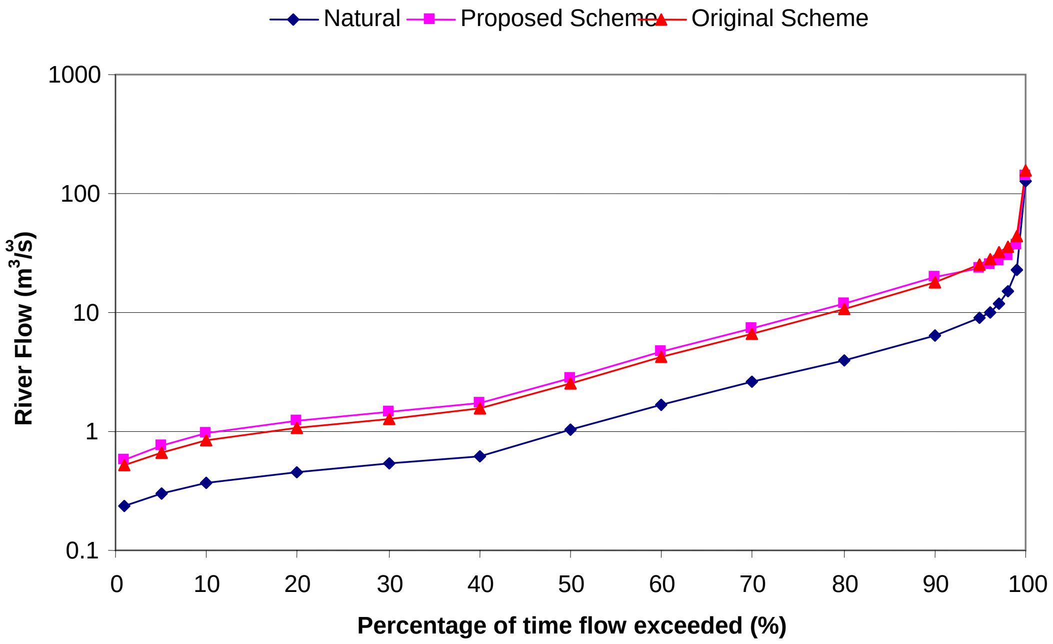
Table 4-3 shows that the resulting mean flow and maximum daily flow of the Ba River under the proposed Nadarivatu scheme is slightly reduced compared to the original scheme, whilst all other lower flows are increased due to greater capture of upper Sigatoka River base flow from an enlarged contributing catchment.

The impact of the proposed scheme on flow duration in the Ba River is illustrated in Figure 4-4 below. The figure shows scheme operation is likely to increase discharge in the Ba River under low to moderate flows with limited impacts during high flow events.

- **Figure 4-4 Flow Duration Curve For Ba River Downstream Of Power Station**



As a result of less live storage for the proposed Nadarivatu scheme means there is limited impact on the Ba River at medium to high flows. There is likely to be a similar impact of peak generation pulses in the Ba River as calculated for the previous scheme design, as both schemes require a peak generation flow of 15m^3/s. There is however, the potential for some daily pulsing/variation of peak generation flows.

Catchment specific flows have been derived from the mapping of the Ba River catchment into individual (major) sub-catchments. The resulting estimated flow contribution from sub-catchments of the Ba River is shown in Table 4-4.

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Table 4-4 Percentage of Flow Contribution to Ba River of Headwater Catchments.

River location	Distance downstream (km)	Sub-catchment area (km^2)	Mean rainfall (m)	Percentage of flow contribution to river (%)
Ba at Power house	0	44.12	2.5	100
				100
Ba at Aurata Ck confluence	7.87	73.18	2.5	37.6
Ba at Nahara Ck confluence	16.08	195.64	2.4	14.5
Ba at Navala	23.75	93.66	2.3	11.3
Ba at Huniku Ck confluence	28.68	58.15	2.3	9.9
Ba at Nalaga	62.03	474.16	2.1	5.2

The impact on the median flows of the Ba River, from median flows from the power house is shown in Table 4-5. The natural median flows for the Ba River have been derived from catchment specific discharges as shown in Table 4-4 and are approximate only, as they are based on the synthetically derived flow at the Ba power house site in the first instance. Thus it should be noted that the median flows derived in Table 4-5 are independent of flow variability and timing within sub-catchments, and only represent a generalised median flow regime based on the calculated catchment specific discharges.

Table 4-5 Estimated Percentage Increase in Median Flow in the Ba River for Median Power Station Discharge.

River location	Distance downstream (km)	Median flow (m^3/s)	Resulting median flow (m^3/s)	Resulting percentage increase from natural median flow (%)
Ba at Power house	0	1.03	2.82	173.8
Ba at Aurata Ck confluence	7.87	2.74	4.53	65.3
Ba at Nahara Ck confluence	16.08	7.12	8.91	25.1
Ba at Navala	23.75	9.13	10.92	19.9
Ba at Huniku Ck confluence	28.68	10.38	12.17	17.2
Ba at Nalaga	62.03	19.69	21.48	9.1

The resulting median flows in the Ba River from the operation of the proposed Nadarivatu scheme will not be significantly different to that of the original scheme, with a resulting percentage increase in median flow at Nalaga of 9.1%.

In order to describe the maximum possible impact on flows in the Ba River, Table 4-6 shows the percentage increase in median river flows as a result of a maximum power house discharge of 15m^3/s.

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Table 4-6 Estimated Percentage Increase In Ba River Median Flow For A $15m^3/S$ Power House Discharge.

River location	Distance downstream (km)	Median flow (m^3/s)	Resulting flow (m^3/s)	Resulting percentage increase from natural median flow (%)
Ba at Power house	0	1.03	16.03	1456.3
Ba at Aurata Ck confluence	7.87	2.74	17.74	547.4
Ba at Nahara Ck confluence	16.08	7.12	22.12	210.6
Ba at Navala	23.75	9.13	24.13	164.3
Ba at Huniku Ck confluence	28.68	10.38	25.38	144.5
Ba at Nalaga	62.03	19.69	34.69	76.2

Table 4-6 shows that for a $15m^3/s$ maximum discharge to the Ba River at the proposed power house location, the Navala Village approximately 24km downstream, could potentially see a 200% increase in median river flow. Overall, in the Ba River at Nalaga (62km downstream), there is potential for median flow to double if the scheme is operated continuously at full capacity for an extended duration. These data indicate that there will be no significant changes resulting from the proposed scheme to that calculated for the previous scheme.

Because the scheme is 'run of river' due to limited storage, the worst case scenario described above will not occur often, as maximum power station discharges are likely to occur during high flows or receding flows in the Ba River, where extra flow in the river will have less effect.

The potential impact of maximum discharge from the Ba power house on the rise in river stage and the timing of a $15m^3/s$ generation "pulse" down the Ba River is shown in Table 4-7.

Table 4-7 Estimated Flow Travel Times, Lag Times, Flow Depths And Rate Of Rise At Specified Sites, For A $15m^3/S$ Power Station Discharge.

River location	Distance downstream (km)	Travel time for flow pulse (hrs)	Lag time for full effect of pulse (minutes)	Total rise (m)	Rate of rise (m/hr)
Ba at Power house	0	0	151	0.33	1.32
Ba at Aurata Ck confluence	7.87	1.41	24	0.35	0.90
Ba at Nahara Ck confluence	16.08	3.04	33	0.33	0.60
Ba at Navala	23.75	4.99	45	0.35	0.47
Ba at Huniku Ck confluence	28.68	6.72	55	0.34	0.37
Ba at Nalaga	62.03	23.88	158	0.35	0.13

[1] allows for a 15 minute ramping of flow at the Power Station

Flow velocities for the $15m^3/s$ discharge have been derived by Manning's equation, in conjunction with the scaling of river widths and elevations from the 1:250,000 topographical map of Fiji. Time lag for the full effect of the 15m^3/s flow pulse has been estimated at 10% of the total travel time between specified sites.

Table 4-7 shows that the effect of the flow pulse would not occur at the Navala Village (approx. 24km downstream of the Ba power house) until about 5 hours after the discharge commenced. The predicted total water level rise is generally above 0.33m for the discharge. However, at rates of rise less than 2 m/hour, the water level rise should not pose any threat to in-stream water users. There is ample time in most cases (at rates below 2 m/hour) for recreational users of the river to be aware of an increase in flow, and enable safe exit of the river as appropriate. At the Ba power house, much sharper rises may be experienced, and at this site, suitable measures may be taken to warn river users of flow variability.

4.2.6 Impact on Riparian Groundwater Levels in the Ba Catchment

Inspection of the 1:250,000 topographical map of Fiji has shown potential riparian aquifers located adjacent to the Ba River downstream of Hiniku Creek confluence (28.7km downstream of the Ba River discharge point). These riparian aquifers are likely to show effects of any long-term increase in flow by a maximum corresponding increase in the water table level adjacent to the river. This maximum increase in water table level also assumes a direct connection between the aquifer and the river.

Changes to flow contribution for the Nadarivatu scheme (Table 4-7) at Hiniku Creek confluence is for an increase in median flow of approximately 1.79m^3/s, for a natural median flow of 10.38m^3/s. Based on River geomorphology changes indicated in Table 4-7 the net (maximum) increase in adjacent riparian water tables would be of the order of 40 mm downstream of Hiniku Creek confluence at median flow.

4.3 Geology, Soils, Land Use and Land Cover

The significant change from the Final EIA, May 2005, is that there will no longer be any effects on land use and land cover from the inundation of land behind the dam in the Qaliwana catchment.

4.4 Terrestrial Ecology

The significant change from the original EIA is that there will no longer be ecological impacts from the inundation of the forest and riverine cliff habitats in the Qaliwana / Nadala valleys behind the dam in the Qaliwana catchment.

The proposed weir impoundment is unlikely to have any significant adverse effects on terrestrial flora or fauna, because of the small footprint.

4.5 Changes to Natural Sediment Regime in the Sigatoka Catchment

Sediment flux at low flows for the catchment is estimated to be relatively low, with an average suspended solids concentration of 2.2 milligrams per litre (mg/L). This equates to a daily mass of 1127 kilograms (kg) and 373kg for the mean and median flow of 5,930 and 1,960 L/s respectively. The modification of the low to medium flows will result in less sediment flux in that flow range being discharged below the weir. Based on Monasavu scheme results, the sediment flux will typically be marginally reduced or remain similar to conditions at present.

Higher flows in the upper Sigatoka catchment from the combined Qaliwana and Nukunuku Streams may yield up to 2,200T/day of sediment, based on a maximum average daily flow of 268m^3/s and suspended solids concentration of 95 mg/L from monitoring data. At higher flows and hence higher sediment flux, the weir would be "flushed" minimising sediment build up.

Reservoir flushing and sluicing is expected to be carried out during flood events greater than approximately 40m^3/s and at least six times per year (average flood event of 90m^3/s). The duration is expected to be approximately 16 hours per event.

It is unlikely that during flood events, any measurable impact of sediment quality will occur during flushing of the weir. The overall sediment flux and transport mechanisms will be similar to larger floods. However, for low to medium flows and minor freshes, modification of sediment flux through the weir will reduce the sediment in the outgoing stream flow.

To mitigate these effects the scheme construction, including the Korolevu Weir, and effective operation of the weir and water take from the upper Sigatoka River catchment, shall include the following provisions:

- During construction of the weir and associated infrastructure there will be suitable containment of out of river spoil areas and in-river construction areas to prevent excessive runoff of sediments to the stream. Bunding and diversion of stream flow during weir construction will ensure that the natural flow / sediment regime should remain unaffected.
- Monitoring of sediment quality above, at and below the weir will be undertaken on a six monthly basis during construction and operation of the scheme.
- The weir sediment sluicing shall coincide with a suitable river input flow of at least 40,000 L/s. This is approximately the 99th percentile flow, which occurs on average, about 4 days (in duration) per year, and would provide sufficient flushing flows and allow suitable sediment re-distribution below the weir.

4.6 Surface Water Quality and Ecology

4.6.1 Introduction

The nature of potential impacts is the same as those identified for the previous scheme and described in SKM (2005a), however the location and scale of impacts will change. Any significant differences are described below, and relate to:

- Construction impacts.
- Operational impacts (Sigatoka and Ba catchments).

4.6.2 Construction Impacts

The potential impacts associated with increased sediment loads in water bodies are well documented (refer to SKM 2005b). Sediment can affect habitat and aquatic organisms while in suspension in the water and as deposited material on the streambed and banks. For further detail on potential construction impacts refer to SKM (2005a).

Overall, no additional potential impacts relating to construction activity have been identified over and above those identified for the previously consented scheme. The potential for construction impacts has been reduced as there are fewer work areas and the duration of the construction period has been reduced.

4.6.3 Operational Impacts

4.6.3.1 Qaliwana Creek

The potential impacts associated with the operation of water retention structures are well documented and are referenced and described in SKM (2005a). The key potential impacts following construction and the subsequent operation relate to changes in:

- Water quality within the water body behind the water retention structure itself and, as a consequence, the downstream water quality.
- Ecology within the water body behind the structure and downstream including fish and macroinvertebrate communities.
- Direct loss of habitat beneath the footprint of the weir and associated infrastructure, and the upstream area inundated by the water body.

Water Quality

The potential impacts on water quality of the currently proposed weir are expected to be less than that compared with the previously consented scheme for a number of reasons as follows:

- The residence time of water behind the weir will be shorter with a considerably smaller (96% less) storage capacity than the previously consented scheme (244,000m^3 compared with 6,000,000m^3). With a reduction in the height of the weir (from 60m for the previously

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consented dam to 21.5m) the holding lake at full capacity will cover 83% less area compared with the previously consented scheme (i.e., 1.6 ha compared with 9 ha respectively).

- The water body behind the weir when full will not be typically deep over its length and will be long and narrow, stretching up the Nukunuku and Qaliwana Creeks. However, compared with the previously consented dam the water body will not be as deep (maximum water depth will be 19-20m compared with 43m with the previously consented scheme) and will not extend as far upstream for the minimum and maximum operating levels, and the one in 100,000 year flood level (see Table 4-8 for further detail).
- It is anticipated that it will be full for approximately 8% of the time (at an inflow to the lake of $15.2m^3/s$) and when it is full it will not exceed existing flood levels. Because of the highly variable lake levels and potentially rapid draw down times it is therefore unlikely that the water within the reservoir will become stratified resulting in anoxic conditions. The potential changes in water chemistry, identified in SKM (2005a), that could affect downstream conditions are therefore unlikely to occur.
- A residual flow of $0.2m^3/s$ will be maintained downstream of the weir. Note that for 96% of flow durations, the flow at the new proposed weir location is greater for the previously consented scheme (see Figure 4-2) due to the increase in available catchment between locations.
- Sluicing of sediments behind the weir will be timed to coincide with the tail end of floods when sediment loads are naturally high.

Table 4-8 Comparison of Estimated Upstream Extent (km) of Water Bodies Behind the Current Proposed Weir and the Original Dam.

Watercourse	Type	Current Proposed Weir[1]	Original Dam
Nukunuku Creek	Minimum	0.33	-
	Maximum	0.39	-
	1 in 100,000 yr	0.53	-
Nadala Creek	Minimum	-	0.50
	Maximum	-	1.05
	1 in 100,000 yr	-	1.07
Qaliwana Creek	Minimum	0.94	1.25
	Maximum	1.13	3.15
	1 in 100,000 yr	1.54	3.25

Notes: [1] RLs are 517.5m, 521.5m and 530m for the minimum and maximum operating levels, and the one in 100,000 year flood level.

Ecology

The potential changes relate to the creation of a new water body behind the weir and the impacts of the existing biological communities downstream of the dam following the changes in the hydrological regime. The biological characteristics of the new water body will be highly variable due to the fact that the water levels will vary so dramatically over short periods of time due to the limited storage capacity.

The potential impacts on aquatic ecology of the currently proposed weir (as described in SKM 2005a) are expected to be different to the previously consented scheme for a number of reasons as follows:

- Below the weir it is possible that benthic algae or periphyton cover will be more prolific as flows at this point for the previously consented scheme would have been greater. However, flood flows below the weir are expected to be larger creating greater potential for the removal of nuisance algae growths.
- Greater reduction of instream habitat for macroinvertebrate colonisation and fish below the weir due to a reduction in wetted channel area particularly along the varial zone (river channel edge). Note that below the original Nadarivatu Dam there would have been a greater reduction in wetted channel area as a result of the proposed 0.1m^3s residual discharge.
- It is likely that ecological impacts will extend for some kilometres downstream. Table 4-2 presents a comparison of median flows for the current proposed weir with the previously consented scheme for distance downstream on the Sigatoka River. It is not until Jauvakarua, 21km downstream, that flows return to similar levels to that which would have been experienced with the previously consented scheme, a difference of 5.6% compared with natural median flows.

A number of mitigation measures will be documented in the Operational Environmental Management Plan and the Environmental Monitoring Plan[5] to assist in minimising the impacts of the weir on the downstream aquatic environment. In addition, it is anticipated that the potential impacts will be minimised due to the following factors:

- A flow of 0.2m^3/s will be maintained as a residual discharge (unless flows are less than this entering the weir) for 90% of the time (the discharge will be greater for higher input flows above 15.2m^3/s). It is anticipated that this flow should be sufficient to maintain the ecological communities that currently exist downstream.
- The fish fauna in the Qaliwana Creek is particularly depauperate.
- The habitat supporting macroinvertebrate communities at sites located above and below the weir structure is limited and the communities present are not considered to be particularly sensitive to changes in water quality. No species of any particular ecological concern were identified.

[5] An updated Environmental Monitoring Plan to the original EIA is provided in Appendix F.

- Due to the flashiness of the existing flows (80% of flows are below 8.1m3s), existing habitat for macroinvertebrates in the varial zone is expected to be limited.

Direct Loss of Habitat

The weir and spillway structures will occupy a smaller area of stream channel and banks (approximately 0.2 ha) compared with the previously consented dam and weir structures (0.5 ha). The habitat lost consists primarily of several large pools which apart from potentially providing habitat for fish, is not considered to be a very productive part of the creek. Given the amount of pool habitat available further downstream, the loss of habitat is minor and is not considered to be significant overall.

4.6.3.2 Ba River

The key potential impacts relating to the discharge of the water discharged to the Ba River relate to changes in the following:

- Water quality due to the introduction of water from the adjacent catchments and the increase in flows.
- Stream ecology including fish and macroinvertebrate communities due to the potential changes in water quality and the introduction of water from adjacent catchments.

These are addressed in further detail below.

Water Quality

The potential physical and chemical changes in water quality that could occur downstream of the discharge from the power station are dependent on:

- The quality of water stored behind the weir, entering from Nukunuku and Qaliwana Creeks, and in the Ba River at the time of the discharge.
- The amount of fine material deposited downstream of the power station at the time of discharge.

Overall, the potential impacts relating to changes in water quality are anticipated to be minimal and not significantly different to the previously consented scheme.

Ecology

As described in SKM (2005a), the extent of the hydrological influence in the Ba River will be significant during receding and median river flows and maximum scheme discharge flows. The potential impacts relate to the increase in flow and the possible changes in water quality downstream of the discharge. The hydrological assessment concluded that there will be a slight increase in flow for the low to medium flows for the current proposed scheme compared with the previously consented scheme. However higher flows will be less.

The key potential impacts on the Ba River system as a result of the discharge are described in SKM (2005a). Overall, the potential effects are expected to not be significantly different. A number of mitigation measures are proposed to assist in minimising the impacts of the dam on the downstream aquatic environment.

4.7 Tunnel Construction and Dewatering

The impacts at the Buya Buya tunnelling location will remain the same. The impacts from tunnelling at the Lewa location will be removed.

4.8 Roading / Access

No changes from the original scheme, except for the location changes as shown on the drawings in Appendix B.

4.9 Air Quality and Carbon Emissions

The only change to the air quality section of the original scheme EIA is that there will be a reduction in impacts from no burning of rubbish.

Note that the project will displace the air emissions of approximately 22,000T of diesel per annum, and approximately 66,000 T of CO_2 per annum. This is based on the following:

- 0.22T diesel per MWh.
- 0.656 T CO2 per MWh for diesel generators in Fiji.
- 101MWh.

This is a reduction in the displacement of fossil fuel use and resultant carbon emissions from the original scheme, which was:

- 26,400 T diesel per annum.
- 78,000T CO_2 per annum.

4.10 Visual Amenity

The significant change from the original EIA is that the dam and road will no longer change the visual nature of the Qaliwana valley.

4.11 Archaeological and Historic Impacts

There will no longer be a threat to archaeological or historical sites as a result of the change in the scheme.

4.12 Social Impacts

The social impacts (negative and positive) will remain similar in nature, however the scale will be reduced. Key changes from the previous scheme include:

- No flooding of forestry.
- Reduction in migrant workers into the area, for a shorter duration (the construction period will be reduced).
- Reduction in employment opportunities, but the total number of jobs will remain significant for locals wanting income.
- One worker's camp instead of two.
- Instream uses in the Sigatoka catchment will be affected in a similar manner, but will occur approximately 5km further downstream compared to the original scheme.
- There will be no reservoir in which to fish, compared to the original scheme.

All other impacts will remain the same.

4.13 Summary

In this section, a number of potential impacts of the proposed scheme have been identified and compared to those from the original scheme. Overall the nature of the effects would be similar, although the scale may be reduced in many cases. In summary:

- Sedimentation effects on aquatic ecology as a result of sediment discharges from earthworks in and around the rivers will remain, but will be reduced in scale.
- Disturbance and loss of terrestrial ecology under the Nadarivatu Dam and Lake is no longer an impact.
- The diversion of water from the Qaliwana and Nukunuku Creeks will create uniformly low river flows downstream in the Sigatoka River, similar in scale to the previous scheme.
- Changes to downstream ecosystems and fish populations in the Sigatoka River as a result of the change in flow and the weir structure, similar in scale to the previous scheme.
- Changes to Ba River flow during some scenarios, affecting fording and other river uses downstream, but providing improved fish habitat, similar in scale to the previous scheme.
- Disturbance to traditional village life, and in particular to Buya Buya Village, during construction as a result of the works and influx of workers to the district. These effects are likely to be reduced in scale due to the reduced construction period and the reduction in the number of workers and workers' camps.

Table 4-9 highlights the potential significant effects from the original scheme with those of the proposed scheme.

SKM

Table 4-9 Comparison of Significant Environmental Impacts

Potential Significant Environmental Impacts – Original Nadarivatu Scheme EIA	Comparative Impact Assessment – Proposed Nadarivatu Scheme
Social impacts during construction and operation – at the project site and downstream in the Ba and Sigatoka catchments.	Similar impacts predicted, although reduction in number of workers, duration of construction period, reduction in workers camps (one camp rather than two), and spatial extent of work areas.
The hydropower scheme avoids approximately 78,000T of CO_2 annually by displacing diesel.	The hydropower scheme avoids approximately 66,000T of CO_2 annually by displacing diesel.
Resettlement of villages, agricultural and commercial land uses.	No change. The hydropower scheme avoids the displacement of communities and land of agricultural or commercial value.
Vulnerable and threatened status of the masked shining parrot, giant honey eater and the samoan flying fox.	Reduced risk to bird and bat species.
Reduction of flow in the Sigatoka River leading to a change in aquatic habitat. This could impact on species populations and range.	Similar impacts, now further downstream in the Sigatoka catchment.
Increase in flow in the Ba River creating erosion potential.	Similar impacts.
Sediment discharges to surface water courses.	Similar impacts, although reduced in scale due to reduction in duration of construction period and size and number of work areas.
Change in river ecology due to changes in flow.	Similar impacts, now further downstream in the Sigatoka catchment.
Dam impeding fish passage.	Provision of a pool at the downstream base of the weir to allow for fish transfers from the base to the lake.
Loss of vegetation in the inundation zone.	Very little loss of vegetation overall, due to small inundation zone of cliff environments behind the weir.
Archaeological sites damaged or flooded at Lewa.	No threat to archaeological sites at Lewa.

5. Mitigation and Abatement Measures

5.1 Introduction

Mitigation and abatement measures are proposed in this section as follows:

- Environmental Management Plans – for construction and operation, including monitoring plans. These will remain as proposed in the original EIA.
- Hydrological controls on the scheme – during construction and operation. Some changes have been made compared to the original EIA.
- Water quality and ecology monitoring – during construction and operation. Minor changes compared to the original EIA (including location and number of monitoring sites).
- Terrestrial ecosystem monitoring during construction. Removal of monitoring requirements due to reduction in risk.

No other changes are proposed compared to the original EIA.

The updated Environmental Monitoring Plan is provided in Appendix F.

5.2 Management Plans

The original scope for the Environmental Management Plans was provided in Appendix F of the original EIA (SKM 2005b). These plans are still valid as the key mitigation tool for SEL.

- **Environmental Management Plan.** This is the overriding document that sets out the principles to be applied to the project. From this cascades the following three plans.
- **Construction Environmental Management Plans.** These control the adverse impacts associated with earthworking activities.
- **Site Operation Plans.** These outline the operations controls on various aspects of the project including traffic management, noise and vibration management and operation of the workers camps.
- **Operational Environmental Management Plan.** Mitigation measures during operation of the power scheme.
- **Environmental Monitoring Plans**. These set out the ongoing monitoring required before during and after the construction to assess the impacts of the scheme.

5.3 Hydrology

The proposed Nadarivatu scheme construction and operation shall consider the following provisions for control of catchment hydrology, and any requirements for compliance of proposed minimum flows and discharges to natural water.

5.3.1 Sigatoka Catchment

The scheme shall include the following provisions:

- During weir construction there shall be suitable by-pass of Qaliwana and Nukunuku Creek flow i.e. the natural flow regime should be unaffected by the construction of the weir.
- Post weir construction and during initial filling of the weir, suitable provision via sluice gates shall enable a minimum of 200 L/s flow continuation to the Sigatoka River below the weir, at catchment input flows of 200 L/s and above.
- The sluice gates shall be in operation over the full range of weir storage, and shall provide 200 L/s to the river as a continuous residual flow when applicable.
- Monitoring of catchment input flow to the weir, and residual flow released, shall be provided by continuous measurement / recording. Residual flows released shall be reduced in conjunction with monitored input flow to the weir.
- Provision is to be made for suitable release of flood flows down the river.
- The take of water from the weir for scheme operation shall be up to 15000 L/s.

5.3.2 Ba Catchment

The effective operation of the Nadarivatu 2 Power Station discharge to the Ba River shall include the following provisions:

- The discharge of water to the Ba River for scheme operation shall be up to 15000 L/s.
- Flow from the Nadarivatu 2 Power Station to the Ba River shall be ramped up and down at a rate no greater than 1000 L/s flow per minute, to avoid unnecessary sediment transport during median – mean flows, and to avoid sudden loss of habitat from stream flow reduction.
- Appropriate early warning system in place at Ba Power house to warn of impending hydropower discharges to the Ba River.
- Sediment concentrations from the Ba power station should remain below 17mg/L for Ba River flows at / or below the natural mean (estimated at 2822 L/s).

Monitoring prior to, during and after power scheme construction should provide for compliance and operational requirements.

Proposed automated river flow monitoring at the following project sites:

- Qaliwana River at Bulu – currently operating.
- Ba River at below Ba power house – new.

Proposed automated river flow monitoring stations downstream in each river:

- Sigatoka at Korovouiti (10 – 12km downstream).
- Ba at Nivala (8 - 10km downstream).

Survey cross-sections on the Ba River are to be confirmed / completed at: Ba, Koro, Becamoui, Cuave, Nivala and Toge.

Survey cross sections on the Sigatoka River are to be confirmed / completed at least six locations downstream.

5.4 Surface Water Quality and Ecology

Minor changes to proposed sampling sites compared to the original EIA, as described in the Environmental Monitoring Plan in Appendix F.

5.5 Terrestrial Ecology

No monitoring or restrictions on timing of work is now required, as the proposed disturbances to bird and bat habitat is of a lesser scale than the original scheme. It is recommended that the Environmental Approval be changed to accommodate this reduction in risk.

5.6 Air Quality

No change to proposed mitigation measures in the original EIA.

5.7 Archaeological and Historic Impacts

No change to proposed mitigation measures in the original EIA.

5.8 Economic

No change to proposed mitigation measures in the original EIA.

5.9 Social Impacts

No change to proposed mitigation measures in the original EIA.

5.10 Workers Camps

No change to proposed mitigation measures in the original EIA.

6. Proposed Variations to the Environmental Approval

Proposed changes to the conditions of the Environmental Approval, dated 25 July 2005, from the Department of Environment, are listed in this section. **Bold and underlined** highlighting is used to indicate a proposed addition, and [*brackets and italics*] are used to indicate a proposed deletion.

1) All work shall be carried out in accordance with the following documents that have been approved by the Director, Department of Environment, and any subsequent amendments submitted to, and approved by, the Director of Environment:

- Nadarivatu Hydropower Project EIA (Final). May 2005. SKM.
- Nadarivatu Hydropower Project Appendices. (Final). May 2005. SKM.
- Nadarivatu Hydropower Project Supplementary Report 1 to the EIA. July 2005. SKM.
- **Nadarivatu Hydropower Project Supplementary Report to the EIA Report 2. September 2006. SKM.**
- [*Nadarivatu Hydropower Project. Information for EIA. Final. July 2005. Montgomery Watson Harza.*]

2) Construction Environmental Management Plan (CEMP)

Submit a CEMP (at least one month) … [*The CEMP shall as a minimum provide a clear strategy for the preservation and protection of engendered / threatened terrestrial flora and fauna such as the giant forest honeyeater and the shining masked parrot and other tree species.*] The CEMP….

Appendix 2 (OEMP)

a. ….
b. Maximum water abstraction rates from the [*Nadarivatu reservoir and*] **Korolevu** weir
c. Management of water levels in the [*Nadarivatu reservoir*] **Korolevu weir**
d. Management of flood flows and low flows into [*Nadarivatu reservoir*] **Korolevu weir**
e. Minimum flow regimes from [*Nadarivatu dam*] **Korolevu weir**
f. Desilting of the [*Nadarivatu dam*] **Korolevu weir**
g. [*Operation of the desander at Nadarivatu weir*]
h. …
k. River channel surveys in the Ba River **and the Sigatoka River**
l. Monitoring water quality and aquatic environments in the Sigatoka and Ba Rivers, [*and the Nadarivatu reservoir*]
m. …

7. Conclusions

The Nadarivatu Hydropower Project is part of a programme of developments being undertaken by Sustainable Energy Limited, a joint venture company between the Fiji Electricity Authority and Pacific Hydro Limited. Renewable energy is seen as a key source of future power for Fiji.

The Department of Environment issued an Environmental Approval to the original Nadarivatu scheme in July 2005. The scheme has now been changed and this EIA report provides the supporting information for Sustainable Energy Limited to apply for a change to the original Environmental Approval.

The project still involves diverting headwaters from the Sigatoka River to the Ba River, within the upland Nadrau Plateau of Viti Levu. Instead of a dam in the Qaliwana and Nadala Creeks and a weir in the Nukunuku Creek providing water to two power stations with a combined capacity of 54MW, the scheme has been changed to one weir at the confluence of the Qaliwana and Nukunuku Creeks providing up to $15m^3/s$ to a 44MW power house at the Buya Buya Village on the banks of the Ba River.

The development of this renewable energy source has a number of benefits for Fiji, these include:

- The project represents an opportunity for Fiji to reduce its reliance on imported fossil fuels and develop a more sustainable long-term power generation strategy.
- The annual replacement of diesel fuel and reduction in CO_2 emissions.
- Industry and other development in Fiji will benefit by ensuring power supplies are more consistent.
- Temporary employment will be created in the project area with local workers being employed for suitable positions.

A reassessment of the original baseline data was carried out on the revised scheme. The studies covered:

- Terrestrial species and habitats
- Community impacts
- Hydrological modelling of modified flows in the Sigatoka and Ba Rivers
- Archaeological impacts.

An additional round of water quality and instream biomonitoring was carried out.

The EIA process has identified a number of potential impacts of the proposed scheme and compared those to the original scheme. Overall the nature of the effects would be similar, although the scale has reduced in many cases.

The key points to note are:

- Sedimentation effects on aquatic ecology as a result of sediment discharges from earthworks in and around the rivers will remain, but will be reduced in scale.
- Disturbance and loss of terrestrial ecology under the Nadarivatu Dam and Lake is no longer an impact.
- The diversion of water from the Qaliwana and Nukunuku Creeks will create uniformly low river flows downstream in the Sigatoka River, similar in scale to the previous scheme.
- Changes to downstream ecosystems and fish populations in the Sigatoka River as a result of the change in flow and the weir structure, similar in scale to the previous scheme.
- Changes to Ba River flow during some scenarios, affecting fording and other river uses downstream, but providing improved fish habitat, similar in scale to the previous scheme.
- Disturbance to traditional village life, and in particular to Buya Buya Village, during construction as a result of the works and influx of workers to the district. These effects are likely to be reduced in scale due to the reduced construction period and the reduction in the number of workers and workers' camps.
- Displacement of approximately 22,000T of diesel per annum, based on a mean annual output of 101GWh, at a relative diesel consumption rate of 0.22T/MWh. This compares to approximately 26,000T of diesel per annum for the original scheme.
- Displacement of approximately 66,000 T of carbon dioxide (CO_2) per annum, based on the conversion of 0.656T CO_2 / MWh for diesel generators in Fiji. This compares to approximately 78,000T of CO_2 per annum for the original scheme.

Mitigation and management to address these issues has not changed significantly from the original EIA, as the nature of the effects would be similar and the scale of effects in most cases reduced. It is considered that if the actions in Section 5 are implemented then the adverse effects of the project will be minimised. The measures outlined in this Supplementary Report No 2 to the EIA should ensure that the development could proceed and provide a significant benefit to Fiji's power supply and future economic development.

8. References

MWH. 2006. Nadarivatu Hydropower Project Environmental Impact Assessment Scheme Description.

SKM. 2005a. Nadarivatu Hydropower Project EIA (Final).

SKM. 2005b. Nadarivatu Hydropower Project Appendices. (Final).

SKM. 2005c. Nadarivatu Hydropower Project Supplementary Report 1 to the EIA.

Appendix A Environmental Approval

MINISTRY OF LOCAL GOVERNMENT, HOUSING, SQUATTER SETTLEMENT AND ENVIRONMENT

LOCAL GOVERNMENT AND HOUSING
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DEPARTMENT OF ENVIRONMENT
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DEPARTMENT OF TOWN & COUNTRY PLANNING
PO Box 2350, Government Buildings,
Suva.
Telephone: (679) 330 5336
Fax: (679) 330 4840

Fiji FA House, 4 Gladstone Road, Suva, Fiji Islands

OUR REF. NO.: YOUR REF. NO.:

EP 5/1/1

25 July 2005

The Chief Executive Officer
Fiji Electricity Authority
Suva

Attention: Mr. Victor Prasad

Dear Sir

Re: EIA for the Proposed Nadarivatu Hydropower Project

With reference to the above-mentioned subject we wish to inform you that we have found the EIA report to be satisfactory, subject to the following conditions:

1. All work shall be carried out in accordance with the following documents that have been approved by the Director, Department of Environment, and any subsequent amendments submitted to, and approved by the Director of Environment:
   - Nadarivatu Hydropower Project EIA (Final). May 2005- SKM.
   - Nadarivatu Hydropower Project Appendices (Final). May 2005- SKM.
   - Nadarivatu Hydropower Project Supplementary Report1 to the Final. July 2005- SKM.
   - Nadarivatu Hydropower Project. Information for EIA. Final. July 2005- Montgomery Watson Harza.

2. **Construction Environment Management Plan (CEMP)**
   Submit a CEMP (at least one month prior to commencement of any phase of construction) to the Department of Environment and Tavua Rural Local Authority for approval. Refer to appendix 1 for issues to be covered under CEMP. The CEMP shall as a minimum provide a clear strategy for the preservation and protection of endangered/ threatened terrestrial flora and fauna such as

the giant forest honeyeater and the shining masked parrot and other tree species. The CEMP may be submitted in stages that correlate to the construction phase or for specific construction activities, such as roading, tunnel construction etc.

3. **Operation Environment Management Plan (OEMP)**
   Submit an OEMP (at least one month prior to commencement of any phase of operation) to the Department of Environment and Tavua Rural Local Authority for approval. Refer to appendix 2 for issues to be covered under OEMP.

4. There shall be no on site incineration.

5. Any treated wastewater used for irrigation purposes shall be done so at least 100m away from any watercourse.

6. Development in or around areas with archaeological/ historical sites shall be carried out at the written consent of the Fiji Museum.

7. The villagers shall be made aware of the traffic impacts and all practicable measures shall be undertaken to avoid traffic related accidents.

8. The proponent shall ensure that the villagers adjacent to Ba River are educated through workshops etc about the changing water level so as to avoid any mishap. Appropriate signage in the main three languages shall be placed in the affected areas for this purpose as well.

9. All construction sites such as the workers camp shall be rehabilitated to the satisfaction of the Tavua Rural Local Authority and the Department of Environment at the end of construction.

10. The proponent shall take all feasible measures ensure that activities related to the construction and operation of the project will not have any unforeseen adverse effects on community health and safety, community welfare and the environment. However in an event, where it has been proved that there has been significant damage and/or losses to the community and/or environment due to an unforeseen consequence of the hydropower project, the project proponent shall immediately take full responsibility for the damage and/or losses and take all possible measures to remedy for the losses in addition to restoring the site to the satisfaction of the Department of Environment.

11. A monitoring committee shall be formed between SEL, DOE and other government department stakeholders for the purpose of communicating results of environmental monitoring and communications with local villagers during the construction period. The continuation and consultative committee shall be reviewed at the time of commissioning of the plant.

12. A one-stop contact centre shall be set up to deal with issues raised related to the development, including the results and discussions addressed in the EIA report.

For any further information or clarifications please contact the undersigned.

Yours Faithfully

E. Nasome
Director of Environment
For
Chief Executive Officer
Ministry of Local Govt, Housing, Squatter Settlement and Environment

cc: Ms. Pene Burns- SKM
cc: The Director- DTCP

Appendix 1 (CEMP)

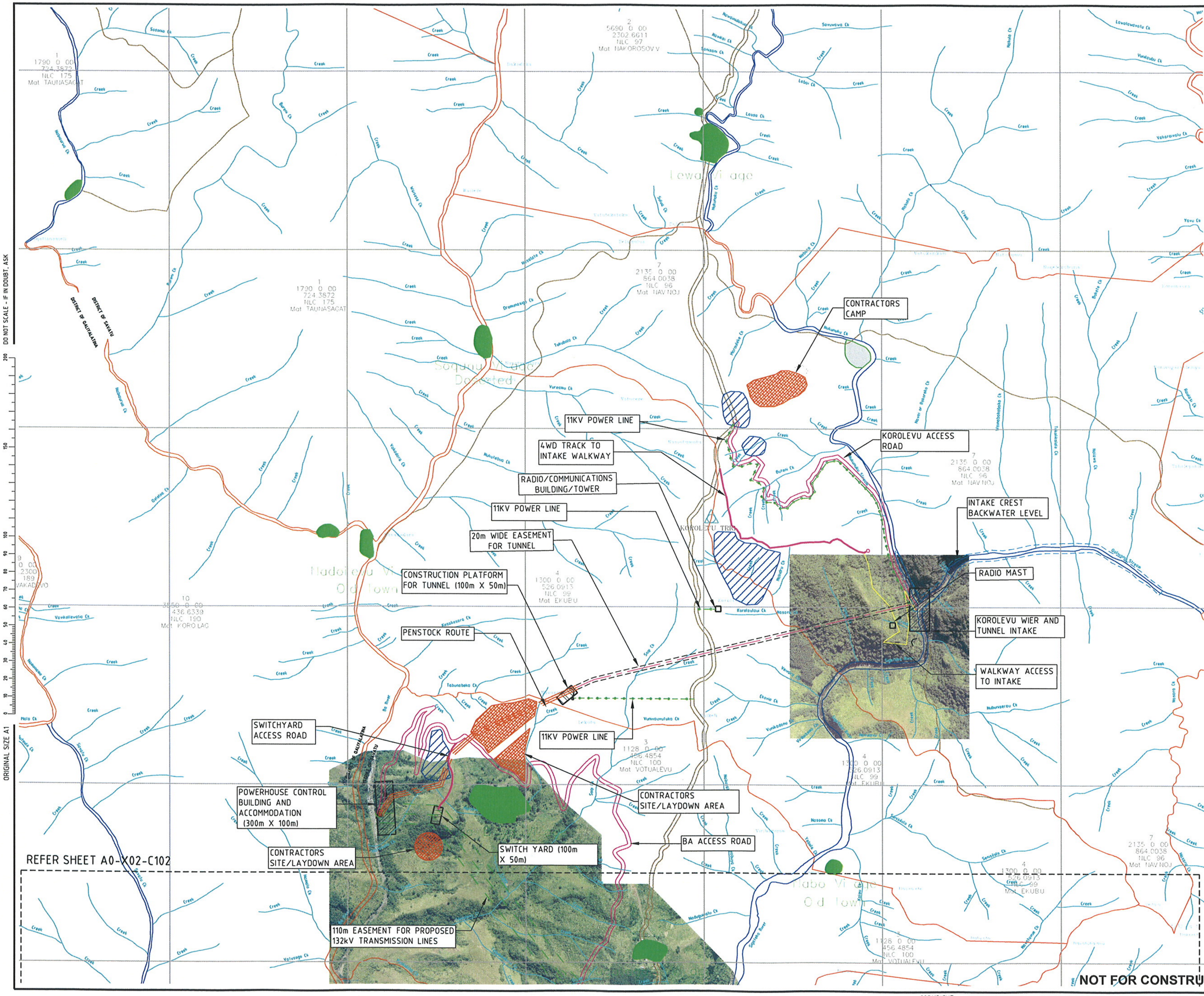
a. Slope stability, stockpile management, works in the river bed, erosion and sediment control measures to minimize sediment laden discharges to water courses.
b. The clearance of vegetation at work sites
c. The management of waste water discharges from tunnel dewatering and concrete manufacture
d. Impacts on water quality and aquatic environments in the Ba and Sigatoka catchments
e. The management of solid waste from work sites and workers camps
f. The treatment and disposal of waste water at the workers camps, including the specifications for the waste water treatment plants and measures to inspect the performance of the plants
g. The supply of water to workers camps and the work areas
h. The management of dust, blasting and noise nuisances
i. Communication with villages within and adjacent to the development areas, and adjacent to the Ba and Sigatoka Rivers up to 10km downstream from the development area. This includes details of the operation of the SEL project contact centre
j. Management and communications of traffic hazards
k. Operational management of the workers camps
l. Hazardous materials and waste handling
m. Complaints register
n. Responsibilities of SEL staff and contractors
o. Monitoring and reporting requirements (including incident reporting to DOE)
p. Emergency response plans
q. Scheme commissioning procedures

Appendix 2 (OEMP)

The Operational EMP shall, as a minimum, prescribe the following operational procedures in accordance with the EIA and supporting documents listed above:

a. Operational regime for the power plant, including ramping up and down of power generation, expected generation over a daily, monthly and annual period
b. Maximum water abstraction rates from the Nadarivatu reservoir and weir
c. Management of water levels in the Nadarivatu reservoir
d. Management of flood flows and low flows into Nadarivatu reservoir
e. Minimum flow regimes from Nadarivatu dam
f. Desilting of the Nadarivatu dam
g. Operation of the desander at Nadarivatu weir
h. Communications with villages within and adjacent to the development areas, and adjacent to the Ba and Sigatoka Rivers up to 10km downstream from the development area. This includes communication methods and messages to warn river users of changes to river flow, and to address issues and concerns as a result of the project.
i. The OEMP shall, as a minimum, prescribe the following methods to avoid, remedy and mitigate environmental and social impacts as a result of scheme operation, in accordance with the EIA and supporting documents listed above:
j. Monitoring of river flows in the Sigatoka and Ba Rivers
k. River channel surveys in the Ba River
l. Monitoring water quality and aquatic environments in the Sigatoka and Ba Rivers, and the Nadarivatu reservoir
m. Surveys of river users to address changes as a result of operations
n. A 2 yearly review of environmental data and assessment of impacts, with subsequent changes to the Operations EMP as required.
o. The Operations EMP shall also include, as minimum:
p. Responsibilities of SEL staff and contractors
q. Reporting requirements (including incident reporting to DOE)
r. Emergency response
s. Complaints register

Appendix B Location Plans



DO NOT SCALE - IF IN DOUBT, ASK

ORIGINAL SIZE A1

LEGEND

- PROPOSED ACCESS ROADS
- PROPOSED TUNNEL ALIGNMENT
- PROPOSED PENSTOCK
- PROPOSED 132KV TRANSMISSION LINES
- PROPOSED CONTRACTORS SITE/LAYDOWN AREA
- PROPOSED STRUCTURE LAND ACQUISITION
- MAXIMUM FLOOD LEVEL FOR QALIWANA RESERVOIR
- POTENTIAL SPOIL DISPOSAL SITE
- POTENTIAL AGGREGATE BORROW SITE
- CADASTRAL ACCESS ROADS
- CADASTRAL CREEKS
- CADASTRAL RIVERS
- CADASTRAL LAND BOUNDARIES
- EXISTING TRANSMISSION LINES

NOTES

1. BOUNDARIES TO BE CONFIRMED AFTER CONSTRUCTION
2. DATE OF CADASTRAL DATA DISPLAYED IS NOT KNOWN BUT IS DATED. IT DOES NOT ALWAYS MATCH CURRENT PHYSICAL LOCATIONS OF VILLAGES, ROADS, RIVERS ETC.
3. BUYA BUYA VILLAGE NOT SHOWN ON CADASTRAL DATA. IT HAS BEEN ADDED FROM INFORMATION ON TOPOGRAPHICAL MAP.

REV	REVISIONS	DRAWN	CHECKED	APPROVED	DATE
A	ISSUED FOR CLIENT CONSENT	GDH	CWP	CWP	04/06

SUSTAINABLE ENERGY LIMITED

NADARIVATU HYDRO POWER SCHEME

PROJECT WIDE LAND PLAN SHEET 1 OF 2

	Name	Date
SURVEYED	--	--
DRAWN	George D Homan	2006-06-26
DRAWING CHECK		
DESIGNED	Chris Pile	2006-06-26
DESIGN CHECK		
APPROVED		

MWH

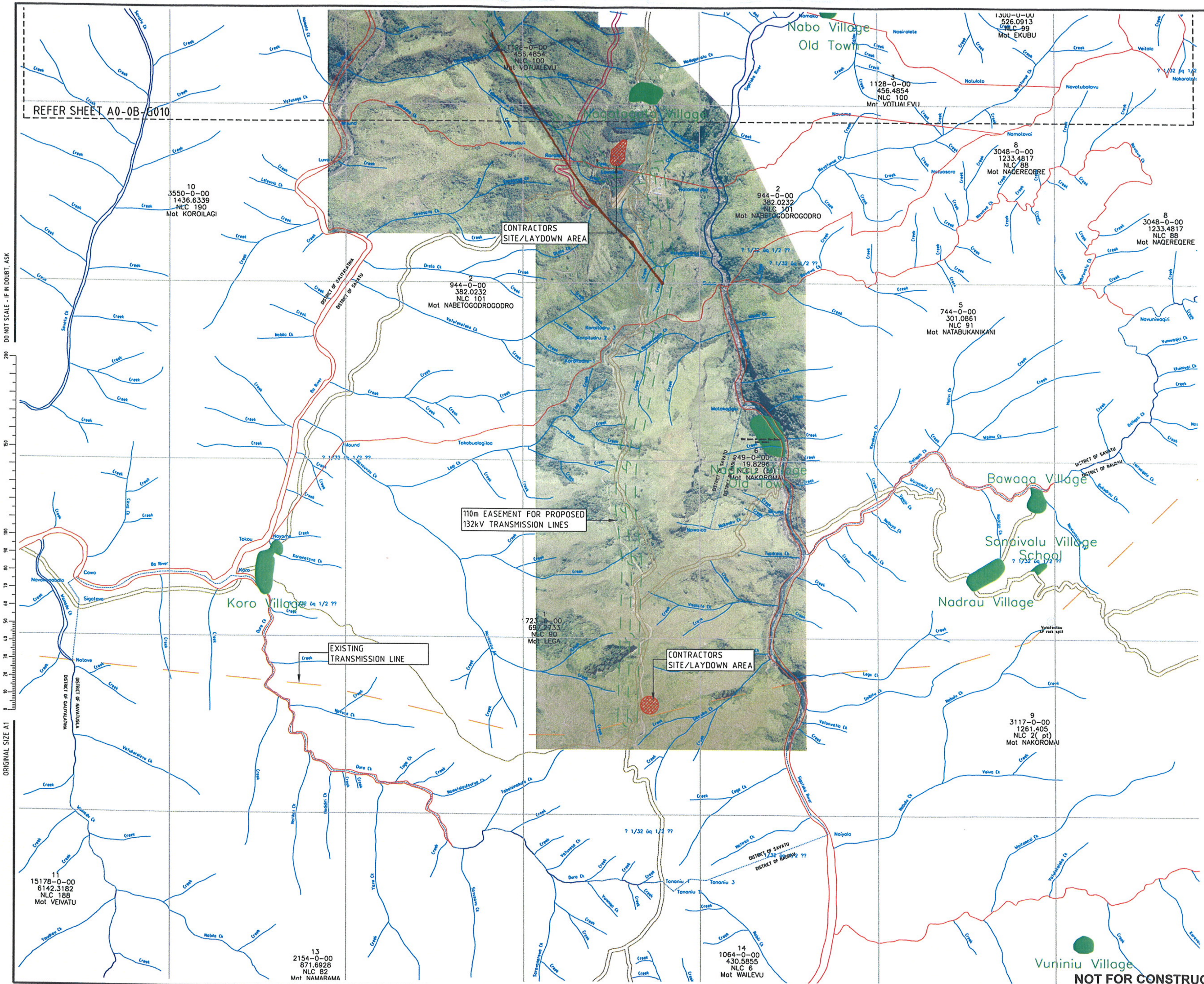
Status Stamp: WORKING PLOT

Date Stamp

SCALES (A1) 1:10000

Job No.	Sheet No.	Revision
Z13309	A0-X02-C101	D

NOT FOR CONSTRUCTION



LEGEND

- PROPOSED ACCESS ROADS
- PROPOSED TUNNEL ALIGNMENT
- PROPOSED PENSTOCK
- PROPOSED 132KV TRANSMISSION LINES
- PROPOSED CONTRACTORS SITE/LAYDOWN AREA
- PROPOSED STRUCTURE LAND ACQUISITION
- MAXIMUM FLOOD LEVEL FOR QALIWANA RESERVOIR
- POTENTIAL SPOIL DISPOSAL SITE
- POTENTIAL AGGREGATE BORROW SITE
- CADASTRAL ACCESS ROADS
- CADASTRAL CREEKS
- CADASTRAL RIVERS
- CADASTRAL LAND BOUNDARIES
- EXISTING TRANSMISSION LINES

NOTES

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REV	REVISIONS	DRAWN	CHECKED	APPROVED	DATE
A	ISSUED FOR CLIENT CONSENT	GDH	CWP	CWP	06/06

SUSTAINABLE ENERGY LIMITED

NADARIVATU HYDRO POWER SCHEME

PROJECT WIDE LAND PLAN SHEET 2 OF 2

	Name	Date
SURVEYED	--	--
DRAWN	George D Homan	2006-06-26
DRAWING CHECK		
DESIGNED	Chris Pile	2006-06-26
DESIGN CHECK		
APPROVED		

MWH

Status Stamp: WORKING PLOT

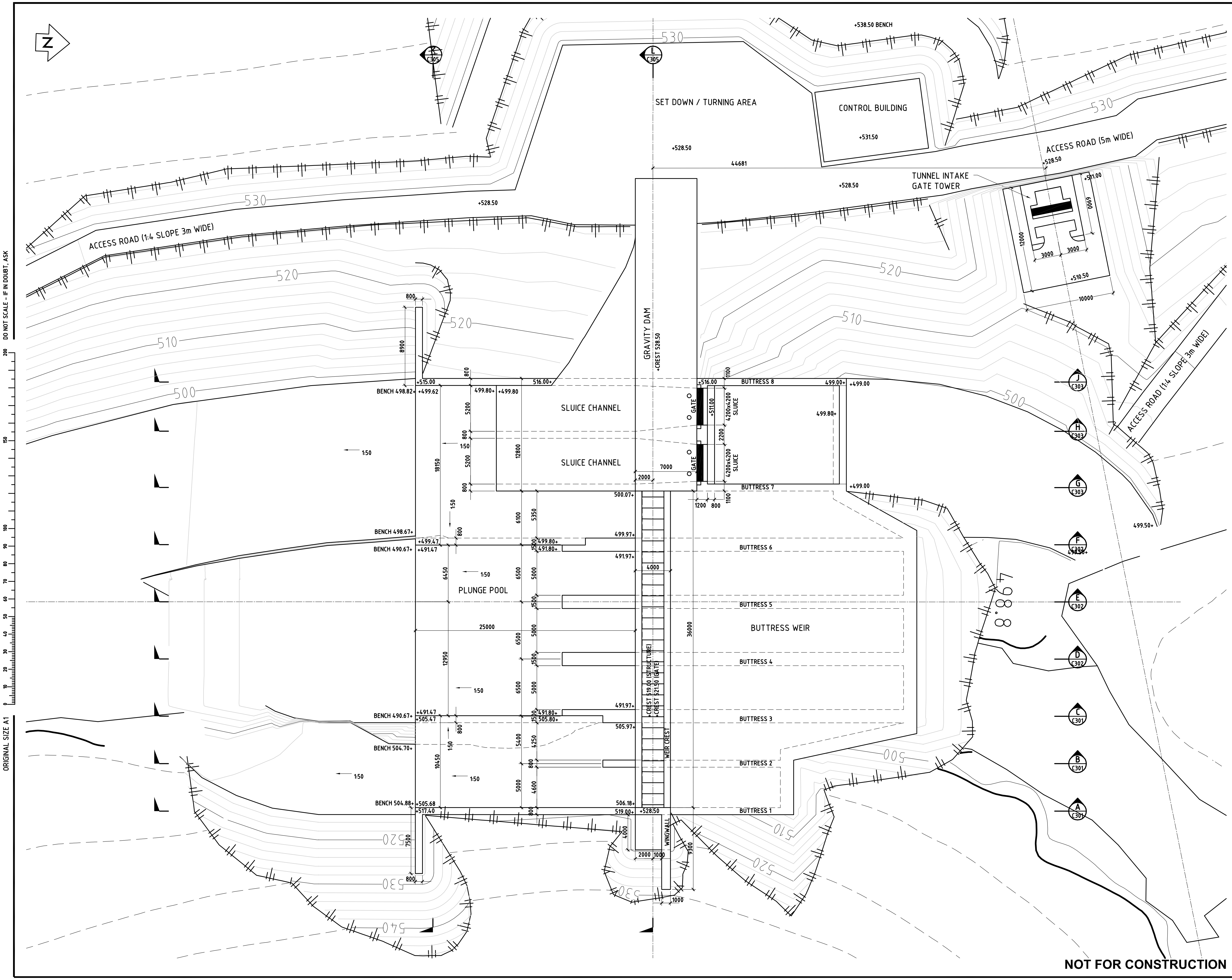
Date Stamp

SCALES (A1) AS SHOWN

Job No.	Sheet No	Revision
Z13309	A0-X02-C102	B

NOT FOR CONSTRUCTION

Appendix C Design Plans



REV	REVISIONS	DRAWN	CHECKED	APPROVED	DATE
A	ISSUED FOR INFORMATION ONLY	GDH		GG	2006-06-28

SUSTAINABLE ENERGY LIMITED

NADARIVATU HYDRO POWER SCHEME

KOROLEVU WEIR GENERAL ARRANGEMENT PLAN

	Name	Date
DRAWN	Richard Houghton	2006-07-11
DRAWING CHECK		
DESIGNED	Ross Cleeton	
DESIGN CHECK		
REVIEWED		
APPROVED		

MWH

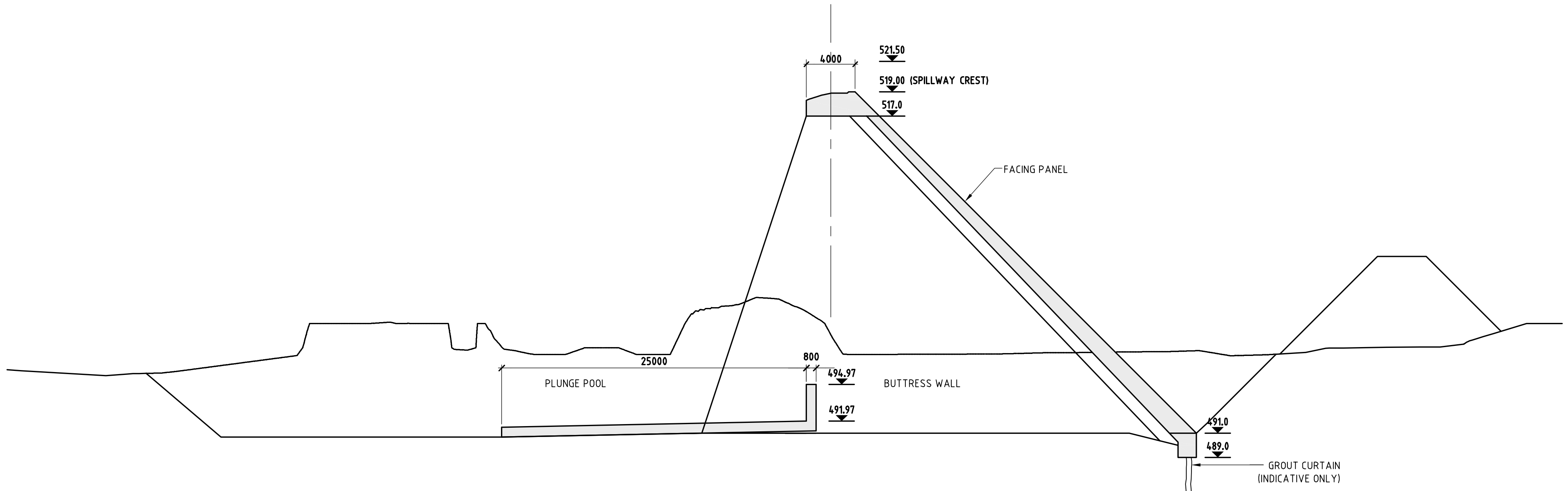
Status Stamp: WORKING PLOT

Date Stamp

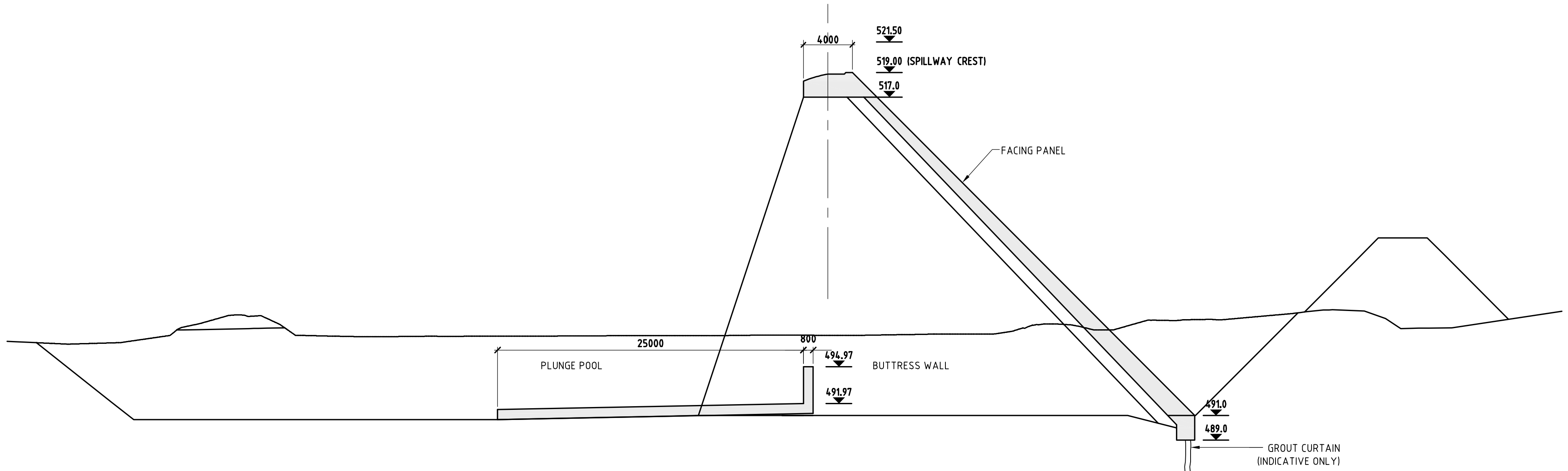
SCALES (A1) 1:200

Job No.	Sheet No.	Revision
Z13309	K0-LNC-C300	A

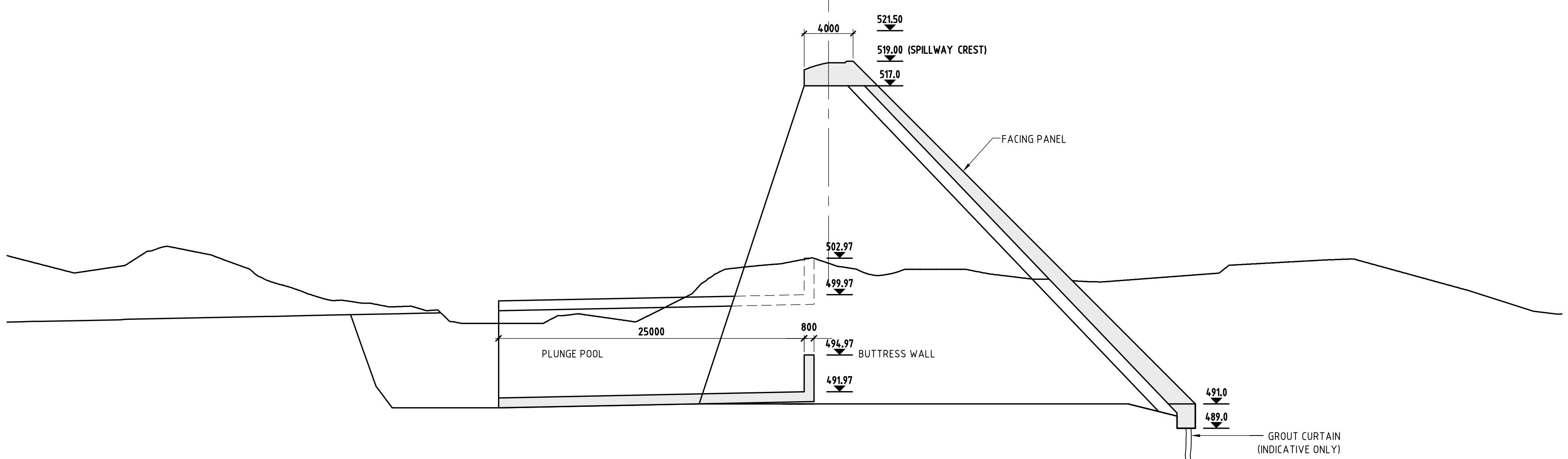
DO NOT SCALE - IF IN DOUBT, ASK



SECTION D
1 : 250 C300



SECTION E
1 : 250 C300



SECTION F
1 : 250 C300

ORIGINAL SIZE A1

REV	REVISIONS	DRAWN	CHECKED	APPROVED	DATE

SUSTAINABLE
ENERGY
LIMITED

NADARIVATU
HYDRO POWER SCHEME

KOROLEVU
WEIR
GENERAL ARRANGEMENT
LONG SECTIONS SHEET 2 OF 3

	Name	Date
DRAWN	Richard Houghton	
DRAWING CHECK		
DESIGNED	Ross Cleeton	
DESIGN CHECK		
REVIEWED		
APPROVED		

MWH

Status Stamp: WORKING PLOT

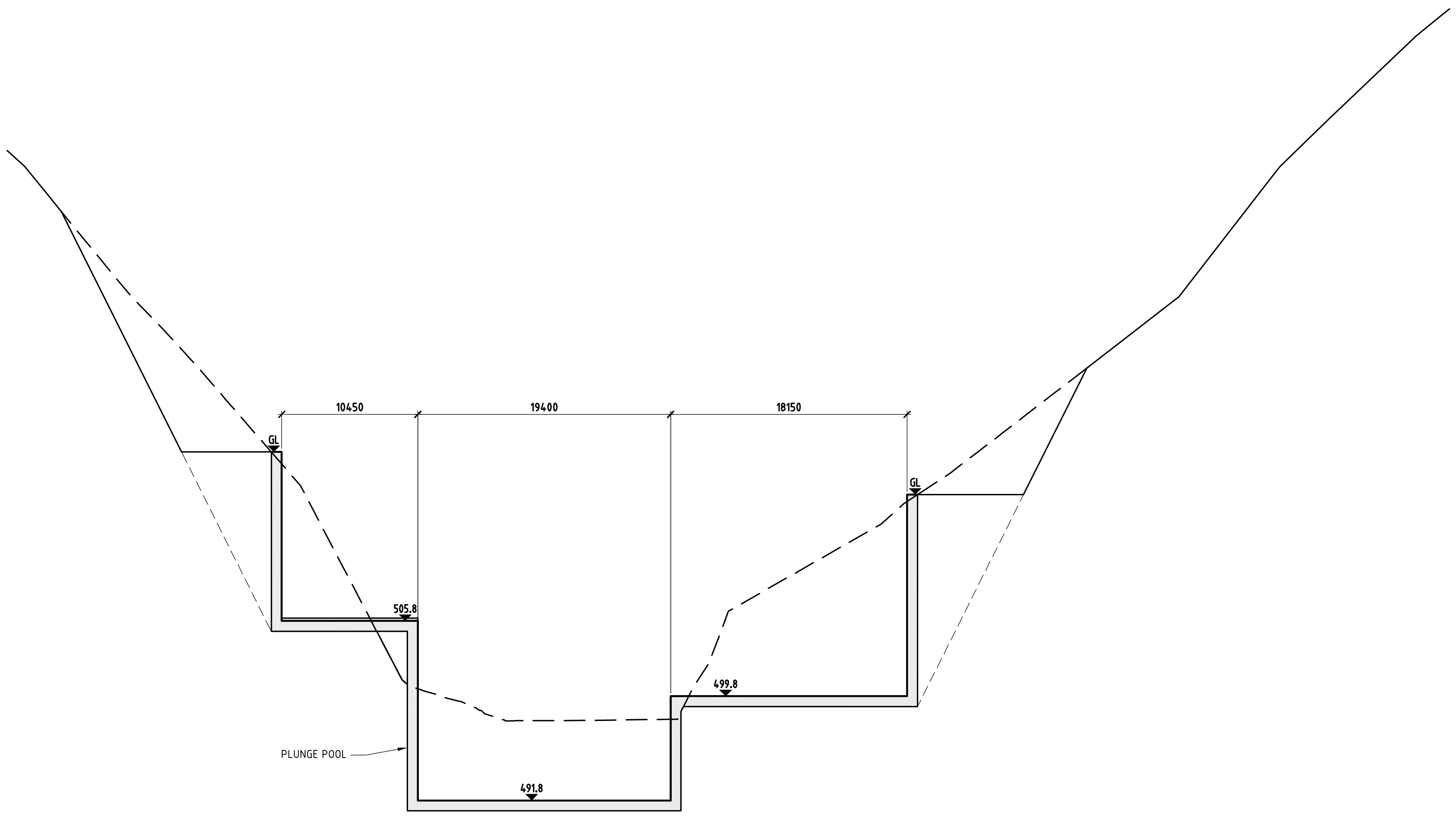
Date Stamp

SCALES (A1) AS SHOWN

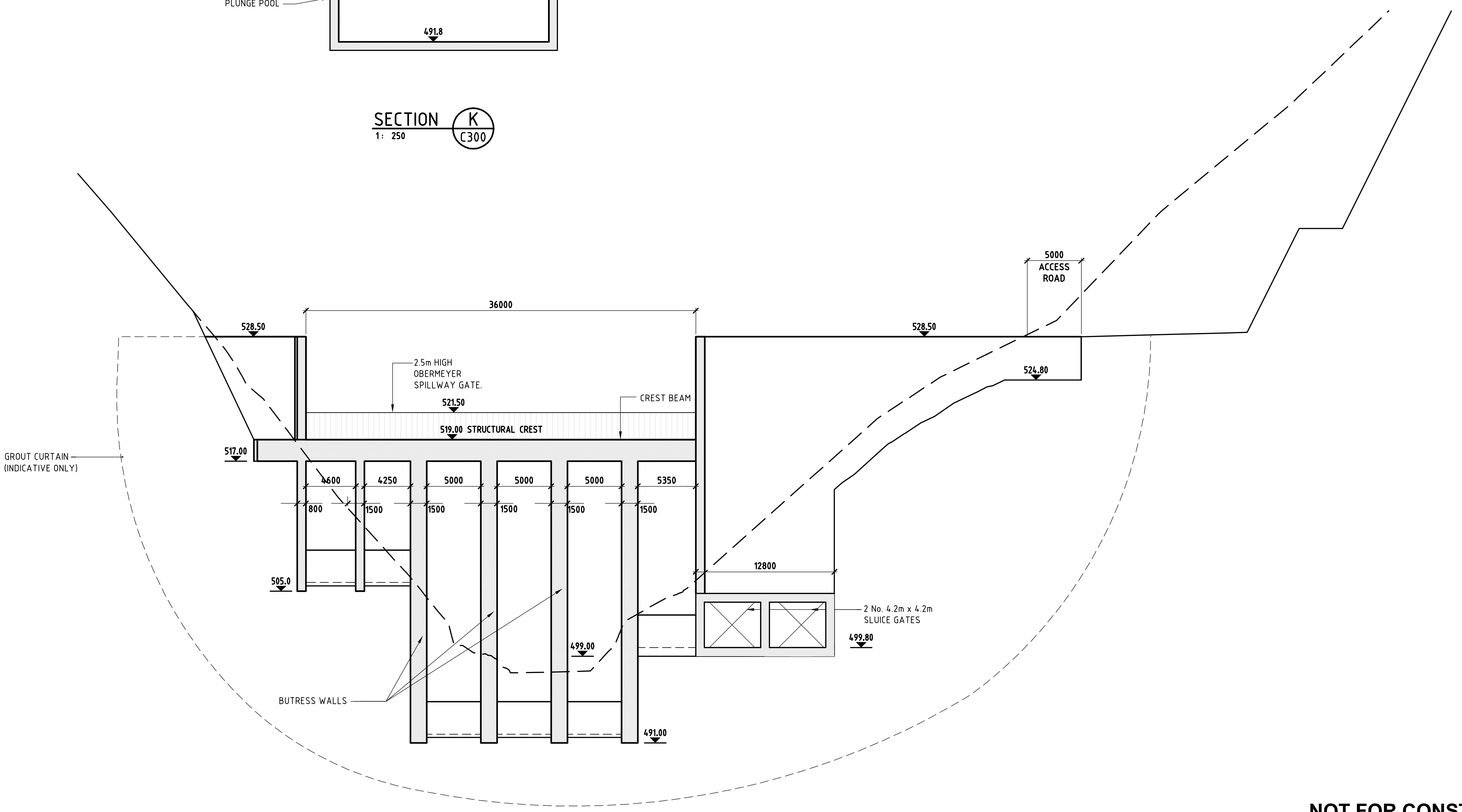
Job No.	Sheet No.	Revision
Z13309	K0-LNC-C302	A

NOT FOR CONSTRUCTION

ORIGINAL SIZE A1



SECTION K C300
1 : 250



SECTION L

REV	REVISIONS	DRAWN	CHECKED	APPROVED	DATE
A	ISSUED FOR INFORMATION ONLY	GDH		GG	2006-06-28

SUSTAINABLE ENERGY LIMITED

NADARIVATU HYDRO POWER SCHEME

KOROLEVU WEIR GENERAL ARRANGEMENT SECTIONS SHEET 1 OF 1

	Name	Date
DRAWN	George D Homan	2006-07-26
DRAWING CHECK		
DESIGNED	Ross Cleeton	
DESIGN CHECK		
REVIEWED		
APPROVED		

MWH

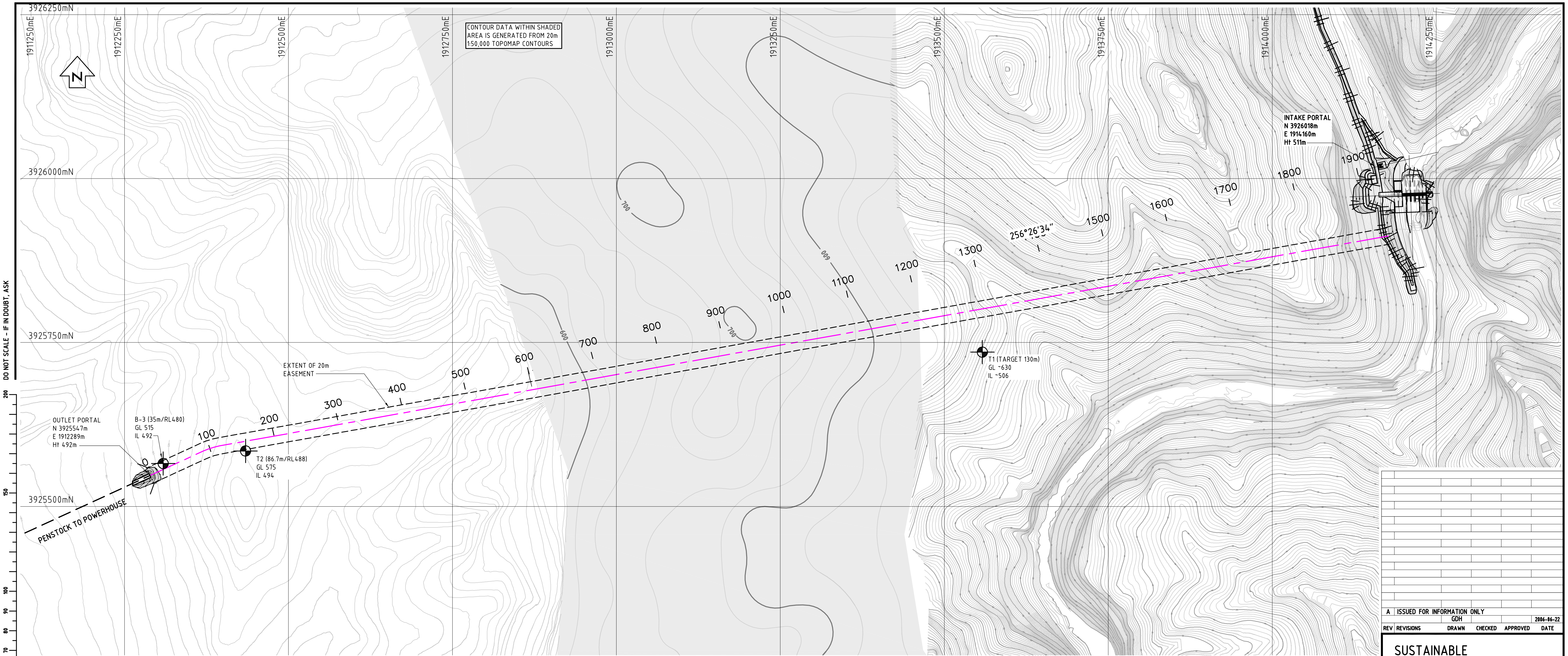
Status Stamp: **WORKING PLOT**

Date Stamp

SCALES (A1) AS SHOWN

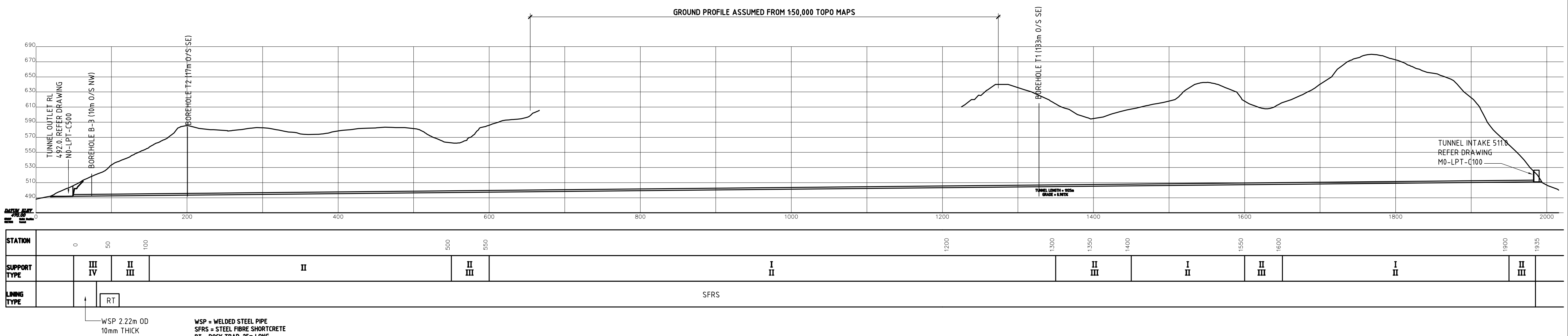
Job No.	Sheet No.	Revision
Z13309	K0-LNC-C305	A

NOT FOR CONSTRUCTION



TUNNEL ALIGNMENT PLAN

1 : 3,000



WSP = WELDED STEEL PIPE
SFRS = STEEL FIBRE SHOTCRETE
RT = ROCK TRAP, 25m LONG
NOTE: REFER DRAWINGS A0-LPT-C010 AND A0-LPT-C011 FOR SUPPORT AND LINING DETAILS.

TUNNEL ALIGNMENT LONGITUDINAL SECTION

1 : 3,000

REV	REVISIONS	DRAWN	CHECKED	APPROVED	DATE
A	ISSUED FOR INFORMATION ONLY	GDH			2006-06-22

SUSTAINABLE ENERGY LIMITED

NADARIVATU HYDRO POWER SCHEME

TUNNEL ALIGNMENT AND LONGITDINAL SECTION

	Name	Date
DRAWN	George D Homan	2006-07-07
DRAWING CHECK		
DESIGNED	Chris Ottsen	2006-07-07
DESIGN CHECK		
REVIEWED		
APPROVED		

MWH

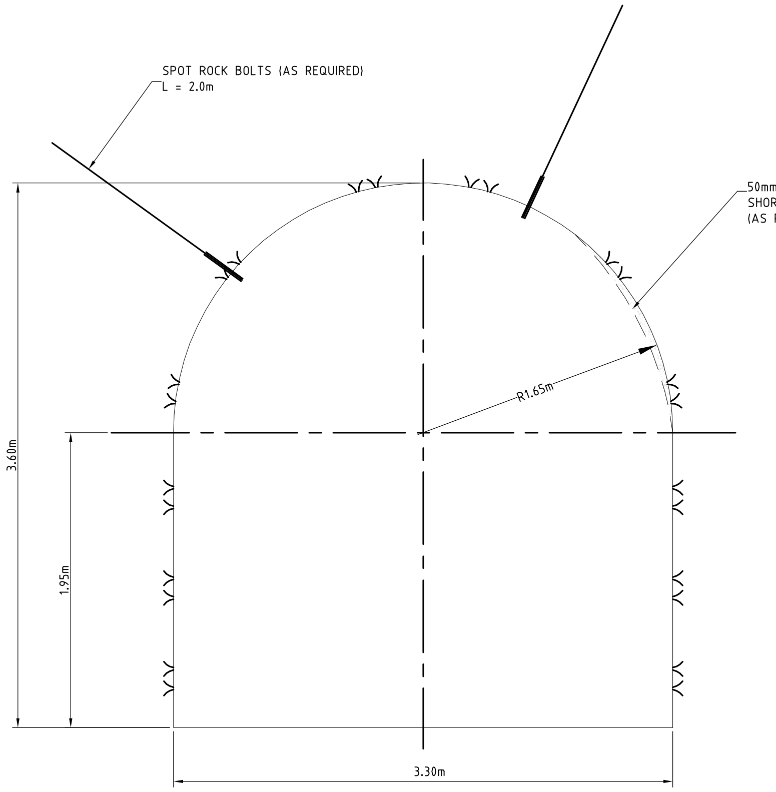
Status Stamp: WORKING PLOT

Date Stamp

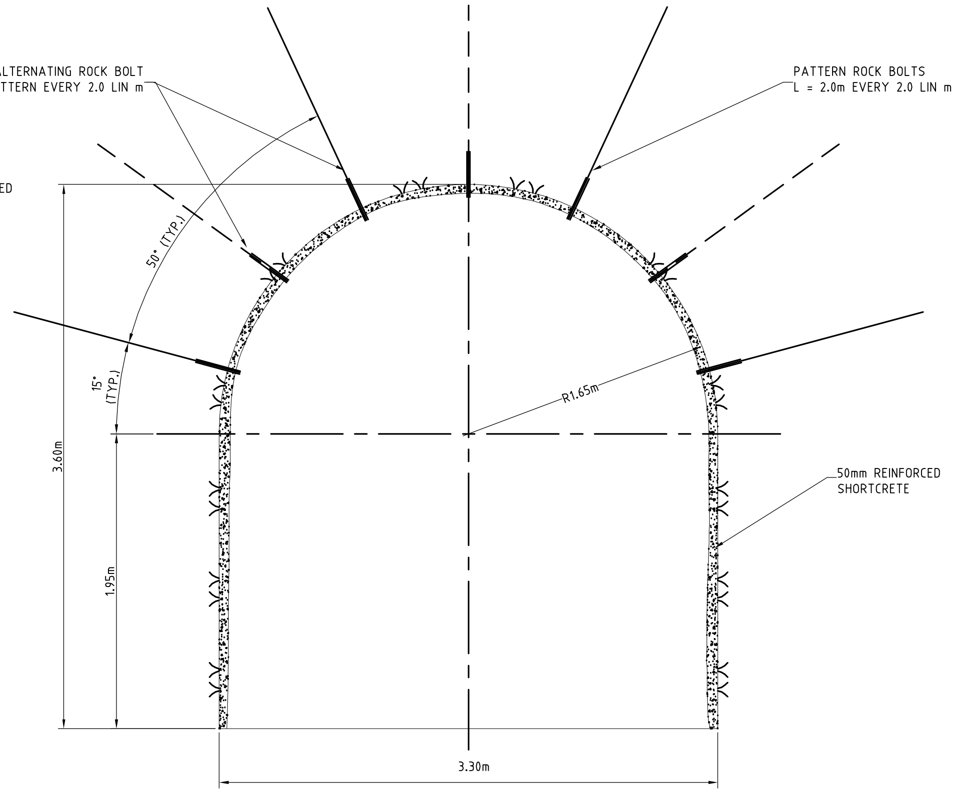
SCALES (A1) 1:3,000

Job No.	Sheet No.	Revision
Z13309	M0-LPT-C001	B

NOT FOR CONSTRUCTION



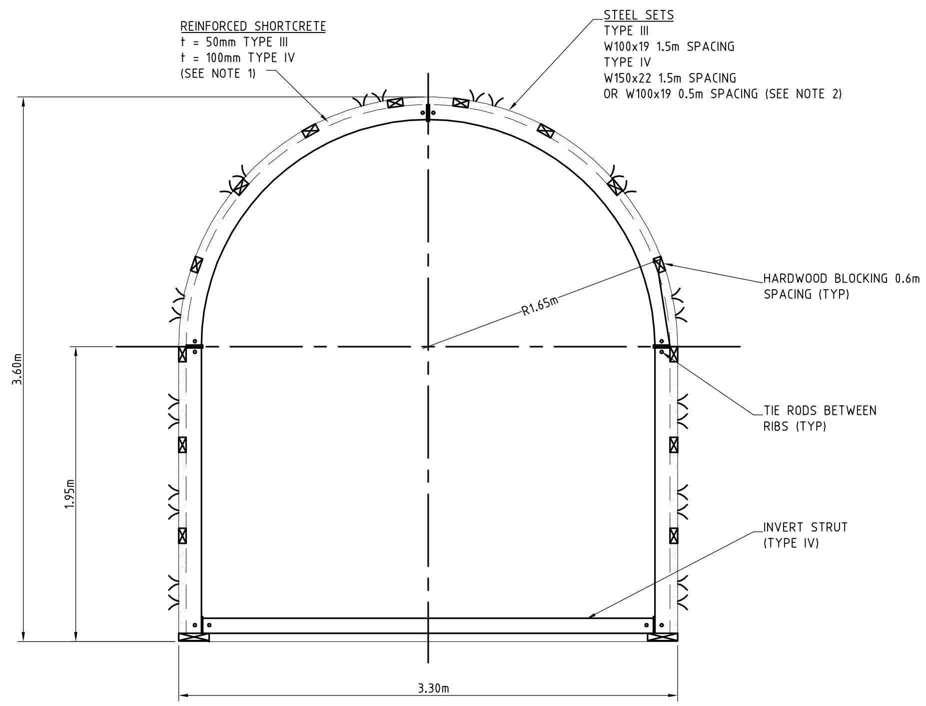
TYPE I
1 : 25



TYPE II
1 : 25

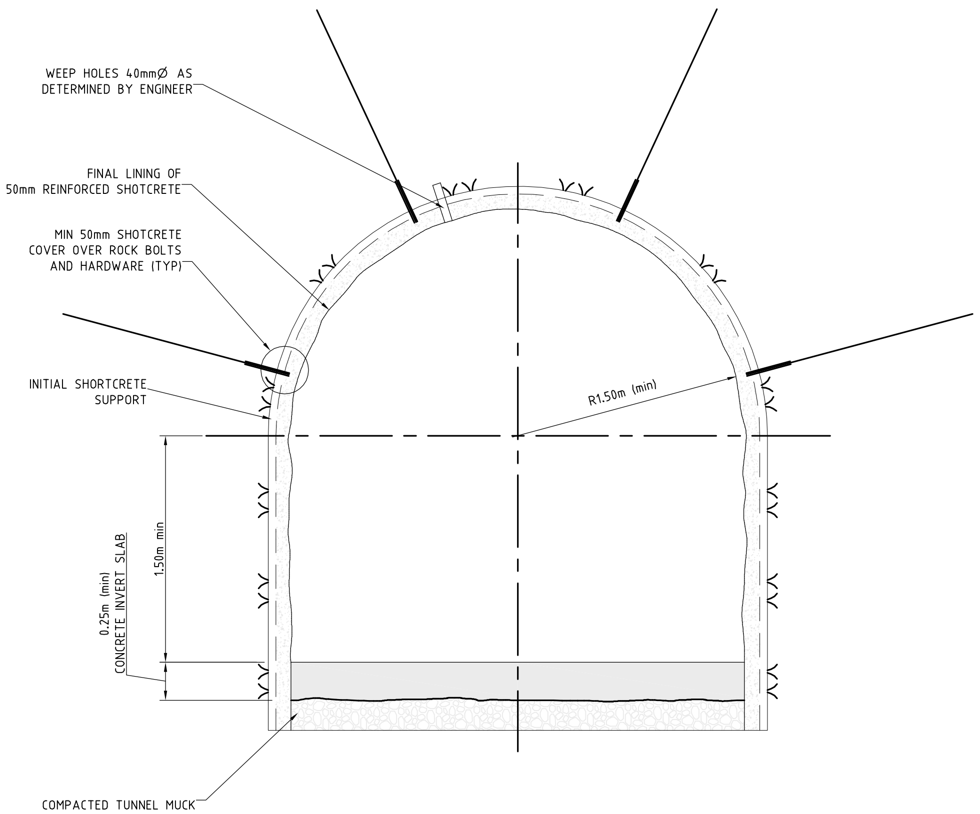
NOTES:
1) INSTALL SHOTCRETE TO WITHIN 10m OF HEADING AS EXCAVATION IS ADVANCED.
2) ROCK BOLT PATTERN MAY BE ADJUSTED TO SUIT ROCK CONDITIONS.
3) CONTRACTOR MAY INSTALL ADDITIONAL TEMPORARY SUPPORT MEASURES TO PROVIDE SAFE WORKING CONDITIONS AND FACILITATE CONSTRUCTION OPERATIONS. TEMPORARY SUPPORTS MAY INCLUDE WIRE MESH, MINE STRAPS, STEEL CHANNELS AND RIBS, ROCK BOLT, SPILING, AND OTHER SUPPORT MEASURES THAT ARE COMPATIBLE WITH THE PRIMARY ROCK SUPPORT SYSTEM AND THE FINAL LINING.
4) ALL ROCK BOLTS TO BE 22mm DIAMETER (MIN) AND EITHER FULLY CEMENT OR RESIN GROUTED. REFER TO SPECIFICATION FOR SPECIFIC REQUIREMENTS.

ROCK SUPPORT SECTIONS

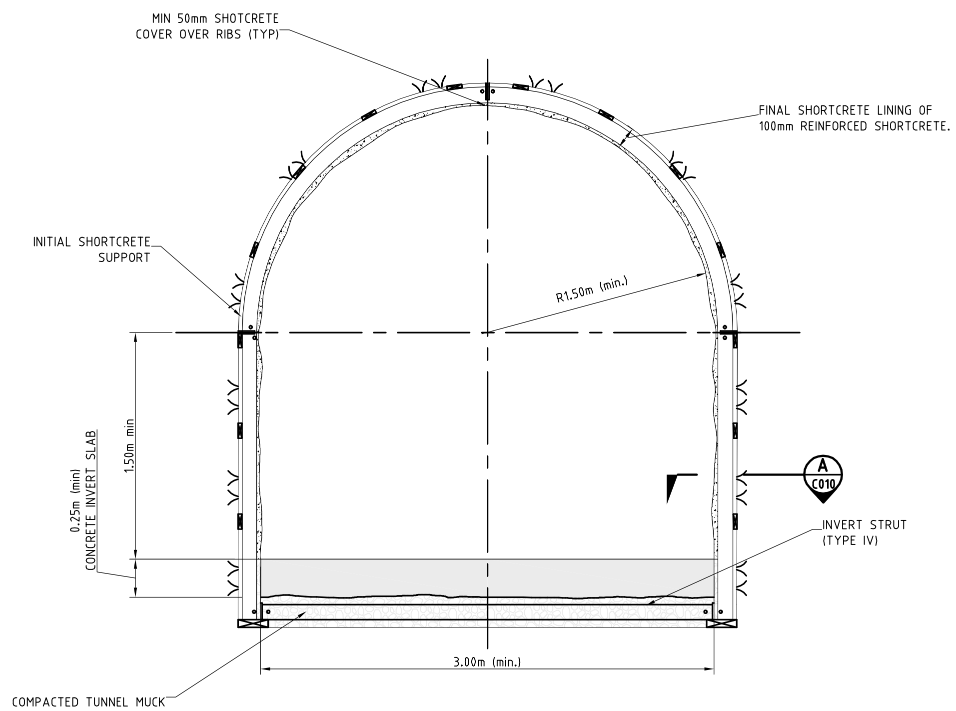


NOTES:
1) INSTALL INITIAL 50mm SHOTCRETE IMMEDIATELY UPON EXCAVATION TO WITHIN 2m OF HEADING.
2) INSTALL LAGGING, CRIBBING AND BACKPACKING AS NECESSARY TO SUPPORT ROCK BETWEEN STEEL SETS.
3) ALTERNATIVE TYPE III SUPPORT MAY INCLUDE PATTERN BOLTING, L = 2.0m AT 1.5m ON CENTER, WITH 100mm REINFORCED SHOTCRETE ON CROWN AND WALLS.

TYPE III & IV
1 : 25

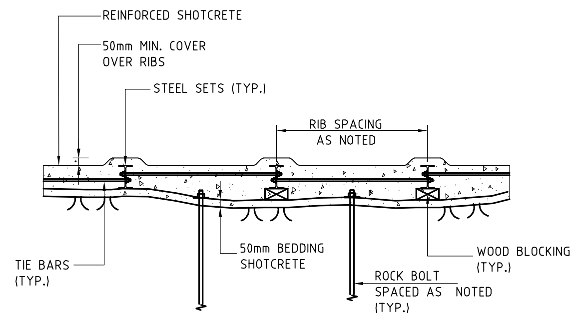


TYPE I & II
1 : 25



TYPE III & IV
1 : 25

FINAL LINING SECTIONS



SECTION A (C010)
1 : 25

REV	REVISIONS	DRAWN	CHECKED	APPROVED	DATE
A	ISSUED FOR INFORMATION ONLY	GDH		GG	2006-06-28

SUSTAINABLE ENERGY LIMITED

NADARIVATU HYDRO POWER SCHEME

TUNNEL SUPPORT AND LINING SECTIONS SHEET 1 OF 2

	Name	Date
SURVEYED	--	--
DRAWN	George D Homan	2006-06-12
DESIGNED	Chris Ottsen	2006-06-12
DESIGN CHECKED		
REVIEWED		
APPROVED		

MWH

Status Stamp: WORKING PLOT

Date Stamp

SCALES (A1) 1:25

Job No.	Sheet No.	Revision
Z13309	MO-LPT-C010	B

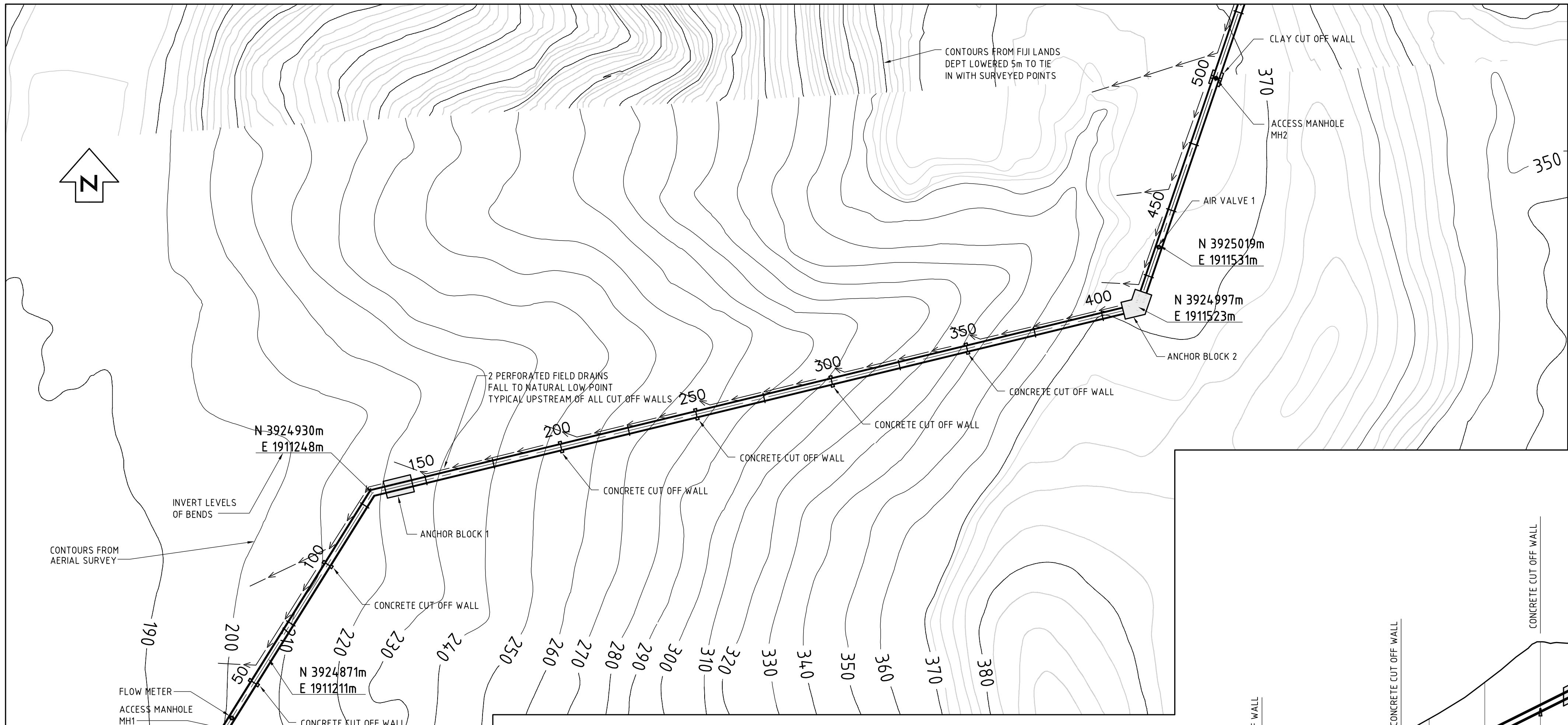
NOT FOR CONSTRUCTION

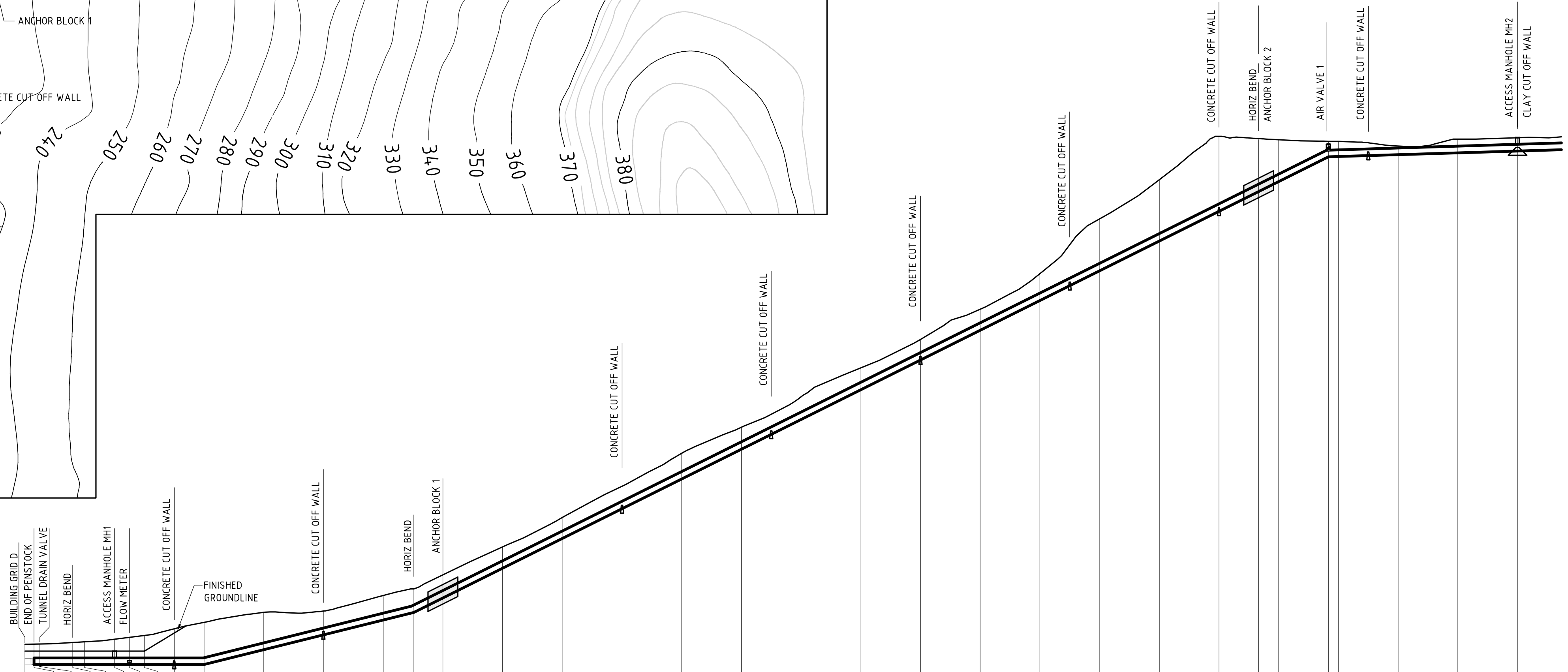
DO NOT SCALE - IF IN DOUBT, ASK

ORIGINAL SIZE A1

DO NOT SCALE - IF IN DOUBT, ASK

ORIGINAL SIZE A1





HAD = 190 m

CHAINAGE	DEPTH TO INVERT	EXISTING GROUND LEVELS	DESIGN INVERT LEVEL
0.00	6.65	199.82	193.17
3.00			193.02
5.00			
16.00		200.41	
20.00		200.65	
30.00			
35.00			
40.00		202.75	
50.00			
60.00	14.16	207.18	193.02
80.00		210.66	
100.00		210.93	
120.00		216.16	
130.30	7.92	218.38	210.46
140.00		223.02	
150.00			
160.00		232.42	
180.00		242.27	
187.00			
200.00		252.69	
220.00		263.81	
227.00			
240.00		272.55	
260.00		282.74	
266.00			
280.00		292.40	
300.00		301.89	
306.00			
320.00		312.07	
340.00		323.94	
350.00			
360.00		342.30	
380.00		355.42	
400.00		370.00	
413.30	17.62	369.23	351.61
420.00		368.85	
436.66	5.22	368.30	363.08
440.00		368.23	
460.00		366.70	
480.00		369.00	
500.00		369.48	

Chainage range	GRADE
0.00 – 60.00	
60.00 – 130.30	+1 in 4.02 (+24.85%)
130.30 – 436.66	+1 in 2.01 (+49.81%)
436.66 – 500.00	+1 in 32.23 (+3.10%)

Chainage range	PIPE WALL THICKNESS (mm)	MAXIMUM COVER TO PIPE
0.00 – 187.00	17	7.70m
187.00 – 227.00	16	7.40m
227.00 – 266.00	15	7.20m
266.00 – 306.00	14	6.50m
306.00 – 350.00	13	5.90m
350.00 – 420.00	12	5.25m
420.00 – 500.00	11	4.65m

Chainage range	PIPE WELD TYPE
0.00 – 150.00	DOUBLE V BUTT WELD
150.00 – 500.00	WELDING BAND

REV	REVISIONS	DRAWN	CHECKED	APPROVED	DATE

SUSTAINABLE ENERGY LIMITED

NADARIVATU HYDRO POWER SCHEME

PENSTOCK LAYOUT PLAN AND LONG SECTION CHAINAGE 0 - 500

	Name	Date
DRAWN	Grant S Murray	2006-06-20
DRAWING CHECK		
DESIGNED	Nik G Devlin	2006-06-06
DESIGN CHECK		
REVIEWED		
APPROVED		

MWH

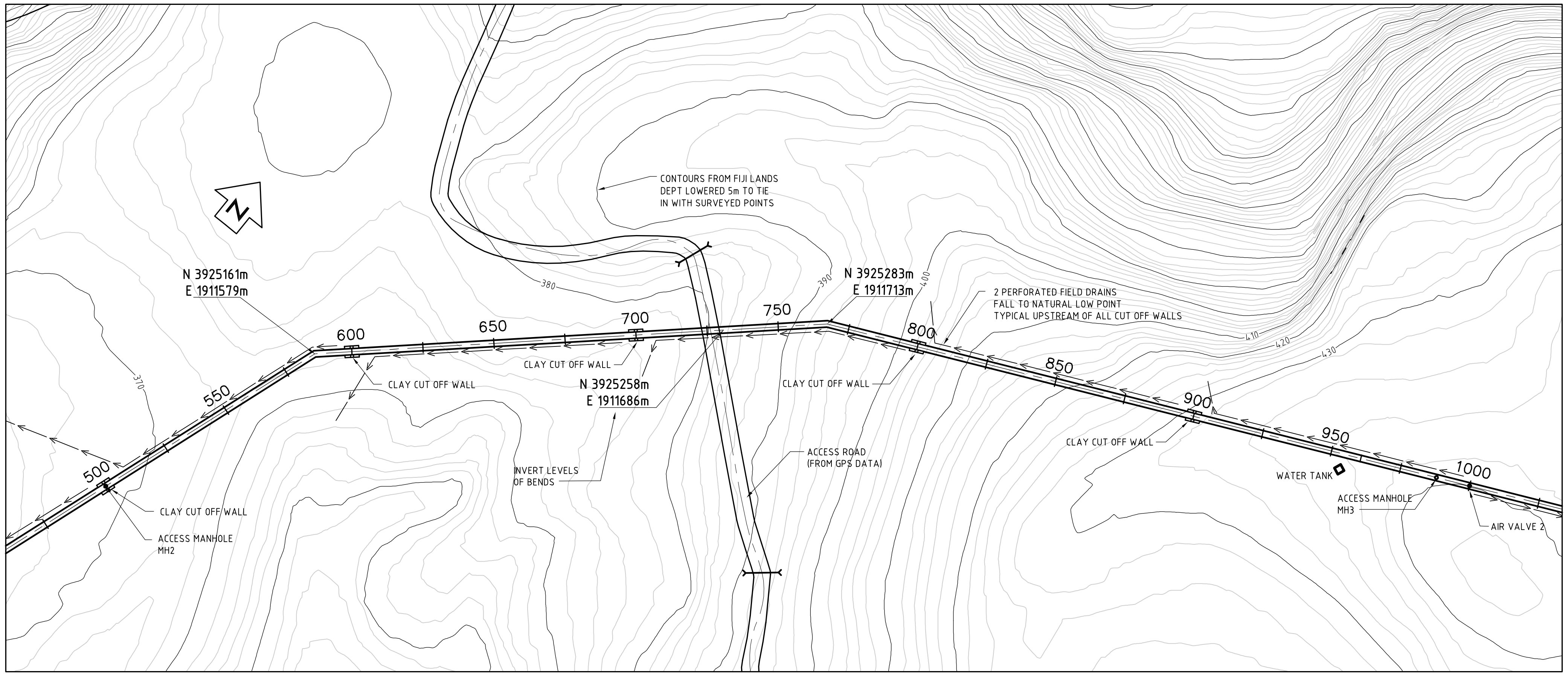
Status Stamp: WORKING PLOT

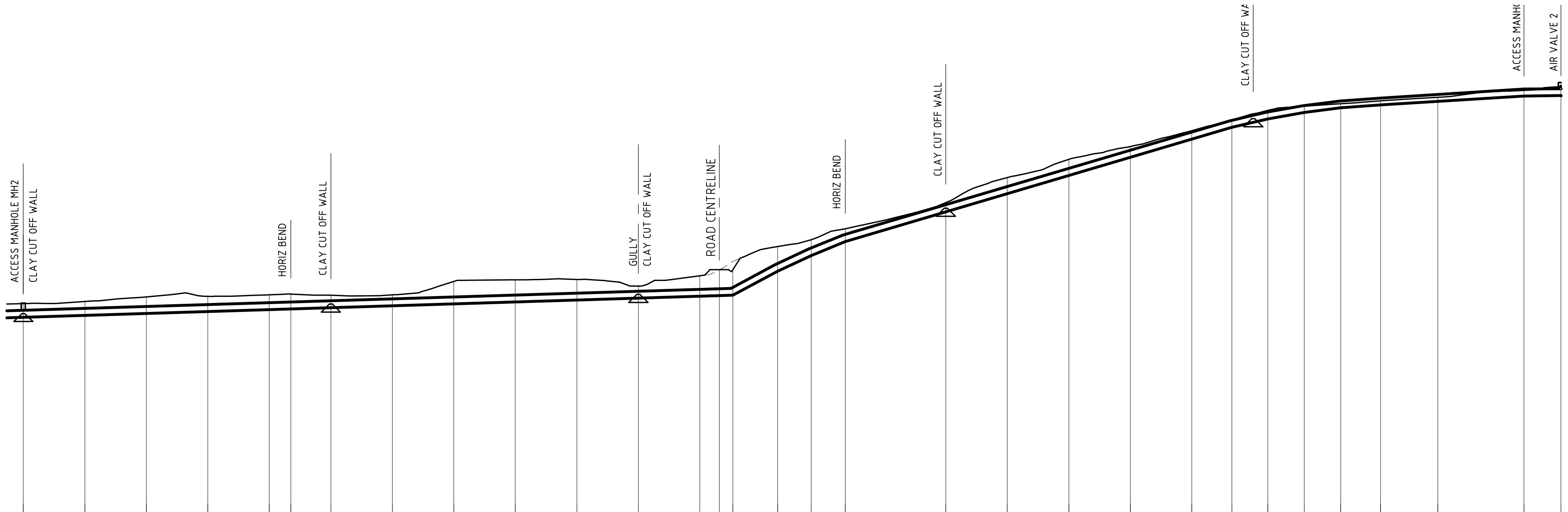
Date Stamp

SCALES (A1) 1:1000

Job No.	Sheet No.	Revision
Z13309	00-LPC-C002	B

NOT FOR CONSTRUCTION





HAD = 300 m

DEPTH TO INVERT						4.85							
EXISTING GROUND LEVELS	369.48	370.13	371.65	371.83	372.33	372.59	372.21	372.31	376.67	377.19	377.28	375.16	378.55
DESIGN INVERT LEVEL						367.74							
CHAINAGE	500.00	520.00	540.00	560.00	580.00	587.00	600.00	620.00	640.00	660.00	680.00	700.00	720.00

DEPTH TO INVERT		8.32	8.04	5.14	4.21						2.34	2.77	2.00	1.32	1.31		1.84	2.92
EXISTING GROUND LEVELS	380.47	380.52	388.02	390.22	393.82	402.28	410.42	416.34	420.50	425.69	429.09	432.25	433.60	434.42	435.35	436.51	438.78	439.86
DESIGN INVERT LEVEL		372.20	379.98	385.08	389.61						426.75	429.48	431.60	433.10	434.04		436.94	437.06
CHAINAGE	726.30	730.75	745.33	756.19	767.30	800.00	820.00	840.00	860.00	880.00	893.05	904.73	916.55	928.45	941.33	960.00	988.00	1000.00

GRADE	+1 in 32.23 (+3.10%); +1 in 1.88 (+53.32%); +1 in 2.13 (+47.02%); +1 in 2.45 (+40.77%); +1 in 3.39 (+29.53%); +1 in 4.27 (+23.42%); +1 in 5.57 (+17.96%); +1 in 7.94 (+12.60%); +1 in 13.68 (+7.31%); +1 in 16.11 (+6.21%); +1 in 103.95 (+0.96%)
PIPE WALL THICKNESS (mm)	11 / 10
MAXIMUM COVER TO PIPE	4.65m / 4.00m
PIPE WELD TYPE	WELDING BAND

DO NOT SCALE - IF IN DOUBT, ASK

ORIGINAL SIZE A1

REV	REVISIONS	DRAWN	CHECKED	APPROVED	DATE

SUSTAINABLE ENERGY LIMITED

NADARIVATU HYDRO POWER SCHEME

PENSTOCK LAYOUT PLAN AND LONG SECTION CHAINAGE 500 - 1000

	Name	Date
DRAWN	Grant S Murray	2006-06-20
DRAWING CHECK		
DESIGNED	Nik G Devlin	2006-06-06
DESIGN CHECK		
REVIEWED		
APPROVED		

MWH

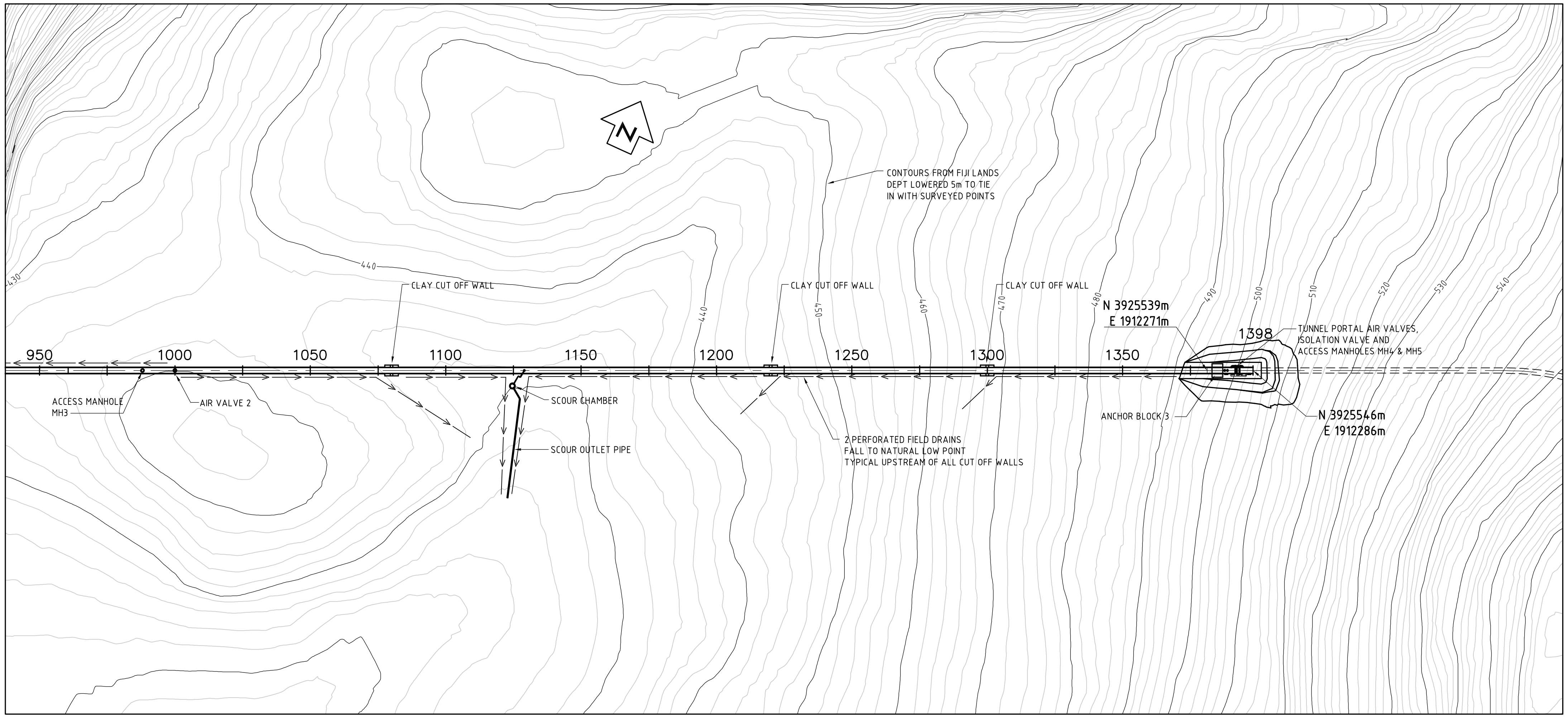
Status Stamp: WORKING PLOT

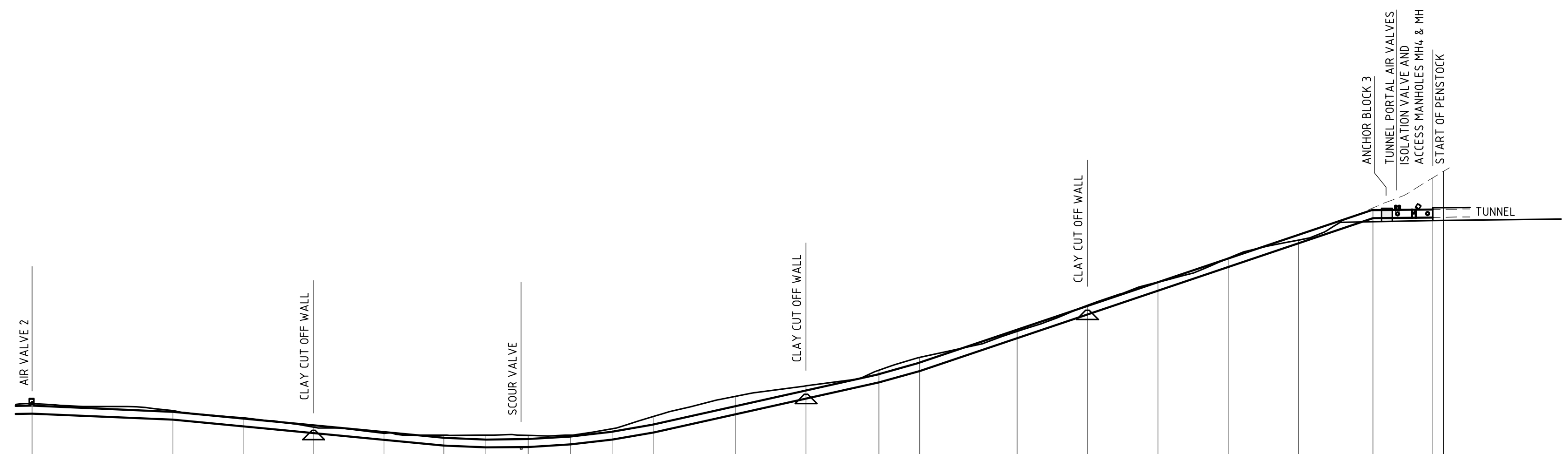
Date Stamp

SCALES (A1) 1:1000

Job No.	Sheet No.	Revision
Z13309	00-LPC-C003	B

NOT FOR CONSTRUCTION





HAD = 400 m

DEPTH TO INVERT	2.92	2.54				3.00	3.49	3.44	3.40	3.06	4.61			3.46	3.90						2.92	11.26	
EXISTING GROUND LEVELS	439.86	437.89	435.88	433.24	431.50	431.00	430.98	430.93	431.00	432.78	436.32	441.99	444.97	449.41	453.07	460.42	467.79	474.38	481.21	486.37	495.51	504.02	
DESIGN INVERT LEVEL	437.06	435.35				428.00	427.49	427.60	428.35	429.72	431.71			445.95	449.17						492.59	492.76	
CHAINAGE	1000.00	1040.00	1060.00	1080.00	1100.00	1117.01	1129.00	1140.99	1152.97	1164.89	1176.73	1200.00	1220.00	1240.73	1252.29	1280.00	1300.00	1320.00	1340.00	1360.00	1381.18	1398.18	1401.18 0.00 (TUNNEL CHAINAGE)
GRADE	%)	-1 in 23.38 (-4.28%)				-1 in 10.48 (-9.54%)	-1 in 23.38 (-4.28%)	+1 in 103.95 (+0.96%)	+1 in 16.11 (+6.21%)	+1 in 8.71 (+11.48%)	+1 in 5.94 (+16.83%)			+1 in 4.49 (+22.26%)	+1 in 3.59 (+27.83%)						+1 in 3.07 (+32.53%)	+1 in 101.77 (+0.98%)	
PIPE WALL THICKNESS (mm)	10																						
MAXIMUM COVER TO PIPE	4.00m																						
PIPE WELD TYPE	WELDING BAND																						

DO NOT SCALE - IF IN DOUBT, ASK

ORIGINAL SIZE A1

REV	REVISIONS	DRAWN	CHECKED	APPROVED	DATE

SUSTAINABLE ENERGY LIMITED

NADARIVATU HYDRO POWER SCHEME

PENSTOCK LAYOUT PLAN AND LONG SECTION CHAINAGE 1000 - 1401

	Name	Date
DRAWN	Grant S Murray	2006-06-20
DRAWING CHECK		
DESIGNED	Nik G Devlin	2006-06-06
DESIGN CHECK		
REVIEWED		
APPROVED		

MWH

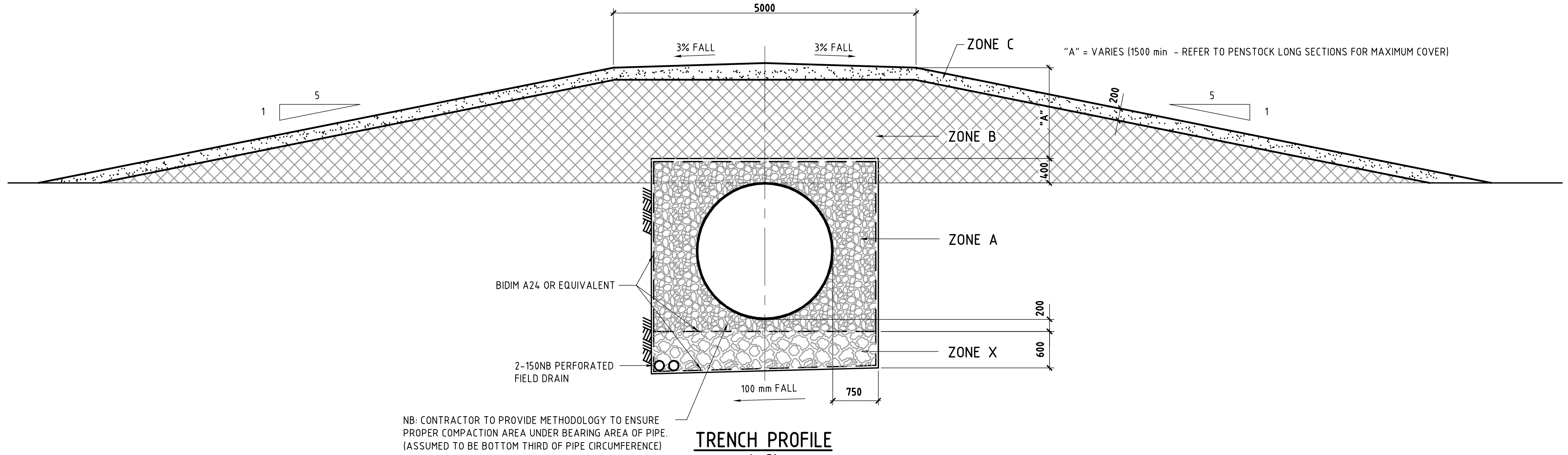
Status Stamp: **WORKING PLOT**

Date Stamp

SCALES (A1) 1:1000

Job No.	Sheet No.	Revision
Z13309	00-LPC-C004	B

NOT FOR CONSTRUCTION



TRENCH PROFILE
1 : 50

NOTES

1. MINIMUM PIPE COVER IS 1.5m

2. TRENCH SIDES ARE SHOWN VERTICAL FOR ILLUSTRATION PURPOSES. THE APPROPRIATNESS OF VERTICAL TRENCH SIDES SHALL BE DETERMINED BY THE CONTRACTORS GEOTECHNICAL ENGINEER ON A SECTION BY SECTION BASIS. WHERE VERTICAL SIDES ARE CONSIDERED INAPPROPRIATE SHORING OR RELAXATION OF THE TRENCH SIDE SLOPE SHALL BE ADOPTED.

3. EXCAVATION:-
THE CONTRACTOR SHALL FURNISH, PLACE & MAINTAIN ALL SUPPORTS & SHORING THAT MAY BE REQUIRED FOR THE SIDES OF THE EXCAVATION TO ENSURE COMPLIANCE WITH ALL SAFETY REGULATIONS.

4. BACKFILL:-
BACKFILL SHALL NOT BE DROPPED DIRECTLY ONTO THE PIPE OR STRUCTURE. BACKFILL SHALL BE PLACED EVENLY IN LAYERS NOT EXCEEDING A COMPACTED LAYER THICKNESS OF 150mm. THE DIFFERENTIAL HEIGHT OF BACKFILL ON EITHER SIDE OF THE PIPE SHALL NOT EXCEED 150mm.

5. BACKFILL IN ZONE X SHALL BE WELL GRADED ROCKFILL WITH 100% PASSING 100mm AND A MINIMUM SIZE OF 4.5mm.

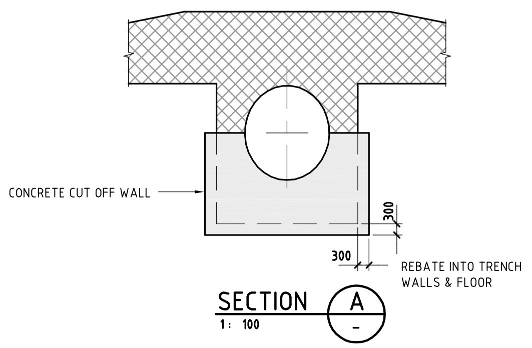
6. BACKFILL IN ZONE A SHALL BE A WELL GRADED AP20 MATERIAL FREE OF ORGANICS & A SAND EQUIVALENT OF NO LESS THAN 30.

7. ZONE B SHALL BE RECOMPACTED INSITU MATERIAL ALTHOUGH SOIL CLASSIFICATION Pt, OH & OL SHALL NOT BE USED.

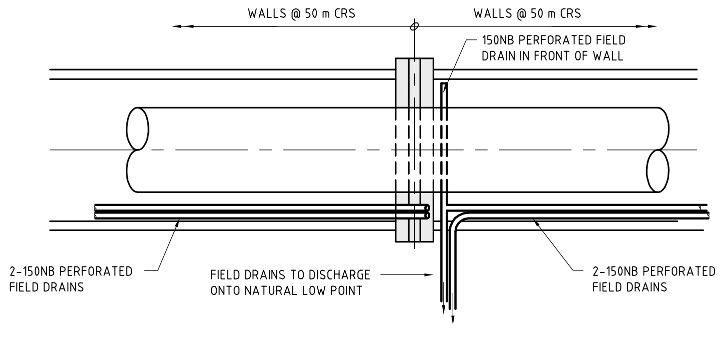
8. ZONE C - MATERIAL & COMPACTION AS ZONE X.

9. COMPACTION REQUIREMENT SHALL BE:-
ZONE B - 8% AIR VOIDS & 80kPa SHEAR VANE VALUE FOR INSITU SOILS OR 90% MAXIMUM DRY DENSITY FOR GRANULAR SOILS
ZONE A MATERIAL - 95% MAXIMUM DRY DENSITY FOR GRANULAR SOILS
ZONE X MATERIAL - 90% MAXIMUM DRY DENSITY

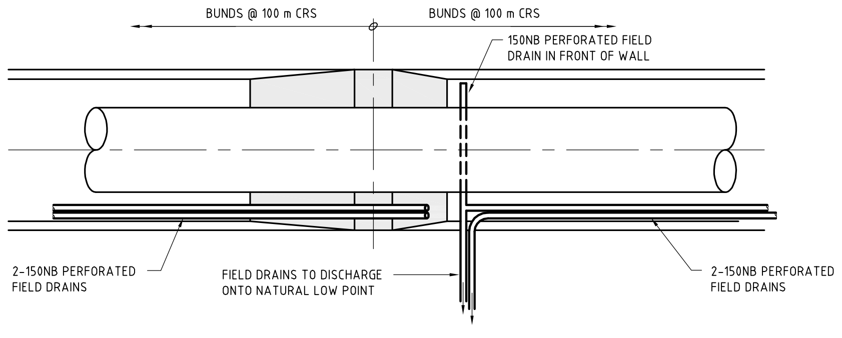
10. FIELD TESTING:-
REFER TO SPECIFICATION



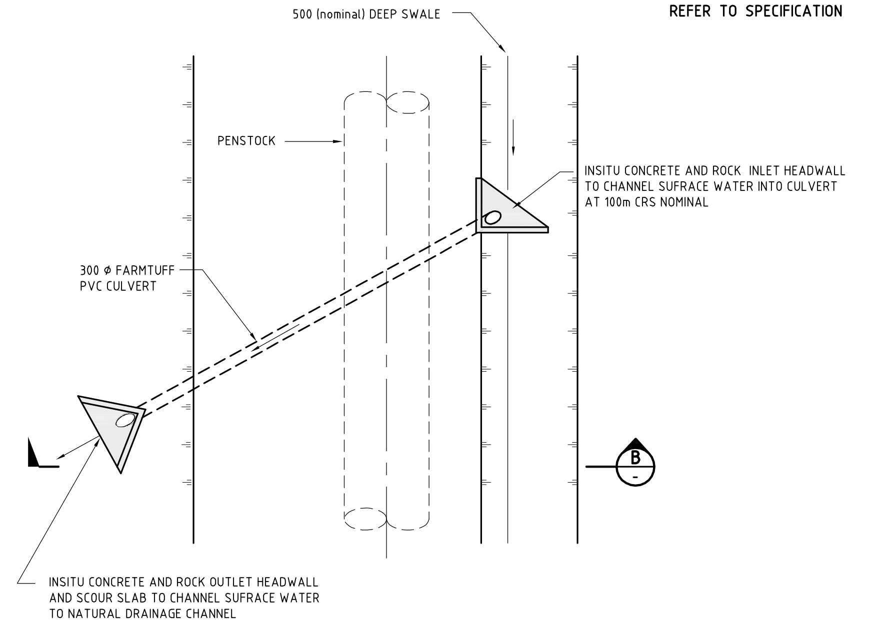
SECTION A
1 : 100



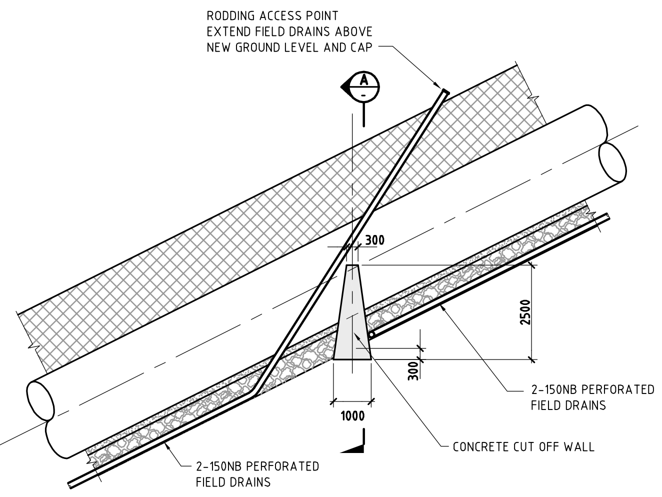
PLAN - CONCRETE CUT OFF WALL
1 : 100



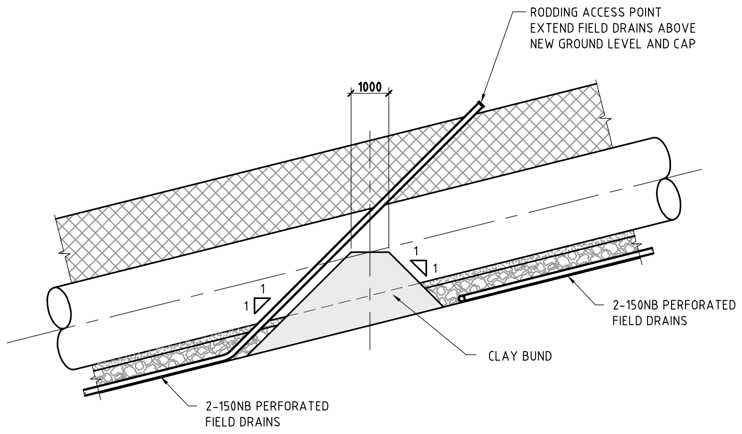
PLAN - CLAY CUT OFF WALL
1 : 100



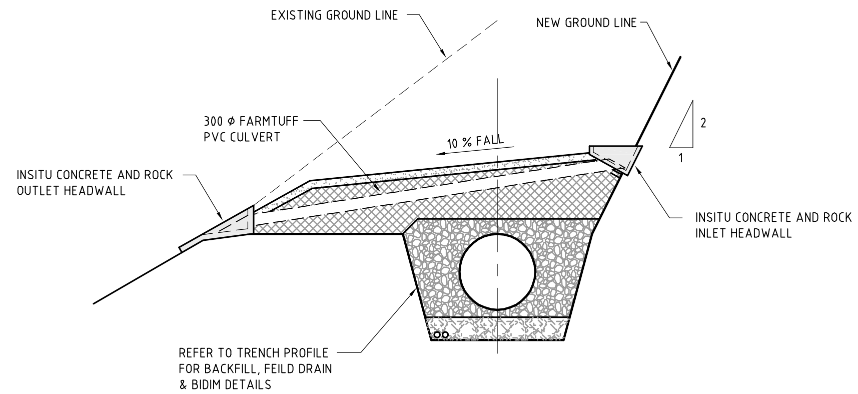
PLAN - SURFACE DRAINAGE CULVERT
1 : 100



ELEVATION - CONCRETE CUT OFF WALL
1 : 100
CHAINAGE 0.0 TO 440.0



ELEVATION - CLAY CUT OFF WALL
1 : 100
ALTERNATE OPTION CHAINAGE 440.0 TO 1379.0



SECTION B
1 : 100

DO NOT SCALE - IF IN DOUBT, ASK

ORIGINAL SIZE A1

REV	REVISIONS	DRAWN	CHECKED	APPROVED	DATE

SUSTAINABLE
ENERGY
LIMITED

NADARIVATU
HYDRO POWER SCHEME

PENSTOCK
TRENCH
AND DRAINAGE DETAILS

	Name	Date
DRAWN	Mike A Becht	2006-07-03
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MWH

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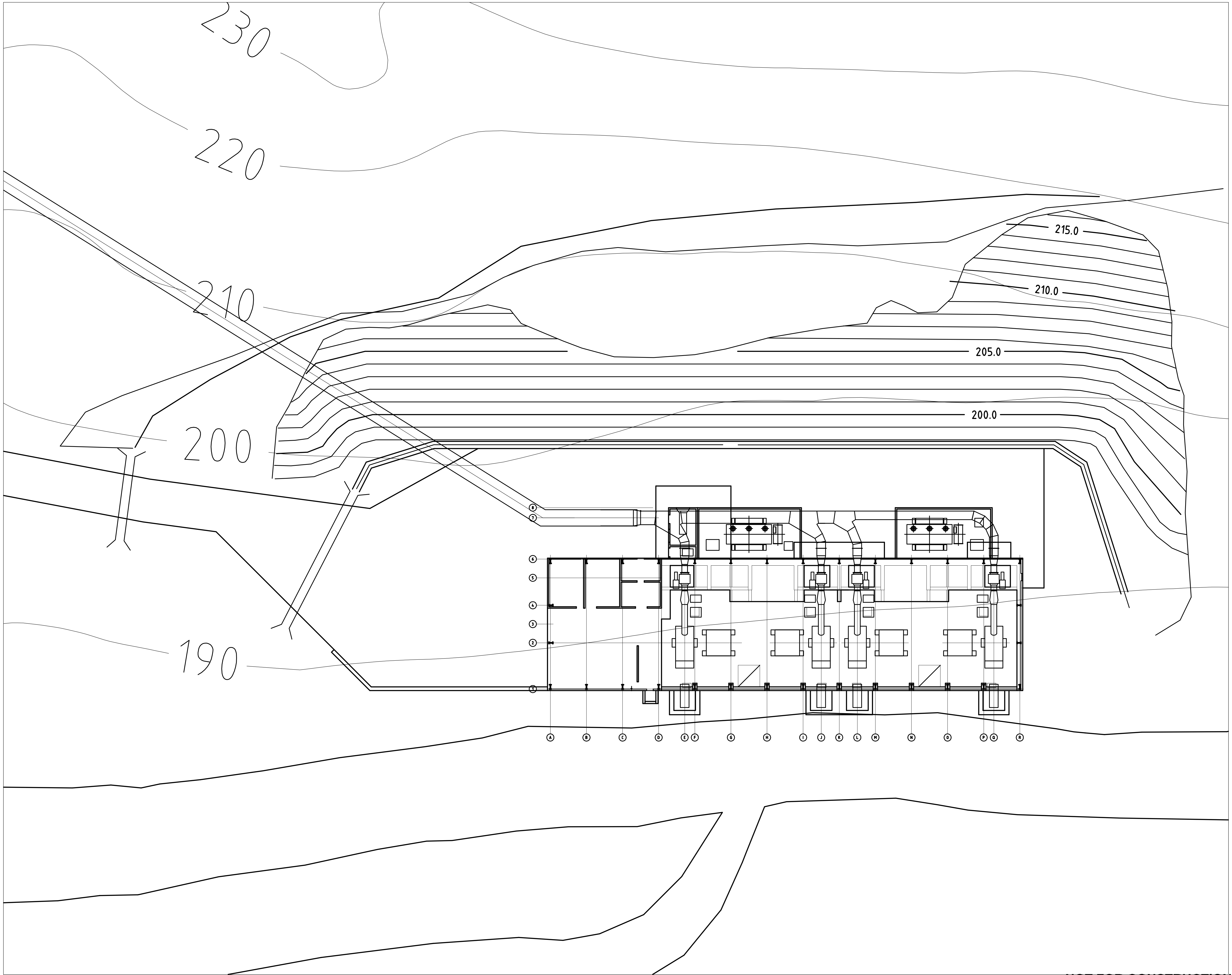

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SUSTAINABLE ENERGY LIMITED

NADARIVATU HYDRO POWER SCHEME

POWERHOUSE SITE DRAINAGE PLAN

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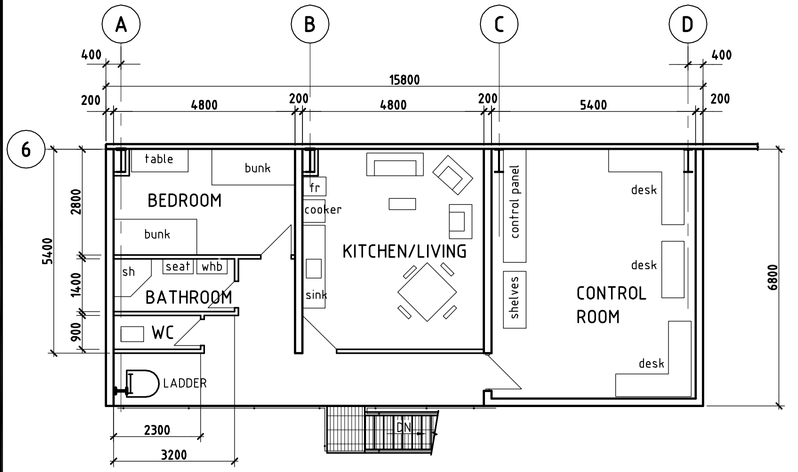

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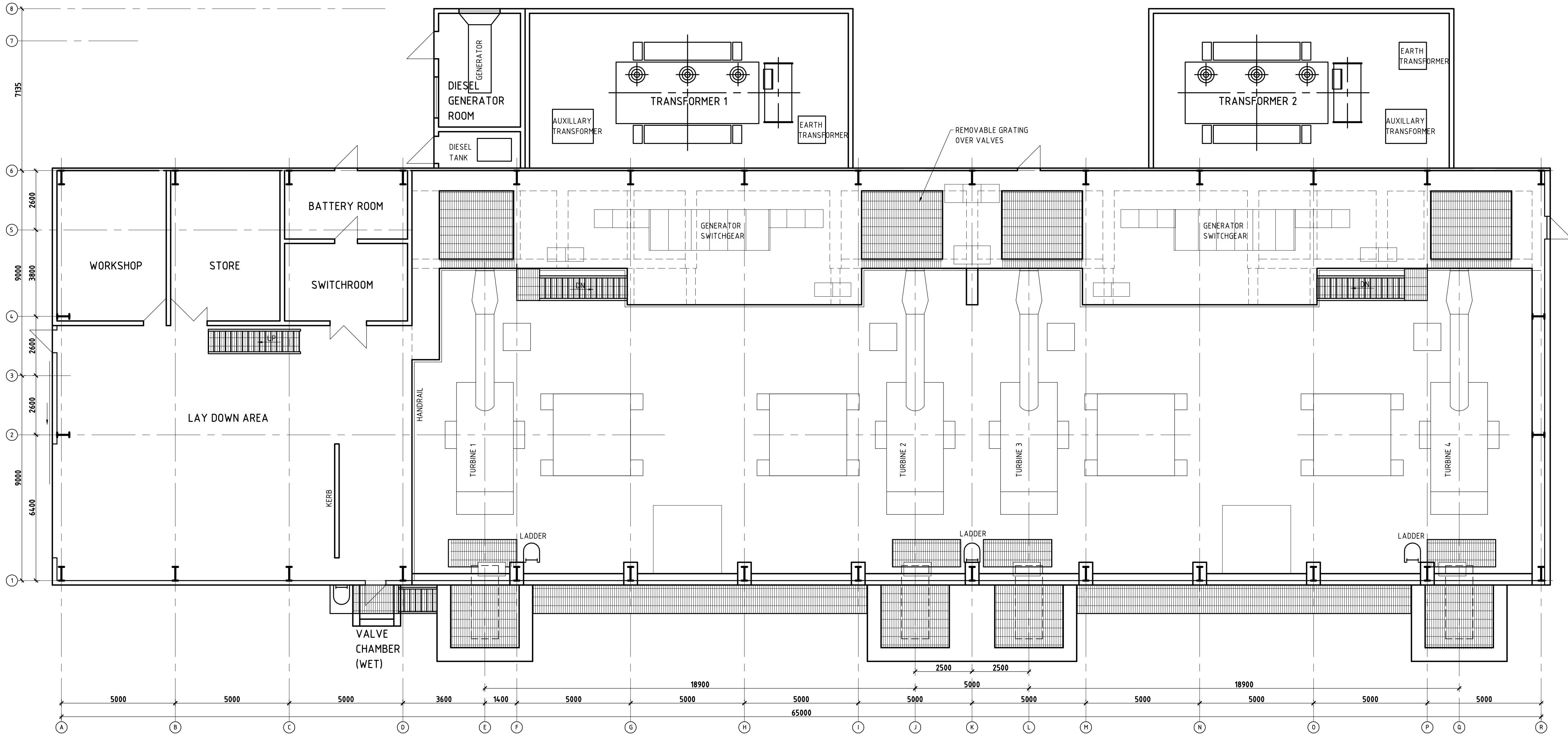

FLOOR PLAN AT R.L. 197.80

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NADARIVATU HYDRO POWER SCHEME

POWERHOUSE ARCHITECTURAL PLAN R.L. 197.80

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FL = FINISHED LEVEL
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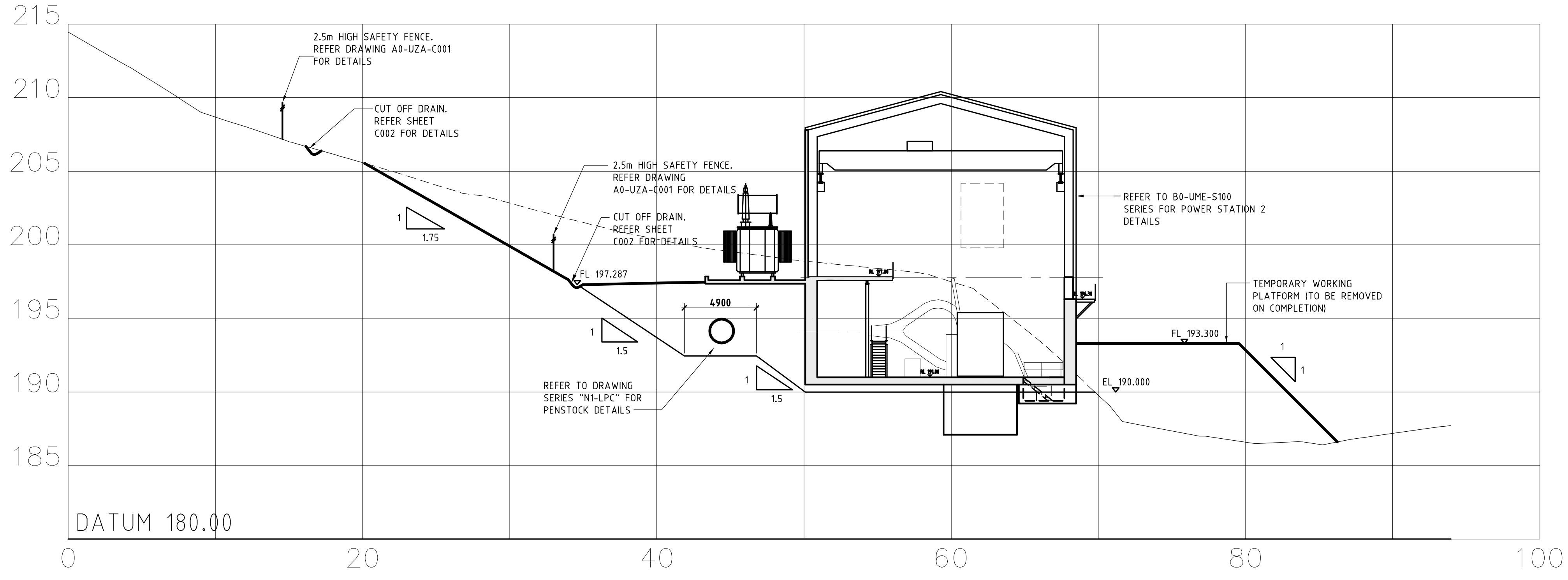

SECTION C
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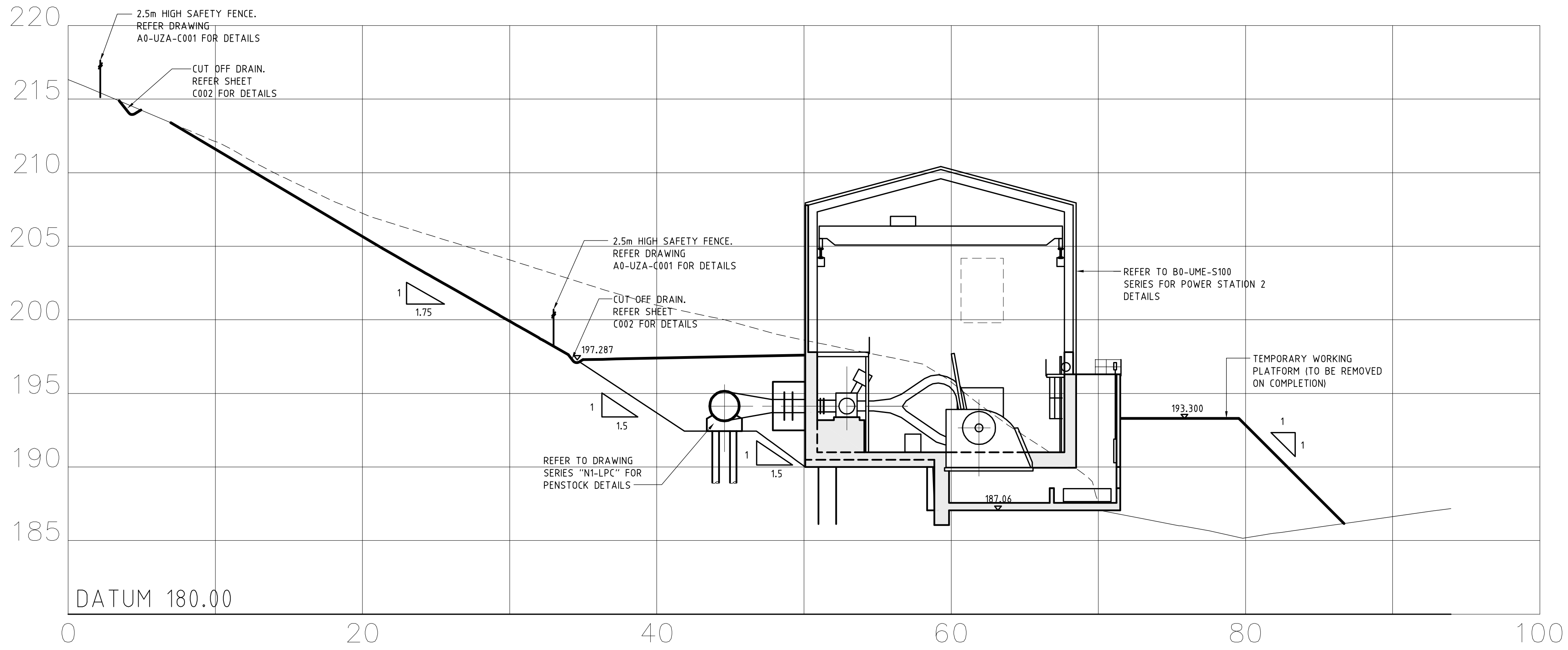

SECTION D
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NADARIVATU
HYDRO POWER SCHEME

POWER STATION 2
SECTIONS C & D

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APPROVED	Peter J Robinson	14-10-2005

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Appendix D Water Quality and Ecology Report

Sustainable Energy Limited

Nadarivatu Hydropower Project

FRESHWATER ECOLOGICAL AND WATER QUALITY MONITORING SURVEY (JULY 2006)

- Final
- September 2006

Sustainable Energy Limited

Nadarivatu Hydropower Project

FRESHWATER ECOLOGICAL AND WATER QUALITY MONITORING SURVEY (JULY 2006)

- Final
- September 2006

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Appendix 1 Site Photos

Appendix 2 Field Sheet

Appendix 3 Water Quality Analysis Results

Appendix 4 Habitat Assessment Data

Appendix 5 Macroinvertebrate Data

Appendix 6 Results of Statistical Analysis

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Document history and status

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1. Introduction

1.1 Background

The Fiji Electricity Authority (FEA) propose to construct a hydropower scheme which will divert water from the headwaters of the Sigatoka River (Qaliwana, Nadala and Nukunuku Creek tributaries) to the Ba River, through a power station located on the bank of the Ba River near Buyabuya.

Past studies assessing the ecological and water quality of watercourses in the vicinity of the proposed development and streams potentially affected consist of the following:

- USP undertook the first round of specific baseline water quality and ecological monitoring in 2004.
- A second round of baseline water quality and ecological monitoring was undertaken by SKM in February 2005 (see SKM 2005).
- Monitoring undertaken by the Institute of Applied Science (IAS) in relation to the biological communities within Monasavu Dam between 1986 and 1997 (INR 1986, 1989, 1991, IAS 1994, 1998, 1999 and 2002).
- Investigations undertaken by the Fiji Institute of Technology (FIT) at sites in streams in the vicinity of the current streams of interest as part of a Fiji – wide water quality monitoring programme using macroinvertebrates.
- Investigations undertaken by the IAS at sites in the current streams of interest between 25 and 31 August 2004 as part of background investigations (IAS 2004).

This data is addressed in detail in SKM (2005).

1.2 Scope of Report

This report documents the results of the July 2006 baseline assessment of aquatic macroinvertebrates, and habitat and water quality in watercourses potentially effected as a result of the construction and operation of the proposed hydro power scheme development, and compares this data with that collected during the February 2005 round undertaken by SKM.

The July 2006 round of monitoring was conducted to provide information on the natural seasonal variation in water quality and ecological data to further describe the baseline condition prevailing in the watercourses potentially affected by development.

Note that the design of the monitoring programme has changed in light of the changes to the design of the scheme.

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2. Methods

2.1 Introduction

This section of the report presents the methods used by SKM to describe the aquatic resources (macroinvertebrate communities), habitat and water quality present in the watercourses potentially affected as a result of the construction and operation of the proposed hydro power scheme.

The first round of monitoring was conducted in February 2005. The fieldwork for this round of monitoring was conducted on 5 and 6 July 2006.

2.2 Sampling Sites

Figure 2-1 presents the locations of the sampling sites used for the collection of macroinvertebrate, instream habitat and water quality samples and Table 2-1 describes the site locations used. In the 2006 survey the majority of sites were revisited and an additional site (Site 9) sampled based on a change in scheme design. Appendix 1 presents photographs of the sites.

▪ **Table 2-1 Location of sites for macroinvertebrate, habitat and water quality sampling**

Area	Site	Description	Study	
			2005	2006
Ba River	1	Marou Village (above proposed powerstation)	√	√
	2	Drala Village (below proposed powerstation)	√	√
Nukunuku Creek	3	Above hydrological station (approximately 1km above proposed weir and intake)	√	√
	4	50m below hydrological station	√	-
Nadala Creek	5	Nadala village	√	-
Qaliwana Creek	6	Nabuyasa village	√	-
	7	50m above hydrological recording station (approximately 1km above proposed weir and intake)	√	√
	9	Below confluence with Nukunuku Creek (approximately 200m below proposed weir and intake)	-	√
Savatu Creek	8	Savatu Creek access from Drala Village (control site)	√	√

Notes: - = Sites not sampled as they will no longer be directly affected by the Nadarivatu scheme.

As well as selecting a control site (Savatu River) in a stream with similar physical and hydrological characteristics, sites were located in the watercourses above and below the location of the various proposed development activities in each catchment. The control and upstream sites will allow comparisons to be made to determine whether any observed changes that occur during and post construction are the result of the activity or are due to natural variability. Further detail on site selection is provided in SKM (2005).

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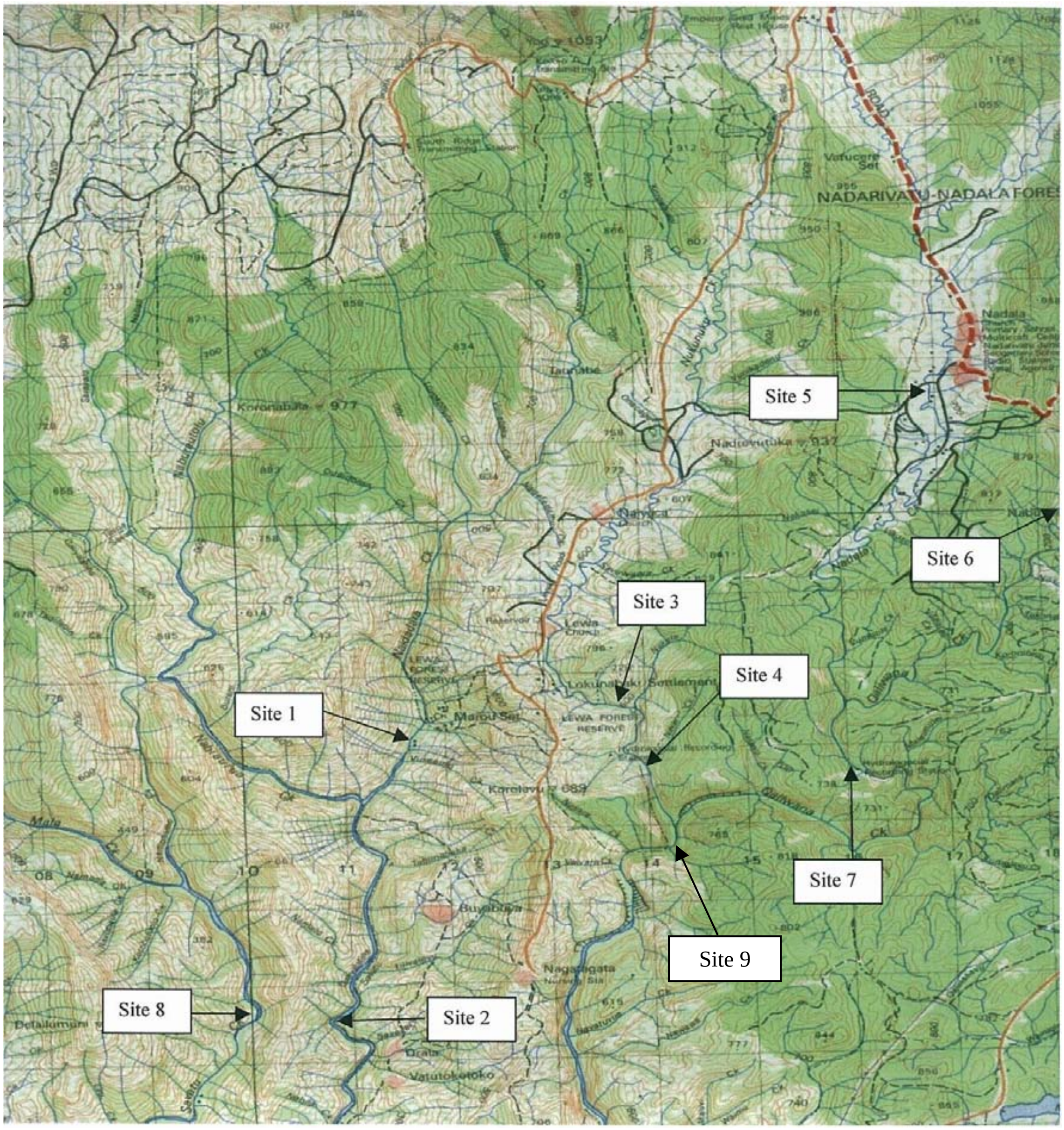
■ **Figure 2-1 Sample Site Locations**



2.3 Habitat Assessment

Habitat assessments were undertaken over representative 100 m stream reaches at each site. A suite of instream and riparian habitat characteristics were visually assessed using habitat assessment protocols adopted by a number of Regional Councils in New Zealand for high gradient streams (Appendix 2 provides an example of the field sheet). Each habitat parameter was assessed by scoring it a value between 0 and 20 based on a defined set of criteria, where scores between 0-5 represented poor quality, 6-10 marginal quality, 11-15 suboptimal quality and 16-20 optimal quality. Further detail on habitat assessment process is provided in SKM (2005).

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2.4 Macroinvertebrate Communities

2.4.1 Introduction

In New Zealand, macroinvertebrate communities have been shown to respond readily to changes in their surrounding environment and are thus used extensively to indicate instream habitat quality (Stark 1985, 1993; Winterbourn 1981). In light of this, a monitoring programme has been implemented to describe the baseline environment and allow the assessment of any potential changes that may occur in the macroinvertebrate communities as a result of the proposed development.

2.4.2 Sample Collection

The sampling methodology and protocols detailed in the New Zealand MfE guidelines (Stark *et. al.* 2001) were used in the current investigations. More specifically the protocols for collecting quantitative samples from hard-bottomed streams were adopted.

Samples were collected from riffle / run habitat where macroinvertebrate diversity and density is considered to be greatest (Pridmore & Roper 1985). This type of habitat was chosen as it best represents the macroinvertebrate communities present and allows comparisons to be made across sites as similar habitat conditions were sampled.

At each site five 0.1m^2 surber samples (0.5 mm mesh) were collected from within each riffle. Each surber sample was collected by placing the sampler on the substrate and the cobble-sized material, to a depth of 100 mm, was scrubbed to remove macroinvertebrates. Samples were preserved in methylated spirits, placed in ice and delivered to Fiji Institute of Technology (FIT) for sorting and identification. The macroinvertebrates were identified to the lowest practical level, usually genus.

2.4.3 Data Analysis

The following ecological indices, as well as descriptive analysis, were used in the examination of the macroinvertebrate data:

- Taxa richness which is a measure of the number of types of organisms (taxa) present in each sample. As a general rule, the "richer" a community, the "healthier" the stream environment (Plafkin et al. 1989).
- Density which measures the total number of organisms per unit area. In this investigation density refers to the number of macroinvertebrates per 0.1 m^2. As with richness, density loosely correlates with the health of the stream environment. In extremely degraded environments the density of organisms tends to be lower than in higher quality environments. However, this cannot be taken as a hard-and-fast rule, and depends to a large extent on the types of species present.

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- Quantitative Macroinvertebrate Community Index (MCI) which was developed largely for the purposes of determining the tolerance of macroinvertebrate communities in New Zealand stony streams to organic enrichment, but is now commonly used as a general indicator of water and habitat quality (Stark 1993). The MCI is based on macroinvertebrate taxa being assigned a score between 1 and 10 reflecting their sensitivity to pollution, 1 representing taxa with high tolerance to organic pollution such as worms and snails, and 10 representing taxa highly sensitive to organic pollution such as most mayflies and stoneflies. Scores for all organisms collected are then combined and averaged to provide an estimate of water/habitat quality, with higher MCI scores indicating higher stream health (refer Table 2-2) (Stark 1993).

A similar scoring system has yet to be developed for the Fijian situation and is currently being investigated (A Suren (NIWA), *pers. comm.*). For the purposes of this investigation, the same scores given to New Zealand species have been applied to those that were found in Fiji. Where an equivalent species score was not found then either a score for other similar species was used or a score was not assigned (this occurred on the rare occasion).

Table 2-2 Estimates Of Water And Habitat Quality In Streams Using Qmci Scores.

Water / Habitat Quality	QMCI
Degraded	0 – 4
Moderate Quality	5 – 6
High Quality	6 – 10

Statistical analyses of the 2005 survey macroinvertebrate data was undertaken using two-way analysis of variance (ANOVA) with JMP software (version 5.0.1.2, SAS Institute). ANOVA is able to detect differences between sites or groups of sites which cannot be explained by inherent variability or randomness.

As the abundance data was determined to be significantly different from normal in the previous round of sampling, it was corrected using a natural logarithmic transformation to satisfy the assumptions of the statistical comparison. Statistical significance was evaluated at the 95% confidence level however biological significance is evaluated in the discussion.

2.5 Water Quality

Water quality data has been collected to assist in describing the baseline environment in streams within the proposed development area. Water samples were collected at the same sites as the macroinvertebrate samples. The data is compared with accepted water quality guidelines to assist in the interpretation of the current status.

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At each site, water temperature (°C), dissolved oxygen (mg/L and % saturation), conductivity (S/cm) and pH were measured using a calibrated YSI 556 meter. In addition, water samples were collected at each site, stored on ice and sent to Hills Laboratory in New Zealand for analysis. Appendix 3 presents a list of the parameters determined, the laboratory methods and detection limits.

The results of the analysis are discussed in Section 5.

3. Habitat Characteristics

3.1 Introduction

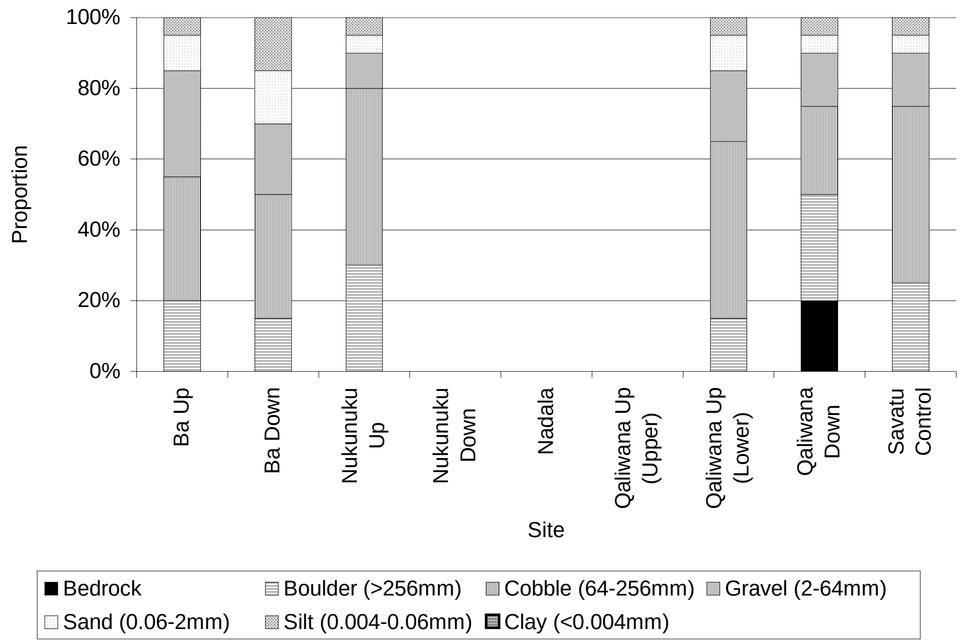
This section of the report details the habitat characteristics that were determined at each site. Appendix 2 contains an example of the field sheet used to record site details.

3.2 Results

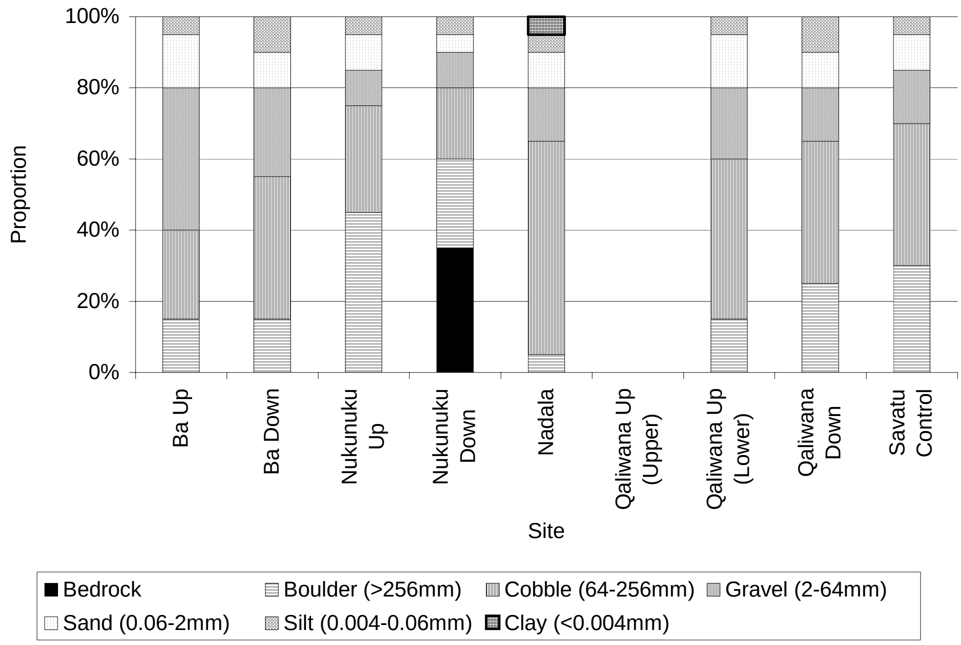
Figure 3-1 and Figure 3-2 compare the proportion of substrate types present at each site for the 2005 and 2006 surveys. Tables 4a – 4d (Appendix 4) present the results of the analysis of the habitat characteristics present at each of the sites investigated. The key points to note are as follows:

- All sites reflect the substrate characteristics targeted to yield the greatest densities and abundances of macroinvertebrates e.g., gravel (2-64mm) and cobble (64-256mm) sized substrates ranged from 40 – 70% of the total size classes. Of all the watercourses in the 2006 survey, cobble – sized substrate are greatest in the Nukunuku Creek, upstream Qaliwana and Savatu Creek sites 50%) and gravels are greatest in the upstream site in the Ba River (30%). This is similar to the 2005 survey.
- At all sites the following characteristics ranged from optimal to sub – optimal: the abundance and diversity of macroinvertebrate habitat, the velocity and depth regimes present, the amount of sediment deposition and channel alteration, the frequency of productive riffle habitat, and the stability of the banks. Marginal levels of the riparian zone width were observed at the upstream site in the Ba River. On the true right bank of the Savatu Creek control site the amount of vegetation protection and width of the riparian zone were marginal. In the 2005 survey the amount of periphyton growth at all sites, with the exception of the Savatu Creek and the upstream (lower) Qaliwana Creek sites (optimal to sub – optimal), was marginal or poor. In the 2006 survey the upstream (lower) Qaliwana Creek site was poor however both Ba River sites had improved to optimal levels.
- All of the sites in the 2006 survey were dominated by substrate that was: either tightly packed and / or overlapping or moderately packed with some overlap; had less than 24% of the substrate covered by fine sediment with the exception of the Nukunuku Creek site which had between 25 and 49% of the substrate covered; the majority of sites had no algal cover however in the 2005 survey sites mainly ranged from ‘slippery’ to ‘obvious’; and <5% macrophyte cover at nearly all sites in both surveys.

- **Figure 3-1 Comparison Of Sediment Substrate Composition (%) At Sites Investigated In The 2006 Survey**



- **Figure 3-2 Comparison Of Sediment Substrate Composition (%) At Sites Investigated In The 2005 Survey**



3.3 Summary

The analysis of site habitat characteristics has shown that all sites reflect the substrate characteristics targeted to yield the greatest densities and abundances of macroinvertebrates. The gravel and cobble substrates at all sites ranged from 40 – 70% of the substrate. The majority of habitat characteristics can be described as optimal to sub – optimal (e.g., the abundance and diversity of macroinvertebrate and fish habitat, the velocity and depth regimes present). The amount of periphyton growth at the majority of sites in the 2005 survey was marginal or poor. Improvement at some of these sites during the 2006 round was noted. With the exception of the amount of periphyton growth, similar characteristics were observed between surveys for all parameters.

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4. Macroinvertebrates

4.1 Introduction

This section of the report provides a baseline assessment of the macroinvertebrate communities present in the key streams potentially affected by the development of the proposed hydropower scheme.

4.2 Results and Discussion

4.2.1 General Description

In the 2006 survey, a total of 9,991 individuals representing 33 taxa were collected and identified. In the 2005 survey, a total of 10,630 individuals representing 42 taxa were collected and identified. The 2006 samples included species from the following orders: trichoptera (or caddisflies – 9 species), gastropoda (6 species), diptera (or two-winged flies – 6 species); two species each of odonata (damselflies and dragonflies) and ephemeroptera (mayflies); and one species each of hemiptera (or waterbugs), heteroptera (or true bugs) and crustacea (or shrimps and prawns) and a group of ‘others’ consisting of lepidoptera (moths), hirudinea (leeches), oligochaetae (bristle worms) ostracoda and sufferini. The raw data is presented in Appendix 5.

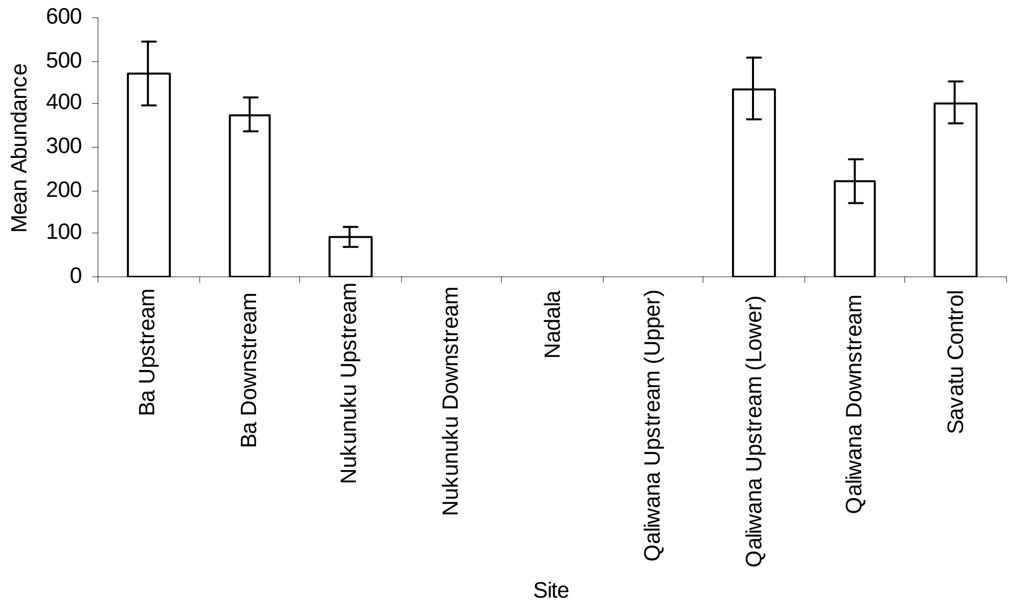
4.2.2 Densities and Number of Taxa

Figure 4-1 and Figure 4-3 presents a summary of the macroinvertebrate data identified during the current survey. The 1995 survey data is provided in Figure 4-2 and Figure 4-4 for comparison.

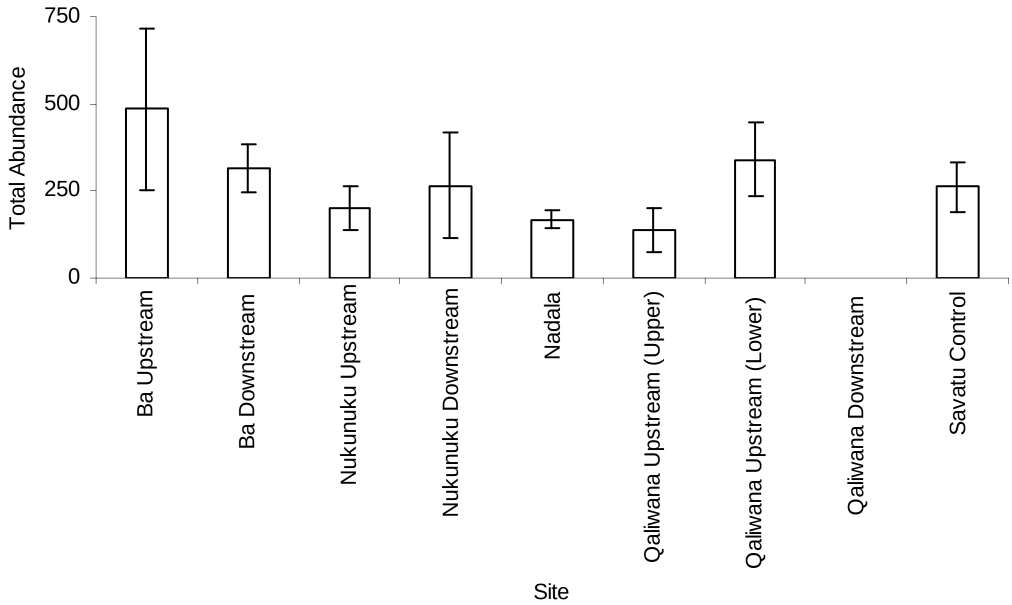
The following key points can be made:

- Mean macroinvertebrate densities (or abundances) in the 2006 survey ranged from 92 ± 47 at the Nukunuku Creek site to 470 ± 150 at the upstream site in the Ba River. This is the same as the 2005 survey where the upper Nukunuku Creek site had the lowest mean macroinvertebrate densities (201 ± 122) and the upstream site in the Ba River the highest (484 ± 462). The statistical comparison of the two surveys shows that although there is a significant ($p < 0.001$) difference between sites for both surveys, the overall interaction effect between surveys and sites is not significantly ($p > 0.05$) different (see Appendix 6).
- Mean number of species in the 2006 survey ranged from 10.6 ± 1.5 at the Nukunuku Creek site to 13.8 ± 1.1 at the downstream site on the Ba River and 13.8 ± 2.0 at the upstream site on the Qaliwana River. For sites in the 2005 survey that were repeated in the 2006 survey, the downstream site on the Ba River had the lowest mean number of species (12.2 ± 1.3) and the Savatu Creek site the highest (15.4 ± 2.1). The statistical comparison of the two surveys shows that there is a significant ($p = 0.026$) difference between sites for both surveys, with the overall interaction effect between surveys and sites also being significant ($p = 0.011$) (see Appendix 6) i.e., overall fewer species were identified across all sites in the 2006 survey which is likely to be due to natural seasonal variation.

- **Figure 4-1 Mean (± 1 SD) Macroinvertebrate Abundance For Sites (n = 5 Replicates Per Site) In The 2006 survey. Sites With No Data Were Not Sampled.**



- **Figure 4-2 Mean (± 1 SD) Macroinvertebrate Abundance For Sites (n = 5 Replicates Per Site) In The 2005 Survey. Sites With No Data Were Not Sampled.**



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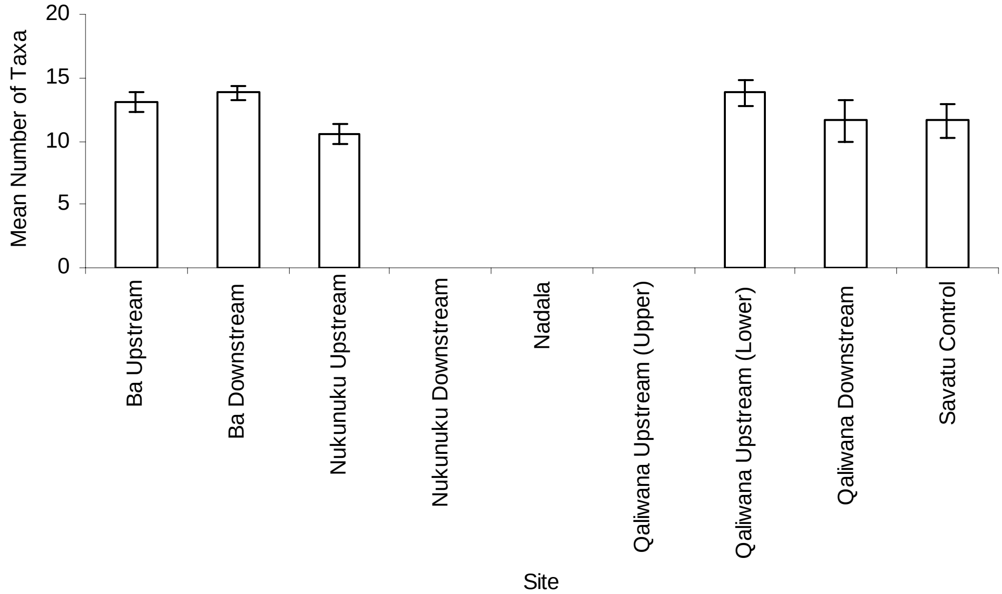
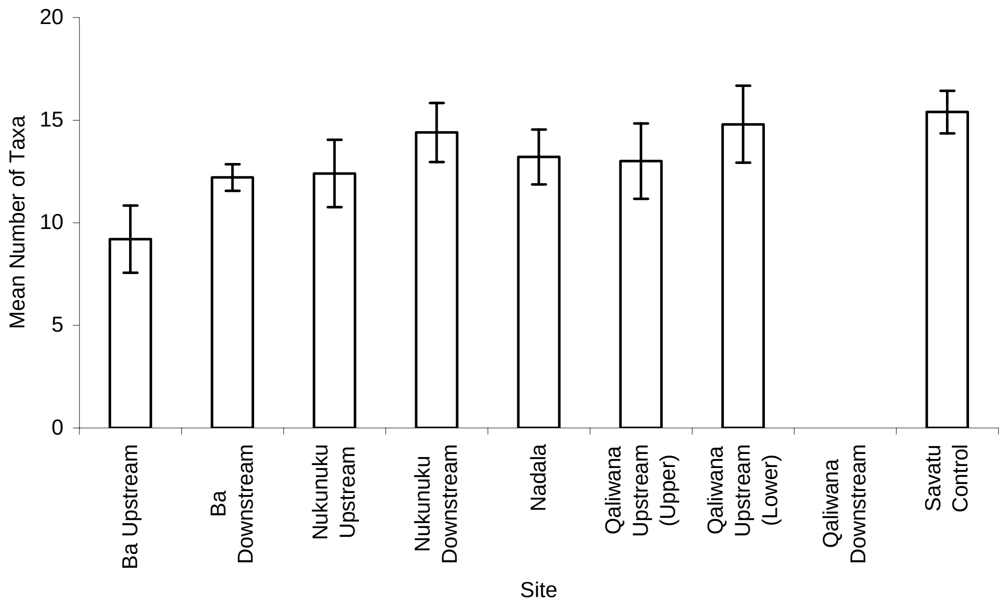
▪ **Figure 4-3 Mean (± 1 SD) Number Of Macroinvertebrate Taxa At Sites Surveyed (n = 5) In The 2006 Survey. Sites With No Data Were Not Sampled.**



▪ **Figure 4-4 Mean (± 1 SD) Number Of Macroinvertebrate Taxa At Sites Surveyed (n = 5) In The 2005 Survey. Sites With No Data Were Not Sampled.**



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4.2.3 Relative Abundance

The relative abundances of the major macroinvertebrate groups identified at sites in the 2006 and 2005 surveys are summarised in Figure 4-5 and Figure 4-6. The key points to note are as follows:

- The proportion of ephemopteran and trichopteran species in the 2006 survey which are typically amongst the most sensitive to changes in water and habitat quality were greatest at the upstream and downstream sites in the Ba River and the control site on the Savatu Creek comprising between 86 and 89% of the total taxa present. Overall, there has been a notable increase in the proportion of these taxa at all sites compared with the 2005 survey, with the exception of the Nukunuku Creek site which has remained relatively consistent.
- The proportion of dipterans (especially chironomidae), gastropods (snails) and species classified as ‘other’ such as lepidoptera (moths), hirudinea (leeches) and oligochaetae(worms), which tend to be the most tolerant to changes in water and habitat quality, was greatest at the Nukunuku Creek site (34.5%). This is similar to the results of the 2005 survey where 45.2% of the total taxa present at this site were represented by these taxa.

As expected, the types of species present are largely determined by habitat conditions. The sites with a high proportion of ephemoptera and trichoptera were characterised by what was considered to be optimal to sub-optimal conditions in relation to habitat (see Section 3 for more detail). On the other hand, the sites with a high proportion of diptera and other more tolerant species were characterised by what was considered to be sub-optimal to marginal or poor conditions in relation to habitat quality particularly the amount of periphyton growth and fine sediment present.

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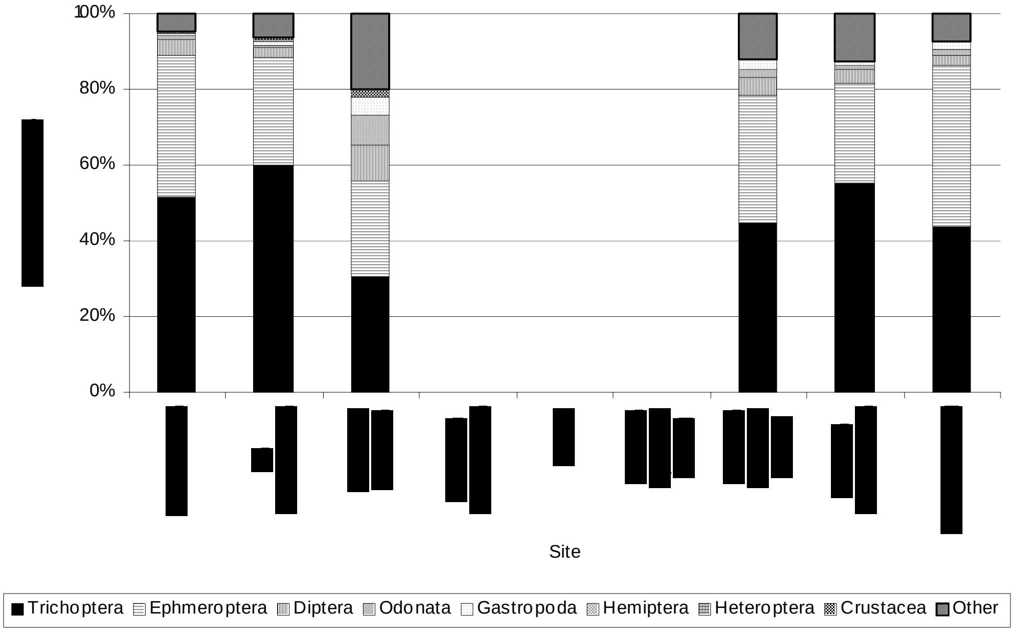
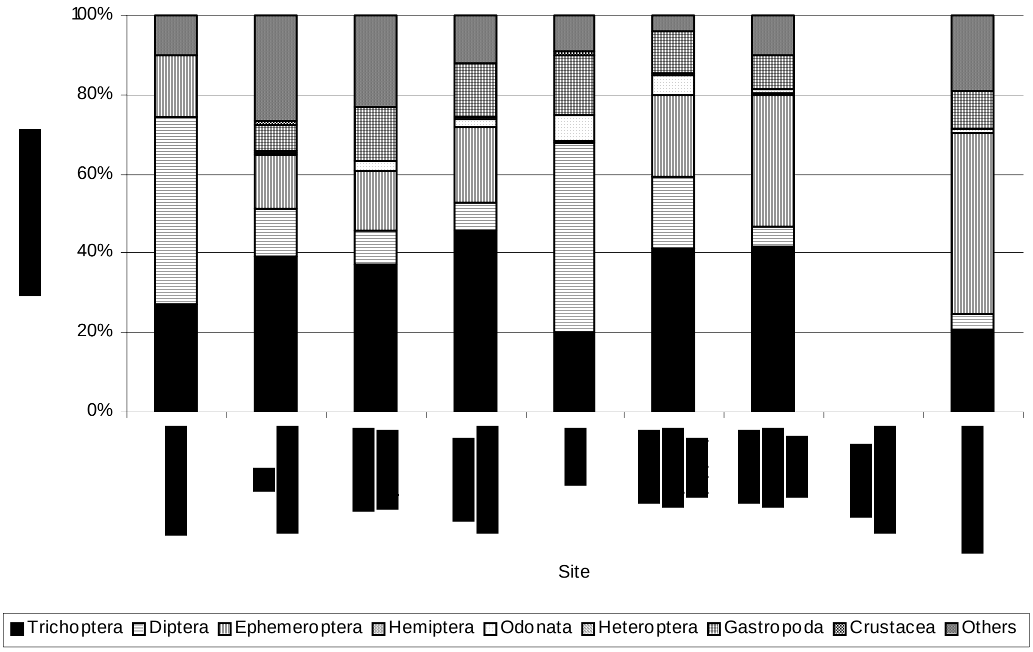
- **Figure 4-5 Relative Abundance (%) of key Macroinvertebrate Groups Identified In Samples From The 2006 Survey. Sites With No Data Were Not Sampled.**



- **Figure 4-6 Relative Abundance (%) Of Key Macroinvertebrate Groups Identified In Samples From The 2005 Survey. Sites With No Data Were Not Sampled.**



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4.2.4 QMCI

As indicated in Section 2.4.3, the QMCI scoring system devised for New Zealand stony streams and rivers has been applied to the Fijian species data. The QMCI data is presented in Figure 4-7 and Figure 4-8. The key points to note are as follows:

- Mean QMCI ranged in the 2006 survey ranged from 2.4 ± 0.8 at the downstream site in the Ba River to 3.6 ± 0.7 at the control site in Savatu Creek. In the 2005 survey, for sites repeated in the 2006 survey, mean QMCI ranged from 3.3 ± 0.6 at the upstream site in the Ba River to 5.3 ± 0.4 at the control site in Savatu Creek. The statistical comparison between surveys and sites shows that the interaction effect is significant difference ($p = 0.04$).
- All of the sites have habitat conditions that are considered to be 'degraded' (see Table 2-2) based on the types of species present. In the 2005 survey the Qaliwana and Savatu Creek sites were described as having habitat conditions of 'moderate quality'.

4.3 Summary

The analysis of macroinvertebrate samples collected in the 2006 survey from the watercourses potentially effected by the proposed development has shown that densities and number of taxa overall are moderately high. A statistically significant difference was observed between site and surveys for macroinvertebrate density and QMCI score which is likely to be due to natural seasonal variation. Where habitat conditions are optimal, such as at sites in Qaliwana Creek and Savatu Creek (control site), the fauna is dominated by trichopteran (mayflies) and ephemopteran (caddisflies) taxa which are typically most sensitive to changes in habitat and water quality. Where habitat conditions were sub optimal to marginal such as in the Nukunuku Creek site the fauna was dominated by dipterans (two – winged flies), lepidoptera (moths), hirudinea (leeches) and oligochaetae.

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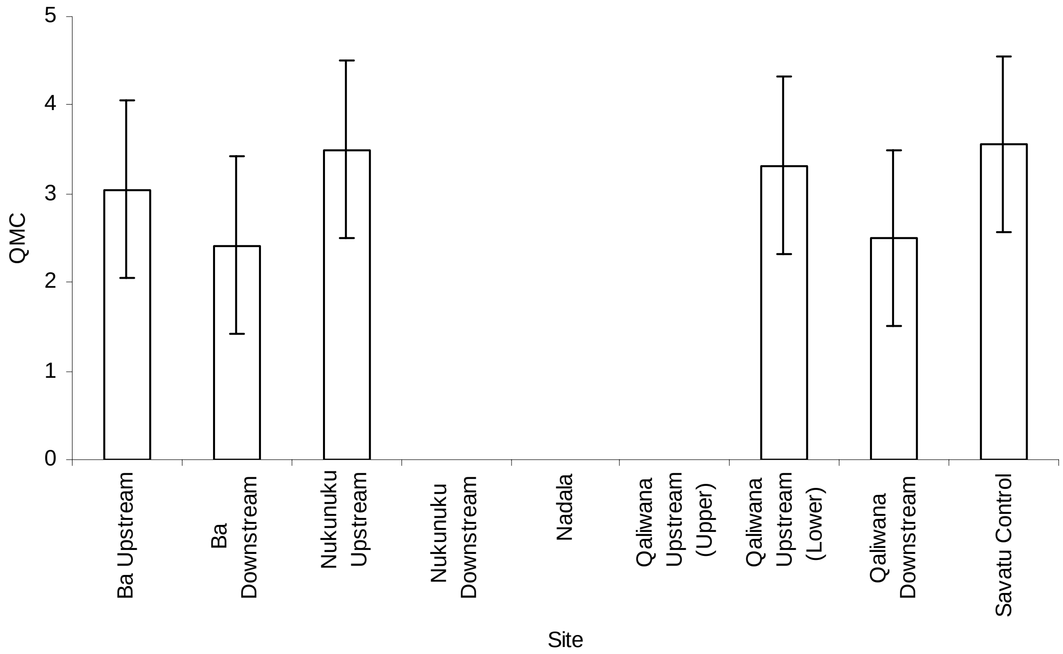
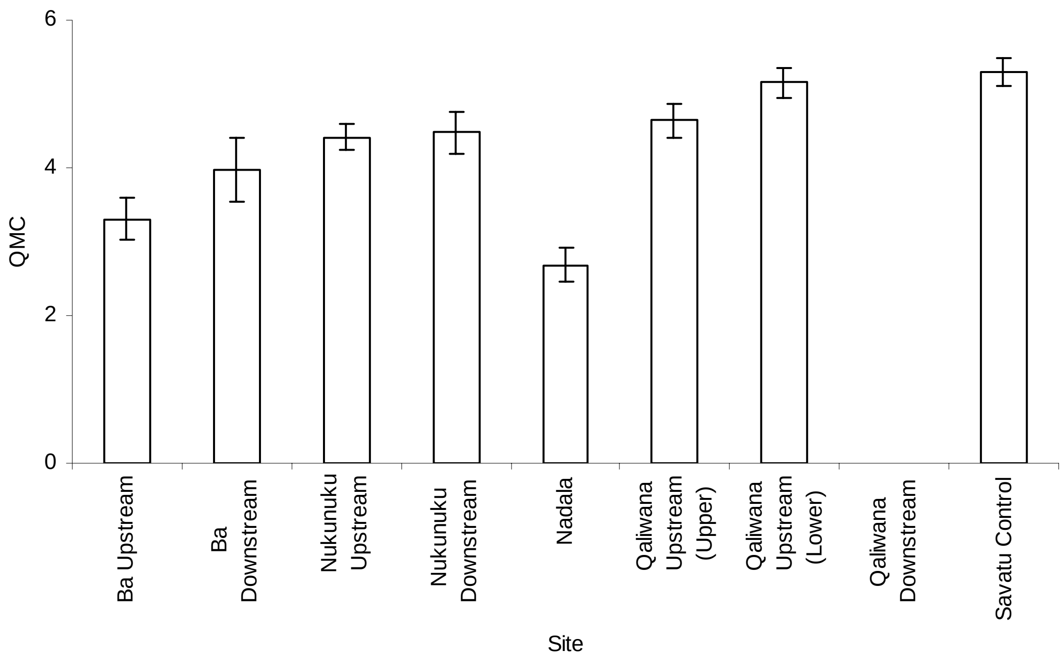
- **Figure 4-7 Mean (± 1 SD) QMCI score At Sites Surveyed (N = 5) In The 2006 Survey.**



- **Figure 4-8 Mean (± 1 SD) QMCI Score At Sites Surveyed (n = 5) In The 2005 Survey.**



SKM

5. Water Quality

5.1 Introduction

This section of the report provides a summary of the surface water quality data collected during the 2006 fieldwork undertaken by SKM and compares the results with the 2005 survey data.

5.2 Results

The results of the 2005 and 2006 surveys are presented in Table 5-1 and Table 5-2. For sites that were repeated in the 2006 survey, the key points to note are as follows:

General Parameters

- Water temperatures ranged from 19.7°C at the upstream site (lower) in the Qaliwana Creek to 26.3°C at the Savatu Creek site.
- Dissolved oxygen concentrations ranged from 7.34 mg/L at the upstream site in Nukunuku Creek to 9.46 mg/L at the upstream site on the Qaliwana River. All concentrations are above the ANZECC (2000) guideline minimum concentration of 6 mg/L.
- Conductivities ranged from 55 µS/cm at the upstream site (lower) in the Qaliwana Creek to 164 µS/cm at the Savatu Creek site. Overall, the high conductivities tended to be in the watercourses with greater flows at the time of sampling.
- pH ranged from 7.2 at the upstream site in Nukunuku Creek to 8.4 at the upstream site on the Ba River. All pH recorded are within the ANZECC (2000) guideline range of 6.5 – 8.5.
- Turbidity ranged from 0.31 NTU at the Savatu Creek site to 2.9 NTU at the upstream site in Qaliwana Creek. All turbidity results are within the ANZECC (2000) guideline of 4.1 NTU.
- Total suspended solids concentrations for both surveys were at (3 mg/L) or below the detection limits of the analysis (<3 mg/L).
- Total alkalinity and total hardness ranged from 26 and 22 mg/L respectively at the downstream site in the Ba River to 83 and 75 mg/L at the Savatu Creek site.

Nutrients

- Total N and TKN in samples collected in both SKM surveys were at (0.1 mg/L) or below the detection limits (<0.1 mg/L) of the analysis with the exception of the downstream site in the Qaliwana River (0.2 mg/L). No samples exceed the ANZECC (2000) guideline concentration of 0.295 mg/L.
- Ammonium – N concentrations at all sites were below the detection limits (<0.01 mg/L) of the analysis and the recommended ANZECC (2000) guideline concentration of 0.9 mg/L.

- Nitrate concentrations ranged from 0.002 mg/L at the upstream sites in Nukunuku and Qaliwana Creeks to 0.048 mg/L at the downstream site on the Ba River. No samples exceeded the ANZECC (2000) guideline concentration of 0.7 mg/L.
- Nitrite concentrations at all sites in both surveys were below the detection limits (<0.002 mg/L) of the analysis and the recommended ANZECC (2000) guideline concentration of 0.7 mg/L.
- Total phosphorus concentrations ranged from 0.011 mg/L at the upstream site (lower) on the Qaliwana Creek and Nukunuku Creek to 0.084 mg/L at the Savatu Creek site. A number of samples exceeded the ANZECC (2000) guideline concentration of 0.026 mg/L.
- DRP concentrations ranged from <0.004 mg/L at the upstream site on Nukunuku Creek and the upstream site (lower) on the Qaliwana Creek to 0.082 mg/L at the Savatu Creek site.

Cations, Anions and Metals

- Calcium concentrations ranged from 3.44 mg/L at the Nadala Creek site to 14.1 mg/L at the Savatu Creek site.
- Magnesium concentrations ranged from 3.16 mg/L at the upstream site (upper) on the Qaliwana River to 9.57 mg/L at the Savatu Creek site.
- Sodium concentrations ranged from 1.67 mg/L at the Nadala Creek site to 7.34 mg/L at the downstream site on the Ba River.
- Potassium concentrations ranged from 0.28 mg/L at the Nadala Creek site to 2.63 mg/L at upstream site on the Ba River.
- Chloride concentrations ranged from 1.8 mg/L at the Nadala Creek site to 2.5 mg/L at the downstream site on the Qaliwana River.
- Sulphate concentrations ranged from <0.5 mg/L at a number of sites to 1.0 mg/L at the Nadala and Savatu Creek sites.
- Total Fe concentrations ranged from 0.03 mg/L at the upstream site in the Qaliwana River and the Savatu Creek site to 0.55 mg/L at the downstream site on Nukunuku Creek.
- Total Mn concentrations ranged from 0.0016 mg/L at the Savatu Creek site to 0.0211 mg/L at the downstream site on Nukunuku Creek. There were no exceedences of the ANZECC (2000) guideline value of 1.2 mg/L.

5.3 Summary

Samples were collected from six sites in the July 2006 survey compared to eight sites in the February 2005. Samples were analysed for a range of general parameters, nutrients, cations, anions and trace metals. Sites that have been repeatedly sampled are located upstream and downstream of the various proposed hydropower scheme elements in the Qaliwana and Nukukunuku Creeks, and Ba River, and in a control stream. Several minor exceedences of ANZECC (2000) guideline values were observed.

▪ Table 5-1 A Comparison Of Water Quality Data For Streams Sampled By Skm In 2006 And 2005 With Accepted Water Quality Guideline Concentrations (All Results Mg/L Unless Stated).

	Ba River		Nukunuku Creek		Nadala Creek	Qaliwana Creek			Savatu Creek	
Parameter	Upstream	Downstream	Upstream	Downstream		Upstream (upper)	Upstream (lower)	Downstream		Guideline Values
Temp (°C)	24.1, 21.5	23.3, 21.5	26.1, 22.1	23.9, -	25.7, -	25.7, -	25.9, 19.7	19.9	26.3, 20.8	-
DO (%)	105.0, -	93.9, -	102.9, -	86.1, -	100.5, -	104.3, -	92.7, -		92.5, -	99 – 103[1]
DO	8.82, 8.5	8.00, 8.3	8.33, 7.34	7.25, -	8.20, -	8.52, -	7.53, 9.46	8.6	7.45, 8.31	
Conductivity (μS/cm)	146, 115	146, 132	84, 62	87, -	50, -	57, -	58, 55	76	164, 146	-
pH	8.4, 7.5	8.3, 7.9	7.9, 7.2	7.7, -	7.3, -	8.1, -	8.2, 7.6	7.5	7.9, 7.3	7.3 – 8.0[1]
Turbidity (NTU)	0.53, 1.63	0.55, 0.93	0.94, 2.45	2.93, -	0.4, -	0.34, -	0.92, 0.44	2.9	0.31, 0.64	-
TSS	<3, <3	<3, <3	<3, <3	<3, -	<3, -	<3, -	<3, <3	3	<3, <3	4.1[1]
Total alkalinity	28, 64	26, 73	43, 34	26, -	71, -	70, -	45, 32	40	83, 83	-
Total hardness	24, 55	22, 62	38, 32	22, -	57, -	55, -	39, 30	36	72, 75	-
Total N	<0.1, <0.1	<0.1, <0.1	0.1, <0.1	<0.1, -	<0.1, -	<0.1, -	0.1, <0.1	0.2	<0.1, <0.1	0.295[1]
TKN	<0.1, <0.1	<0.1, <0.1	0.1, <0.1	<0.1, -	<0.1, -	<0.1, -	0.1, <0.1	0.2	<0.1, <0.1	-
Ammonium - N	<0.01, <0.01	<0.01, <0.01	<0.01, <0.01	<0.01, -	<0.01, -	<0.01, -	<0.01, <0.01	<0.01	<0.01, <0.01	0.9[2]
Nitrate	0.030, 0.05	0.031, 0.048	0.01, 0.002	0.004, -	0.003, -	<0.002, -	0.011, 0.002	0.024	0.05, 0.06	0.7[2]
Nitrite	<0.002, <0.002	<0.002, <0.002	<0.002, <0.002	<0.002, -	<0.002, -	<0.002, -	<0.002, <0.002	<0.002	<0.002, <0.002	-
Total Phosphorus	0.06, 0.064	0.059, 0.067	0.02, 0.02	0.022, -	0.009, -	0.009, -	0.013, 0.011	0.047	0.083, 0.084	0.026[1]
DRP	0.058, 0.049	0.057, 0.049	0.016, <0.004	0.016, -	0.005, -	0.010, -	0.011, <0.004	0.029	0.082, 0.073	0.009[1]

Notes: - = no data available. 1 ANZECC (2000). 2 ANZECC (2000) for level of protection afforded to 95% of species.

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Table 5-2 Comparative Summary Of Cations, Anions And Trace Metals For Streams Sampled By Skm In 2005 And 2006 With Guideline Values (All Results Mg/L Unless Stated).

Parameter	Ba River		Nukunuku Creek		Nadala Creek	Qaliwana River			Savatu Creek	Guideline Values[2]
	Upstream	Downstream	Upstream	Downstream		Upstream (upper)	Upstream (lower)	Downstream		
Calcium	11.7, 10.9	12.4, 12.9	6.45, 5.25	6.83, -	3.44, -	3.54, -	3.82, 4.74	-, 7.16	14.1, 14.1	-
Magnesium	6.32, 6.65	6.41, 7.2	5.22, 4.59	5.3, -	3.31, -	3.16, -	3.4, 4.31	-, 4.35	8.86, 9.57	-
Sodium	6.53, 5.91	7.33, 7.34	2.24, 1.76	2.22, -	1.67, -	2.29, -	2.33, 2.29	-, 3.02	6.58, 6.18	-
Potassium	2.63, 2.55	2.59, 2.76	1.03,	1.09, -	0.28, -	0.82, -	0.82, 0.75	-, 1.87	2.26, 2.24	-
Chloride	2.2, 2.2	2.3, 2.4	2, 1.9	1.9, -	1.8, -	2.3, -	2.3, 2.2	-, 2.5	2.4, 1.9	-
Sulphate	0.9, 0.6	1, 0.6	<0.5, <0.5	<0.5, -	<0.5, -	<0.5, -	<0.5, <0.5	-, 0.5	1, 0.7	-
Total Anions	1.47, 1.36	1.5, 1.55	0.91, 0.73	0.95, -	0.57, -	0.59, -	0.62, 0.69	-, 0.88	1.76, 1.73	-
Total Cations	1.46, 1.41	1.53, 1.63	0.87, 0.74	0.9, -	0.52, -	0.56, -	0.59, 0.71	-, 0.89	1.78, 1.82	-
Total Fe	0.03, 0.08	0.05, 0.08	0.14, 0.161	0.12, -	0.55, -	0.15, -	0.12, 0.12	-, 0.21	0.04, 0.03	ID
Total Mn	0.0026, 0.0063	0.0056, 0.0122	0.0142, 0.0175	0.0151, -	0.0211, -	0.0058, -	0.0051, 0.0042	-, 0.0139	0.0016, 0.0044	1.2[1]

Notes: - = no data available. ID – Insufficient data to derive a reliable trigger value. 2 ANZECC (2000) for level of protection afforded to 99% of species.

6. References

IAS, 2004. Insititue of Applied Science. Baseline water quality and biological survey of the proposed new hydroelectricity generating sites at the headwaters of the Ba and Sigatoka Rivers. Report prepared for the Fiji Electricity Authority.

Plafkin, J. L.; Barbour, M. T.; Porter, K. D.; Gross, S. K.; Hughes, R. M. 1989: Rapid bioassessment protocols for use in streams and rivers: benthic macroinvertebrates and fish. USEPA Report EPA/444/4-89-001, Washington DC.

Pridmore, R. D.; Roper, D. S. 1985: Comparison of the macroinvertebrate faunas of runs and riffles in three New Zealand streams. New Zealand journal of marine and freshwater research 19: 283-291.

SKM 2005. Sigatoka Ba Hydropower Project. Freshwater Ecological and Water Quality Investigations. Final. Unpublished.

Stark J. D. 1985: A Macroinvertebrate Community Index of water quality for stony streams. Water and soil miscellaneous publication No. 87, National Water and Soil Conservation Authority, Wellington. 53p.

Stark, J. D. 1993: Performance of the Macroinvertebrate Community Index: effects of sampling methods, sample replication, water depth, current velocity and substratum on index values. New Zealand journal of marine and freshwater research 27: 463-478.

Stark J.D.; Boothroyd I.K.G.; Harding J.S.; Maxted J.R.; Scarsbrook M.R. 2001: Protocols for sampling macroinvertebrates in wadeable streams. New Zealand Macroinvertebrate Working Group Report No. 1. Prepared for the Ministry for the Environment.

Tukey, J. 1991: The philosophy of multiple comparisons. Statistical Science. 6, 100–116.

Winterbourn, M. J. 1981: The use of invertebrates in studies of stream quality. Water and soil technical publication No. 22.

Appendix 1 Site Photos

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Appendix 1 Site Photos

- Plate 1: Upstream (lower) Qaliwana Creek site looking upstream

- Plate 2: Upstream (lower) Qaliwana Creek site looking downstream

- Plate 3: Downstream Qaliwana Creek site looking upstream

- Plate 4: Downstream Qaliwana Creek site looking downstream

- Plate 5: Upstream Nukunuku Creek site looking upstream

- Plate 6: Upstream Nukunuku Creek site looking downstream

- Plate 7: Upstream Ba River site looking upstream

- Plate 8: Upstream Ba River site looking downstream

- Plate 9: Downstream Ba River site looking upstream

- Plate 10: Downstream Ba River site looking downstream

- Plate 11: Savatu Creek site looking upstream

- Plate 12: Savatu Creek site looking downstream

Appendix 2 Field Sheet

FIELD ASSESSMENT COVER FORM:
WADEABLE HARD-BOTTOMED AND SOFT-BOTTOMED STREAMS

STREAM NAME: | **ASSESSOR:**

SITE NUMBER: | **SAMPLE NUMBER:** | **DATE:** | **TIME (NZST):**

GPS COORDINATES: **Downstream end of reach - Easting –** **Northing –**
Upstream end of reach - Easting – **Northing –**

CHANNEL AND RIPARIAN FEATURES

Canopy Cover:

µ Open µ Partly shaded µ Significantly shaded

Fencing:

µ None or ineffective
µ One side or partial
µ Complete both sides

Riparian Vegetation:

µ Pasture µ Retired grass
µ Crops etc µ Native-young
µ Exotic trees µ Native-old

INSTREAM HYDRAULIC CONDITIONS

Estimated or measured reach average:

Stream width (active channel) _________ m
Stream width (water) _________ m
Stream depth _________ m
Surface velocity _________ m/sec

WATER QUALITY

Temperature: _________ ^{o}C Conductivity: _______ µS/cm @ 25^{o}C
Dissolved Oxygen: _______ % _______ mg/L
Turbidity: µ Clear µ Slightly turbid µ Highly turbid µ Stained µ Other______________

INORGANIC SUBSTRATE

Compaction:

µ assorted sizes tightly packed &/or overlapping
µ moderately packed with some overlap
µ mostly a loose assortment with little overlap
µ no packing / loose assortment easily moved.

Embeddedness:

µ <5% gravel-boulder particles covered by fine sediment
µ 5-24% covered by fine sediment
µ 25-49% covered by fine sediment
µ 50-75% covered by fine sediment
µ >75% covered by fine sediment

% surficial substrate size composition
(should sum to 100%)

Substrate type	**Dimension (middle axis)**	**Percentage**
Bedrock	-	
Boulder	> 256mm	
Cobble	>64-256mm	
Gravel	>2-64mm	
Sand	>0.06-2mm	
Silt	0.004-0.06mm	
Clay	<0.004mm	

ORGANIC MATERIAL (% cover - need not sum to 100%)
Large wood (>10 cm diameter): _______%
Detritus (small wood, sticks, leaves etc > 1 mm): _____%
Fine organic matter < 1 mm): _______%

INSTREAM PLANTS

Algal cover (focus on stable substrates):
µNone µSlippery µObvious µAbundant µExcessive

Macrophyte cover:
µ<5% µ5-25% µ26-50% µ51-75% µ>75%

HABITAT TYPES SAMPLED (% of effort; each column should sum to 100%)

Stones: ______%
Wood: ______%
Macrophytes: ______%
Edges: ______%

Riffles: ______%
Runs: ______%

COMMENTS

NO. INVERTEBRATES RETURNED:
Shrimps: _______
Crabs: _______ Mussels: _______
Others (specify) __________________________

WADEABLE HARD-BOTTOMED STREAMS

Qualitative Habitat Assessment Field Data Sheet

STREAM NAME:	**SITE NUMBER:**
SAMPLE NUMBER: **ASSESSOR:**	**DATE:**

Habitat Parameter	**Category**			
	Optimal	**Suboptimal**	**Marginal**	**Poor**
1. Riparian Vegetative Zone Width (score each bank; determine left or right side by facing downstream)	• Bankside vegetation buffer is >10m • Continuous and dense	• Bankside vegetation buffer is <10m • Mostly continuous	• Pathways present and/or stock access to stream • Mostly healed over	• Breaks frequent • Human activity obvious
Left bank	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1
Right bank	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1
Mean LB&RB_____				
2. Vegetative Protection (score each bank; determine left or right side by facing downstream	• Bank surfaces and immediate riparian zones covered by native vegetation • Trees, understorey shrubs, or non-woody plants present • Vegetative disruption minimal	• Bank surfaces covered mainly by native vegetation • Disruption evident • Banks may be covered by exotic forestry	• Bank surfaces covered by a mixture of grasses/shrubs, blackberry, willow and introduced trees • Vegetation disruption obvious • Bare soil/closely cropped vegetation common	• Bank surfaces covered by grasses and shrubs • Disruption of streambank vegetation very high • Grass heavily grazed • Significant stock damage to the bank
Left bank	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1
Right bank	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1
Mean LB&RB_____				
3. Bank Stability (score each bank; determine left of right side by facing downstream	• Banks stable • Erosion/bank failure absent or minimal • <5% of bank affected	• Moderately stable • Infrequent, small areas of erosion mostly healed over • 5-30% of bank eroded	• Moderately unstable • 30-60% of bank in reach has areas of erosion • High erosion potential during floods	• Unstable • Many eroded areas • 60-100% of bank has erosional scars
Left bank	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1
Right bank	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1
Mean LB&RB_____				
4. **Frequency of Riffles**	• Riffles relatively frequent • Distance between riffles divided by width of stream = 5-7 • Variety of habitat is key	• Occurrence of riffles infrequent • Distance between riffles divided by width of stream = 7-15	• Occassional riffle or run • Bottom contours provide some habitat • Distance between riffles divided by width of stream = 15-25	• Generally flat water, shallow riffles • Poor habitat • Distance between riffles divided by width of stream = >25
SCORE ___	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1

SUBTOTAL : _____________

Habitat Parameter	Category			
	Optimal	**Suboptimal**	**Marginal**	**Poor**
5. Channel Alteration	• Changes to channel/dredging absent or minimal • Stream with normal pattern	• Some changes to channel/dredging • Evidence of past channel/dredging • Recent channel/dredging not present	• Channel changes/dredging extensive • Embankments or shoring structures present on both banks • 40 to 80% of reach channelised and disrupted	• Banks shored with gabion or cement • >80% of the stream reach channelised and disrupted. • Instream habitat altered or absent
SCORE ___	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1
6. Sediment Deposition (out of channel and in channel)	• Little/no islands or point bars present • <20% of the bottom affected by sediment deposition	• New increase in bar formation, mostly from gravel, sand or fine sediment • 20-50% of the bottom affected • Slight deposition in pools	• Some deposition of new gravel, sand or fine sediment on old and new bars • 50-80% of the bottom affected • Sediment deposits at obstructions, constrictions, and bends	• Heavy deposits of fine material • Increased bar development • >80% of the bottom changing frequently • Pools almost absent due to sediment deposition
SCORE ___	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1
7. Veloctity/Depth Regimes	• 4 velocity/depth regimes present • Slow/deep, Slow/shallow, Fast/shallow, Fast/deep	• 3 of 4 velocity/depth regimes present • If fast/shallow is missing then score lower	• 2 of 4 velocity/depth regimes present • If fast/shallow or slow/shallow are missing score low	• Dominated by 1 velocity/depth regime • Usually slow/deep
SCORE ___	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1
8. Abundance and Diversity of Habitat	• >50% substrate favourable for invertebrate colonisation and wide variety of woody debris, riffles, root mats • Snags/ submerged logs/ undercut banks/ cobbles provides abundant fish cover • Must not be new or transient	• 30-50% substrate favourable for invertebrate colonisation • Snags/submerged logs/undercut banks/cobbles • Fish cover common • Moderate variety of habitat types. Can consist of some new material	• 10-30% substrate favourable for invertebrate colonisation • Fish cover patchy • 60-90% substrate easily moved by foot • Woody debris rare or may be smothered by sediment	• <10% substrate favourable for invertebrate colonisation • Fish cover rare or absent • Substrate unstable or lacking • Stable habitats lacking or limited to macrophytes
SCORE ___	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1
10. Periphyton	• Periphyton not visible on hand held stones • Stable substrate • Surfaces rough to touch	• Periphyton not visible on stones • Stable substrate • Periphyton obvious to touch	• Periphyton visible • <20% cover of available substrate	• Periphyton obvious and prolific • >20% cover of available substrate
SCORE ___	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1
Total Score ____	NB: Use only means of LB and RB values			

Appendix 3 Laboratory Results

Hill Laboratories

R J Hill Laboratories Limited

Address:
1 Clyde Street,
Private Bag 3205,
Hamilton, New Zealand

Telephone:
+64 (7) 858-2000
Facsimile:
+64 (7) 858-2001

Email:
mail@hill-labs.co.nz
Internet:
www.hill-labs.co.nz

Client: *Sinclair Knight Merz Limited*
Address: *P O Box 9806, Newmarket AUCKLAND*
Contact: *Luke Gowing*

Laboratory No: *424797*
Date Registered: *10/07/2006*
Date Completed: *20/07/2006*

Client's Reference: Overseas Samples

The results for the analyses you requested are as follows:

Sample Type: Water,

Sample Name	Lab No	pH (pH units)	Electrical Conductivity (mS/m)	Total Alkalinity (g.m-3 as CaCO3)	Bicarbonate (g.m-3 at 25°C)	Turbidity (NTU)
Ba Upper 06/07/06	424797/1	7.9	13.2	64	78	1.63
Ba Lower 06/07/06	424797/2	8.0	14.9	73	88	0.93
Nukunuku 06/07/06	424797/3	7.7	7.0	34	41	2.45
Qaliwana Upper 05/07/06	424797/4	7.7	6.8	32	38	0.44
Qaliwana Lower 06/07/06	424797/5	7.7	8.4	40	49	2.90
Savatu 06/07/06	424797/6	8.0	16.5	83	100	0.64

Sample Name	Lab No	Total Suspended Solids (g.m-3)	Dissolved Calcium (g.m-3)	Dissolved Magnesium (g.m-3)	Total Hardness (g.m-3 as CaCO3)	Dissolved Sodium (g.m-3)
Ba Upper 06/07/06	424797/1	< 3	10.9	6.65	55	5.91
Ba Lower 06/07/06	424797/2	< 3	12.9	7.20	62	7.34
Nukunuku 06/07/06	424797/3	< 3	5.25	4.59	32	1.76
Qaliwana Upper 05/07/06	424797/4	< 3	4.74	4.31	30	2.29
Qaliwana Lower 06/07/06	424797/5	3	7.16	4.35	36	3.02
Savatu 06/07/06	424797/6	< 3	14.1	9.57	75	6.18

Sample Name	Lab No	Dissolved Potassium (g.m-3)	Total Ammoniacal-N (g.m-3)	Total Nitrogen (g.m-3)	Total Kjeldahl Nitrogen (TKN) (g.m-3)	Nitrate-N + Nitrite-N (TON) (g.m-3)
Ba Upper 06/07/06	424797/1	2.55	< 0.01	< 0.1	< 0.1	0.051
Ba Lower 06/07/06	424797/2	2.76	< 0.01	< 0.1	< 0.1	0.048
Nukunuku 06/07/06	424797/3	0.74	< 0.01	< 0.1	< 0.1	0.002
Qaliwana Upper 05/07/06	424797/4	0.75	< 0.01	< 0.1	< 0.1	0.002
Qaliwana Lower 06/07/06	424797/5	1.87	< 0.01	0.2	0.2	0.025
Savatu 06/07/06	424797/6	2.24	< 0.01	< 0.1	< 0.1	0.061

Sample Name	Lab No	Nitrate-N (g.m-3)	Nitrite-N (g.m-3)	Dissolved Reactive Phosphorus (g.m-3)	Total Phosphorus (g.m-3)	Chloride (g.m-3)
Ba Upper 06/07/06	424797/1	0.050	< 0.002	0.049	0.064	2.2
Ba Lower 06/07/06	424797/2	0.048	< 0.002	0.049	0.067	2.4
Nukunuku 06/07/06	424797/3	0.002	< 0.002	< 0.004	0.020	1.9
Qaliwana Upper 05/07/06	424797/4	0.002	< 0.002	< 0.004	0.011	2.2
Qaliwana Lower 06/07/06	424797/5	0.024	< 0.002	0.029	0.047	2.5
Savatu 06/07/06	424797/6	0.060	< 0.002	0.073	0.084	1.9

Sample Name	Lab No	Sulphate (g.m-3)	Total Iron (g.m-3)	Total Manganese (g.m-3)	Total Anions (mEquiv/L)	Total Cations (mEquiv/L)
Ba Upper 06/07/06	424797/1	0.6	0.08	0.0063	1.36	1.41
Ba Lower 06/07/06	424797/2	0.6	0.08	0.0122	1.55	1.63
Nukunuku 06/07/06	424797/3	< 0.5	0.16	0.0175	0.73	0.74
Qaliwana Upper 05/07/06	424797/4	< 0.5	0.12	0.0042	0.69	0.71
Qaliwana Lower 06/07/06	424797/5	0.5	0.21	0.0139	0.88	0.89
Savatu 06/07/06	424797/6	0.7	0.03	0.0044	1.73	1.82

Sample Containers

The following table shows the sample containers that were associated with this job.

Container Description	Container Size (mL)	Number of Containers
Unpreserved (1L)	1000	6
Sulphuric Preserved (250 mL)	250	6
Nitric Preserved (100 mL)	100	6

Details of sample bottle preparation procedures are available upon request.

Summary of Methods Used and Detection Limits

The following table(s) gives a brief description of the methods used to conduct the analyses for this job.
The detection limits given below are those attainable in a relatively clean matrix. Detection limits may be higher for individual samples should insufficient sample be available, or if the matrix requires that dilutions be performed during analysis.

Substance Type: Water

Parameter	Method Used	Detection Limit
Sample filtration for general testing	Sample filtration through 0.45µm membrane filter.	N/A
Sample filtration for metals analyses	Sample filtration through nitric washed 0.45µm membrane filter. APHA 3030 B 20th ed. 1998	N/A
Total (nitric) acid digest for low level metals	Nitric acid digestion. APHA 3030 E 20th ed. 1998	N/A
pH	pH meter APHA 4500-H^+ B 20th ed. 1998	0.1 pH units
Electrical Conductivity	Conductivity meter, 25°C APHA 2510 B 20th ed. 1998	0.1 mS/m
Total Alkalinity	Titration to pH 4.5 (M-alkalinity), Radiometer autotitrator. APHA 2320 B (Modified for alk <20) 20th ed. 1998	1 g.m-3 as CaCO3
Bicarbonate	Calculation: from alkalinity and pH, valid where TDS is not >500 mg/L and alkalinity is almost entirely due to hydroxides, carbonates or bicarbonates. APHA 4500-CO_2 D 20th ed. 1998	1 g.m-3 at 25°C

Parameter	Method Used	Detection Limit
Turbidity	Analysis using a Hach 2100N, Turbidity meter. APHA 2130 B 20th ed. 1998	0.05 NTU
Total Suspended Solids	Filtration (GF/C, 1.2 µm), retained residue dried at 103 - 105 °C, Gravimetric. APHA 2540 D 20th ed. 1998	3 g.m-3
Dissolved Calcium	Filtered sample, ICP-MS APHA 3125 B 20th ed. 1998	0.05 g.m-3
Dissolved Magnesium	Filtered sample, ICP-MS APHA 3125 B 20th ed. 1998	0.02 g.m-3
Total Hardness	Calculation: from Dissolved Ca and Dissolved Mg APHA 2340 B 20th ed. 1998	1 g.m-3 as CaCO3
Dissolved Sodium	Filtered sample, ICP-MS APHA 3125 B 20th ed. 1998	0.02 g.m-3
Dissolved Potassium	Filtered sample, ICP-MS APHA 3125 B 20th ed. 1998	0.05 g.m-3
Total Ammoniacal-N	Filtered sample. Phenol/hypochlorite colorimetry. Discrete Analyser. (NH4-N = $NH4^+$-N + NH3-N) APHA 4500-NH_3 F (modified from manual analysis) 20th ed. 1998	0.01 g.m-3
Total Nitrogen	Calculation: TKN + Nitrate-N + Nitrite-N	0.1 g.m-3
Total Kjeldahl digestion	Sulphuric acid digestion with copper sulphate catalyst. APHA 4500-N_{org} D. (modified) 20th ed. 1998	N/A
Total Kjeldahl Nitrogen (TKN)	Kjeldahl digestion, phenol/hypochlorite colorimetry (Discrete Analysis). APHA 4500-N_{org} B. (modified) 4500-NH_3 F (modified) 20th ed. 1998	0.1 g.m-3
Nitrate-N + Nitrite-N (TON)	Total oxidised nitrogen. Automated cadmium reduction, Flow injection analyser. APHA 4500-NO_3^- I (Proposed) 20th ed. 1998	0.002 g.m-3
Nitrate-N	Calculation: (Nitrate-N + Nitrite-N) - Nitrite-N.	0.002 g.m-3
Nitrite-N	Automated Azo dye colorimetry, Flow injection analyser. APHA 4500-NO_3^- I (Proposed) 20th ed. 1998	0.002 g.m-3
Dissolved Reactive Phosphorus	Filtered sample. Molybdenum blue colorimetry. Discrete Analyser. APHA 4500-P E (modified from manual analysis) 20th ed. 1998	0.004 g.m-3
Total Phosphorus	Acid persulphate digestion, ascorbic acid colorimetry, Discrete Analyser. APHA 4500-P E (modified from manual analysis). 20th ed. 1998	0.004 g.m-3
Chloride	Filtered sample. Ferric thiocyanate colorimetry. Discrete Analyser. APHA 4500-Cl^- E (modified from continuous-flow analysis) 20th ed. 1998	0.5 g.m-3
Sulphate	Filtered sample. Ion Chromatography. APHA 4110 B 20th ed. 1998	0.5 g.m-3
Total Iron	Nitric acid digestion. ICP-MS. APHA 3125 B 20th ed. 1998	0.02 g.m-3
Total Manganese	Nitric acid digestion. ICP-MS. APHA 3125 B 20th ed. 1998	0.0005 g.m-3
Total Anions	Calculation: sum of anions as mEquiv/L [Includes Alk, Cl, NOxN & SO4]	0.07 mEquiv/L
Total Cations	Calculation: sum of cations as mEquiv/L [Includes Ca, Mg, Na & K]	0.05 mEquiv/L

Analyst's Comments:

These samples were collected by yourselves and analysed as received at the laboratory.

Samples are held at the laboratory after reporting for a length of time depending on the preservation used and the stability of the analytes being tested. Once the storage period is completed the samples are discarded unless otherwise advised by the submitter.

Terry Cooney MSc (Hons), PhD, MNZIC
Divisional Manager - Environmental

Peter Robinson MSc (Hons), PhD, FNZIC
Client Services Manager - Environmental Division

Appendix 4 Habitat Assessment Data

Appendix 4 Habitat Assessment Data

- **Table 4a Summary of habitat parameters determined at sites in the 2006 survey using established habitat assessment protocols**

	Nukunuku Creek	Qaliwana Creek		Ba River		Savatu Creek
Parameter	Upstream	Upstream (lower)	Downstream	Upstream	Downstream	
Habitat abundance / diversity	O	SO	O	O	SO	SO
Velocity / Depth regimes	SO	O	O	SO	O	SO
Sediment deposition	SO	O	O	SO	O	O
Channel alteration	O	O	O	O	O	O
Frequency of riffles	O	O	O	O	O	O
Left bank stability	O	O	O	O	O	O
Right bank stability	O	O	O	SO	O	SO
Left vegetative protection	O	O	O	SO	O	O
Right vegetative protection	O	O	O	SO	O	M
Left riparian vegetative zone width	O	O	O	M	O	O
Right riparian vegetative zone width	O	O	O	M	O	M
Periphyton growth	M	P	M	O	O	O

Notes: O = Optimal, SO = Sub-optimal, M = Marginal and P = Poor. Refer to Appendix A for definitions.

- **Table 4b Summary of habitat parameters determined at sites in the 2005 survey using established habitat assessment protocols**

	Nukunuku Creek		Nadala Creek	Qaliwana Creek		Ba River		
Parameter	Upstream	Down-stream		Up-stream (upper)	Up-stream (lower)	Up-stream	Down-stream	Savatu Creek
Habitat abundance / diversity	O	SO	SO	SO	O	M	SO	SO
Velocity / Depth regimes	SO	SO	SO	O	O	SO	O	SO
Sediment deposition	O	O	SO	O	O	SO	O	O
Channel alteration	O	O	O	O	O	O	O	O
Frequency of riffles	O	O	SO	O	O	O	O	O
Left bank stability	O	O	SO	SO	O	SO	O	O
Right bank stability	O	O	SO	SO	O	SO	O	SO
Left vegetative protection	O	O	M	M	O	SO	O	O
Right vegetative protection	O	O	M	P	O	SO	O	M
Left riparian vegetative zone width	O	O	M	M	O	M	O	O
Right riparian vegetative zone width	O	O	M	M	O	M	O	M
Periphyton growth	M	M	P	M	O	M	M	SO

Notes: O = Optimal, SO = Sub-optimal, M = Marginal and P = Poor. Refer to Appendix A for definitions.

- **Table 4c Summary of habitat parameters determined at sites in the 2006 survey using established habitat assessment protocols**

	Nukunuku Creek	Qaliwana Creek		Ba River		Savatu Creek
Parameter	Up-stream	Up-stream	Down-stream	Up-stream	Down-stream	
Compaction		√		√		
Tightly packed & / or overlapping						
Mod. packed with some overlap	√		√		√	√
Mostly loose with little overlap						
No packing/loose assort./easily moved						
Embeddedness						
<5% covered by fine sediment		√	√	√	√	√
5-25%						
26-49%	√					
51-75%						
>76% covered by fine sediment						
Algal Cover						
None				√	√	√
Slippery	√					
Obvious		√	√			
Abundant						
Excessive						
Macrophyte Cover						
<5%	√	√	√	√	√	√
5-25%						
26-50%						
51-75%						
>75%						

- **Table 4d Summary of habitat parameters determined at sites in the 2005 survey using established habitat assessment protocols**

Parameter	Nukunuku Ck		Nadala Creek	Qaliwana Ck		Ba River		Savatu Creek
	Up-stream	Down-stream		Up-stream (upper)	Up-stream (lower)	Up-stream	Down-stream	
Compaction								
Tightly packed & / or overlapping			√		√	√		
Mod. packed with some overlap	√	√		√			√	√
Mostly loose with little overlap								
No packing/loose assort./easily moved								
Embeddedness								
<5% covered by fine sed.					√			√
5-25%	√			√		√	√	
26-49%		√						
51-75%								
>76% covered by fine sed.			√					
Algal Cover								
None								
Slippery		√		√	√		√	√
Obvious	√					√		
Abundant			√					
Excessive								
Macrophyte Cover								
<5%	√	√		√	√	√	√	√
5-25%			√					
26-50%								
51-75%								
>75%								

Appendix 5 Macroinvertebrate Data

	SITE																													
	Ba Downstream					Ba Upstream					Nukunuku					Qaliwana downstream					Qaliwana Upstream (lower)					Savatu (Control)				
SPECIES	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
Ephmeroptera																														
Baetidae	92	162	127	114	38	214	110	217	147	187	9	34	6	34	33	27	19	49	126	71	124	180	135	156	145	106	115	256	180	203
Canidae						4	1																							
Hemiptera																														
Veliidae					7	1																								
Diptera																														
Chirominidae	7	3	1	1	11	12	9	14	21	15		5	9	5	13	1		7	13	2	1	14	19	20	7	10	3	2	3	3
Chirominidae Pupae	2				1	1		9		4								1	3		1	3	9	8	1	2		2		2
Empididae	4	2	5	1	5		1		4	3	2			2	5	1	2	2	1	1	3	2	3	1	3	14	4	8	2	
Empidiade Puape			4	1		2				4					1			1					2	1						
Culicidae		2																												
Tipulidae																														
Tipulida sp.					2				1		2								5			1				1		1		
Limonia sp.						2										1														
Simulidae													1																	
Odonata																														
Anisoptera					6		5	3	2			16		2					4	2	1		11	1	12	14	2	1	3	
Zygoptera						1	4	2	1	4	2		5	7	2	1		1		1	4	1	7	9	1	7		2	1	
Heteroptera																														
Gerridae	1		1															1												
Trichoptera																														
Hydropsychidae																														
Species #1	191	289	132	174	288	340	90	203	169	304	4	5	9	54	58	129	32	117	141	88	54	256	179	165	138	100	152	216	251	82
Species #2		7	3	10		3	28	10		17	3		1			7					8	5		26				6		5
Species #3																												6		
Leptoceridae																														
Species #1		2	9			5														1		3		3		3			1	
Hydroptilidae																														
Oxyethira A							2	1					3					2	3	5		4		47	1		5		1	
Oxyethira B	4																				11		5			10				
Paroxyethira	1		4										1						1	6				1				1		
Hydroptilidae sp	1			1		6									1							1								4
Polycentropodidae																														
Species #1		4		1	6	17		1	4	7						26	1	38	8	11	3	32	7	1	23	2	5	10	22	
Gastropoda																														
Melanoides tuberculata			3	1	1	2	1	4		1	3	6	3		3	2						9		30			2	1		1
Melanoides arthurii		2															1				8									
Physastra	1		1		5		3	4	2	2		2	3	1				2	1	3			4		6	23	9			2
Neritina sp.	1	1	4	1	2		2									2														
Ancyclidae																														
Ferrissia														1																
Unided sp			3															1				1								
Crustacea																														
Shrimp sp.		1		1	1					1	1	7		1	2															
Others																														
Lepidoptera	33	19	32	6	18	17	25	17	5	47	12	3	6	27	24	76	4	17	14	19	40	22	42	130	10	63	33	28	1	22
Hirudinea			3									6						1	1	2						1				
Oligochaetae	2	3		1	6				2	4		4	5	2		1						2	11		2	2				
Ostracoda													2											4						

Appendix 6 Results of Statistical Analysis

Total Abundance
Anova: Two-Factor With Replication

SUMMARY	Ba Downstream	Ba Upstream	Nukunuku	Qaliwana Upstream	Savatu Control	Total
2006						
Count	5	5	5	5	5	25
Sum	12.84924068	13.26881394	9.572873908	13.10686829	12.98838899	61.7861858
Average	2.569848135	2.653762788	1.914574782	2.621373658	2.597677797	2.471447432
Variance	0.006517063	0.022169898	0.06088388	0.021712577	0.009649946	0.101705709
2005						
Count	5	5	5	5	5	25
Sum	12.27751397	12.61646293	11.14992973	12.40517004	11.84664061	60.29571729
Average	2.455502795	2.523292587	2.229985945	2.481034009	2.369328122	2.411828692
Variance	0.051382905	0.181083585	0.092974002	0.05121172	0.051022518	0.082527889
Total						
Count	10	10	10	10	10	
Sum	25.12675465	25.88527688	20.72280363	25.51203833	24.8350296	
Average	2.512675465	2.588527688	2.072280363	2.551203833	2.48350296	
Variance	0.029365224	0.095063346	0.096015781	0.037881692	0.041449865	

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Sample	0.044429928	1	0.044429928	0.80986643	0.373545891	4.084745651
Columns	1.76805312	4	0.44201328	8.056995267	7.30761E-05	2.605974949
Interaction	0.459120882	4	0.11478022	2.092207937	0.099830661	2.605974949
Within	2.194432368	40	0.054860809			
Total	4.466036298	49				

Number of Species
Anova: Two-Factor With Replication

SUMMARY	Ba Downstream	Ba Upstream	Nukunuku	Qaliwana Upstream	Savatu Control	Total
2006						
Count	5	5	5	5	5	25
Sum	69	65	53	69	58	314
Average	13.8	13	10.6	13.8	11.6	12.56
Variance	1.2	2.5	2.3	4.2	7.3	4.59
2005						
Count	5	5	5	5	5	25
Sum	61	46	62	74	77	320
Average	12.2	9.2	12.4	14.8	15.4	12.8
Variance	1.7	10.7	10.8	14.2	4.3	12
Total						
Count	10	10	10	10	10	
Sum	130	111	115	143	135	
Average	13	11.1	11.5	14.3	13.5	
Variance	2	9.877777778	6.722222222	8.455555556	9.166666667	

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Sample	0.72	1	0.72	0.121621622	0.729111375	4.084745651
Columns	72.88	4	18.22	3.077702703	0.026654037	2.605974949
Interaction	88.48	4	22.12	3.736486486	0.011256115	2.605974949
Within	236.8	40	5.92			
Total	398.88	49				

QMCI Score

Anova: Two-Factor With Replication

SUMMARY	Ba Downstream	Ba Upstream	Nukunuku	Qaliwana Upstream	Savatu Control	Total
2006						
Count	5	5	5	5	5	25
Sum	12.09847298	15.24809614	17.49401763	16.58016294	17.78800133	79.20875102
Average	2.419694596	3.049619227	3.498803527	3.316032588	3.557600266	3.168350041
Variance	0.569464749	0.166402442	0.852384127	0.402108766	0.543459923	0.600867368
2005						
Count	5	5	5	5	5	25
Sum	19.86416994	16.53000835	22.09211327	25.77131445	26.48682525	110.7444313
Average	3.972833988	3.306001669	4.418422653	5.154262891	5.297365051	4.42977725
Variance	0.742241833	0.307333311	0.111397482	0.156635641	0.152824082	0.817860738
Total						
Count	10	10	10	10	10	
Sum	31.96264292	31.77810448	39.5861309	42.3514774	44.27482658	
Average	3.196264292	3.177810448	3.95861309	4.23514774	4.427482658	
Variance	1.253047916	0.228808101	0.663263865	1.186967138	1.150232199	

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Sample	19.88998256	1	19.88998256	49.67215048	1.60893E-08	4.084745651
Columns	13.59858413	4	3.399646033	8.490089363	4.6678E-05	2.605974949
Interaction	4.433880976	4	1.108470244	2.768232732	0.040235574	2.605974949
Within	16.01700942	40	0.400425236			
Total	53.9394571	49				

SKM

Appendix E Stakeholder Group Meeting Minutes

Meeting minutes

Purpose of Meeting	**Presentation of EIA for Nadarivatu Revised Scheme**		
Project	Nadarivatu Hydropower Scheme	Project No	AE02809 / LT00884
Prepared By	Pene Burns	Phone No	+64 21 728 767
Place of Meeting	Holiday Inn, Suva	Date/Time	6 September 2006 11am – 12pm
Attendees	Kamalesh Lalchan. Ministry of Agriculture. Senior Agricultural Officer Isineli Vuetilsau. Native Land Trust Board. Corporate Accounts Officer. Naisia Khan. Director Town and Country Planning. Shivan Gounder. Land and Water Resource Management Division. Ministry of Agriculture.	Jope Davetanivalu. Ministry of Environment. Jerry Taganesia. Mineral Resources Department. Priya Nair. Ministry of Environment. Shivangini Bishwa, FEA Pene Burns, SKM Peter Sullivan. World Bank representative. Ron Steenbergen, Victor Prasad FEA (present for introductions)	
Distribution	Murray Chopping, PHL Ron Steenbergen, FEA Victor Prasad, FEA Fatiaki Gibson, FEA Shivangini Bishwa, FEA Rouven Lau, SKM Kenn Wood, PHL		

Item		Person
1)	**Introductions.** Ron welcomed people to the meeting, thanked people for their interest and attendance and discussed the importance of the Nadarivatu project going ahead (amongst other FEA hydro projects). Introductions around the room. Naisia Khan, Shivan Gounder, Jope Davetanivalu and Priya Nair were party to the original stakeholder group meetings for the original scheme. Other attendees were not familiar with the scheme.	Ron Steenbergen

Item		Person
2)	**Presentation of the Revised Nadarivatu Scheme and EIA** Pene provided a power point presentation of the proposal. Some time was taken to discuss the hydrological effects of the scheme, using flow duration curves, and discussion centred around the downstream water availability and sediment movement effects in both the Sigatoka and Ba Rivers.	Pene Burns
3)	**Nature of the Application** It was discussed that the process for the revised scheme is for a change to the existing Environmental Approval. There would be no public submission period, but that this stakeholder group could contribute to the decision of the Ministry of the Environment. Discussed that the scheme was similar in effects to the original scheme, that was discussed previously with this group. Mentioned lodgement on 20th of September.	Pene Burns
4)	**Why is FEA doing a JV with a private firm (PHL)?** Questions and concerns were raised about the set up of the JV, where the funds were going to go and would it be profitable and what would be the effect on power consumers. PB and SB made it clear that we could not answer those questions and that it was not relevant in the context of a discussion regarding the EIA.	Kamalesh Lalchan. Ministry of Agriculture. Senior Agricultural Officer
5)	**Reduction in water in the Sigatoka River is a concern for growers in the Sigatoka Valley who use water and rely on the water tables.** Discussed that growers require water in the Sigatoka Valley for vegetable and fruit growing. Concerned that there would be less water in the river for them. Discussed the changes are very similar to the original scheme, and that at median flow it is approximately 7% change at the Sigatoka River mouth. Riparian groundwater levels will have a minor impact. Overall SKM's assessment is that downstream impacts in the valley will be minor, although upstream in the headwaters it will be noticeable. There are were records available regarding who is using water, how much water and where this water is from, therefore it is difficult to assess actual impacts. Discussed monitoring requirements, such as cross sectional surveys of the river to more accurately predict changes in river depth / flow.	Kamalesh Lalchan. Shivan Gounder. Land and Water Resource Management Division. Ministry of Agriculture.

Item		Person
6)	**Reduction in water in Sigatoka River may affect sedimentation in the lower stretches, and affect navigation.** Navigation in the river is already being affected by sedimentation. Will this scheme make it worse? SKM discussed that sediment movement was looked at in the EIA studies based on changes in river flows and flushing events, and that the impacts appear minor, although no data on sediment has been gathered. Will make sure this is assessed in the final document. Contribution / impacts from the scheme may be minor or unmeasureable against all of the other impacts on sedimentation / sediment movement in the catchment.	Kamalesh Lalchan.
6)	**Increases in flow in the Ba River may affect flooding and sedimentation.** Concerns were raised about the effect of more flow in the Ba River. Discussed the predicted changes in flow in the Ba River, and mentioned that they will be similar to the existing scheme. Approximately 9% increase in median flow. Ministry of Agriculture is responsible for, and pays for, dredging of Ba and Sigatoka River mouths – will SEL pay for any increased dredging requirements? Discussed that SKM does not have any data on current sediment movements in the Ba. Discussed it would be difficult to isolate the hydropower scheme's influence compared to other instream and land uses. Discussed monitoring that could assist to measure the impacts from the scheme, including sediment movements and surveys of river beds to more accurately determine changes to downstream flow / depth.	Kamalesh Lalchan. Shivan Gounder. Jerry Taganesia. Mineral Resources Department.
	A request was made to provide all attendees with a copy of the final Supplementary Report.	All

Appendix F Environmental Monitoring Plan

Sustainable Energy Limited

Nadarivatu Hydro Power Scheme

ENVIRONMENTAL MANAGEMENT PLAN

- EIA
- Draft
- 20 September 2006

SKM

Sustainable Energy Limited

Nadarivatu Hydro Power Scheme

ENVIRONMENTAL MONITORING PLAN

- Draft
- 20 September 2006

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1. Introduction

This Plan is a sub-plan of the Environmental Management Plan and sets out the ongoing monitoring required to assess the impacts of the Nadarivatu Hydropower Scheme during construction and operation.

The plan supersedes any plan provided as part of the following documents:

SKM. 2005a. Nadarivatu Hydropower Project EIA (Final).

SKM. 2005b. Nadarivatu Hydropower Project Appendices. (Final). Including Appendix F Environmental Management Plans.

SKM. 2005c. Nadarivatu Hydropower Project Supplementary Report 1 to the EIA.

2. Water quality and instream ecosystem monitoring

The following water quality and ecology monitoring has been proposed to assess the impacts on water quality and ecology from construction and operation. Monitoring locations are to be those located in Figure 1 and described in the following report, an appendix to the Supplementary Report No 2 to the EIA:

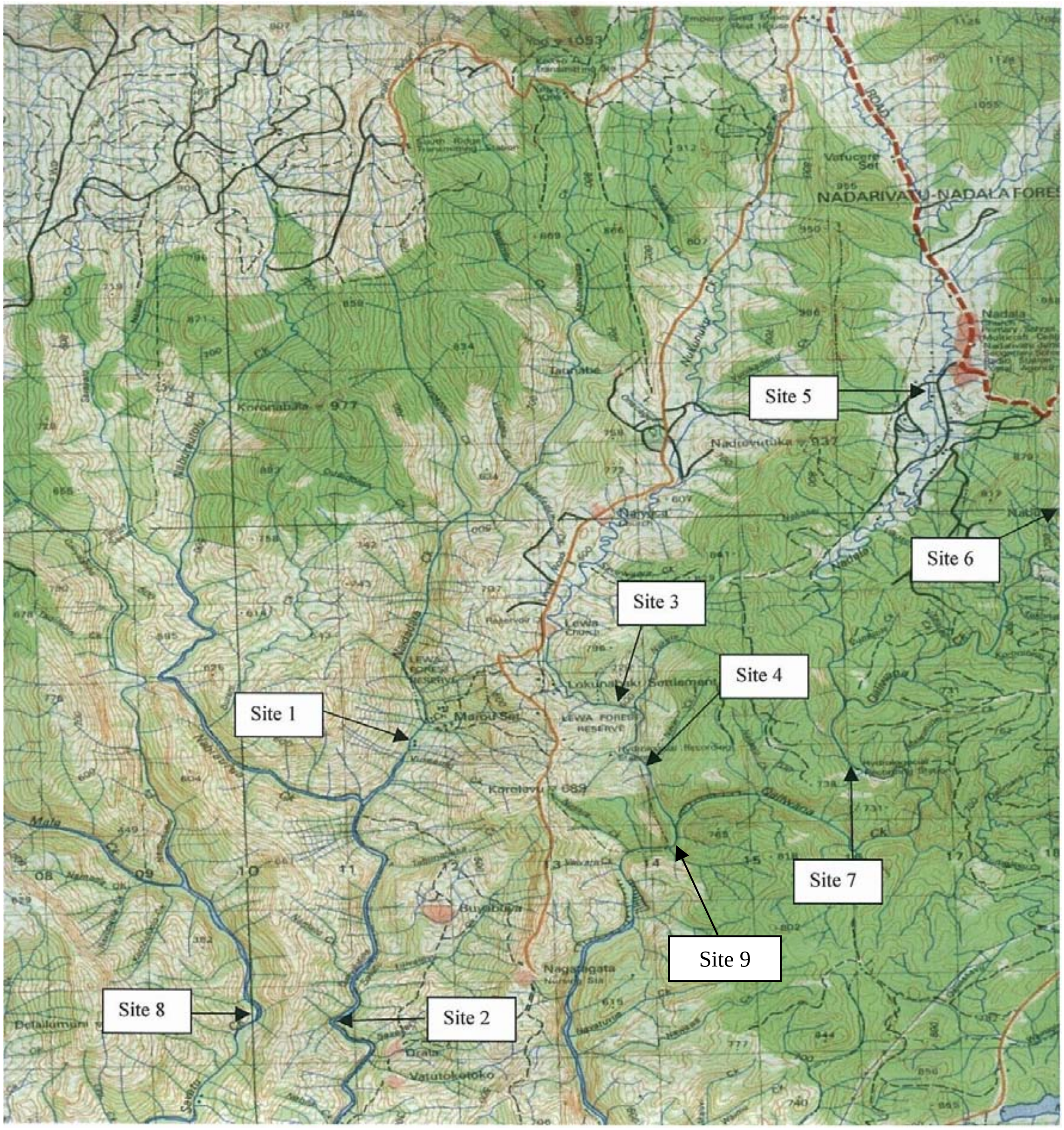
SKM 2006. Nadarivatu Hydropower Project. Freshwater Ecological and Water Quality Monitoring Survey (July 2006).

- **Table 1 Proposed Water Quality and Aquatic Ecosystem Monitoring Programme**

	Phase in project	Frequency	Timing / River flow conditions	Sampling parameters	Sampling sites
1	Prior to construction	At least 1 further round, , to ensure at least 3 in total at different times of year and different river flows.	Preferably a low flow and high flow event.	Baseline establishment: Water quality: *ph* *temperature* *dissolved oxygen* *conductivity* *clarity* *total alkalinity* *total suspended solids* *nutrients* *iron* *manganese* Visual substrate assessment Macroinvertebrates Suspendible inorganic sediment loads.	All sites in Figure 1 excluding sites 4, 5 & 6, plus: Sigatoka River @ Nadraumakawa Hydrological station Ba River @ Koro (exact locations to be confirmed)
2	During construction	One month prior, then monthly until completion of works.	Not during flood or high flow conditions.	Visual substrate assessment Clarity.	Korolevu Weir site Ba power station site
3	During construction	6 monthly until completion of works.	na	Water quality as per 1 above. Suspendible inorganic sediment loads.	All sites in Figure 1 excluding sites 4, 5 & 6, plus: Sigatoka River @ Nadraumakawa Hydrological station Ba River @ Koro
4	During	6 monthly for 2	Not during or	Water quality as per 1	All sites in Figure

	Phase in project	Frequency	Timing / River flow conditions	Sampling parameters	Sampling sites
	operation	years.	following flood event.	above.	1 excluding sites 4, 5 & 6, plus: Sigatoka River @ Nadraumakawa Hydrological station Ba River @ Koro
				Water quality (DO, Temp, pH profile). Clarity. Macroinvertebrates (qualitative assessment).	Two sites located in water body behind weir
5	During operation	Annually for 2 years.	Not during or following flood event.	Macroinvertebrate sampling. Water quality as per 1 above. Suspendible inorganic sediment loads.	All sites in Figure 1 excluding sites 4, 5 & 6, plus: Sigatoka @ Nadraumakawa Hydrological station Ba @ Koro
6	During operation	Once in 2 years	Not during or following flood event.	Fisheries assessment	All sites in Figure 1 excluding sites 4, 5 & 6, plus: Sigatoka River @ Nadraumakawa Hydrological station Ba River @ Koro

Figure 1 Sample Site Locations



3. Hydrological Data Gathering and Monitoring

Monitoring prior to, during and after power scheme construction should provide for compliance and operational requirements.

Proposed automated river flow monitoring at the following project sites:

- Qaliwana River at Bulu – currently operating
- Ba River at below Ba power house - new

Proposed automated river flow monitoring stations downstream in each river:

- Sigatoka at Korovouiti (10 – 12 km downstream)
- Ba at Nivala (8 - 10 km downstream)

Survey cross-sections on the Ba River are to be confirmed / completed at: Ba, Koro, Becamoui, Cuave, Nivala and Toge.

Survey cross sections on the Sigatoka River are to be confirmed / completed at least six locations downstream.