Hydro Tasmania Consulting

# Huro Mini Hydropower Scheme

## Feasibility Study

**204622-Huro MHP Report-03**

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Prepared by
**Hydro-Electric Corporation**
ARBN: 072 377 158
ABN: 48 072 377 158
t/a **Hydro Tasmania Consulting**
89 Cambridge Park Drive, Cambridge
Tasmania, Australia

# Document information

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| Client organisation | Secretariat of the Pacific Regional Environment Programme |
| Client contact | Mr Solomne Fifta |
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| Approved by | Fraser White | [signature] for FW | 3/6/10 |
| | (name) | (signature) | (date) |
| Distributed to | Solomone Fifita | SPREP | |
| | Mr Solomne Fifta | Solomon Islands Government - Energy Divison | |
| | (name) | (organisation) | (date) |

# Executive summary

Hydro Tasmania Consulting (HTC) has undertaken the update of feasibility studies for the Huro Mini Hydropower schemes at the Makira Ulawa provinces of the Solomon Islands.

The objective of the study is to validate the resource assessment and system design of the 1996 Huro mini hydropower feasibility studies that was conducted under the assistance of the GTZ/ SI Ministry of Energy joint programme ("1996 study").

The proposed project site is located in the Makira Ulawa province of Solomon Islands, at approximately 2 km west of Kirakira town. Kirakira is located on the north coast of Makira, one of the six larger islands of the Solomon Islands.

The hydrology of the proposed Huro River mini hydro development as outlined in the 1996 study has been reviewed. In general the outcome is that there is likely to be more water available compared to the adopted duration curve of the 1996 study.

The Coanda intake on the Huro River is proposed at an altitude of 140 meter above sea level (masl). The power house is located on a narrow terrace on the banks of the Huro River near to the Waitetei village at an altitude of 15 masl; therefore the gross head available for the scheme is 125m.

A preassembled 6m x 2.4m wide shipping container is recommended as potential arrangements to house the 110 kW Turgo turbine and generator, and act as a powerhouse.

The hydropower assessment of the Huro River in this feasibility study analysed two scheme development options:

1. Pipeline and civil infrastructure being implemented for the current and immediate future demand (with 1 turbine and generator installed initially); or
2. Layout similar to option 1 arrangement, but with a larger weir and pipeline to cater for future expansion of the Huro River hydro system. This future expansion would consist of an additional powerhouse and turbine sized for future demand.

In both cases, the Kirakira power system must be supplemented by the existing diesel power plant during periods of low river flow, and during periods of hydro plant maintenance. Additional diesel generator over and above the existing capacity would not be required for the Kirakira system in the next 20 years with the inclusion of hydro capacity. Diesel capacity is only required to be enhanced to

cover the demand without hydro capacity in the system. Also the Huro River does not have enough capacity to supply 90% firm reliable energy for the full hydro system.

The estimates of capital cost for each of the options investigated are as below:

| Project Alternatives | Capital Cost (SBD) |
|---|---|
| Option 1 – DN355 pipeline | **7,641,000** |
| Option 2 – DN450 pipeline | **8,428,600** |

Since an electricity supply is already established in Kirakira, the issue therefore, is not to electrify but rather consideration of alternative supply options that would best meet the future electricity demand of the community, in terms of economic and environmental sustainability.

Therefore, an incremental cost-benefit analysis is conducted which evaluates the benefits between two alternative supply scenarios namely:

- Mini Hydro scheme with Diesel supplement
- All Diesel system

During the analysis period of 20 years, only one turbine generator of 110 kW capacity is considered for project option 1 along with the existing diesel capacity of 170 kW. For project option 2 another machine of similar capacity is considered after 2019 when the peak demand is more than 110 kW. This additional machine capacity in option 2 is considered at this stage to compare the economic benefits of these two scenarios. However, the viability and sizing of a future additional machine will depend on actual growth, future cost of diesel generation, and long term flow availability in the Huro River. This should be re-assessed at that time when more accurate information is available.

The NPV and the economic IRR of the additional investment cost and the savings in recurrent cost when switching from an all diesel system to proposed Huro mini hydro scheme supplementing the diesel generators at Kirakira are as follows:

| Incremental Cost – Benefit Analysis | | |
|---|---|---|
| **Project Alternatives** | **Net Present Value (NPV, @ 8%)** | **Internal Rate of Return (IRR)** |
| | **(SBD)** | **(%)** |
| Option 1 – DN355 pipeline | 10,137,796 | 19.9% |
| Option 2 – DN450 pipeline | 7,839,968 | 17.1% |

The results of the incremental cost benefits analysis shows clearly that the Huro mini hydro scheme for both options 1&2 supplementing the diesel generation is the least cost option to supply electricity to the Kirakira system.

Considering the economic results of the Mini hydro system supplemented with diesel generation, the NPV and IRR is marginally higher for option 1 compared to option 2. However, as the IRR for both options is well above the cost of capital, it is recommended that Option 2 be developed so that the system will have capacity for future expansion.

Based on the technical feasibility, economic viability, social and environmental benefits and institutional management aspects of this project, Hydro Tasmania Consulting recommends the development of this hydro electric energy resource for the Makira province as proposed in this report.

The final design and tender documents should therefore be prepared without delay. This will entail the performance of additional exploratory works, survey and investigations as recommended in this report. Meanwhile an airborne LiDAR survey has been undertaken for the Huro River area during April-May 2010 as an opportunistic data capture which is outside the scope of this study. However, the scheme head and location have been checked against this information received in mid May 2010 and this topographic data set will be helpful in the next stage of this project.

# Contents

## Appendices

# 1. Introduction

Hydro Tasmania Consulting (HTC) is currently undertaking the update of feasibility studies for the Huro Mini Hydropower schemes at the Makira Ulawa provinces of the Solomon Islands. In 1996, the German Government (GTZ) supported the study of three mini hydropower schemes in the Solomon Islands. The GTZ supported the construction of the Jejevo (Buala) hydropower scheme in Santa Isabel province, but did not fund the construction of the Huro and Rualae Mini hydropower schemes in Makira and Malaita provinces respectively. This was due to changes in policy of the German Government and furthermore, the projected cost of the civil works for the two schemes were said to be too high.

The findings of the 1996 study confirms that a 111 kW mini hydropower scheme with diesel backup at Kirakira is the least cost option to supply electricity to the Kirakira station. The proposed scheme generates electricity form a renewable indigenous energy resource and would thus substitute over 160,000 litres of imported diesel fuel each year (average of first twenty years of operation). Not only would this substitution have a positive effect on the country's foreign exchange requirements, it would also avoid the emission of almost 500 tonnes of $CO_2$ gas into the atmosphere each year (average of first twenty years).

The Solomon Islands Government (SIG) gives priority to developing renewable energy resources in the country. Therefore, revisited these two mini hydropower schemes, Secretariat of the Pacific Regional Environment Programme (SPREP) provided the funds to conduct these studies, so that the implementation can eventuate.

In order to get the views of the landowning tribes in the project region, SIG did the site visit in 2008 and found them enthusiastic in working towards the establishment of the two schemes.

The objective of the study is to validate the resource assessment and system design of the 1996 Huro feasibility studies.

# 2. Location

## 2.1 General

The proposed project site is located in the Makira Ulawa province of Solomon Islands, at approximately 10°28' S, 161°54' E and 2 km west of Kirakira town. Kirakira is located on the north coast of Makira, one of the six larger islands of the Solomon Islands. Kirakira is the Provincial capital of Makira Ulawa province and is therefore headquarters of the Provincial Government. It is envisioned that the project would harness the flow of Huro River to generate hydro-electric power.

The location of the proposed Huro mini hydropower project site is shown in Figure 2-1 and in drawing no. 204622-001 in Appendix A.

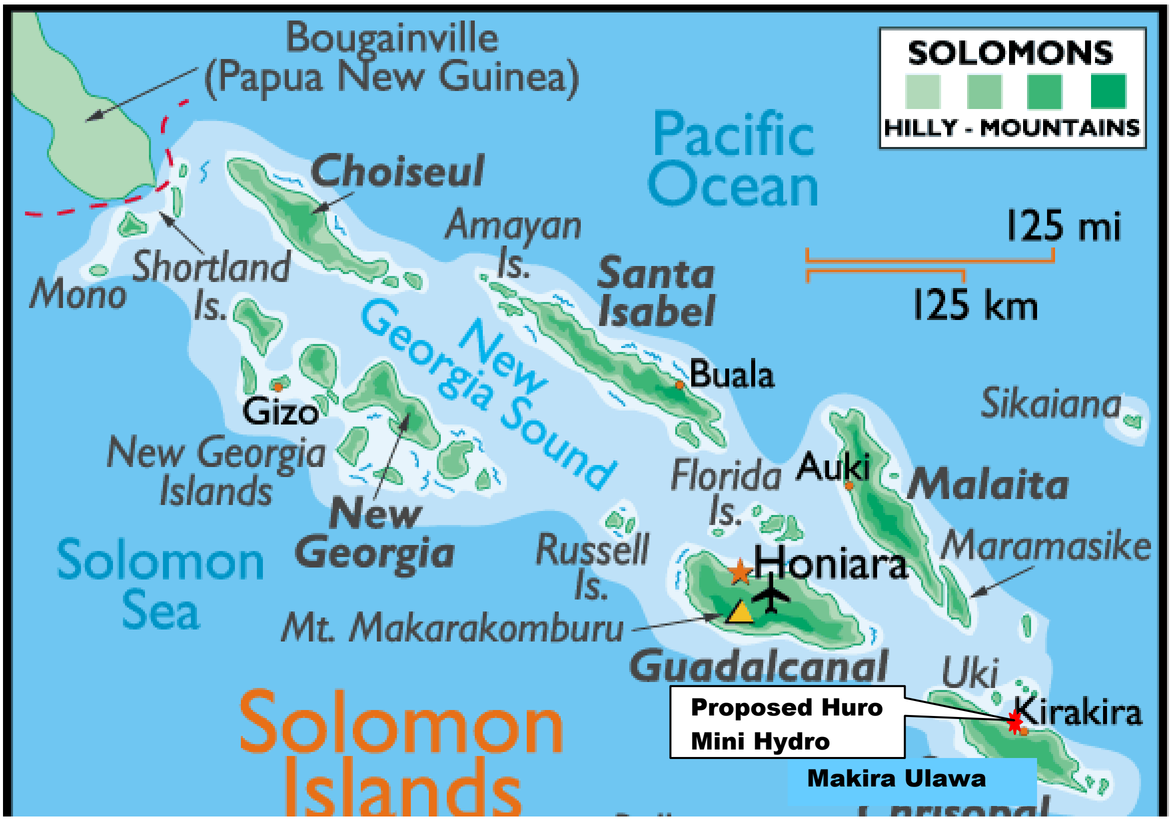


**Figure 2-1: Map showing Project location**

The Huro River which emerges at an altitude of above 600m in the catchment flows in a northerly direction and discharges at a distance of 1.5 km from the Kirakira station into the Bay. The lower reaches of the Huro fall steeply over exposed rock and large boulders and have been identified to have good hydropower potential, and further investigation for hydropower development was therefore proposed by many consultant in the past (notably B.Glover,UNIDO,1986).

The site was selected during pre-feasibility studies conducted in 1996 by SIEA under the assistance of the GTZ/ SI Ministry of Energy joint programme.

# 3. Infrastructure Facilities

The proposed mini hydropower project is a green field in nature and therefore requires infrastructure facilities during investigation and implementation of this project.

Access to site is available through a gravel road which connects Kirakira with the central and western parts of the Makira north coast. However, the flow of goods and people on that road is often hampered by flooding rivers. The power house site is very close to Waitetei village which is connected to the main road on north coast by a gravel track.

Kirakira can be accessed by sea or by plane with regular connections to Honiara in Guadalcanal. There is no wharf or jetty at Kirakira station and unloading of fuel shipped from Honiara to supply the power station is therefore difficult (the fuel drums are thrown into the sea and then swam ashore). The nearest jetty is at Koanasughu situated 17 km west of Kirakira station on the only road of the island in the north coast.

The delivery of the plant equipment is considered through the available wharf facility and road network. Machinery and materials for the construction of the proposed Huro mini hydropower plant will be transported to site in the following manner:

- delivered by ship to the Port of Honiara, Solomon Islands,
- transferred to a barge and transported to the jetty facility at Koanasughu, and
- Offloaded onto trucks and transported to the Huro power plant construction site.

Construction areas and construction residential area are arranged close to the flat land available near the Weitetei Village. Most of the basic facilities are available in Kirakira town close to the site, these facilities include hospital, primary and secondary school, bank, post and telecom.

The construction power will be drawn through the nearby network on 415 V available in the area. Alternatively a standby arrangement could also be made by providing suitable size diesel generating sets.

# 4. Site Visit Outcomes

Members of the Hydro Tasmania Consulting and SIG-Energy Division officials visited the proposed site of the Huro Mini Hydropower scheme on December 14th, while in Kirakira- Makira province of Solomon Islands from 14th to 15th December 2009[1].

The team also visited the diesel power station operated by SIEA in Kirkira, the station has 3 diesel generation sets as shown in Figure 4-1. The capacities for these generators are 110, 145 and 90 kVA.

**Figure 4-1 Kirakira Diesel Power Station**

The capacity and condition of the Kirakira wharf as shown in Figure 4-2 has been analysed and found not suitable for the transportation of material and equipment for the mini hydro plant.

**Figure 4-2 Kirakira Wharf**

[1] [1] A second site visit was undertaken by HTC on the 8/9th February to Kirakira in Makira and 11th/12th February to Auki in Malaita 2010. The purpose of the second site visit was to discuss the social and environmental impacts of the projects with the provincial Governments and landholding groups were possible.

The proposed hydropower scheme is located approximately 2 km from the Kirakira town on the Huro River as shown in Figure 4-3. The site is approached by a motorable road from Kirakira town up to Weitetei Village along the Huro River banks and then by foot up to the intake site.


**Figure 4-3 Huro Mini Hydropower site.**

The intake site investigated by GTZ in the earlier study in 1996 is located on the left hand tributary of the Huro, which results in an increased head and was found to provide a promising site for siting intake or head works.

The intake site is very well established on the Huro River by the fact that the flow measuring plate still exists at the site as shown in Figure 4-4.


**Figure 4-4 Huro Weir/Intake site**

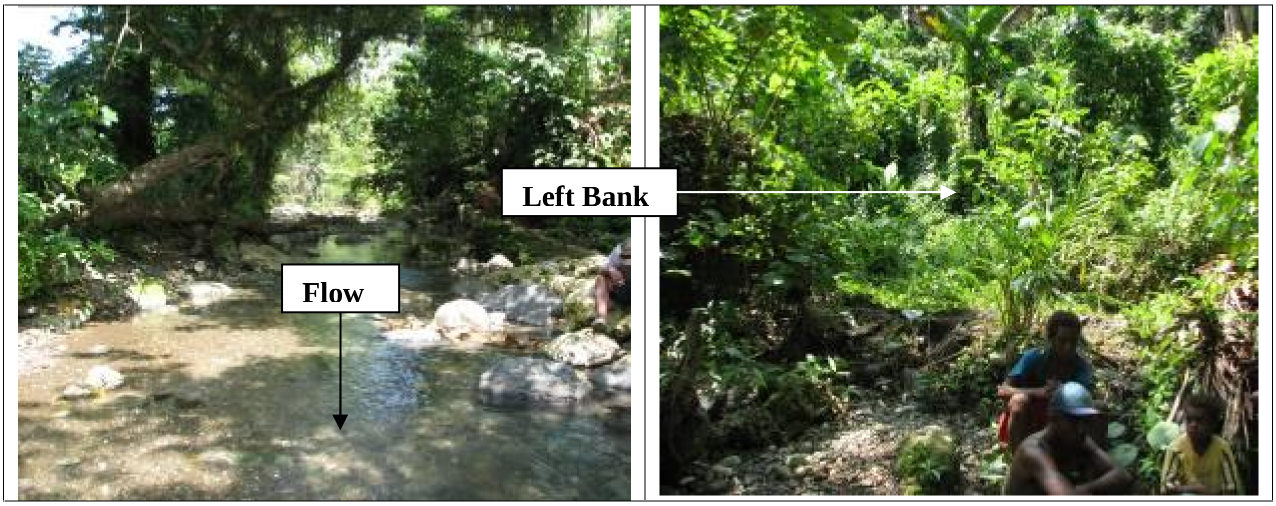


**Figure 4-5 Huro Power station site on the left bank of River**

# 5. Data Collection and Review of Existing Documents

## 5.1 Data Collection

A complete list of the data collected is as follows:

1. Feasibility Study report for Kirakira Mini Hydropower scheme in Makira Ulawa province of Solomon Islands prepared by Solomon Islands Electricity Authority (SIEA) under the assistance of the GTZ/ SI Ministry of Energy joint programme: "Improvement of rural electricity supplies in the Solomon Islands", March 1996. (Here-in referred to as the "1996 study")

2. Feasibility Study report for Rualae Mini Hydropower scheme in Auki System, Malita province of Solomon Islands prepared by Solomon Islands Electricity Authority (SIEA) under the assistance of the GTZ/ SI Ministry of Energy joint programme: "Improvement of rural electricity supplies in the Solomon Islands", September 1996.

3. Data Audit Report for Huro at Waitatei site 3007704, from Ministry of Natural Resources-Geology Division' November 1990.

4. Hydrological data collected from Water Resource Department are as follows:

| | | |
|---|---|---|
| Monthly rainfall data (1962-2006) | Auki Station - Malaita | Solomon Islands Meteorological Service |
| Flow data for Kwaibala at Gwaidalo (1986-1996) | Site 4022002 - Auki - Malaita | |
| Daily Rainfall data for Kwaibala at Ofalaomoe (1986-1996) | Site 4022050 - Auki - Malaita | |
| Flow data for Huro at Waitetei (1987-1995) | Site 3007704 - Kirakira - Makira | |
| Monthly rainfall data (1965-2000) | Kirakira Station - Makira | Solomon Islands Meteorological Service |

5. Topographical Maps collected are as follows:

   a) 1:50,000 Topographic Map for Auki, Solomon Islands 0816016

   b) 1:50,000 Topographic Map for Kirakira, Solomon Islands 1016112

   c) 1:7,500 orthophoto map for Auki

d) 1:7,500 orthophoto map for Kirakira

6. Diesel power station data collected from SIEA for Auki and Kirakira stations, the data include production figures and fuel usage for first quarter of 2009. A summary of SIEA 2010 budget for these plants has also been provided.

# 6. Background Information

As per the 1996 study, the salient features of the Huro mini hydro power scheme was described as follows:

| Huro Mini Hydropower Scheme, Kirakira | |
|---|---|
| **Key Data** | **Details** |
| Location | Kirakira, Provincial Capital, Makira Ulawa Province |
| Main Supply Area | Kirakira township and surrounding villages |
| Name of the River | Huro River |
| Catchment Area | 3.5 $Km^2$ |
| Gross Head | Max. 102.5 m / Min 100.5 m |
| Net head | 98.0 m |
| Minimum Streamflow | Approx. 35 litres/sec (100% exceedance) |
| Design Flow | 150 litres/sec |
| Penstock diameter | 300 mm |
| Maximum Plant Output | 111 kW |
| Transmission Line | 2.2 km of aerial bundled conductors 11 kV |
| Distribution Lines | Existing (2500m in Kirakira Township) |
| Project Capital Cost | SBD $ 3,491,000.00 |
| Period of Analysis | 20 Years |
| Internal rate of return | 3.3 % (economic)<br>9.4% (incremental, on savings to all diesel station) |

This report considers the suitability of the above technical features, and updates the economic analysis to suit currently available information.

# 7. Power Demand

The current diesel power station in Kirakira was built by SIEA in the early seventies. The configurations of the diesel generators as per the Masterplan study (JICA) are as follows:

| Name of Power Station | Unit No. | Name Plate Rating (kVA) | Name Plate Rating (kW) | De-Rated (kW) | Installed year | Remarks |
|---|---|---|---|---|---|---|
| Kirakira (Makira) | 1 | 100 | 80 | 60 | 1992 | Caterpillar |
| | 2 | 114 | 91 | 50 | 1993 | Perkins |
| | 3 | 80 | 64 | 60 | 1994 | Cummins |

Since the complete power demand survey of the Kirakira system is out of the scope of this study, SIEA long term operational data for Kirakira system has been used for power demand and peak load demand of the system along with the inputs from the social scientist visit and data collected on the current electricity usage in the system.

In the Kirakira system, there were 218 electricity consumers (As per SIEA 2006 statistics – no further update available) and from the 2009 statistics the peak load of system is 80 kW with total energy generated by the three diesel generators is 340MWh. The long term data for maximum annual demand for Kirakira system has been obtained from SIEA as shown in Figure 7-1.

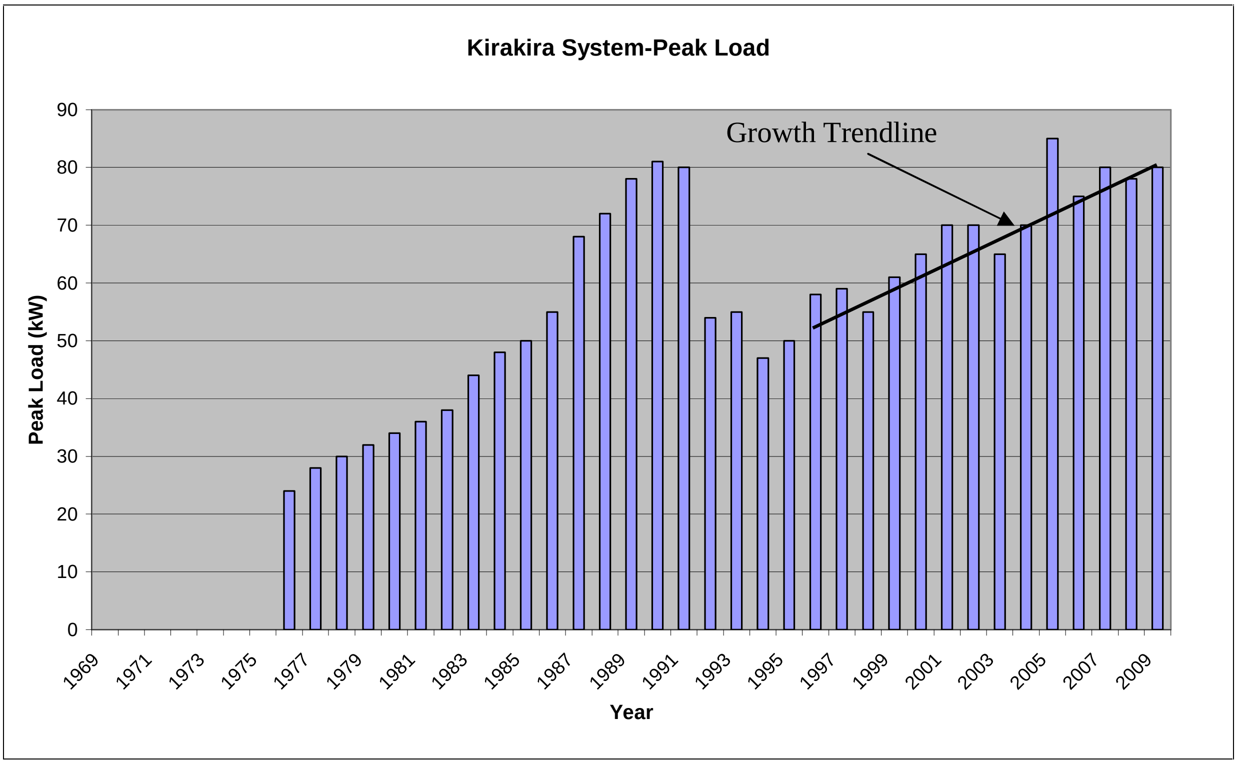


**Figure 7-1 Kirakira System – Maximum annual peak load**

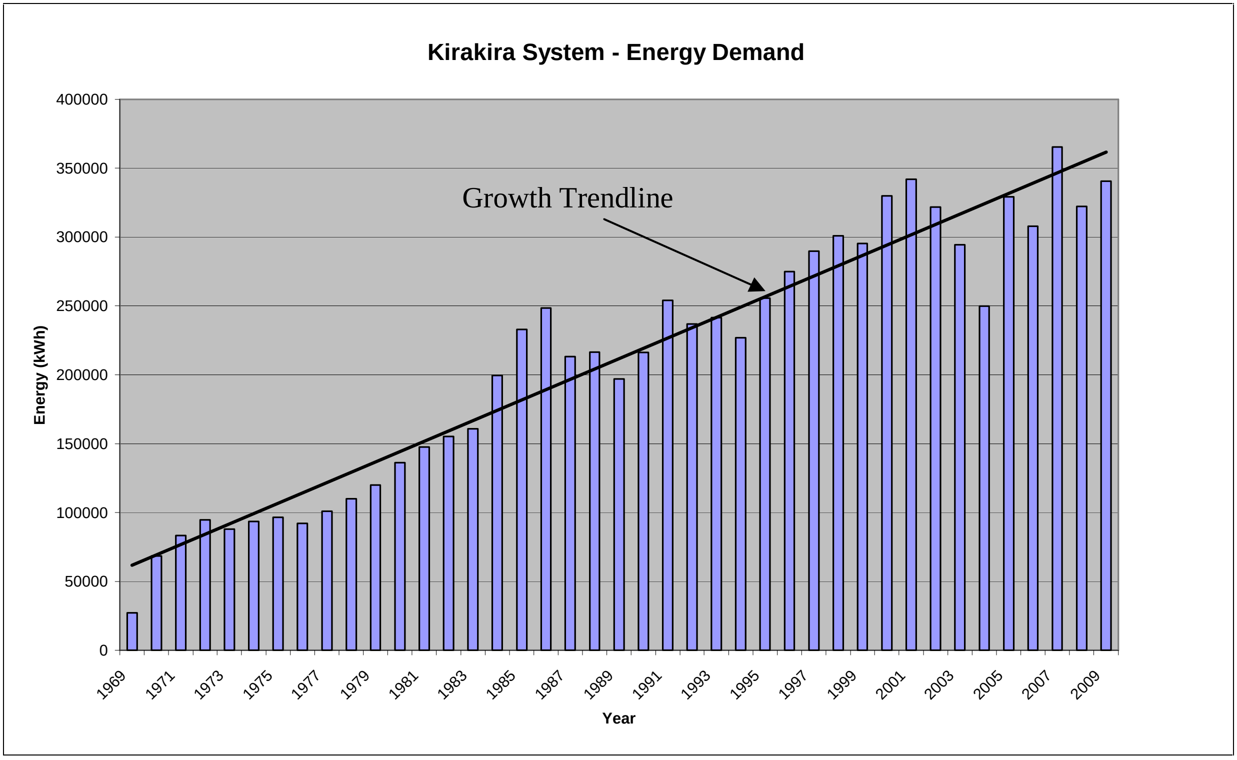


**Figure 7-2 Kirakira System – Energy Demand**

After high growth rates during the first few years and a peak in 1991, the electricity sales and the system load declined to the same level as 10 years earlier. Based on this SIEA system data for Kirakira, the long term average of growth in energy demand is approximately 4.5% as shown in Figure 7-2.

Typical daily load curves as shown in Figure 7-3 were derived from log books of the SIEA power station operators. Based on the development of region in last two decades and in absence of any industrial energy requirement, it is considered that these load curves with distinct evening peaks on week-ends and an equally high consumption level for both business and evening hours on week days would remain the same throughout the analysis period. These load curves will be scaled to meet the future demand and calculating the total energy required as shown in Figure 7-3.

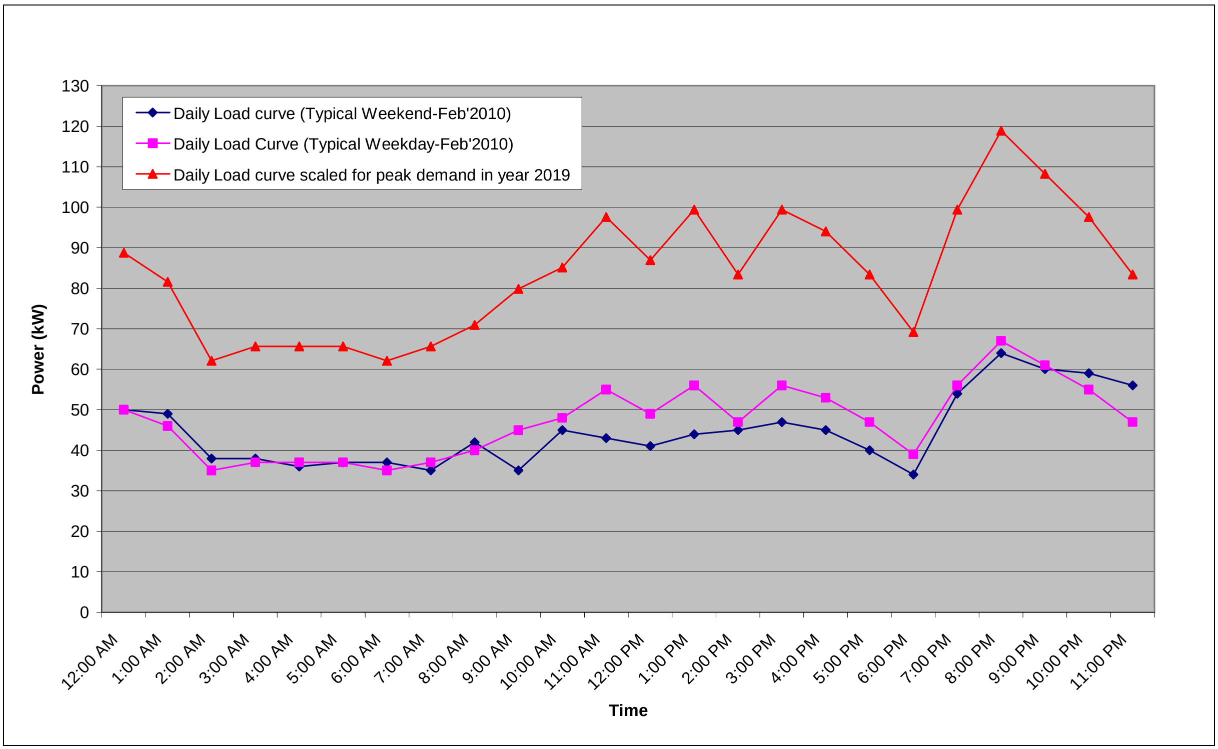


**Figure 7-3 Typical daily load curve of Kirakira System – Scaled for future demand**

Unless a major commercial or industrial enterprise establishes its production unit in Kirakira, the peak load at the rate of 4.5% growth in demand would reach 80 kW to 125 kW in next 10 years and up to 200 kW in 20 years time, provided that the current load pattern does not change dramatically. The load projections in next 20 years for the Kirakira system are as shown in Figure 7-4.

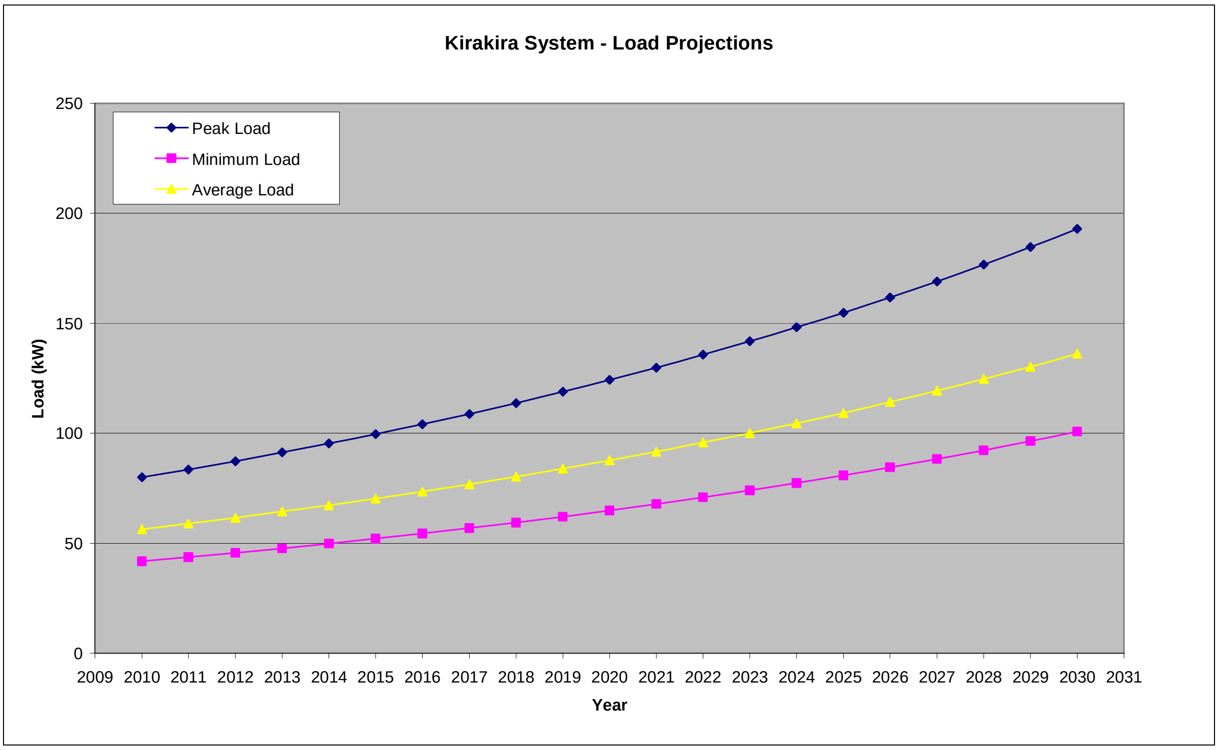


**Figure 7-4 Load projections for Kirakira system**

Based on the load projections, the total annual energy required for the system in next 20 years and supplied by the planned hydro system depending upon the flows available is as shown in Figure 7-5.

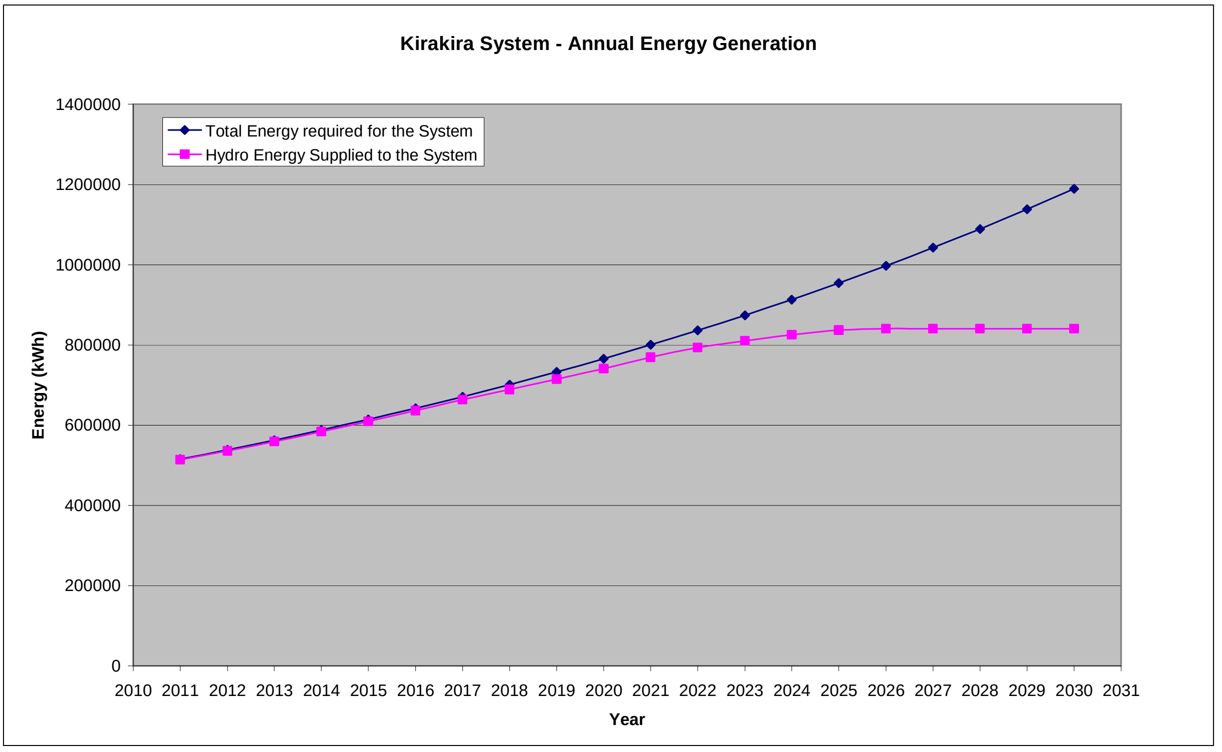


**Figure 7-5 Kirakira system – Future Energy Generation**

The proposed Huro mini hydro is therefore, designed at this stage for the current and immediate future demand and where costs allow, size the civil infrastructure for full design capacity so that the future expansion is possible with power station upgrade only.

# 8. Hydrological Assessment

The hydrology of the proposed Huro River mini hydro development as outlined in the last feasibility study (SIEA, 1996) has been reviewed. Details of the review are outlined below and in general the outcome is that there is likely to be more water available compared to what the adopted duration curve suggests. However due to the lack of useful data no replacement duration curve can be produced.

A map showing the catchment boundaries of the proposed intake location and the Huro River at Waitatei flow gauge is shown below in Figure 8-1. The catchment area factor used to scale the Waitatei flows in the feasibility report (0.55) is valid.

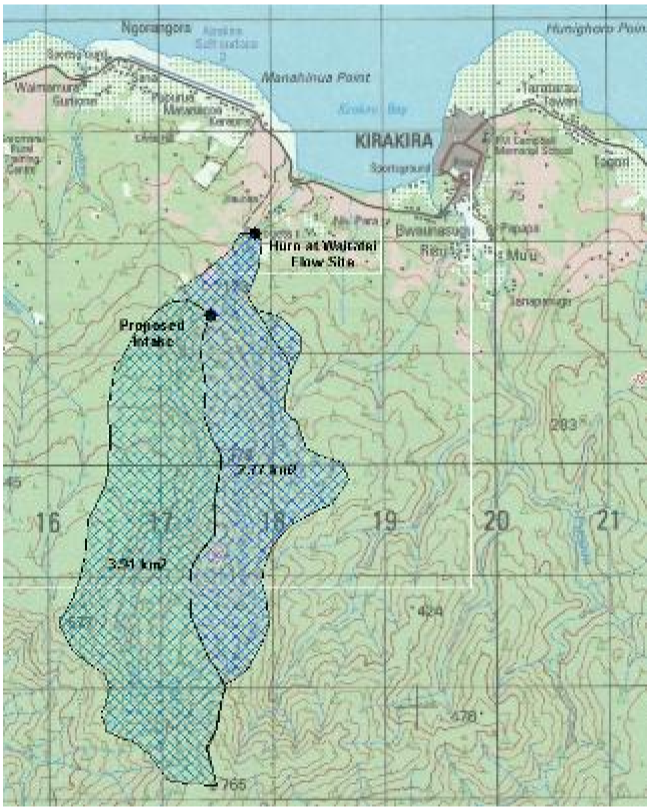


**Figure 8-1 Catchment boundaries of the historical flow gauge and proposed intake.**

Additional rainfall data is available at the Kirakira met station. The monthly average rainfalls are plotted in Figure 8-2 which shows that the rainfall (and most likely the catchment yields) has not decreased in recent times.

Hydrological data in the form of flow in the Huro River close to Waitetei village is available from 1987 to 1992 recorded from an automatic water level recorder (AWLR). A flow measuring device (weir) was also installed in the Huro River at the proposed intake site in September 1995 and daily recordings have been recorded over the period from September 1995 to February 1996.

Some additional data was made available since the 1996 review at the Huro River at Waitatei. Unfortunately the flow data could not be verified as reliable and attempts to reproduce the duration curve in the previous feasibility report (Annex 5) were unsuccessful. The flow data was then compared to information in the supplied Data Audit Report (Ministry of Natural Resources, 1990) and found to be different to this report. Further investigations and communications with the Ministry of National Resources could not completely resolve this issue. Mr. Issac Lekelalu replied in his email dated 2nd Feb 2010, that "*I tend to trust the values given in the report (Huro audit report) other than mine (additional data supplied by him). Data in the report was taken by our staff to NZ then and checked before compilation. I have also checked repsentative streamflow data from our gauging records that Huro is a small stream hence data from the report is acceptable*".

The outcome of the communications was that the data used in the 1996 report is most likely to be correct and the supplied data should not be used in this review. There is evidence that the flow rating at the site might have been changed following the 1990 Audit Report as the last rating review was undertaken in 1994. It will be important for the detailed design of this scheme to have up-to-date and continuous records of flow in the Huro River.

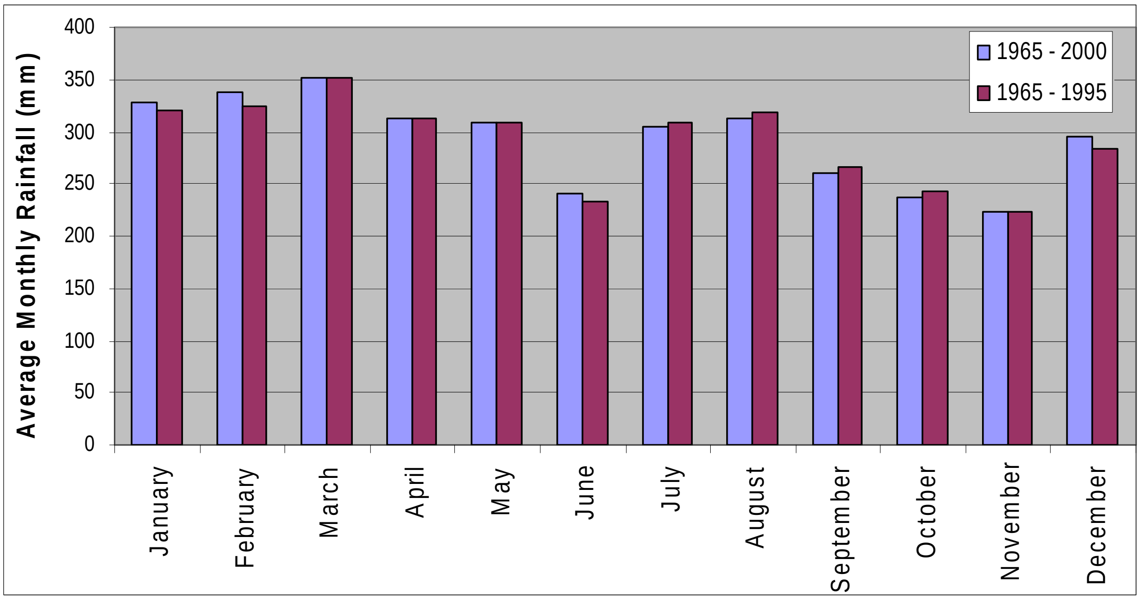


**Figure 8-2 Average monthly rainfalls at Kirakira met station.**

Unfortunately the data collected at the temporary weir installed at the proposed intake location (as detailed in the feasibility report) was not available for this review. This data covered a very short period of time (September 1995 – February 1996) but was the major input to the "idealised" duration curve in the previous study. During five of these six months the monthly rainfall recorded at Kirakira was below average.

In an attempt to verify the adopted flow duration curve from the 1996 study, flows at Lungga River at Komarindi (located on Guadalcanal) were catchment area scaled and compared to both the idealised curve and the AWLR (Waiatei scaled flows) curve displayed in Annex 5 of the 1996 report. No rainfall scaling was applied as both catchments are at similar elevations and there was not enough information to make a valid judgment on the difference in rainfalls in each catchment.

Figure 8-3 shows that the scaled Lungga flows are best represented by the AWLR line, but show increased amounts of discharge at low flows and most likely lower flows at the higher magnitudes (by looking at the trend of the AWLR duration curve). This is to be expected as the Lungga River at Komarindi catchment is 133 $km^2$ compared to 4 $km^2$ at the location of the proposed intake on the Huro River. So the runoff in the Huro River should respond much faster and therefore result in lower base flows.

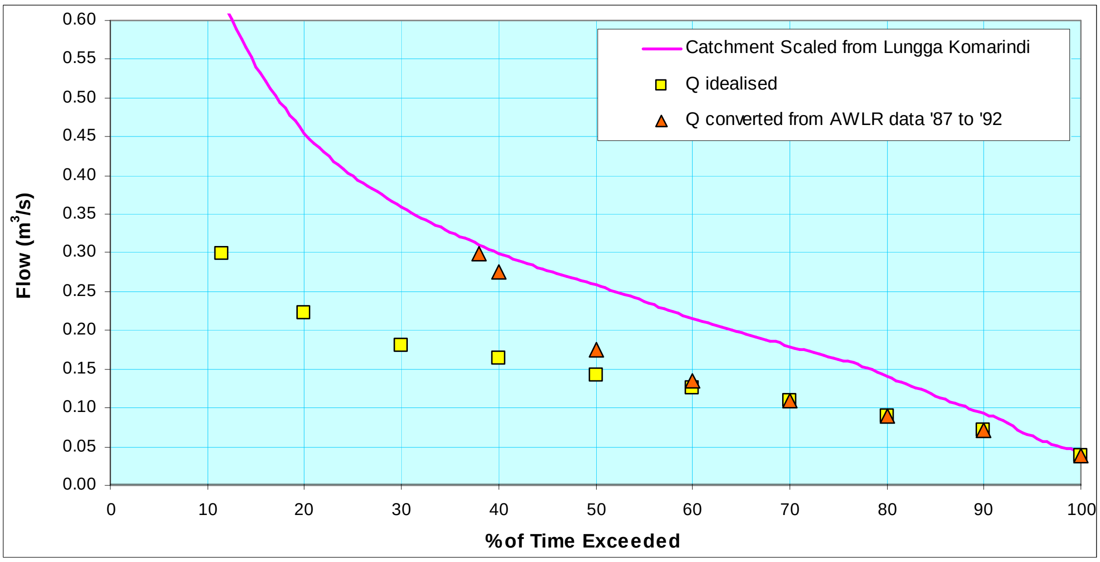


**Figure 8-3 Duration curve comparison of Lungga River (Guadalcanal) with the results of the 1996 feasibility report.**

After comparing the scaled Lungga flows with AWLR and idealised curve, it is recommended to use the AWLR curve as the best representation of the flows in Huro River at intake in this feasibility study.

# 9. Hydropower Assessment and Concept Design

## 9.1 Project Objectives

The main objectives for the Huro mini hydro power project are summarised below:

- Reduce reliance on diesel generation.
- Supply of electricity to Kirakira system, allowing connection to small villages.
- Meet current demand with capacity to expand as demand increases.
- To improve standard of living, improve water supply, education, telecom and health facilities and the production of value added goods

## 9.2 Preliminary Assessment

A preliminary assessment to determine the viable option for the development of a mini hydro scheme on Huro River in Makira island near Kirakira town has been done, based on the Topographical map (1:50,000) of Kirakira and the hydrological data available. The preferred site is located approximately 2 km from the Kirakira town on the Huro River as shown in Figure 9-1 .

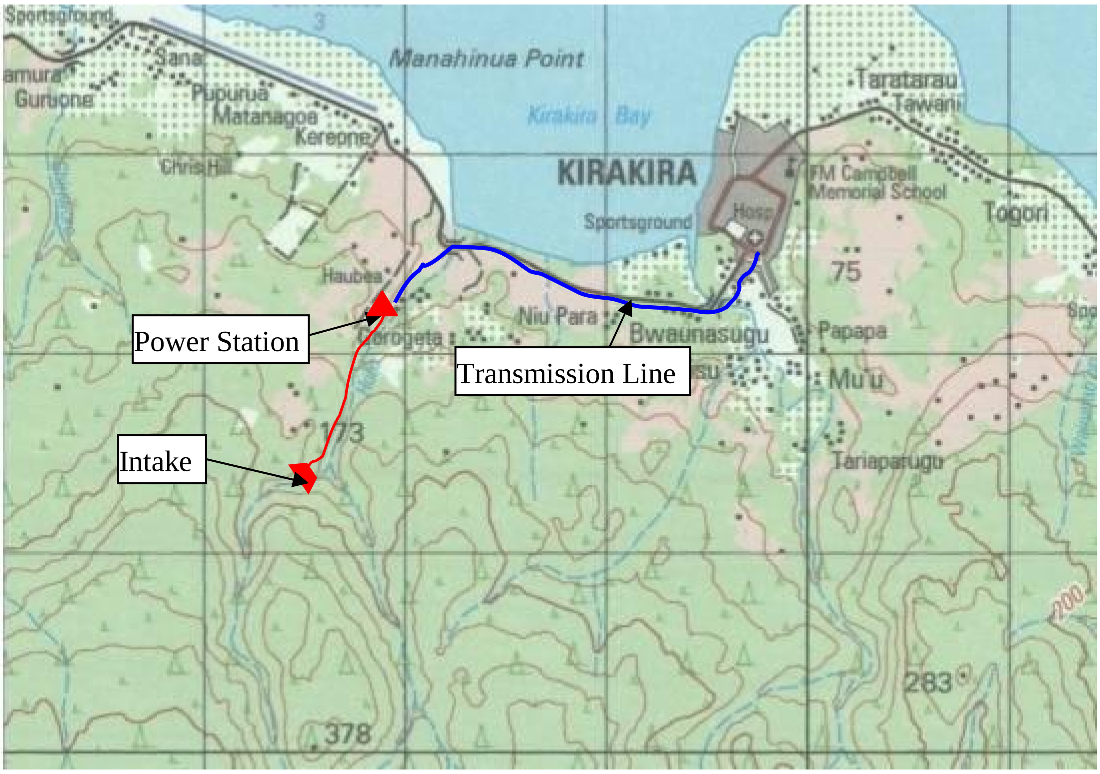


**Figure 9-1 Proposed Mini Hydropower site on Huro River.**

In order to meet the project objectives, following design philosophy was adopted:

- Size machine to cater for base and peak load demand.
- Where costs allow, size the civil infrastructure for full design capacity so that future expansion are required at the power station only.
- Modular power station arrangement to allow for future expansion

### 9.2.1 Flow & Head Data

As described in section 8, hydrological data in the form of flow in the Huro River close to Waitetei village is available from 1987 to 1992 recorded from an automatic water level recorder (AWLR). A flow measuring device (weir) was also installed in the Huro River at the proposed intake site in September 1995 and daily recordings have been recorded over the period from September 1995 to February 1996.Unfortunately the AWLR flow data could not be verified as reliable and weir site data is not available, therefore an attempt to reproduce the duration curve is unsuccessful.

To verify the adopted flow duration curve in 1996 study (Annex 5), flows at Lungga River at Komarindi (located in Guadalcanal) were catchment area scaled and compared to both the 'idealised' and AWLR duration curve as shown in Figure 8-3.

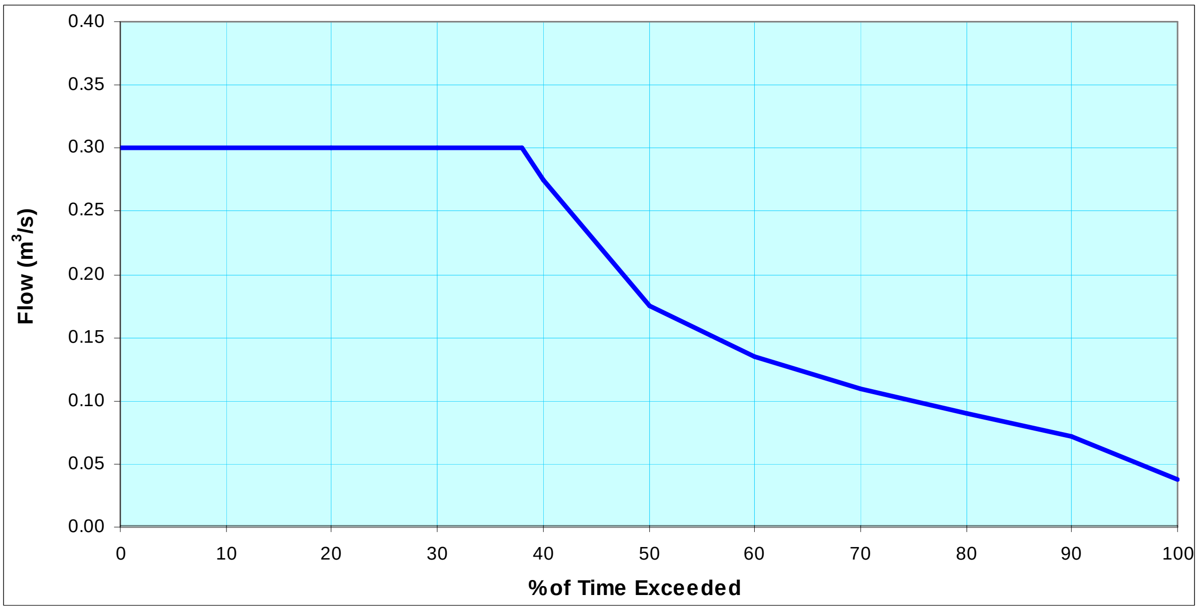


**Figure 9-2 Flow duration curve for Huro intake.**

After comparing the scaled Lungga flows with AWLR and idealised curve, the flow duration curve recommended for the Huro River intake in this feasibility study is as shown in Figure 9-2.

From the available flow, the proposed plant is designed to cater for the current and immediate peak load demand and therefore a design flow of 150 l/s was selected for present scenario. As shown in Figure 9-2, flow of 150 l/s is available approximately 60% of the time based on the flow duration curve.

A LiDAR survey has been undertaken following this study to confirm the levels from the topographic maps and to provide more precise determination of pipeline layout and elevation levels of proposed weir/intake and power house for the future design stage. The intake on the Huro River is proposed at an altitude of 140 masl, locating the intake any further upstream does not appear feasible because of the steep side slope and rugged terrain through river ravine. The power house is located on a narrow terrace on the banks of the Huro River near to the Waitetei village at an altitude of 15 masl; therefore the gross head available for scheme is 125m.

Considering the load growth in next 20 years and future expansion of the power plant, the civil structure is designed for the high flow in order to harness the hydropower potential of the Huro River at a high but economically acceptable level.

### 9.2.2 Machine Selection

There are various turbine and generator combinations to suit the hydraulic and operating conditions, and economic viability for this project

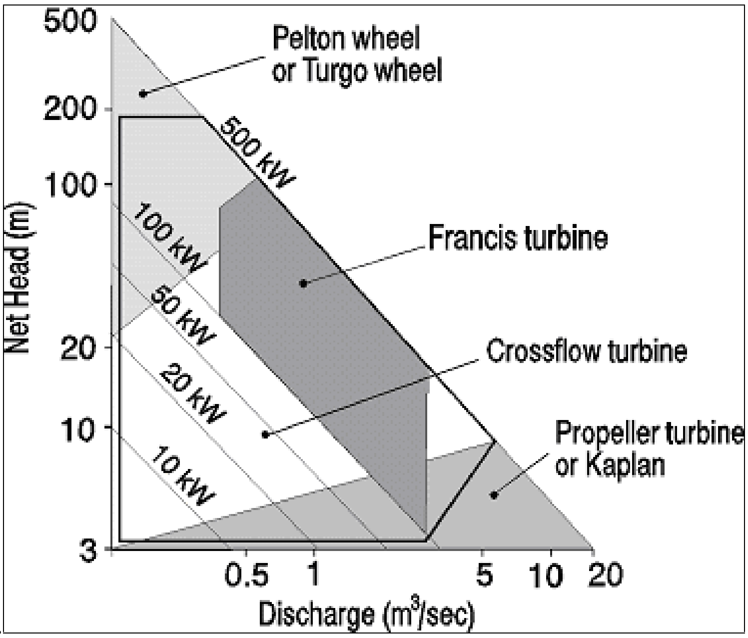


**Figure 9-3 Typical mini Hydro Turbines – Range of Flow & Head**

For this proposed mini hydropower station, a Turgo Impulse turbine would typically best suit the flow and head range, see Figure 9-3. The *Turgo* turbine, see Figure 9-4, is similar to the Pelton but the jet strikes the plane of the runner at an angle (typically 20°) so that the water enters the runner on one side and exits on the other. Therefore the flow rate is not limited by the discharged fluid interfering with the incoming jet (as is the case with Pelton turbines). As a consequence, a Turgo turbine can have a smaller diameter runner than a Pelton for an equivalent power. Nearly all the energy of the water goes into propelling the bucket and the deflected water falls into a discharge channel below.

The Turgo turbines are considerably robust machines and ideally suited for remote installation.

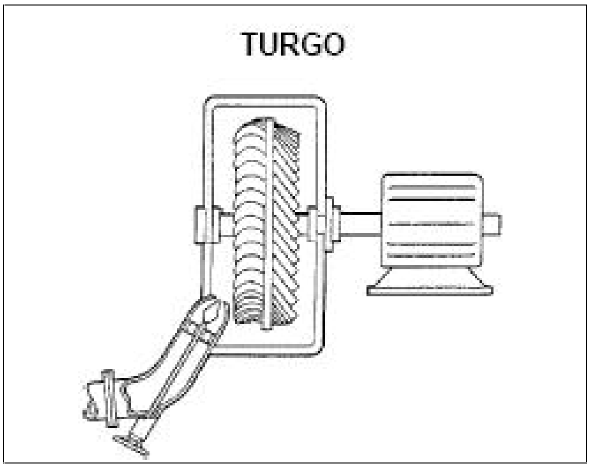


**Figure 9-4 Typical Turgo Machine**

This Turgo Turbine suits the variable operating flow regime, and yields maximum energy. Given the net head of approximately 100m and flow variation of 50 l/s to 150 l/s, a configuration of a Turgo turbine of 110kW is considered to best utilise the range of available flow. The generator would be a 4-pole 110kW induction machine mounted horizontally to the turbine.

Maintenance requirements will be minimal for the turgo turbine, and with appropriate training during equipment installation and commissioning, should be manageable by the current powerstation operators. Sufficient spare parts and consumables should be provided with the turbine, as replacement parts will not be available locally or in Honiara.

### 9.2.3 Energy Production

Energy modelling has been performed to determine potential energy production based on the flow duration curve and available head.

An indicative budgetary quote and details for the turbine and generator has been obtained from Tyco Tamar as shown in Appendix B.  Based on the quote provided by manufacturer, the efficiency for the Turgo turbine is as shown in Figure 9-5.

These efficiency values are based on quoted efficiencies and not guaranteed values.

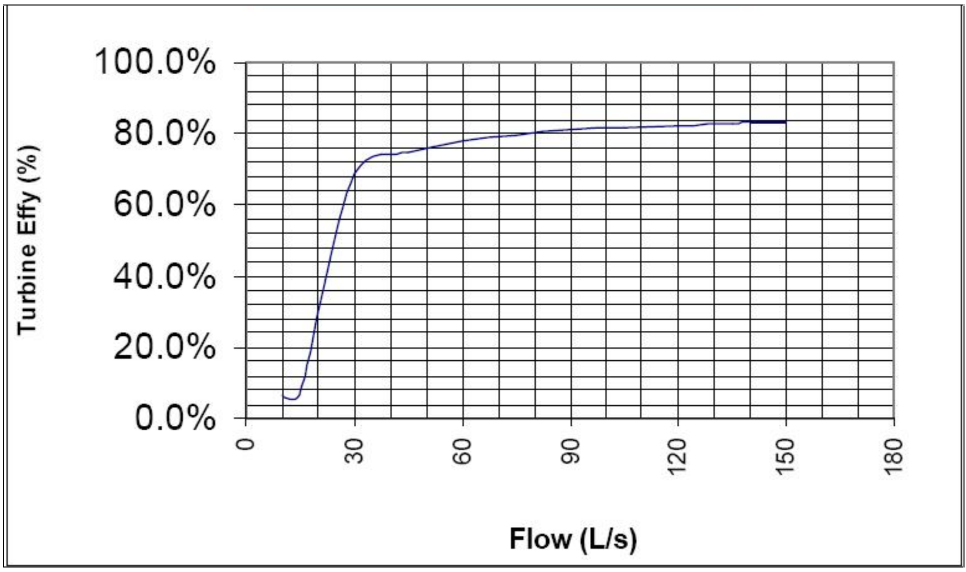


**Figure 9-5: Efficiency Curve for Turgo Turbine**

Although efficiency for the Turgo turbine is comparatively less than the Pelton and Francis turbine but it is not critical due to sufficient flow being available and is preferred over Pelton and Francis because of its robustness.

A Turgo machine is preferred over Francis because the flow strongly varies and due to long penstocks, as the deflector allows avoidance of runaway speed in the case of load rejection and the resulting water hammer that can occur with a Francis. Compared to the Pelton, a Turgo turbine has a higher rotational speed for the same flow and head.

Based on the efficiencies for the turbines and generators as shown in Figure 9-5, the electrical power output for flows in the range of 50 l/s to 150 l/s is shown in Figure 9-6.

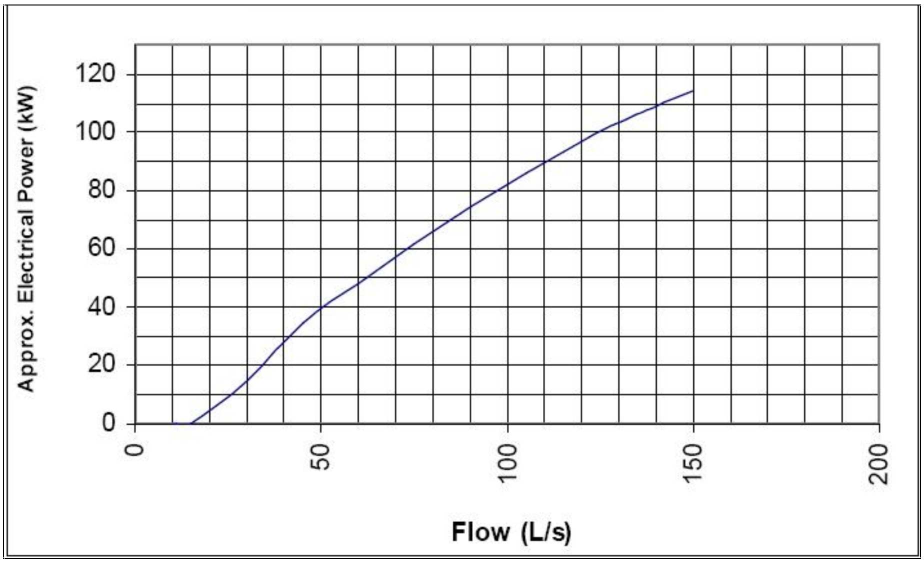


**Figure 9-6: Electrical power output for Turgo Turbine**

The annual average energy production based on the flow duration curve Figure 9-2 and the electrical power output from Figure 9-6 is calculated as per table Table 9-1 below:

**Table 9-1: Total potential annual energy production**

| % time exceedence | % time period | Flow Available | Power | Energy |
|---|---|---|---|---|
| | | Litre/sec | kW | kWh |
| 0% | | | | |
| 60% | 60% | 150 | 110 | 578160 |
| 70% | 10% | 110 | 90 | 87600 |
| 80% | 10% | 90 | 75 | 72270 |
| 90% | 10% | 75 | 60 | 59130 |
| 100% | 10% | 50 | 40 | 43800 |
| | | | Total | 840960 |

The total average potential annual energy production from the proposed Huro mini hydro project is approximately 840 MWh but actual energy production will be dependant on the demand in the system as shown in Figure 9-7.

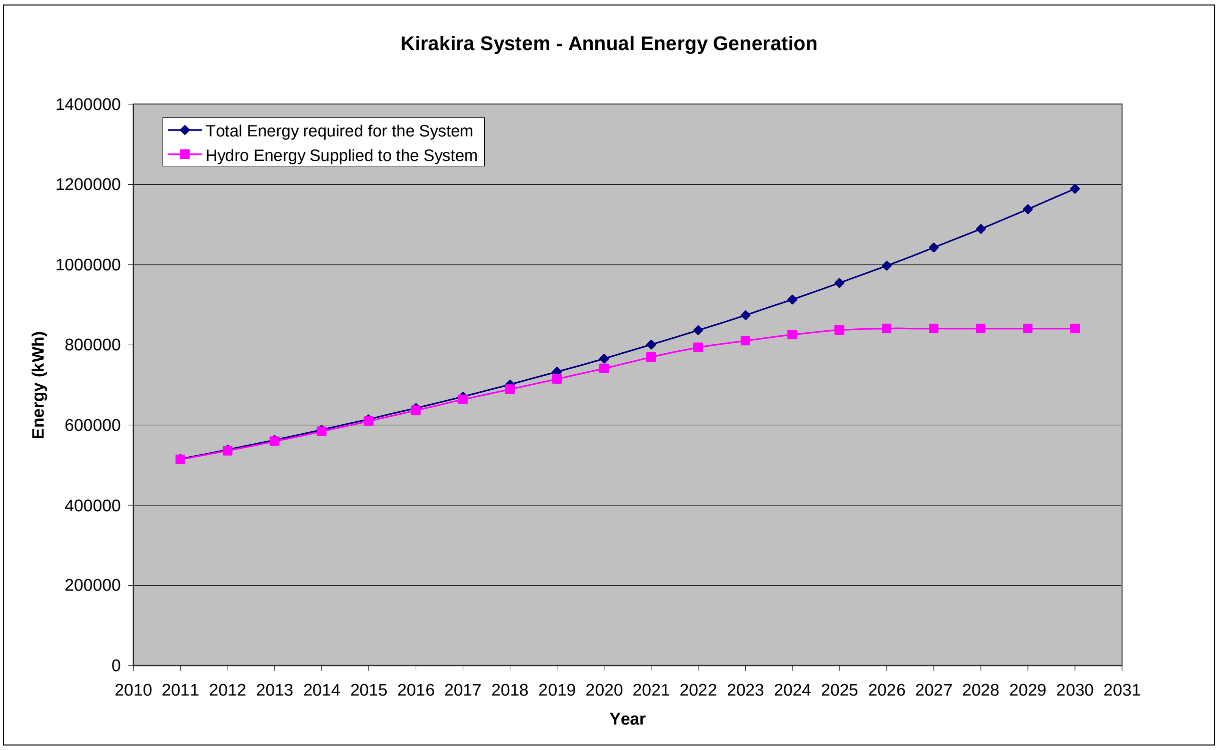


**Figure 9-7: Average annual energy generation from Huro MHP as per the demand**

## 9.3 Concept Design

### 9.3.1 General Layout

The general layout of the scheme as shown in Figure 9-1 along with infrastructure required is shown on the 1:50,000 topographical map obtained for Kirakira. Detailed siting of the infrastructure required for the project (access road, weir and powerhouse) has not been carried out due to the lack of reliable survey data. This can be carried out once the detailed topographical survey has been made available.

However, from the site visit carried out by HTC, a hydropower scheme consisting of following components is recommended:

- Diversion weir - Coanda Intake.
- High density poly ethylene (HDPE) pipeline connecting the intake to powerhouse.
- Surface power house.

Description of these components along with transmission and access requirements are provided below:

### 9.3.2 Diversion Weir – Coanda Intake

It is proposed that a Coanda Intake be used as the diversion structure for this project. The river at the selected weir site cascades over exposed rock and huge boulders in several steps. This rugged terrain requires an intake structure which can operate satisfactorily even during floods with considerable amounts of bed load and floating debris.

A Coanda intake is a self cleaning intake where flow passes through a wedge-wire screen and into a collection trough in the centre of the intake. Due to self-cleaning nature of the screen, maintenance requirements are reduced. Small particles (diameter as low as 1 mm) are screened out by the wedge wire mesh while larger particles and debris (trees, branches and boulders etc) pass over the weir. This will eliminate the requirement of a sediment trap also.

Figure 9-8 shows a schematic of a typical Coanda Intake and Coanda intake in operation.

It is anticipated that the weir across the Huro River will be approximately 5m wide, with 1m of the weir covered in Coanda screens that are approximately 1m in length for 150 l/s of flow through. For a flow of 300 l/s to pass through the Coanda intake, a screen width of 2 m is required. For environmental releases, an offtake pipe of required capacity will be connected to the intake box to discharge water back in river. The Coanda weir/intake drawing is shown in Appendix A.

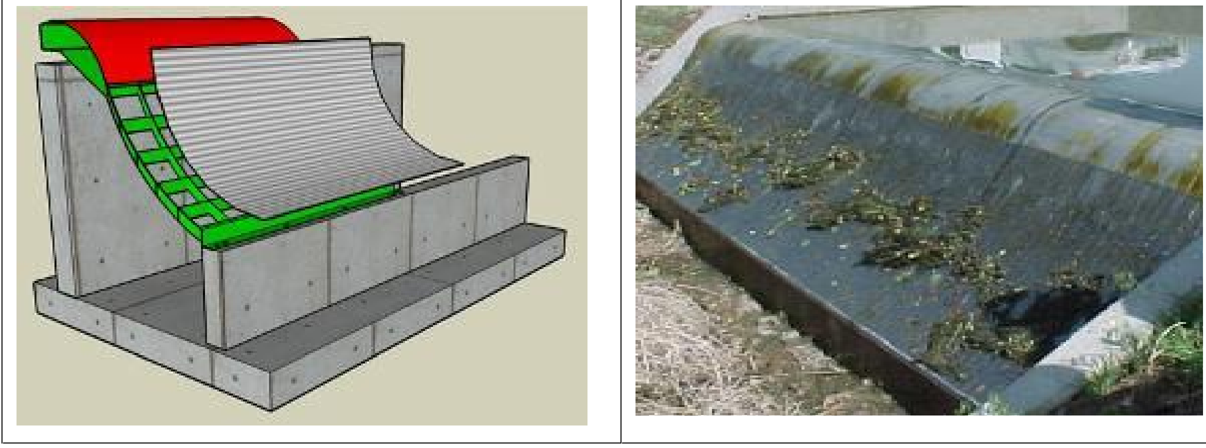

**Figure 9-8: Typical Coanda Intake- Schematic and in operation**

The weir and the intake box will be constructed from the reinforced concrete which required small quantity of material to be carried and constructed at the site by manual labour. The prefabricated Coanda screen will than be fixed over the top of the intake box as shown in the schematic.

### 9.3.3 Pipeline from Intake to Powerhouse

Considering the rugged nature of terrain and side slope along the river, a surface laid pipeline is recommended to connect the intake to the power house as a flume or buried pipeline is not likely to be feasible.

A HDPE pipeline has been recommended over steel, uPVC and alternative pipe material because of the following advantages:

- PE pipes are relatively cheap and light in weight.
- Low friction losses in PE compared to other materials.
- No corrosion of PE pipes, steel or concrete would have to be protected.
- Robust nature of poly during the installation process allowed pipes to be easily cut, transported and stored.
- Fast and reliable jointing system.
- Flexible nature of PE allowed for pipe to be laid around curves etc without the need for additional fittings elbows.

An optimisation study has been done to select the pipeline diameter suitable for the following scenarios:

1. Pipeline and civil infrastructure being implemented for the current and immediate future demand (with 1 turbine and generator installed initially); or
2. Layout similar to option 1 arrangement, but with a larger weir and pipeline to cater for future expansion of the Huro River hydro system. This future expansion would consist of an additional powerhouse and turbine sized for future demand.

The pipeline optimisation study is based on the capitalised lost revenue due to head loss in varying diameter of pipeline; the basic parameters used for the study are as follows:

- Pipeline diameter ranging from 200mm to 1000mm,
- Hydraulic roughness for the PE pipe as 0.0025 mm,
- Pipeline utilisation of 60% time exceedence,
- Life of project 20 years, Discount rate of 8.0% and
- Revenue as Diesel generation cost of 150 SB cents/kWh.

For scenario 1, the design discharge of 150 litre/sec has been selected for the machine to cater for the current demand of up to 100 kW. The head loss calculated for the PE pipeline (PN 12.5) from DN 280 to DN 500 is as per Table 9-2.

**Table 9-2: Head loss through pipeline for design flow of 150 l/s**

| Nominal Diameter (DN) | Internal Diameter (ID) | Head loss (m) |
|---|---|---|
| 280 | 237.90 | 65.84 |
| 315 | 267.55 | 38.80 |
| 355 | 301.60 | 23.56 |
| 400 | 339.90 | 15.20 |
| 450 | 382.35 | 10.66 |
| 500 | 424.85 | 8.34 |

The optimisation study result as shown in Figure 9-9 suggests that the optimum diameter for design discharge of 150l/s, is somewhere between 350 to 400mm internal diameters based on the net benefit curve. But considering the rough terrain for installing and handling the pipe, a light and smaller size pipe is warranted, therefore a pipe of internal diameter 300mm i.e. DN 355 is selected having head loss of 23.56m which satisfy the net head requirement of approximately 100m out of 125m available gross head.

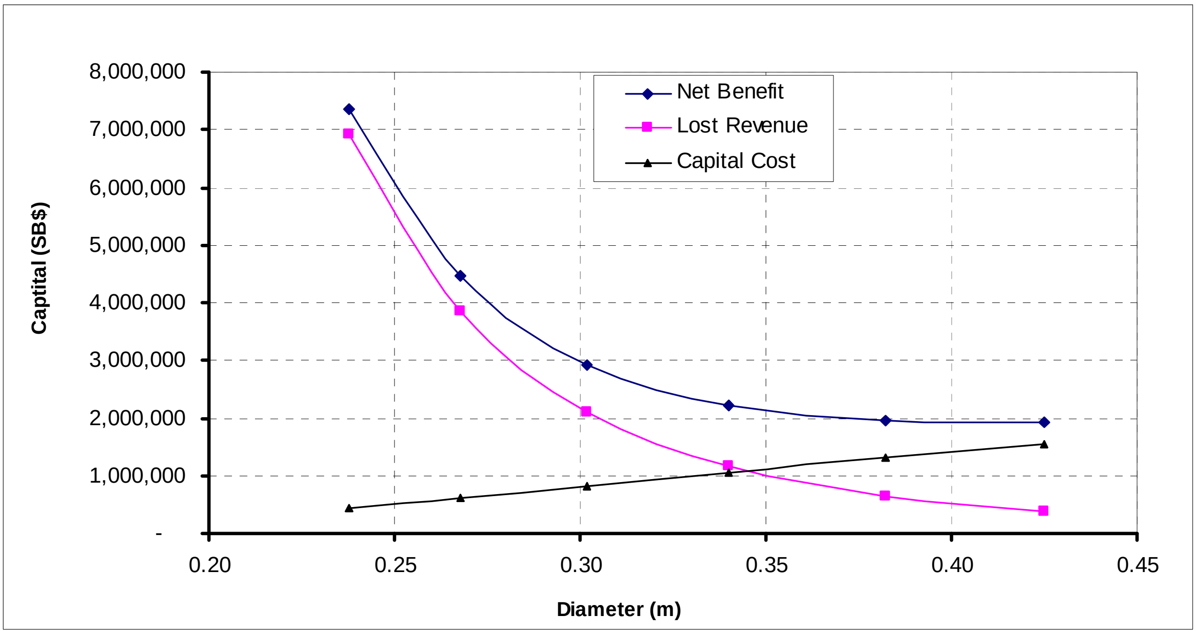


**Figure 9-9: Pipeline diameter optimisation for Scenario 1.**

For scenario 2, the design discharge of 300 litre/sec has been selected for the machine to cover the demand of next 20 years at the rate of 4.5% i.e. 200 kW approximately. The head loss calculated for the PE pipeline (PN 12.5) from DN 280 to DN 500 is as per Table 9-3.

**Table 9-3: Head loss through pipeline for design flow of 300 l/s**

| Nominal Diameter (DN) | Internal Diameter (ID) | Head loss (m) |
|---|---|---|
| 280 | 237.90 | 218.45 |
| 315 | 267.55 | 123.54 |
| 355 | 301.60 | 70.07 |
| 400 | 339.90 | 40.76 |
| 450 | 382.35 | 24.84 |
| 500 | 424.85 | 16.71 |

The optimisation study result as shown in Figure 9-10 suggests that the optimum diameter for design discharge of 300l/s is beyond 400mm internal diameter based on the net benefit curve. But considering the rough terrain for installing and handling the pipe, a light and smaller size pipe is warranted, therefore a pipe of internal diameter 382mm i.e. DN 450 is selected having head loss of 24.84m which satisfy the net head requirement of approximately 100m out of 125m available gross head.

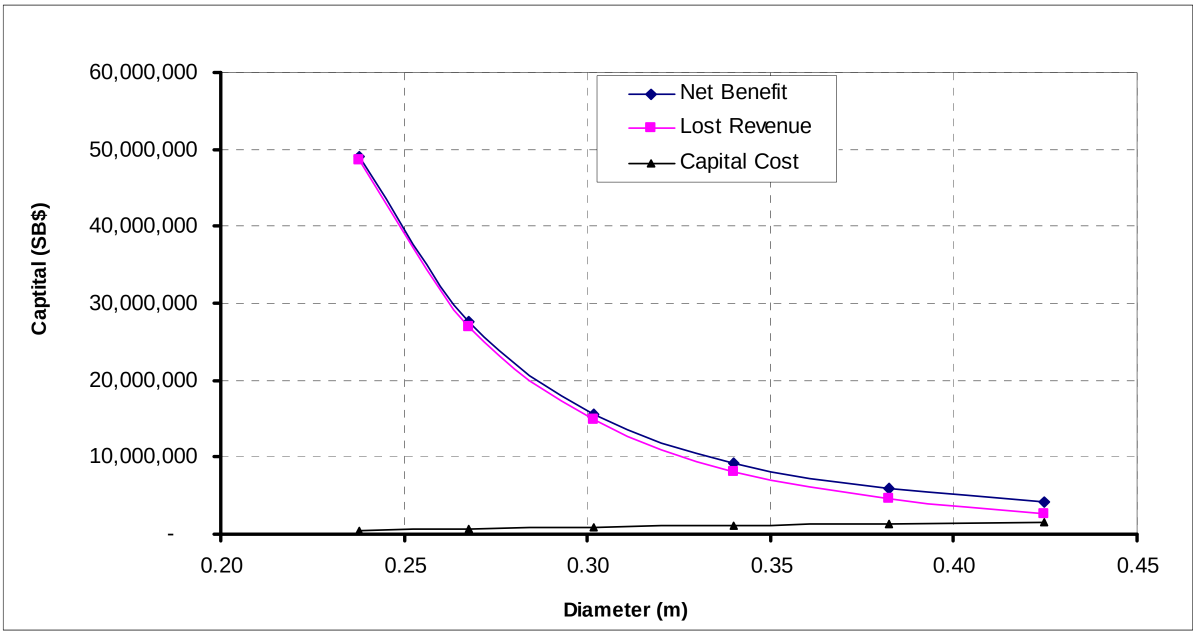


**Figure 9-10: Pipeline diameter optimisation for Scenario 2.**

The optimisation study results for scenario 1 and 2 indicate that the increase in the pipe diameter for scenario 2 will result in marginal increase of civil works cost, however this makes the scheme ready for future expansion and would not become too small in just few years time.

### 9.3.4 Powerhouse

The preferred location for a powerhouse is near to the Waitetei village on the banks of the Huro River. This location is quite accessible by the gravel road to the village and is close to existing infrastructure in Kirakira town. The power station can be located further downstream and away from the village without gaining any extra head depending upon the social and environmental requirements.

A preassembled standard freight container is recommended as potential arrangements to house the turbine and generator, and act as a powerhouse as shown in Appendix A.

It is proposed to utilise a preassembled 6m x 2.4m wide standard freight container, to act as the powerhouse. This will allow reduced civil costs and works, and allow factory assembly and pre-commissioning of the machine, resulting in reduced site costs and installation time. A new container would be modified to suit the pipework layout required for the turbine. The container will include an inbuilt low profile mono-rail hoist, access doors, internal lining for noise insulation, turbine, generator, main inlet valve, outlet butterfly valve, and control board. Electrical equipment such as circuit breaker, revenue meter, and capacitor banks (if required) will be housed within the powerhouse.

The power house container will sit on the concrete slab foundation having discharge pit cutout on the slab, the discharge pit beneath the slab will take the turbine discharged water to the tail race channel and back to Huro River. The turbine discharge flow velocity will be controlled through the outlet structure in order to avoid the erosion in the river. These outlet structure will be designed in the detailed design phase.

Station services such as lighting, ventilation and auxiliary power would be included in the powerhouse. No allowance has been allowed for a fire detection system or security system.

No allowance has been allowed for architectural treatment of the powerhouse, such as cladding with a colorbond steel finish, or cladding with a rendered finish to suit the environment. However, this can be included so that the mini hydro power house will appears to be a permanent structure.

A photograph of a typical containerised installation is included below, in Figure 9-11. This installation was supplied by Tyco Tamar to ACTEW AGL for Bendora Dam.

**Figure 9-11: Turbine in shipping container**

### 9.3.5 Control & Operation

The Turgo turbine will allow variable control that can better match the current inflows in the Huro River and the variable intra day demand of the Kirakira system. It has been sized to allow operation over the maximum flow range suitable for this type of machine.

The Turgo turbine would be able to utilise flows in the range of 50 l/s to 150 l/s. Any greater than 150 l/s would be bypassed or spill through the weir. In case of turbine shutdown, the total flow is being spill through the weir.

The operation of the mini-hydro will be fully automatic under the control of station PLC with provision for radio communications.

As per the discussions with SIEA officials, the existing diesel power plant will be relocated near to the Huro mini hydro site in immediate future. Therefore, the operation of both hydro and diesel plant will be linked to the PLC for supplementing the diesel generation to cover the demand of the Kirakira system.

## 9.4 Transmission & Distribution

Because the city area is small in Kirakira, presently the diesel generated power at 415 V is distributed to each user directly by a 3 phase 4 wire distribution line without transformation.

The transmission line required to connect the proposed hydro scheme to the existing distribution network in Kirakira is about 3 km long and thus requires a high voltage 11 kV line to reduce voltage drop and excessive power losses. The route proposed for the transmission line follows the road that connects the Kirakira airport with Kirakira station.

The transformers are required at the power station to step up to 11 kV and than at Kirakira town to step down to 415 V. The existing distribution system is sufficient for the current load, it consists of low voltage overhead lines on steel and concrete poles with timber cross arms.

# 10. Cost Estimate and Economic Analysis

## 10.1 Approach to Cost Estimation

Cost estimates have been undertaken for the potential mini hydropower scheme options identified. Hydro Tasmania Consulting has used previous experience with developing similar projects in Australia, New Zealand, Fiji, Papua New Guinea, the Solomon Islands and India as a basis for the estimates.

In developing the cost estimates it was found that there were a number of items within the costing that weighed greatly on the overall cost. Unit rates for the main civil works used in the estimates are obtained locally from Solomon Islands with the assistance of SIG-Energy Division personnel.

The unit rates for the main material such as electro-mechanical, pipe, coanda screen etc were obtained through budgetary quotes from the suppliers in Australia. Significant unit cost items are listed in Table 8-1 below.

These costs were found to be the greatest factors determining the overall capital cost for the potential development. Quantities were estimated and prepared based on the preliminary scheme layout as shown in Appendix B. The estimate has been based on January 2010 Solomon Islands dollars (SBD), and are suitable for feasibility study purposes only.

**Table 10-1 Significant Unit Costs**

| Item | Unit | Rate/Unit |
|---|---|---|
| Access Road - Sealed | km | SBD 1,000,000 |
| Access Road - Unsealed | km | SBD 400,000 |
| Mass Concrete | $m^3$ | SBD 700 |
| Structural Concrete | $m^3$ | SBD 800 |
| Supplying PE pipe Ex.Honiara – DN 355 - PN12.5 | m | SBD 546 |
| Supplying PE pipe Ex.Honiara – DN 450 - PN12.5 | m | SBD 970 |
| Electro–Mechanical works in Containerised Powerhouse for Turbine and Generator of 110 kW | item | SBD 3,984,500 |
| Transmission & Distribution line works | m | SBD 200 |
| Contingency – Civil<br>– E&M | | 15%<br>10% |

The Electro-mechanical works cost provided by the manufacturer (Tyco Tamar) includes the following:

- One only Tamar Turgo Impulse turbine,
- One hydraulically actuated spear valve,
- One hydraulically actuated jet deflector,
- Synchronous generator,
- Main inlet valve with hydraulic open/spring close actuator,
- Hydraulic power pack,
- Digital electronic governor,
- Control panel,
- Electrical cabinet.

All installed in a 6m container complete with sea freight certification.

Project preliminaries such as project management and basic design were taken to be 2 % and 1.5% respectively of the project cost. Site establishment, such as setting up infrastructure and construction facilities, office etc has been taken to be SBD 200,000.

Environmental and social program costs have not been considered in these cost estimates.

## 10.2 Cost Estimates

The estimates of capital cost for each of the options investigated are set out in Table 10-2 below. The table gives the estimates for the major components of the scheme. The total cost incorporates these components, plus all other costs associated with the development of the scheme. Details of the estimates are presented in Appendix B.

**Table 10-2 Capital Cost Estimates**

| Item | Scheme Costs (SBD) | |
|---|---|---|
| | Option 1 (DN 355 pipe) | Option 2 (DN450 pipe) |
| Design, Engineering & Project Management | 234,750 | 257,910 |
| Site Establishment-Camp, Offices & Communications | 200,000 | 200,000 |
| Access Road | 700,000 | 700,000 |
| Weir/Intake | 79,700 | 112,970 |
| Hydraulic Conduit - Pipeline | 1,008,240 | 1,636,685 |
| Power House including Electro-Mechanical Works | 3,999,100 | 3,999,100 |
| Transmission & Distribution | 720,150 | 720,150 |
| Contingency | 842,060 | 944,795 |
| **Total** | **7,784,000** | **8,428,600** |

## 10.3 Economic Analysis

The economic analysis of the Huro Mini Hydropower Development is to demonstrate that the development is part of the least cost development program for Kirakira system in Makira Province. Since an electricity supply is already established in Kirakira, the question therefore, is not to electrify but rather choose a best suitable alternative supply option that would be less expensive and more reliable than the current all diesel system.

Therefore, an incremental cost-benefit analysis is conducted which evaluates the benefits between two alternative supply scenarios namely:

- Mini Hydro scheme with Diesel supplement
- All Diesel system

For each scenario, the net present value (NPV) and the economic internal rate of return (IRR) have been developed, as has the long run marginal costs of supply (LRMC). Tabular data of these analysis presented in this section can be found in Appendix C.

### 10.3.1 Economic Analysis Assumptions

1. The project life is assumed to be 20 years.
2. Capital cost for Mini Hydro scheme is as per section 10.2 with electro-mechanical components will be overhauled (runner and auxiliaries replacement cost of SBD 600,000) after 10 years.
3. The discount rate for the project is taken to be 8%. Market lending rates as per Central Bank of Solomon Islands is currently around 16% and the domestic inflation rates in last few years are ranging in 7 to 10%. Hence the minimum real discount rate should be between 8% to 10%. For the analysis we have considered 8% on the lower side of the discount rate which reflects the socio-economic benefits of the reliable energy development programme. The European Investment Bank uses a discount rate of 10% for projects in the Pacific region, and in particular, for the Tina River Hydropower Project currently under study in Guadalcanal. The results for 9% and 10% discount rates are shown in the sensitivity analysis.
4. The price of energy is the base tariff, which is currently SBD 3.39/kWh, based on the fuel prices supplied to SIEA from Markwarth Oil Ltd, the fuel price adjustment [AFPA] at 1 January 2010 is calculated at $0.6317 per kWh and will be shown as a separate item on all customer bills in compliance to the Electricity Regulations (As per the information provided by Mr. John Korinihona of SIG-Energy Division via email dated 19/02/10)

5. Cost of Diesel generation is based on the Energy Information Administration (EIA) oil price projections (DOE/EIA – May 2009) up to 2030 as shown in Figure 10-1, and assuming an efficiency of 0.35 litres/kWh used for generation.

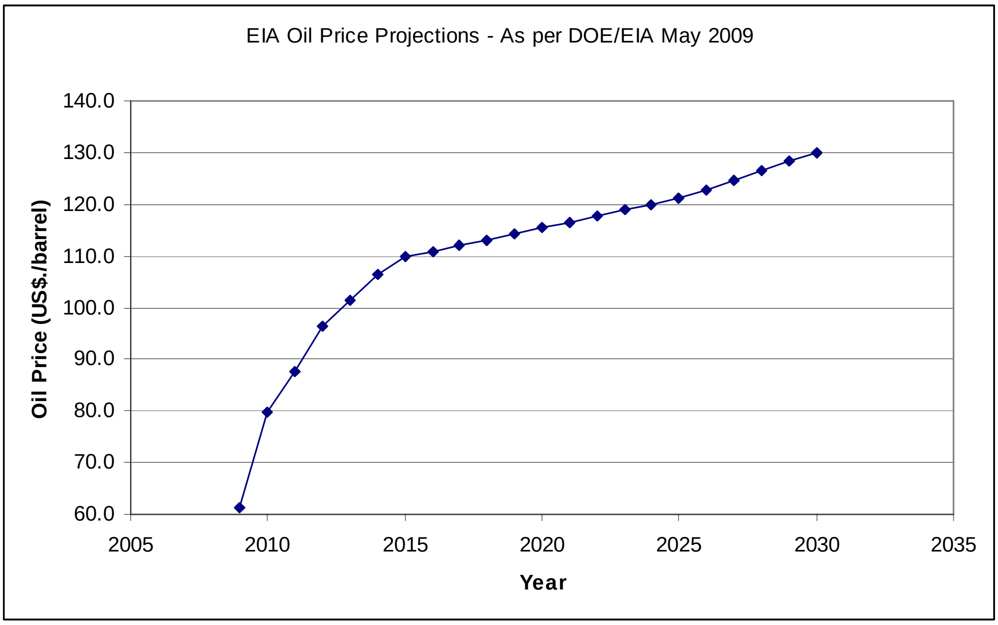


**Figure 10-1: EIA Oil Price Projections**

6. The operation and maintenance cost for the mini hydro scheme is 1.5% of the electro-mechanical equipments cost, whereas for the diesel generation plant the fixed O&M cost is SBD 235/kW/yr and variable O&M is 0.07 SBD/kWh.

7. The peak load for Kirakira system is projected to grow at the rate of 4.5% based on the long term data of SIEA system provided. The current peak load is about 80 kW and will forecast to reach 200 kW in next 20 years. Typical daily load curves were derived from log books of the SIEA power station operators as shown in Figure 7-3 in section 7.

8. As per previous adjustments, these daily load curves with distinct evening peaks on week-ends and an equally high consumption level for both business and evening hours on week days would remain the same throughout the analysis period. These load curves will be scaled to meet the future demand and calculating the total energy required as shown in Figure 10-2.

9. For project option 1 - having one 110 kW machine during the analysis period of 20 years, the annual energy is calculated for those years based on the flow duration curve as per section 9.2.1 catering for the future demand. It can bee seen from Figure 10-2 that diesel supplement is required more after year 2020 when the peak demand goes more than 110 kW and the hydro generation gets restricted.

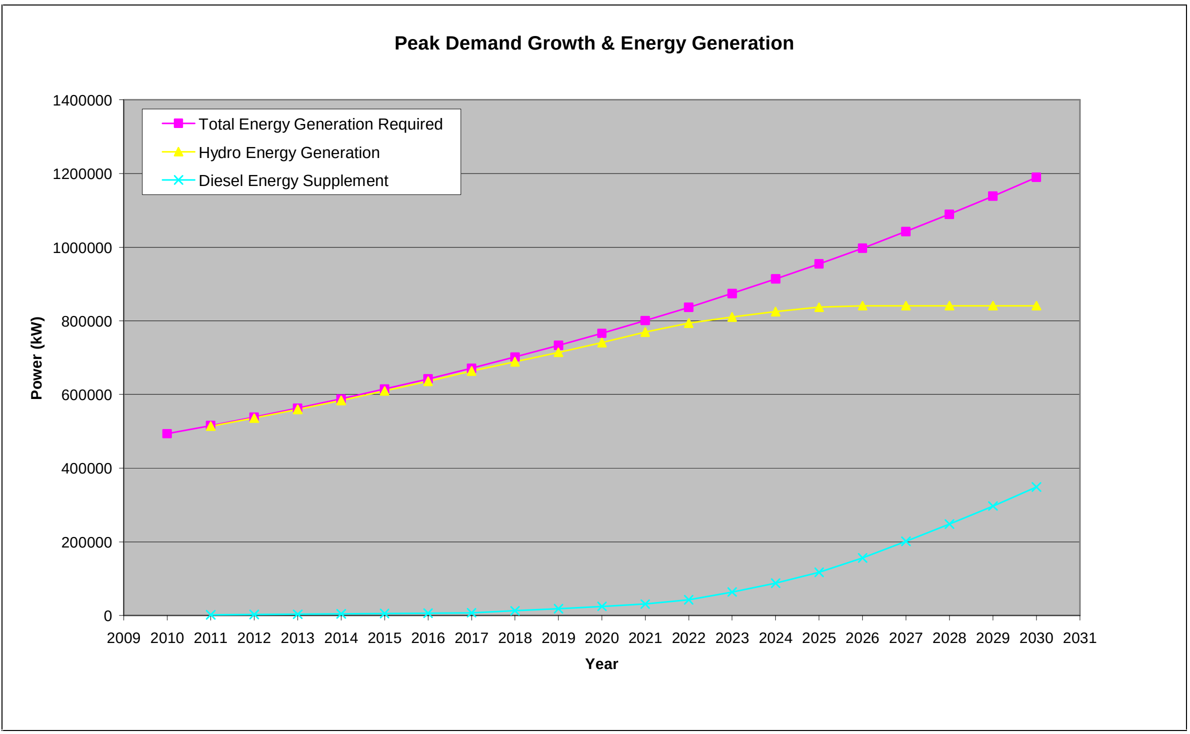


**Figure 10-2 Project Option 1 - Hydro Energy Generation supplemented with Diesel**

10. Backup diesel generation will be required for the hydropower development as, during drier times, there will not be enough water to produce power to meet demand. The amount of diesel supplement in the mini hydro operating system is calculated by converting the flow duration curve to a power duration curve, which allows the amount of diesel backup to be known and is shown in Figure 10-3 for peak demand of 111kW in year 2019.

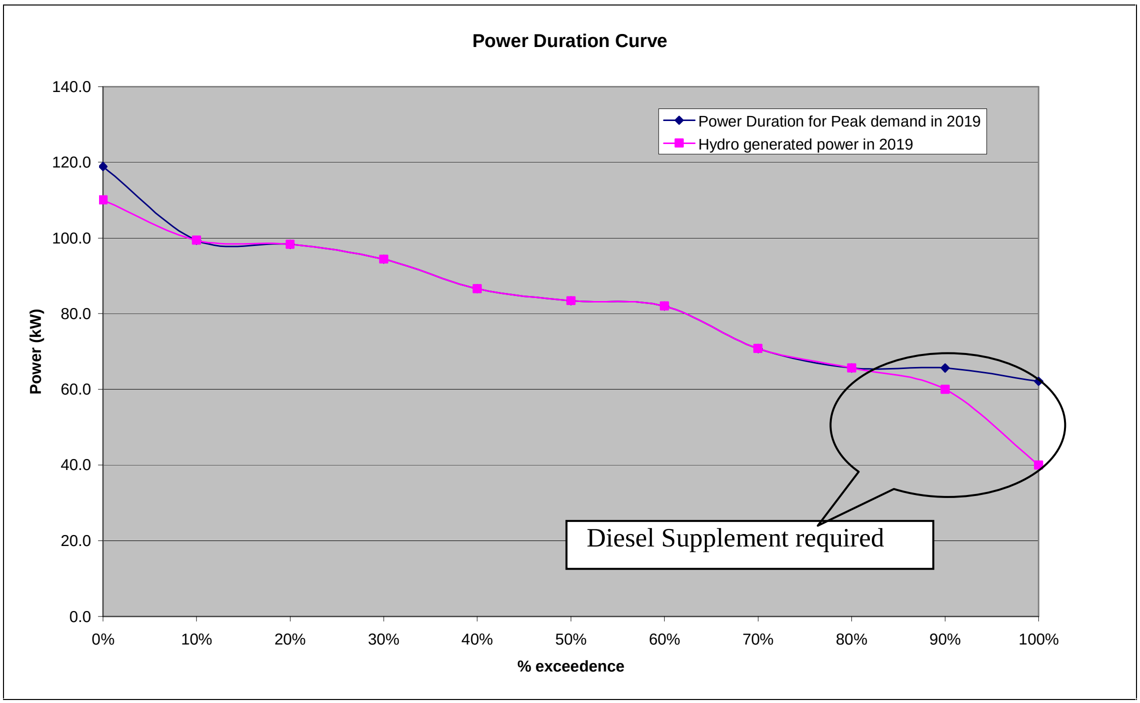


**Figure 10-3 Power Duration curve showing Diesel Supplement**

11. For mini hydro project option 2, having civil infrastructure ready for future expansion of power house with another 110kW hydro machine after 2019 when the peak demand is more than 110 kW, the annual energy generation calculated as per flow duration curve is shown in Figure 10-4. This clearly shows that the diesel generation is reduced substantially even after year 2020.

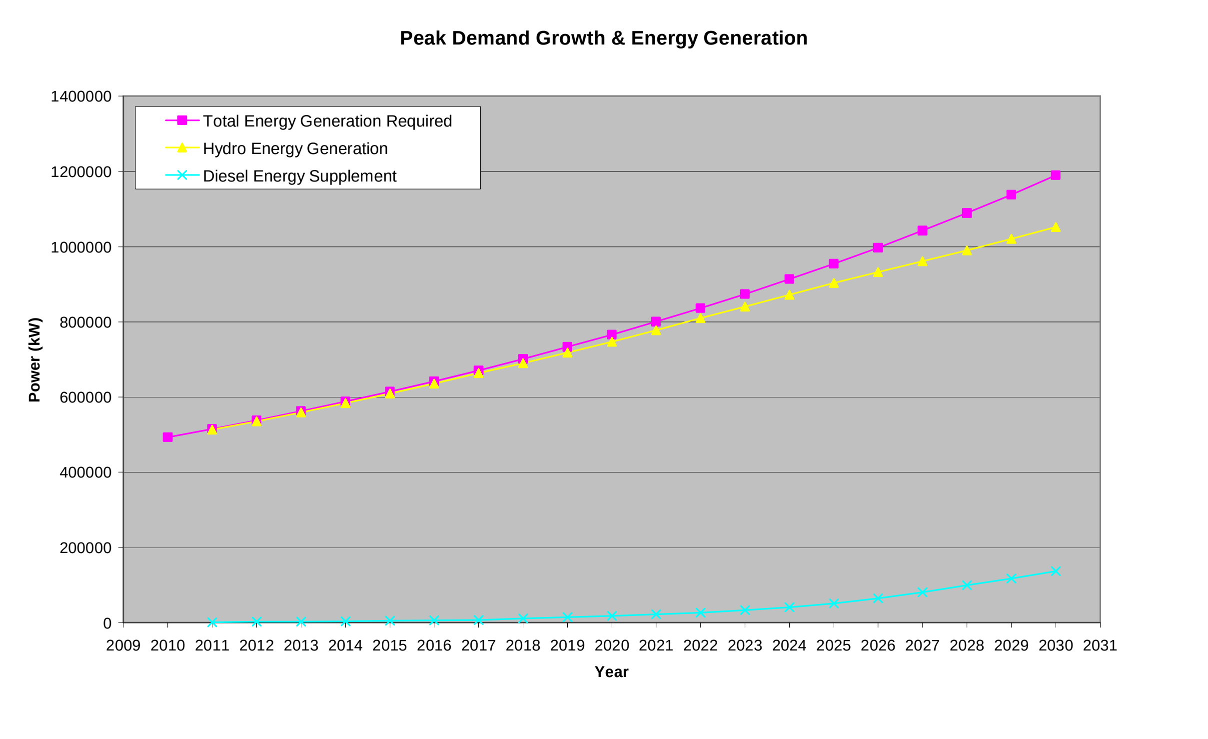


**Figure 10-4 Project Option 2 - Hydro Energy Generation supplemented with Diesel**

12. The life of a diesel generating set is considered 10 year. As per the Masterplan study (JICA), the 3 generators sets were installed in 1992, 1993 and 1994 respectively. The commissioning year of these generator sets are therefore considered as 2002, 2003 and 2004 for the purpose of this study which needs replacements in next 10 years both with mini hydro scheme and all diesel scheme system. The installation cost for the diesel plant is estimated to be SBD 8425/kW.

13. For all diesel generation system other than the replacement of existing generators in 10 years there will be an additional capacity addition of 60kW later in 18$^{th}$ year for project option 1 whereas for project option 2 an addition of 110kW generator is considered in 9$^{th}$ year.

14. Although the existing diesel power station building with switch gear, electrical protection and monitoring equipment, transformers and diesel fuel storage tanks need not be replaced at year 0 of the analysis period, the residual value or the opportunity costs of these items must nevertheless be taken into account. The opportunity cost of this investment is taken as SBD 1,000,000 excluding three generating sets.

15. System losses of 10% energy generation are considered in both scenarios.

### 10.3.2 Economic Analysis Results

Based on the conditions considered above, the economic analysis on the basis of discounted cash flows has been performed to evaluate the NPV, IRR and LRMC for system scenarios of mini hydro with diesel supplement and all diesel system. The results for both the scenarios and project alternatives are mentioned below.

#### *10.3.2.1 Mini Hydro with Diesel Supplement*

The results of the analysis are as follows;

| Project Alternatives | Net Present Value (NPV, @ 8%) | Internal Rate of Return (IRR) | Long Run Marginal Cost (LRMC) |
|---|---|---|---|
| | (SBD) | (%) | (SBD/kWh) |
| Option 1 – DN355 pipeline | 7,869,629 | 17.5% | 1.73 |
| Option 2 – DN450 pipeline | 6,010,615 | 14.7% | 2.00 |

These results shows that the mini hydro scheme operating in the Kirakira system supplemented with diesel generation is economically viable based on the high positive NPV and IRR well above the cut-off rate of assumed 10%. The LRMC for the project is also comes out to be considerably well below the current tariff. But to assess whether the hydro scheme in the system is least cost option, the incremental benefit analysis is required with the all diesel generation option.

#### *10.3.2.2 All Diesel Generation*

The results of the analysis are as follows;

| Project Alternatives | Net Present Value (NPV, @ 8%) | Internal Rate of Return (IRR) | Long Run Marginal Cost (LRMC) |
|---|---|---|---|
| | (SBD) | (%) | (SBD/kWh) |
| Option 1 – DN355 pipeline | -1,517,219 | Not defined | 3.07 |
| Option 2 – DN450 pipeline | -1,829,353 | Not defined | 3.11 |

The results show that the all diesel generation is economically not feasible with negative NPV and IRR not being defined because at the present tariff level, the costs (mainly recurrent costs) cannot be recovered regardless of the discount rate chosen.

### 10.3.3 Incremental Cost-Benefit Analysis

The NPV and the economic IRR of the additional investment cost and the savings in recurrent cost when switching from an all diesel system to proposed Huro mini hydro scheme supplementing the diesel generators at Kirakira are as follows:

| Incremental Cost – Benefit Analysis | | |
|---|---|---|
| **Project Alternatives** | **Net Present Value (NPV, @ 8%)** | **Internal Rate of Return (IRR)** |
| | **(SBD)** | **(%)** |
| Option 1 – DN355 pipeline | 10,137,796 | 19.9% |
| Option 2 – DN450 pipeline | 7,839,968 | 17.1% |

The results of the incremental cost benefits analysis shows clearly that the Huro mini hydro scheme supplementing the diesel generation is the least cost option to supply electricity to the Kirakira system.

The analysis conducted in this study is for 20 years period only and therefore does not include benefits beyond 20 years, if considered this will increase the viability of option 2.

### 10.3.4 Sensitivity on Discount rate

The base case scenario for the project in this report considered a discount rate of 8% as mentioned in section 9.3.1 (Economic analysis assumptions) but the discount rate up to 10% has been considered by some financial institutions like EIB in Solomon Islands hydropower development projects. Therefore sensitivity on the discount rate is warranted for the incremental cost benefit analysis as mentioned below:

| | **Base Case Scenario** | **Sensitivity** |
|---|---|---|
| Discount Rate | 8% | 9% & 10% |

The sensitivity analysis results for the incremental cost benefit analysis for both the project alternatives are mentioned below.

| **Sensitivity Analysis** | | | | | |
|---|---|---|---|---|---|
| | | **Option 1 – DN355 pipeline** | | **Option 2 – DN450 pipeline** | |
| **Parameters** | | **NPV** | **IRR** | **NPV** | **IRR** |
| | | (SBD) | (%) | (SBD) | (%) |
| Base Case | 8% | 10,137,796 | 19.9% | 7,839,968 | 17.1% |
| | 9% | 8,652,895 | 19.9% | 6,432,081 | 17.1% |
| | 10% | 7,342,009 | 19.9% | 5,211,354 | 17.1% |

The sensitivity analysis results suggest that, raising the discount rate from 8% to 10% results in net present value (NPV) reduction by 15% and 19% for Option1 and Option2 respectively.

Overall profitability of the project (IRR) will not be affected because both the cost and benefits of the project are subject to higher inflation to the same degree.

The discount rate affects the long run marginal cost of energy for the hydropower scheme. Because the hydro-power projects are highly capital intensive, the discount rate has a significant influence on the unit cost of energy. The higher the discount rate, the higher is the unit cost of energy.

The long run marginal cost for the variation of discount rate to 9% and 10% are shown in table below for both the alternatives in Mini hydro with diesel supplement scenario.

| Parameters | | Long Run Marginal Cost (SBD/kWh) | |
|---|---|---|---|
| | | **Option 1 – DN355 pipeline** | **Option 2 – DN450 pipeline** |
| Discount Rate | | (SBD/kWh) | (SBD/kWh) |
| Base Case | 8% | 1.73 | 2.00 |
| | 9% | 1.82 | 2.10 |
| | 10% | 1.92 | 2.21 |

Raising the discount rate from 8% to 10% results in an increase of long run marginal cost by about 5.0% for both the options. Thus the LRMC for Option 1 increases from 1.73 SBD/kWh to 1.92 SBD/kWh and for Option 2 from 2.00 SBD/kWh to 2.21 SBD/kWh.

### 10.3.5 Conclusion

Considering the economic analysis and sensitivity results of the Mini hydro system supplemented with diesel generation as per section 10.3.2.1 and 9.3.4, the NPV and IRR is marginally higher for option 1 compared to option 2, similarly the LRMC has marginal difference in two project options. Since the IRR calculated for both these options is above the considered discount rate of 10% for the development projects in the region, it is recommended to develop the Huro Mini hydro project "Option 2" having civil infrastructure ready for future expansion with power house only. This is to ensure that the scheme would not become too small in just few years time.

# 11. Policy Context

## 11.1 Scope

This section of the report outlines the policy context and drivers for the proposed hydro scheme.

## 11.2 National Policy

### 11.2.1 Solomon Islands National Medium Term Development Strategy

The Solomon Island Medium Term Development Strategy 2008 – 2010 (MDTS) is core to delivering the long term national strategic plan. The MDTS has been set in the context of Government's "Policy Statements" of January 2008. The Policy Statements set out the Governments six Priority Areas and the priority activities in each of those areas. The MDTS also addresses the commitment of the Solomon Islands to the Millennium Development Goals (MDGs), although the direct linkage of the six Priority Areas to the MDGs is not reported. The Priority Areas are:

1. Reconciliation and Rehabilitation;
2. National Security and Foreign Relations;
3. Infrastructure Development;
4. Social Services Sector;
5. Economic/Productive Sector; and
6. Civic Affairs.

The Energy Sector Programme is seen as a key area for development under the Economic/Productive sector priority area. The Energy Sector Programme promotes the availability of affordable energy in rural areas and the harnessing of the indigenous renewable energy sources as an alternative to imported fossil fuels. The Government has three on-going energy programmes two of which are focused on rural electrification through renewable energy. The principal targets are schools, clinics and hospitals to improve service delivery in provincial centres.

Key outcomes of the Energy Sector Programme are stated in the MTDS as:

- State Owned Enterprise (SOE) performance is improved each year so that each SOE reduces losses and increases returns to assets and equity
- Access to electricity supplies substantially increased from 13% of households
- SIEA and SI Water Authority are operating commercially by 2010

- Rural households for whom electricity is the primary source of lighting is substantially increased from 6.5% (2005/06).

The MTDS reports that the Rural Electrification Master Plan and Legal Framework for Rural Electrification will be completed in 2009 and a Rural Electrification Fund will be established in 2010.

The design and construction of the Rualae Hydro scheme in Malaita and the Huro Hydro scheme in Makira Ulawa are planned projects under the Energy Sector Programme. The two schemes are planned for completion by 2011 under the Energy Sector Programme.

### 11.2.2 National Energy Policy Framework

The current National Energy Policy Framework[2] outlines the Government's policies and strategies for the energy sector for the next 10 years. The Huro and Rualae Mini-Hydro Schemes clearly support four of the Governments twelve strategic areas for development and have strong overlaps with other strategies. The core policy areas supported by the schemes are:

- Electricity Sector, Urban - Policy 4.1: Ensure a reliable and affordable power supply system in all urban centers.
- Electricity Sector, Rural - Policy 5.1: Provision of reliable, affordable and efficient electricity services to rural areas.
- Renewable Energy - Policy 6.1: Promotion of renewable energy resources. Hydro power is noted as key in the development of this sector.
- Environment - Policy 7.1: Preservation of a clean and well-maintained environment.

In the delivery of these schemes there is also potential to support additional policy areas:

- Capacity building and information - Policy 9.1: A well informed population on energy issues.
- Gender – Policy 12.1: Promote a gender balanced energy programme.

## 11.3 Provincial Policy

The Makira Ulawa Provincial Government's vision for service delivery is that "All people in Makira-Ulawa Province have access to quality public service". Makira Ulawa Provincial Government has identified seven goals to actively work towards over the next three years[3]. The Makira Ulawa Provincial Government goals are:

1. To improve the quality of, and access to clean water and sanitation.

[2] Produced by the Energy Division of the Ministry of Mines and Energy and Rural Electrification.
[3] Extracted from the Makira Ulawa Provincial Development Council strategy document, Feb 2010.

2. To improve the standard of health services.
3. To increase the level of education standards
4. To increase the level of economic activities.
5. Law and order at the community level.
6. To improve communication and transport infrastructure
7. Quality and good governance.

Improvement in the reliability of electricity supply to Kirakira station is noted as fundamental in increasing the level of economic activity in Makira Ulawa province. Improving the reliability of the electricity supply is also acknowledged to have positive impacts on the standard of health services and the planned improvements to communications.

## 11.4 International

### 11.4.1 Millennium Development Goals

As a UN member, the Solomon Islands is a part of the MDG program which aims to improve the socio-economic conditions of the lesser developed countries of the world. The eight MDGs range from halving extreme poverty to halting the spread of HIV/AIDS and providing universal primary education, all by the target date of 2015. The Solomon Islands is classified as a Least Developing Country under the United Nations Classifications of Countries. This is a group of countries which represent the poorest and weakest segments of the international community. It is currently considered unlikely that the Solomon Islands will achieve its MDGs by 2015.

This hydro scheme may contribute to multiple MDGs, including:

- Goal 1: Eradicate extreme poverty and hunger
- Goal 7: Ensure environmental sustainability

However, a scheme of this size is unlikely to have a significant impact on the MDG indicators.

### 11.4.2 Clean Development Mechanism

The Clean Development Mechanism (CDM), defined in Article 12 of the Kyoto Protocol, allows a country with an emission-reduction or emission-limitation commitment under the Protocol to implement an emission-reduction project in developing countries. Such projects can earn saleable certified emission reduction (CER) credits, each equivalent to one tonne of $CO_2$, which can be counted towards meeting Kyoto targets. The mechanism stimulates sustainable development and emission reductions, while giving industrialized countries some flexibility in how they meet their emission reduction or limitation targets[4]. The CDM currently has over 1400 registered projects in 53 countries. An estimated 33 per cent of all projects transfer both technology and knowledge to developing countries[5].

To be considered an eligible CDM project applicants must:

- Provide emission reductions that are 'additional' to what would otherwise have occurred[6]; At present, the CDM Executive Board deems a project additional if its proponents can document that realistic alternative scenarios to the proposed project would be more economically attractive or that the project faces barriers that CDM helps it overcome;
- Qualify through a rigorous and public registration and issuance process. Approval is given by the Designated National Authorities[7]; and
- Public funding for CDM project activities must not result in the diversion of official development assistance.

Assuming the above requirements are met, there remains a risk that the scale of the project in isolation is too small to be attractive to investors. There may however, be an opportunity to 'bundle' multiple CDM projects together to make the opportunity more attractive. Typically only project over 10MW are considered a reasonable investment. If the Solomon Islands Government can identify additional renewable energy projects with the potential to meet the CDM eligibility criteria, the opportunity to bundle these projects should be evaluated.

It should be noted that post 2012 and the end of the first reduction target commitment period, the future of CDM is unclear. Following the UN Climate Change Conference 2009 in Copenhagen it is currently expected that the Kyoto Protocol will continue into a second commitment period after 2012. However, many of the details of the second commitment period were not confirmed, including what the length of this commitment period will be, the country targets and the base year against which they will be determined or how excess credits resulting from previous decisions would be dealt with.

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[4] United Nations Framework Convention on Climate Change UNFCCC.
http://unfccc.int/kyoto_protocol/mechanisms/clean_development_mechanism/items/2718.php

[5] Carbon Market Insights 2009 Copenhagen, 17 March 2009. Address by Yvo de Boer, Executive Secretary United Nations Framework Convention on Climate Change

[6] Assessed for compliance with EB 39 annex 10: "Tool for the demonstration and assessment of additionality".
http://cdm.unfccc.int/methodologies/PAmethodologies/tools/am-tool-01-v5.2.pdf

[7] At the time of reporting the Solomon Islands does not have a registered Designated National Authority. It is anticipated that this Authority will be in place by late 2010.

These, along with outstanding questions regarding the operation and streamlining of CDM, will shape the future viability and applicability of this scheme.

### 11.4.3 International Environmental Agreements

The Solomon Islands is either a party to or adheres to a number of multi-lateral environmental agreements both as a member of the Pacific Islands Forum and independently these include the United Nations Framework Convention on Climate Change; the Convention on Biological Diversity; The World Heritage Convention; Convention on International Trade in Endangered Species (CITES); Stockholm Convention on Persistent Organic Pollutants; and the United Nations Convention to Combat Desertification. The final scheme design and project implementation should be in accordance with its commitments under these agreements.

# 12. Planning and Legislative Requirements

## 12.1 Scope

A summary of the key legislative requirements for the project is reported in this section. The key national legislative requirements for this project are currently considered to be:

- Land acquisition in accordance with the Land and Titles Act (*1996*)
- Abstraction (offtake) and discharge permitting under the Rivers Act (*1973*)

## 12.2 Land and Titles Act (1996)

The Land and Titles Act relates to the management of land including 'customary lands' and sets out a procedure for the acquisition and lease arrangements concerning such lands. Customary lands are typically defined as land and water interests, including all resources, which are owned by tribes and that are not written in any law but are governed customary rules and behaviours.

Lands required for the project (including the water source) is subject to customary land ownership and as such will be acquired through the powers of the Solomon Islands Land and Titles Act (1996).

The legislation requires the identification of customary land tribe who claim ownership to the land, water sources or waterways. Under the Land and Titles Act, resources are then recorded; mapped and defined land boundaries are agreed. Lands are then legally registered to the tribes identified. The process requires consultation with the affected communities and the establishment of a board of land trustees to represent the wider landholding group and act as signatories in the land declaration or agreement to lease the land and the resources affected. Public notice must be made to provide an opportunity for objections or disputes to be raised. Following this a public hearing is held and a determination made. The determination is subject to public notice and a three month appeal period. Lands are then surveyed and marked by Government Land Surveyors prior to mapping and legal registration of the lands.

## 12.3 Environment Act (1998)

The Project is categorized as a prescribed development under the Second Schedule of the Solomon Islands Environment Act 1998 and as such will be subject to compliance with the Act and the supporting Environment Regulations 2008.

The objectives of the Act are to:

- Provide for and establish integrated systems of development control environmental impact assessment an pollution control;
- Prevent, control and monitor pollution;
- Reduce risks to human health and prevent degradation of the environment; and
- Comply with and give effect to regional and international conventions and obligations relating to the environment.

The Second Schedule of the Act lists prescribed development for which consent accompanied by an Environmental Impact Assessment (EIA) may be required. The mini-hydro is categorised as a *Public Works Sector Development, Type 9.e (hydropower schemes)* under the Second Schedule of the Act.

The Regulations have been developed to assist in the preparation of EIAs. Compliance with the Regulations is a legislative requirement under section 55 of the Environment Act. The Regulations replace the Solomon Islands EIA Guidelines for Planners and Developers (May 1996). The EIA Guidelines were developed prior to the issue of the Environment Act and were not legally binding.

For prescribed projects a scoping assessment must be prepared to highlight the potential impacts and to identify the need for further EIA. The scoping assessment must be submitted to the Director of the Environment and Conservation Division for consideration. The Director may request a Public Environment Reports (PER) or Environment Impact Statements (EIS) in addition to the scoping report. Most prescribed projects requires a PER as a minimum.

### 12.3.1 Provincial legislation

Under the Provincial Government Act 1997 there is provision for provinces to create their own legislation in respect to environment and conservation. With respect to Makira Ulawa province it is noted that the Makira Province Preservation of Culture and Wildlife (1984) should be considered in the development of the Huro scheme.

## 12.4 Rivers Act (1973)

The Rivers Act (1973) controls river waters for equitable and beneficial use and establishes activities for which permits are required including abstractions and discharges.

# 13. Description of development area environment

## 13.1 Geology

### 13.1.1 General overview

The Solomon Islands and adjacent sea floor areas are tectonically complex, as shown in Figure 13-1. The region comprises the central portion of the Melanesian Borderlands, a system of island arcs of various ages. The Solomon arc consists of several island groups forming a double echelon chain. A major trench system occurs to the south of the Solomon Islands. At least two possible spreading centres occur in the region. A discontinuous trench system lies in the coral sea on the southern side, and another poorly defined trench in the pacific on the north east side. Most of the area is seismically active. The geology can be briefly described in terms of three structural/stratigraphic elements. The geological provinces are divided by distinctive assemblage of rocks. The three elements are oceanic basement, calc-alkaline volcanics and older/younger sedimentary cover. Each island consists of two or three main elements in each composition.

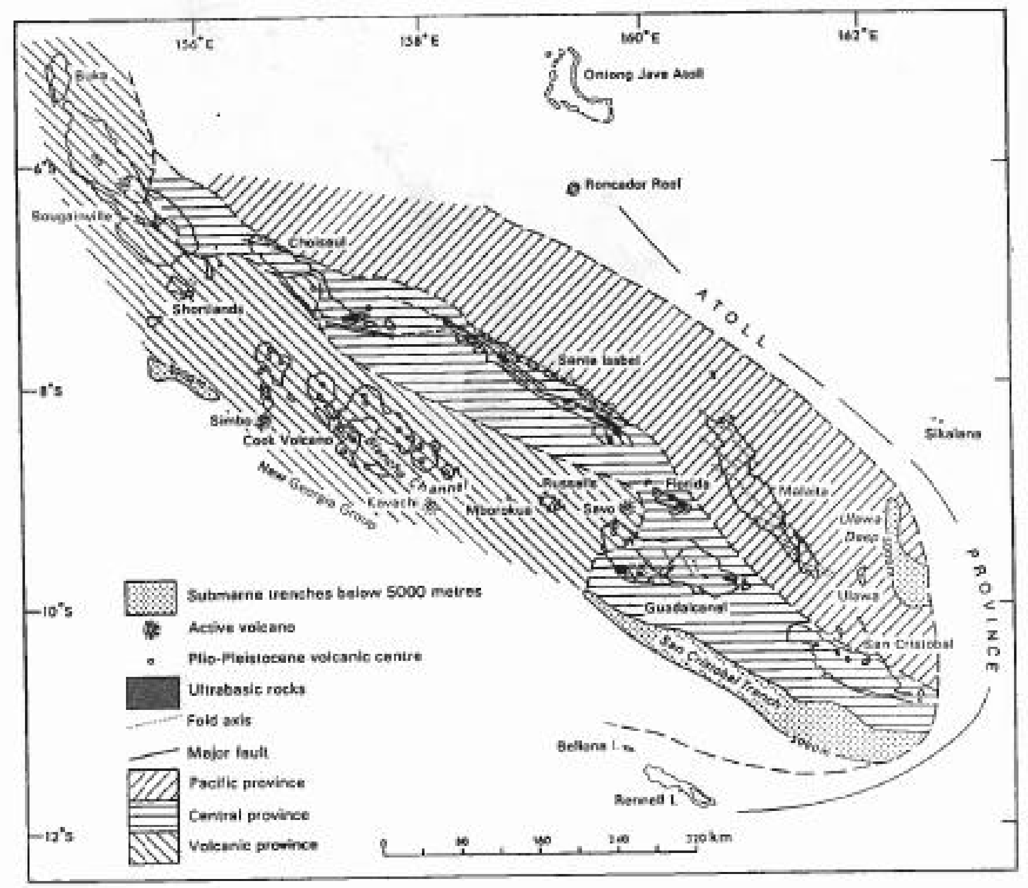



**Figure 13-1 The geological provinces of the Solomon Islands**

a) Structural/stratigraphic elements

Oceanic basement – The basement is formed of basalt lava, cognate dolerite/gabbro intrusions and ultramafic bodies. They are alkali basalt family that is generally considered as upraised ocean floor. In Guadalcanal, Florida, San Cristobal, Santa Isabel and Choiseul the basalt is fractured and metamorphosed. In contrast, Malaita has practically no deformation or metamorphism.

Calc-alkaline volcanics – The volcanics consist of andesite lava, volcaniclastic rocks and diorite. The main development was in the plio-pleistocene in New Georgia. There are several small volcanic islands such as Savo, and other islands have limited volcanic areas such as Gold ridge.

Sedimentary cover – The sedimentary cover comprises very thick varied sediments that lie uncomfortable in the basement. The earliest sediments are thicker cretaceous sandy successions, although there are extensive developments of Miocene and Pleistocene reef limestone. From the Pliocene onwards volcaniclastic sediments become an increasing component.

b) Geological provinces

- Central province has fractured, metamorphosed basement and complex geology.
- Pacific province has more stable un-metamorphosed, but folded basement and pelagic sedimentation.
- Volcanic province is the latest addition to the arc being a series of volcanic cones and still continuing fumarolic activity.
- Atoll province consists of upraised coral atolls.

### 13.1.2 Regional Geology

Most of the area in Makira Ulawa Province is composed of altered and pillowed basaltic lava basement. In the Western Hills and the Northern Foothills there is older volcanicalastic sedimentary cover. Northern coasts have raised reef limestone. The basement and cover have abundant E-W and NE-SW faults and lesser N-S fractures. The geology of the Kirakira area is described in the 1:1,000,000 geological map of the Solomon Islands (1969).

### 13.1.3 Site Geology

The station and its adjacent area is located in the Reef Limestone of the Pleistocene geologic age. Geology of the area shown shows limestone, siltstone and mudstone and basaltic layers further inland. The map does not indicate any major fault lines in the Kirakira area. Visual observations also shows that the rugged terrain around Kirakira is fairly stable despite the clearings for food gardens even on steep hill sides. Only a few recent and relict landslides have been identified. Except for the steep cross slope (70%) along the headrace route, the hydro site chosen is favourable from the geotechnical point of view, none of the major components of the schemes are directly in danger of being damaged by landslides or other geotechnical hazards.

The limestone is expected to have karstic properties and sinkholes must be present in the Huro River although none has physically been identified so far.

As per the earlier study done in 1996, a number of trial pits were dug along the proposed penstock and headrace routes. The majority of pits show individual limestone blocks and boulders of 200mm diameter and more in a clayey silt matrix to a depth of 2 m. At some sections, the scheme crosses limestone boulders of more than 2 m diameter. Basaltic layers of dark grey to greenish grey colour are present at the intake site, individual basaltic boulders and stones of less 400mm diameter have been observed in the river bed.

The river bed at the weir site is characterised by huge boulders set in limestone rock while river bank and adjacent areas are composed of alluvial gravel and boulders set in a clayey silt matrix.

Seismicity around Kirakira is among the highest in the Solomon Islands. As per the earlier study report, the data obtained from the United States Geological Survey in Denver, Colorado, earthquake of magnitudes between 4.0 and 6.0 within a radius of 50 km from Kirakira occurs practically every year. However, a seismic risk assessment for the proposed hydro site using Gaull’s intensity attenuation and peak acceleration/intensity relationships shows that the construction of mini hydro schemes does not require special earthquake design measures since the horizontal accelerations are less than 0.1g at the proposed hydro site for a 100 year return period. This assessment is confirmed by the fact that no earthquake damage has been reported at Kirakira station over the last 20 years.

## 13.2 Climate

This region, similar to much of the Solomon Island is described as continuously wet with 40 weeks or more per year of rainfall in excess of 50mm per week although rainfall is variable according to topography, latitude and orientation.

Average rainfall in Makira is 3,600mm to 4,000mm per year. Seasonal variations depend on the geographic location. Rainfall in the southeast of Makira is typically heaviest from May to October, when the Solomon Islands are subject to the south-east trade winds, and from November to April in the west of the province. The central area, including the Kirakira region and the project study area, has high rainfall throughout the year. The north-west winds between November and April are associated with heavy rains and cyclones. On average one to two cyclones travel through the Solomon Islands every year and Makira, is one of the most frequently and heavily affected provinces.

Temperatures in the Solomon Islands are relatively consistent ranging from 22°C to 31°C throughout the year. There is limited seasonal trend in relative humidity, which can frequently reach 90 per cent, although there is a marked diurnal variation.

## 13.3 Air quality and noise

With very few vehicles and minimal industrial activity the air quality in the Solomon Islands is largely very good, particularly outside of Honiara. This is true of the study area including the Weiteitei village. The same can be said with respect to noise, which is typically only a consideration in urban centres such as Honiara.

The SIEA diesel generator currently supplying Kirakira station is located near to the main markets and alongside the main thoroughfare through the township. The diesel generator is noisy and disruptive and, although there are no air quality or emissions standards under Solomon Islands law, it is considered that fumes emitted have a negative impact on the current environment. No monitoring data relating to air quality or noise are available to report at this time.

## 13.4 Land ownership and current land use

*Huro Mini-hydro Scheme*

It is believed that the land acquisition arrangements for the Huro Mini-Hydro Scheme were initiated in 1996 and that a draft Land Acquisition Report exists (unsighted). However, the Land Acquisition proceedings have not been finalised. To date, two landholding groups have been identified. Both landholding groups were present at the second HTC site visit at which the social impact of the project was discussed with the representatives from the Provincial Government and the Huro Town Development Planning Committee (8th February 2010).

The source, intake site and a section of the pipeline route are within lands owned by a primary landowner, Mr Edmund Kawakai. Mr Kawakai and his family live (approximately 20 people) approximately 500m from the source of the scheme on the left bank of the stream. This community use water from the stream (mini-hydro source) for domestic use including drinking water, washing, cleaning and watering of small market gardens.

The site access route, tailrace and powerhouse are located in an area owned by a secondary landholding group living in Weiteitei village, on the right bank of the Huro River downstream of the proposed discharge point. The village is home to approximately 100 people, for whom the Huro River is a focal point.

Water is reported to be piped direct from an upstream tributary (independent from the mini-hydro scheme) to a series of tapstands in the village. Treatment of water prior to drinking is not commonly practiced. Washing and cleaning occur directly in the Huro River as it makes its way through the village. The Huro River is supplemented by additional tributaries at this point in its course. Access to small areas of cultivated lands maintained by residents of the Weiteitei village and access to neighbouring properties (owned by My Kawakai) is made across the Huro River from the Weiteitei village at a point near the end of village. The crossing point is upstream of most washing activity.

At the second HTC site visit on the 8th February 2010 to discuss the social impacts of the project both landholding groups present were positive about the project and expressed a willingness to progress with the land acquisition process.

*Transmission Line*

The route proposed for the transmission line follows the road that connects the Kirakira airport with Kirakira station. The roadway is subject to an existing easement that spans 15m either side of the midline of the road. Locating the transmission route within this existing easement removes the need for further land acquisition.

## 13.5 Waterways

The hydrology of the Huro River catchment is discussed in Section 7 of this report.

The surrounding volcanic and limestone geology results in the Huro River and its tributaries being characterized by clear water with low turbidity and high mineral content and minimal in channel vegetation throughout the rivers reach. The geology of the area and anecdotal evidence suggest the River may have karstic properties including sinkholes resulting in a loss of water over its course between the source of the Huro and its discharge to the sea approximately 500m downstream.

Water is abstracted from the Huro River and its tributaries for domestic supply, including potable use with no treatment.

## 13.6 Biological environment

### 13.6.1 Protected areas

The is currently no provision under Solomon Islands national law for the establishment or protection or areas based on ecological, biodiversity or heritage values for the purposes of conservation. Currently protected areas are in the form of national parks or registered under provincial ordinances. Across the Solomon Islands there are seven protected areas totalling some 2,000 ha[8]. There are no provincially protected areas (terrestrial or marine) within the study area. The current extent of protected area may represent a very small proportion of the lands that may be eligible for such controls.

### 13.6.2 Rare and endangered species

The International Union for Conservation of Nature & Natural Resources (IUCN) Red List identifies 65 species of fauna in the Solomon Islands which are endangered or threatened, including 35 of 44 bat species and all eight rat species[9]. The Red list also identifies 11 bird species as endemic to the Solomon Islands, nine of which are reported to be found in Makira-Ulawa province.

The 2006 Red List reports that two species of giant rat and one frog species as extinct in addition to two bird species; the Thick-billed ground dove (*Galliolumba salamonis*) and the Solomon Islands Crowned pigeon (*Microgoura meeki*)

There have been no known assessments of rare or endangered plant species with in the study area.

### 13.6.3 Terrestrial habitat

Terrestrial habitat in the Solomon Islands is dominated by tropical moist forests, estimated to represent 85 per cent of country's vegetation communities and comprised primarily low altitude forest, with a significant amount (approximately 10 per cent) of crop land and bush.

The study area is located within low altitude forest with some cleared lands used as residential areas and agricultural plots on a small scale. Many plants found growing locally are known to be used by the local community for medicinal purposes. No vegetation surveys have been undertaken within the study area to date. The presence and extent of weeds within the study area is not currently known.

[8] EarthTrends2003: Biodiversity and Protected Areas Country Profiles – Solomon Islands.
[9] IUCN Solomon Island Country Profile: http://cmsdata.iucn.org/downloads/appendix_12_country_profiles.pdf

### 13.6.4 Fauna

Fauna in the Solomon Islands is reported to be extremely diverse, with islands experiencing a high degree of endemism. The IUCN country profile for the Solomon Islands reports that there are 89 assessed species endemic to the Solomon Islands – nearly 10% of all assessed species[10].

Makira is reported to have 17 species of mammal, of which three are believed to be endemic to the island.

It is reported that the lower reaches of the Huro River support fish and shrimps, however no fish species have been observed or reported within the River between the offtake and the proposed discharge point.

No fauna surveys have been undertaken within the study area to date. No fauna has been observed within the study area during HTC site visits.

## 13.7 Cultural heritage

Landholders and representatives of the provincial government were requested to identify the existence of any special, sacred or restricted sites, or “Tambu” sites within the study area. No such sites were identified by those persons present at the site meeting, either within the construction area or within the vicinity of the access routes.

[10] IUCN Solomon Island Country Profile: http://cmsdata.iucn.org/downloads/appendix_12_country_profiles.pdf

# 14. Environmental impacts

## 14.1 Scope

The potential impacts of the construction and operation of the hydro project on the environment are considered in this section rather than the impacts of the electrification because the electricity supply is already established in Kirakira. There is anticipated to be a requirement under the Environment Act (1994) to prepare a PER for the implementation of the Huro Mini-Hydro scheme. As such this section of the Feasibility report provides a review of the potential environmental impacts resulting from the construction and operation of the Huro Mini-Hydro scheme. In accordance with the Environment Regulations (2008) an assessment of the extent and significance of the impacts and development of the construction environmental management plan including the proposed safeguards and mitigation measures is anticipated in the form of the PER. Data currently unavailable and considered necessary for the development of a PER is flagged here.

## 14.2 Construction impacts

Construction phase impacts at a minimum to be considered in development of the construction environmental management plan are summarised in Table 14-1.

Table 14-1 Summary of high-level construction impacts.

| **Construction activities affecting env. resources and values** | **Risk to the environment** | **Mitigation measures** | **Further information / data required** |
|---|---|---|---|
| Increased activity in the area resulting from presence of construction workers.<br>Increased traffic (human and vehicular) on existing access tracks. The bulk of the construction materials will be transported to site by hand. This will mean a high increase in the use of what are currently small access paths. | SOCIAL DISRUPTION / CULTURAL HERITAGE<br>Risk of disruption to and confrontation with local residents.<br>Reduced access for local residents.<br>Noise disturbance to local residents.<br>Potential risk of accidents to site workers and local residents resulting from increased traffic.<br>Risk of encroachment on lands not defined within the construction footprint causing damage to property. | Develop agreed site behaviours and operating conditions in consultation with local village. Design site access and operation to minimize impact on local residents.<br>Traffic management should be addressed as part of the construction environmental management plan.<br>Clear communication of construction footprint and acceptable standards of behaviour to all contractors.<br>Preferential recruitment of members of the landholding groups and surrounding | |

| | | | |
|---|---|---|---|
| | | villages.<br>No Tambu sites have currently been identified but this should be reconfirmed prior to construction. | |
| | EROSION<br>Erosion of tracks and banks. | Improvement of access tracks as required prior to construction and reinstatement as required post construction. | |
| | WEEDS AND DISEASE<br>Introduction of weeds and disease through use of plant and equipment imported. | All plant and equipment to be brought to site and clean of sediments, seeds and vegetation. | Vegetation survey of areas to be disturbed including weed species. |
| Works in and adjacent to watercourses may cause bank erosion and an increase in sediment entering the Huro River and subsequent increase in turbidity.<br>This may be particularly significant at the uncontrolled Huro River crossing point in the Weiteitei village. | WATER QUALITY<br>Potential negative impacts on channel ecology in the vicinity of the construction works and downstream.<br>The Huro River is used by the Weiteitei village community for general domestic use. Any increase in turbidity may limit use by the local community. | Protection of potable water supplies.<br>Improvement/protection of the access routes to be used to transport construction materials.<br>Improvement/protection around the Huro River crossing point to minimize risk of bank erosion. | |
| Accidental spills of hazardous substances introduced as part of the construction phase. | SOILS / WATER QUALITY<br>Pollutants, including hydrocarbons and materials used in concrete works, are to be stored appropriately and used responsibly. | All site workers involved in the handling of potential pollutants should be aware of the risks and appropriate methods for responsible use.<br>An incident/emergency response plan should be developed relative to the hazardous materials to be used on site. The plan should consider risks to water supply. | |
| Waste generated at construction sites. | WASTE MANAGEMENT<br>Contamination of local environment, cultivated lands | Protocols to be developed with local residents. Waste is to be | |

| | | | |
|---|---|---|---|
| | and water supplies through irresponsible waste disposal.<br>Negative impact on local wildlife. | removed from site and disposed of responsibly. All site workers to be aware of responsible waste management. Separation of construction site from residential properties and private property. | |
| Clearance of land, removal of trees, relocation of properties to enable access on approaches and work site. | SOCIAL DISRUPTION / VEGETATION<br>Any requirement for vegetation clearance/relocation will be identified at detailed design.<br>Damage to habitat and negative impacts on wildlife. | Design of scheme and access areas to minimize land clearance, vegetation removal and need for relocation of property.<br>Compensation payments may be made where such impacts are unavoidable.<br>Compensation payments would be agreed by the Provincial Government. | |

## 14.3 Operation impacts

Operation phase impacts to be considered in development of this project are summarised in Table 14-2. These are the minimal requirement, at Detailed Design wider impacts are expected to be identified.

Table 14-2 Summary of high-level operation impacts.

| Operation activities affecting env. resources and values | Risk to the environment | Mitigation measures | Further information / data required |
|---|---|---|---|
| Abstraction of water | SOCIAL DISRUPTION / WATER QUALITY / AQUATIC ENVIRONMENT<br>The abstraction of water for the purposes of hydropower generation must be within tolerances. Water must be available to maintain domestic supply. The environmental flow requirement is unknown.<br><br>Negative impact on fish. | Design of offtake structure to allow for a minimum flow to pass through. This is to take in to consideration the requirement of those residents (estimated at 20) who source their domestic supply from the Huro River in this reach. Consideration must also be given to the rate of infiltration of surface water to groundwater over the affected reach.<br><br>No fish have been observed in the Huro River. The water depth is considered to low to | Hydrological study into seasonal flow trends and rate of loss.<br>An assessment of the potential impact of low flows and the need for an environment al flow is required. |

| | | | |
|---|---|---|---|
| | | make for fish habitat in this reach. | |
| Discharge of water | EROSION<br>Erosion of the river bed by resulting from the discharge of water from the hydro scheme. | Design of the discharge structure to impede the flow of discharge water and minimize risk of erosion. | |
| Aesthetic impact of the scheme | SOCIAL DISRUPTION<br>Unsightly powerhouse / transmission lines. | Minimise impact through design where possible. Consult with local community as to the final outcome prior to construction. | |
| Noise arising from operation of generator | SOCIAL DISRUPTION<br>Noise levels disrupt quality of life of local residents. | Minimise impact through design where possible. Consult with local community as to the final outcome prior to construction. | |

# 15. Greenhouse gas emissions

## 15.1 Greenhouse gas emissions saving associated with Option 2

The mini-hydro scheme will deliver greenhouse gas emissions (GHGs) savings by substituting electricity generated by burning GHG intensive diesel with zero emissions hydropower. The potential GHG saving from the implementation of the project is quantified as the mass of carbon dioxide equivalents ($CO_{2\text{-}e}$) in Table 15-1. The potential GHG saving under Option 2 varies dependent on flow in the Huro River and as such the scheme is unable to completely remove the need for a supplementary diesel generation and subsequent emissions during low river flow periods. Nevertheless, over a 20 year life, the project could result in the saving of over 13,500 tonnes **$CO_{2\text{-}e}$** that would otherwise be emitted[11].

Table 15-1
Greenhouse gas emissions saving associated with Option 2.

| Year | Carbon emissions* assuming 100% diesel generators (Baseline Scenario) | Carbon emissions* 'avoided' assuming Option 2 scheme | Carbon emissions* resulting from supplementary diesel assuming Option 2 scheme |
|---|---|---|---|
| | tonnes$CO_{2\text{-}e}$/annum | tonnes$CO_{2\text{-}e}$/annum | tonnes$CO_{2\text{-}e}$/annum |
| 2010 | 526 | 0 | 526 |
| 2011 | 549 | 507 | 42 |
| 2012 | 574 | 524 | 50 |
| 2013 | 600 | 542 | 57 |
| 2014 | 627 | 561 | 65 |
| 2015 | 655 | 579 | 76 |
| 2016 | 684 | 596 | 88 |
| 2017 | 715 | 615 | 100 |
| 2018 | 747 | 634 | 113 |
| 2019 | 781 | 653 | 128 |
| 2020 | 816 | 670 | 147 |
| 2021 | 853 | 687 | 166 |
| 2022 | 891 | 705 | 186 |
| 2023 | 931 | 724 | 208 |
| 2024 | 973 | 743 | 230 |
| 2025 | 1017 | 764 | 253 |
| 2026 | 1063 | 785 | 278 |
| 2027 | 1111 | 806 | 305 |
| 2028 | 1161 | 827 | 334 |
| 2029 | 1213 | 850 | 363 |
| 2030 | 1268 | 873 | 395 |
| **Total** | **17,756** | **13,645** | **4,111** |

* Assuming a 170kW diesel generator at load factor of 95% the emissions factor is 0.8 in kg CO2-e/kWh. A conversion factor of 3.2kg $CO_2$ per kg diesel has been used following revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories.

[11] The embedded emissions in the construction of the scheme have not been considered to date.

# 16. Social Impact Assessment

## 16.1 Description of Existing Social Conditions

At the time of the last census the population of the Kirakira township was 996. Using the estimated Annual Growth Rate for the Makira province of 8%[12], this figure could have increased to 1580 persons in 2005/2006.

As discussed in Appendix D (Preliminary Social Impact Assessment Report), it must be recognised that the publicly available data in relation to social demographic conditions in the Solomon Islands is largely outdated. Whilst a new census was conducted in late 2009, this data is as yet unavailable. As such, projected socio-economic and demographic conditions have been used throughout this report. Whilst these projections are reliably based on the outcomes of the 1999 census and some subsequent survey and analysis, but due to lack of data at the township level (ie.kirakira), it makes these projections even more difficult, as the growth rate of the country does not necessarily translate to small communities of less than 1000.

These figures can be revisited when the new census data will be released, until then the projected figures for the Kirakira township are considered in this report for the social impact assessment study.

The township is serviced by a number of key facilities including:

- Provincial Government Headquarters. Equipped with solar panels.
- 80 bed Kirakira Hospital (Provincial Base Hospital). Equipped with solar panels.
- Numerous small general goods stores
- Early Childhood to Secondary Schooling (There  two high schools in nearby areas of Makira)
- 4+ churches, including Anglican, United, Catholic and Seventh Day Adventists
- 3 Guesthouses.
- 2 Joinery Workshops
- Timber Milling Business
- Postal and Telecom Services
- Library

[12] Compound figure calculated based on figure for Makira Province Annual Growth Rate cited in the Solomon Islands Household Income and Expenditure Survey 2005/06 (National Statistics Office, 2006) http://www.spc.int/prism/country/sb/stats/Publication/Annual/HIES-Report.htm

- Airstrip in close vicinity

The villages outside of the Kirakira township have been growing rapidly. Discussions with the Commins Iriioa, Deputy-Director of the Makira Ulawa Provincial Government suggest that a number of development projects in and around Kirakira could result in significant growth of the township. These projects include the Makira Phase of the Solomon Islands Road Improvement Project (SIRIP) and a new wharf proposal which was submitted the National Government in September 2009 (the existing jetty is no longer in operation following extensive storm damage some years ago). The lack of adequate transport facilities is considered an inhibitor to trade and increased commercial operations within the Kirakira township and surrounds.

A growth plan has been developed for the province, which includes the development of a significant residential area in the Huro River area (south of the Mini-Hydro site). It is a long term vision of the province to relocate the Kirakira township to protect the population from tsunami risk and rising sea levels associated with climate change.

Approximately 180 mixed use sub-divisions have been identified in the Huro River area. Within this sub-division, six plots have been allocated to the SIEA for the relocation of the existing diesel power station from its current location in the centre of Kirakira township[13.]

### 16.1.1 Current Electricity Supply and Use

The Kirakira township is currently serviced by a diesel generator. The power station which generates this supply is serviced by four permanent employees; with an additional 10 persons casually employed to assist with diesel deliveries.

Gas and kerosene are the most common energy sources used by those residents who not currently have access to the electricity network. Firewood is also used as a common energy source for cooking.

Reliability has been a significant issue for the diesel power supply. The ageing diesel generators are reported by users and SIEA employees to break down frequently. Replacement parts typically have to be supplied from either Honiara or offshore, resulting in long delays before generators are operational again. Additionally, there have been issues in securing adequate diesel supply. Currently diesel is distributed by ship from Honiara, this service may be interrupted in times of bad weather. In addition the transfer of diesel barrels can be a risky and haphazard process as diesel drums must be thrown into the sea from the cargo boat and swum ashore as the wharf is no longer fit for use .

[13] Per comms with Commins Iriioa, Deputy-Director of the Makira Provincial at the at the Kirakira Provincial Government Offices. 9th & 10th February 2010.

Currently both the Hospital and Provincial Government offices are equipped with solar panels to ensure continued access to electricity when outages occur.

The diesel power station is currently located in the centre of the Kirakira township. There are numerous amenity issues, including noise and air quality, associated with its current location. As such, the Makira Province and SIEA have discussed moving the diesel power station to the proposed Huro Subdivision. It is the belief of the Makira Provincial Government that this will occur during the construction of the Huro Mini-Hydro scheme (pending funding and approval). Land has been allocated to SIEA in the Huro subdivision to facilitate this relocation.

Villages outside of the main Kirakira township boundary do not have access to the SIEA electricity network.

### 16.1.2 Site Description

Two villages are located immediately south of the proposed Mini-hydro scheme. The upper village (comprising of the members of the Kawakia family) consists of approximately 20 individuals, and the lower village, Weitetei, has approximately 100 people.

The Huro River supplies domestic water use at these villages, with the larger village accessing water below the planned discharge point of the Huro Mini-Hydro scheme.

The Weitetei village has grown significantly in the past 10 years.  All dwellings appeared to be thatched/traditional, as determined by a visual inspection of the village during site visits in February 2010.

### 16.1.3 Land Ownership

Customary land ownership is passed down through the female tribal heirs. As such decision making processes with regard to access and use of customary land lies with the female tribal members. Despite the matrilineal land rights, women are underrepresented in meetings and discussions at the provincial and national government level with regard to land acquisition process.

Refer to Section 12.4 for further information on the land acquisition process associated with the Huro Mini-Hydro.

## 16.2 Potential socio-economic benefits of the Huro Mini-Hydro

### 16.2.1 Electricity supply and reliability

The proposed Huro Mini-Hydro is large enough to service the current demand of the Kirakira electricity system. With the retention of the existing diesel generator as a supplementary system to the Mini-Hydro, it is anticipated that reliability issues will cease. However, this is dependent on the continued maintenance and operation of the Huro Mini-Hydro for the duration of its expected life span (approx. 25 years).

Increasing the distribution of the existing electrification network is not currently within the Huro Mini-Hydro Scope but improved reliability may encourage new residential and business customers. Additionally, there is the potential for significant cost savings to the SIEA from the reduced reliance of diesel in Kirakira. The SIEA tariff structure is currently set at a standard national rate, therefore the price of electricity will not alter for Kirakira customers. However, SIEA have expressed a willingness to prioritize capital investment back in to regions which provided them cost savings from the use of cheaper electricity sources[14.]

Currently new customers outside of the existing transmission line network must pay for the infrastructure costs to service the newly electrified area. This acts as a serious disincentive for adoption of electricity supply, particular since neighbours who subsequently sign up to the extended electrification costs, are only required to pay the connection fee. SEIA are currently looking at alternative payment methods to combat this issue, including undertaking potential user estimates during installation of new infrastructure, and charging subsequent users a percentage of the infrastructure cost over time. Should such a policy be enforced continued electrification of rural areas may be encouraged. It is understood that the SIEA Act will be reviewed later this year and the issue of equitable distribution of connection costs is expected to be addressed through this review.

### 16.2.2 Provincial growth, investment and business participation

As discussed in Section 10.3, the development of the Huro Mini-Hydro is seen as a key process to facilitate provincial growth.

Electricity supply reliability issues are seen by the provincial government as an inhibitor to investment and business participation at the Kirakira township and surrounds. This is coupled with a poorly maintained and connected transport system, and the absence of major commercial operations in the vicinity of Kirakira.

[14] Per.comms with Martin Sam, Acting GM/Chief Engineer, Solomon Islands Electricity Authority (SEIA) at the SIEA Headquartes, Honiara on 12th February 2010

The SIRIP project and Huro Mini-Hydro, and should it be progressed a new wharf project, may facilitate increased investment in the region. In particular, opportunities for expanded cocoa and copra production have been identified, including on site processing and milling (E.g. Up to 250 tonnes of cocoa was produced on Makira last year but there is no power to available to process the raw product).

### 16.2.3 Employment and Income generation during construction and operation

The construction and operation of the Huro Mini-Hydro may provide some new employment opportunities in the Makira Province. Rough estimates have been provided below, based on HTC's previous experience with mini-hydro projects of this nature. A more detailed assessment of employment requirements will be undertaken at later stages of the mini-hydro development process.

Table 16-1 Preliminary employment estimates during Construction

| Labour Type (by Project Stage) | Est. Number of Employees | Est. Labour Rates (per hour) |
|---|---|---|
| **Unskilled** | 25 | SBD 5 |
| **Skilled** | 15 | SBD 8 |
| **Tradespeople** | 10 | SBD 12 |
| ***TOTAL*** | 50 | - |

As outlined in Table 5-1 at least half of the labour requirements during construction are for unskilled labour, which can most likely be sourced from the Kirakira township and surrounding villages. A proportion of skilled labour and tradespeople may also be required, but it is unclear at this stage as too what proportion of these jobs can be serviced by the existing labour force in Makira

In order to maximise community benefits from the Huro scheme, it is recommended that labour is sourced from within the Makira province where possible. Additionally, where feasible, training of unskilled local labour should be considered to fill roles within the other identified labour types.

Table 16-2 Preliminary employment estimates during operation

<table>
<tr><th>Labour Type (by Project Stage)</th><th>Est. Number of Employees</th><th>Current Supply Employment Requirements</th></tr>
<tr><td>Operation & Plant Management</td><td>3</td><td rowspan="2">4 (Permanent)</td></tr>
<tr><td>Maintenance</td><td>2</td></tr>
<tr><td>Fuel Transportation</td><td>-</td><td>10 (Casual)</td></tr>
<tr><td>TOTAL</td><td>5</td><td>14</td></tr>
</table>

It is roughly estimated that five ongoing positions will be required, to operate, manage and maintain the Huro Mini-Hydro. With four ongoing positions currently servicing the existing diesel power supply, there may be only one further position created during operation.

As the existing diesel system will be a supplementary system, used during low/no flow periods, the 10 casual positions responsible for fuel delivery will diminish. While diesel supplies will still be required, the frequency of deliveries is likely to be significantly reduced (depending on the successful operation of the mini-hydro).

#### *16.2.3.1 Income generation through rental payments /compensation*

Depending on the outcomes of the land acquisition and negotiation process, opportunities for supplementary income generation may occur through rental payments associated with land acquisition and, if required, compensation[15] arrangements from any losses incurred which may be through the Mini-Hydro development process.

It should be noted, that SIEA are keen to adopt a socially equitable, asset/services based model for payments associated with mini-hydro schemes throughout the Solomon Islands. This could include the funding or building of community facilities, or improvements to facilities and services at affected villages, in place or in addition to monetary payments. A monetary payment model has previously been employed on network capital development projects on the Solomon Islands, and there have reportedly been some associated negative impacts. A move toward an asset/services based model is seen as a way to ensure a more equitable distribution of financial benefits associated with the land acquisition process. It may also mitigate the risk of deliberate supply disruption by customary landowners as a way of demanding higher rental or compensation payments (as has been experienced on another mini-hydro project within the Solomon Islands).

### 16.2.4 Increased access to services and facilities for targeted communities, including women, youth, elderly and the ill

The improved reliability of the Kirakira electricity supply, coupled with current growth plans for the province, may provide the potential to increase the quality of services and facilities in and around the Kirakira township. However, it must be noted that the harnessing of these opportunities is not implicit.

Women are currently the primary users of domestic fuel and water. An improved electricity supply system, facilitated by the Huro Mini-Hydro scheme, has the potential to improve the conditions and efficiencies by which domestic duties and household activities are conducted.

[15] At this stage the necessity for compensation has not been determined.

In Kirakira, hospitals and schools currently have their own supplementary power supplies (solar power or separate diesel generators). While these supplementary supplies are likely to remain, an improved network supply may facilitate the expansion and improvement of facilities within these institutions.

## 16.3 Potential issues / disbenefits of the Huro Mini-Hydro Scheme

### 16.3.1 Community division and conflict

The progression of the land acquisition and negotiation process may have negative impacts on community cohesion in the villages surrounding the Huro site. While the customary land ownership arrangements are believed to have been determined. The selection of Trustees, negotiation for rental and distribution of benefits amongst tribal members (particularly secondary or tertiary landowners) may create division and conflict within the Weitetei village in particular.

Furthermore, should existing divisions exist within and between the two identified customary landowner tribes along the site, relationships could further deteriorate if there are differing views on how best to progress negotiations associated with the Mini-Hydro development.

It is recommended that a land acquisition officer with an understanding of some of the issues which may accompany the mini-hydro development process is appointed for the Huro scheme.

Furthermore, when determining land Lease and compensation arrangements, the adoption of asset/service based equitable benefits rather than monetary should be considered (as outlined in section 5.1.3.1). This may assist in maintaining relationships within and between tribes (in particular between the Land Trustees), and also ensure the potential benefits of the scheme are distributed in a manner which can maximize community benefits.

### 16.3.2 Perceived benefits of the Huro Mini Hydro

It was evident from the February 2010 site visit to Makira, that there is great anticipation within the local community for the completion of this project. The implementation of the scheme is heavily supported by the provincial government and is a fundamental element of provincial growth plans and strategies for Kirakira.

It must be noted that locally there is a degree of misconception surrounding the extent of the project as currently scoped. There is a view amongst residents of the Weitetei village that they will be automatically connected to the electrical grid as a result of this project. Additionally, the relocation of the existing diesel power station to the Huro sub-division has also been assumed by the Provincial

Government and local landholders to be a component of the Huro Mini-hydro scheme. Both of these items are not currently within the project scope at this time.

It will be necessary to effectively communicate to the Provincial Government, landowners and other stakeholders the current project scope and its relationship to additional electrification activities. This is a particularly pertinent with regards to the assumed electrification of the Weitetei village.

Should these issues not be effectively communicated and agreed, there is a potential for community backlash against the scheme which could result in vandalism, or further requests for compensation which may have negative impacts on the functioning capacity of the scheme.

### 16.3.3 Disruption during construction and operation

The construction of the Huro Mini-Hydro scheme will cause disruptions to the villages located at the site. As outlined in section 13.1 and 13. 2 of this report, there are a number of construction and operation impacts which can cause social disruption or losses in amenity, including increased activity in the area from presence of construction workers, increased traffic and reduced amenity impacts such as visual and noise.

An Environmental Management Plan should be prepared to minimize social and environmental disruptions during construction and operation.

Community consultation should be undertaken during the detailed design phase to identify further impacts during construction, including the identification of “no go” clearance zones (for example, where a dwelling or prized crop is in the path of design elements, these design elements should be altered to eliminate impacts). It is recommended that acceptable site behaviours are drawn up in consultation with the local residents and that labourers are preferentially recruited from the local area to mitigate the “influx” of construction workers to the village during construction.

Relocation of dwellings should be avoided at all cost, except for where there is an explicit desire by the home owner or where there is no possible alternative location.

### 16.3.4 Water access, use and environmental considerations

As outlined in Section 13.3 the abstraction of water could impact negatively on domestic supply in the Huro River area, and the discharge of water at the offtake could cause erosion which can impact on the quality of the stream. The minimization of proposed impacts through design combined with community consultation will be undertaken to mitigate these impacts.

# 17. Institutional and Management Structure

Institutional building is a key factor for planning, implementation and management of the proposed mini hydro project in Kirakira system. Based on the available data and information an effective institutional framework for promoting rural electrification is described here. The current institutional setting for electricity services in the Kirakira system is considered for planning and managing the plant.

## 17.1 Operation and Management of Kirakira System

Presently, the diesel power station in Kirakira is operated and maintained by SIEA. SIEA was established according to the provisions of the Electricity Act of 1968. SIEA is a statutory authority responsible for electricity generation and distribution meant to contribute to the national development of the Solomon Islands. To strengthen organisational and managerial ability, SIEA has following objectives to achieve:

- Improvement of Collection rate of electricity tariff
- Efficiency of generation and distribution of electricity
- Strengthening of management capability and
- Managing electricity tariff to produce operational profit.

The outstation section at SIEA headquarters in Honiara provides the logistics (shipment of fuel, spare parts) and the administrative support for the operations in Kirakira. Manpower assistance from Honiara is only occasionally required for emergency repairs or breakdown maintenance on electrical equipment. Otherwise the diesel station in Kirakira is manned by officer in charge and operators including linesman permanently posted at Kirakira. This system is working well from decades under SIEA's operation in Kirakira.

Since the proposed Huro mini hydro is implemented by the Government inturn SIEA and the hydro project is planned to operate with diesel supplement during dry periods, it is recommended that the operation and maintenance of the mini hydro or the complete Kirakira system for power supply will be managed by SIEA.

Technical transfer of operation and maintenance knowledge is must for the SIEA operators stationed in Kirakira. During mini hydro implementation, it is recommended that the electro-mechanical equipment provider will organise the training for the local staff to operate and maintain the hydro turbine, generator and other auxiliaries.

A standardized operation and maintenance manual should be produced for technicians and maintenance staff to check and repair the equipments. A training manual should also include for strengthening the organizational capacity in the area of operation and maintenance.

## 17.2 Tariff collection and Administration

All consumers in Kirakira are currently metered. Metering, billing and revenue collection is carried out by the office in charge of Kirakira station. The realisation of the proposed mini hydro scheme will enable SIEA to expand its supply to the surrounding villages which in turn will add more small consumers to the residential consumer class. Tariff should be collected by the SIEA representative and transferred to SIEA headquarters in Honiara. Bank branches or the provincial treasurers can accept the payments and transfer of tariffs. The outstation section at SIEA headquarters in Honiara provides the funds and the administrative support for the operations in Kirakira. It is envisaged at this stage that the operation of the mini hydro scheme is automatic and therefore require a nominal staff to work during official working hours and they can be supplemented with the diesel plant operating and maintenance staff. The overall administration responsibility of the Kirakira system lies with the SIEA headquarters in Honiara.

# 18. Terms of Reference for EPC Contract

After the endorsement by the Energy Division of the preferred option for the Huro mini hydro scheme development, the next stage of this project is detailed/tender design for Engineering Procurement and Construction (EPC) contract.

It is envisaged at this stage that detailed/tender design will be done for the selected site before finalize the EPC tender. The broad scope of detailed/tender design will require the completion of the following:

- Review of Feasibility Study, findings and preparing a Basis of Design for the Tender Design,
- Identify scope & conducting the detailed topographical survey;
- Identify scope & conducting geology and geotechnical investigations;
- Establish gauge site at river intake and continuous flow data collection;
- Update design flood hydrology;
- Optimise and finalise the project layout and configuration; and,
- Preparing a Basis of Design document for the Tender Design.

## 18.1 Terms of Reference

The terms of reference for the EPC contract are meant for the contractor to provide the owner with the complete and fully functional Huro Mini Hydro Project.

### 18.1.1 General description of the contractors scope of work

These principle elements of the Contractor’s work are as follows:

#### *18.1.1.1 Design and Planning of the Works*

The Contractor is responsible for the Design and Planning of the Works. The Contractor shall further establish and operate a Quality system, to ensure and verify that his work is in accordance with the requirements of the contract. The Contractor is responsible to fulfil the performance requirements.

The Contractor may improve the design of Works as opportunities occur subject to the understanding that the Owner has the right to review and accept the changes. The Owner will not unreasonably withhold acceptance of such changes.

#### *18.1.1.2 Construction of Permanent Works.*

The Permanent Works are to be designed, engineered, constructed, completed, tested and handed over as summarized below.

- Upgrading/construction of existing access roads and tracks the Huro mini hydro site as required by the Contractor for construction of the Works and for permanent access for operation and maintenance by the Owner.

- Contractor shall design and construct all the works civil, hydro-mechanical and electro-mechanical as per hydraulic requirements of the project and as shown on both EPC Tender and basic design drawings

#### *18.1.1.3 Provision of Temporary works.*

The Contractor shall design, install and maintain throughout the execution of the work and remove at completion of the Work, as agreed with the Owner, all temporary facilities such as workshops, site office, Power supply, stores etc., which he requires for the work and are not handed over to the Owner at completion of the Project.

#### *18.1.1.4 Environmental Impact Assessment, Mitigation and Monitoring Plan.*

The Contractor shall meet the requirements of the *Environment Act 1998* in the preparation of Environmental Impact Assessment (EIA) documentation. The EIA requirements for the works will be decided by the Director of the Environment and Conservation Division in accordance with the *Environment Regulations 2008*. As a minimum the contractor will establish an Environmental Mitigation and Monitoring plan, for the design, planning, construction, completion and handing over of the Project. The contractor shall deliver regularly monitoring reports during the Project implementation to the Owner.

#### *18.1.1.5 Provision of Materials and Equipment.*

The Contractor shall organise all the material and equipment required for the construction and installation of electro-mechanical works and maintain throughout the execution of the work and remove at completion of the Work, as agreed with the Owner. The testing of materials is the responsibility of the contractor; the owner will check the testing results at any time during construction.

#### *18.1.1.6 Training of operating personnel.*

The Contractor shall transfer all necessary knowledge and documentation to the Owner and to the Owner's operating personnel. The contractor shall educate the Owner's Personnel in such way that a safe and proper operation and maintenance of the Project after the commissioning can be fulfilled.

#### *18.1.1.7 Testing and Commissioning of the Works.*

The Contractor shall be responsible for the testing and commissioning of the power plant including civil and electro-mechanical works and handing over of the Project.

### 18.1.2 Design requirements from EPC contractor

In order to provide the fully functional Huro Mini Hydro project the EPC Contractor shall fulfil all the basic design and performance requirements which are as follows:

#### *18.1.2.1 General design requirements*

The basic design requirements for EPC contractor are;

- Lifetime requirement for technical life of civil structural and electro-mechanical works,
- Drawing and documents as per the standards,
- Safety requirements in design for unforseen loads and varying geological conditions,
- Civil and structural design requirements,
- Seismic design requirement,
- Future inspection and maintenance requirement shall be met.

#### *18.1.2.2 Performance requirement*

These are mainly related to the turbine, generator and for other electro-mechanical works, the performance criteria will be set for:

- Capacity guarantee
- Efficiency guarantee
- Operation properties
- Verification of capacity and efficiency
- Expected capacity and energy production.

The terms of reference for EPC contract descriptions given in this chapter are outlines only. Such descriptions do not include or give full details of all materials or other items to be supplied or all works and service to be executed by the Contractor in order to fulfil his obligations under the EPC Contract. The detailed scope of work and contractors requirement will be finalised during the next phase of detailed/tender design.

# 19. Summary & Recommendations

## 19.1 Technical Feasibility

The technical feasibility of the Huro mini hydro project is proven in this study. The hydropower assessment of the Huro River in this feasibility study analysed two scheme development options:

1. Pipeline and civil infrastructure being implemented for the current and immediate future demand (with 1 turbine and generator installed initially); or
2. Layout similar to option 1 arrangement, but with a larger weir and pipeline to cater for future expansion of the Huro River hydro system. This future expansion would consist of an additional powerhouse and turbine sized for future demand.

Taking into account future peak demand, rugged terrain for civil construction, construction material availability and also the cost and economy aspects, "Option 2" having civil infrastructure ready for future expansion has been selected as the technically feasible alternative for development.

A Coanda self cleaning intake be used as the diversion structure for this project. The water way consists of a DN450 - HDPE pipeline of approximate 1500m from the intake to power house. A preassembled standard freight container is recommended as potential arrangements to house the turbine and generator, and act as a powerhouse.

The preferred location for a powerhouse is near to the Waitetei village on the banks of the Huro River. The power house consists of a Turgo type turbine and generator of 110 kW rated capacity.

## 19.2 Economic Viability

The estimated construction cost of the project in 2010 prices is 8.42 Million SBD. For the mini hydro project supplemented by diesel generation, the net present value (NPV) is 6.0 million SBD and economic internal rate of return (IRR) is 14.7%, well above the considered discount rate of 10% for the development projects in the region, which makes it economically viable.

The results of the incremental cost benefits analysis shows clearly that the Huro mini hydro scheme supplemented by the diesel generation is the least cost option to supply electricity to the Kirakira system.

## 19.3 Social Benefits

The Huro Mini-Hydro Scheme has the potential to significantly improve the reliability of the SIEA Kirakira Electricity Supply. It has the capacity to meet both current demand, and projected demand in to the future, and can play a key role in fostering the development and growth of the Kirakira township.

Whilst there remains the potential for some negative impacts associated with development process, including potential impacts to community cohesion at the project site and disruptions during development, there are extensive positive social benefits, including an improved electricity supply, increased investment, employment opportunities and improved services and facilities in the Kirakira township and surrounds.

As such, the proposed development is likely to have a significant net positive social benefit to the Makira Province.

## 19.4 Recommendations

This study has identified the hydropower potential of the Huro Mini Hydro project. Based on the technical feasibility and economic viability of this project, Hydro Tasmania Consulting recommends the development of this hydro electric energy resource for the Makira province as proposed in this report.

The final design and tender documents should therefore be prepared without delay. This will entail the performance of additional exploratory works and investigations which are as follows:

### 19.4.1 Hydrological Data Collection

For next Phase it is recommended that a new level recorded is installed at Huro River, with the stage tied into the previous level data. It is recommended that the flows at this site get properly verified and data collection is continued either here or at the location of the proposed intake prior to detailed design.

It is also recommended that a series of gaugings be taken at Huro River in both high and low flow conditions to enable a rating curve to be developed. The continuous flow data is required to firm up the flow and derive the flow duration curve for the scheme.

### 19.4.2 Topographic Survey

There is a degree of uncertainty surrounding the accuracy of existing topographical information available for this study. The published 1:50,000 scale maps have only 40 m contour intervals. This mapping is suitable for obtaining catchment areas and distances, which have been used throughout the study.

A LiDAR survey has been undertaken following this study to confirm the levels from the topographic maps and to provide more precise determination of pipeline layout and elevation levels of proposed weir/intake and power house for the future design stage.

### 19.4.3 Geological Survey

To complete the geological assessment of the Huro mini hydro site it is recommended that geological and geotechnical investigation work be undertaken. However due to the magnitude of the scheme components such as small weir, containerized power house etc and the remoteness of the site, the assessment would be more of mapping nature rather than mechanized investigations. The important aspects need to be covered during geological survey will include:

- Terrain mapping programme of the site abutments including any associated structure;
- Assess the nature of the overburden for power house site as directed by the site geologist; and
- Assessment of the overall slope stability along the pipeline route.

### 19.4.4 Environmental Assessment

It is recommended that the EIA requirements for this project are confirmed with the Director of the Environment and Conservation Division through submission of and Environmental Scoping Report in accordance with the *Environmental Regulations 2008*. As this project is categorised as a *Public Works Sector Development, Type 9.e (hydropower schemes)* under the Second Schedule of the *Environment Act 1998* it has been assumed that a PER will be required.

It is recommended that the following activities are completed to support the development of a PER:

- Consultation with community to develop site behaviours.
- Vegetation survey including weed species.
- Water use survey to determine what if any reliance local people have on the watercourse.
- Hydrological study into seasonal flow trends and rate of loss.
- An assessment of the potential impact of low flows and the need for an environmental flow is required.

Very limited information regarding the scheme baseline environment has been identified. A compilation of any survey information held by NGOs or Government Authorities in the local area would be valuable exercise.

The land acquisition process for the Huro scheme has been initiated but is not complete. The Makira Provincial Government are facilitating this process. Land Acquisition and Land Lease arrangements must be finalised prior to the implementation of this project.

It is also recommended that the potential for the project is further investigated, including an assessment of the opportunity to 'bundle' with larger projects.

### 19.4.5 Social Assessment

- A detailed Community Consultation Plan, including comprehensive stakeholder list, should be prepared to ensure communication and awareness of the project scope and associated benefits or impacts of the scheme. This would inform the detailed design process in order to assess in the identification of further impacts (particularly to individual landowners) and to mitigate these impacts through design or the development of appropriate management plans during construction.
- A land acquisition officer, preferably with an understanding of the issues associated with mini-hydro development process is appointed for the Huro scheme.
- When determining appropriate rental and/or compensation arrangements during the negotiation stage, the adoption of asset based equitable benefits, rather than monetary should be encouraged (i.e. Building a community facility, rather than a lumps sum payment). This may assist in maintaining relationships within tribes (in particular between the trustees and tribal members) whilst potentially maximising localised community benefits
- Where possible, labour should be sourced as close to the hydro site as possible, and should be open to community members of vaying demographic, including youth (who have enetered the labour force) and women
- Further investigation into maximizing regional opportunities for procurement of goods and services should be undertaken.

# 20. References

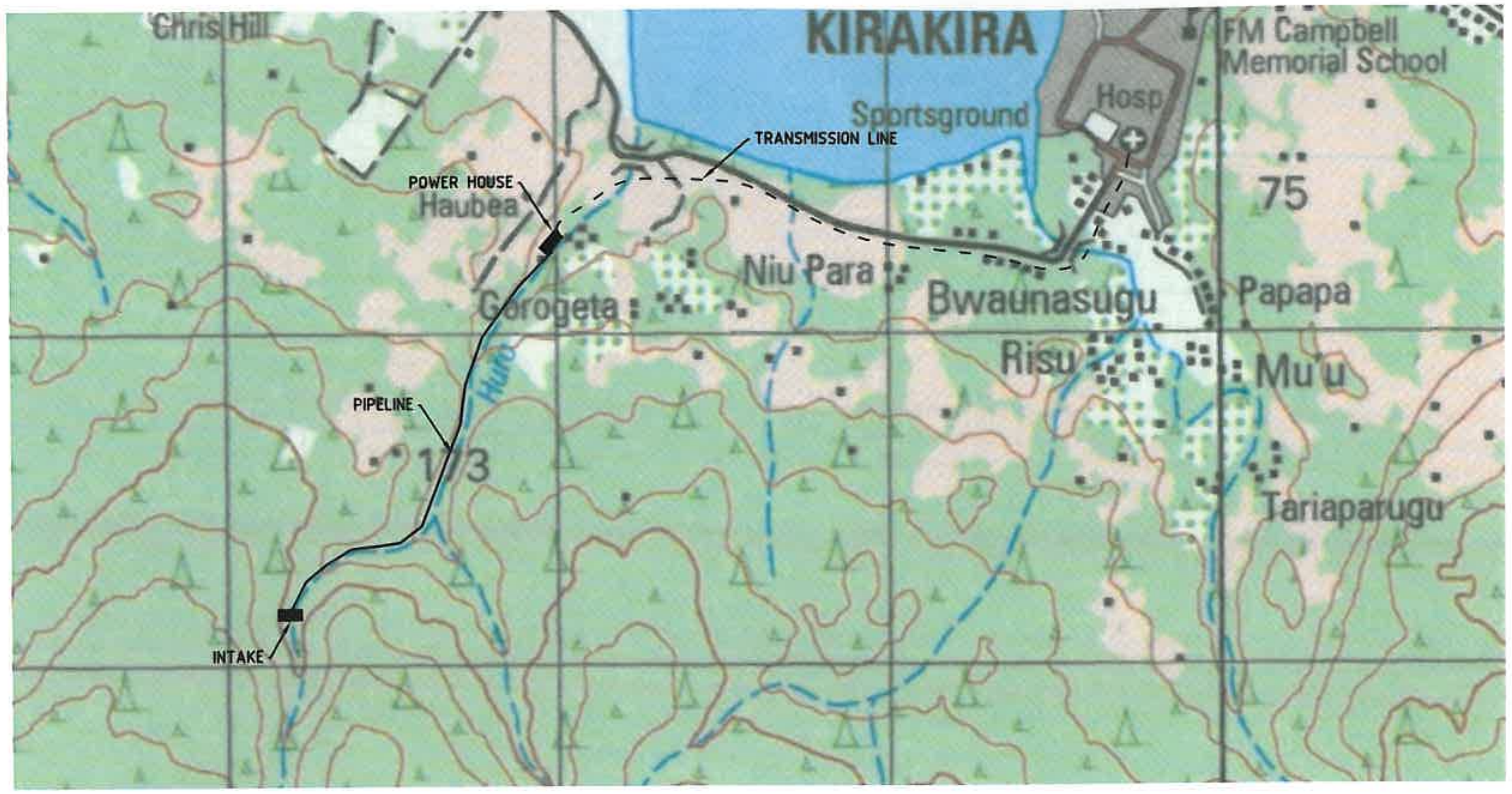
Japan International Cooperation Agency (JICA), 2000, *Masterplan study of Power Development in Solomon Islands*, August

Solomon Islands Electricity Authority (SIEA) under the assistance of the GTZ/ SI Ministry of Energy joint programme: "Improvement of rural electricity supplies in the Solomon Islands", 1996, *Huro Mini Hydropower Scheme Feasibility Report*, March

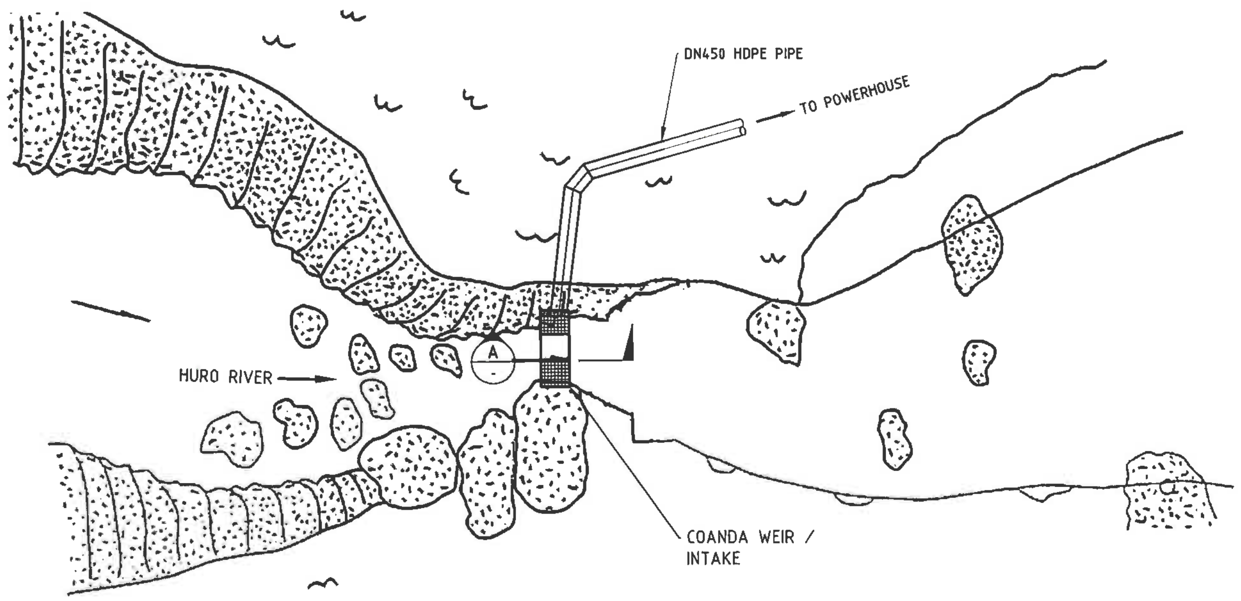
Solomon Islands Electricity Authority (SIEA) under the assistance of the GTZ/ SI Ministry of Energy joint programme: "Improvement of rural electricity supplies in the Solomon Islands", 1996, *Rualae Mini Hydropower Scheme Feasibility Report*, September

# Appendices

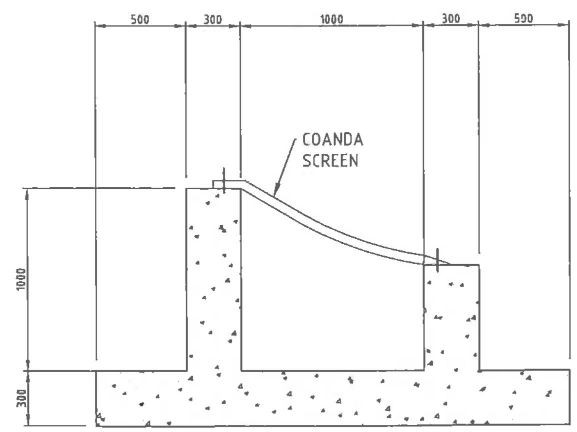
# A Drawings



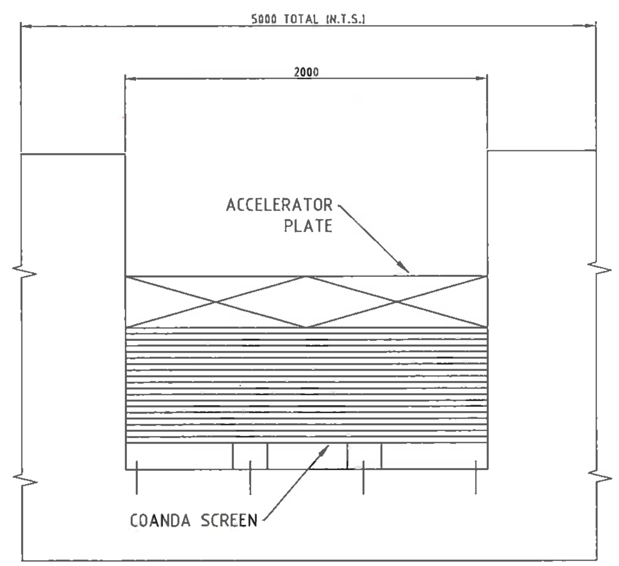

LOCALITY PLAN
N.T.S.




INTAKE PLAN
SCALE 1:100




SECTION A
SCALE 1:50




INTAKE WEIR ELEVATION
SCALE 1:50

ALTERATIONS

SIGNATURES INDICATED ARE ON ORIGINAL OR REVISION(S) STORED IN PLAN ROOM.

| REFERENCE | | |
|---|---|---|
| | DRAWN | C.J.L. |
| | CHECKED | |
| | DESIGNED | |
| | CHECKED | |
| | APPROVED | |
| | DATE | |
| REPR'D FROM | CLIENT AG'D | |
| REV | PAE APP'D | |

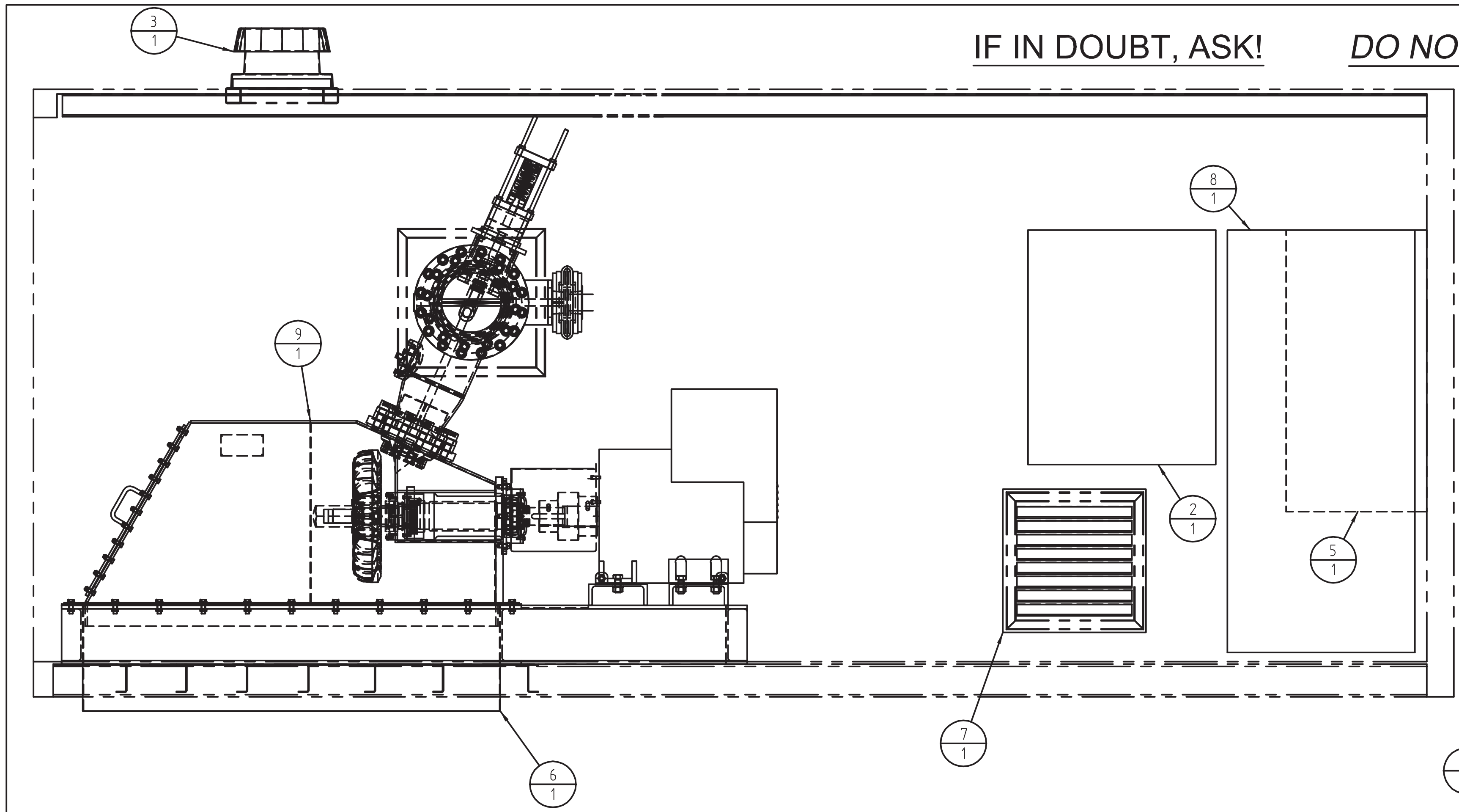
Hydro Tasmania
*the renewable energy business*



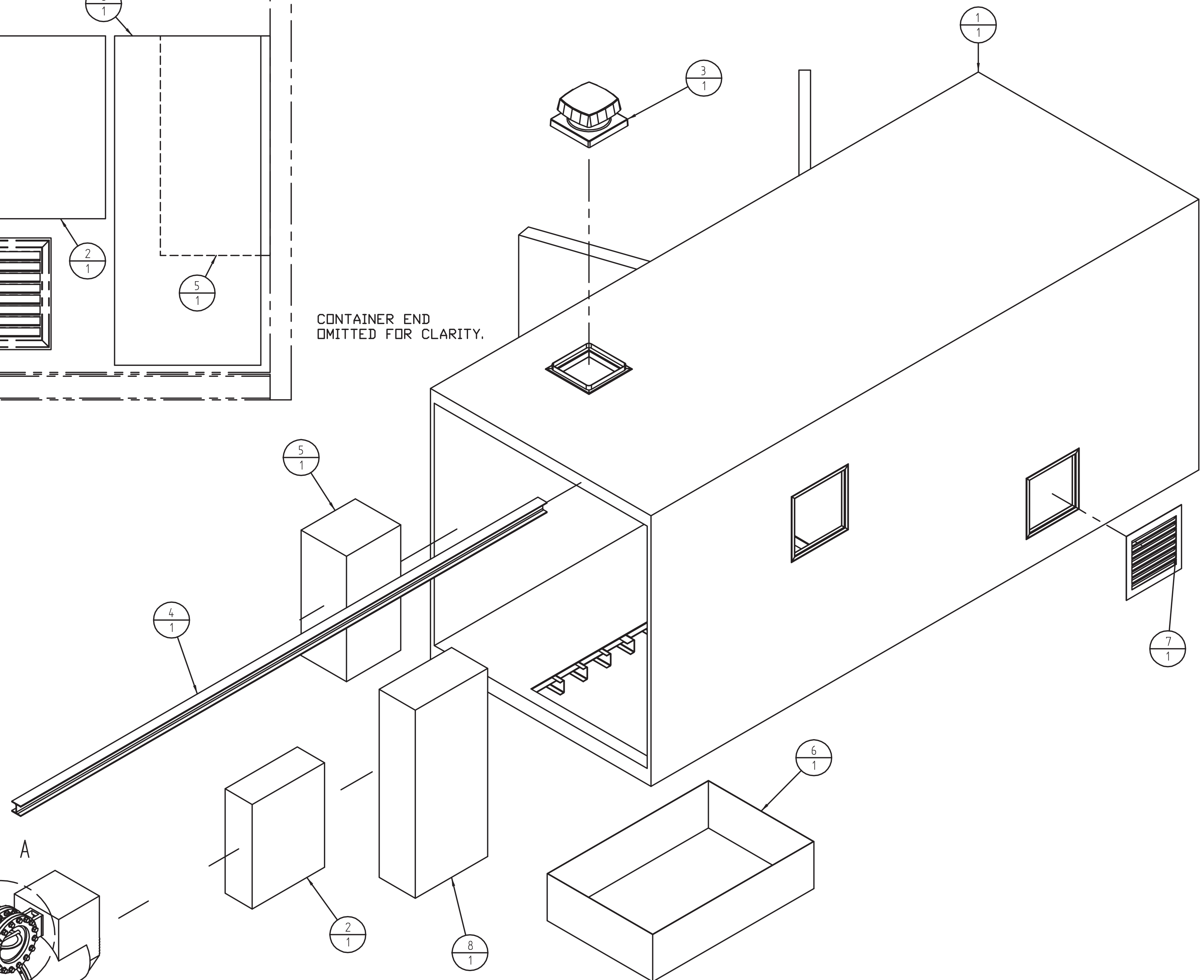
CLIENT
TITLE
HURO MINI-HYDRO
FEASIBILITY STUDY
GENERAL ARRANGEMENT

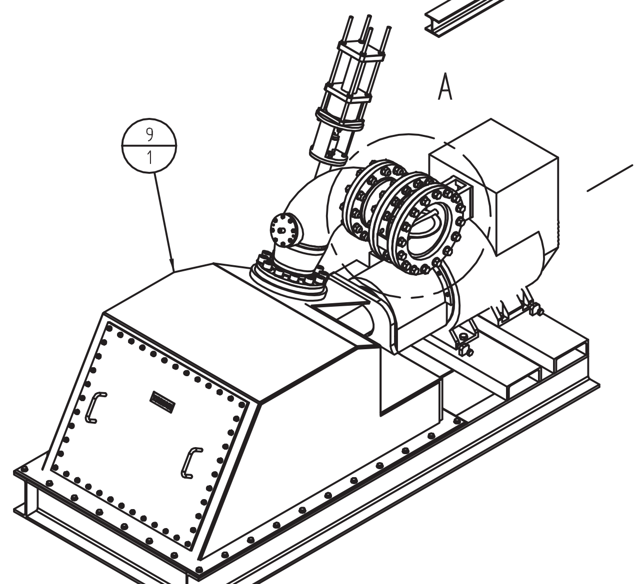
DRAWING 204622-01 SHT. X1 A1

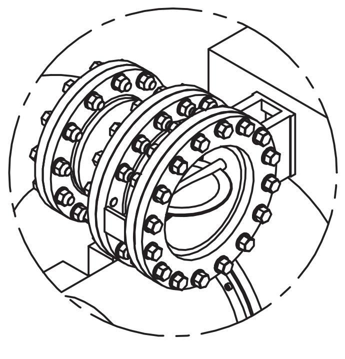
IF IN DOUBT, ASK! *DO NOT SCALE*




CONTAINER END
OMITTED FOR CLARITY.



DETAIL A
1:10

| Item No | Title | QTY | Mass | Comments |
|---|---|---|---|---|
| 1 | CONTAINER 6m HICUBE | 1 | 2750.00 Kg | 6.05m x 2.44m x 2.59m |
| 2 | GOVERNOR CUBICAL | 1 | | |
| 3 | HOODED ROOF FAN | 1 | | INSTALL AFTER SHIPMENT |
| 4 | MONO RAIL | 1 | | |
| 5 | HYDRAULIC POWER PACK | 1 | 400 Kg | |
| 6 | CONTAINER SPLASH GUARD | 1 | 63.762 kg | INSTALL AFTER SHIPMENT |
| 7 | 500 SQ INLET LOUVRES | 1 | | INSTALL AFTER SHIPMENT |
| 8 | DISTRBUTION CABINET | 1 | | |
| 9 | TURBINE & GENERATOR ASSEMBLY | 1 | | |

| REV | DWN | PSNo. | DESCRIPTION | CKD | DATE | REV | DWN | PSNo. | DESCRIPTION | CKD | DATE |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | | | | | | 6 | | | | | |
| 2 | | | | | | 7 | | | | | |
| 3 | | | | | | 8 | | | | | |
| 4 | | | | | | 9 | | | | | |
| 5 | | | | | | 10 | | | | | |



GENERAL MANUFACTURING TOLERANCES
UNLESS OTHERWISE NOTED:

| | | | |
|---|---|---|---|
| TOLERANCES, NON-CUMULATIVE | | MACHINING, LINEAR: | ± 0.25 |
| FABRICATION: | ± 2 | MACHINING, ANGULAR: | ± 0.5° |
| CASTING: | ± 2 | RADII: | ± 0.5 |
| WHOLE NUMBERS: | ± 1 | UNDIM. TAPERS: | ± |
| DECIMAL NUMBERS: | ± 0.5 | CONCENTRICITY: 0.05 T.I.R. | |

ALL DIMENSIONS IN MILLIMETRES UNLESS OTHERWISE NOTED

MACHINING: 3.2 U.O.N.

PROJECTION:

tyco / Flow Control / TAMAR
67 Main Road, Exeter, Tasmania. Australia, 7275.
A division of tyco Flow Control Pacific Pty. Ltd. A.C.N. 000 922 690

TITLE : TYPICAL CONTAINERISED MINI HYDRO 275 – 325mm TURGO IMPULSE TURBINE CONTAINER ASSEMBLY DETAIL

DRAWN: D.L. GILL | CKD: N. WYNWOOD

DATE: 11/04/05 | SCALE: 1:20

DRG. No : | REV: 1 | A1

# B Cost Estimates & Budgetary quote

**Huro Mini Hydro - Solomon Islands**
**Cost Estimate**
**Option 1 (300mm dia. Pipe)**
**Cost Estimate**
Reference Date Feb 2010

| ITEM | Unit | Quantity | Unit Cost | Total SBD |
|---|---|---|---|---|
| **Cost Estimate** | | | | |
| **1. Land Acquisition** | | | | **-** |
| **1.1 River Area** | item | | | **-** |
| **1.2 Access road land acquisition** | item | | | **-** |
| **1.3 Transmission Line** | item | | | **-** |
| **2. Basic Engineering** | | 1.5% | | **100,608** |
| | | | | **-** |
| **3. Project Management** | | 2.0% | | **134,144** |
| | | | | **-** |
| **4. Access Roads** | | | | **-** |
| **4.1 Access Road Highway-Power Station** | m | 300 | 1000 | **300,000** |
| **4.2 Access Track upto Intake site** | m | 1000 | 400 | **400,000** |
| | | | | **-** |
| **5. Coanda Weir** | | | | **-** |
| **5.1 Weir Concrete** | m3 | 10 | 800 | **8,000** |
| **5.2 Coanda Screens** | item | 1 | 23049 | **23,049** |
| **5.3 Diversion** | m3 | 10 | 1800 | **18,000** |
| **5.4 Gate** | item | 1 | 30650 | **30,650** |
| **6. Hydraulic Conduit** | | | | |
| **6.1 Penstock/ Pipe Supply** | m | 1,500 | 546 | **818,355** |
| **6.2 Laying & install pipeline** | m | 1,500 | 20 | **30,508** |
| **6.3 Penstock Fittings** | item | 1 | 30650 | **30,650** |
| **6.4 River Crossings** | item | - | | **-** |
| **6.5 Flood Protection** | m3 | - | | **-** |
| **6.6 Penstock Supports** | item | 1 | 128730 | **128,730** |
| | | | | **-** |
| **7. Powerhouse** | | | | **-** |
| **7.1 Clearing vegetation** | m2 | 400 | 8 | **3,200** |
| **7.2 Concrete work for foundation** | m3 | 8 | 800 | **6,400** |
| **7.2 Turbine-Genertaor in Containerised powerhouse** | item | 1 | 3984500 | **3,984,500** |
| **7.3 Tail Race channel** | item | 1 | 5000 | **5,000** |
| | | | | **-** |
| **8. Transmission Line** | | | | **-** |
| **8.1 All transmission line works** | km | 3 | 200000 | **600,000** |
| **8.2 Transformers** | item | 2 | 60074 | **120,148** |
| | | | | **-** |
| **9. Jobsite Camp and Offices** | item | 1 | 200000 | **200,000** |
| | | | | **-** |
| **10. Contingency** | item | | | **-** |
| **10.1 Civil 15%** | item | 15% | | **443,616** |
| **10.2 Mech and Elec 10%** | item | 10% | | **398,450** |
| **TOTAL COST** | | | | **7,784,008** |

**Huro Mini Hydro - Solomon Islands**
**Cost Estimate**
**Option 2 (400mm dia.pipe)**
**Cost Estimate**
Reference Date Feb 2010

| ITEM | Unit | Quantity | Unit Cost | Total SBD |
|---|---|---|---|---|
| **Cost Estimate** | | | | |
| **1. Land Acquisition** | | | | **-** |
| **1.1 River Area** | item | | | **-** |
| **1.2 Access road land acquisition** | item | | | **-** |
| **1.3 Transmission Line** | item | | | **-** |
| **2. Basic Engineering** | | 1.5% | | **110,533** |
| | | | | **-** |
| **3. Project Management** | | 2.0% | | **147,378** |
| | | | | **-** |
| **4. Access Roads** | | | | **-** |
| **4.1 Access Road Highway-Power Station** | m | 300 | 1000 | **300,000** |
| **4.2 Access Track upto Intake site** | m | 1000 | 400 | **400,000** |
| | | | | **-** |
| **5. Coanda Weir** | | | | **-** |
| **5.1 Weir Concrete** | m3 | 10 | 800 | **8,000** |
| **5.2 Coanda Screens** | item | 1 | 46098 | **46,098** |
| **5.3 Diversion** | m3 | 10 | 1800 | **18,000** |
| **5.4 Gate** | item | 1 | 40867 | **40,867** |
| **6. Hydraulic Conduit** | | | | |
| **6.1 Penstock/ Pipe Supply** | m | 1,500 | 969 | **1,452,810** |
| **6.2 Laying & install pipeline** | m | 1,500 | 10 | **15,300** |
| **6.3 Penstock Fittings** | item | 1 | 39845 | **39,845** |
| **6.4 River Crossings** | item | - | | **-** |
| **6.5 Flood Protection** | m3 | - | | **-** |
| **6.6 Penstock Supports** | item | 1 | 128730 | **128,730** |
| | | | | **-** |
| **7. Powerhouse** | | | | **-** |
| **7.1 Clearing vegetation** | m2 | 400 | 8 | **3,200** |
| **7.2 Concrete work for foundation** | m3 | 8 | 800 | **6,400** |
| **7.2 Turbine-Genertaor in Containerised powerhouse** | item | 1 | 3984500 | **3,984,500** |
| **7.3 Tail Race channel** | item | 1 | 5000 | **5,000** |
| | | | | **-** |
| **8. Transmission Line** | | | | **-** |
| **8.1 All transmission line works** | km | 3 | 200000 | **600,000** |
| **8.2 Transformers** | item | 2 | 60074 | **120,148** |
| | | | | **-** |
| **9. Jobsite Camp and Offices** | item | 1 | 200000 | **200,000** |
| | | | | **-** |
| **10. Contingency** | item | | | **-** |
| **10.1 Civil 15%** | item | 15% | | **546,346** |
| **10.2 Mech and Elec 10%** | item | 10% | | **398,450** |
| **TOTAL COST** | | | | **8,571,605** |

**tyco**

**Flow Control**

**Tamar**

67 Main Rd, Exeter, Tasmania,
Australia, 7275
Tel: +61 3 6394 0300
Fax: +61 3 6394 3179
*E-mail*: lgoodsell@typac.com.au
*Web*: www.tamar.com.au

TO: Hydro Tas Consulting

ATTENTION: Vishal Srivastava

FROM: Laurie Goodsell

DATE: 15th February 2010

REF: 10/942 Huro Mini Hydro

NO OF PAGES: 2

Dear Vishal,

We thank you for your enquiry and have pleasure in detailing our budget quotation for the design, manufacture, supply, freight and commissioning of a containerised hydro turbine generating system as follows:

**Scope**

One only Tamar Turgo Impulse turbine, complete with:

- One hydraulically actuated spear valve
- One hydraulically actuated jet deflector
- Synchronous generator
- Main inlet valve with hydraulic open/spring close actuator
- Hydraulic power pack
- Digital electronic governor
- Control panel
- Electrical cabinet

installed in a 6m container complete with sea freight certification.

**Design Details**

| | |
|---|---|
| Design Flow: | 150 L/s |
| Nett Head at Design Flow: | 100 m |
| Turbine Type: | Single Jet 275 Turgo Impulse |
| Approximate Power: | 114 kW electrical |
| Voltage: | 415V 3 phase |
| Turbine speed: | 1500 rpm |
| Generator speed: | 1500 rpm |
| Estimated weight: | 6000kg incl. container |

**Price**

AUD 650,000.00 +/- 10% Nett excluding GST CIF Honiara

***Exclusions***

There has not been any allowance made:

- for any civil work which may be required e.g:
    - Building or engineering of powerhouse location slab or associated buildings.
    - Intake design, excavation, construction or installation.
    - Concrete machinery foundations.
- Penstock supply and installation.
- Supply of transformer communications and externals to power house.
- Labour for container installation.
- Costs associated with any site visit for design stage.

**Delivery (shipment)**

Approx 8-10 months from receipt of order and final instructions subject to prior sales.

We trust the above is a correct interpretation of your requirements and we would be pleased to discuss any queries you may have.

Yours sincerely,

Laurie Goodsell

# C Economic Analysis Sheets

# D Social Impact Assessment