MULLUMBIMBY MINI-HYDRO

Prefeasibility assessment

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WE OWN. WE OPERATE. WE CONSULT.

This is Part B of this report. Please see file Pre-feasibility report - Mullumbimby mini-hydro-Part A.pdf for the first part of this report internal and external coating reinstated, and the generators reconditioned before they can be put back into service. The equipment will need to be inspected by hydro-mechanical engineers to assess their full condition and refurbishment requirements. However, it is considered that the turbines and generators could be potentially reused, and this should be a significant savings compared to procuring new equipment. Importantly, it will also preserve the heritage aspects of the scheme.

Electrical equipment and cabling:

All the original electrical and control equipment is out of date, and would need to be replaced with modern gear. New 11kV cables would be required to connect to the 11kV bus within the adjacent substation. A spare bay exists where a new circuit breaker could be installed for this connection.

2.4 Mini-hydro potential

As described above the existing mini-hydro equipment and headworks may be suitable for reinstatement, following inspection, refurbishment and repair. This would allow the mini-hydro scheme to be re-instated cheaply, and would respect its heritage values. This would also assist with providing for COREM's principal objective, being to facilitate 100% renewable energy in Mullumbimby.

The current capacity of the headrace channel has been advised as 510 l/s (excluding WTP flow), although confirmation of this figure is not available in the provided literature. A calculation of the flow capacity of the headrace channel confirms that this flow should be available. Therefore, with 270' (83m) and assumed 10% headloss, the turbines should be able to generate their name plate capacity of 144kW each, at a net efficiency of approximately 77%. New equipment would have a higher net efficiency (say 85%) but at a considerably higher cost.

According to the heritage register description, the total storage behind the weir is 30m gallons (=136ML) of which the live (usable) storage above the hydro take-off point is 5.5 million gallons = 25ML. However, according to the report "Lavertys Gap Weir Yield Study" prepared by DPWS in 1998, the volume of the top 1m is approx. 53ML (refer Table 2.1 below). At a scheme flow rate of 0.5m3/s (43ML/d), the hydro could operate for 12 hours without any inflow and lower the water level by approx. 300mm. This is approximately the night-time period when solar PV is not available. Operating the hydro during the night-time would contribute to COREM's principal objective of supplying 100% renewable energy. Note that the current maximum demand for Mullumbimby is 4MW. During the late evening and night, the demand is significantly less than this, so hydro production of 288kW will be able to provide a substantial portion of the night-time demand.

Table 5 - Storage–Height-Area

Elevation RL mAHD	Volume ML	Surface Area m^2
117.16	136	33000*
116.66	99	31793
116.16	83	31024
115.66	68	29839
115.16	54	27220
114.66	41	24568
114.16	29	20597
113.66	20	15760
113.16	13	11613
112.66	8	8661
112.16	4.7	6055
111.66	2.3	3853
111.16	0.96	1648

* extrapolated

Table 2.1: Weir storage

Wilsons Creek flow data is available from 8th March 2016 through to the current date. For this short record, the inflow into the storage is above 25ML for 46% of the time. The maximum daily WTP demand is 2.5ML/day, with an average of 1ML/day. Wilsons Creek riparian flow is currently limited to the discharge through a 150mm outlet pipe, assumed to be 12ML/month or 0.4ML/day.

Considering the WTP and riparian flow requirements, hydro could operate for 12 hours per day or more for 164 days per year, with the reservoir fully recharging or spilling. For the remainder of the year, the hydro would only be able to operate for less than 12 hours, to allow the reservoir to recharge. This is illustrated in Figure 2.11 below.

The calculated energy from the standalone hydro scheme is 1234 MWh/year, for the years March 2016 to March 2018. This is a capacity factor of 49%, but depends on the level of WTP and riparian flow allowed. If riparian or WTP flows increase, the available energy will reduce.

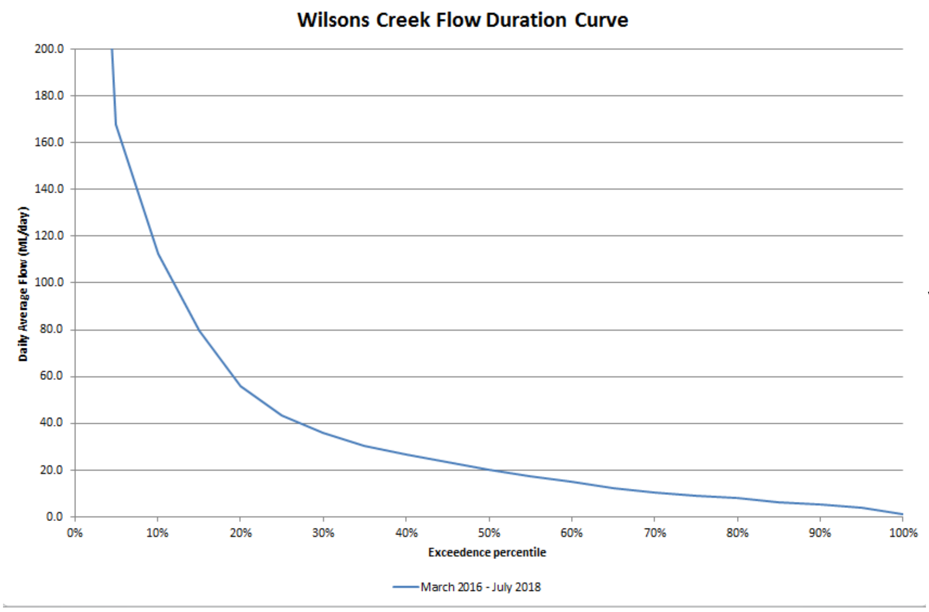

Figure 2.10: Flow Duration Curve – average daily inflows

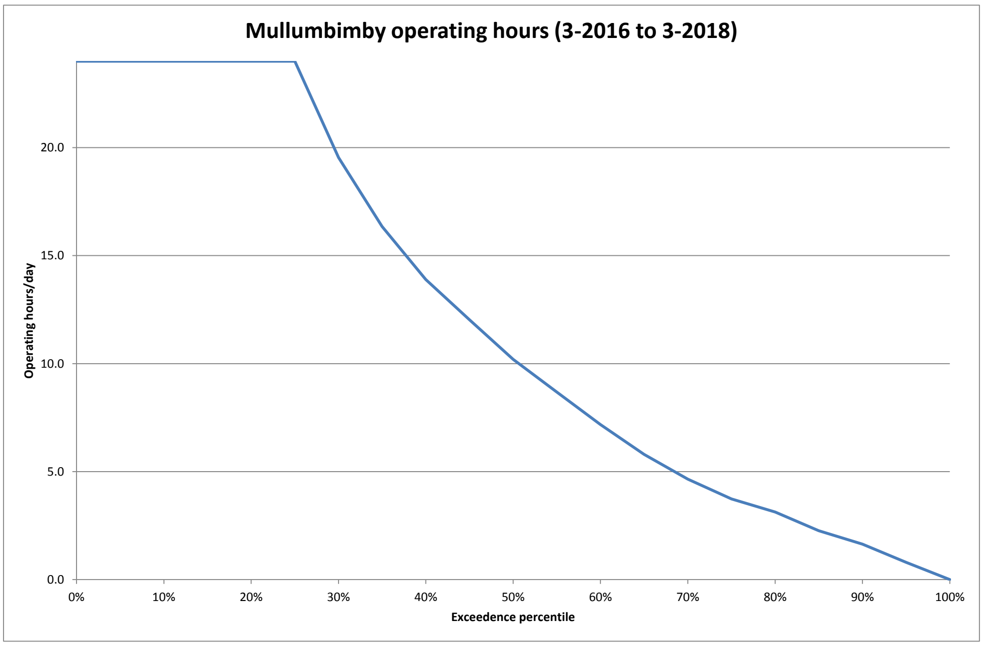

Figure 2.11: Operating times (duration curve)

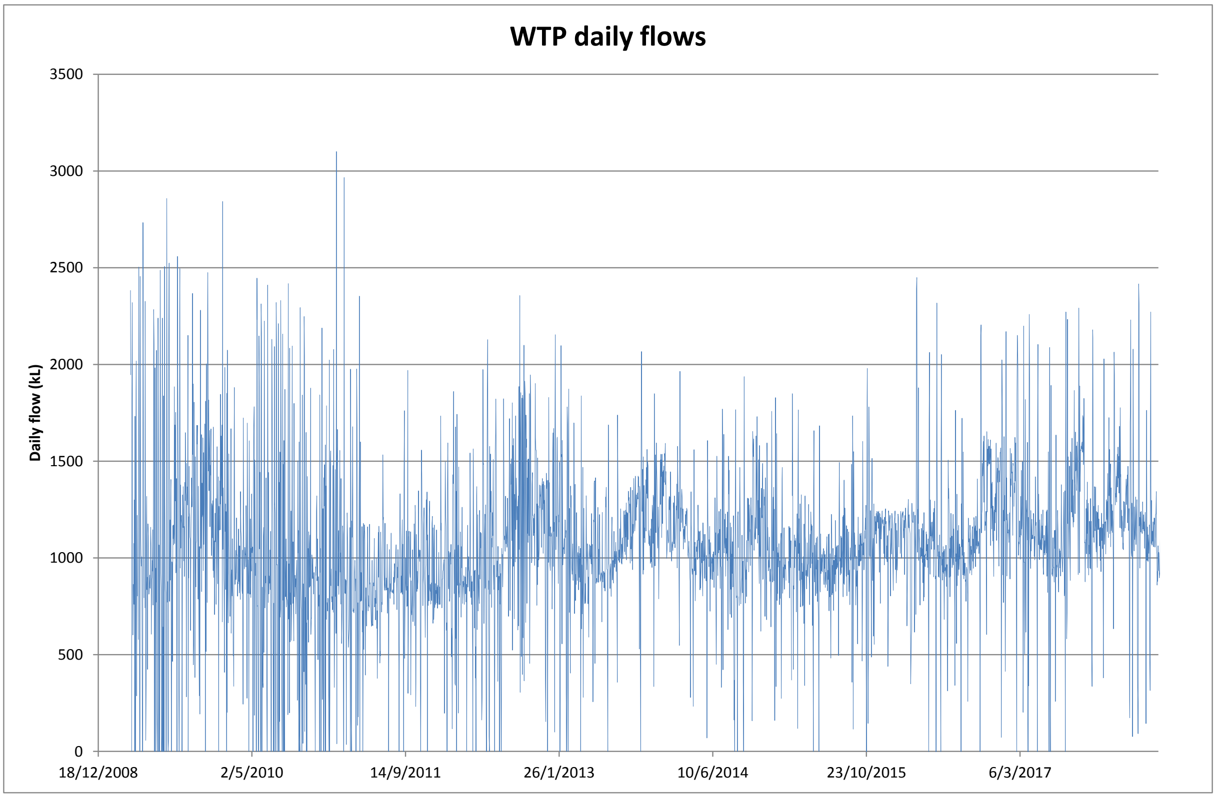

Figure 2.12: WTP flows (10 years)

2.5 Environmental considerations

The current water licenses on Wilsons Creek do not consider any offtake by the mini-hydro station. Any further analysis will need to consider the requirements for both Water Treatment Plant (WTP) demand and riparian discharges past the weir into Wilsons Creek.

In particular, there may be concerns about transferring water from the Wilsons Creek catchment to the Yankee Creek catchment. This would have a terminal impact on the ability to use Wilson Creek water through the hydro, unless measures are taken to return the flow back to Wilsons Creek.

3. Pump Storage Potential

3.1 General

From the above mini-hydro basic analysis (based on a very short period of record), the hydro can supply full renewable energy for the 12 hour night-time period for perhaps 45% of the year. During the remainder of the year, there would not be enough flow in Wilsons Creek to keep the hydro operating fully during the night period. Refer to Table 3.1 below for a summary of the potential operation.

Period of the year	Hours of operation	Timing
25% of the year	Full day operation	Day and night
20% of the year	12 to 24 hours operation	Part day and full night
55% of the year	0 to 12 hours operation	Part night

Table 3.1: Hydro operation

There is potential to increase the period of night-time operation to 365 days per year, by returning the water to the Lavertys Gap weir via a pumped storage scheme. For example, when inflows to Wilsons Creek are minimal, the hydro would utilise up to 21ML of storage (out of the 25ML active storage) during the night. This would be stored in a holding tank below the hydro station, and then pumped up to the weir during the day time when there is excess regional solar energy production.

Note that the pumping cycle will consume more energy than will be delivered by the hydro. Therefore, this operation is only suited to the following circumstances:

- There is a requirement to shift renewable energy production from the daytime to the evening/night-time period.
- There is an excess of solar energy production that can be used to power the pumps during the day.
- The local mini-grid with excess daytime energy is considered in isolation to the statewide grid (since there is potential to export excess solar energy to reduce fossil fuel production elsewhere in the state)
- There is a mechanism in place with the local energy retailer to provide offsetting of the day-time energy with night-time production, or other favourable terms so that pumping costs are less than generation costs. Local solar production at the site could be used directly for this purpose, bypassing some of the local retailer requirements.

In the event that flow from Wilsons Creek can-not be discharged across catchments to Yankee Creek, then all hydro discharge would need to be captured and stored, ready to be pumped back to the Wilsons Creek catchment. The above requirements would be essential, as there would be net energy consumption by the pumping system.

3.2 Pumping arrangement

The mini-hydro pelton turbines discharge to atmosphere, so that the discharge exits the powerstation tailrace under stream flow (i.e it is not under pressure). Since the discharge point is at a very low point near Yankee Creek, there is no potential to store the water in a tank or reservoir at the discharge point, unless it is pumped up to the tank first.

On a daily basis, the hydro will discharge up to 21.6ML over the 12 hour night-time period. Therefore, this is the volume that would need to be stored ready for pumping. If pumping could occur during the solar window (10-12 hours per day), then the pumped flow would be the same as the hydro flow (= 0.5m3/s).

The pumping arrangement could include the following:

- A low head pump that could lift the tailrace outflow from a small catchpit into the storage reservoir. This pump would have a flow rate of 0.5 m3/s, and a pump head ranging from 1 m to say 10m (i.e the head would increase as the reservoir filled up). The pump would operate at the same time as the hydro, and would therefore directly reduce the energy output of the hydro station. The required pump power would average say 0.5m3/s x 9.8 x 5m/80% = 30kW. Therefore the hydro night-time output of approx. 288kW would reduce to 258kW.

- A 21.6 ML storage reservoir located adjacent to Yankee Creek. This could be approx. 50m dia. X 7m high, so is quite substantial. Most likely this would be a concrete reservoir.

- A pump station located adjacent to the reservoir, with a pipeline extending up the hill to the Lavertys Gap weir. It will not be possible to utilise the existing hydro penstock to return the water, as it would discharge to the low end of the headrace channel, and water could not flow backwards along the race to the weir. The pipeline would extend over the top of the ridge (above the tunnel) and would follow the distribution line route up the hillside. The pipe diameter would be 500-600mm, and could be constructed from polyethylene or GRP to keep costs down. The head is approx. 100m, and assuming 5% head losses, the pump power would be approx. 0.5 x 100 x 9.8/(95% x 80%) = 650kW. This is more than double the hydro net output of 258kW, so there is very large energy loss occurring in this round trip. This can be attributed to:

    - Difference in head: hydro – 83m x 90% = 75m net; low lift pump + high lift pump – (5m + 100m)/95% = 110m. Net = 110 – 75 = 35m

    - Hydro and pump round trip efficiency: hydro – 77%; pumps 80% (net = 77%x80% = 62%

  It may be possible to pass the pump pipeline through the tunnel, thereby reducing the pump head by 15-20m. However, this may restrict flow available for the turbine.

An overview of a potential scheme is included in Figure 3.1 and detail of the hydro/pump station site is included in Figure 3.2 below.

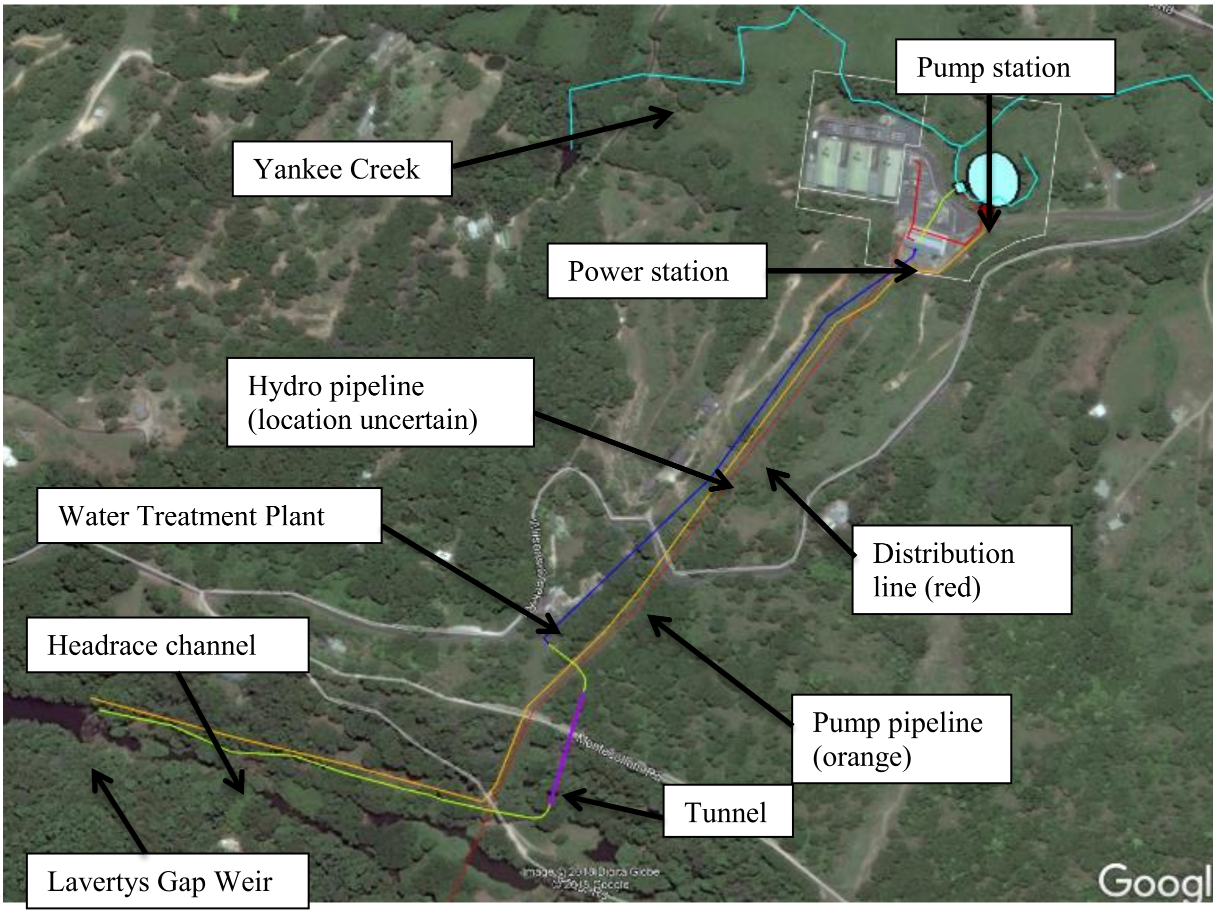

Figure 3.1: Scheme general arrangement

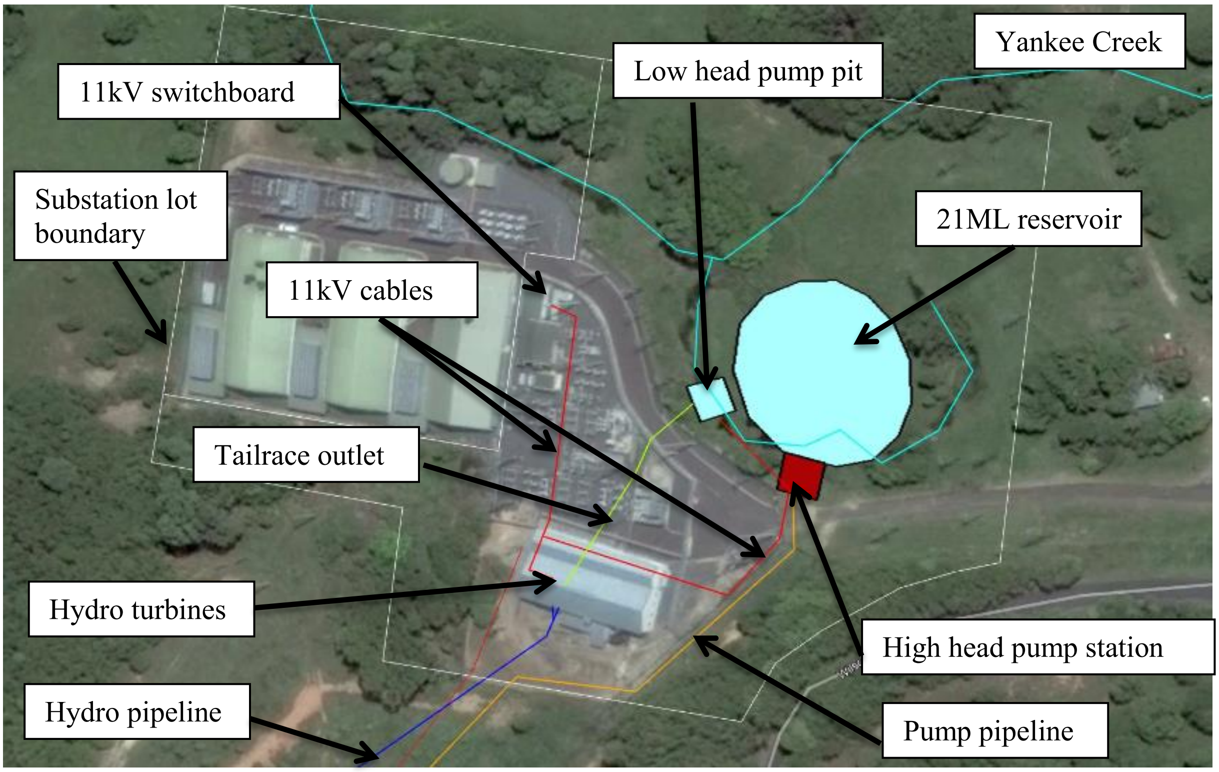

Figure 3.2: Detail at hydro/pump station

4. Potential output/demand

4.1 Energy calculations

The energy generation and pumping requirements will depend on the selected arrangement. Initial indications on limited data are provided in Table 4.1: Energy production/requirementsTable 4.1 below. These are subject to adjustment following a full feasibility assessment and are provided for indicative purposes only.

Option	Description	Hydro generation (power/energy)	Pumping demand
1	Hydro only – daytime Hydro only – night-time (natural inflows – no pumping)	288kW/401MWh 288kW/833MWh	
		Net energy = 1234MWh	
2	Hydro (nightime) pumping(daytime) (pump return all water to Wilsons Creek)	288kW/1259MWh	30kW/131MWh 650kW/2847MWh
		Net energy= -1720MWh	
3	Hydro (daytime) (wet season) Hydro (night-time) (wet season) Hydro (night-time) pumping (daytime) (dry season) (pump return water to Wilsons Creek only when flow insufficient)	288kW/401MWh 288kW/833MWh 288kw/426MWh	30kW/45MWh 650kW/963MWh
		Net energy = 383MWh	

Table 4.1: Energy production/requirements

This table shows that maximum net production can occur when the hydro operates when there is sufficient water in Wilsons Creek, and there is no requirement to return water to Wilsons Creek. Net night-time production will be approx. 833MWh.

This night-time energy can be increased to 1259MWh if a pumped storage scheme is provided. However, this requires heavy energy demand if all the water is required to be returned to Wilsons Creek, but this demand is considerably reduced if water can be spilled to Yankee Creek when there is sufficient water supply from Wilsons Creek to recharge the weir. In this case, there is a net energy surplus of 383MWh.

It is clear that the pumped storage scheme would need to be substantially cross-subsidised by a substantial solar PV array that had excess day-time energy compared to local demand. This would require the solar array to provide energy at reduced or no cost to the pumped storage scheme, while the hydro generation would need to get a generous feed-in-tariff for its supply to the local grid.

4.2 Solar supplement

The powerstation has a roof area facing north of approx. 33m wide x (6m + 3m) in length. This could support approx. 165 x 300w panels, with a total rating of 50kW. This has the potential to produce an annual average of 76MWh, with a daily maximum of 300kWh.

For the full option 3 pumped energy requirement of 1008MWh per annum, a commercial solar array of approx. 0.7MW would be required.

4.3 Other micro hydro potential

The water treatment plant feeds two small storage reservoirs located near Mullumbimby:

- 4.5ML Azalea Street reservoir
- 1.5ML Tristran reservoir

Data is limited, however, from council records, the reservoirs are connected by 300mm and 200mm diameter pipelines. The approx. elevation of the WTP is 107m. From Google Earth, the elevation of Azalea Street is 41m and Tristran is at 82m. Net head can be calculated by assuming say a 20% headloss (may be significantly higher)

Flows from the WTP are a maximum of 2.5ML/day (0.029m3/s) and an average of 1ML/day (0.012m3/s). Assuming the discharge is divided between the reservoirs according to size, and all flow goes to the reservoirs prior to distribution, the potential power from each site can be estimated:

Azalea:

  - power = (107-41)*80% x 4.5/6 x 0.029 x 9.81 x 90% x 80% (efficiency) = 8kW
  - annual energy = 1/ 2.5 x 8 x 24 x 365 = 28MWh/a

- Tristran
  - power = (107-82)*80% x 1.5/6 x 0.029 x 9.81 x 90% x 80% (efficiency) = 1kW
  - annual energy = 1/ 2.5 x 1 x 24 x 365 = 3.5MWh/a

Clearly, the potential power is low, and annual energy also very low. Net head assumption may also be significantly over-estimated. It would potentially be more beneficial to place solar panels on the reservoir roof than to harvest the micro-hydro potential.

5. Conclusions

The following early stage conclusions are made with regards to the Mullumbimby mini hydro and pumped storage scheme:

- There is potential to reinstate the two existing 144kW pelton turbines in the heritage listed Mullimbimby mini-hydro scheme and return them to active service. They can potentially generate 401MWh of daytime energy and 833MWh of night-time energy from natural inflows (determined from small sample 2 years of inflow data)

- Subject to getting a suitable water license that allows use of available water after deducting the water treatment plant requirements and a small summer riparian flow, and allows water transfer from the Wilsons Creek catchment to the Yankee Creek catchment, this can be done quite simply and potentially cheaply by repairing the headrace channel, confirming the pipeline condition, and reconditioning the turbines and generators.

- Large Generation Credits (LGCs) should be available from a reinstated scheme, although the value of such credits is expected to diminish significantly as the scheme becomes over-subscribed and winds down. Energy would be sold to the local retailer at the current Feed-in-Tariff rate.

- The potential night-time generation could be increased by storing hydro discharges and pumping back to the weir using daytime excess solar energy from local solar PV sources. However, the pumping energy would be similar (net gain of 383MWh/a) to the generated energy and therefore, there must be a substantial difference between generation Feed-in-tariff and the cost of pumping. The pumping costs could be heavily cross-subsidised by a large community owned PV array.

- The pumping scheme would require considerable capital input, as it would require a new reservoir, pump station and pipeline. Low cost of capital or generous subsidies would be required to allow the scheme to be sustainable.

- The pumping scheme would potentially only become viable when the large community owned solar is commissioned. However, it would potentially be beneficial to reinstate the hydro immediately, followed by the pump scheme at a later date

- If all the hydro discharge water was required to be returned to Wilsons Creek, the pumping requirements would increase considerably, and the scheme would be a considerable net user of energy. On a statewide basis, this would be a net emitter of CO_2. This is not desirable for a renewable energy project, and therefore such a scheme is unlikely to be sustainable.

- Micro-hydro potential at the distribution reservoirs on the domestic water system is very limited, and is not considered feasible to harvest.

6. Recommendations

In order to move this project forward, the next steps should be undertaken:

- Repair the headrace channel where it is at risk of failure. This should be done regardless of the status of this project.
- Confirm the condition of the hydro pipeline, including pipe diameter, remaining wall thickness, and internal surface condition.
- Confirm requirements for refurbishment/reconditioning of the turbine and generators. This may require an internal inspection and undertaking testing of the equipment.
- Source additional historical flow data for Wilsons Creek. This may be available from old records, including hydro production data. Otherwise, a hydrological model based on historical rainfall and catchment area will need to be developed (as per the 1998 DPWS report “Lavertys Gap Weir Yield Study”.
- Determine whether a suitable water licence can be obtained, including the potential cross-catchment transfer of water.
- Request data from Essential Energy on the Mullumbimby township daily electricity demand profile, particularly to determine the evening/night-time demand requirements to see how the hydro output could best support the 100% RE objective.
- Initiate discussions on the potential to operate the hydro station as a working heritage museum.

Once the above information can be sourced or determined, a full feasibility study should be commissioned to determine the cost of the options, and to confirm the potential energy and revenue from the scheme.