Micro-Hydro

Robin Eugenio Rodriguez, Kevin J Kircher and K. Max Zhang

Executive Summary

Total Potential

Energy Source	Installation Capacity (MW)	Annual Energy Output (GWh)	Percent of Total 2008 Electricity Demand
Micro-hydro Electricity Generation Potential	88.5 (+/- 18.6)	**725.7**	**93%**
2008 Community Demand	NA	779.3	

Major Assumptions

- We set the threshold for classifying a location as having high potential to generate hydropower as those in the upper 20% of both flow accumulation and slope steepness. This was selected to be certain that the sites obtained have a non-stop, continuous flow of water.
- Only water flow due to precipitation was considered. Evaporation and soil filtration data were not included in the analysis.
- We adopted a ratio of 8,200 kWh/year for 1 kW of hydro to convert installation capacity to annual electricity generation. The ratio was based on studies conducted in Madison County, NY.

The large number of streams, abundant rainfall and hilly topography in Tompkins County could provide an excellent resource for low-impact micro hydroelectric (referred to as “micro-hydro”) power generation. The objective of this study was to quantify the micro-hydro capacity potential in the County. We utilized a Geospatial Information System (ArcGIS) to pinpoint locations with high potential for producing clean renewable energy and estimate the run-of-river generation capacity of said sites.

We identified 232 potential sites, and estimated the total generation potential as 88.5 (+/- 18.6) MW. The generation potential at individual sites varied from 114 kW to 2950 kW. One-hundred ninety-nine sites could generate between 100kW to 600kW individually. In 2008, the Tompkins County residential sector consumed 293,371,081 kWh of electricity. Professor Phillip Hofmeyer, Assistant Professor at Morrisville State College, has had vast experience with the installation process of micro-hydro. Professor Hofmeyer states that 1 kW of hydro can generate 8,200 kWh/year. If we were to tap in to the estimated capacity of all 232 potential sites, in theory this could lead to a total generation of 725,700,000 kWhs per year.

Micro-hydro presents both opportunities and challenges to achieving the County’s greenhouse gas reduction goal. It offers many benefits over solar and wind, including relatively continuous generation, long-term system affordability, high efficiency and system reliability. In addition, micro-hydro avoids many of the environmental concerns associated with large-scale hydroelectric development (e.g., dams, siltation, and ecological disruption).

However, micro-hydro is a technology where site-specific conditions need to be met in order to achieve successful implementation and maintain operating conditions. One of the challenges is that such systems should be located on a site that is easily accessible and that is closely located to the community, home, or business to which it will be supplying energy. Additionally, micro-hydro faces financial challenges that other renewables do not, as it has not yet been recognized as a form of renewable energy that qualifies for incentives by New York State, except for qualifying for net metering. Thus it is essential that the State make micro-hydro eligible for the same subsidies and tax rebates solar and wind energy receive in order to move support for a more widespread adoption of this technology.

1. Introduction

Hydropower has the potential to provide viable renewable energy in Tompkins County due to the large number of streams and relatively steep terrain found here. However, there have been no previous studies to quantify the hydropower generation potential from water resources.

Hydropower is currently the most important renewable energy worldwide, providing ~16% of the global electricity generation (EIA, 2014). However, large hydropower generators require the construction of dams and flooding of land to create a reservoir where water is abundant for continuous operation. Micro-hydro, or low-head hydro, is a type of hydropower that looks to reduce this environmental impact and still produce sufficient clean energy at the community level. It is smaller, localized, and more ecologically friendly than its larger counterparts. A micro-hydro unit is typically designed to generate between 10kW and 500kW, and can last for 50 years with light maintenance (O Paish, 2002).

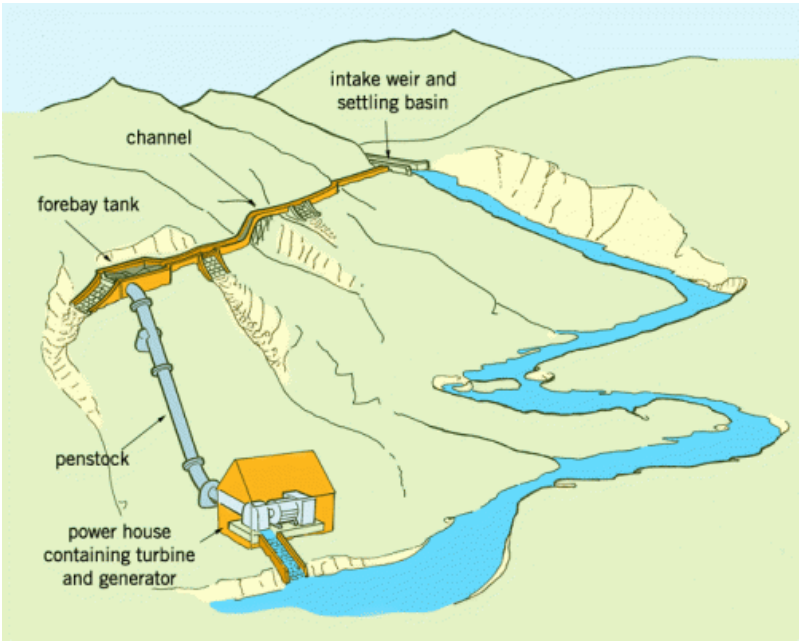

Figure 1: Example of a micro-hydro generator model with a water reservoir

As shown in Figure 1, micro-hydro may or may not require a small reservoir. For this study, we quantified the hydrological potential for applications that require no dams, called “run-of-river”

systems, and identified associated challenges and opportunities. We hope this study can serve as a model for other communities that aspire to assess their micro-hydro potential.

2. Micro-Hydro Potential in Tompkins County

Tompkins County has 304,704 acres of land that contains a vast network of running water. Unfortunately, there are only five stream gauges that provide the stream flow measurements needed for a proper hydrologic analysis. The purpose of our analysis was to determine sites with the highest potential for micro-hydro production and estimate the average annual power output. Some of the promising sites are locations without gauges. Thus, part of the study was to look at historical data and analyze how the stream flow is influenced by certain conditions such as elevation change and rainfall. Given a model of these influences, we were able to estimate annual stream flow values and determine the annual average power generation capabilities for these sites without gauges.

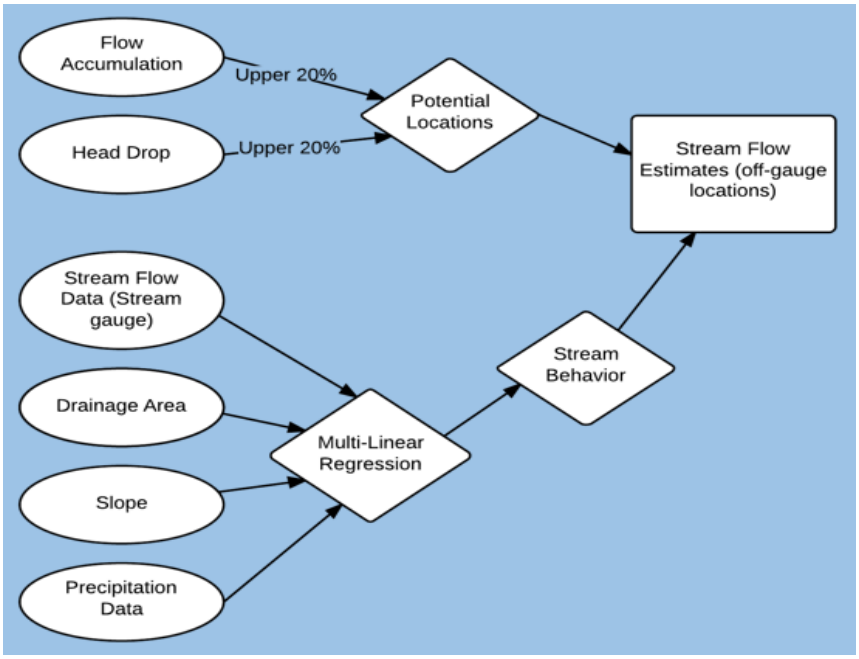

Figure 2: Steps to determine stream flow estimates in ungauged sites.

2.1 Potential Sites

The first step for the hydrologic analysis was to determine potential locations most favorable for micro-hydro applications, i.e., where there is a sufficient amount of running water and elevation drop, also known as head. Head determines the amount of potential energy in water that can be transformed into kinetic energy.

For this study, a Geographic Information System program, ArcGIS, was to determine and pinpoint locations with hydrologic potential in the County. The main input to the ArcGIS analysis was a Data Elevation Model (DEM) raster, which models the height of elevation in each cell. Two sets of DEM were obtained for our study, however only one was used. The first had a resolution of $1m^2$ per cell, but only contained data inside of the County's boundaries. The other had a resolution of $100m^2$ and included elevation data for the surrounding counties. Since some

of the watersheds' land areas extended beyond the boundaries of the County, and the entire amount of water draining into the County's streams needed to be taken into consideration, the 100m^2 dataset was utilized for this study.

ArcGIS contains a Hydrology System Toolbox with various tools that can help determine where rainfall water accumulates and forms river streams. The first step was to fill any sinks in the DEM that might cause discontinuity in the flow raster by using the Fill Sink tool as shown in Figure 3. The fill sink simulates when the water fills and overflows to continue the stream path (the new filled value will only be as tall as the adjacent cell with the lowest elevation). By filling this sink, the flow will be continuous, and the entirety of the stream can be modeled.

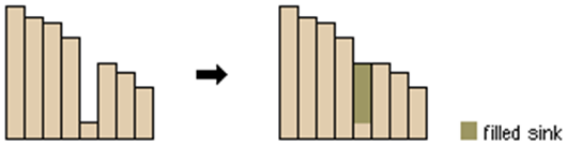

Figure 3: Shows the DEM Fill Sink process

After obtaining the DEM with the sink corrections, the next step was to determine the direction in which water would flow through each cell. ArcGIS can create a raster of flow direction from each cell to its steepest adjacent cell as shown in Figure 4.

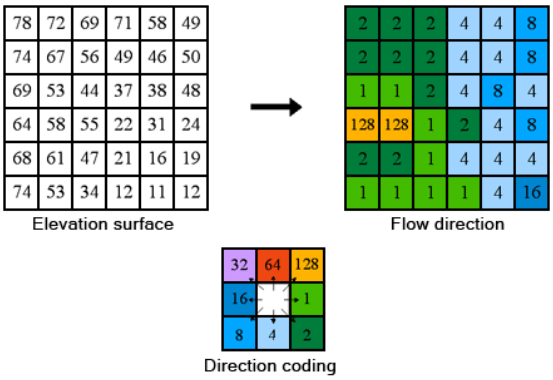

Figure 4: Shows how a Flow Direction raster is created from the DEM

The next step was to obtain the accumulation of flow which helped us simulate stream flow. This step calculates the number of contributing cells that flow into each other cell and creates a raster for it, as shown in Figure 5. In other words, the Flow Accumulation raster indicates a value of contributing area where rainfall water drains or collects. Areas with higher flow accumulation values are most likely streams, rivers, ponds, or other bodies of water.

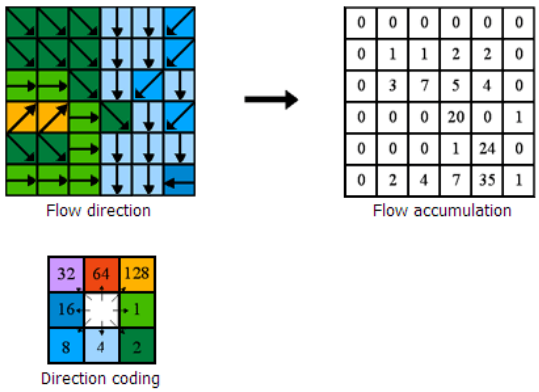

Figure 5: Shows how a Flow Accumulation raster is created from the Flow Direction Raster\

The final dataset needed to determine sites with high hydrologic potential, was head drop. However, ArcGIS has no accurate tool to determine the head drop along a non-linear stream. To get around this, we used the Slope tool, found in the Hydrology Toolbox, to determine the drop percentage (rise/run) between the steepest adjacent cells. Rise is the vertical change in elevation calculated for that cell, while run is the horizontal distance for which the elevation is calculated. A higher percentage would signify a steeper slope and a higher head drop rate for a set distance.

After analyzing all the necessary datasets, the locations with good micro-hydro potential were determined. A site with sufficient water accumulation and head drop was considered a potential location for micro-hydro. Evaluation of these potential locations can be done in many ways, but after careful consideration we set the threshold for classifying a location as having high potential site potential to generate hydropower as those in the upper 20% of both flow accumulation and slope steepness was to be certain that the sites obtained have a non-stop, continuous flow of water. A wider selection (for example, to 30%) would increase the chances of including sites where the stream is not continuous all year long and could also include sites with small generation potential but with relatively large uncertainties. The Raster Calculator tool was used to map the points where both of these criteria were satisfied, and 232 locations were identified. Figure 6 shows that although all the watersheds in Tompkins County were evaluated, most of the potential points fall predominantly throughout four streams: Fall Creek (118), Taughannock Creek (57), Six Mile Creek (37), and Salmon Creek (20).

2.2 Stream Flow Estimation

This section explains the procedure used to estimate unmeasured flow rates based on utilizing historical data from the five streams for which gauge data was available to other streams in the County. The five gauges used for this study were the following:

- USGS 04234000 – Fall Creek near Ithaca
- USGS 0423401815 – Salmon Creek near Ludlowville
- USGS 04233286 – Six Mile Creek at Brooktondale
- USGS 04233300 – Six Mile Creek at Bethel Grove
- USGS 04233255 – Cayuga Inlet at Ithaca

Two estimation approaches, i.e., the Drainage-Area Ratio method and the multiple linear regression method, were considered. The Drainage-Area Ratio assumes that the stream flow of an unmetered site for the same stream or watershed can be deduced from the drainage area

(Perry, Wolock, & Artman, 2004). This assumption only makes sense for unmetered sites not far from a gauged site. It assumes 1) that all conditions are equal except for the amount of contributing water drainage area, and 2) that the estimated stream flow is a ratio of the drainage area of both metered and unmetered sites. This method requires that the potential sites share a watershed with a gauged stream. There are a total of 18 separate watersheds in Tompkins County. This would mean that we would at least need a minimum of 18 gages, each located in a different watershed. However, this presented a problem because, as Figure 6 shows, there are only 5 stream flow gauges with stream data.

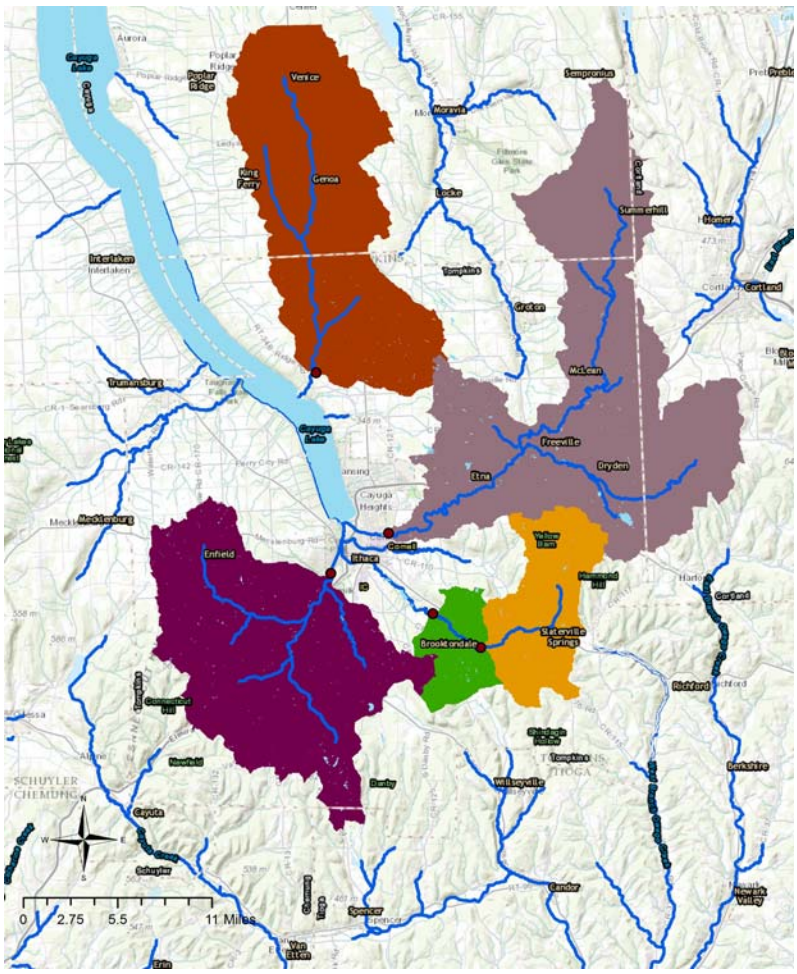

Figure 6: Stream Gage locations (red points), and corresponding Drainage Area (colored polygons).

Because the Drainage-Area Ratio method was impractical, we adopted the multiple linear regression method. This method has been used by USGS and many hydrology researchers (Perry, Wolock, & Artman, 2004). The regression fits a linear model that relates stream flow to a variety of predictors. The multiple linear regression model is

$$y = b_1 x_1 + b_2 x_2 + \cdots + b_n x_n + \in$$

where,

$$n = number\ of\ independent\ variables$$

$$x_n = n^{th}\ independent\ variable$$
$$b_n = n^{th}\ coefficient\ corresponding\ to\ x_n$$
$$y = dependant\ variable;\ \ \in = residual$$

The regression develops an equation that represents the behavior of the stream flow and how that behavior changes. Three predictors were selected to study: slope (head drop), flow accumulation (drainage area), and precipitation (rainfall).

Monthly grid precipitation raster data and monthly stream flow data for all gauge locations were obtained from the PRISM climate group (PRISM Climate Group, Oregon State University) and USGS, respectively, from 2006 to 2013. The precipitation data has a resolution of 4km. The multiple linear regression was performed with MATLAB, and our equation was,

$$y_{fr} = b_{prec} \cdot x_{prec} + b_{DA} \cdot x_{DA} + b_{sl} \cdot x_{sl} + \in$$

Our independent variables were,

$$x_{prec} = precipitation\ (mm)$$
$$x_{DA} = drainage\ area\ (cell\ count\ of\ contributing\ area)$$
$$x_{sl} = slope\ \%\ \left(\frac{rise}{run} \times 100\right)$$

And our dependent variable was,

$$y_{fr} = flow\ rate\ (cfs)$$

After undergoing the multiple linear regression we obtained,

$$b_{prec} = 0.25285\ ;\ b_{DA} = 1.4774 \times 10^{-5}\ ;$$
$$b_{sl} = 10.130\ ;\ \in = 13.241$$

And the resulting equation was,

$$y_{fr} = 0.25285(x_{prec}) + 1.4774 \times 10^{-5}(x_{DA}) + 10.130(x_{sl}) + 13.241$$

This equation can be used to predict streamflow behavior at the ungauged sites.

2.3 Statistical Analysis of Multiple Linear Regression

A statistical analysis was made to quantify the uncertainty of the multiple linear regression model. Utilizing MATLAB, a computational numeric analysis was made which calculated an estimate of the Error Variance ($\hat{\sigma}^2$), the Coefficient of Determination (R^2), and the P-value (P).

An estimated Error Variance ($\hat{\sigma}^2$) of 10,000 was obtained. The error variance was used to calculate the Standard Error ($\hat{\sigma}$), which is the value of possible variation in the dependent variable obtained from the regression equation. The standard error calculated was $\hat{\sigma}$=100. This

means that the obtained stream flow-rate has a variation of +/-100 cfs (cubic feet per second). The coefficient of determination was then calculated to explain the variance.

The coefficient of determination is the percentage of variance explained by the regression. It determines the multiple linear regressions precision to predicting the dependent variable (y_{fr}) to the independent variables (x_{prec}, x_{DA}, and x_{sl}). Our regression model had a coefficient of determination, R^2=0.174. In theory, the regression equation should predict correct flow rate values roughly 17.4 percent of the time. This signifies that 82.6% of the total variation of the values of y_{fr} is unexplained by the variation in the 'x' variables, which poses challenges for predicting precise values.

On the other hand, the P-value was calculated to determine if changes in the independent variables in the multiple linear regression were related to changes in the dependent variable. A low P-value signifies that differences in the response variable (y_{fr}), were not coincidental. Whereas a large P-value means that the changes in the response may not be related to changes in the output variable (x_{prec}, x_{DA}, x_{sl}). P-values below 0.05 are considered to be statistically significant ("*Statistical Interference"*). The P-Value returned after the computational analysis was of 5.7861 x 10^{-14}. This means that the regression is very significant and a change in the dependent variable is more than likely explained by a change of the independent variables, with a certainty greater than 99.9%.

In conclusion, the low coefficient of determination is of concern since the predicted variables may have large uncertainties. However, the low P-value indicates a strong relationship between the independent and dependent variables. Thus, when the regression shows a low R^2 and low P-value, including more predictor variables may help increase the precision of the response. Predictor variables such as evaporation rate and soil filtration rate may improve the precision based on a runoff flow rate. The runoff flow is the actual net flow of the water due to precipitation minus the water lost due to evaporation or soil filtration. For this project, only the water flow due to precipitation was considered. To include the total runoff flow rate, separate studies must be conducted where it can determine the evaporation rate changes with the seasons, and the different types of soils found throughout the Tompkins County and their ability, or lack thereof, to filtrate water.

2.4 Average Annual Stream Flow-Rates

The most critical sites, a subset of the 232 listed potential sites, were selected for study. These critical sites represent the highest available power generation potential of a group of sites that lie within the same stream and precipitation grid area. That is to say, if multiple potential sites lie within the same stream and precipitation data grid, the site with the highest generation potential (the "critical site"), was studied to measure the peak power output of that general area. The critical sites are those that have the highest Head (slope) and Flow-rate values. These critical study sites can be seen in Figure 7. The critical locations of interest summed to be a total of 17 sites. The average of these flow rate values was determined per site as shown in Table 1.

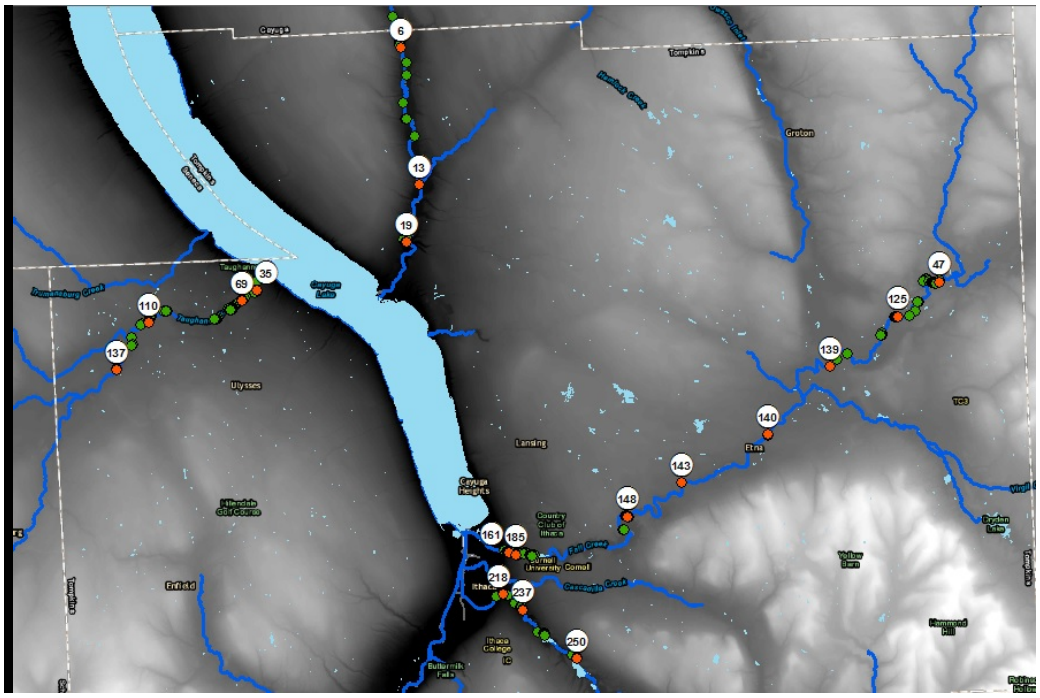

Figure 7: Critical Study Point Locations in red with corresponding "point ID" number.

Table 1: Critical Study Point Locations.
The Point ID acts as an indicator where each number is assigned to a different site. The Point ID's found in this table correspond to the number bubbles in Figure 7. Each site corresponds to a different precipitation grid area.

Stream Location	point id	Longitude	Latitude	Slope (rise/run %)	Drainage Area (cell count)	Avg Annual Streamflow Rate (cfs)
Fall Creek	47	76° 17' 56.3" W	42° 32' 30.5" N	31.4	1255028	373.0
Fall Creek	125	76° 19' 2.5" W	42° 31' 49.6" N	26.4	1297108	322.4
Fall Creek	139	76° 20' 52.1" W	42° 30' 50.2" N	20.7	1424728	266.3
Fall Creek	140	76° 22' 31.1" W	42° 29' 29.0" N	22.5	2808127	304.2
Fall Creek	143	76° 24' 50.5" W	42° 28' 32.5" N	25.5	3099050	339.6
Fall Creek	148	76° 26' 16.7" W	42° 27' 51.9" N	40.1	3179347	487.4
Fall Creek	161	76° 29' 28.3" W	42° 27' 9.6" N	41.9	3254563	504.7
Taughannock	35	76° 36' 12.8" W	42° 32' 19.8" N	54.7	1710603	610.2

Taughannock	69	76° 36' 38.0" W	42° 32' 7.9" N	57.7	1708396	641.1
Taughannock	110	76° 39' 7.8" W	42° 31' 42.3" N	39.3	1577532	454.1
Taughannock	137	76° 40' 0.6" W	42° 30' 45.5" N	24.9	1101818	302.1
Six Mile Creek	218	76° 29' 36.8" W	42° 26' 19.2" N	41.4	1291523	470.3
Six Mile Creek	237	76° 29' 6.2" W	42° 26' 1.1" N	48.2	1275442	540.0
Six Mile Creek	250	76° 27' 38.6" W	42° 25' 2.6" N	69.7	1157130	757.2
Salmon Creek	6	76° 32' 22.8" W	42° 37' 7.6" N	26.5	1364797	322.1
Salmon Creek	13	76° 31' 53.4" W	42° 34' 25.6" N	22.2	1851364	285.1
Salmon Creek	19	76° 32' 13.2" W	42° 33' 17.3" N	41.2	2022059	478.8

2.5 Estimated Hydro Generation Potential

With the stream flow estimates calculated in section 2.4, we then had sufficient data to predict the micro-hydro power output for each of the 18 Critical Sites. The resulting equation for determining the raw power output of a hydro-generator is determined by the following equation:

$$P = \eta \rho g h \dot{q}$$

Where,

$$P = power\ (W)$$
$$\eta = water\ to\ wire\ efficiency$$
$$\rho = 1{,}000\ \left(\frac{kg}{m^3}\right);\ density\ of\ water$$
$$g = 9.81 \frac{m}{s^2}\ ; gravity$$
$$h = net\ head\ (m)$$
$$\dot{q} = flow\ rate\ \left(\frac{m^3}{s}\right)$$

First, an appropriate turbine must be selected that can function within all conditions of the site locations. The Turbine Selection Chart seen in Figure 8 establishes the parameters to which each turbine functions efficiently.

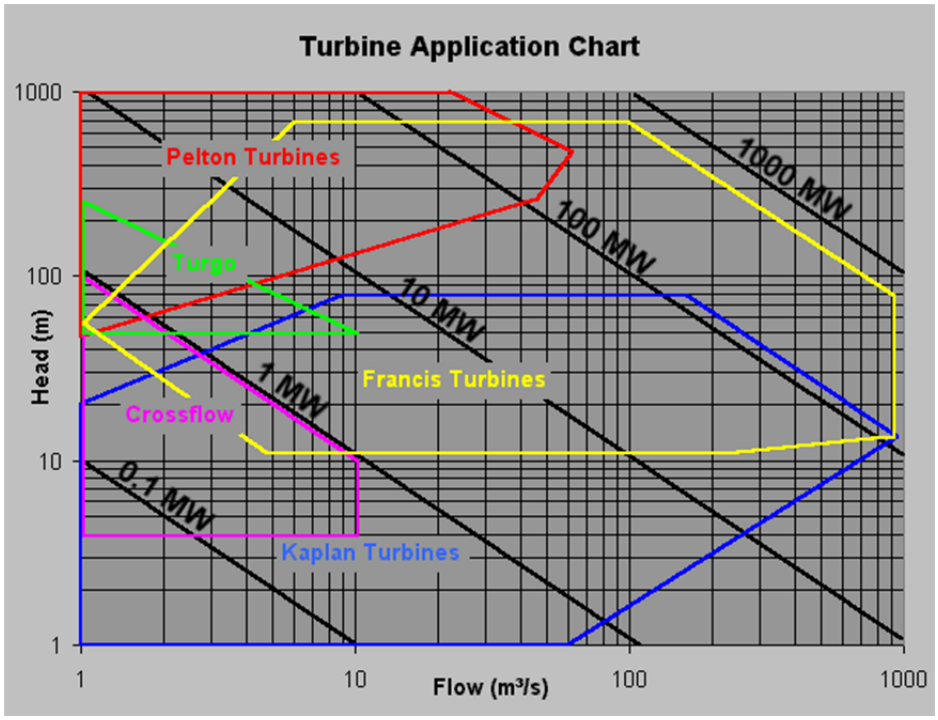

Figure 8: Demonstrates the range of Head and Flow at which the corresponding turbine would function efficiently. (Scheuber, Kircher, & Zhang)

These parameters are Head (m) and Flow Rate$\left(\frac{m^3}{s}\right)$. However, due to the limitations of the data, we only have the rise over run percentage value of the slope rather than the actual Head in meters. An estimated Head was calculated for the run distance of the cell from which the slope was obtained. It was decided that the run distance would be the length of the cells resolution, which was 10m. Multiplying this length by the slope, we obtained the head value for that cell.

The appropriate turbine that fell within the parameters of the calculated Head and Flow Rate was selected. The Kaplan Turbine was decided as the best fit for the calculated values. This turbine is usually designed to function efficiently in low-head applications. It will also function for the variations of the Flow Rate, as determined by the Standard Error. Of course, the head is not an exact value of the entire stream. Thus, for higher head, the Francis Turbine might be more appropriate. Both turbines have an efficiency of 90%.

With the obtained Turbine Efficiency, Head, and Flow Rate, the next step was to calculate the Power generation, as seen in Table 2, which shows the power potential of the Critical Sites in each Precipitation Grid area.

Table 2: Turbine power generation for each site shown in Figure 7.
*Each site corresponds to a different precipitation grid area and has the highest Power generation potential for its respective precipitation grid area. (*Is a site located at the edge of a waterfall drop).*

Stream Location	point id	Slope (rise/run %)	head [10m run] (m)	Avg Annual Streamflow Rate (cfs)	Avg Annual Streamflow Rate (m^3/s)	Turbine Power (KW)	Uncertainty (+/-KW)
Fall Creek	47	31.4	3.14	373.0	10.6	293.2	78.60
Fall Creek	125	26.4	2.64	322.4	9.1	213.0	66.1
Fall Creek	139	20.7	2.07	266.3	7.5	137.9	51.8
Fall Creek	140	22.5	2.25	304.2	8.6	170.8	56.2
Fall Creek	143	25.5	2.55	339.6	9.6	216.8	63.8
Fall Creek	148	40.1	4.01	487.4	13.8	488.9	100.3
Fall Creek	161	41.9	4.19	504.7	14.3	528.9	104.8
Taughannock	35	54.7	5.47	610.2	17.3	834.4	136.7
Taughannock	69	57.7	5.77	641.1	18.2	924.1	144.1
Taughannock	110	39.3	3.93	454.1	12.9	445.9	98.2
Taughannock	137	24.9	2.49	302.1	8.6	188.0	62.2
Six Mile Creek	218	41.4	4.14	470.3	13.3	486.6	103.5
Six Mile Creek	237	48.2	4.82	540.0	15.3	650.2	120.4
Six Mile Creek	250	69.7	6.97	757.2	21.4	1319.1	174.21
Salmon Creek	6	26.5	2.65	322.1	9.1	213.1	66.15
Salmon Creek	13	22.2	2.22	285.1	8.1	158.0	55.41
Salmon Creek	19	41.2	4.12	478.8	13.6	493.4	103.06

We estimate the total power generation potential of all 232 sites combined and its uncertainty as 88.5 +/- 18.6 MW. In Table 3, we can see how these sites are distributed according to their capabilities. The generation potential at individual sites varies from 114.4 kW to 2950.6 kW. One-hundred ninety-nine sites generate between 114kW to 600kW individually. It is important to note that sites that have a capability of 1000kW or more are sites that contain waterfalls or are near them. Thirteen of these sites are found just downstream of Beebe Lake while the other two are located right after the Ithaca Reservoir.

Table 3: Distribution of sites according to amount of power generation

Power	No. of Sites
114-150 kW	44
151-200 kW	73
201-400 kW	60
401-600 kW	22
601-800 kW	9
801-1000 kW	9
1001-1500 kW	5
1501-2000 kW	1
2001-2500 kW	6
2501-2950.6 kW	3

2.6 Limitations

It is important to emphasize that these results are very rough estimates with considerable uncertainties due to various factors. The most important one is the lack of USGS gauge data. There are only 5 gauged sites for the entire 1,233 km^2 area that is Tompkins County. Furthermore, additional predictor variables such as evaporation rate and soil-filtration rate should be included as part of the regression analysis to calculate the actual net flow. Also, the PRISM precipitation data has a very low resolution due to it being obtained from a precipitation grid-map intended to show the precipitation throughout the entire country. And the last factor was the complicated method for obtaining an adequate Head value. It is possible to obtain the desired head value by building a small reservoir upstream of the turbines' location, as shown in Figure 1. The height difference will determine the total hydraulic head. In conclusion, periodical on-site stream flow measurements are needed to reduce uncertainty and to determine real quantifiable values for a more precise analysis on ungauged locations. Despite all this, the study helps as a model to locate interesting sites for further research.

3. Opportunities and Challenges

There are both opportunities and challenges that may affect successful and acceptable implementation of micro-hydro in Tompkins County. Various factors, such as the unpredictability of weather and high initial installation costs, may present complications. Weather is expected to be highly unpredictable in the future due to climate change and stream flow which tends to vary considerably with the seasons. Drought may cause low-flow in streams, whereas very abundant rainfall may cause overflowing and flooding. In addition, very cold weather may cause water to freeze which may affect the functionality of the turbine or generator house. As for installation costs, micro-hydro can range between $1,500 to $2,500 per kilowatt of installed capacity (*Economics, 2004*). "Systems that are less than 5 kW in power output, the cost per kW is approximately $2,500 or higher because of the smaller size and the cost of additional components" (*Economics, 2004*). Because our power output is over 100kW, we can assume that "typical" system will cost $1,500 per kilowatt of installed capacity. Therefore, assuming this condition, a system of 5-10 kW to power a home, for example, would cost $7,500 to $15,000,

and a larger 100 kW to 600 kW would cost $150,000 kW to $900,000 kW. Thus, we must study what range of kilowatt capacity is economically feasible.

A factor in favor of micro-hydro is that it has the capability to generate significant amounts of electrical energy because of its continuous generation due to an unlimited source of running water. Because of this, the installation costs become reasonably affordable due to a shorter payback time as compared to solar energy (which only produces energy when there is sufficient sunlight), and wind energy (which can vary based on wind velocity and turbulence intensity). In addition, the micro-hydro generators produce energy even when energy consumption is very low (e.g., during the night). Currently, micro-hydro is qualified for net metering, capped at 20 kW for residential units, and 2 MW for non-residential units. This factor may help with the economics of these installations.

On the challenge side is that, the New York State Energy Research and Development Authority (NYSERDA) classifies micro-hydro as a form of renewable energy, meaning that it should be eligible for incentives and tax rebates from New York State (Jablonski & Hofmeyer). However, NYSERDA does not provide any financial support towards micro-hydro. In addition, The US Department of Agriculture (USDA)'s Rural Energy for America Program (REAP) recently added micro-hydro to the list of renewable energy infrastructure projects that are eligible for low-interest federal loans. It is essential that New York State and NYSERDA follow the federal government's lead and make micro-hydro eligible for the same subsidies and tax rebates solar and wind receive.

Finally, geographical accessibility and public opinion may present both a challenge and an opportunity. The micro-hydro site should not be too distant from the community, home, or business to which it will be supplying energy, as distance may present a problem for transferring the energy to the user. Also, for means of easy maintenance, the site should be easily accessible whether on vehicle or on foot. Public opinion is probably the most important factor for successful implementation. Some may find it positive to change to renewable as a means of clean energy. However, some may relate micro-hydro to the civil work done on large scale hydro-generation plants that, due to their size and necessity to flood the area, are ecologically harmful. A public forum is needed to discuss the implications and inform the community of the project by discussing how micro is different from typical, large scale, hydro generators and how the environmental impact is minimal.

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