# Hydroelectricity in Washington State
## Finding New Locations for Hydroelectric Dams

Victoria Karout, University of Washington-Tacoma
2010-2011 GIS Certificate Program

## Introduction

Society's longstanding dependence on non-renewable energy sources such as oil and coal has proven to be incredibly harmful to the environment. Hydroelectricity has presented the future with an opportunity to utilize an alternative type of energy source - a renewable one. Hydroelectric power is best produced through the implementation of dams that contain turbines. The turbines turn as water passes through, which in turn rotates a metal shaft in an electric generator that outputs electricity. Power lines distribute electricity across space from the power source to areas of demand.  An ideal placement for a damn is in a section of a river that has a large drop in elevation, creating a higher stream flow. This allows the water to move more rapidly through the turbines and in turn allows the generator to produce power at a higher rate (USGS, 2011). Since hydropower is a renewable source, the dam requires only a single building so it does not continuously deplete resources, but still continuously produces electricity. The dam also does not emit pollution in the air, land, or water, which is contrary to the side effects of most typical electric power plants. Current consumption of hydropower in the United States lies at 28 million households, which is the equivalent of 500 million barrels of oil (US Department of Energy, 2011). Washington State boasts itself as the leading hydroelectric power producer in the nation, as it produces nearly 75% of the state's electricity via hydropower.  The Grand Coulee hydroelectric power plant located on the Columbia River is the highest capacity electric plant in the nation. The remainder of the state consumes non-sustainable energy sources such as coal, natural gas, petroleum, and even nuclear power to fuel consumer demands (US Energy Information Administration, 2011). The purpose of this project is to propose the best sights for the building of hydroelectric dams in Washington State. The hypothesis is that one or more possible dam sites will be found, where the state will be able to supply the remaining 25% of non-hydroelectric consumers with hydroelectricity. Washington State has already proven itself as a leader in hydroelectric power. By further excelling in this endeavor for a more sustainable electric supply, Washington State can serve as an exemplary role model on both a domestic and global level.

## METHODS

Throughout the course of the Certificate Program, this project changed significantly. Originally, the project was going to be on finding out where each hydroelectric dam was located, then where each dam provided electric services to. The final step was going to be finding out why each place that did not have hydroelectric power delivered to them was using other, environmentally harmful sources of energy. Through numerous group discussions, it was discovered that performing an analysis like this did not fully, or even partially, use much of the GIS techniques provided throughout the Certificate Program. Since the main goal of the project is to transform all of Washington State into a completely hydroelectric power state, why not find new locations to install hydroelectric facilities to be used to achieve this goal? Performing an analysis like this requires much more extensive GIS techniques, knowledge, and research.

Since the extent of this project was Washington State, the first thing needed was a Washington State base map. This was obtained from WAGDA. River and stream locations were then needed and found through The Northwest Habitat Institute. Dam coordinate locations were found at the Lattitude-Longitude search engine. Coordinate locations were inputted into a Microsoft Excel table file, then imported into ArcMap as a table. The 'add x-y coordinate' tool was then used to create a point shapefile. Stream flow data was found for 582 various sample locations throughout Washington State rivers through studies performed by the US Department of Ecology. These points were then interpolated using the IDW interpolation method to estimate stream flow of rivers in between these sample points. This raster file was classified using the standard deviation method and broke up the data into four classes. The class with the highest stream flow was used to represent ideal areas to build a hydroelectric dam. Restricted rivers in Washington State due to salmon and steelhead populations were found through a reference at the Washington State Department of Fish and Wildlife: Lori Guggenmos, the Protected Habitat and Species (PHS) Data Release Manager. Restricted lands due to Native American tribal protected lands and lands of critical environmental concern were found through the same protected lands website. All raster data was input into a geodatabase and vector data into a feature dataset, all of which were set to the coordinate system: NAD_1983_UTM_Zone_10N.

## Results

Based on the analyses that were performed, it was found that areas with the highest stream flow already had dams built on them (figure 2). However, it was found that in many places, dams were built very close to each other (figure 1), which means there is no restriction as to how close a dam could be built to another dam. Based on restrictions for land of critical environmental concern, tribal areas, (figure 3) and salmon and steelhead populations (figure 4), overlayed with stream flow information, there were still several areas found - all of which on the Columbia River - to be available (figure 5, as seen in red).

## Discussion

This project, in a sense, performed a gap analysis. Gap analysis is defined by Savitsky *et al.*, (1998) as able to: "Provide a method for assessing present measures to protect biological diversity and for identifying focus areas for optimal conservation efforts. Gap analysis is a GIS technique which superimposes species distributions with boundaries of ecosystems and protected areas to identify gaps in the protection of species." Basically, gap analysis is a tool that identifies gaps. Although in this project gaps were not found to protect species, the same kind of technique was used to find gaps where hydroelectric dams were not placed, but could be placed. Gap analysis could be considered an extension of the overly technique. For example, for a biology project, gap analysis could be performed by combining two layers: (1) being land in parks and protected wilderness areas and (2) being the ranges of the region's deer population. By overlaying these two layers we could look for unprotected places where deer roam - in other words, looking for gaps in deer protection. In this project, we essentially combined two layers as well: (1) rivers ideally available for hydroelectric dam building, based on stream flow, (2) areas restricted due to salmon and steelhead populations, land of critical environmental concern, and tribal areas. A similar project was performed by Vandergast *et al.,* (2009). Here, the goal was to establish a spatially explicit evolutionary framework for Southern California, and evaluate whether current land reserves adequately protected areas with high evolutionary potential. To do this, genetic landscapes were overlaid with a protected lands layers. In relating to my project, genetic landscapes could be considered river and stream flow information, whereas protected lands layers would be the considered the three protected land layers I used. They created 'hotspots' of misdistributions of protection and drew attention to the problem. Relating this to my project, I created 'hotspots' in a similar manor of areas that could have a hydroelectric dam built on them, or areas of misdistribution of electrical power.

Through the numerous readings prior to performing the analyses for this project, a new perspective was gained on many aspects of GIS, especially in relation to cartography. An article in particular that stood out argued that critical cartography and GIS would benefit from an analysis of how the average person interprets maps (Cidel, 2008). In this case, they talked about bringing together local residents, state officials, and scientists, all of which have varying interpretations on the maps they were to look at, which were based on where planes fly near the St Paul International Airport, MN. They did this in an effort to show how the public creates their own critical cartographies. One person in particular stated: "I saw the map, and the map is a lot of waves and things like that, which is completely beyond my understanding. All I know is that planes fly in a straight line over my house." This quote clearly shows that not everybody sees things the same way, and made me realize that just because I have done my own extensive research on my project and fully understand it, does not mean that everybody else who is going to be looking at my final layout will interpret it the same way. Nobody else has seen or experienced the same exact things I have in life, nor have I about their lives. In order to avoid any confusion, a clearly labeled key was created, and the final output being shown was clearly labeled in red, while everything else was in earth-tones.

## Figures

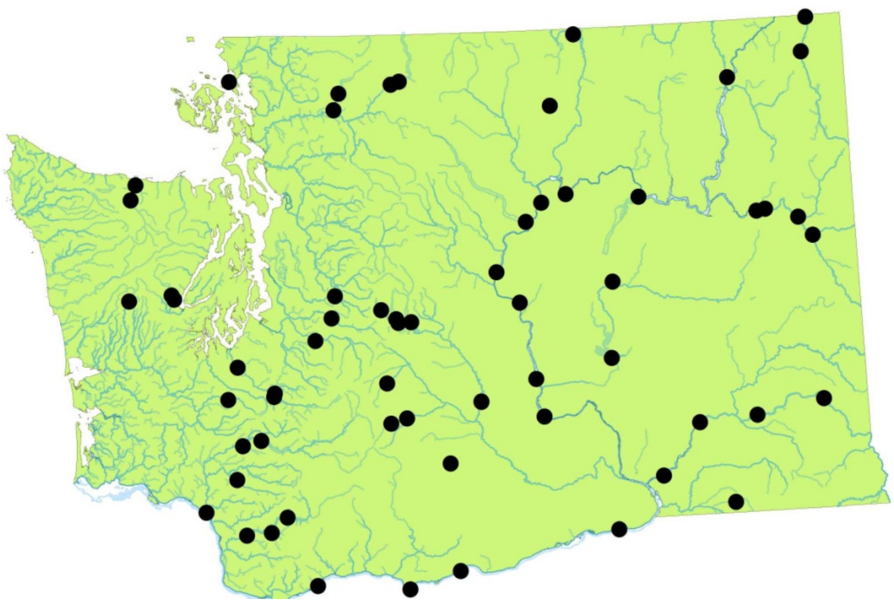

**Figure 1: Current Dam and River Locations**

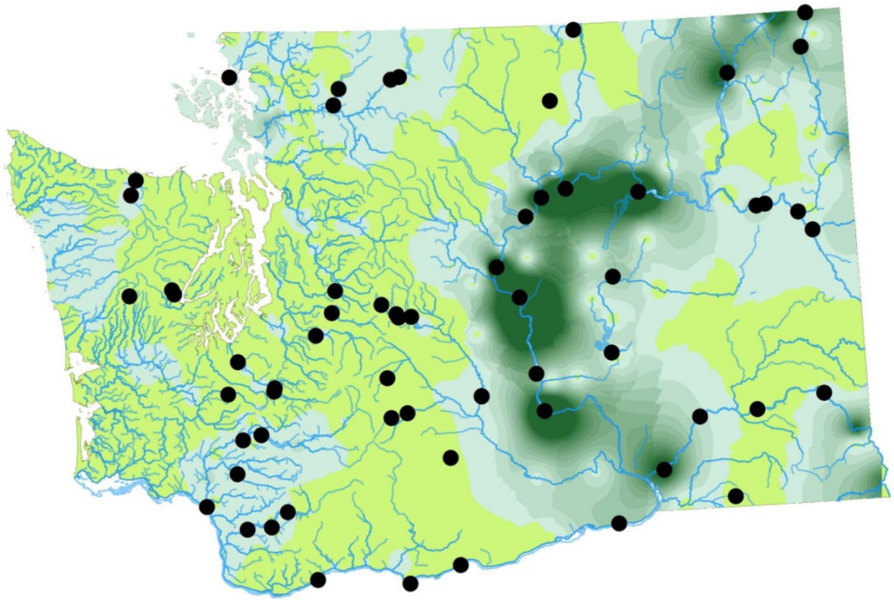

**Figure 2: Stream Flow**

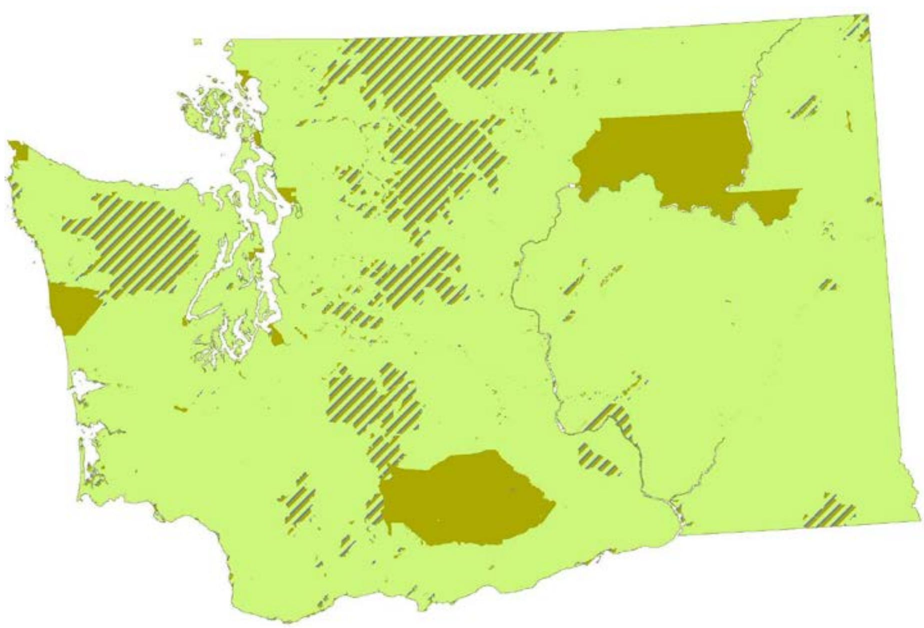

**Figure 3: Restricted Lands Due To Areas of Critical Environmental Concern and Tribal Areas**

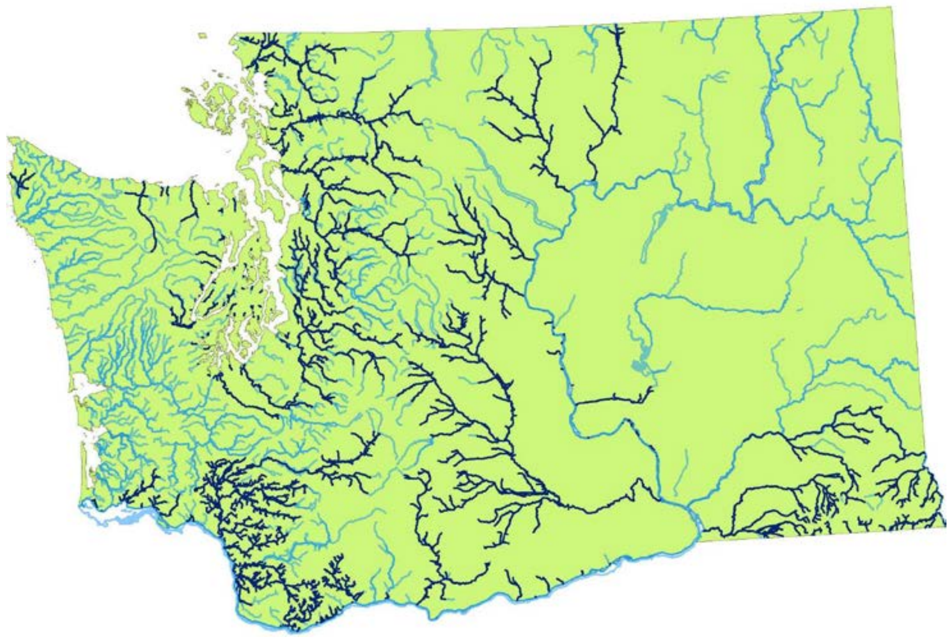

**Figure 4: Restricted Rivers Due To Salmon and Steelhead Populations**

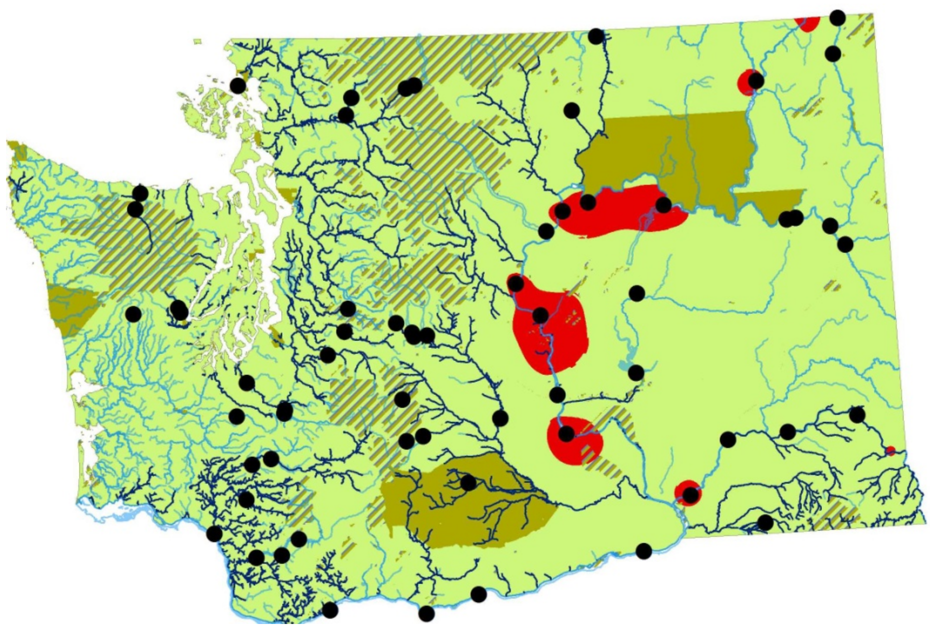

**Figure 5: Ideal Areas For Hydroelectric Dams Based on Restrictions and Stream Flow**

## DATA SOURCES

Wagda: http://wagda.lib.washington.edu/

The Northwest Habitat Institute: www.nwhi.org/index/gisdata

Latitute-Longitude Search Engine: www.lat-long.com

US Department of Ecology: www.ecy.wa.gov/services/gis/data/data.htm

Washington State Department of Fish and Wildlife: http://www.protectedlands.net/padus/

## REFERENCES


Cidell J. 2008. Challenging the Contours: Critical Cartography, Local Knowledge, and the Public. Environment and Planning. 40:1202-1218.

Savitsky BG, Lacher TE Jr. 1998. GIS Methodologies for Developing Conservation Strategies: Tropical Forest Recovery and Wildlife Management in Costa Rica. New York. Columbia University Press.

USGS. May 22, 2011. Hydroelectricity. http://www.epa.gov/cleanenergy/energy-and-you/affect/hydro.html.

US Department of Energy. May 22, 2011. Hydropower. http://www.energy.gov/energysources/hydropower.htm.

US Energy Information Administration. May 23, 2011. Washington. http://www.eia.gov/state/state-energy-profiles.cfm?sid=WA

Vandergast AG, Bohonak AJ, Hathaway SA, Boys J, Fisher RN. 2009. Are Hotspots of Evolutionary Potential Adequately Protected in Southern California. Biological Conservation. 141: 1648-1664.