INTRODUCTION

Hydroelectric power captures the energy released from falling water. In the most simplistic terms, water falls due to gravity, which causes kinetic energy to be converted into mechanical energy, which in turn can be converted into a useable form of electrical energy. Ancient Greeks used wooden water wheels to convert kinetic energy into mechanical energy as far back as 2,000 years ago. In 1882 the first hydroelectric power plant was built in the United States using a fast flowing river. Humans in time began creating dams to store water at the most convenient locations in order to best utilize power capacity (Australia Renewable Energy). Additional engineering and structural changes have followed, providing for a much more complicated process in designing a hydroelectric power plant.

Hydroelectric power plants are categorized according to size. They fit into one of four different size ranges: Micro, Mini, Small, and Large. A Micro sized plant is one that generates less than 100 kW of electricity and would typically be used to power 1-2 houses. A Mini facility can serve an isolated community or a small factory by generating 100kW-1MW of electricity. A Small plant generates 1MW-30MW and can serve an area while supplying electricity to the regional grid. Lastly, a Large facility generates more than 30MW of power. Hydroelectric power accounts for about 10% of the total energy produced in the United States. The United States has the hydroelectric power potential to create 30,000MW of electricity by utilizing 5,677 undeveloped sites. This figure is based on environmental, legal, and institutional constraints. In Pennsylvania, we could potentially produce 5,525,646 MWhr of electricity annually; however, this would still only account for 3% of total electricity generation in the commonwealth.

According to the US Hydropower Resource Assessment Final Report, there are a total of 104 projects that have a nameplate capacity of 2,218MW. One of these sites is the Flat Rock Dam in Manayunk, PA and this will be the site of our proposed hydroelectric power plant. It is or endangered species, the dam construction could further threaten that species risk of extinction (Biswat, 1981).

The reservoir that has been rapidly filling up with water immediately begins filling up with sediment as well. Obviously the use of the reservoir is inhibited by sedimentation, so less water can be stored when more sediments fill in the bottom of the reservoir. The engineering problem with sedimentation is that less power is generated as the reservoir's capacity shrinks. Clean water stripped of its sediment load is now flowing downstream of the dam. This clean water has more force and velocity then water carrying a high sediment load and thus erosion of the riverbed and banks becomes problematic. Since this is unnatural and a form of "forced erosion" it occurs at a much faster rate then natural river process erosion to which the local ecosystem would be able to adapt. Environmentalists must work to slow down the water by creating barrages, although the effectiveness of these techniques is not exactly known (Thorndike, 1976).

An additional problem the sedimentation of the dam creates is erosion of the delta at the mouth of the river. All the sediments that are now trapped in the reservoir previously ended up in the delta. The Aswan Dam on the Nile River is a perfect example; the delta that is 1,000 km away is heavily eroded by winter waves. Sediments carried downstream during flood season would build the delta back up again before the dam was constructed. However, lacking sediments during flood season now, the delta is eroded nearly year round.

Oftentimes some of the most severe environmental implications of a project occur during the construction phase. The case of building a dam is no exception. Many new roads are built which requires the removal of vegetation and topsoil since dams tend to be built in undeveloped regions. The fill used for the dam often comes from the local area, in an effort to reduce

Biological

Animal and plant life are impacted significantly by the dam construction. As mentioned earlier the large scale flooding destroys a large area of habitat for animals and destroys an equally large number of plants. If the region was forested prior to the construction of the dam the timber is harvested before the flooding begins. Reservoirs that in the future will be used for recreation such as boating or fishing tend to be completely cleared of trees. In addition, in very cold climates such as Canada, deterioration of fully submerged trees occurs very slowly – increasing the likelihood that the trees must be removed first (Biswat, 1981). The impact of tree removal is more logging equipment around the dam site which of course increases roads and pollutants into the region.

Flora

Another negative biological impact of dams is the growth of aquatic weeds. Tropical and semi-tropical regions seem to have the largest problem with weed growth. In Surinam, Lake Brokopondo has become inundated with *Eichhornia crassipes*, which is commonly referred to as water hyacinth. In just four years the water hyacinth has covered more then fifty percent of the reservoirs surface. The impacts of weeds can be significant to water loss. More weeds growing in the reservoir result in a higher rate of evapotranspiration. Also, more water must be released for irrigation purposes to ensure that an adequate supply makes it to the lower reaches of the irrigation channel if there are weeds growing in the channel as well. The weeds will compete with fish for space and nutrients that are already under stress living in an unnatural setting.

Some disease rates such as malaria and schistosomasis tend to increase as weeds provide a very favorable habitat for mosquitoes and other invertebrates that spread these diseases. How do we contain these problems? The weeds can be controlled, although the task is often very environment but spend their adult lives at sea in the salt water. The eel, a kind of fish classified as catadromous, is hatched at sea but spends much of its adult life in freshwater streams (Biswas 1981). Since these fish rely on streams and rivers to get to and from different environments, creating a dam makes a large roadblock for these animals to overcome. This is especially true in the Pacific Northwest in the United States. Without features such as fish ladders these fish would die off. However, even the fish ladders do not work perfectly and many fish die due to the dams.

There are a number of measures that can be taken to help minimize fish mortality at hydroelectric power plants. The most obvious step is to lower the number of fish that pass through the turbine. This can be accomplished by using better screens to capture the fish or establishing diversion passageways. A more complicated and emerging technology involves making "fish-friendly" turbines.

It is thought that gap sizes, runner-blade angles, wicket gate openings, overhang, and flow patterns are the components that most lead to fish injury. Pelton turbines, which are small turbines designed for high head installations cause nearly complete mortality of fish passing through. Kaplan, Francis, and Bulb turbines tend to be safer for small fish with mortality rates of only about thirty percent. These types of turbines have much larger areas of water passage. Kaplan turbines are thought to be the most fish-friendly of the conventional turbines. These turbines are used on the Columbia and Snake Rivers in the Northwestern United States and have a low mortality rate of just twelve percent. Scientists and engineers hope to work together to make changes to the design of turbines to ensure fish safety. Research is showing that reducing gaps might help fish pass through turbines safely. By reducing the gaps there should be less shear stress and grinding. However, it should be noted that all of this research is too preliminary

In order to evaluate this site for a hydroelectric power plant, we must consider the fact that there is a pre-existing dam, the ownership of the dam (land use rights) and how much it will cost to modify and maintain the dam (covered in the site construction analysis). BAMR (The Pennsylvania Department of Environmental Protection's Bureau of Abandoned Mines Reclamation) has full ownership to the Flat Rock Dam. However, Lower Merion Township maintains a boat launch and picnic area that provides recreational access to the pool and dam. There is currently some controversy surrounding the use of powerboats in the pool area.

The debate surrounding the economics and environment of the dam provides us with the question of "Should the dam be used for maximum potential, or be maintained as is?" The dam has historically provided a means of livelihood; however, what is its future potential? The Flat Rock Dam was destroyed previously in a flood and rebuilt; the costs that accrued with rebuilding were substantial. Were they unnecessary? The dam is currently not providing any means of power to the residents of Manayunk. Historically it proved to be an invaluable asset to the community. When considering extensive technological improvements, the provision of power would not be of high interest to the citizens of Manayunk who now receive their power from Philadelphia based electric providers. Though the Flat Rock Dam is a historically important site, many environmental problems mentioned above have contributed to the idea that it should be removed. Alternatively, if the dam was not removed but rather upgraded and built upon as an energy provider for the community, what would it look like and what would the details involve? We will turn to these questions in the remaining section.