A Discussion on the Historical, Present, and Future Flow of the Millrace

Leah Youngquist 2017

Introduction

The Eugene Millrace was founded in 1851 by Hilyard Shaw, when he climbed atop one of the Eugene's buttes and noticed two natural sloughs that had been disconnected from the Willamette River. The two sloughs were turned into one via a man-dug channel and reconnected to the Willamette River, originally for industrial purposes. However, as time went on, water-powered industry became outdated and inefficient, and recreation began to dominate the Millrace. As early as 1884, ice skating on the frozen Millrace was a popular activity of Eugene residents and university students. Canoeing, swimming, and various aquatic activities were enjoyed by all along the Millrace. However, the Millrace's place in Eugenian culture has fallen away entirely, thanks to several floods in the early 1940s that destroyed the dam and the intake channel, leaving the Millrace as it had once been – completely disconnected from the Willamette River (Willingham). Since then, little has been done to reinstate the Millrace, and it has become a sluggish, smelly creek. The University utilizes pumps to keep the water from becoming totally stagnant during the warmer, drier months of the year, but there is still no significant flow in the channel.

Comparing the historical flow to the modern flow of the Millrace is an astonishing example of urbanization falling short on the improvement of land and culture, as a place which was once a hub for social interaction and industry has become nothing more than a dirty eyesore. In the interest of presenting viable solutions for the unseemly Millrace, the past and present flow of the Millrace were examined to determine whether it could be reinstated to its original flow patterns. There are many drawbacks to the restoration of the Millrace, including a heinous cost and potentially devastating movement of sediment, but there are also rewards which could be reaped, such as a renewal of a historical community bond. While I would encourage the reinstatement of the Millrace's flow, it is unlikely that it will ever come to be.

Methods

To assess the modern flow of the Millrace, I took cross-sectional measurements of the Millrace at five different spots. These spots are shown in Figure 1 below. These spots were picked based on ease of access, the need to sample the entire length of the Millrace, and the historical data available to me.

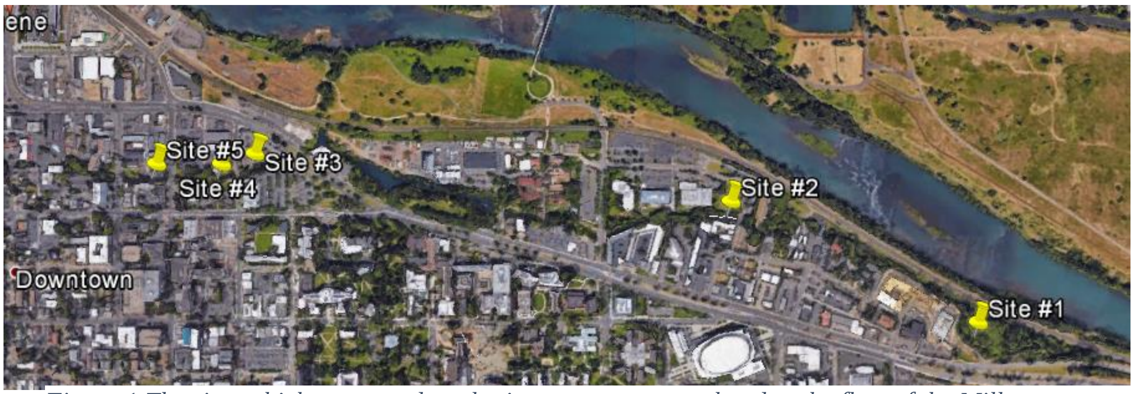

Figure 1 The sites which were used to obtain measurements related to the flow of the Millrace.

To obtain the cross-sectional measurements for sites 1 and 2, I had a partner (Alison Oriba, a fellow student at the University) hold one end of a 30-meter measuring tape while I took the other end to the opposite bank. On my way across, I stopped in the middle and measured the deepest part of the channel with a meter stick. For sites 3, 4, and 5, I worked alone. To measure the width, I used the same measuring tape and laid it on the ground on the bridges nearest to the sampling sites. To measure depth, I tied the meter stick to the measuring tape and lowered the contraption from the bridge to the floor of the channel, stopping first at the surface and noting the length and then subtracting that from the length of the measuring tape when the meter stick had reached the bottom. Figure 2 shows this meter stick-measuring tape combination tool. To measure velocity, I dropped leaves and orange peels into the Millrace and timed how long it took for the object to travel one meter (measured with the meter stick).

To assess the historical flow of the Millrace, I consulted the University of Oregon Archives for photos of the Millrace from its inception through the 1970s. From these photos, I could estimate the water depth of the past, thanks to the unchanged, uniform concrete siding of the Millrace downtown as well as the landmark buildings that are still standing. I was able to go to the spots where the pictures were taken and measured the depth shown in the photographs. To estimate the historical velocity, I watched *Ed's Coed* (1929) and used canoes and other objects floating in the Millrace in the background of the shots.

Figure 2 The meter stick-measuring tape combination tool

To predict the possibility of the Millrace being returned to this higher flow rate, I used the Eugene Water and Electric Board (EWEB)'s website to estimate costs of increased pumping based off the pump information given to me by Mo Soleimani (a man who works at the Campus Facilities Office).

Results

The modern Millrace had an average discharge (area*velocity) of 0.5 m^3/s (standard deviation=20.7 m^3/s) when the pumps are turned on. The average hydraulic radius is 0.3 m (standard deviation=0.126 m), and the average shear stress is 40 N/m (standard deviation=23.9N/m). These standard deviations are the compound deviations of the averages which were used in the larger equations (i.e., average area and velocity were used to find the average discharge, and the standard deviation reflects this).

The historical Millrace had an average discharge of 20 m^3/s (standard deviation=2.405m^3/s). The average hydraulic radius was 0.7 m (standard deviation=0.670 m), with an average shear stress of 60 N/m (standard deviation=9.64 N/m). Again, the standard deviations consider the averaged values used in the larger equations.

There are, of course, multiple sources of error in these values, including imprecise measuring utensils and human error, measuring the historical water depth assuming today's sediment height is an appropriate parallel for the historical flow, and weather-related changes in flow from day to day. As such, each average has been given only one significant figure, while the standard deviations have been given more to reflect these sources of error.

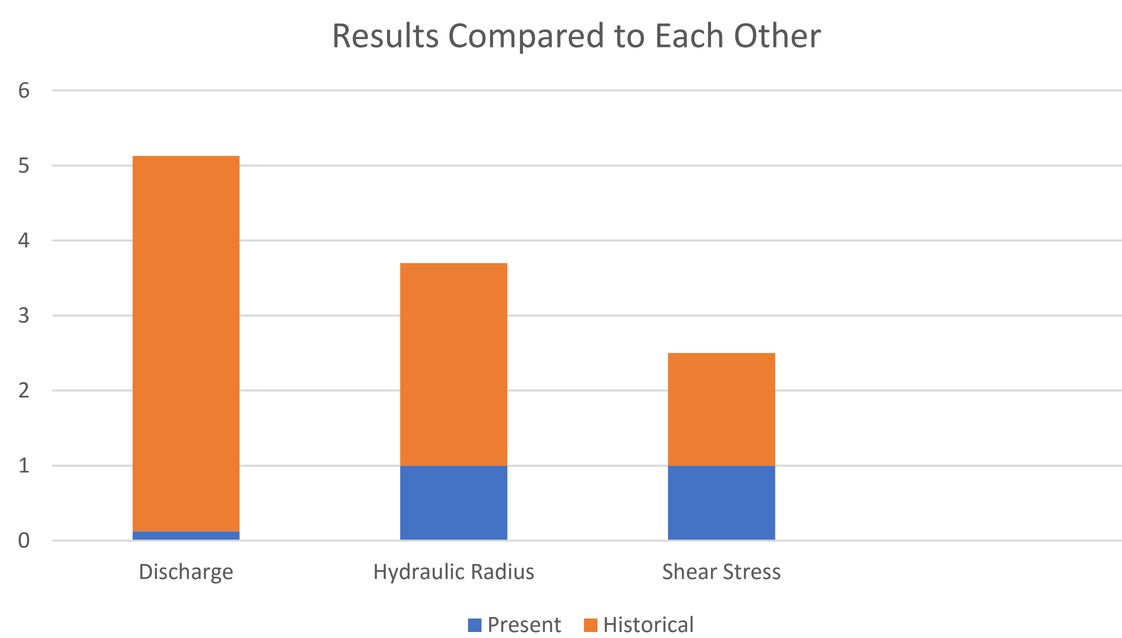

Table 1- 1: Note, units are irrelevent here. This is only a visual comparison of the two Millrace flows.

Discussion

It is clear to see that the Millrace has taken on a completely new flow regime since the intake was separated from the Willamette River. The historical discharge is forty times larger than the modern discharge, and the shear stress is 20 Newtons larger. Plus, the hydraulic radius of the historical Millrace is 0.4m larger than the hydraulic radius today. This means the Millrace was moving a significantly larger amount of water in a more efficient manner than the Millrace moves its water today, as shown by the discharge and hydraulic radius values. Before the Millrace can be returned to this original rate of flow, consideration must first be given to the potential consequences of increasing the discharge.

The first consideration must be given to the increased shear stress that would result from an expanded discharge in the Millrace. Shear stress is indicative of a stream or river's ability to do geomorphic work via sediment transport and erosion, and it is defined as ρgRS (density of water*acceleration due to gravity*hydraulic radius*slope) (Charlton). As one can see from the mathematical definition, shear stress increases as the hydraulic radius, and therefore the discharge, increases. This is a concern especially in the Millrace because there is upwards of five feet of unconsolidated sediment settling on the bed, according to Ethan Niyangoda. Roberts et. al. (2003) observed the simple yet important fact that the ratio of a channel's suspended load to bedload sediment is dependent primarily on grain size and shear stress. For the purposes of the Millrace, grain size is negligible due to the extremely fine nature of the sediment which is easily transported. It is more important to consider that an increased shear stress will lead to a larger suspended load, which moves sediment much more quickly than bedload transport (Evans). Before forty times more water is pumped through the Millrace, there must be careful consideration given to what such massive movements of sediment could mean for the Willamette River.

The Millrace empties into the Willamette River at two locations: one at the west end of the Millrace Pond and one near the intersection of 11th Avenue and Patterson Street. Therefore, careful scrutiny must be given to the potential negative impacts an increased Millrace discharge could have on the Willamette River. For example, Suttle et. al. (2004) conducted a study on the Steelhead Trout in northern California. They found that when fine sediment deposits increased in the larger rivers, growth and survival rates of the trout decreased in a linear fashion, suggesting that “there is no threshold below which exacerbation of fine sediment delivery…will be harmless” (Suttle et. al.). In the Willamette River, we have not to worry about trout, but rather salmon. However, the same principle applies, and if the Millrace were restored to its original flow, there would be significantly more fine sediment delivered to the Willamette River on a local scale. Furthermore, reopening the full connection between the Millrace and the Willamette River would leave the Willamette River even more susceptible to urban runoff and pollution issues, as the city of Eugene is primarily paved and runoff is purposefully channeled into the Millrace. For instance, Gurnell et. al. (2007), discuss in their study methods to prevent polluted runoff from entering urban river channels, such as increased filtration of runoff – something which is already being utilized at the Millrace Pond. If more of these installations were placed along the length of the Millrace, it would decrease the chances of urban runoff polluting the river. As of now, the flow is not sufficient enough, in my opinion, to truly transport damaging amounts of litter or urban chemical pollution into the Willamette River. However, should the discharge of the Millrace increase forty times with no increased filtration, there is potential for the delicate ecology of the Willamette River to suffer.

Of course, not only are there ecological and geomorphic hazards for the Willamette River, but there are some concerns to be had for the Millrace itself. In the event of increased flow in urban channels, Gurnell et. al. (2007) noted that channel enlargement is a “characteristic response.” The Millrace would be subject not only to erosion of its bed sediments, but it would also be subject to erosion of its banks. This would create a positive feedback cycle, according to Simons and Senturk, who have said that shear stress in an open channel is highly dependent on the cross-sectional shape of the channel. Therefore, as the discharge increases, the erosion of the banks and beds of the Millrace will increase, causing a spike in the shear stresses, which will in turn cause *more* erosion. This cycle would continue until the entirety of the Millrace would require cement channel walls to prevent further channel migration and deterioration.

A final drawback to reinstating the historical flow regime of Eugene's Millrace is the cost of maintenance. If the intake is not reconnected to the River such that water flows naturally into the Millrace, the flow must be regulated by pumps that are located just west of the original intake spout. According to Mo Soleimani, the pumps run twenty-four hours a day, seven days a week from May to October. Only one pump runs at a time, and they are switched every week. The pumps run at 5,500 gallons per minute (0.4 m^3/s), 480 volts, and 30 kilowatts (Soleimani). At the current level of usage, the electricity required to run the pumps costs the University $32,723.31. This total comes from six monthly payments of $5,453.89. Specifically, there is a flat $59.30 "basic charge," $7.431 per kilowatt-hour "demand charge," and $0.6148 per kilowatt-hour "energy charge" for the "Moderate Use" under which the pumps' current needs fall under ("Commercial Pricing"). To bring the Millrace back up to its historical flow, the pumps would need to be utilized year-round, running both at a time twenty-four hours a day. This would lead to the University pumps' being classified as "Maximum Use," resulting in more expensive charges. To run both pumps year-round, it would cost $99,935.48. This is twelve monthly payments of $8,327.96, composed of a $2,757 "basic charge," a $7.688 per kilowatt-hour "demand charge," and a $0.04944 per kilowatt-hour "energy charge" ("Commercial Pricing").

This heinous sum of money required for the pumps is a deterrent for any organization which desires to redevelop the historical flow regime in the Millrace.

These are the most prominent drawbacks to refilling Eugene's fallen-from-grace Millrace. However, there are solutions which have the potential to resolve most of the concerns. Economically speaking, one must remember that the University of Oregon does not own the entire Millrace. The University owns the pieces of the Millrace which flow through campus property, and the rest is managed by the city or private property owners. This means that the University is not solely responsible for the costs of the Millrace, especially as refilling the Millrace would have benefits for every one of its partial owners. If the electricity costs could be split up between at least the city and the university, it would cause only increase the current pumping costs to the university by a small fraction. Furthermore, the hazards of fine sediment deposition in the Willamette River could be mitigated by dredging the bed of the Millrace. If the several feet of sediment were removed from the bottom of the Millrace and moved elsewhere, such as to a city park or public garden, there would be significantly less sediment transported to the river. Of course, this doesn't resolve the issues of the Millrace channel migrating or its banks eroding, but even a small reduction in the sediment delivery would be an improvement. Plus, channel migration and bank erosion can be delayed or resolved by reinforcing the channel's banks with riparian vegetation, as the roots create a cohesive matrix within the bank.

Not only are there solutions which directly address all the drawbacks, but there are also potential benefits to be reaped from refilling the Millrace. Most notably, if the Millrace had any semblance of flowing water, it would increase dramatically in aesthetic value. As it is now, the Millrace looks sluggish, clogged, and gross. It also smells like rotting mud. However, if the discharge were upped to 20 m^3/s again, the flow would look more appealing, and it would reduce the odor. Furthermore, if the Millrace were engaging, there would be greater community interest in the wellbeing of the Millrace. In the early 1900s, when the Millrace was still young, it was used by the community as a swimming and canoeing resource (Willingham). If there were only more water in the channel, the Millrace could once again become a mainstay in the local Eugenian lifestyle. Common places provide a place for community to foster and local connections to become stronger. Overall, having communal areas which are open and available to all are critical to forming a tightly knit community of peers. Finally, flowing water and a larger surrounding wetted area can provide a more adequate habitat for some animals and plants, including native plants such as *Myriophyllu hippuoides* (Western Water Milfoil) and *Pleuropogon oreganus* (Oregon Semaphore-grass) – both of which require swampy ground or moving water (Steward et. al.).

Conclusion

Because the refilling of the Millrace would be more aesthetically pleasing and unifying for the community, I believe the Millrace's discharge should be increased. There are, undoubtedly, ecological, economic, and geological risks which must be thoroughly assessed by someone more qualified than I am, but I am firmly of the opinion that these risks could be mitigated through discussion, compromise, and common sense within the community. Historically, the Millrace has been more like a river's side channel than a swampy, sluggish creek, and it is best fit to be as much, due to the social and ecological benefits that could arise from an increased flow in the Millrace.

Works Cited

Charlton, Ro. "Flow in Channels." Fundamentals of Fluvial Geomorphology. London: Routledge, 2013. 69-92. Print.

"Commercial Pricing." EWEB. Eugene Water and Electric Board, n.d. Web. 04 June 2017. <http://www.eweb.org/business-customers/commercial-pricing>.

Evans, Mark. "Types of Sediment Load." Encyclopedia of Environmental Change (n.d.): n. pag. 2002. Web. 10 June 2017. <http://www.lc.pitt.edu/distilledlandcpdf/10_sediment.pdf>.

Gurnell, Angela, May Lee, and Catherine Souch. "Urban Rivers: Hydrology, Geomorphology, Ecology and Opportunities for Change." *Geography Compass* 1.5 (2007): 1118-137. *Wiley Online Library*. Web. 10 June 2017. <http://onlinelibrary.wiley.com/doi/10.1111/j.1749-8198.2007.00058.x/full>.

Roberts, Jesse D., Scott C. James, and Richard A. Jepson. "Measuring Bedload Fraction with the Asset Plume." *Journal of Hydraulic Engineering* 129.11 (2003): n. pag. *USGS Water*. United States Geologic Survey. Web. 09 June 2017. <https://water.usgs.gov/osw/techniques/sediment/sedsurrogate2003workshop/roberts.pdf>.

Simons, Daryl B., and Fuat Senturk. "Flow Resistance in Streams." *Sediment Transport Technology: Water and Sediment Dynamics*. Littleton, CO: Water Resources Publications, 1992. 107-60. *Academia.edu*. Dr. Caglar Ozcan. Web. 09 June 2017. <https://www.academia.edu/33299748/FLOW_RESISTANCE_IN_STREAMS>.

Steward, Albert Newton, Larea J. Dennis, and Helen M. Gilkey. Aquatic Plants of the Pacific Northwest. 2nd ed. Corvallis: Oregon State UP, 1963. PDF.

Suttle, Kenwyn B., Mary E. Power, Jonathan M. Levine, and Camille Mcneely. "How Fine Sediment In Riverbeds Impairs Growth And Survival Of Juvenile Salmonids." *Ecological*

Applications 14.4 (2004): 969-74. *Wiley Online LIbrary*. Web. 10 June 2017. <http://onlinelibrary.wiley.com/doi/10.1890/03-5190/full>.

Willingham, William F. "A Historical Context for the Eugene Millrace and Intake Structures." *Scholars Bank*. University of Oregon, n.d. Web. 10 June 2017. <https://scholarsbank.uoregon.edu/xmlui/bitstream/handle/1794/18653/EugeneMillraceIntakeStructures_HistoricalContext_20100226.pdf?sequence=1>.