Final Design Report

May 7th, 2018

Quantitative Analysis of Gilman Pond Reservoir

Team #24

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Disclaimer

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This project was under the Investigation and Assessment category for the CEE 797/798 Project Planning and Design course. All potential solutions posed in this document are not set to a full scale design, rather a preliminary 30% design.

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Introduction

Gilman Pond Reservoir located in Unity, NH, shown in Figure 1, is used as the town of Newport's main water supply which provides a substantial portion of the drinking water for the 6,500 residents, using up to 500,000 gallons per day. In 2016, 100 percent of New Hampshire experienced some extent of drought conditions and left 19 percent of the state experiencing extreme drought conditions from early September to late October (NIDIS, 2018). During this time, small towns including Newport NH, were having trouble with supplying adequate quantities of water to their citizens. For the last few years Newport has had to periodically mandate a town-wide water ban due to their main source of water, Gilman Pond, being unable to meet water demands during drought conditions. Although the water ban does not happen often, the town would like to avoid future bans. To help alleviate this problem the town reached out to the university for assistance in research efforts and requested the team to quantify the volume of water in the pond and to evaluate the current intake system. Last fall, the team performed a bathymetric survey and found the pond contained more water than the town originally thought. They determined the pond volume to be approximately 430 million gallons and the existing intake location to be roughly only 6 feet below the surface. This leaves the town with access to only 54 million gallons of water of the total water in pond. The data collected allowed the team to propose possible solutions for the problem the town is currently facing.

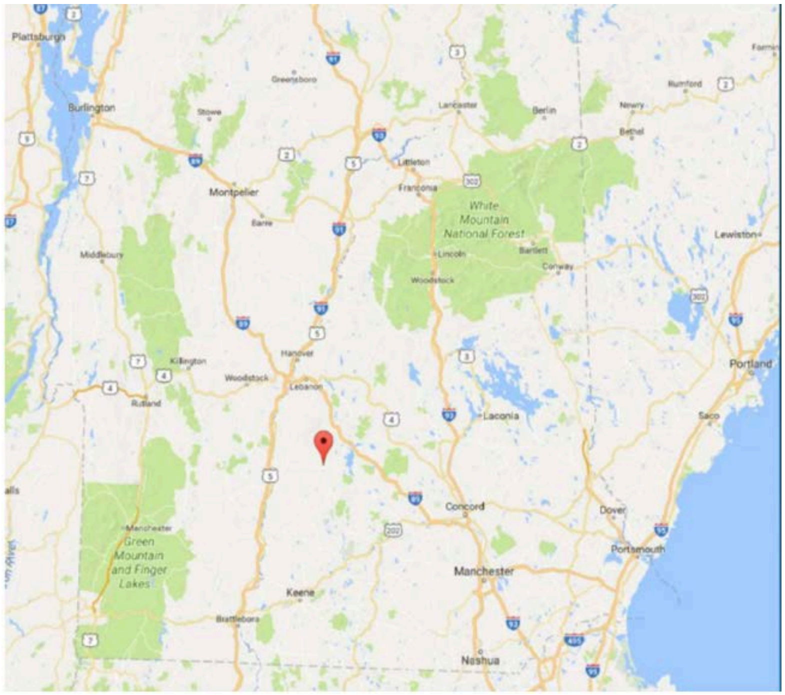


Figure 1: Location of the Gilman Pond Reservoir noted by the red marker.

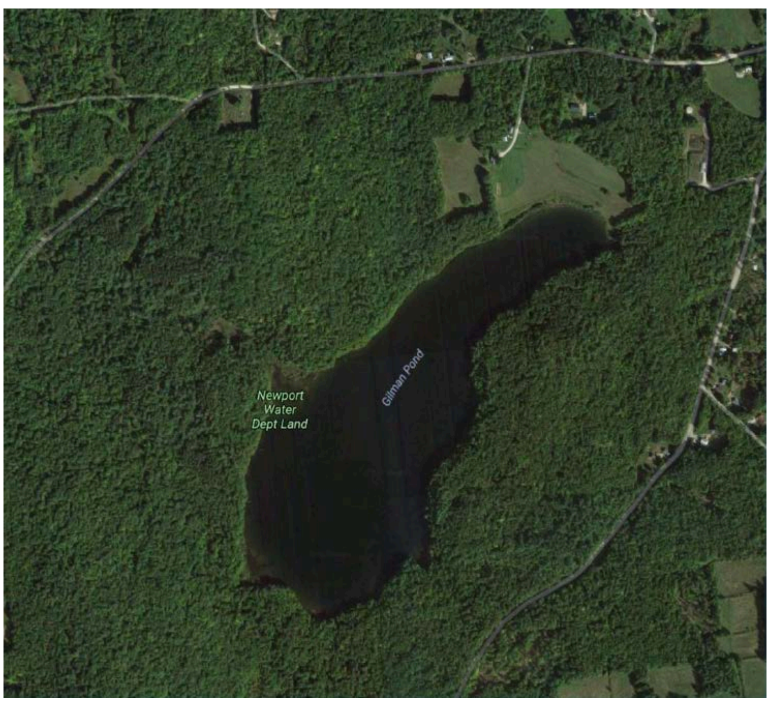


Figure 2: Aerial view of the Gilman Pond Reservoir.

Figure 3: Ground level view of the dam on the northeastern end of the reservoir

Figure 4: Aerial View of the Gilman Pond dam

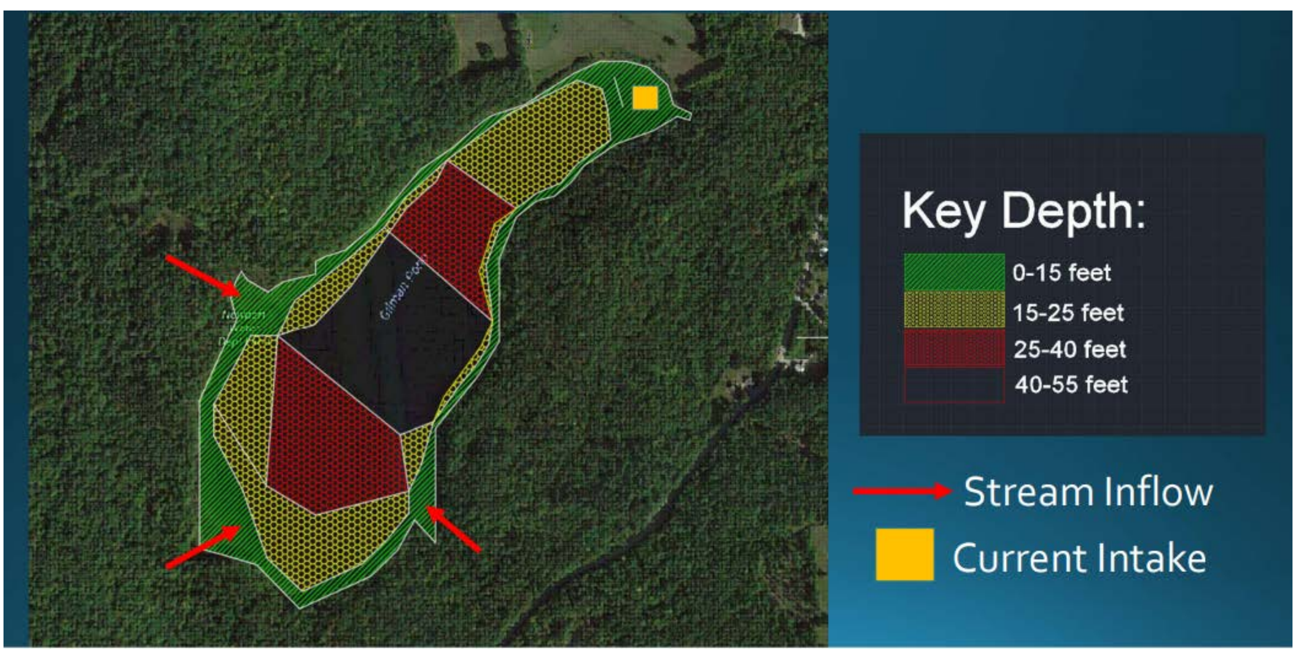


Figure 5: Aerial View of the Gilman Pond Depths

Goals and Objectives

The goals and objectives for this project ranked in order of importance from highest to lowest are bathymetric survey, determine intake location and alternatives to current system, implement a volume measuring system, preliminary environmental conservation plan, alternatives to water supply and hydraulics on the dam respectively. To meet all these goals, it was vital to conduct the bathymetric survey before the pond started to freeze over. This can be seen in Figure 6 as the bathymetric survey is early in the Gantt chart. Possible solutions that were explored included new intake locations as well as methods and a preliminary environmental conservation plan. The purpose of this project is to quantify the amount of water in the pond to propose possible solutions to the drought problem the town has encountered in the past. Although the town is not currently facing a problem it would like to avoid water quantity issues that future droughts could cause. The reason the town would like to avoid this is because it negatively effects the economy and quality of life and of its citizens. This report lays out possible solutions to the problem that could easily be implemented by the town at a relatively low cost.

Scope of Work

The scope of work for this project includes conducting a bathymetric survey, determining intake location, exploring alternatives to the current system, implementing a volume measuring system, environmental conservation plan, alternatives to water supply and hydraulics on the dam respectively. The bathymetric survey was performed to quantify the volume of water in the pond. The next objective was to determine the current location of the intake system and evaluate its condition, dimensions, and any possible alternative locations. This will be based on the quantity of water determined from the bathymetric survey and current and future necessities for the town of Newport. In addition to the intake system, the objective to obtain as much information on the current pipe network from the intake system to the water treatment plant down gradient of the reservoir. The volume measuring system for the pond was calculated based off the bathymetric survey data and will use a simple measuring device mounted on the side of the dam. The volume measuring system will allow maintenance workers to easily calculate the volume of the pond using the height of the water table in the reservoir in relation to mounted measuring tool on the side of the dam. The environmental conservation plan outlined general precautions that should be taken to maximize the sustainability of the reservoir without compromising its current and future usability and the surrounding environment health. Proposing alternatives to water supply would give the town different options for their water supply; however, due to the new data obtained from the bathymetric survey, the reservoir contains about two times the volume previously thought. This eliminated the need to search for alternatives to the water supply such as onsite wells and raising the height of the dam. Investigating the hydraulics on dam would allow for possible increase in height of dam in the future to increase the volume of water in the pond but the bathymetric survey data eliminated the need for this task as well.

The most important aspect of this project was developing a three-dimensional map of the Gilman Pond Reservoir. From the bathymetric survey the team got the X and a Y coordinate based off the handheld GPS unit. The depth was measured manually, and this made up the Z-axis. The combination of ArcGIS, AutoCAD and Carlson allowed for the 3D model to be made. In GIS, since the individual GPS point of perimeter of the pond were not taken at the site, GPS points were taken from GIS and a perimeter was able to be made. The next step was using AutoCAD files which was done by placing the perimeter over the surveying data which consisted of the 175 data points and combining the drawings. Lastly opening the join 3D drawing of the pond in in Carlson, the program was able to contour the drawing into a 3D model. With the 3D model, not only was the total volume in the pond quantifiable but the volumes of water at different elevations as well. There is a function in the program that allowed for the calculation of the entire reservoir based off a certain water level. This will be used in combination with the measuring system on the dam to allow the Newport employees to estimate how much water they have more accurately.

The following tasks have been completed from first to last respectively, project proposal/scope of work, Gantt chart, decision matrix, bathymetric survey, locate current intake system, midyear presentation, intake alternatives, conservation plan, undergraduate research conference, and final presentation. After the conclusion of the bathymetric survey, it was concluded that the reservoir has about times the quantity of water the town previously thought. The previous volume was based off a 10-15 feet water depth. Referencing Figure 5, the data from the bathymetric survey shows that the pond had a steep slope increasing in depth as it got toward the center of the pond. The shallowest parts of the pond were around the edges of the pond and ranged from 0 to 15 feet deep as seen in green. The maximum depth of around 57 feet with areas constantly between 40-55 feet deep at the center of the pond, which can be seen in black. The current intake system was shown to be in a water depth around 7 feet deep. The scuba surveying that was conducted by firefighter Joe Attenhofer confirmed these findings. During the Scuba surveying, it was also concluded that the current intake system is constructed of wood and that was most likely made during the late 1800's. The dimensions of the intake system are 8x9 feet with the individual pieces of wood being 2x6 inches. The intake system is clearly outdated and has accumulated a large amount of an unknown algae growth. During the bathymetric survey it was observed that 3 different tributary streams enter the pond as seen in Figure 5. These results are supported by the consistent shallow water of around 3 feet over a large area not seen anywhere else in the pond. This is due to transport of sediment in the streams and over time which would accumulate and settle in these areas resulting in the current sand bar like locations at the far end of the pond.

This project was very front loaded with data collection. All the data regarding evaluations of alternatives was collected before the start of the spring semester. During the spring semester the portion of this project completed included looking at different locations and style of intakes, drafting a conservation plan, putting together the three dimensional model of the reservoir using CAD, URC presentation, and two project presentation.

Schedule

GANTT CHART

	Ta M	Task Name	Dura	Start	Finish	Predeces
1		Project Scope	5 days	Mon 9/25/17	Fri 9/29/17	
2		Site visit	1 day	Fri 10/20/17	Sat 10/21/17	
3		Decision Matrix	5 days	Mon 10/23/17	Fri 10/27/17	2
4		Site visit and survery	1 day	Fri 10/27/17	Sat 10/28/17	
5		Project Design	16 days	Mon 10/30/17	Mon 11/20/17	3
6		Site visit and survey	1 day	Fri 11/3/17	Sat 11/4/17	
7		Project presentation	1 day	Tue 11/21/17	Tue 11/21/17	5
8		Preliminary Design Report	10 days	Mon 11/27/17	Fri 12/8/17	7
9		Evaluation	5 days	Mon 12/4/17	Fri 12/8/17	
10		Updated project proposal	10 days	Mon 1/22/18	Fri 2/2/18	8,9
11		Updated design report	20 days	Mon 2/19/18	Fri 3/16/18	10
12		Undergrade research conference	1 day	Wed 4/18/18	Wed 4/18/18	11
13		Final report and panel presentation	11 days	Mon 4/23/18	Mon 5/7/18	12
14		**Meeting with advisor & progress report to client**	**146 days**	**Fri 10/13/17**	**Fri 5/4/18**	

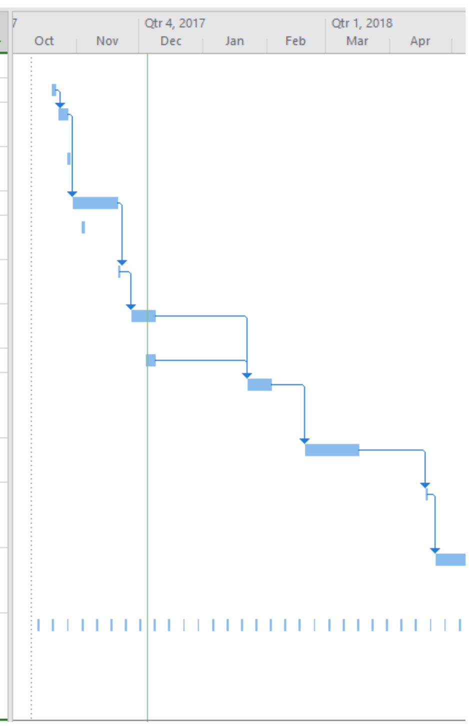


Figure 6: Gantt chart of tasks to be completed

The schedule for this project was constructed using Microsoft project. The date of each task and what preceded it considered deliverable deadlines that needed to be met. The first deliverable was the project scope, and this was to be done before the site visit in order to understand what needed to be done at the site visit. The decision matrix was to be complete before the bathymetric survey to determine which method was to be used to conduct the bathymetric survey. The site visit was necessary to get done early in the semester for two important reasons. The first reason was to be sure the pond did not freeze over before this site visit was conducted. The second reason was to allow enough time to put the data into AutoCAD and GIS to make sense of it. The first project presentation was made after the data was collected. The presentation provided an outline for the preliminary report which was one of the last task to complete for the fall semester. The other tasks complete during the fall semester, which was done at the same time as the preliminary report, included the evaluations of the capstone coordinator as well as the team.

The tasks for the spring semester that are complete are as follows; updated project proposal, CAD three-dimensional model of pond, updated design report, undergraduate research conference presentation and poster, and finally the second presentation. A schedule was made to lay out the deadlines for the senior project class as well as team deadlines for the spring semester which can be seen in figure 7.

Spring Semester Schedule

Senior project class deadlines highlighted

Deadlines within group for advisor are bolded

2/5 (Updated project scope)

3/5 (Fluid mechanic calculations complete)

3/26 (CAD model complete)

3/26 (Cost estimates complete)

3/26 (Conservation plan preliminary outline)

4/9 (75% design report)

4/9 (Conservation plan preliminary draft)

4/13 (URC poster draft)

4/17 (URC poster final & set up)

4/18 (URC presentation)

4/20 (Presentation PowerPoint draft)

4/25 (Presentation PowerPoint final)

5/7 (Final design report)

Figure 7: Spring Semester Schedule

Various tasks were distributed among project team members based upon strengths. Certain members were responsible for communicating with the town of Newport, NH in order to set up the site visit and bathymetric survey whereas other members were responsible for obtaining the materials for the survey. The whole team was responsible for conducting the site visit as well as the bathymetric survey. After the survey, the members who had the best understanding of AutoCAD and GIS were responsible for plotting and producing images from the data points taken from the bathymetric survey. Once the bathymetric survey was complete the volume of water was determined which allowed the group to suggest alternate intake methods and locations as well as determine the cost for each. Understanding of fluid mechanics and engineering economics was crucial in determining the location and cost of the alternative intakes. The last tasks which included the design report, conservation plan, undergrad research conference, and final presentation were worked on simultaneously throughout the spring semester.

Calculations

Fluid Mechanic Calculations

The intake alternatives involved finding out how deep the intake could be relocated to and still use gravity to flow the water to the treatment plant. To figure out a max depth the intake could be, head loss needed to be calculated. The Darcy-Weisbach equation was able to be used with the information gathered as well as a few assumptions that had to be made to solve for head loss. The elevation of the water level in the pond (1268 feet), the elevation of the treatment plant (1250 feet), and the flow per day (700,000 gallons per day) were all information provided by the town. The pipe diameter was believed to be 12 inches in diameter, from existing plans and the length was estimated to be roughly 1000 feet. The Reynolds number for both summer and winter were found using the moody chart. The f_D for both summer and winter were calculated by dividing 64 by the Reynolds number. The given information was plugged into the Darcy-Weisbach equation to calculate the head loss for the summer and winter. An average head loss of 3.1 feet was found by taking the mean number from the summer and winter. This average head loss of 3.1 feet was added to the know intake depth of 6 feet which equaled 9.1 feet. The conclusion that can be drawn from this is that 9.1 feet is the maximum achievable depth the intake can be while still maintaining a gravity fed system to the treatment plant.

AutoCAD

Using all the points hand collected from the survey of the pond, the X and Y coordinates from the GPS and the Z coordinate from the measuring rods were copied onto excel. The survey took place from the kayaks so the perimeter of the pond was not recorded. Using ArcGIS, the perimeter of the pond was traced as accurately as possible. The ArcGIS file was then exported to an AutoCAD compatible file and set to an elevation of 0 feet in order to show the depth at the shoreline. The two files were then overlaid and a surface file in Carlson Civil 3D was created. Using one of the commands within the program, contours were created, and the volume of the pond was calculated at different heights. It was determined that the current intake system has access to approximately 54 million gallons and the model allowed for different volumes to be calculated based on what the intake depth was set at.

Assumptions

To complete this project with the information given there were several assumptions that needed to be made. The elevation of the water height in Gilman pond was considered to be 1268 feet and the elevation of the water surface in the treatment plant was 1250 feet. The town needed 500,000 gallons of water per day and the treatment plant was said to handle up to 700,000 gallons of water per day. Other assumptions for the fluid mechanics and costs can be seen in the sections Fluid Mechanics and Intake Solutions and Cost sections, respectively.

Conservation plan

The environmental conservation plan was issued to help protect Gilman Pond and ensure sufficient drinking water access to improve quality of life for the residents of Newport. The conservation plan addressed the current conditions of the pond, management of the pond, and an emergency response plan.

Management of Pond

The first proposed solution to this problem would be to extent the existing pipeline to a depth of 9 feet. This would increase the water availability by 30 million gallons. The submerged pipe would run water up and through the current intake system during drought like conditions that were seen in 2016. This proposed solution has the least economic influence on the town and would roughly cost $20,000 dollars for installation. This would also have the least amount of construction time and labor. Due to its lower construction intensity it would still allow the town to use the current intake system while installing the pump and pipes to the intake. Electrical power would need to be provided to the pump for it to operate and an additional line would be needed to run from the pump to a power source capable of running it during drought like conditions.

The second proposed solution would be to install a completely different intake that would require new pipes that run to the treatment plant. The intake would be a multi-level intake system that could operate by both gravity and pump flows. The ability to take water from different levels during different times of the year is a great advantage for water quality and adaptability. The University of New Hampshire does this with their intake system and takes water from different levels of the oyster river during different types of the year to have the highest quality raw water flow to the plant before treatment. This reduces operation and maintenance costs. During drought like conditions, having a multilevel intake could be used to pump water to the treatment plant and during normal conditions would use gravity to flow water to the plant. This proposed solution would require an addition of 1,000 feet of pipe that would run on the side of the dirt road that leads from the plant to the pond. Having the pipe installed on the side of the road would allow for easier access if problems were to occur. As with the first proposed solution an additional power source would be needed to operate the pump during drought like conditions. This design would also require the most money costing an estimated $110,000 dollars would be needed to construct and install the new intake system. This would also be the most labor intensive and time-consuming project. The design might also require the current plant to go offline for a short period of time.

Preserving the quantity and maintaining the quality of water is important in making sure the needs of Newport's residents are met as well as ensuring health and safety. The quantity of water could be preserved by encouraging residents to adopt water friendly methods. These methods involve cutting down on activities that use water during an active drought, installing low flow shower heads, and using rain barrels. The quality of water could be maintained and deemed safe by conducting a sanitary survey. A future group of students could conduct the sanitary survey as part of a senior project or a company could be hired. NHDES has strict guidelines for a sanitary survey and they would need to be followed.

Emergency response plan

Water shortage has been a problem for the town of Newport especially during times of drought. With the unexpected weather patterns in our ever-changing climate a plan for a water shortage should be in place. The plan could involve using the groundwater wells the town has sparingly during times of no drought that way they could rely on the wells during times of drought. Another plan could be installing a temporary pump to a deeper location within the pond that would pump water to the intake. These plans would easily be able to be put to action if the town doesn't have sufficient water due to a drought.

Intake Solutions and Cost

One portion of the initial scope of work for this project included looking into potential alternatives for the intake to maximize the amount accessible water. All of the solutions involve extending the pipeline in some form down to the allowable 9 foot depth based off the hydraulic calculations. The costs are based off a combination of RS Means and contractor estimates. Due to the fact this is a 30% design, the prices are estimated to be within +/- 50% accuracy. One major assumption for the cost estimation was using a 12'' PVC pipe. Any extension options need to have an air tight seal in order to maintain the siphon effect on the system.

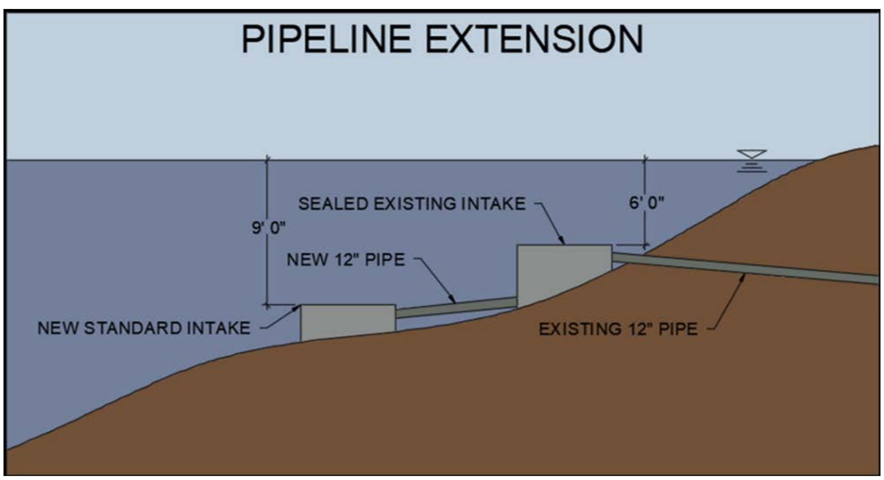


Figure 8 Existing Pipeline Extension

The first option, Figure 8, is an extension off the existing intake at its current 6 foot depth. This would involve creating a seal at the existing 8' x 9' inch intake structure, adding approximately 50 linear feet of 12 inch PVC pipe, and installing a new intake screen. This is the most reasonable economic option for the town and is estimated at approx. $20,000.

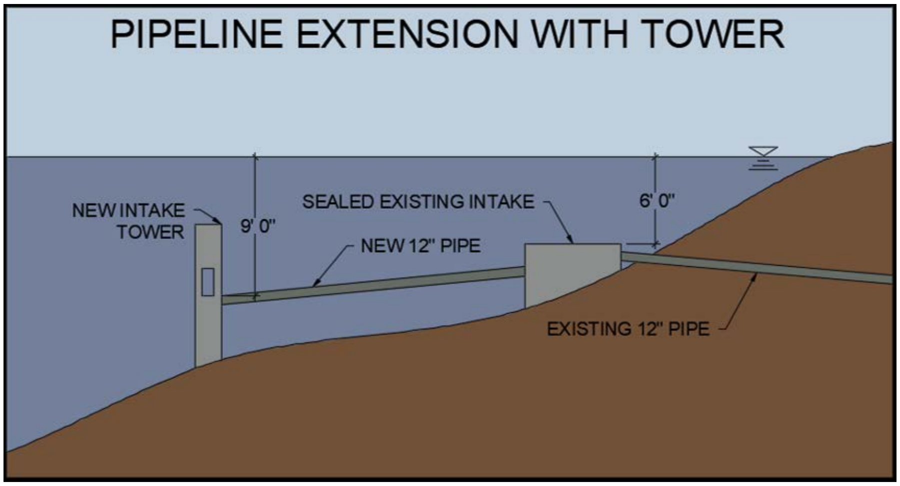


Figure 9 Existing Pipeline Extension with Intake Tower

Figure 9 is similar to the first option, however, instead of leading to a new intake screen it will be connected to an intake tower. This tower is a 24’’ reinforced concrete pipe that will be placed in a depth greater than 9 feet. Should the water level ever drop to a depth beneath the 9-foot mark, an emergency 500 gpm pump will come online and pump water from the base of the tower, up into the riser and will fill it above the 9-foot mark, where it will continue the gravity fed system. This option is estimated to be $52,000

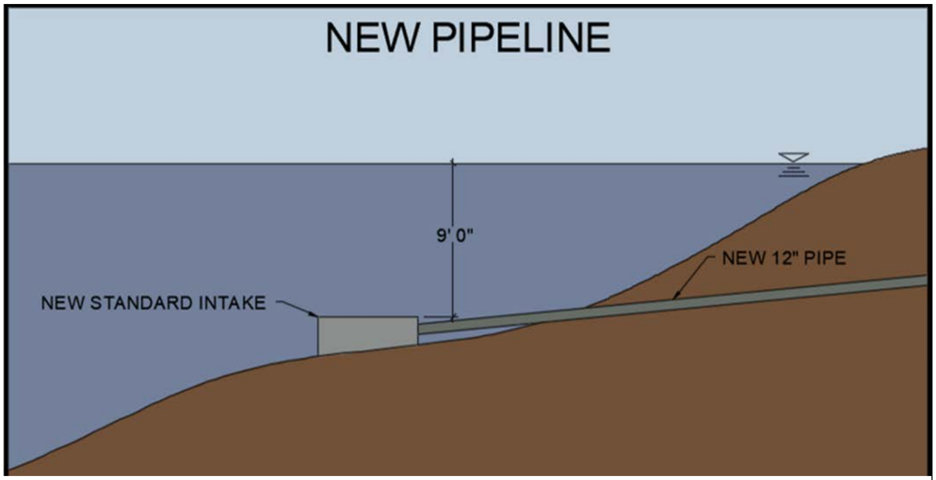


Figure 10 New Pipeline

This option is to simply place a new 12 inch PVC pipeline in a new location, and have it go directly to the 9-foot depth with an intake screen. This is an estimated $60,000.

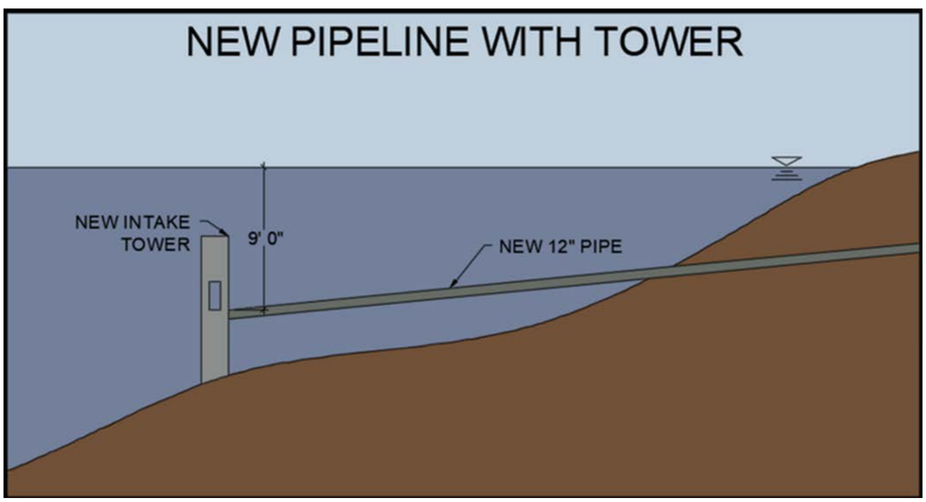


Figure 11: New Pipeline with Intake Tower

The final proposal is to install a new pipeline and intake tower. This estimate was approximately $110,000.

Future Projects

The scope of work for this project consisted of mainly investigation work. The first and most important aspect of this was a quantitative analysis to determine the volume of water the town had available. From survey data, the team was able to put forward solutions the town could possibly use. During the project there were many things that arose that the group wanted to know more about but were unable to because it was out of the scope of work. The first possible future project would be to expand on the conservation plan. In this project the team put forward a preliminary conservation plan that mainly consisted on what the town could do to in an emergency scenario and try to conserve as much water as possible during drought like conditions. Going more in depth and exploring the options of the watershed of the pond and determining if pollutants are affecting the pond and if they are what could be done to protect it. A future project could also look at the stream quality. With the intensity of storms becoming an issue, the sediment transport during intense storms could affect the water depths in certain parts of the pond. As of now three tributary streams flow into the pond and can been seen in the bathymetric data by sand bars. Around the mouths of the streams sand builds up and shallow depths are present as they exit into Gilman Pond.

Another issue that could be looked at are the water quality changes from the moving of the intake system to a lower depth. A lower depth allows for more access to water but also changes the water quality. Currently the water treatment plant uses a rapid sand filter and in the past has been known to be sensitive to water quality. Knowing the current conditions of the water at the intake system and comparing them to the 4 different solutions being put forward, would aid in the pros and cons of each type of system. Knowing the water quality conditions at each level in the water column and where would also help in aiding how deep the intake can go.

As of now gravity and pumps are the factors in the maximum depth the intake can go but if the water quality varies enough, the current treatment plant might not be able to handle the new quality of water. With that said the town would have to retrofit their current treatment plant to meet the water quality at different depths. This would be a project in its own sense.

For this project there was a 30% design of the system and did not go in depth of the complexity of each type of intake. This includes the ideal locations for the intake system, looking at the construction time, how it would be constructed, and more accurate costs on each system.

Summary

The first task completed last semester was establishing a scope of work. A schedule was created for the plan to complete the project. The bathymetric survey methods have been evaluated using a decision matrix. The bathymetric survey was completed, as per the Gantt chart, in a one-day trip to Newport under the supervision of an on-site EMT. The AutoCAD drawing was completed and the volume of water wad determined from this file. Five suggestions were made for alternatives for the intake. These five included, onsite wells, extending existing pipeline, extending existing pipeline with inlet tower, new pipeline with standard intake, and new pipeline with inlet tower. The onsite wells were determined unnecessary due to the quantity of water determined.

One obstacle encountered this year was lack of documentation on the existing intake. It was not possible to develop any alternatives without knowing the elevations and slopes of the pipes between the water treatment building and the reservoir. Slope and elevation are incredibly limiting factors for what would have been able to propose to the town.

After making assumptions in order to move forward with the project, the information collected from the bathymetric survey and put into AutoCAD created a model that allowed 4 different intake solutions to be proposed for the town. This project could have been more complicated if the volume of water was found to be smaller than what was originally thought by the town. The volume of water was fortunately found to be larger than the town had estimated. The amount of water the town has in Gilman Pond is an adequate amount to provide its citizens with a better quality of life even during drought conditions. The issue with the intake system was causing the town to only have access to a small portion of its water. Any of the alternative intake solutions proposed will help the town have access to a larger portion of the water and be able to avoid the problems that caused them to seek assistance last Fall.

Moving forward with this project could involve creating a full-scale design of the intake systems as this report only accounts for a 30% design. Another aspect of this project that could be expanded upon is the conservation plan. The conservation plan created for Gilman Pond is only a preliminary plan and a full plan could entail a whole project in and itself. This report only addresses water quantity and a full conservation plan could address water quality. Water quality is not only important because the new intake location could affect it but because the citizens should be informed on the quality of water for their health and safety.

References

Newport. “Welcome to Newport, NH.” Newport NH, 8 Dec. 2017, www.newportnh.gov/home/pages/welcome-newport-nh.

NHDES. “Welcome | NH Department of Environmental Services.” Welcome | NH Department of Environmental Services, www.des.nh.gov/.

Appendix

Calculations

Gilman pond stats		
		Units
Flow per day	700000	gallons per day
Elevation pond	1268	feet
Elevation plant	1250	feet
Elevation change (Z)	18	feet

darcy weisbach equation					
L	1000	feet			
D	1	feet	gph	gpm	feet/second
V	700000	gallons/day	29166.6667	486.111111	4.5264
g	9.81	m/s^2			
fD (or 0.01 for winter)	0.0095	from table			
L	304.8	meters			
D	0.3048	meters			
V	1.38	meters/second	(average)		
g	9.81	m/s^2			
u winter (1c)	0.001731	kg/ms			
u summer (20c)	0.001003	kg/ms			
u winter (1c)	3.62E-05	lbf-s/ft^2			
u summer (20c)	2.1E-05	lbf-s/ft^2			
V	4.5264	fps			
p	62.4	lbs/ft^3			
d	0.3048	meters			
Re winter	2381465				
Re summer	4109306				

fD winter smooth pipe	0.01	
fD summer smooooth pipe	0.0095	
hL winter	**3.183**	**feet**
hL summer	3.024	feet
hL average	3.1035	feet

hp	0.04847	feet	pressure head
hv	0.318141	feet	velocity head
Z	11	feet	potential head
Pressure head	11.36661		

Current intake	6ft
hL	3.1035 ft
Max depth for intake	9.1035ft
So this makes the max depth achievable with only gravity to be about 9ft	

Costing

			Material Cost			Labor&Equipment		Backfill		Total Installed Cost	
Type of Pipe	Diameter (in)	LF Required	Cost/LF	Total Cost	Install Rate (LF/HR)	Cost/LF	Total Cost	$/LF	Total Cost	Cost/LF	Total Cost
PVC	12	1000	$ 3.00	$ 3,000.00	100	$ 6.00	$ 6,000.00	$ 5.00	$ 5,000.00	$ 14.00	**$ 14,000.00**
DIP	12	1000	$ 15.00	$ 15,000.00	100	$ 7.00	$ 7,000.00	$ 5.00	$ 5,000.00	$ 27.00	**$ 27,000.00**

Pump	**Cost**
KG 500gpm 30hp	**$ 2,500.00**

		TOTAL MAT&LABOR		TOTALS	
Type	LF	Total	Total+ O&P	Total Cost	Total Cost + O&P
12" Ductile Iron	1000	$ 164.00	$ 102.00	$ 164,000.00	**$ 102,000.00**
12"PVC	1000	$ 80.70	$ 53.50	$ 80,700.00	**$ 53,500.00**

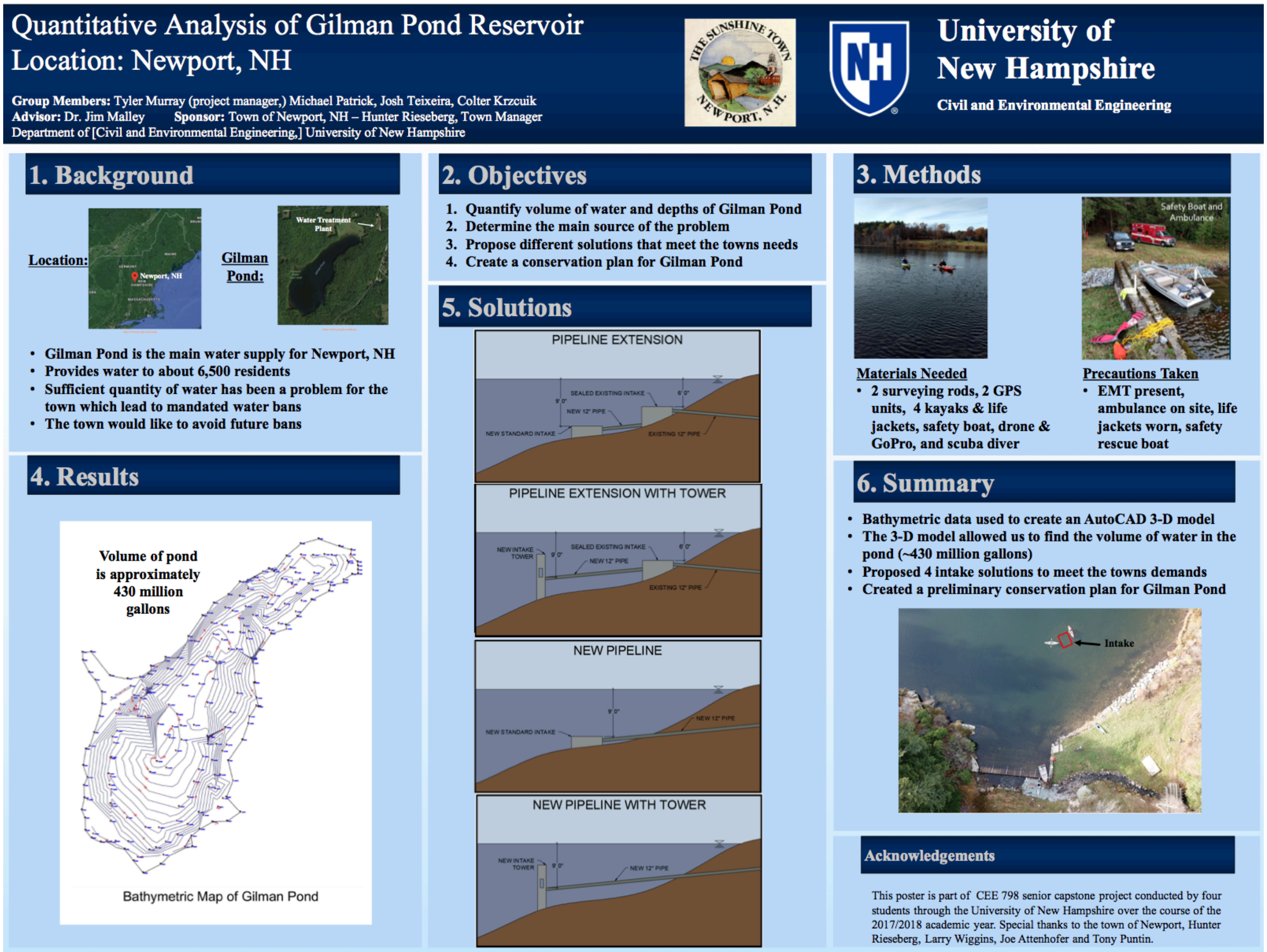
From rs means							
Excavation and Fill 1 cy	Cubic Yards	Labor	Equipment	Total	Total + O&P	TOTAL COST	
4'-10'	375	$ 1.92	$ 1.86	$ 3.78	$ 4.95	$ 1,856.25	
10'-14'	150	$ 2.13	$ 2.06	$ 4.19	$ 5.50	$ 825.00	
14'-20'	150	$ 2.40	$ 2.32	$ 4.72	$ 6.20	$ 930.00	
						Total	$ 3,611.25

For 12"							
Piping	Linear Feet	Material	Labor	Equipment	Total	Total + O&P	TOTAL COST
DIP	1000	$ 37.50	$ 12.50	$ 2.27	$ 52.27	$ 75.00	$ 75,000.00
PVC	1000	$ 6.00	$ 4.90	$ -	$ 10.90	$ 16.80	$ 16,800.00
HDPE	1000	$ 5.65	$ 4.84	$ 1.80	$ 12.29	$ 18.72	$ 18,720.00

Total cost with pump	Total cost with emergency pump
$ 77,500.00	$ 80,000.00
$ 19,300.00	$ 21,800.00
$ 21,220.00	$ 23,720.00

Item	Cost (2018 USD)
Sitework	
Trenching, Backfill, Staging, Cleanup	$9,000
10 foot x 24 inch RCP Riser Pipe Cost	$5,000
60 foot x 12inch lateral pipe cost Sch 80 PVC	$3,500
Subtotal:	**$17,500**
Specialty Items	
Dive Crew and Equipment	$15,000
Anchored Screened Intake	$1,000
Subtotal:	**$16,000**
General Fees	
Contractor Overhead and Profit (~10%)	$3,000
Related design and legal fees (~15%)	$4,500
Contingencies (~25%)	$8,000
Subtotal:	**$15,500**
TOTAL:	**$49,000**

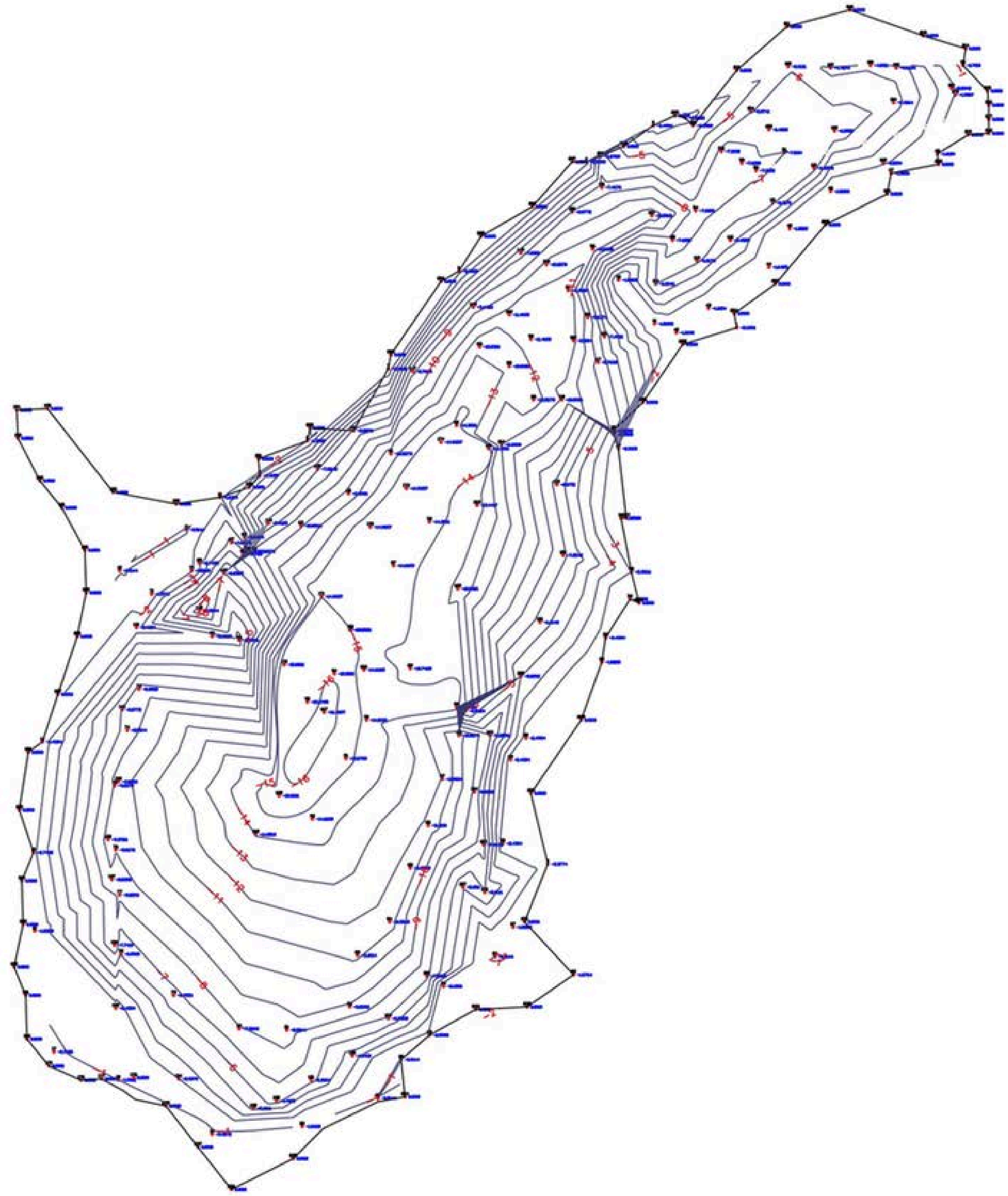
URC Poster and Presentation



Video Link

https://www.youtube.com/watch?v=1gTHAS3FNrk

2D Contour Model



Bathymetric Map of Gilman Pond