Civicus Engineering

J. Lannister Surface Water Treatment Plant

Project No. 52318

May 30, 2018

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Prepared For:
Professor David Whipple, PE
Castaic Lake Water Agency

Letter of Completion

Subject: J. Lannister Water Treatment Plant

Date: May 30, 2018

Project No. 52318

Dear Professor Whipple,

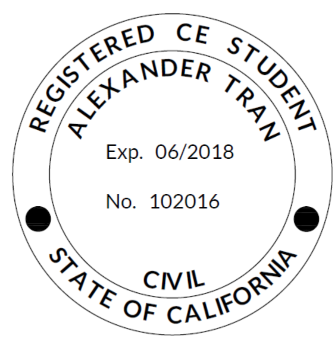
Civicus Engineering has been contracted on March 26, 2018 to design a surface water treatment plant in Castaic Lake in Sierra Pelona Mountains of northwestern Los Angeles County, California, near the town of Castaic.

We have prepared a report that outlines the desk study of the site, site conditions, water treatment plant and intake design, recommendations, plans, and renderings. We hope you find this report satisfactory.

We at Civicus Engineering appreciate the opportunity in providing our services for this project. It was a pleasure working with you. If you have any questions about the report or would like to request any services in the future, please feel free to contact us.

Sincerely,

Civicus Engineering
Website: civicusengineering.github.io



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1.0 Introduction

1.1 Project Description

Castaic Lake Water Agency (CLWA) is in need of a new water treatment plant. The existing water treatment, called the Earl Schmidt Filtration Plant, is in dire need of repair. However, CLWA has calculated the cost of repair and deemed it too expensive. A completely new water treatment plant was a more viable option for the agency. Also, the new intakes will be needed for the plant. CLWA has named the new water treatment plant J. Lannister Water Treatment Plant. The new intakes will be named Dinklage Memorial.

Civicus Engineering is dedicated to sustainable design. To fulfill our client's need for a new water treatment plant, this project will be designed with sustainability in mind. Representing CLWA is Professor David Whipple. He will be overseeing the design throughout the duration of the project.

1.2 Project Location

1.2.1 Castaic Lake

Castaic Lake is a manmade reservoir located in Castaic, California. The reservoir is 330' deep. The surface of the lake is currently 1493' above sea level (ASL). The area of the lake is about 2,232 acres. The reservoir is owned by the County of Los Angeles Department of Parks and Recreation. Not only is Castaic Lake home to recreational activities such as boating and fishing, Castaic Lake is a water source for surrounding residents. Castaic Lake Water Agency takes water from the lake to provide potable drinking water to its customers in Santa Clarita, Newhall County, Valencia, and some parts of LA County. Castaic Lake will be used as the influent for the new water treatment plant.

1.2.2 Proposed Intake Location

The intakes will be located close to shore near a parking lot for the Castaic Lake Boat Rental (Lat: 34.523347° Long: -118.599049°). The surface of the lake is approximately 1493 feet above sea level while the elevation of the parking lot is 1560' above sea level (ASL).

1.2.3 Proposed Plant Location

The plant will be located southeast of Earl Schmidt Filtration Plant (Lat: 34.496020° Long: -118.602831°), approximately 500' away. The site is about 17.2 acres and is about 1373' ASL (at center of site). The site is vacant; there are no current uses of the site.

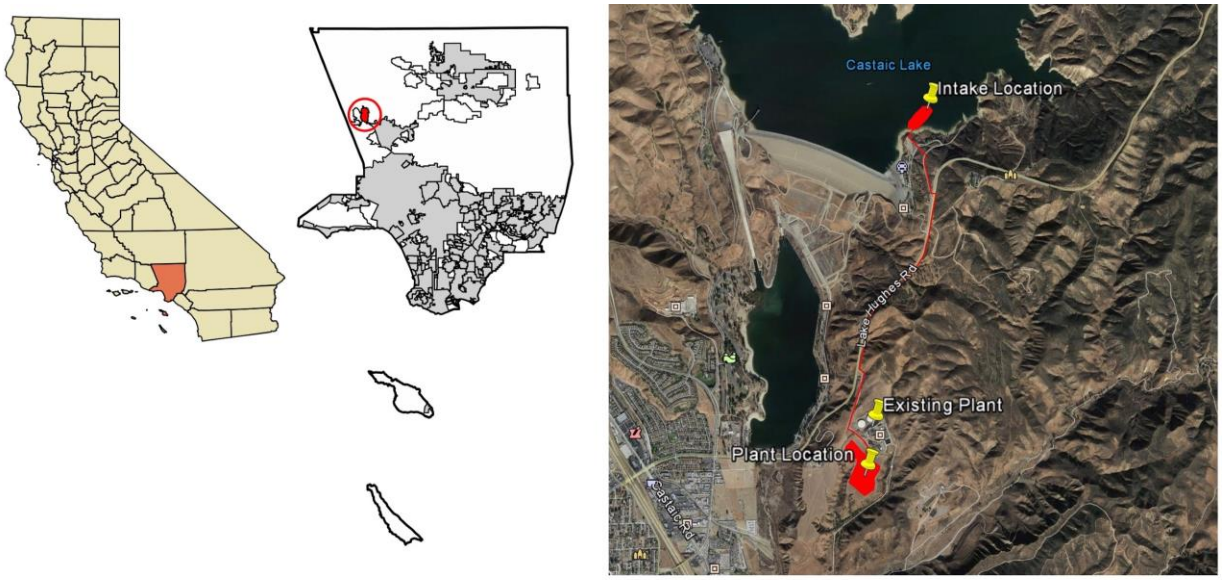

Figure 1-1. Vicinity Map of Project.

Figure 1-2. Proposed Dinklage Memorial Intake Location.

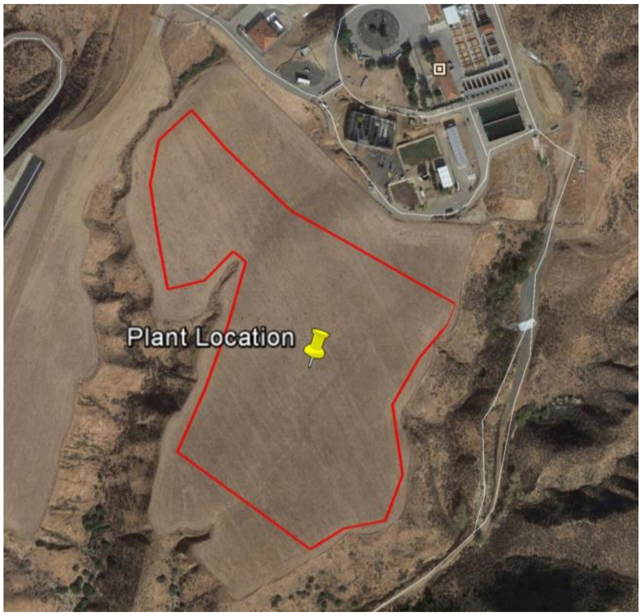

Figure 1-3. Proposed J. Lannister Water Treatment Plant Location.

1.3 Project Scope

Civicus Engineering will perform preliminary site research, preliminary geotechnical analysis, water treatment plant design, intake design, and CAD plans. Additionally, a presentation and report will be given.

2.0 Sustainability

2.1 Sustainability Summary

Sustainability is the balance between the environment, people, and finance. This is the triple bottom line. Sustainability is all about reducing or eliminating negative impacts on the environment while maintaining or improving the quality of life at a reasonable cost. Sustainability has received much attention over the years in numerous projects. Credentials and certifications have been devised to recognize sustainable projects. Envision - rating system for infrastructure devised by the Institute of Sustainable Infrastructure - will be used as a guideline for this project.

2.2 Sustainable Considerations

Below are sustainable features to incorporate into the project. Considerations are tentative.

- Minimizing Light/noise Pollution
- Enhance public/construction safety
- Repurpose/reuse waste from other sources
- Utilizing permeable pavements for water drainage and reclamation
- Utilizing renewable energy sources (trying to partner with Tesla to gain access to solar panels and battery packs
- Swales to capture water
- Incorporating monitoring systems
- Providing and placing charging stations in vicinity of structures
- Incorporate native species of plants that require little amounts of water and eliminate the need to use fertilizer

2.3 Envision Self Assessment

After completing the assessment, it has been determined that we did not reach a sufficient score to become Envision certified. Minimum award level is 20%. Assessment score was 16%. The full assessment is located in Appendix C.

3.0 Existing Site Conditions

3.1 Castaic Lake Water Level History

From preliminary research, the water level history of Castaic Lake was found for the years between 2013 and 2018. From Figure 3-1, the lowest lake level occurred in 2016 and was interpolated to be 1370’ ASL. The highest lake level occurred in 2017 and was interpolated to be 1510’ above sea level. Current level for the lake is 1493’ ASL.

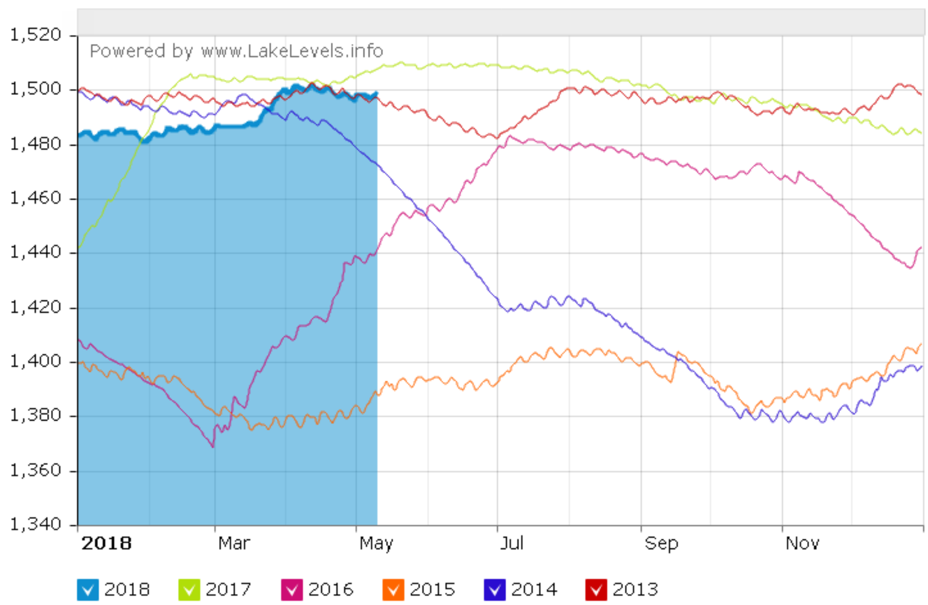

Figure 3-1. Water Level History. *This graph depicts the fluctuating water level of Castaic Lake from 2013 to 2018.*

3.2 Grading and Topography

3.2.1 Intake Location Topography

The intakes will be located close to shore near a parking lot. At the bottom of the cliff of where the parking lot is located, the shore is at a declining slope. At the exact location of the intakes, the elevation of the lake bed is interpolated to be 1365' ASL (Figure 3-2).

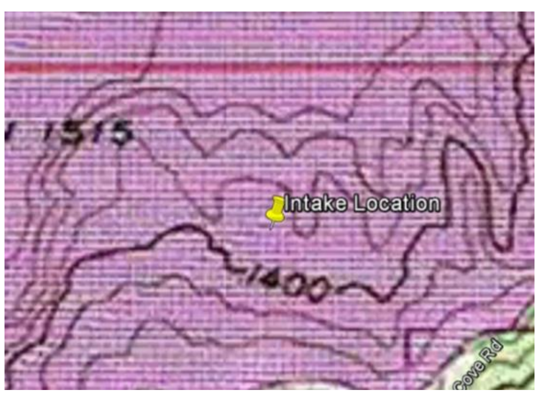

Figure 3-2. Topography of Proposed Intake Site.

3.2.2 Water Treatment Plant Location Topography

The site is not uniformly graded and must require leveling. The highest point of the site is located in the northwest corner and is approximately 1380' ASL. The lowest point of the site is in the south east corner and is approximately 1360 feet ASL. By determining the vertical difference over a 1400' distance between the highest and lowest points, there is a 1.4% slope.

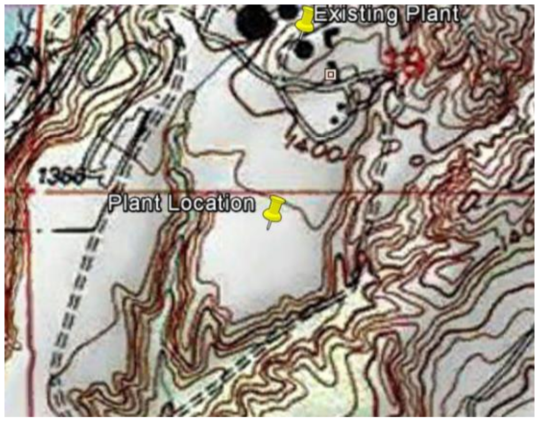

Figure 3-3. Topography of Proposed Water Treatment Plant Site.

3.3 Geology

3.3.1 Intake Location

The soil of the parking lot is Castaic-Balcom series and consists of silty clay loams, which makes up 30-50% of the soil at the site. The soil has good drainage properties.

3.3.2 Water Treatment Plant Location

The soil present is an Ojai series. About 85% of the proposed site consists of clay silty loams. The soil has good drainage properties.

3.4 Faults

Using Google Earth, there are no faults on site for the proposed intake site and plant site. The closest fault is the San Gabriel fault zone, Palomas section (Castaic Valley fault) and is located 1900' away from the plant site. This fault had been formed in the late quaternary period, roughly 0.5 - 1 million years ago. Due to the age of the fault, it is likely that this fault does not present any threat to the water treatment plant or the intakes, whether on the fault or in the vicinity of the fault. For safety reasons, it is best to locate the plant and intakes away from the fault.

4.0 Design Requirements

Below are the design parameters that must be included in the design of J. Lannister Water Treatment Plant and Dinklage Memorial Intakes as required by Castaic Lake Water Agency. United States Environmental Protection Agency (EPA) primary and secondary standards shall be met.

Table 4-1. Required Flow Rates.

Water Production Requirements		
Demand Type	Flow Rate MGD	Flow Rate (cfs)
Minimum Flow	2	3.1
Average Flow	8	12.4
Maximum Flow	12	18.6

Table 4-2. Required Intake Concentrations.

Constituent	Concentration	Units
Calcium	32	mg/L
Magnesium	30	mg/L
Sodium	60	mg/L
Sulfate	116	mg/L
Chloride	61	mg/L
Total Dissolved Solids	340	mg/L
Alkalinity	90	mg/L as $CaCO_3$
Turbidity	20	NTU
Color	18	Color Units

Table 4-3. Required Maximum Concentrations in Treated Water.

Constituent	Concentration	Units
Sulfate	250	mg/L
Chloride	250	mg/L
Total Dissolved Solids	500	mg/L
Coliform	Non-detect	per ml
Turbidity	0.3	NTU
Color	15	Color Units

5.0 Process Diagram

Figure 5-1 illustrates the water treatment process. Each item in the diagram is represented by a box. Number of boxes convey number of tanks of that item. For example, coagulation requires only one tank (one block) while flocculation requires two tanks (two boxes). Each item's design will be further discussed in Section 6.0 Intake Design and Section 7.0 Water Treatment Plant Design.

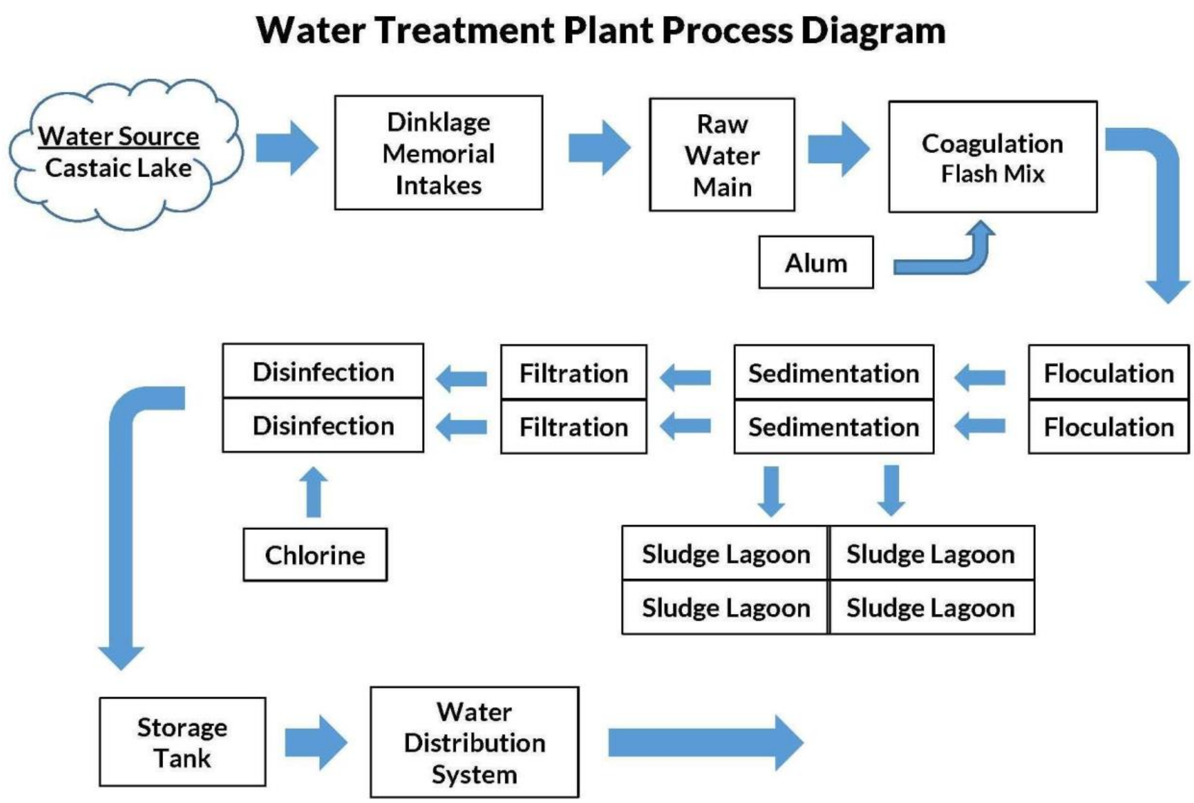

Figure 5-1. Water Treatment Plant Process Diagram.

6.0 Intake Design

This section outlines the design and design rationale for the Dinklage Memorial Intake. Intake design and its constituents will be reiterated in Section 8.0 Recommendations.

6.1 Site Grading

The intakes will be an exposed intake structure, allowing for simple operation and maintenance. The upper portion of the intake structure houses the monitoring systems and pump systems. This upper portion shall not come into contact with water and must be located at least 5 feet above the maximum water level. From Section 3.1 Castaic Lake Water Level History, the maximum water level was 1510 feet above sea level. As a precaution, the tower must be 1515' ASL at the minimum. However, for this project, the tower will be 1530' ASL. In addition, the lowest point the lake had reached was 1370' ASL. Based on Section 3.2.1 Intake Location Topography, the intakes will be located at the floor bed of the lake at 1365' ASL. Locating the intake structure at the specified elevation allows the pumps to continue siphoning of water from the lake should another drastic decrease in the water level occur.

To make access easier to the tower, a bridge will be required. As stated earlier, the intakes are located near a parking lot. The north portion of the parking lot will be used as the entry/exit way of the intake tower. From the entry point to the intake tower, the distance is estimated to be 950'. Therefore, the bridge will be 950' in length. The bridge deck will be 24' wide to allow for personnel and vehicle entry/exit to/from the tower and pipe placement on the bridge.

6.2 Pump Selection

The pump will be located at an elevation of 1375' ASL. A distance of 10' between the intake to the floor bed is required to prevent the pump from siphoning the soil. The system will use five pumps which three will run at minimum flow rate and two will run at maximum flow rate. Based on the result from system demand curve (Table 6-1), Pentair Aurora Split Case Pump 410 Series was chosen for the design. With a capacity of up to 15,000 GPM and heads up to 500', this pump is capable of handling the demands that is required for circulation around the treatment plant.

Table 6-1. System Demand.

System Demand					
Q (gpm)	Q (cubic feet per second)	Major Losses (ft)	Minor Losses (ft)	Static Head (ft)	Total Dynamic Head (ft)
0	0.00	0.00	0.00	100.00	100
1000	2.23	0.70	0.09	100.80	102
2000	4.46	2.52	0.36	102.91	106
3000	6.68	5.34	0.80	106.21	112
4000	8.91	9.09	1.42	110.64	121
5000	11.14	13.73	2.23	116.15	132
6000	13.37	19.24	3.21	122.73	145
7000	15.60	25.59	4.36	130.34	160
8000	17.83	32.76	5.70	138.96	177
9000	20.05	40.74	7.21	148.58	197
10000	22.28	49.50	8.90	159.19	218

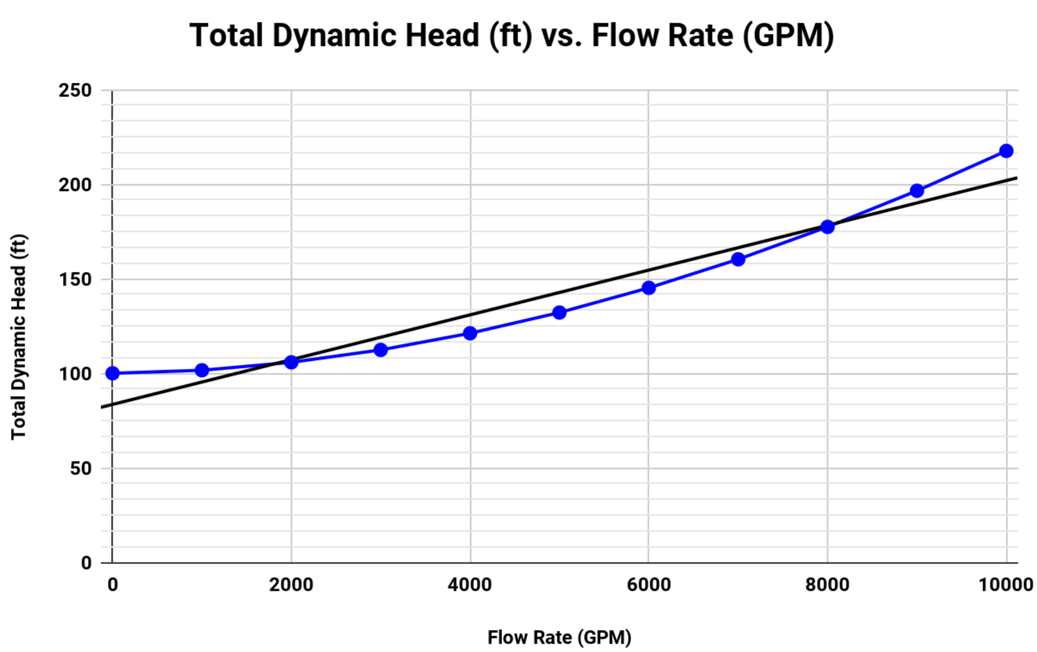

Figure 6-1. System Demand Curve.

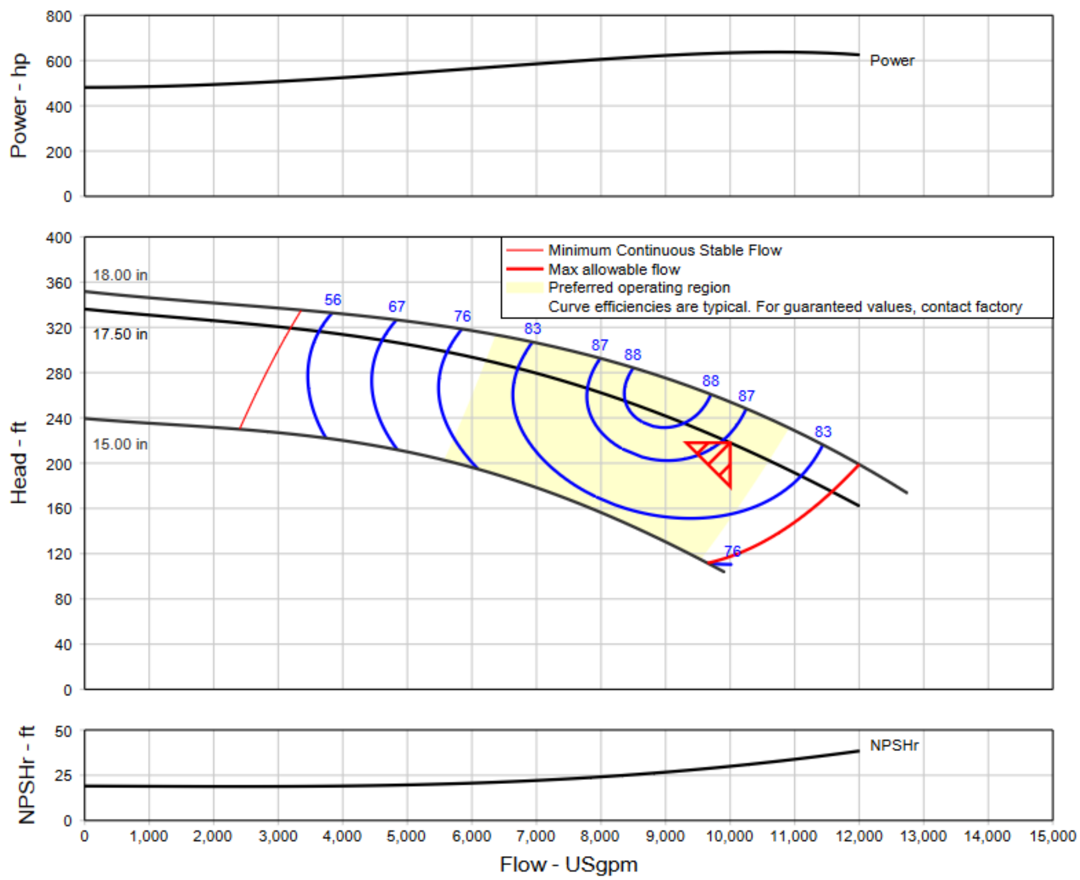

Figure 6-2. Pentair Aurora Split Case Pump 410 Series.

7.0 Plant Design

This section outlines the design and design rationale for the J. Lannister Water Treatment Plant. Intake design and its constituents will be reiterated in Section 8.0 Recommendations.

7.1 Coagulation

7.1.1 Coagulant

There are three types of coagulants: alum (or aluminum sulfate), ferric chloride, and ferric sulfate. Alum is the recommended choice for coagulant. Since suspended particles are negatively charged, alum neutralizes the negative charges, allowing the particles to stick together. As they clump together, the particles increase in weight and sink to the bottom of the tank. Alum is very effective in its function and is used widely, which makes alum very cost effective.

7.1.2 Venturi Meter Design

Venturi meters are used to determine the flow rate at a certain location of the pipeline. Venturi meters decrease in pipe diameter, smaller than the main pipe diameter. This allows for water to increase its velocity, which causes a pressure drop to help determine the flow rate. The design parameters of the venturi meter are outlined in Table 7-1. Since the calculated diameter is 16.86", the standard diameter required for the venturi diameter shall be 18". The length of the venturi meter is designated as L = 10D. The required length of the venturi meter is 180" or 15'.

Table 7-1. Venturi Meter Parameters.

Venturi Meter Design							
Inlet Velocity (ft/s)	ΔP @ Q_{avg} (in)	Max Negative Pressure (ft)	Q_{avg} (cfs)	Diameter Calc (ft)	Diameter Calc (in)	Required Diameter (in)	Length of Venturi (ft)
8	80	2	12.4	1.40	16.86	18	15

7.1.3 Flash Mix Design

This equipment is designed to produce a high G. The order of preference in selection of equipment type is based on effectiveness, reliability, maintenance requirements, and cost. Common alternatives for mixing when the mechanism of coagulation is adsorption/destabilization are: Diffusion mixing by pressured water jets, In-line mechanical mixing, and In-line static mixing.

Table 7-2. Flash Mix Parameters.

Flash Mix Design			
Mixing time (t)	1 sec	**Required HP Liquid Mix**	0.93 HP
Alum Dose	5-50 mg/L	**Mixing Jet Velocity**	23.8 ft/sec
Q_{max}	18.6 cfs	**Diameter of Nozzle**	3 in
Length of Mixing Zone	6 ft	**TDH**	23.5 ft
Diameter of Mixing Zone	2 ft	**BHp**	3.10 HP
Volume of Mixing Zone	18.8 ft^3	**Motor HP**	4 HP Motor
Pump Diffusion Rate at Nozzle	0.93 cfs		

Common alternatives for mixing when the mechanism of coagulation is sweep coagulation are: Mechanical mixing in stirred tanks, diffusion by pipe grid, and hydraulic mixing. Moreover, the mixing zone will have the following conditions: a length of 6'., a diameter of 2'., and a volume of 18.8 ft^3.The pump diffusion rate design will be 0.93 ft^3/s, with a jet velocity of 23.8 ft/sec, and the nozzle diameter will be of 3 in. With all provided a motor pump of 4.0 hp. Calculations can be found in Appendix D-2.

7.2 Flocculation

The Flocculation system of this water treatment plant is an essential part of the disinfection process. Raw water mixed with Alum will come in the flocculation tank for a 10 min detention time per stage of the flocculation system. The final tank volume will be 16,718$ft^3$with tank dimensions of L x W x D → 48' x 32' x 11' as illustrated in Figure 7-4. There will be a total of two flocculation tanks that will be placed parallel to each other. Each flocculation tank will be divided into 3 stages with 2 flocculators per stage. The diameter of the flocculator blades is 6ft. Each stage will have different motors which will decrease in RPM and Hp as the floc grows larger. Table 7-4 summarizes the design of the flocculation tank stages. Between each stage will be a Baffle Wall system. For this design circular ports are used in between walls. Each port is 6" and vary in quantity between stages. A design summary of the baffled wall system can be found in Table 7-5 and Detailed calculations can be found in the Appendix D-3: "Flocculation System Design."

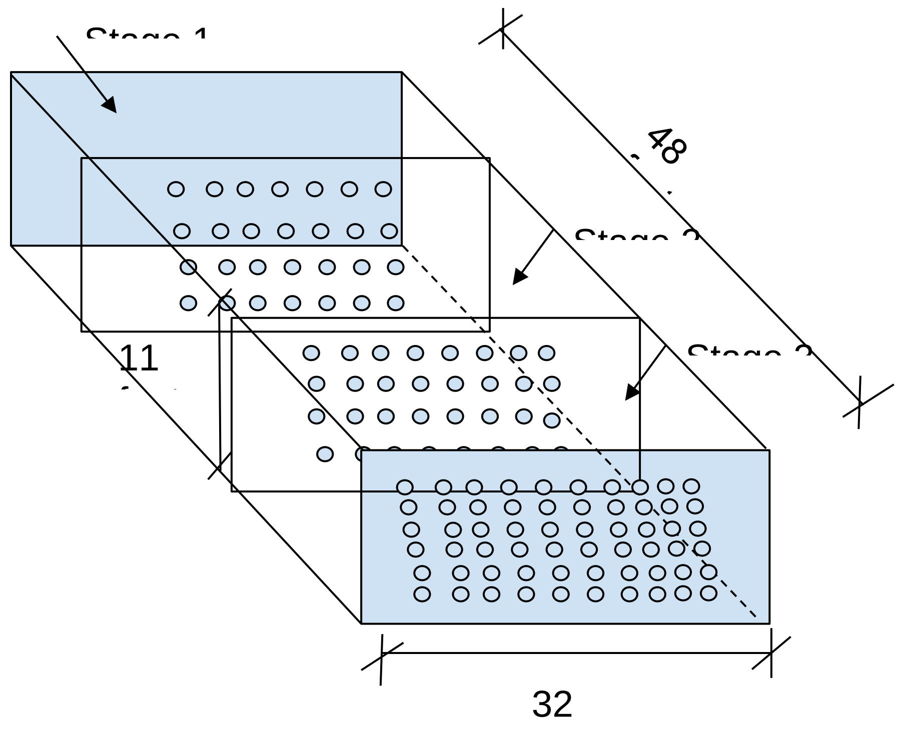

Figure 7-1. 3D Dimensioned Flocculation Tank.

Table 7-3. Flocculation Specifications.

Stage	RPM	HP
Stage 1	22.3	2
Stage 2	15.9	1
Stage 3	3.2	0.25

Table 7-4. Design Summary of the Baffled Wall System.

Stage	Velocity Through Baffle Wall, ft/sec	Number of Circular Ports	Port Layout
Stage 1	1.8	28	7 columns (3.5 ft wide) and 4 rows (2 ft deep)
Stage 2	1.5	32	8 columns (4 ft wide) and 4 rows (2 ft deep)
Stage 3	0.8	60	10 columns (6 ft wide) and 6 rows (3 ft deep)

7.3 Sedimentation

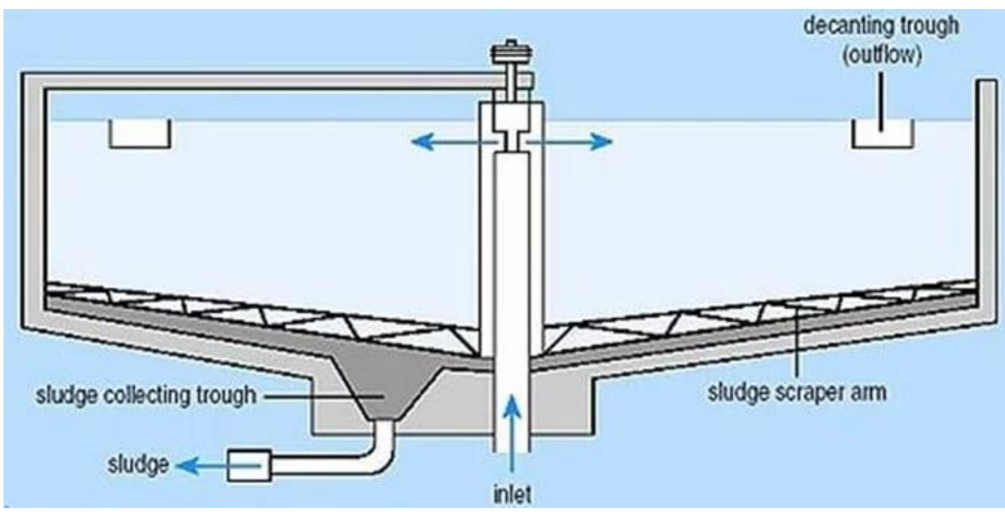

Figure 7-2. Sedimentation Tank System Diagram.

After flocculation, the water flows into sedimentation tanks. The sedimentation system consists of 2 parallel, rectangular tanks with dimensions L x W x D → 220’ x 32’ x 11’. In the tanks, the water is significantly slowed down to allow the coagulated particles to settle. The tanks allow for a total maximum flow of 8333 GPM at a horizontal velocity of 1.6ft/min. The average detention time it takes for water to travel through the sedimentation tanks is 2.2 hours. In the process, the settled particles form a sludge at the bottom of the tank where a sludge scraper pushes the sludge into a hopper. A sludge pump is provided with a pumping capacity of 320 GPM.

A weir and launder system for effluent flow is provided in each tank as shown in Figure 7.5.

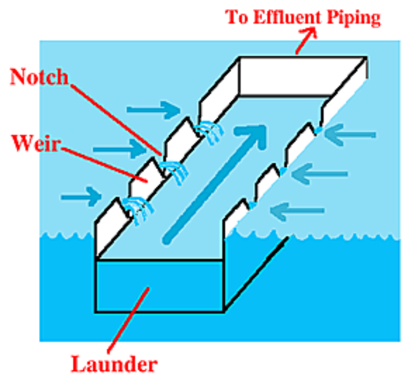

Figure 7-3. Weirs and Launder Diagram.

There are 2 launders in each tank that draw on both sides and are 70' long. Weirs line the sides of the launders, requiring a total weir length of 280'.

7.4 Sludge Lagoon

Four identical sludge lagoons are needed to handle and dispose of excess waste. These lagoons would hold the sludge for about 90 days. Rectangular sludge lagoon will have a L/W ratio of 4:1 will be used in the design. The height will be set at 6 feet for safety of workers and ease of clean up with a bulldozer. With our initial alum dose of 20 mg/L and raw water turbidity of 20 NTU, we get a production of sludge to be 260 pounds of sludge per million gallons of water treated. Since our flow rate is 8 MGD, we have a daily sludge amount of 2080 pounds. The sludge lagoons have to be able to hold 90 days of sludge production, which gives us a value of 187,200 lbs of sludge. Based of the sizing guide from Kawamura, 16 lbs equate to each square feet so in the end we need to design a lagoon with 11,700 ft^2 (Appendix D-7). An area of 12,000 ft^2 will be used to safely contain all the sludge waste so the equation that will be used to find the dimensions is as follows:

$$A = LxW \rightarrow 12{,}000ft^2 = 4WxW$$

To obtain the length and width of the lagoon, the equation was iterated until the calculated area is close to the required area, being slightly bigger but not overly big to control cost. For the first iteration, the width was solved directly from equation. The value was rounded upwards to obtain a new width to be used again in the equation to reach desired area.

After two iterations, dimensions were determined: sludge lagoon length of 220' and width of 55' (Appendix D-7).

7.5 Filtration

The filter system uses a standard dual media filter with anthracite coal as a top layer, and sand as the bottom layer. The system as a whole consists of 2 tanks, each containing 2 392ft^2 filters. The filters are 14' wide, and 28' long. At a filtration rate of 6 GPM/ft^2 , these filters will meet the maximum flow rate demand of 12 MGD. To clean the filter, the system uses a self-backwash with fixed nozzle surface wash system. Details of the gravel support layers are shown in Table 7-6.

Table 7-5. Filter System Layers.

Layer #	Passing Sieve Size	Retaining Sieve Size	Depth of Layer
1	¾"	½"	3"
2	½"	¼"	3"
3	¼"	NO 6 Sieve	3"
4	NO 6 Sieve	NO 12 Sieve	3"

7.6 Disinfection

The disinfection system will receive filtered water that will have microorganisms such as giardia and viruses. For this operation we will use Free Chlorine for disinfection and assume a Ct of 19 mg-min/L for Giardia and a Ct of 3 mg-min/L for Virus Inactivation. Two parallel detention trains will be used each of which has a total volume of 16,740ft^3 per train. Each train will have 3 tanks placed parallel to each other with a volume of 5580ft^3 per tank. Each tank will have dimensions of L x W x D → 50' x 10' x 12'. Chlorine dosing stations will be strategically located throughout the train system to allow for proper plug flow mixing of the chlorine and water. Figure 7-6. illustrates the approximate locations of the dosing stations. For this design a total chlorine residual of 32.3 mg-min/L will be released into the distribution system. The total volume of the two trains is 36,000ft^3 with a final chlorine contact time of approximately 32.3 min.

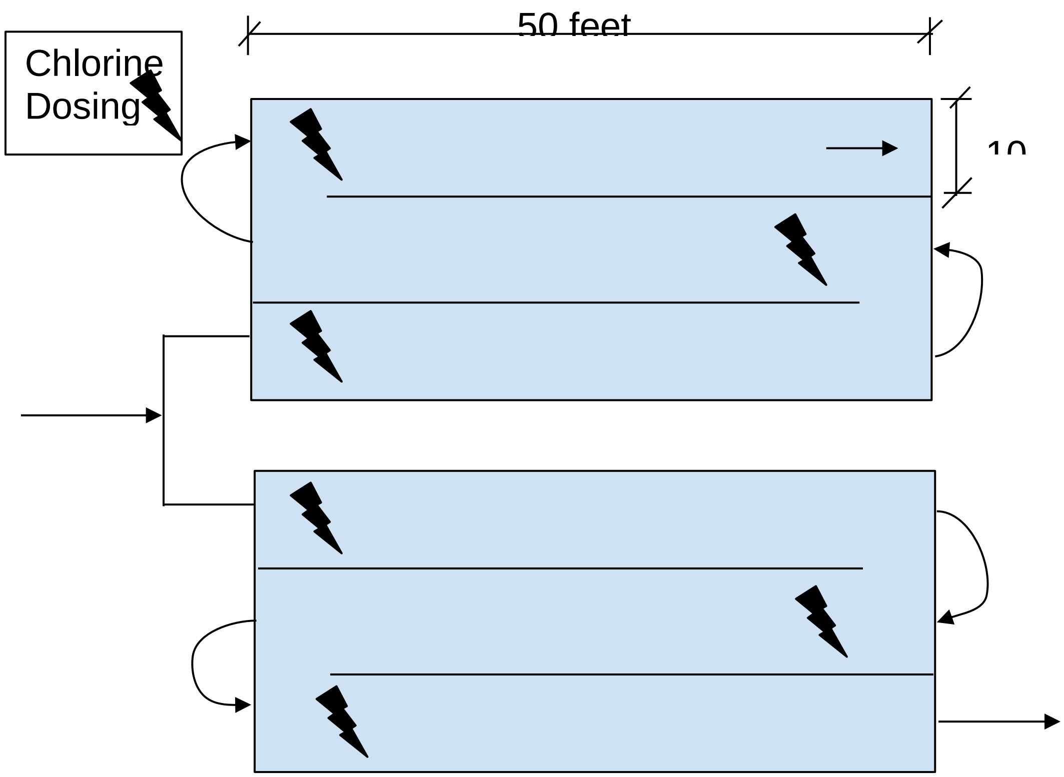

Figure 7-4. Approximate Locations of Chlorine Dosing Stations.

8.0 Recommendations

8.1 Intake

8.1.1 Intake Location
Intake location will be 165' and will be reinforced concrete. Sited near shoreline. Access bridge required with a length of 800' and will be reinforced concrete.

8.1.2 Pump Selection
Five pumps total will be used – three for main functions and two will be reserved for peak hours. Pentair Aurora Split Case Pump 410 Series pump shall be used.

8.2 Water Treatment Plant

8.2.1 Coagulation

Alum shall be used in doses of 5-50 mg/L. Flow meter shall be a venturi meter. 4 HP motor in-line blender will be used to mix alum with water.

8.2.2 Flocculation

Two floc tanks will be used with dimensions L x W x D = 48’ x 32’ x 11’. Each floc tank will have three stages that contain two flocculators in each stage. Flocculators will have a 6‘ blade diameter. Specifications for flocculators are specified in Table 7-4 and 7-5. Each stage is separate by a baffle wall. Table 7-5 illustrates baffle port dimensions and Appendix Sheet 3 illustrates flocculation tank dimensions.

8.2.3 Sedimentation

Two sedimentation tanks are required with dimensions of L x W x D = 220’ x 32’ x 11’. Each tank shall have two launders that are 70’ in length.

8.2.4 Sludge Lagoon

Four sludge lagoons shall be required and will have dimensions of L x W x D = 220’ x 55’ x 6’. Sludge lagoon will hold the sludge for 90 days.

8.2.5 Filtration

Four filters shall be required with dimensions of L x W = 28’ x 14’. Bottom of the filters will be the underdrain, on top of that shall be a sand layer, and on top will be anthracite coal. Refer to Table 7-6 for filter layers.

8.2.6 Disinfection

Two disinfection trains shall be required. Each train shall contain three tanks with dimensions of L x W x D → 50’ x 10’ x 12’. Chlorine residuals will be used in concentrations of 32 mg*min/L with chlorine contact time of 32.3 min.

9.0 Cost Estimate

Construction cost for the water treatment plant is $31,000,000. The operation and maintenance cost is $890,000. Calculations for the cost are in Appendix D-8: Cost Estimate.

10.0 References

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Appendix A: 2D Plans

J. LANNISTER WATER TREATMENT PLANT AND DINKLAGE MEMORIAL INTAKE

CONSTRUCTION NOTES:

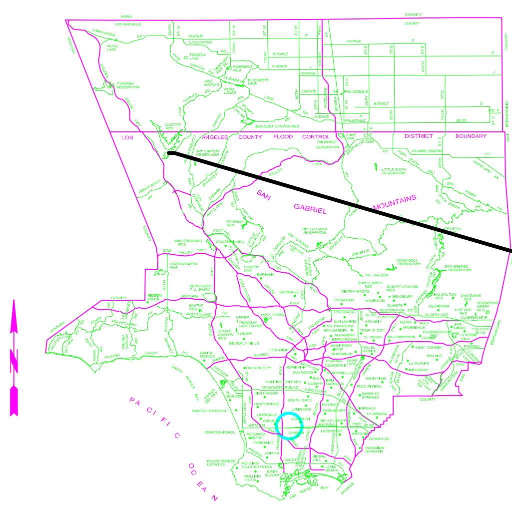
1. INTAKE STRUCTURE IS 30 FT WIDE. THE INTAKE WALL THICKNESS WILL BE 6 IN. REINFORCED CONCRETE.
2. AREA IS DESIGNATED FOR PIPE PLACEMENT. AREA IS 4 FT WIDE.
3. LANES SHALL BE PROVIDED FOR VEHICLE ENTRY AND EXIT.
4. TOWER ROOF HEIGHT SHALL BE 5 FT TO ALLOW FOR RAIN DRAINAGE.
5. ELEVATION OF TOWER ENTRY SHALL BE 1530 FT ABOVE SEA LEVEL.
6. MAX WATER LEVEL ELEVATION IS 1515 FT.
7. CURRENT WATER LEVEL IS 1493 FT.
8. 2 FT DIAMETER COLUMNS FOR THE BRIDGE WITH 2 FT CAP BEAMS. REINFORCED CONCRETE.
9. CENTER LINE OF BRIDGE. BRIDGE WILL BE DESIGNED SYMMETRICALLY.
10. BAFFLE #1 WILL CONTAIN 28 PORTS AT 6 IN DIAMETER.
11. BAFFLE #2 WILL CONTAIN 32 PORTS AT 6 IN DIAMETER.
12. BAFFLE #3 WILL CONTAIN 60 PORTS AT 6 IN DIAMETER.

SHEETS

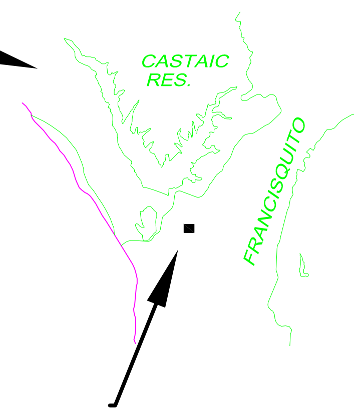
TITLE SHEET

INTAKE TOWER STRUCTURAL PLAN

FLOCCULATION PLAN/PROFILE



LOCATION MAP



CIVICUS ENGINEERING

9400 Flair Dr
El Monte, CA 91731

CLIENT: Castaic Lake Water Agency

CLIENT REPRESENTATIVE: Professor David Whipple

DRAFT NO.: 1

DRAWN BY: Alex Tran — 5-18-18

CHECKED BY: NAME — DATE

REGISTERED CE STUDENT
ALEXANDER TRAN
Exp. 06/2018
No. 102016
CIVIL
STATE OF CALIFORNIA

PLAN TYPE:

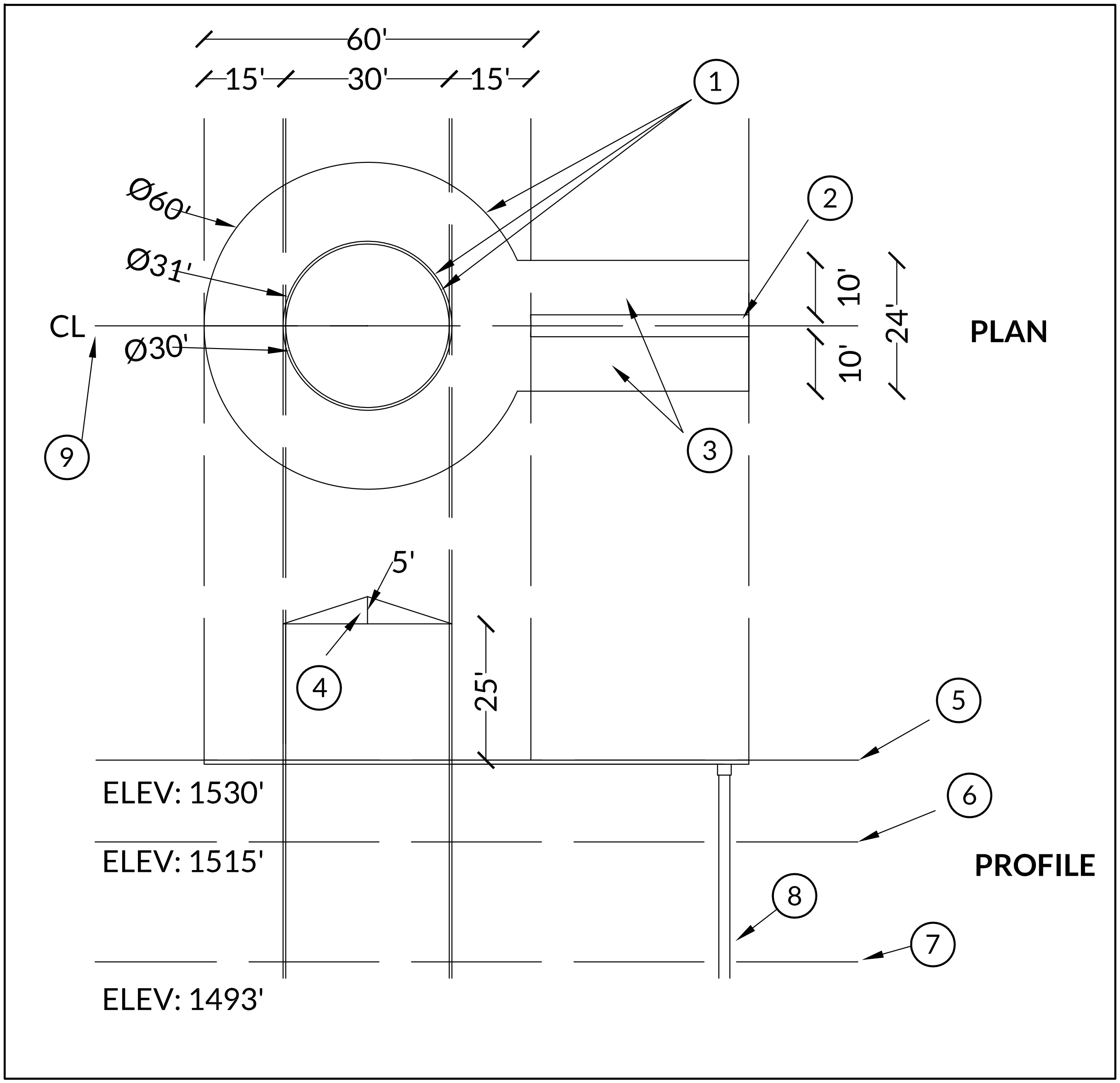
PROJECT ADDRESS

CASTAIC LAKE

TITLE SHEET

PROJECT NO.: 52318

SHEET 1 OF 3



CIVICUS

ENGINEERING

9400 Flair Dr
El Monte, CA 91731

CLIENT: Castaic Lake Water Agency

CLIENT REPRESENTATIVE:
Professor David Whipple

DRAFT NO.: 1

DRAWN BY:
Alex Tran 5-18-18

CHECKED BY:
Chris Estevan 5-19-18

PLAN TYPE: PLAN/PROFILE

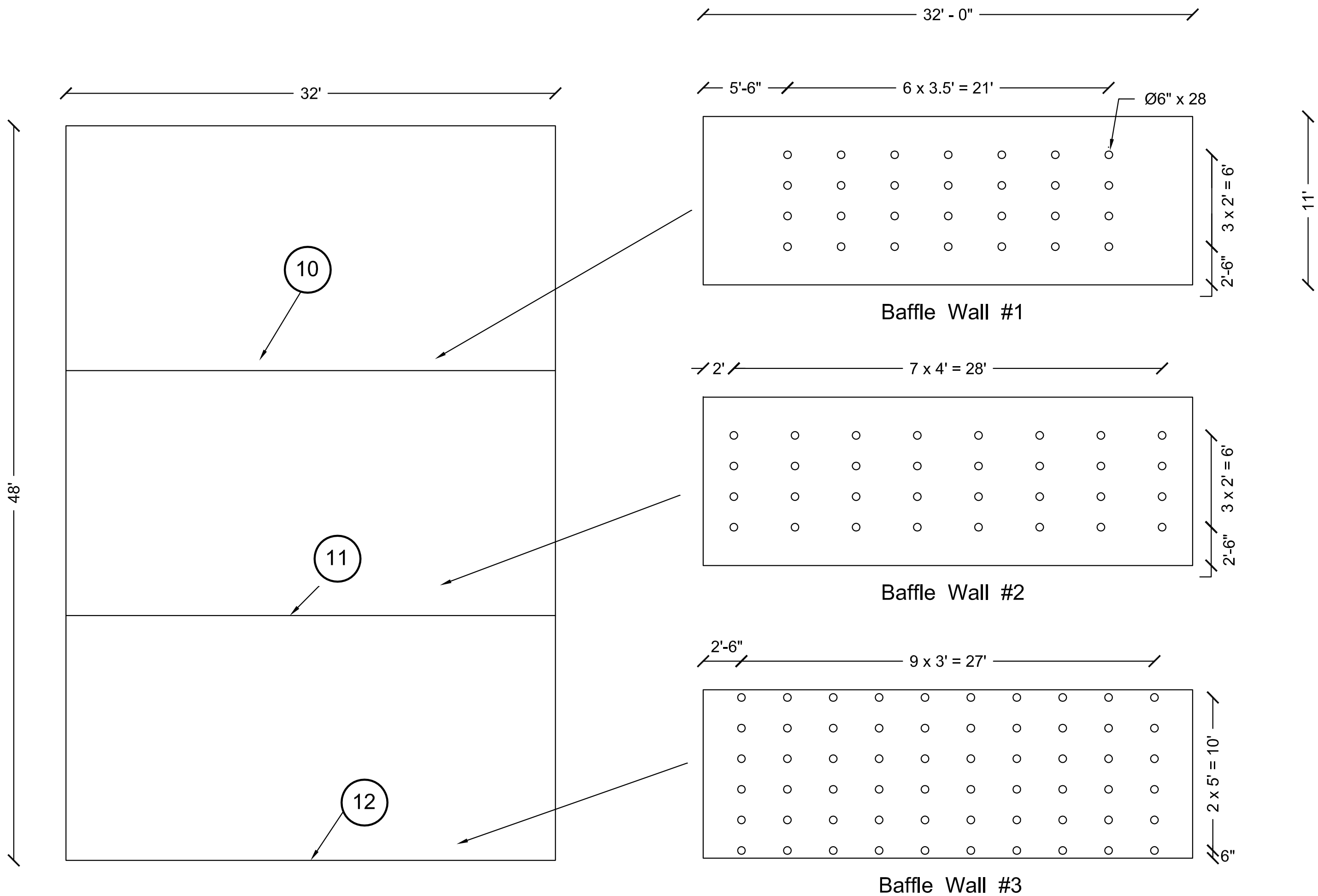
PROJECT ADDRESS

Lat: 34.523347°
Long: -118.599049°

INTAKE TOWER STRUCTURAL PLAN

PROJECT NO.: 52318

SHEET 2 OF 3



PLAN

PROFILE

CIVICUS ENGINEERING

9400 Flair Dr
El Monte, CA 91731

CLIENT: Castaic Lake Water Agency

CLIENT REPRESENTATIVE:
Professor David Whipple

DRAFT NO.: 1

DRAWN BY: Alex Tran 5-18-18

CHECKED BY: Abraham Mercado 5-19-18

REGISTERED CE STUDENT
ALEXANDER TRAN
Exp. 06/2018
No. 102016
CIVIL
STATE OF CALIFORNIA

PLAN TYPE: PLAN/PROFILE

PROJECT ADDRESS

Lat: 34.496020°
Long: -118.602831°

FLOCCULATION TANK AND BAFFLE WALL

PROJECT NO.: 52318

SHEET 3 OF 3

Appendix B: Renderings/3D

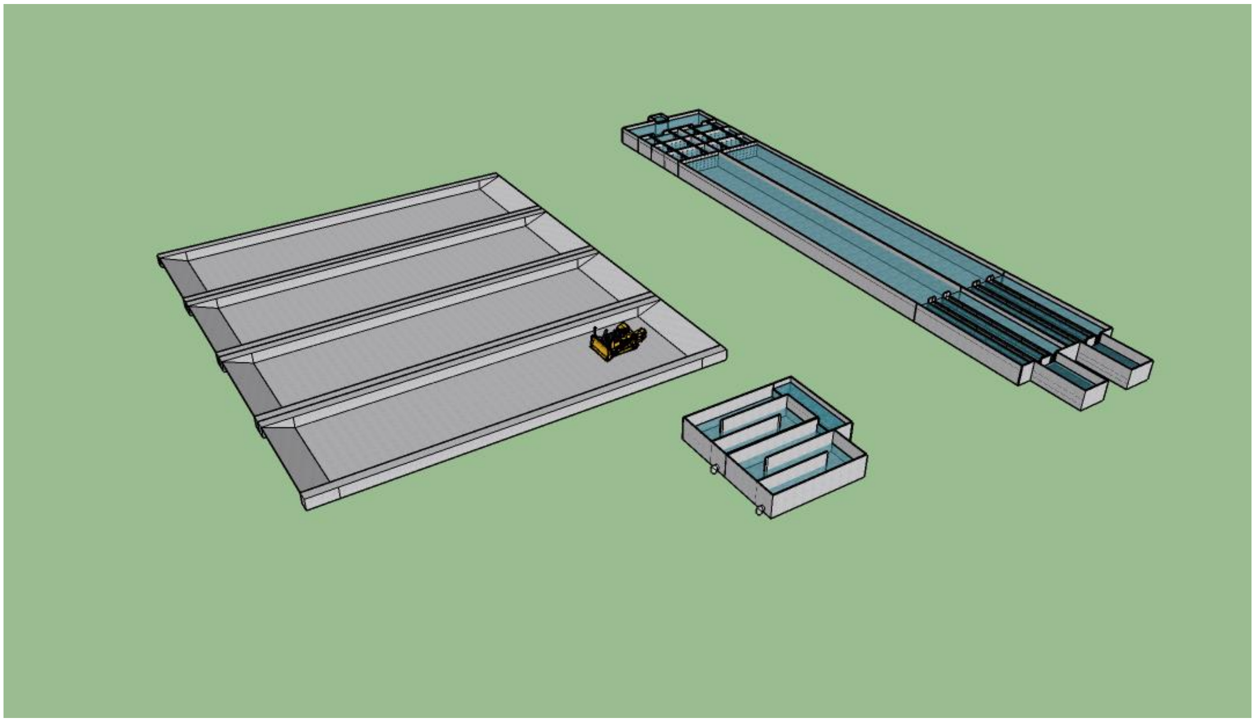


Figure B-1. SketchUp Model of Water Treatment Plant.

Figure B-2. SketchUp Model Visualized in Google Earth.

Figure B-3. Rendering of Intake Tower.

Figure B-4. Intake Tower Visualized in Google Earth.

*More photos can be seen on instagram.com/alexthecivil

Appendix C: Envision Assessment

J. Lannister Water Treatment Plant Design

Project Location: Castaic, CA

Project Score: 16%

No Award Level

Project ID: 2779

Project Stage: Unregistered

Created: 05/21/2018

Project Team: Alex Tran

Project Contact: Alex Tran

ENV SP: AlexTran

Project Description:

This is a school project for CPP CE 431 Water Treatment class. This is not a real project. I just need access to the online score sheet.Contracted by Castaic Lake Water Agency to design a new water treatment plant and intake to replace existing water treatment plant (Earl Schmidt Filtration Plant).

Who	Step	Agree	Level	Comments	Files
QUALITY OF LIFE					
QL1.1 - Improve Community Quality of Life					
ENV SP	Initial Submittal		No Level (0/25)		
QL1.2 - Stimulate Sustainable Growth and Development					
ENV SP	Initial Submittal		Enhanced (2/16)		
QL1.3 - Develop Local Skills and Capabilities					
ENV SP	Initial Submittal		Enhanced (2/15)		
QL2.1 - Enhance Public Health and Safety					
ENV SP	Initial Submittal		Improved (2/16)		
QL2.2 - Minimize Noise and Vibration					
ENV SP	Initial Submittal		Improved (1/11)		
QL2.3 - Minimize Light Pollution					
ENV SP	Initial Submittal		Superior (4/11)		
QL2.4 - Improve Community Mobility and Access					
ENV SP	Initial Submittal		Improved (1/14)		
QL2.5 - Encourage Alternative Modes of Transportation					
ENV SP	Initial Submittal		No Level (0/15)		
QL2.6 - Improve Site Accessibility, Safety and Wayfinding					
ENV SP	Initial Submittal		Superior (6/15)		
QL3.1 - Preserve Historic and Cultural Resources					
ENV SP	Initial Submittal		NA (0/0)		
QL3.2 - Preserve Views and Local Character					
ENV SP	Initial Submittal		Improved (1/14)		
QL3.3 - Enhance Public Space					
ENV SP	Initial Submittal		NA (0/0)		
QL0.0 - Innovate or Exceed Credit Requirements					

LEADERSHIP

LD1.1 - Provide Effective Leadership and Commitment

ENV SP	Initial Submittal	Enhanced (4/17)

LD1.2 - Establish a Sustainability Management System

ENV SP	Initial Submittal	No Level (0/14)

LD1.3 - Foster Collaboration and Teamwork

ENV SP	Initial Submittal	Enhanced (4/15)

LD1.4 - Provide for Stakeholder Involvement

ENV SP	Initial Submittal	Improved (1/14)

LD2.1 - Pursue Byproduct Synergy Opportunities

ENV SP	Initial Submittal	Improved (1/15)

LD2.2 - Improve Infrastructure Integration

ENV SP	Initial Submittal	Enhanced (3/16)

LD3.1 - Plan for Long-term Monitoring and Maintenance

ENV SP	Initial Submittal	Improved (1/10)

LD3.2 - Address Conflicting Regulations and Policies

ENV SP	Initial Submittal	No Level (0/8)

LD3.3 - Extend Useful Life

ENV SP	Initial Submittal	No Level (0/12)

LD0.0 - Innovate or Exceed Credit Requirements

RESOURCE ALLOCATION		
RA1.1 - Reduce Net Embodied Energy		
ENV SP	Initial Submittal	Improved (2/18)
RA1.2 - Support Sustainable Procurement Practices		
ENV SP	Initial Submittal	No Level (0/9)
RA1.3 - Use Recycled Materials		
ENV SP	Initial Submittal	Improved (2/14)
RA1.4 - Use Regional Materials		
ENV SP	Initial Submittal	Improved (3/10)
RA1.5 - Divert Waste From Landfills		
ENV SP	Initial Submittal	No Level (0/11)
RA1.6 - Reduce Excavated Materials Taken Off Site		
ENV SP	Initial Submittal	Improved (2/6)
RA1.7 - Provide for Deconstruction and Recycling		
ENV SP	Initial Submittal	No Level (0/12)
RA2.1 - Reduce Energy Consumption		
ENV SP	Initial Submittal	Improved (3/18)
RA2.2 - Use Renewable Energy		
ENV SP	Initial Submittal	Enhanced (6/20)
RA2.3 - Commission and Monitor Energy Systems		
ENV SP	Initial Submittal	Conserving (11/11)
RA3.1 - Protect Fresh Water Availability		
ENV SP	Initial Submittal	Improved (2/21)
RA3.2 - Reduce Potable Water Consumption		
ENV SP	Initial Submittal	No Level (0/21)
RA3.3 - Monitor Water Systems		
ENV SP	Initial Submittal	No Level (0/11)
RA0.0 - Innovate or exceed credit requirements		

NATURAL WORLD

NW1.1 - Preserve Prime Habitat

ENV SP Initial Submittal NA (0/0)

NW1.2 - Protect Wetlands and Surface Water

ENV SP Initial Submittal No Level (0/18)

NW1.3 - Preserve Prime Farmland

ENV SP Initial Submittal No Level (0/15)

NW1.4 - Avoid Adverse Geology

ENV SP Initial Submittal Enhanced (2/5)

NW1.5 - Preserve Floodplain Functions

ENV SP Initial Submittal Improved (2/14)

NW1.6 - Avoid Unsuitable Development on Steep Slopes

ENV SP Initial Submittal No Level (0/6)

NW1.7 - Preserve Greenfields

ENV SP Initial Submittal No Level (0/23)

NW2.1 - Manage Stormwater

ENV SP Initial Submittal Enhanced (4/21)

NW2.2 - Reduce Pesticide and Fertilizer Impacts

ENV SP Initial Submittal Conserving (9/9)

NW2.3 - Prevent Surface and Groundwater Contamination

ENV SP Initial Submittal No Level (0/18)

NW3.1 - Preserve Species Biodiversity

ENV SP Initial Submittal NA (0/0)

NW3.2 - Control Invasive Species

ENV SP Initial Submittal Restorative (11/11)

NW3.3 - Restore Disturbed Soils

ENV SP Initial Submittal No Level (0/10)

NW3.4 - Maintain Wetland and Surface Water Functions

ENV SP Initial Submittal NA (0/0)

NW0.0 - Innovate or Exceed Credit Requirements

CLIMATE AND RISK

CR1.1 - Reduce Greenhouse Gas Emissions

ENV SP Initial Submittal Improved (4/25)

CR1.2 - Reduce Air Pollutant Emissions

ENV SP Initial Submittal No Level (0/15)

CR2.1 - Assess Climate Threat

ENV SP Initial Submittal No Level (0/15)

CR2.2 - Avoid Traps and Vulnerabilities

ENV SP Initial Submittal No Level (0/20)

CR2.3 - Prepare for Long-Term Adaptability

ENV SP Initial Submittal Conserving (16/20)

CR2.4 - Prepare for Short-Term Hazards

ENV SP Initial Submittal No Level (0/21)

CR2.5 - Manage Heat Island Effects

ENV SP Initial Submittal Improved (1/6)

CR0.0 - Innovate or Exceed Credit Requirements

	Submitted Score Information			Verified Score Information		
Credit Category	Applicable	Submitted	Percentage	Applicable	Verified	Percentage
QUALITY OF LIFE	152	19	13%	181	0	0%
LEADERSHIP	121	14	12%	121	0	0%
RESOURCE ALLOCATION	182	31	17%	182	0	0%
NATURAL WORLD	150	28	19%	203	0	0%
CLIMATE AND RISK	122	21	17%	122	0	0%
Total Points / %	727	113	16%	809	0	0%

Appendix D: Calculations

Appendix D-1: Venturi Meter Design

→ Use Alum

Flow Meter Venturi Meter Design:

Inlet Velocity → 6-10 ft/sec → Average Inlet Velocity (V) = 8 ft/sec

ΔP @ $Qavg$ = 80"

$Negative\ Pressure$ @ $Qmax < 2ft$

$Qavg = 12.4\ cfs$

→ Diameter of Venturi Meter

$Q = V * A = V * \pi/\ 4D^2$

$D = \sqrt{4Q/\pi V} = \sqrt{(4*12.4\ cfs)/(\pi 8\ ft/sec)} = 1.40\ ft \approx 18''$

→ Length L of Venturi Meter

L = 10(18")= 180" = 15 ft

→ Flash Mix Design – Use Pump diffusion system

Appendix D-2: Flash Mix Design

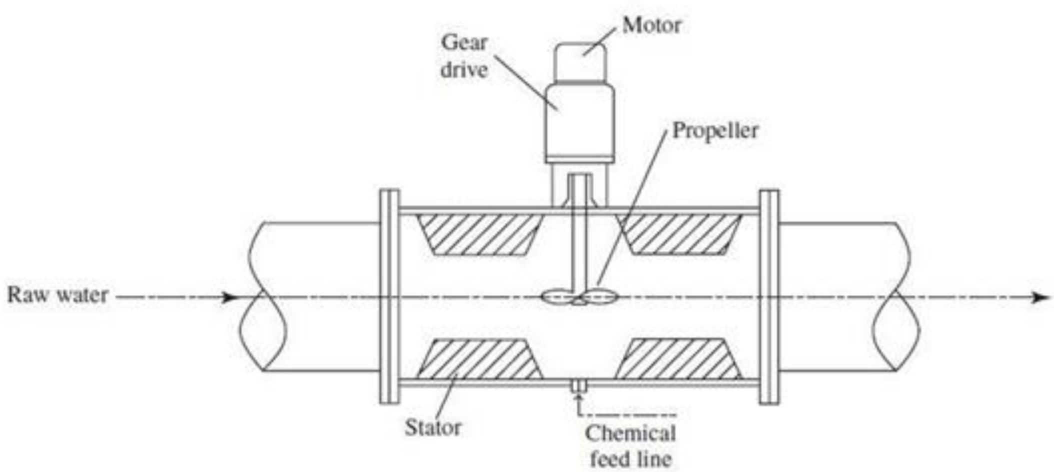


Figure D-1. Flash Mix Design Pump Diffusion System.

$Q = 2{-}5\%\ Plant\ flow$

$G = 1000\ s^{-1}$

$T = 50°F$

Mixing Jet Velocity -----20-25 ft/sec

Length of Mixing Zone = 1.5D

Mixing time (t) = 1 sec

Alum Dose = 5-50 mg/L

Minimum Pressure at Nozzles = 10 psi

D = 2 ft = 24" Raw Water Main = Diameter of Mixing Zone

Q_{max} = 18.6 cfs

Assume a Motor Efficiency of 80%

$\mu = 2.73 \; x \; 10{-}5$ lb-s/ft^3 (Kawamura)

$V = t(Q_{max}) = (1sec)(18.6\,ft^3/sec) = 18.6\,ft^3$

$V = ((\pi D^2)/\,4)^*L,\;\; L = 5.92\,ft$ → Need to Buy 6' of 24" Diameter Pipe

So Recalculate "V" with L= 6'

$V = ((\pi 2'^2)/\,4)^*\,6' = 18.84\,ft^3 \approx 18.8\,ft^3\;\; "OK"$

Specs → Length of Mixing Zone = 6 ft

Diameter of Mixing Zone = 2 ft

Volume of Mixing zone = 18.8 ft^3

→ Required HP (Liquid Mix)

$P = G^2\mu V = 1000^2\,(2.73\,x\,10^{-5})(18.8\,) = 513.24\,ft\,lb/sec$

$P = (513.24\,ft\,lb/sec)\,/\,550 = 0.93\,Hp$

→ Pump diffusion Rate at Nozzle

$Q_{pd} = 0.05\,Q_{max} = 0.05(18.6\,cfs) = 0.93\,cfs$

→ Mixing Jet Velocity

$Hp = (Q\gamma)(V^2/\,2g)/\,550 = 0.93\,Hp \rightarrow\;\; V = 23.8\,ft/sec\;"OK"$

→ Diameter of Nozzle

$A = Q/V \rightarrow \pi D^2/4 = Q/V \rightarrow\;\; D = \sqrt{}(4Q/V\,\pi) = 3" \rightarrow$ "OK"

→ Pump Motor HP

$TDH = V^2/\,2g + 10$ psi

$TDH = (23.8^2$ ft/s$)/2(32.2$ ft/s$^2) + 10\,psi\,(\,2.31\,ft/\,psi)$

$TDH = 23.5\,ft$

$BHp = Q\gamma DH\,/\,550\varepsilon = 3.10$Hp

$Motor\;Hp = BHp/\,\varepsilon = 3.10\,/\,0.8 = 3.87$Hp → 4 Hp Motor

Appendix D-3: Flocculation System Design

Tank Dimensions-

<u>Initial Assumptions:</u>
Depth of tank assumed as 11ft→ D=11ft
Length to Width Ratio L/W=1.5 → Industry Standard
Flocculation Stages= 3
Number of Flocculators per Stage= 2
Detention Time, t_d =10 min per stage
Water Temperature= 50 degree Fahrenheit
$Q_{Max}, MGD = 12$→ 12/0.646=$Q_{Max}, cfs = 18.6$

For Tank Volume:

$$V, ft^3\ per\ Tank = \frac{(Q_{Max})(t_d)(\#\ of\ Stages)(60)}{2\ Tanks}$$
$$= \frac{(18.6\ cfs)(10min)(2)(60)}{2\ Tanks}$$
$$V, ft^3\ per\ Tank = \mathbf{16,718ft^3 per\ tank}$$

For Surface Area:
Volume/Depth= $16{,}718ft^3 / 11ft = 1{,}520\ ft^2/per\ tank$

For Tank Width:

$$W = \sqrt{Surface\ Area/\ L/W\ Ratio} = \sqrt{\frac{1520}{1.5}} = 31.8ft \approx 32ft$$

For Tank Length:
L=$Volume/(W \times D) = 16718/(32 \times 11) = 48ft$

Final Dimensions per Tank= L x W x D= 48 ft x 32 ft x 11 ft

Diameter of Mixing Blades-

<u>Initial Assumptions:</u>
D/T→ Should be between 0.2 to 0.4 thus we will use 0.35

For Blade Diameter:

D=0.35(Tank width, ft)= 0.35(32ft)= 11.12ft≈12ft
Two mixers per Stage → D/2= 12ft/2= **6ft for diameter of one blade**

RPM of Mixing Shaft-

<u>Initial Assumptions:</u>

Mixer tip speed to reduce shear (fps) → 6 to 9 taken from Kawamura
Shaft RPM→ 8 to 25 to prevent Floc Sticking to Shaft taken from Kawamura
Velocity of Tip, Stage 1= 7 ft/sec→ taken from design experience
Velocity of Tip, Stage 2=5 ft/sec → taken from design experience
Velocity of Tip, Stage 3= 1 ft/sec → taken from design experience

For RPM at each stage:

RPM Stage 1$= \frac{V_{tip}\times 1\ rev\times 60sec}{2\pi\times radius\times 1min} = \frac{7\times 1\times 60}{2\pi\times 6/2\times 1} = 22.3\ rpm \leq 25rpm --> \ OK$

RPM Stage 2$= \frac{V_{tip}\times 1\ rev\times 60sec}{2\pi\times radius\times 1min} = \frac{5\times 1\times 60}{2\pi\times 6/2\times 1} = 15.9\ rpm \leq 25rpm --> \ OK$

RPM Stage 3$= \frac{V_{tip}\times 1\ rev\times 60sec}{2\pi\times radius\times 1min} = \frac{1\times 1\times 60}{2\pi\times 6/2\times 1} = 3.2\ rpm \leq 8rpm --> \ not\ OK$

Note: For the RPM of Stage 3 a custom blade will need to be cut for our plant. Even though we were not able to reach the minimum of 8 rpm per our assumptions the plant will have turn up and turn down capabilities to offset the low rpm for stage 3.

Flocculator Motor for Each Stage-

<u>Initial Assumptions:</u>
Flocculator Type= Vertical Shaft
Mixing Energy step down, s^{-1}= 70 ,50, 20 taken from Kawamura
Motor Efficiency of 75%
Length of tank broken into 3 compartments 48 ft/3=16ft long compartments

For Horsepower (P) needed at Each Stage:

Using equation $P = \frac{G^2 \times \mu \times V}{550 \times e}$

Stage 1: $P_1 = \frac{70^2 \times 2.73 \times 10^{-5} \times (16 \times 32 \times 11)}{550 \times 0.75} = 1.8hp \approx 2hp$

Stage 2: $P_2 = \frac{50^2 \times 2.73 \times 10^{-5} \times (16 \times 32 \times 11)}{550 \times 0.75} = 0.93hp \approx 1hp$

Stage 3: $P_3 = \frac{20^2 \times 2.73 \times 10^{-5} \times (16 \times 32 \times 11)}{550 \times 0.75} = 0.15hp \approx 0.25hp$

Note: Each motor spinning 2 flocculators per stage or buy 2 motors spinning individual units at ½ the hosepower. The Belts that will be used is belt drives not chain drive.

Baffle Wall Between Stages and Exit to Sed Tanks-

<u>Initial Assumptions:</u>
Circular ports placed in between walls
Use 6 inch (0.5ft) ports
Velocity through Stage 1= 1.8ft/sec

Velocity through Stage 2= 1.5 ft/sec
Velocity through Stage 3= 0.8 ft/sec

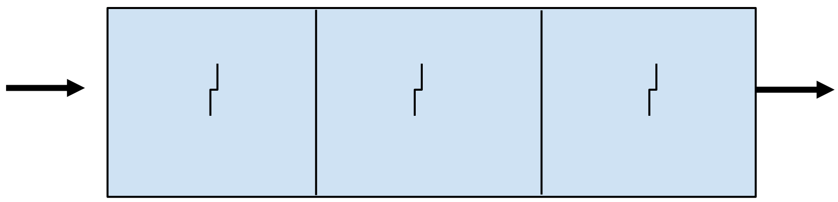


Figure D-2. Flocculation Tank.

Area per Port= $\frac{\pi}{4}D^2 = \frac{\pi}{4}(0.5)^2 = 0.196\ ft^2$

For Baffle Wall 1:

Q=AV→ $A_{total} = \frac{0.5Q_{Max}}{V_{port}} = \frac{0.5(18.6\ cfs)}{1.8\ ft/sec} = 5.2\ ft^2$

Number of Ports= $A_{Total}/A_{port} = 5.2/0.196 = 26.5 \approx 28\ ports$

Thus we will have 7 columns (3.5ft width) with 4 rows (2 ft deep) the Tank itself is 32 ft wide by 11 ft deep we are OK

Check area→ 28$(0.196\ ft/port) = 5.5ft^2 > 5.2ft^2\ OK\ we\ can\ lower\ velocity$

For Baffle Wall 2:

Q=AV→ $A_{total} = \frac{0.5Q_{Max}}{V_{port}} = \frac{0.5(18.6\ cfs)}{1.5\ ft/sec} = 6.2\ ft^2$

Number of Ports= $A_{Total}/A_{port} = 6.2/0.196 = 31.6 \approx 32\ ports$

Thus we will have 8 columns (4 ft width) with 4 rows (2ft deep) the Tank itself is 32 ft wide by 11 ft deep we are OK

Check area→ 32$(0.196\ ft/port) = 6.3ft^2 > 6.2ft^2\ OK$

For Baffle Wall 3→ Diffuser into SED Tank:

Q=AV→ $A_{total} = \frac{0.5Q_{Max}}{V_{port}} = \frac{0.5(18.6\ cfs)}{0.8\ ft/sec} = 11.6\ ft^2$

Number of Ports= $A_{Total}/A_{port} = 11.6/0.196 = 59.2 \approx 60\ ports$

Thus we will have 10 columns (6 ft width) with 6 rows (3 ft deep) the Tank itself is 32 ft wide by 11 ft deep we are OK

Check area→ 60$(0.196\ ft/port) = 11.8ft^2 > 11.6ft^2\ OK$

Head Loss Through Baffle Wall-

Initial Assumptions:
C=0.8 for all Baffles
Do we have enough depth to push floc through walls?

For Head Loss:

$Q = CA(2gh)^{0.5}$→ solving for $h = (Q/CA)^2/(2g)$

Baffle Wall #1:
$h = (Q/CA)^2/(2g)$=$((18.6/2)/(0.8/5.5))^2/(2 \times 32.2) = 0.069ft\ or\ 0.83inches$

Baffle Wall #2:
$h = (Q/CA)^2/(2g)$=$((18.6/2)/(0.8/6.3))^2/(2 \times 32.2) = 0.053ft\ or\ 0.64inches$

Baffle Wall #3:
$h = (Q/CA)^2/(2g)$=$((18.6/2)/(0.8/11.8))^2/(2 \times 32.2) = 0.015ft\ or\ 0.18inches$

Appendix D-4: Sedimentation Tank Design

Assume Qmax = 12MGD ->8333 GPM -> 18.6ft^2/s

Assume Surface Loading Rate (SLR) = .9 GPM/ft^2

Tank Dimensions: $A = Qmax/SLR = (8333GPM)/(.9GPM/ft^2) = 9300\ ft^2$
Design Safety Factor = 1.5 -> $A = 1.5 * 9300ft^2 = 13950\ ft^2$
Because 2 tanks in parallel -> $A = 13950ft^2/2 = 6975ft^2$
Final surface area of tank = 6975 ft^2
Width of sedimentation tanks are the same as floc tanks -> W = 32ft
Depth of sedimentation tanks are the same as floc tanks -> D = 11ft

$$L = A/W = 6975\ ft^2/32ft = 220ft$$
$$W = 32ft$$
$$D = 11ft$$

Check Dimension Ratios:
$L/W = 220/32 = 6.875 > 4$ Ok
$\underline{L/D = 220/11 = 20}$ > 15 Ok

Horizontal Velocity: $V = .5Qmax/A = .0264\ ft/sec = 1.6\ ft/min$
Conformance Check: $1 < 1.6 < 3.5\ ft/min$ Ok

Detention Time: $DT = V/(.5Qmax) = (220ft * 32ft * 11ft)/(.5 * 9300ft^2) = 2.4\ hours$
Conformance Check: $1.5 < 2.4 < 4\ hours$ Ok

Sludge Pumps: $Design\ Rate = (10\ GPM/ft)/W = (10\ GPM/ft)/(32ft) = 320\ GPM$

Effluent Launders: Assigned Loading Rate = 14 GPM/ft
Total Weir Length: $TWL = Qmax/Weir\ Loading = (8333GPM)/(14\ GPM/ft) = 600ft$
Weir Length per Tank -> 2 Tanks -> $L = 600\ ft/2 = 300ft$
Launder Length: $(1/3) * L = (1/3) * 220 = 70ft$
# of Launders per Tank: $n = .5[Total\ Weir\ Length/Length\ of\ Launder] = .5 * 300\ GPM/70\ ft = 2.045 -> 2\ launders/tank$
Launder weir length: $LWL = 70ft * 2\ launders * 2\ sides = 280\ ft/tank$
Loading rate: $Lr = .5 * 8333GPM/280ft = 14.9\ GPM/ft$
Conformance Check: $14.9 < 15$ Ok

Appendix D-5: Sludge Lagoon Design

Initial alum dose = 20 mg/L
Raw water turbidity = 20 NTU
Depth = 6 ft
Average flow rate = 8 MGD
Hold 90 days of sludge
Dry Alum sludge production rate:

$$\frac{lbs\ of\ sludge}{MG\ of\ water\ treated} = [alum\ dosage(mg/L) \times (0.26 \times 8.34)] + [raw\ water\ turbidity\ (NTU) \times 1.3 \times 8.34)]$$

$$\frac{lbs\ of\ sludge}{MG\ of\ water\ treated} = (20\ mg/L)(0.26)(8.34) + (20\ NTU)(1.3)(8.34)$$

$$\frac{lbs\ of\ sludge}{MG\ of\ water\ treated} = 260\ \frac{lbs}{MG}$$

$$daily\ average\ lbs\ of\ sludge = (260\frac{lbs}{MG})(8MGD) = 2080\ \frac{lbs}{day}$$

90 day hold: $(\frac{2080\ lbs\ of\ sludge}{ave.day})(90\ days) = 187{,}200\ lbs\ of\ sludge$

$$(187{,}200\ lbs)(\frac{1\ ft^2}{16\ lbs}) = 11{,}700\ ft^2$$

Round 11,700 ft^2 to 12,000 ft^2

$$A = LxW \rightarrow 12{,}000ft^2 = 4WxW$$

Initial : $W = \sqrt{\frac{12{,}000}{4}} \rightarrow W = 54.7\ ft$

Trial 1: Try $W = 60\ ft$

$4(60)^2 = 14{,}400\ ft^2$

$\frac{14{,}400-12{,}000}{12{,}000}x100\% = 20\%$too big, downsize

Trial 2: Try $W = 55\ ft$

$4(55)^2 = 12{,}100\ ft^2$

$\frac{12{,}100-12{,}000}{12{,}000}x100\% = 0.83\%\ OK$

L = 4(W) = 4(55) = 220 ft
W = 55 ft

Appendix D-6: Filtration System Design

Assume standard Dual Media filter with anthracite coal and sand

Assume filtration rate of 6 GPM/ft^2

Assume backwash system - Self backwash with fixed nozzle surface wash system

Total number of filters: $N = 1.2Q^{.5} = 1.2\,(12)^{.5} = 4.16\, filters -> 4\, filters$

Filter bed size: $A = Qmax/Filtration\ Rate = (8330\ GPM)/(6\ GPM/ft^2) = 1390\ ft^2\ of\ filter\ area$

Area per filter: $A = 1390ft^2/4 = 347.5\ ft^2 -> 350\ ft^2$

Assume L:W = 2:1

Area per filter: $L * W = 2W^2$

$$A = 2W^2 -> 348ft^2 = 2W^2$$

$$348ft^2 = 2W^2 -> W = 13.2ft -> 14ft$$

$$L = 2W = 14ft * 2 = 28ft$$

Conformance Check: $10ft < 14ft < 20ft$ <u>Ok</u>

$$A = L * W = 14 * 28 = 392\ ft$$

Conformance Check: $250 < 392 < 1000ft^2$ <u>Ok</u>

Filter Loading Rate: $(Qmax/Total\ Filter\ Area) = (8333GPM)/(392ft^2 * 4filters) = 5.32\ GPM/ft^2$

Conformance Check: $4 < 5.32 < 10\ GPM$ <u>Ok</u>

Appendix D- 7: Disinfection System Design Calculations

<u>Initial Assumptions:</u>

pH=7.0

Temperature= 50 degrees Fahrenheit

Conventional Filtration

Free Chlorine for Disinfection

Ct= 19 mg-min/L for Giardia

Ct= 3 mg-min/L for Virus Inactivation

Total Contact Time wanted= 30 mins

Desired Chlorine Residual = 1 mg/L taken from Kawamura

Ct Minimum= 30 mg-min/L

For Total Contact Tank Volume:

Total contact tank volume= $(Q_{max})(Contact\ Time) = (18.6cfs)(30min \times 60sec/min) = 33{,}480ft^3$

Design of two Parallel Treatment Trains with 3 Contact tanks:

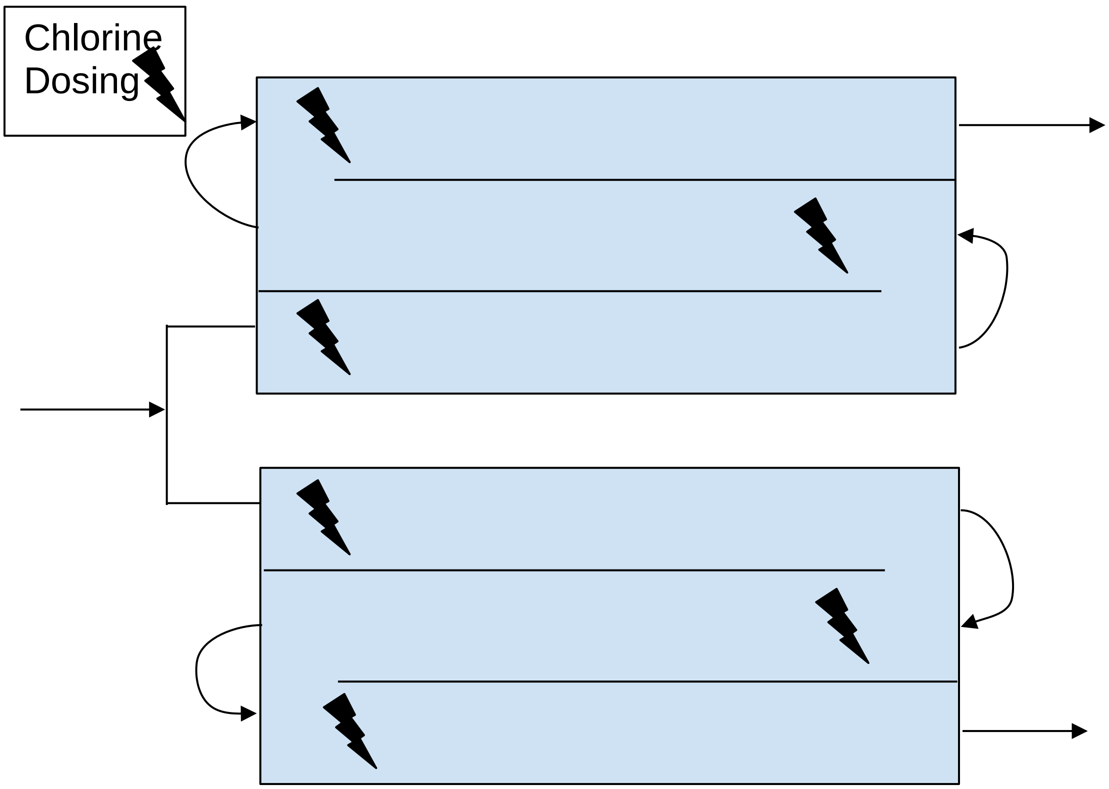


Figure D-3. Chlorine Contact Tanks.

Recall Total Contact Tank Volume Required=$33{,}480ft^3$

Volume per Train=$33{,}480ft^3/2trains = 16{,}740ft^3\ per\ Train$

Size of Each Tank:

There will be three tanks per Treatment Train thus the volume per tank=$16{,}740ft^3\ per\ Train/3 = \ 5580ft^3$

<u>Initial Assumptions:</u>
Plug flow
Standard Tank Size Ratio L:W=5:1
Depth of Tank, D=12ft

Tank Dimensions:

$$L \times W \times D = 5580ft^3$$

→ for W: $5580ft^3 = 5W \times W \times 12 \rightarrow W = 9.6ft \approx 10ft$
→ for L: $L = 5 \times W = 5 \times 10ft = 50ft$

Final Dimensions per Tank= L x W x D= 50 ft x 10 ft x 12 ft (Note: There is 6 Total Tanks)

Check Contact Time:

Total Contact Tank Volume =

$$L \times W \times D \times \#of\ Tanks = 50ft \times 10ft \times 12ft \times 6 = 36{,}000ft^3$$

Total Contact Time for this system→ $t = V/Q_{max} = (36000\ ft^3/18.6\ cfs)(1\ min/60\ sec) = 32.3min \geq 30\ mins\ OK$

Total Ct of Residual=$(1\ mg/L)(32.3\ min) = 32.3\ mg - min/L \geq 30\ mg - min/L\ OK$

Note: The Ct of Residual in the system is approximately 7.7% higher than we initially wanted but this small percentage is ok

Appendix D-8: Cost Estimate

To determine the size of the plant based on the maximum flow of 12 MGD, the following formula was provided by Kawamura:

Q_{max} = 12 MGD
Area > $(12\text{ MGD})^{0.7}$
Minimum Area = 5.7 acres

According to the index of Figure D-4 and Figure D-5, the cost estimate for construction and operation and maintenance is as followed:

Construction Cost:
Adjusted Cost = (Current Index/Chart Index) x (Cost value from chart) x (1.3)
= (10315.44 / 6,500) x (15,000,000) x (1.3) = $31,000,000.0

Operation and Maintenance Cost:
Adjusted Cost = (Current Index/Chart Index) x (Cost value from chart) x (1.3)
= (10315.44 / 6,500) x (420,000) x (1.3) = $890,000.00

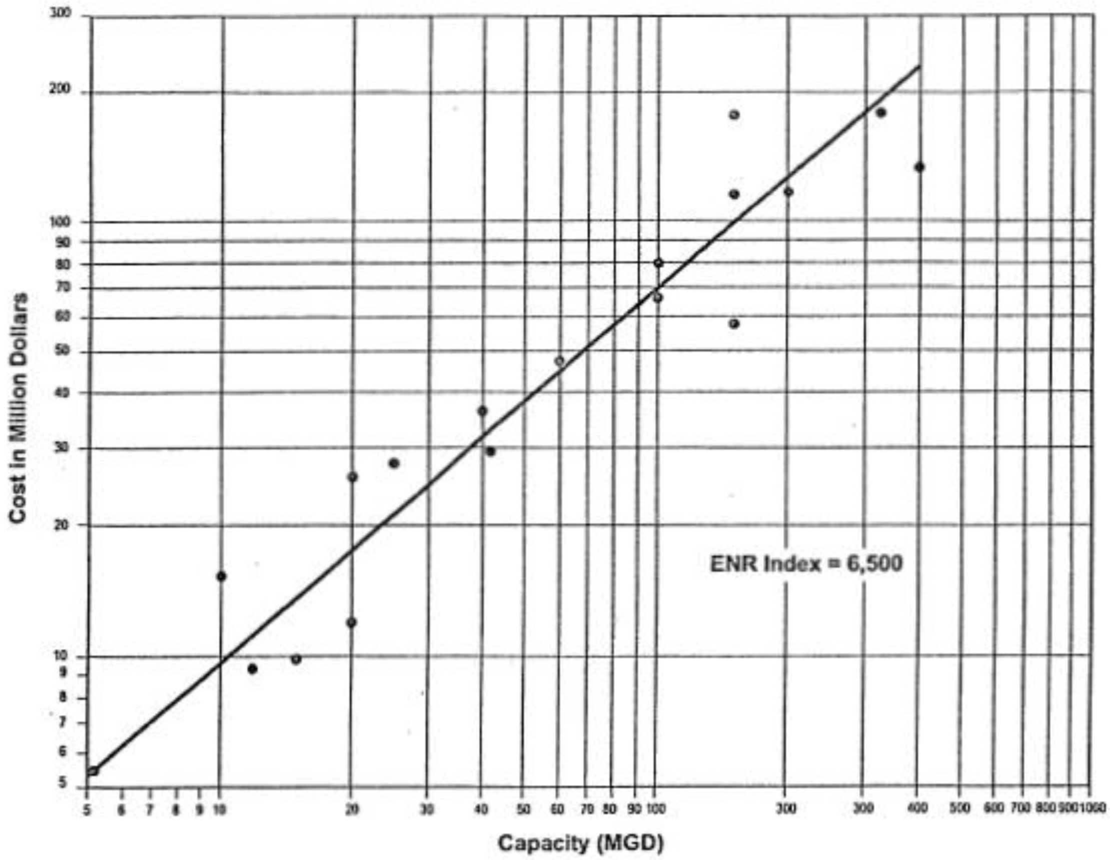


Figure D-4. Construction Cost for a Conventional Water Treatment Plant.

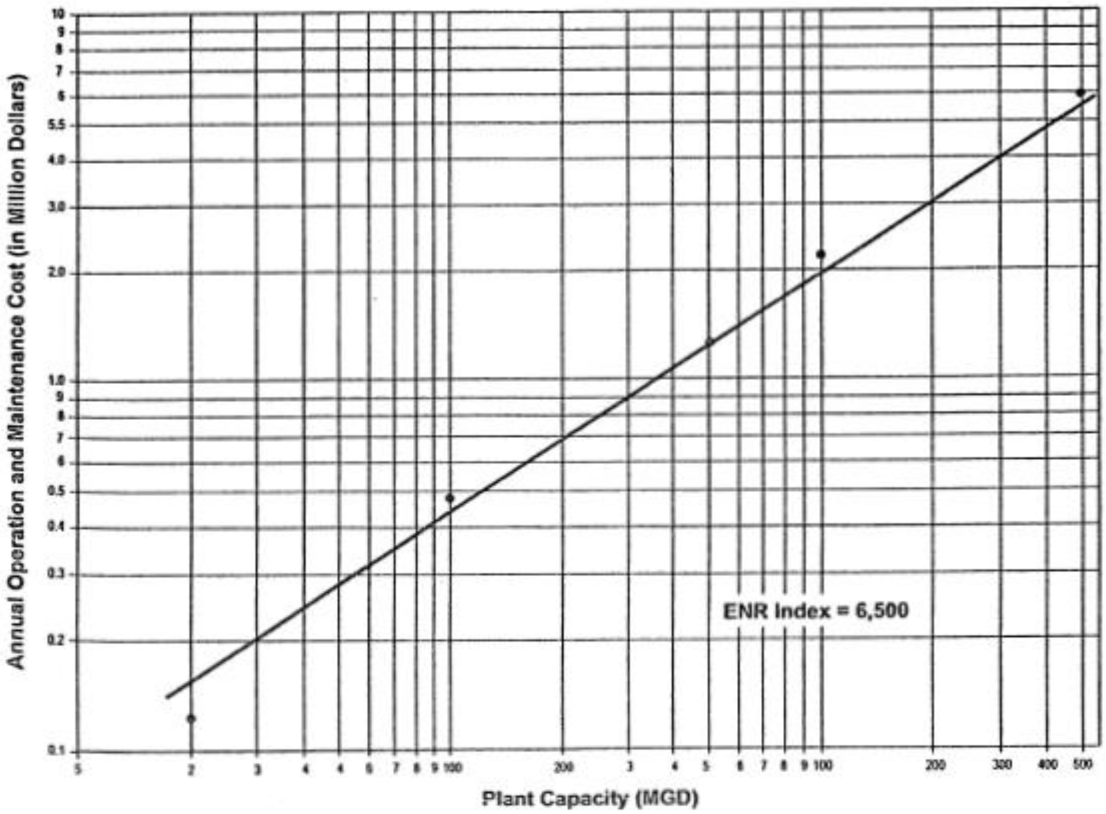


Figure D-5. Plant Operation and Maintenance Cost for a Conventional Plant.