Project 1

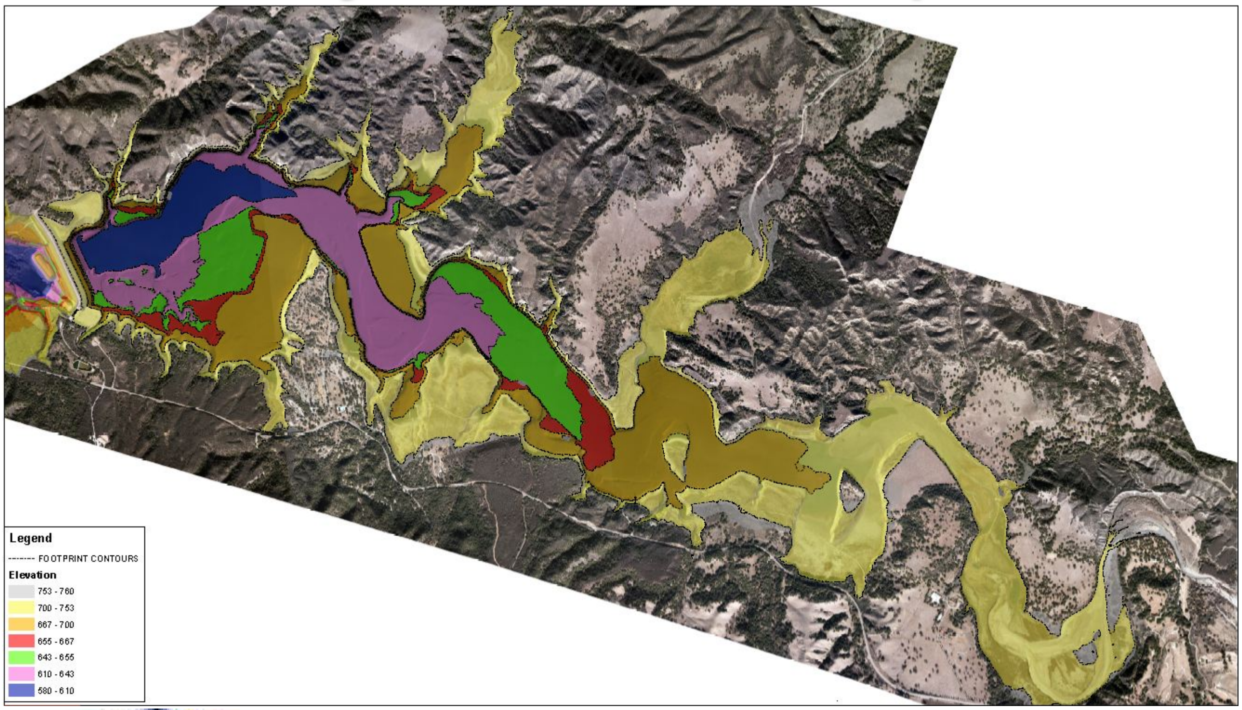
Lake Cachuma Drought Pumping Facility Project

Supporting Documents

County of Santa Barbara
Public Works Department
Water Agency

Lake Cachuma

Formed by Bradbury Dam
Results of 2013
Survey & Sedimentation Update



Prepared by Wallace Group

Survey Date: December 2013
Report Date: February 17, 2014

LICENSED LAND SURVEYOR
PHIL REIMER
Exp.____
No 6391
STATE OF CALIFORNIA

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Appendix A – Controls

Cachuma Lake NGVD 29 Datum

680.2	44,521	44,533	44,545	44,557	44,569	44,581	44,593	44,604	44,616	44,628
680.1	44,402	44,414	44,426	44,438	44,450	44,462	44,474	44,486	44,497	44,497
680.0	44,283	44,295	44,307	44,319	44,331	44,343	44,355	44,355	44,367	44,379
679.9	44,165	44,176	44,188	44,200	44,212	44,224	44,236	44,248	44,260	44,272
679.8	44,046	44,058	44,069	44,081	44,093	44,105	44,117	44,129	44,141	44,153
679.7	43,927	43,939	43,951	43,962	43,974	43,986	43,998	44,010	44,022	44,034
679.6	43,808	43,820	43,832	43,844	43,855	43,867	43,879	43,891	43,903	43,915
679.5	43,692	43,703	43,715	43,727	43,738	43,750	43,762	43,773	43,785	43,797
679.4	43,575	43,587	43,598	43,610	43,622	43,633	43,645	43,657	43,668	43,680
679.3	43,458	43,470	43,482	43,493	43,505	43,517	43,528	43,540	43,552	43,563
679.2	43,341	43,353	43,365	43,376	43,388	43,400	43,412	43,423	43,435	43,447
679.1	43,225	43,236	43,248	43,260	43,271	43,283	43,295	43,306	43,318	43,318
679.0	43,108	43,120	43,131	43,143	43,155	43,166	43,178	43,178	43,190	43,201
678.9	42,991	43,003	43,015	43,026	43,038	43,050	43,061	43,073	43,085	43,096
678.8	42,875	42,886	42,898	42,910	42,921	42,933	42,945	42,956	42,968	42,980
678.7	42,758	42,770	42,781	42,793	42,805	42,816	42,828	42,840	42,851	42,863
678.6	42,641	42,653	42,665	42,676	42,688	42,700	42,711	42,723	42,735	42,746
678.5	42,526	42,538	42,549	42,561	42,572	42,584	42,595	42,607	42,618	42,630
678.4	42,411	42,423	42,434	42,446	42,457	42,469	42,480	42,492	42,503	42,515
678.3	42,296	42,308	42,319	42,331	42,342	42,354	42,365	42,377	42,388	42,400
678.2	42,181	42,192	42,204	42,216	42,227	42,239	42,250	42,262	42,273	42,285
678.1	42,066	42,077	42,089	42,100	42,112	42,123	42,135	42,146	42,158	42,158
678.0	41,951	41,962	41,974	41,985	41,997	42,008	42,020	42,020	42,031	42,043
677.9	41,836	41,847	41,859	41,870	41,882	41,893	41,905	41,916	41,928	41,939
677.8	41,720	41,732	41,743	41,755	41,767	41,778	41,790	41,801	41,813	41,824
677.7	41,605	41,617	41,628	41,640	41,651	41,663	41,674	41,686	41,697	41,709
677.6	41,490	41,502	41,513	41,525	41,536	41,548	41,559	41,571	41,582	41,594
677.5	41,377	41,388	41,400	41,411	41,422	41,434	41,445	41,456	41,468	41,479
677.4	41,263	41,274	41,286	41,297	41,309	41,320	41,331	41,343	41,354	41,365
677.3	41,149	41,161	41,172	41,183	41,195	41,206	41,218	41,229	41,240	41,252
677.2	41,036	41,047	41,058	41,070	41,081	41,092	41,104	41,115	41,127	41,138

CACHUMA OPERATION & MAINTENANCE BOARD

MEMORANDUM

Date:	July 15, 2014
Submitted by:	Iraj Vatankhah
Approved by:	Dave Stewart

SUBJECT: **Drought Contingency Evaluation**

SUMMARY:
Lake Cachuma is the primary water supply reservoir for the City of Santa Barbara, Goleta Water District, Montecito Water District, and Carpinteria Valley Water District. It has been subject to 2 years of severe drought causing significant decline to water levels. The current water level and average demand especially in summer, shows that the Lake's water level may fall below the intake portal that would render the existing gravity fed system inoperable. There are two options as a substitute conveyance system: Pumping System and Truck Delivery. This report shows based on facts and figures how the Pumping System is more reliable, safe, and economic when compared with the water truck.

Option1: Water Truck

The Below table shows that the number of trucks we may need to transmit water from the Cachuma Lake to the South Coast Conduit at the South Portal. We need at least 1,683 trucks per day in order to meet half of average demand in summer.

Cost Estimate for Trucks	
Daily Water Demand AF/Month	3100.00
Daily Water Demand MGD	33.66
Assume %50 less water used MGD	16.83
No. of Trucks need (10,000Gal/truck)	1682.95
Min. quantity of loading ramp for (24/7) based on 20 min load or discharge time	23.00
Total fuel cost ($50/Day) for 1683 trucks	2,524,500

Notes:

1- The access road from Cachuma Lake to the South Portal is the San Marcos Pass Road (HWY 154) which doesn't have the capacity to allow 1,682 trucks on the road daily. This may completely block the road for other cars and trucks.
2- Since we have never had any loading area at Cachuma Lake or discharging area at South Portal for water, we may need to construct at least 23 loading areas. The Cachuma Lake doesn't have any available space for 23 loading areas and the South Portal access road doesn't have capacity for this quantity of trucks.
3- Suppose that the trucks may charge COMB just for their fuel on each round trip (approximately) $50, then, each month COMB has to pay $2,524,500.
4- EPA report for the trucks made after 2010 approximate CO_2 emission is : **8.89×10^{-3}** metric tons CO_2/gallon of gasoline (http://www.epa.gov/cleanenergy/energy-resources/refs.html)

Distance from South portal (GATO) to Cachuma Lake: 50 Miles (Roundtrip)
Water tanker truck fuel consumption: 5 MPG (for flat road)
Total fuel: 50 / 5 = 10 Gallon
Total greenhouse gas emission: $(8.89 \times 10^{-3}) \times (10) \times (2250) \times 30 = 6000$ metric tons CO_2

Option 2: PUMPING System

The pumping system that has been designed for this project has some advantages as below listed:

1- The cost of pumping system is a fixed and one-time cost, and then we can use of this system for many months just by paying for electricity bills.
2- The system has been designed to supply the maximum demand.
3- The system is more reliable than truck to supply water if any disasters such as wild fire happen in Santa Barbara Area.
4- The system allows us to monitor and control the quality of water that is transmitted to other districts.
5- The system will remain for future use. This design allows us to save part of the cost for future droughts.
6- The pumping system is designed to use the maximum gravity available from the bottom of gate 4 to gate 5 without using any electricity.

The historic water demand data shows the average monthly demand from **Jan 2009 to Mar 2014** (attachment #1), the maximum demand is in summer with an average of 3100 AF/ Month and in winter is 1750 AF/Month. Elevation of the bottom of gate 4- the lowest operable gate on intake tower- located at 678', whereas the maximum gravity flows when water level at elevation 679 is about 1910 AF/month (Table Below). This is almost 60% of actual maximum demand in the summer. In fact, the water level below 679.5' has insufficient flow to cover the water demand. Therefore, we have to transmit water with one of the two options: Pumping or Trucks.

Maximum Velocity at Varied Elevations

Elevation	Max Velocity	MAX Flow			
	ft /s	(Cu.ft/Sec)	MGD	AF/Day	AF/Month
682	16.05	256.80	165.96	509.50	15285
681	13.90	166.80	107.80	330.93	9928
680	11.35	90.79	58.68	180.14	5404
679.5	9.83	58.97	38.11	117.00	3510
679	8.02	32.10	20.75	63.69	1911
678.5	5.67	11.35	7.33	22.52	676
678	0.00	0.00	0.00	0.00	0

FISCAL IMPACTS:
N/A

LEGAL CONCURRENCE:
N/A

ENVIRONMENTAL COMPLIANCE:
N/A

COMMITTEE STATUS:
N/A

RECOMMENDATION:
N/A

LIST OF EXHIBITS:
Water Consumption Monthly Comparison Table Attachment A

Water Consumption Monthly Comparison

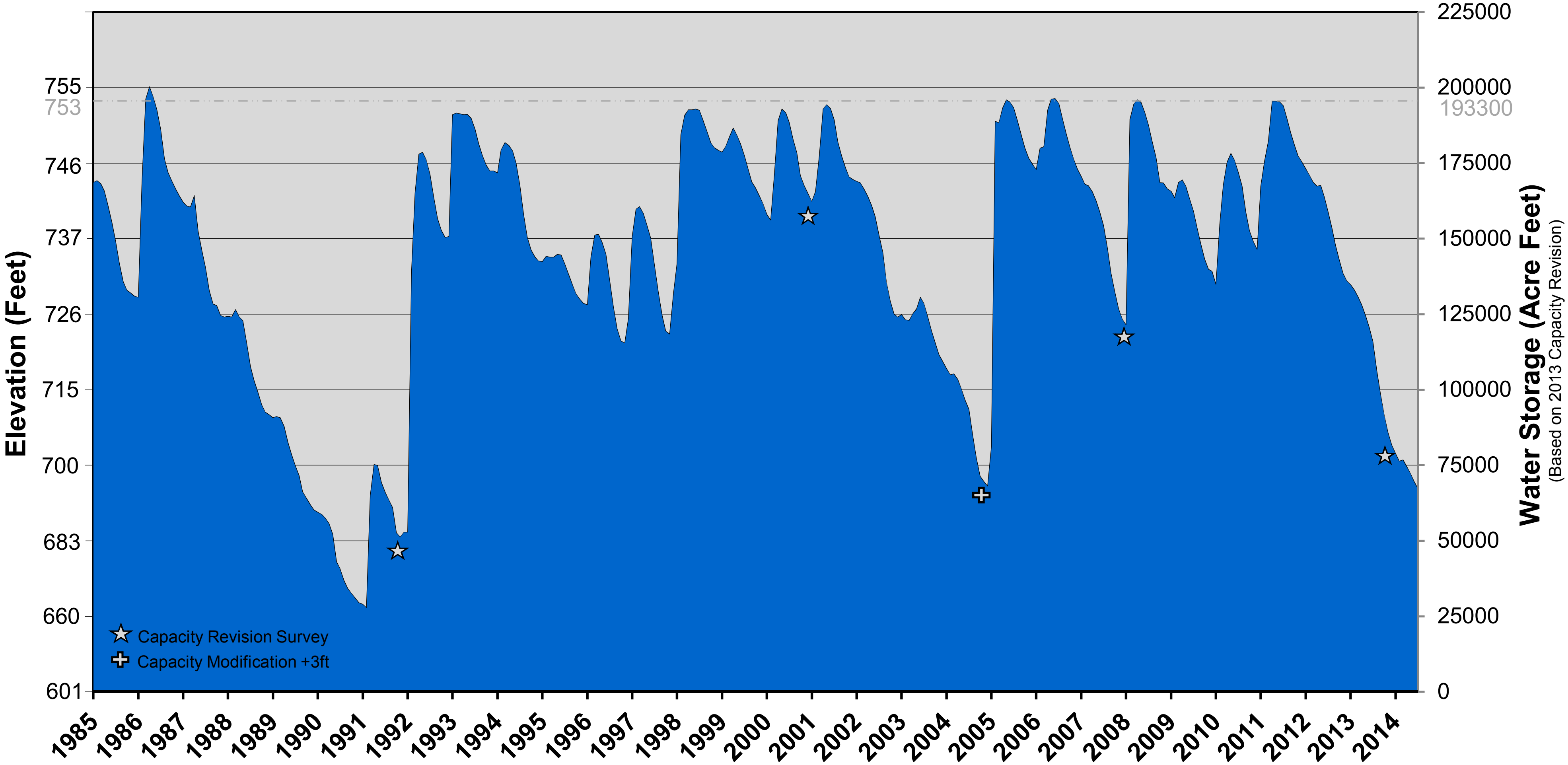
Following is a comparison water consumption table from 2009 to 2013 and for 2014 is considered average of 2009-2013.

Water Consumption monthly Comparison Table (Acre Feet/Month)													
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
2009	2108	1053	1399	2422	3069	2516	3174	2936	2944	2470	2506	1506	28102
2010	1549	1192	1686	1844	2593	2840	2961	3133	2977	2086	2021	1537	26420
2011	1623	1359	1547	2802	3370	2447	2787	2816	2473	2298	1772	1765	27057
2012	2193	2057	2251	1261	2321	2883	3079	3463	3341	3179	1918	994	28938
2013	1609	1994	2288	2416	2978	3273	3471	3459	3461	3343	2604	2442	33337
2014	2991	1649	1523										**28771**

Cachuma Reservoir - Historical Water Storage Levels

30 Years - 1985 to 2014

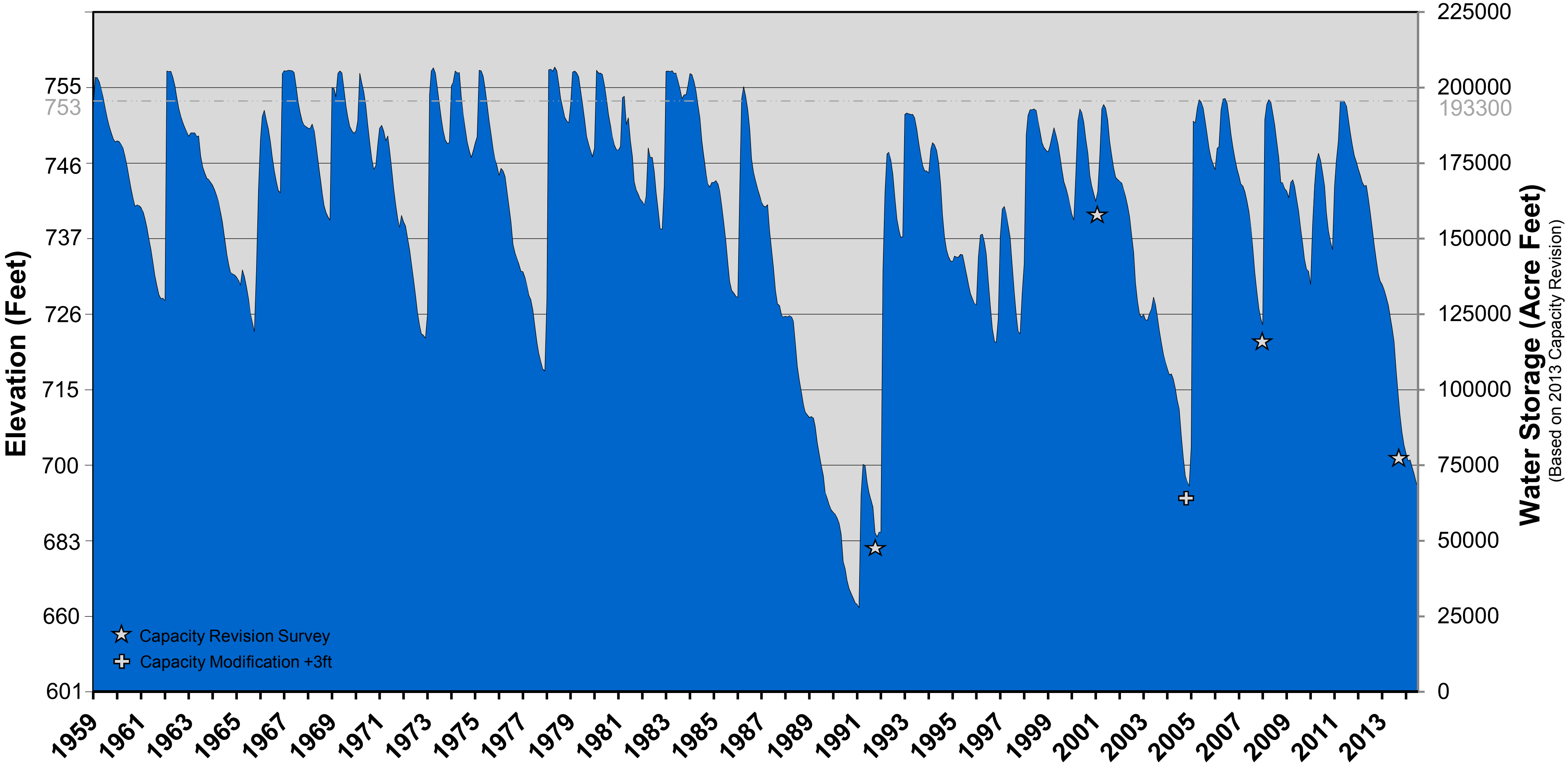
(through July 1st, 2014)



Cachuma Reservoir - Historical Water Storage Levels

55 Years - 1959 to 2014

(through July 1st, 2014)



Analysis of the Energy Intensity of Water Supplies for West Basin Municipal Water District

March, 2007

Robert C. Wilkinson, Ph.D.

Note to Readers

This report for West Basin Municipal Water District is an update and revision of an analysis and report by Robert Wilkinson, Fawzi Karajeh, and Julie Mottin (Hannah) conducted in April 2005. The earlier report, *Water Sources "Powering" Southern California: Imported Water, Recycled Water, Ground Water, and Desalinated Water*, was undertaken with support from the California Department of Water Resources, and it examined the energy intensity of water supply sources for both West Basin and Central Basin Municipal Water Districts. This analysis focuses exclusively on West Basin, and it includes new data for ocean desalination based on new engineering developments that have occurred over the past year and a half.

Principal Investigator: Robert C. Wilkinson, Ph.D.

Dr. Wilkinson is Director of the Water Policy Program at the Donald Bren School of Environmental Science and Management, and Lecturer in the Environmental Studies Program, at the University of California, Santa Barbara. His teaching, research, and consulting focuses on water policy, climate change, and environmental policy issues. Dr. Wilkinson advises private sector entities and government agencies in the U.S. and internationally. He currently served on the public advisory committee for California's 2005 State Water Plan, and he represented the University of California on the Governor's Task Force on Desalination.
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West Basin
Municipal Water District

West Basin Municipal Water District

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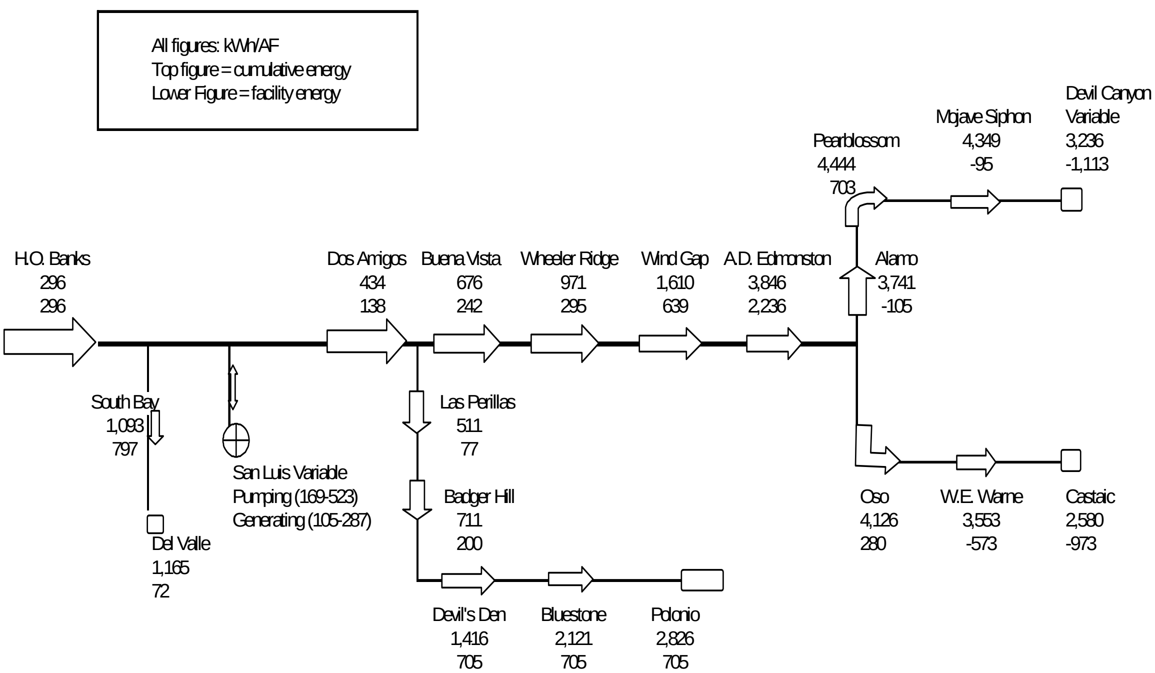
West Basin Municipal Water District www.westbasin.org

The following schematic shows each individual pumping unit on the State Water Project, along with data for both the individual and cumulative energy required to deliver an AF of water to that point in the system. Note that the figures include energy recovery in the system, but they do not account for losses due to evaporation and other factors. These losses may be in the range of 5% or more. While more study of this issue is in order, it is important to observe that the energy intensity numbers are conservative (e.g. low) in that they assume that all of the water originally pumped from the delta reaches the ends of the system without loss.

State Water Project
Kilowatt-Hours per Acre Foot Pumped
(Includes Transmission Losses)



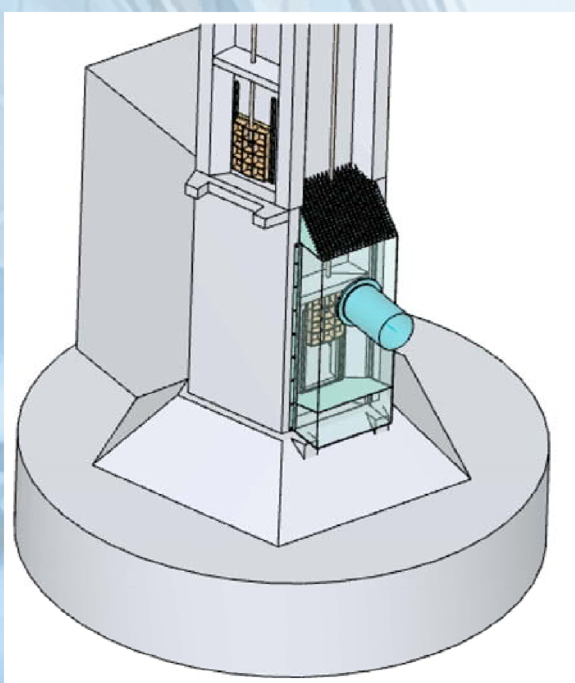
Source: Wilkinson, based on data from: California Department of Water Resources, State Water Project Analysis Office, Division of Operations and Maintenance, *Bulletin 132-97*, 4/25/97.

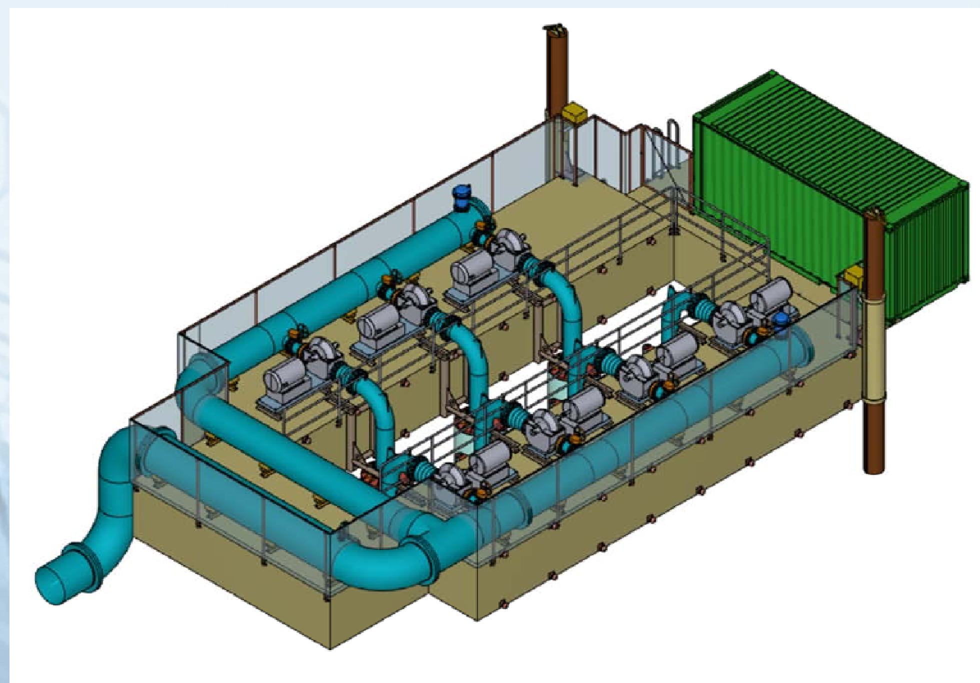
CACHUMA OPERATION AND MAINTENANCE BOARD

P R O P O S A L

FOR DESIGN, BUILD, OPERATE AND MAINTAIN EMERGENCY PUMPING FACILITY AT LAKE CACHUMA

APRIL 4, 2014





CUSHMAN CONTRACTING CORPORATION

WATERWORKS ENGINEERS

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INTRODUCTION

The Cushman Contracting Corporation team has worked to provide the Cachuma Operation and Maintenance Board with a robust solution to the challenges that lie ahead for the water supply from Lake Cachuma for the next several years. We see several key success factors for this project, and have addressed all of them in the approach that we have taken for the project:

1. **Flexibility.** We understand that the exact operating parameters under which this pumping facility must perform are impossible to predict, and that the supply of water to the COMB Member Units (Goleta, Carpenteria Valley, Montecito, Santa Ynez River, and Santa Barbara) is absolutely critical. We have designed our facility to operate under a wide variety of operating conditions (dropping lake level, change in pump barge location, changes in water demand).
2. **Reliability.** This station must perform 24/7 for the entire project duration, even during power outages, outages in communication, and a variety of other failure possibilities. We have designed our station with very simple, straightforward control systems which will continue the delivery of water under a large variety of conditions.
3. **Constructability.** There isn't much time. In order to have this facility on-line by September 1st, the implementation of the facility needs to begin immediately and progress on a number of parallel paths. We have built this kind of facility before and know how to get it done. Our schedule lays out exactly how we will accomplish this, but the only way this is possible is the fact that we have done this before, and we have put considerable effort into the development of our design and construction planning in this proposal.

In this proposal, we are presenting our plan for this project. The plan is detailed, it is thought-through, the design presented herein is comprehensive, the construction sequencing has been detailed and it is ready for immediate implementation. We look forward to helping COMB navigate the challenges that this drought period brings.

PART 1 - FACILITY DESIGN, CONSTRUCTION AND OPERATION

PROJECT TEAM

Our core project engineering and construction team (Water Works Engineers and Cushman Contracting Corporation) is unchanged from the Statement of Qualifications. The team listed in the Statement of Qualifications has prepared this proposal and will continue to deliver the project following project award. We have identified a number of potential subcontractors and suppliers for the various components of the project, but final selections of almost all subcontractors and suppliers will not be made until final design and delivery of the project is under way. Cushman Contracting Corporation participated in the Design, Built and Operated the 1990/91 Cachuma Pump Station, and because of that experience, and the more stringent fish screen requirements outlined in the RFP, we have added one specialty contractor to our team for this project:

1. **Fish Screen Manufacturer:** The fish screen manufacturer for this project will be Intake Screens, Inc. (www.intakescreensinc.com). Intake Screens, Inc. (ISI) has been delivering quality and innovative screens and projects since 1996. ISI provides complete project and product services including: engineering design, manufacturing, fabrication, installation, and maintenance. ISI is also a Class A General Engineerng Contractor in the State of California (CL#796197) and has the experience to handle simple to complex projects. ISI's facilities are located in Sacramento, CA.

   ISI's success is based on a long history of working in the industry and its staff and owners bring together solid experience that is used on each project. Russ Berry, founder of ISI, built the first self-cleaning intake screens on a ranch in north central Nebraska. Seeing the great potential for a product that could solve suction related problems, he started manufacturing them in 1979. In 1990, he sold Plum Creek Mfg. to the Claude Laval Corporation. In 1996, Russ formed ISI to develop custom screens specifically for fish protection that could be used in demanding river environments. In 1999, Russ' son, Russell Berry IV, became involved in all aspects of the business, developing an impressive array of skill sets and abilities that he continues to build on and enjoy. Darryl Hayes joined the company in 2006, bringing his fish facility and engineering expertise from his experiences at CH2M HILL and the California Department of Water Resources. Darryl served as DWR's Fish Facility Chief and lead the design of several large fish screen projects prior being at ISI. Jacob Chapin also joined ISI in 2006, bringing his mechanical engineering expertise, fabrication, and CAD skills to the company. Jacob's resume includes designing fire trucks, heavy portable pump packages, and mechanical systems. ISI's staff also includes skilled fabricators and certified welders that can make about anything.

   Customers such as municipal water agencies, public utility districts, consulting engineering firms, irrigation districts, golf courses and farmers have all benefited from choosing ISI's durable and efficient intake screens. ISI models have successfully protected pumping operations from debris and other contaminants, and provided wildlife protection that meets the requirements of state and federal environmental regulatory agencies.

   ISI's achievements were recently recognized by NOAA Fisheries by receiving the Environmental Stewardship Award for Innovations in Fish Protection.

FEATURES OF THE PROPOSED FACILITY

DESIGN CONDITIONS

In order to provide a pump station optimally designed to meet the needs of COMB, the design conditions must be well understood. The following is our understanding of the design conditions. The RFP (as modified by Addendum 1) defined the following critical design parameters:

1. "Worst Case" Expected Lake Level
    a. September 1, 2014: 684
    b. April 1, 2015: 665
    c. April 1, 2016: 645
2. Required pump station capacity
    a. In location 1 (until April 1, 2015): 45-mgd (Scenario A) or 36-mgd (Scenario B)
    b. In location 2 (April 1, 2015 through September 1, 2016): 25-mgd

This information is summarized in Figure 1.

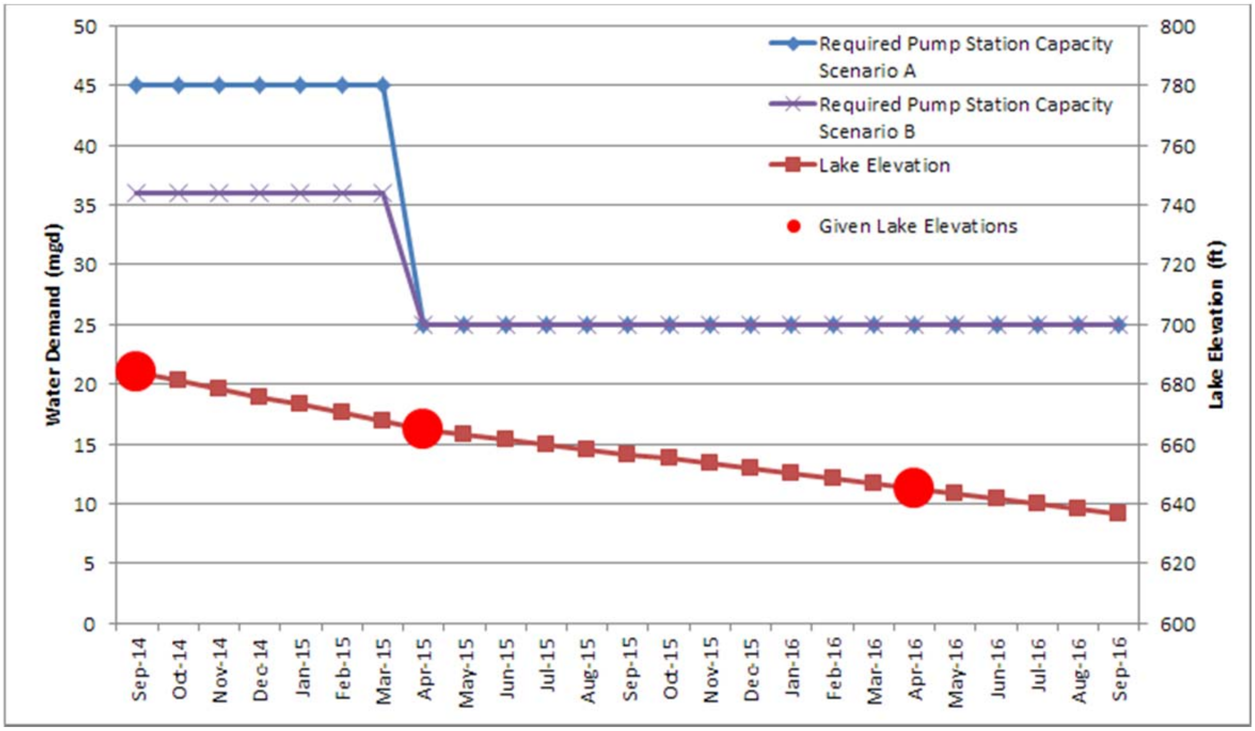


Figure 1. Lake Cachuma Expected Levels and Scenario A Required Pump Station Capacity

The lake levels between the given lake elevations are interpolated. The lake levels after April 1, 2016 are extrapolated based on the drop rate between April 1, 2015 and April 1, 2016. The extrapolation was used because it is unlikely that the lake would fill across the summer of 2016 (between April and September). The low projected elevation in September 2016 is 637. It should be noted that the area of the lake identified for "Location 2" has a bottom elevation of approximately 618, which would allow the station to operate to a lake level to somewhat below 637. This approach to planning allows the lake three winters (2014-15, 2015-16 and 2016-17) during which if it gains some ground, the system will work to provide reliable intake to the water treatment system.

These given data points reflect a lake level drop of approximately 20-ft per year. Historically, such drops in lake level are not an unreasonable "worst case scenario". Since 2011, the lake has dropped over 50-ft (see Figure 2), and as the lake drops further, the surface area is reduced and the rate of drop is accelerated.

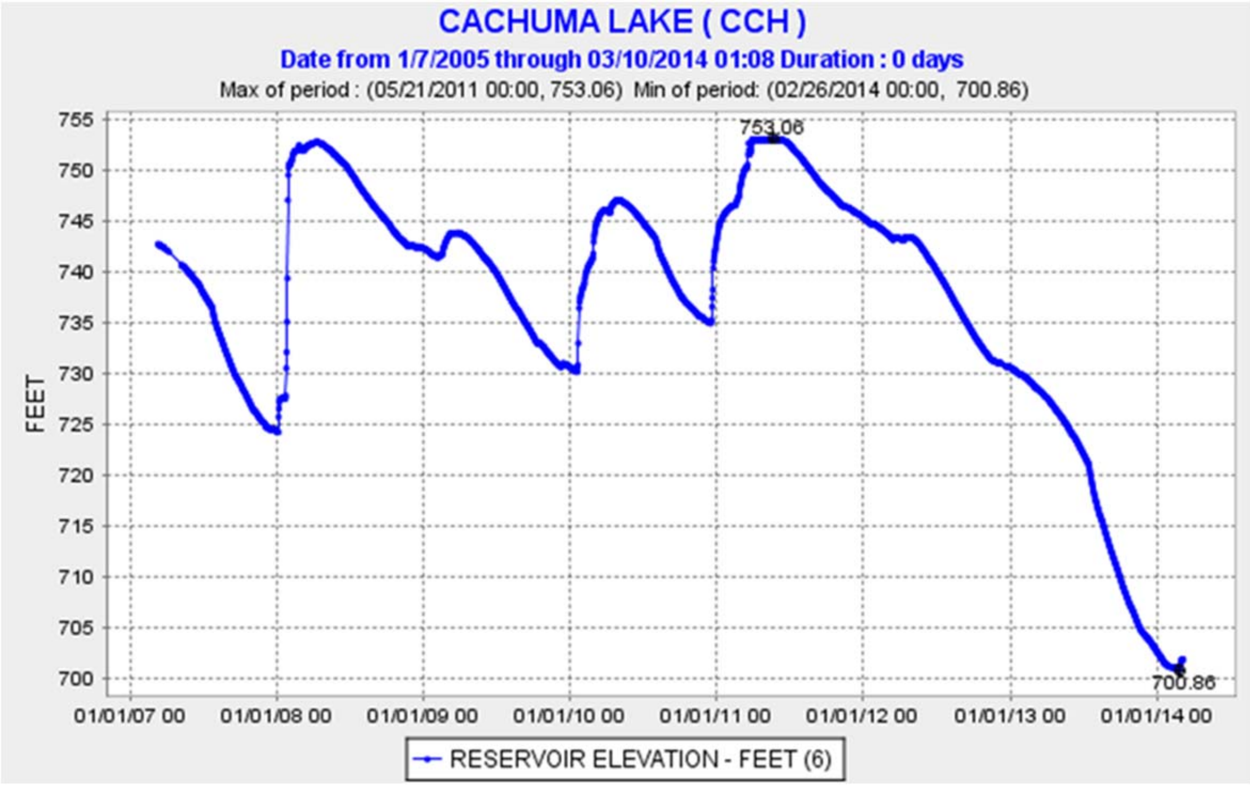


Figure 2. Lake Cachuma Level 2005-2014

If the lake continues to drop, the pump station must be able to continue withdrawing water from the lake for as long as possible. The required level in the intake tower is elevation 672 throughout the project. This information gives us our two "Worst Case" design points for the pump station, shown in Table 1. Each design point is show for both Scenario A (45-mgd pump station capacity) and Scenario B (36-mgd pump station capacity).

Table 1. Design Conditions for Pump Station

Design Date	Lake Level	Static Head	Scenario A		Scenario B	
			Flow	Max HP	Flow	Max HP
April 1, 2015	El 665	7 ft	45-mgd	800	36-mgd	650
September 1, 2016	El 637	35 ft	25-mgd	800	25-mgd	650

Although these design conditions will not occur for extended periods (peak demand periods are only seen during the late summer months), in order for the project to be successful, the pump station needs to be able to meet these pump design points and stay within the power requirements. These design points are our boundary conditions.

DESIGN FEATURES

Pipeline

We examined several alternatives for the floating pipeline which connects the pump station to the inlet tower. We examined a wide range of pipe alternatives and selected the following alternatives (Figure 3) for the pipeline for further investigation:

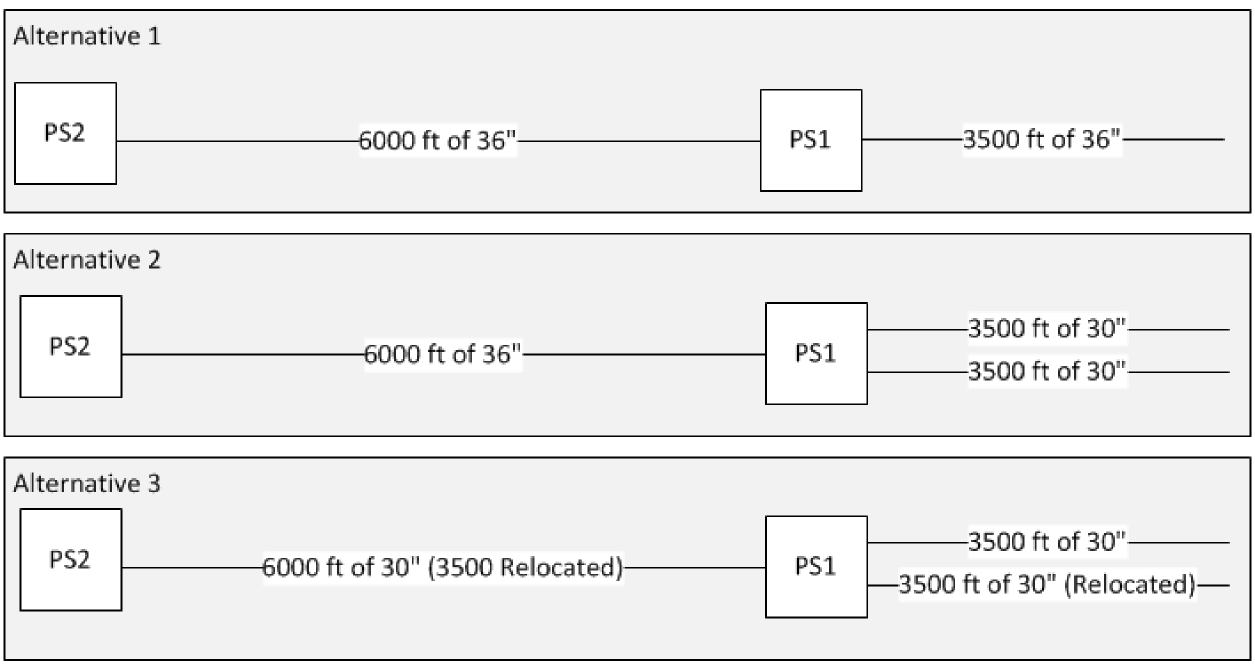


Figure 3. Pipeline Alternatives

Because the decision on which size and how many pipes to use is a balance of capital cost versus power costs over the performance period, in order to examine these alternatives, we had to make some assumptions about what *average* operating conditions would be. The following key input values were used:

1. Average Flow (over the entire operating period): 25-mgd
2. Lake Level: Per the RFP and Figure 1
3. Pump Efficiency: 80%

Each alternative was modeled using a general spreadsheet model to estimate the total required horsepower, power usage, and cost for each alternative. The full spreadsheets are in Appendix A. Note that these are not comprehensive hydraulic models (a separate model was built to make a final pump selection), but a general spreadsheet model to compare pipeline alternatives.

When the spreadsheet model was run, it was discovered that Alternative 3 (the use of two 30" pipes from Pump Location 1 to the Intake Tower, with the relocation of one and connection to Pump Location 2 with a single 30" pipe) was not feasible because it violated the horsepower restrictions placed on the project. With this alternative, when the pump station is moved to Location 2 and 25-mgd is pumped through a single 30" pipe, the required horsepower would exceed 800-hp almost immediately. As the lake level dropped, the required horsepower would increase to nearly 1000-hp. Alternative 3 was discarded at this point.

The following cost estimates were used in the cost comparison of Alternative 1 and 2 (these are not bid prices for the pipe, just general estimated costs):

1. Cost of 36" HDPE pipe: $70/ft
2. Cost of 30" HDPE pipe: $50/ft
3. Average cost of power: $0.15/kW-h

The cumulative cost (pipe + power) was estimated. Figure 4 shows the comparison.

As can be observed from Figure 4, the reduction in power costs associated with Alternative 2 (the use of two 30" pipes for the first 3500-ft of pipeline) are not enough to recover the additional capital cost of the purchase of the two 30" pipes, as compared to a single 36" pipe. The information presented in Addendum 3 regarding the test Cases for the project were also modeled and showed the same general pattern. The recovery of the additional capital cost of two 30" pipes over a single 36" pipe will take more than the entire contemplated operating period of the station.

The floating pipeline that connects the pump station to the inlet tower will be a single 36" HDPE pipeline. This decision was made for the following reasons:

1. It saves the project money over the entire contemplated project period. The shorter time the project is run, or the higher that the lake is during the project period, the more money this approach will save.

2. It provides a simpler, easier to manage system.
3. The fact that there is only one transmission pipe does not increase risk of failure significantly, in our opinion. COMB operates a single transmission tunnel. The extension of that single conveyance system with a single pipeline in the lake does not significantly change the risk of failure.
4. Because it is significantly shorter, it can be stored more easily if COMB decides to keep the pipeline for future use.

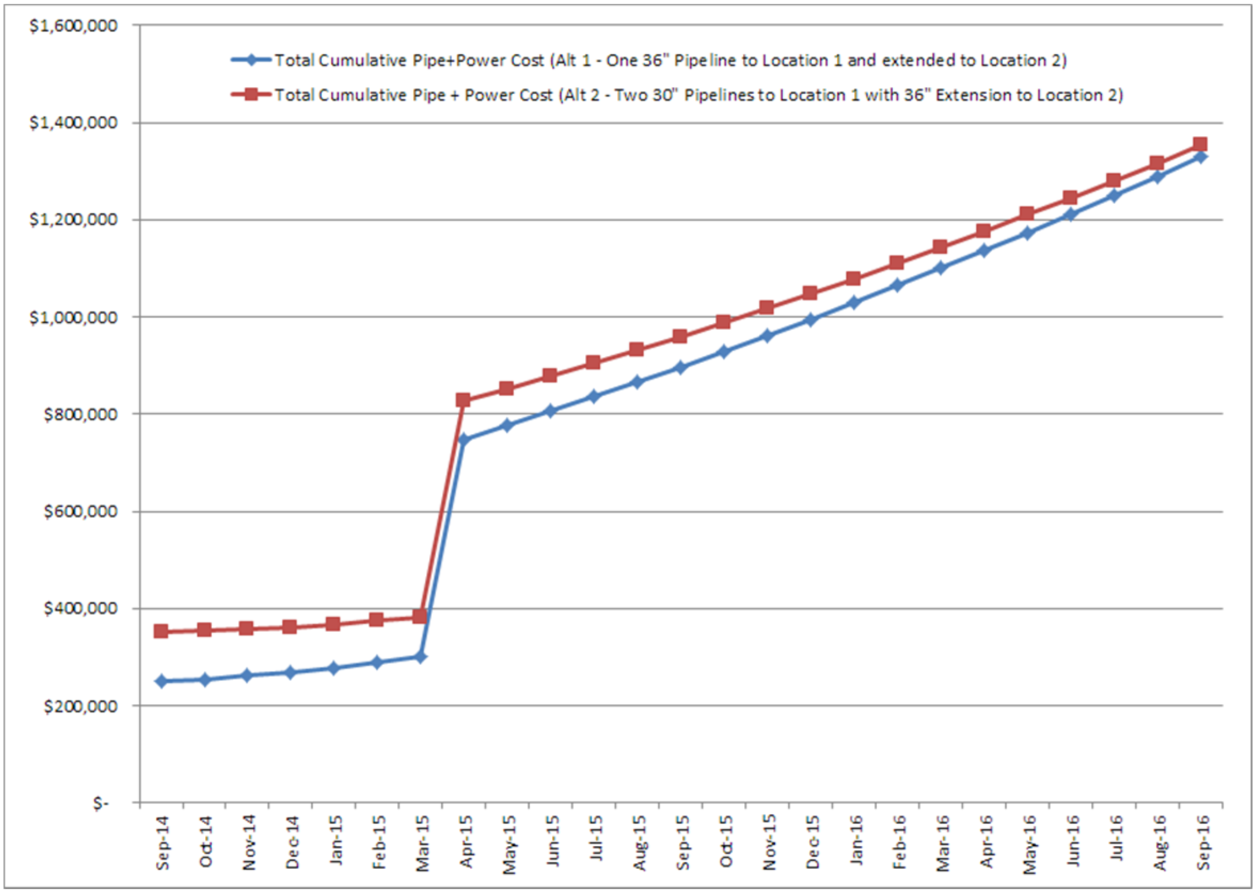


Figure 4. Comparison of Pipe Alternatives 1 and 2

General Pump Station Concept

The general pump station concept will be to provide a pump barge similar to the one successfully used in the 1990-1991 drought. The general concept is shown in Figure 5.

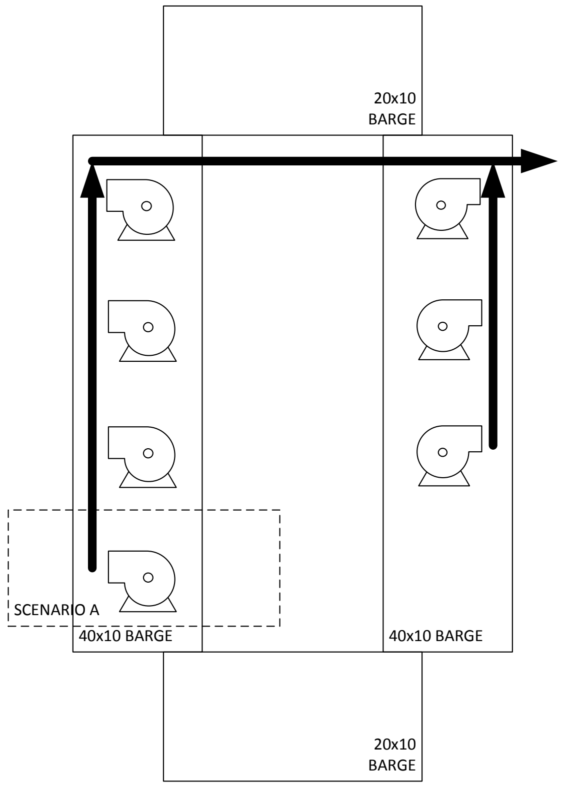


Figure 5. General Pump Station Concept

Pump Selection

Two types of pumps were investigated which are readily available for quick deployment, rental and purchase; split-case centrifugal pumps and submersible centrifugal pumps. The split case centrifugal pumps were selected because the efficiency of the pumps is so much higher than the available submersible centrifugal pumps (65-85% efficiency at Best Efficiency Point compared to 35-50%). The very low efficiency of the submersible pumps pushed the required horsepower above the 800-hp project maximum and had huge impacts on operating costs. Split-case centrifugal pumps are the right pumps for this project. Pumps and impellers which meet the design conditions in Table 1 were selected. Cut sheets and performance curves for the pumps are included in Appendix B.

A hydraulic model was built of the system using AFT Fathom. Fathom model output is included in Appendix C. The model was set up to examine the pump station at both Location 1 and Location 2, using the design conditions in Table 1. Pump curves for the selected pumps were input into the model and the behavior of the station at both Location 1 and Location 2 was examined.

The resultant design of the pump station is simple and straightforward. The same pumps that work in Location 1 work in Location 2. One barge will be built to serve both locations, relocated as needed.

Pump Station Performance

The performance of the pump station is, of course, dependent on the water level in the lake at the time the performance is being measured. The system curve rises as the lake level drops at each of the two locations. Figure 6 shows the family of system curves for this application. The system curves rise at Location 1 as the lake level drops, then at Location 2, the system curve becomes steeper (due to the extension of the discharge pipe from 3500-ft to 9500-ft), and continues to rise as the lake level drops.

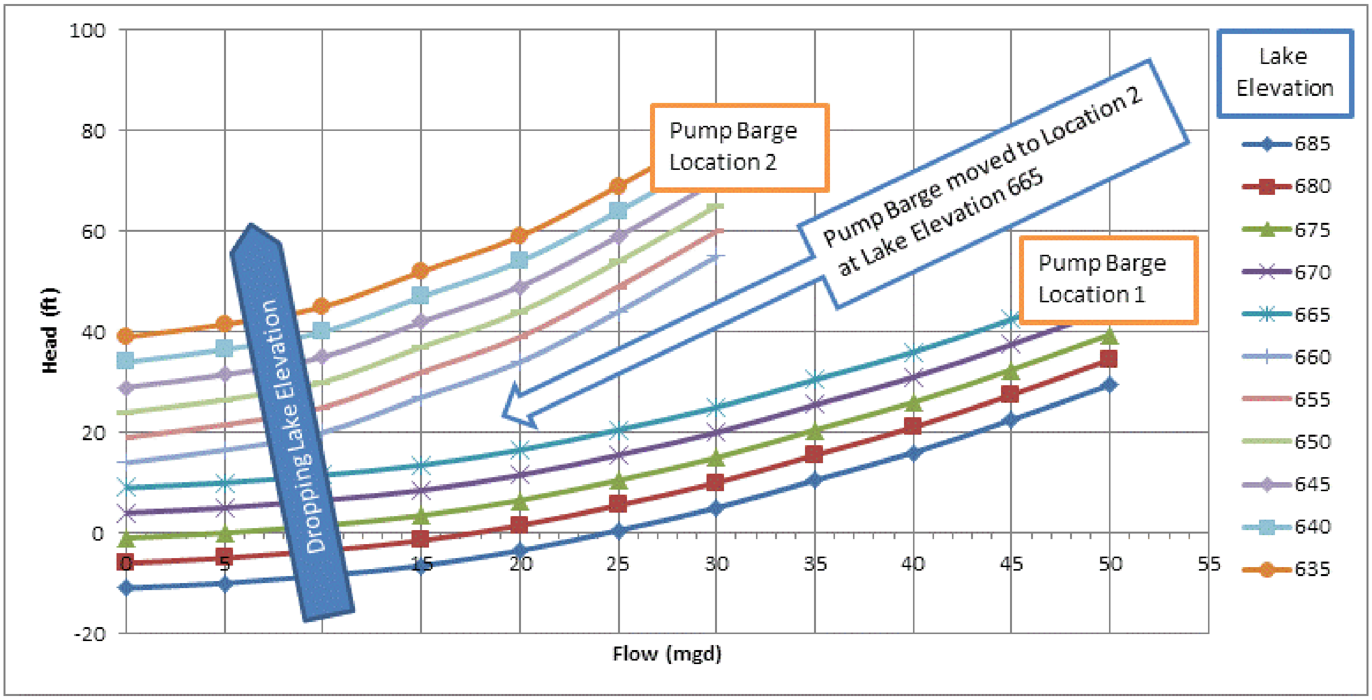


Figure 6. Family of System Curves for Lake Cachuma Emergency Pumping Facility

The pump station must be able to perform across the range of system curves at each location. We have designed our pump station to operate at both Location 1 and Location 2, covering the entire range of system curves shown in Figure 6. The modeling of pump performance involves multiple pump scenarios and variable speed settings on each pump. We made multiple model runs in AFT Fathom (a sample model input screen is shown in Figure 7). Table 3 summarizes expected pump performance for Scenario A and Scenario B with the Pump Barge at Location 1 at 50% and 100% of design flow with the lake at three representative lake levels. Table 4 summarizes expected pump performance at Location 2. As can be seen by examining Table 3 and 4, the pump efficiency improves as the lake level drops. We took this approach because as the lake level drops, power requirements increase, and efficiency becomes more and more critical, both from a cost standpoint and from an electrical service standpoint. We have shown estimated power costs (both daily costs and cost per mgd) to illustrate this point. When the lake is high, not much power is used, so efficiency is not as critical. As the lake drops, the power consumption goes up, and efficiency becomes more critical. At high lake levels, wire-to-water efficiency is approximately 40%, but as the lake drops, the wire-to-water efficiency approaches approximately 70% at Location 1 and 80% at Location 2, giving us the best efficiency when it is most critical (when power usage and cost are at their highest).

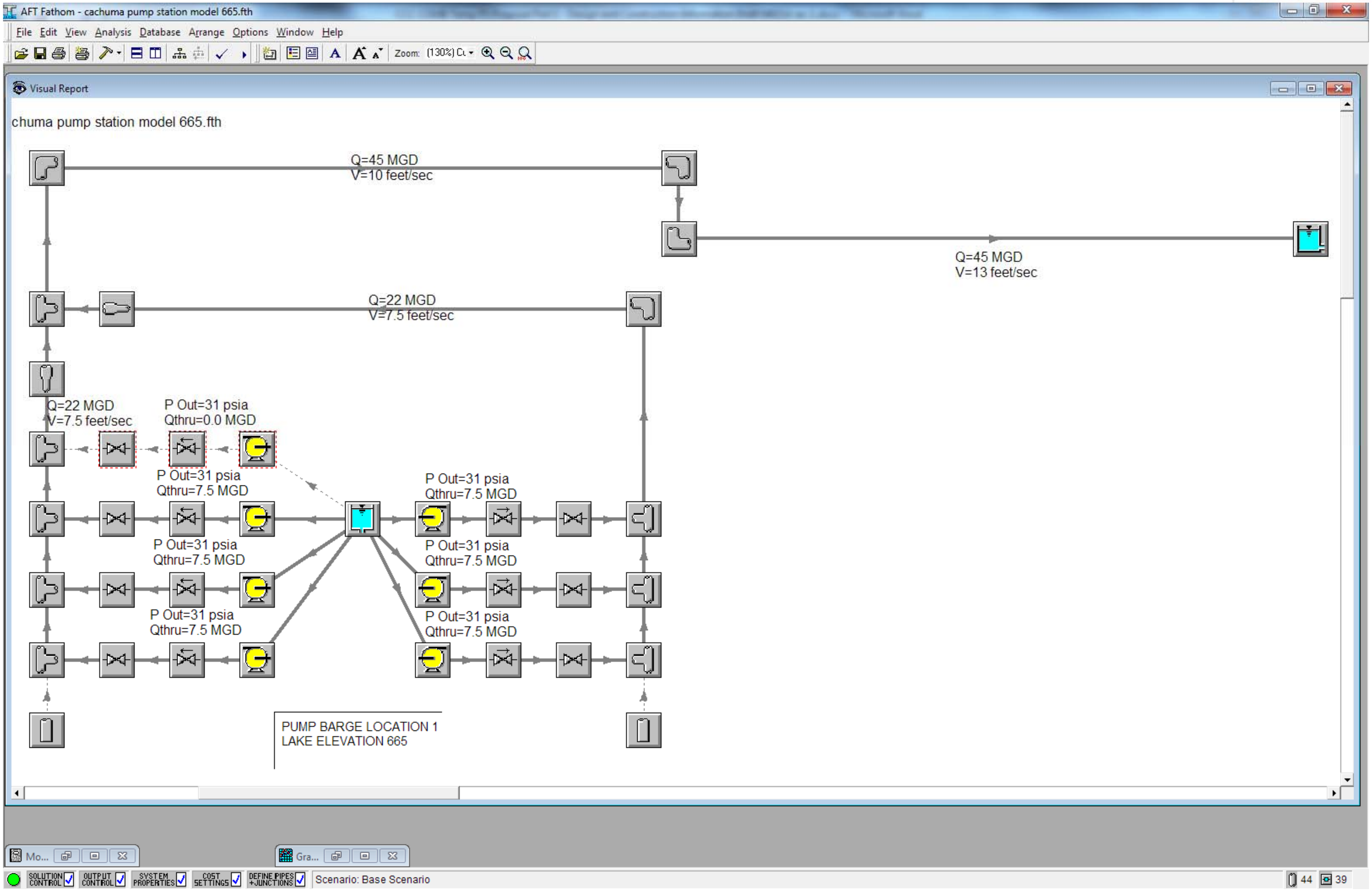


Figure 7. Sample Input Screen for AFT Fathom Hydraulic Model

Table 3. Pump Performance Range, Pump Barge Location 1

	Hydraulic Model Input				Hydraulic Model Output				Pump Energy Performance Calculations									
	Lake Elevation	Flowrate	# of Pumps	Flow Per Pump	Total System Head	% Speed	Pump and Motor Efficiency	Power Req'd per Pump	Total Power Req'd	Total Pump Power Demand	VFD Efficiency	Total Station Power Demand	Hours of Daily Operation	Total Station Daily Power Use	Average cost of electricity	Average Daily Pump Station Power Cost	Pumping Cost per Million Gallons	Wire-to-Water Efficiency
	ft	mgd	ea	mgd	ft	%	%	Hp	Hp	kW	%	kW	hr	kW-hr/day	$/kW-hr	$/day	$/MG	%
Scenario A	684	22.5	3	7.5	7.5	72%	44%	23	69	51	95%	54	24	1300	$0.15	$195	$26	42%
	675	22.5	3	7.5	17	78%	57%	38	114	85	95%	90	24	2148	$0.15	$322	$43	54%
	665	22.5	3	7.5	27	84%	66%	53	159	119	95%	125	24	2997	$0.15	$449	$60	63%
	684	45	6	7.5	32	87%	70%	60	360	269	95%	283	24	6785	$0.15	$1,018	$136	67%
	675	45	6	7.5	41	92%	74%	73	438	327	95%	344	24	8255	$0.15	$1,238	$165	70%
	665	45	6	7.5	51	97%	77%	87	522	389	95%	410	24	9838	$0.15	$1,476	$197	73%
Scenario B	684	18	2	9	8	85%	40%	31	62	46	95%	49	24	1168	$0.15	$175	$19	38%
	675	18	3	6	11	63%	56%	20	60	45	95%	47	24	1131	$0.15	$170	$28	53%
	665	18	3	6	21	70%	70%	31	93	69	95%	73	24	1753	$0.15	$263	$44	67%
	684	36	5	7.2	20	78%	62%	41	205	153	95%	161	24	3863	$0.15	$580	$80	59%
	675	36	5	7.2	29	83%	69%	53	265	198	95%	208	24	4994	$0.15	$749	$104	66%
	665	36	5	7.2	39	89%	75%	66	330	246	95%	259	24	6219	$0.15	$933	$130	71%

Note: The information shown in this table is based on preliminary hydraulic modeling, standard pump performance curves, etc. Actual performance of the station will vary somewhat from the data shown in this table. Pump performance is guaranteed to be within 20% of the efficiencies shown in this table.

Table 4. Pump Performance Range, Pump Barge Location 2

Hydraulic Model Input				Hydraulic Model Output				Pump Energy Performance Calculations									
Lake Elevation	Flowrate	# of Pumps	Flow Per Pump	Total System Head	% Speed	Pump and Motor Efficiency	Power Req'd per Pump	Total Power Req'd	Total Pump Power Demand	VFD Efficiency	Total Station Power Demand	Hours of Daily Operation	Total Station Daily Power Use	Average cost of electricity	Average Daily Pump Station Power Cost	Pumping Cost per Million Gallons	Wire-to-Water Efficiency
ft	mgd	ea	mgd	ft	%	%	Hp	Hp	kW	%	kW	hr	kW-hr/ day	$/ kW-hr	$/day	$/MG	%
655	25	5	5	53	84%	82%	56	280	209	95%	220	24	5277	$0.15	$792	$158	78%
645	25	5	5	63	90%	82%	68	340	254	95%	267	24	6408	$0.15	$961	$192	78%
635	25	5	5	73	95%	81%	80	400	298	95%	314	24	7539	$0.15	$1,131	$226	77%

Note: The information shown in this table is based on preliminary hydraulic modeling, standard pump performance curves, etc. Actual performance of the station will vary somewhat from the data shown in this table. Pump performance is guaranteed to be within 20% of the efficiencies shown in this table.

Fish Screening

The fish screening requirements in the RFP are as follows:

"Provide screening at the pump intakes to exclude fish and debris. Maximum opening size: ¼ inches. Maximum flow velocity through screen: 0.2 feet per second. Include provisions for manual cleaning of the screens. Provide at least 30 percent additional screen area as allowance for plugging and algae accumulation."

Fish Screen Arrangement

For the pump barge, two fish screening concepts were considered, the "fry basket", a rectangular screen encompassing the entire interior of the barge area, and individual drum screens on the pump intakes. Conceptual drawings of the two fish screening concepts are shown in Figure 8.

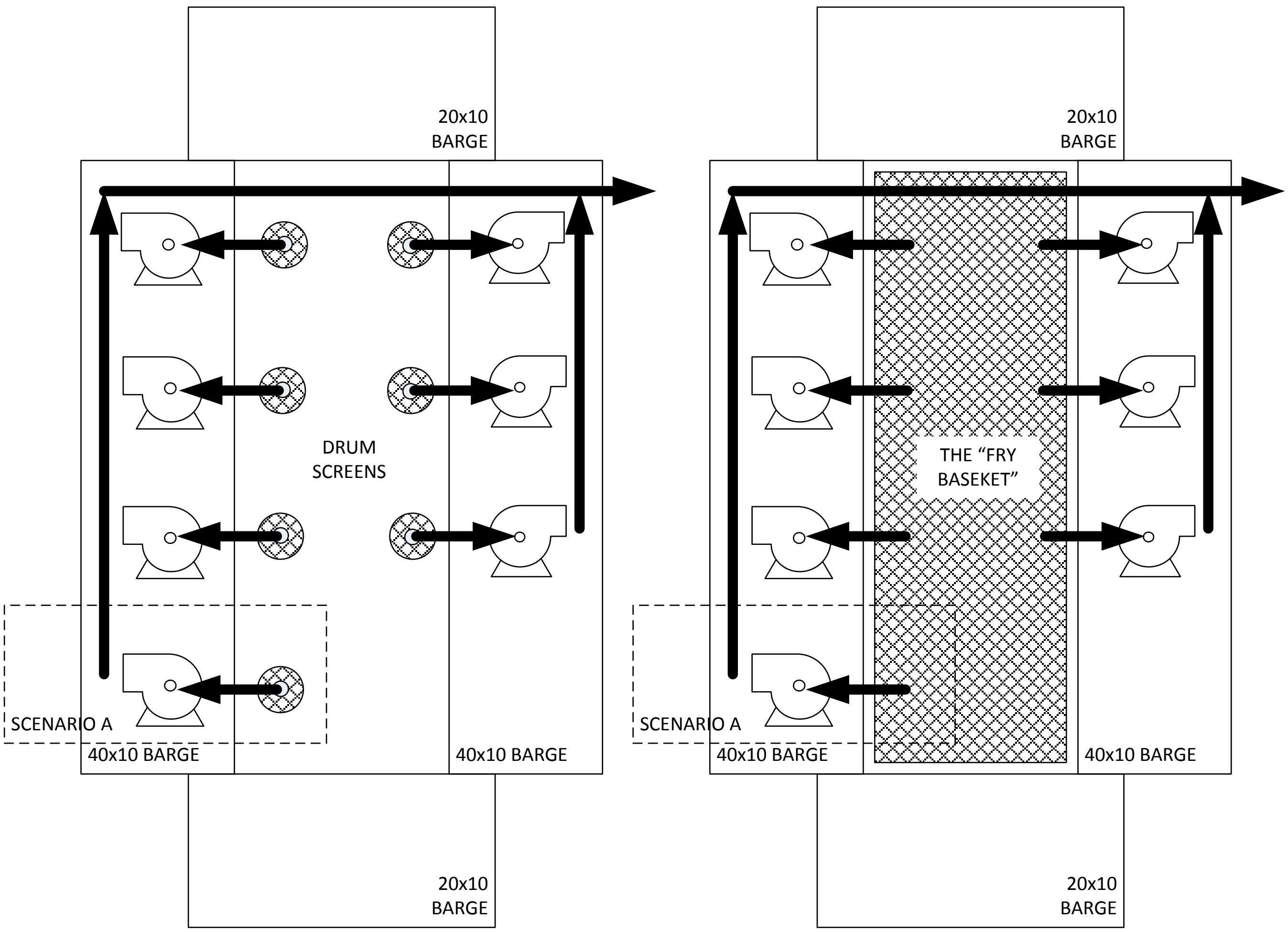


Figure 8. Conceptual Fish Screening Concepts

The individual drum screen approach was selected for several reasons:

1. The individual drum screens provide redundancy in the screening system. If something were to impinge on one screen, that screen could be taken out of service and repaired without decreasing the capacity of the station. The "Fry Basket" or other common-screening approach would result in any screen failure shutting down the station.
2. Individual drum screens can be removed from the water for repair while the pump station is left in operation.
3. The individual drum screens can be designed to avoid "hot spots", ensuring that the approach velocity towards the screen does not exceed 0.2 feet per second ***at any location***. The fish screening requirement is not an average velocity, it is a ***maximum velocity.*** From the California Department of Fish and Wildlife:

   "<u>Flow Uniformity:</u> The design of the screen shall distribute the approach velocity uniformly across the face of the screen. Provisions shall be made in the design of the screen to allow for adjustment of flow patterns. The intent is to ensure uniform flow distribution through the entire face of the screen as it is constructed and operated."

   We have carefully designed the intake screens to give proven, reliable performance in meeting the fish screen requirements, including the flow uniformity requirements. Figure 9 shows a drum screen, mounted horizontally. In this application, the drum screens will be mounted vertically on the pump intakes

Figure 9. Drum Screen (Wedgewire with Automatic Cleaning Brush)

Screen Cleaning

The RFP required only manual cleaning for the screens, and also required (because of the manual cleaning) that we provide 30% additional surface area. We propose to provide screens with automatic cleaning brushes without the 30% additional surface area (as allowed by regulation). The automatic cleaning brushes are operated only by the flow of water through the screen into the pump. The water goes through a propeller which very slowly rotates a brush around the screen continuously while water is being pumped through the screen (see Figure 10). This provides continuous cleaning with extremely high reliability. There are no external systems to maintain (either electrical, hydraulic or mechanical) with this type of continuous cleaning system; the screen is rotated around the fixed brush bracket using only the in-line propeller which is driven by the flow being pulled through the screen by the pump system. Because the propeller is geared to move slowly, the headloss caused by the propeller is minimal and has no significant impact on net positive suction head for the pumps. One of these screens will be mounted on each pump intake. Each screen will be 42" diameter by 66" long with a total screen area of 60.5-square feet. At 0.2 feet/second maximum approach velocity, each screen will have a capacity of 7.8-mgd, requiring 6 screens to be in service for 45-mgd (Scenario A) operation, 5 for 36-mgd operation (Scenario B) and 4 for 25-mgd operation (Both Scenario A and B). This area does not include 30% spare area, however, because the screens will be automatically and continuously cleaned during operation, there should be no requirement for 30% spare area for algae build up. A spare screen will be provided with each spare pump. In the event that there are any malfunctions with a screen, a spare screen and pump will be put into service during the repair.

Figure 10. Drum Screen Showing Propeller Drive and Automatic Cleaning Brush

Screen Size

The RFP required a maximum ¼-inch (5-mm) opening for the fish screens. We propose to exceed this requirement by providing type 304 stainless steel wedgewire screens with 0.068-inch (1.75-mm) screen openings. These screens do not cost significantly more than the ¼-inch opening screens, but they are compliant for use in waters with steelhead rainbow trout fry (the most stringent screening requirements). This is an advantage for two reasons. 1) these screens will be a "slam dunk" in the permitting process with California Department of Fish and Wildlife, 2) the screens will have more universal utility for future potential applications, whether that application is future use in Lake Cachuma (which could be under more stringent future regulation) or elsewhere under more stringent regulation.

Questions asked during the proposal period confirmed that fish screening would also be required for any gravity intake from the lake (the current intake tower has fish screens, so other gravity intakes such as a "snorkel" or "siphon" concept would also need to be screened). This makes sense from a permitting standpoint, and the assumption that screening would be required regardless of whether the water intake was by pump or by gravity seems the most prudent from a permitting risk reduction standpoint. There is a question about approach velocity, however. During normal tower operations, the existing screens (approximately 100-square feet of screen area) exceed the 0.2-fps approach velocity at a flowrate of approximately 13-mgd. At 45-mgd, the existing screens have an approach velocity of approximately 0.7-fps. The specifics of the screening criteria for the temporary intake system will need to be discussed further with the Department of Fish and Wildlife to determine if modifications to the intake tower can use similar design criteria to the current screens. This issue will impact the design and use of the tower intake, as discussed below.

Intake Tower Connection

Our concept for the intake tower is very simple. The pipeline from the pump barge will be connected to the intake tower using an epoxy coated steel tower connection box attached in place of the fish screen on Gate 5. The steel box will extend approximately 20-ft above the invert of the intake tower. Figure 11 shows a conceptual plan view of the tower connection box. The box will allow continued use of Gate 5.

If allowed by permitting, the top of the connection box will have a screened cover (made of ¼-inch screening material). The screened cover will serve three purposes:

1. Allow for the box to overflow in the event that the pump station flows exceed the tunnel flows during pump station operation.
2. The screen will allow for some flow (the amount will be determined by the screen criteria for the intake tower temporary connection) to be directly conveyed through Gate 5 while excluding the silt that has built up around the intake tower. This will be a **permanent improvement to the intake tower**.
3. Even when Gate 5 is closed (when lake levels are above 680 and Gate 4 is in use), the screened cover and design of the Tower Connection Box will keep debris and silt out of the Gate 5 approach area.

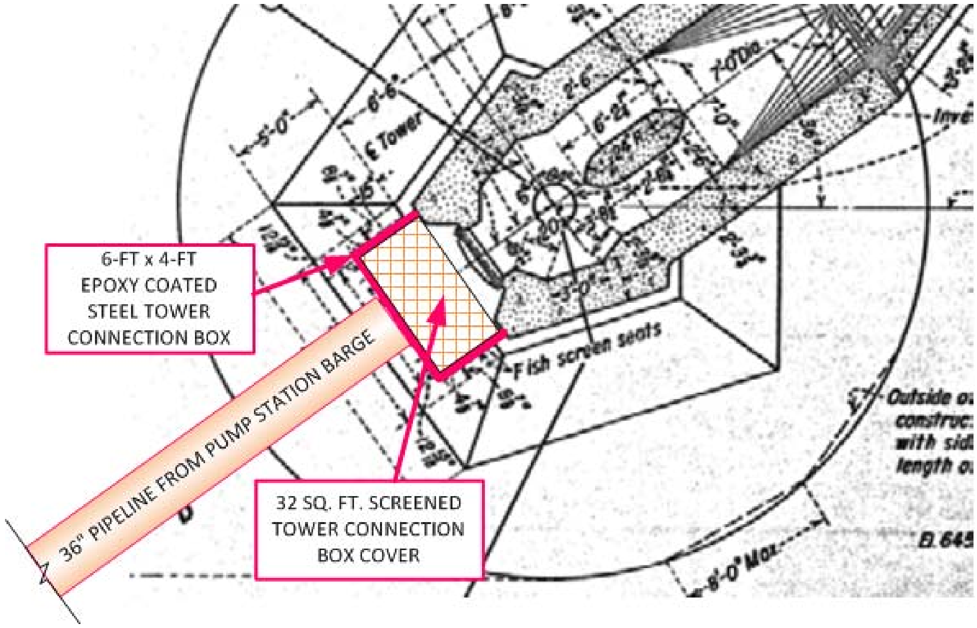


Figure 11. Connection of 36-inch Pipeline to Intake Tower at Gate 5

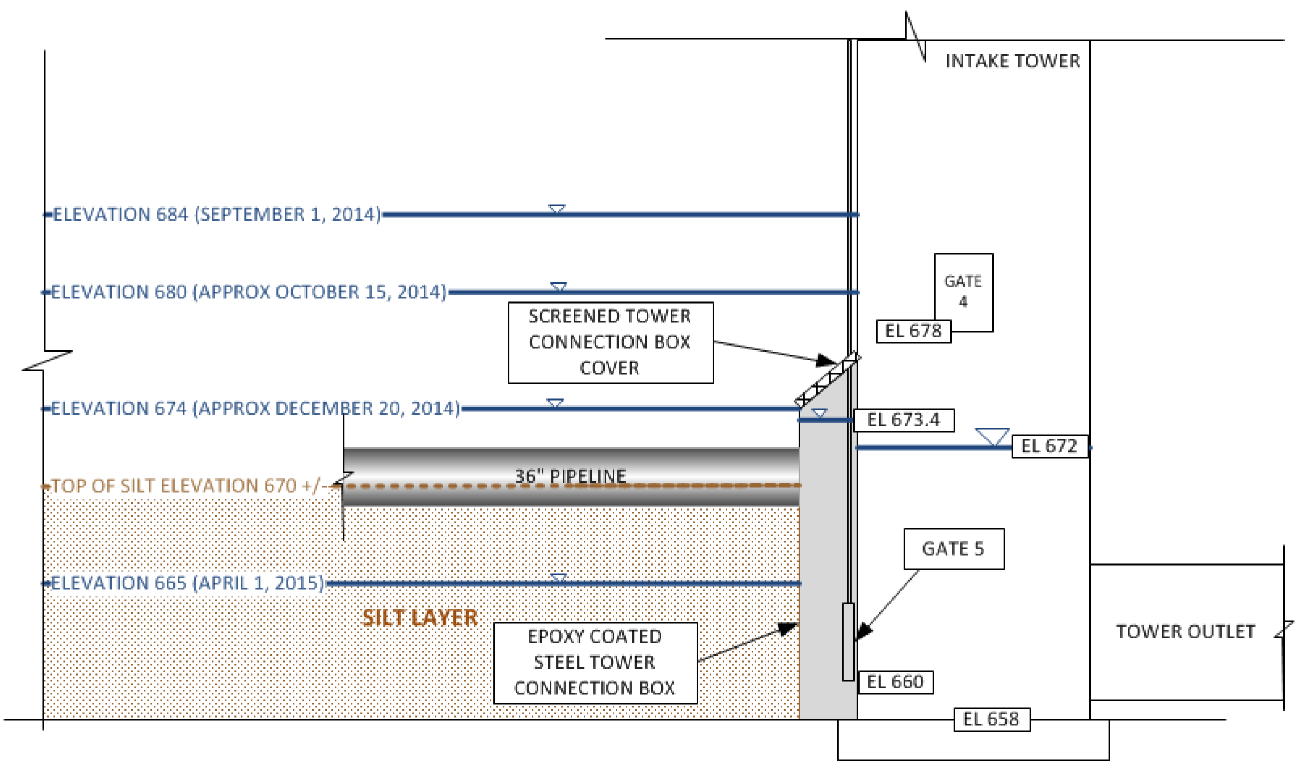


Figure 12. Profile View of Tower Connection Box

Figure 12 shows the tower connection box in profile view, along with some of the anticipated lake levels and the level of the silt which surrounds the lake intake tower. The minimum water surface elevation required in the intake tower is also shown at elevation 672. In order to accommodate the headloss going through Gate 5 at 45-mgd, the water level in the intake box would need to be at 673.4. Figure 13 shows a 3-dimensional model view of the planned tower connection. This connection has the significant advantage that it can be fabricated, delivered to the site, and installed by divers underwater by bolting it to the existing structure. More details on the constructability of the tower connection box will follow later in this proposal.

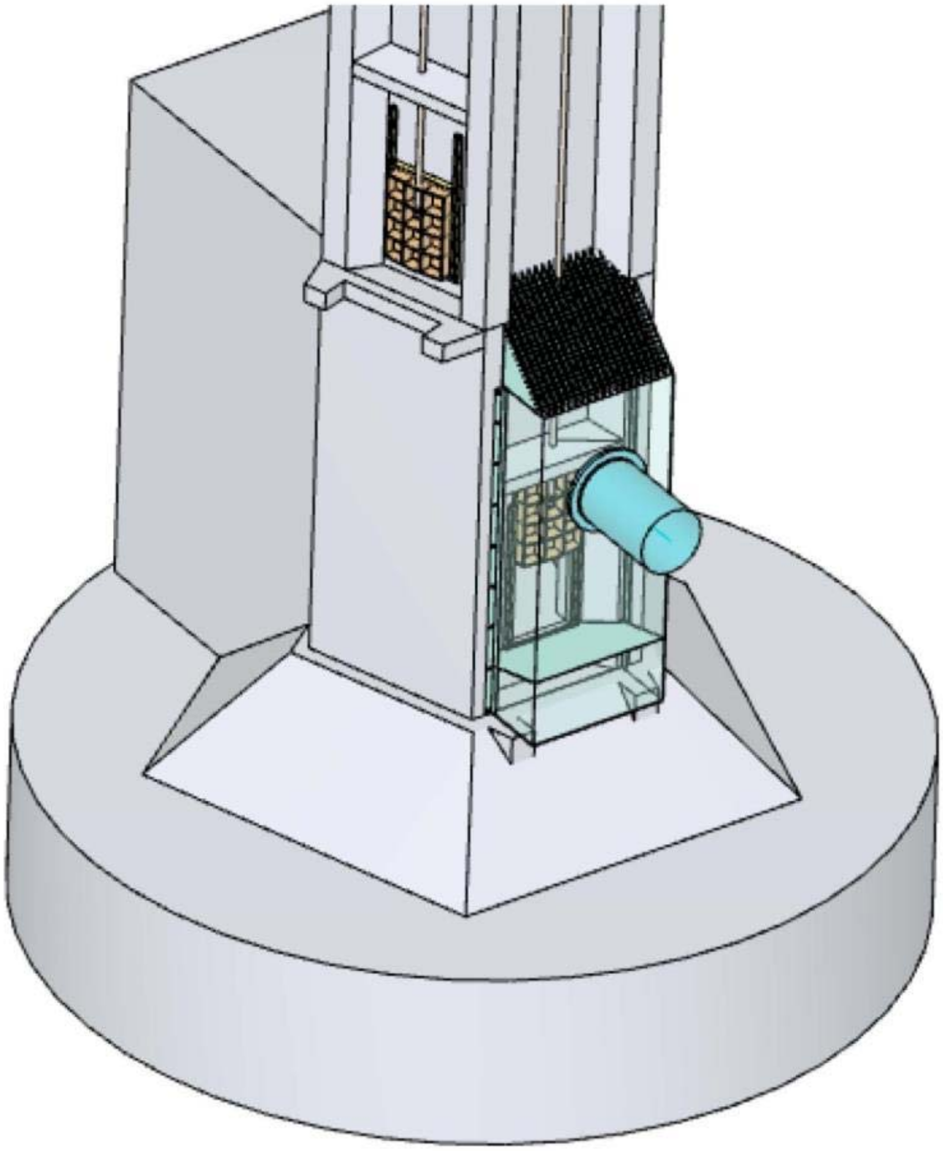


Figure 13. 3-dimensional Model of Intake Tower Connection Box

Gravity Flow Connection to the Intake Tower

In the RFP, there is discussion regarding a gravity flow connection to the intake tower. The “snorkel” and “siphon” concepts are discussed as ways to reduce operating costs and provide a combination of gravity and pumped flow into the intake tower. In order to assess the potential for this to be an economical part of the temporary water conveyance system for Lake Cachuma, first we must estimate the approximate time period during which a gravity flow approach would be useful to the project. Figure 14 shows gravity flow rates through Gate 4 at dropping lake elevation. Above elevation 678, gravity flow through Gate 4 will continue. Until the level in the lake reaches approximately 680, a majority of daily flow demand will be met with gravity flow through Gate 4. During this time, the pump station will only have to operate during peak demand periods for short durations.

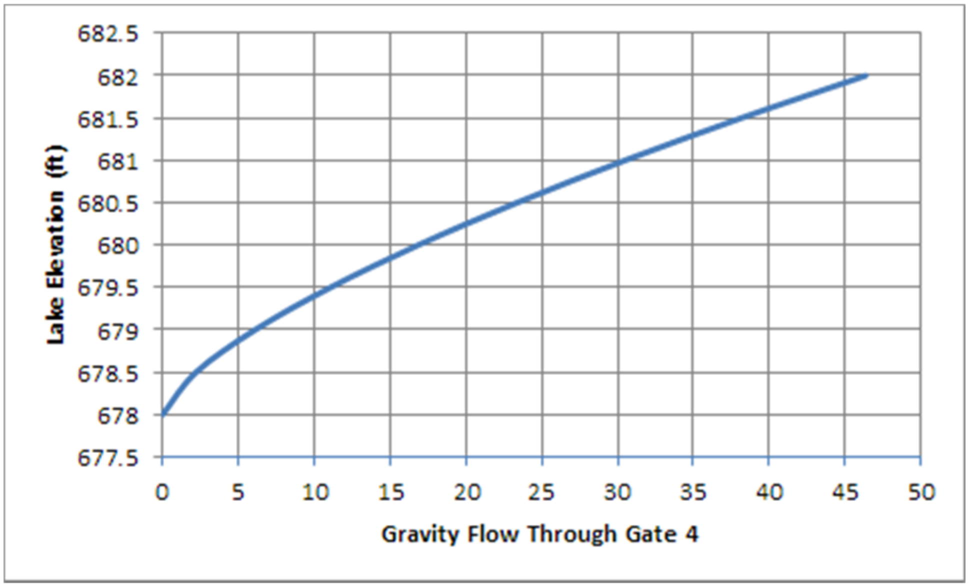


Figure 14. Gravity Flow Through Gate 4 at Dropping Lake Elevation

Referencing Figure 12, it is expected that the lake will not drop to below elevation 680 until approximately October 15, 2014. In order to maintain a minimum water surface elevation of 672 in the intake tower, the level in the lake must be above approximately elevation 674. Additionally, below elevation 674, the lake will be nearing the silt level around the intake tower and water quality/turbidity will become a major concern. The lake level is expected to drop to elevation 674 approximately December 20, 2014. **This leaves approximately 2 months when the gravity intake will be useful (mid-October to mid-December).**

We have provided a gravity intake component integrated into our design of the Tower Connection Box. Flow can go into the box through the screened cover and into the Intake Tower through Gate 5. If the approach velocities to the intake box (which will be 1.2-fps at 25-mgd and 2.2-fps at 45-mgd) are not acceptable to the Department of Fish and Wildlife permitting requirements, we will seal the top of the box and use the pump station full time starting when flow drops below elevation 680. The construction, operation and maintenance of more complex screening facilities will quickly cost more than the power and other operational savings realized from leaving the pump station off. The drum screens on the pump barge are a far more reliable way to meet stringent fish screening requirements.

Pump Barge

Our Pump Barge follows the "general pump station concept" discussed earlier. The Pump Barge approach builds on the success of the 1990/1991 drought-response pump station. This approach is tried-and-true, reliable, and quickly deployable. As discussed earlier, our **pump station is designed to operate in Location 1 and in Location 2, with no changes to any of the on-board systems**. Even if Location 2 is relocated by PG&E, our station design can accommodate many hydraulic conditions, giving COMB maximum flexibility. An overview of our design model for the pump barge is shown in Figures 15, 16 and 17. A complete 3-dimensional .pdf model is attached to this submittal.

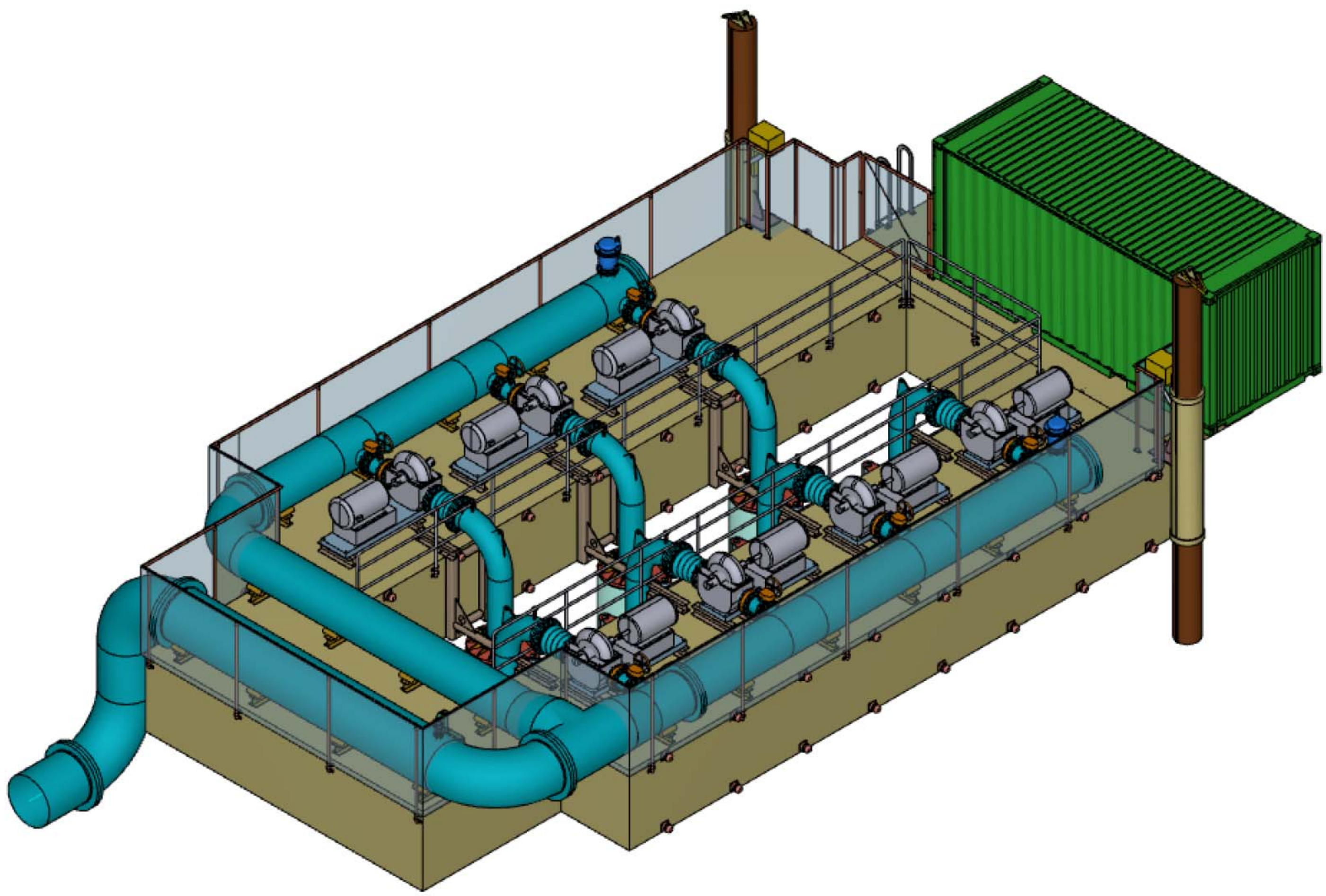


Figure 15. Pump Barge Design Model

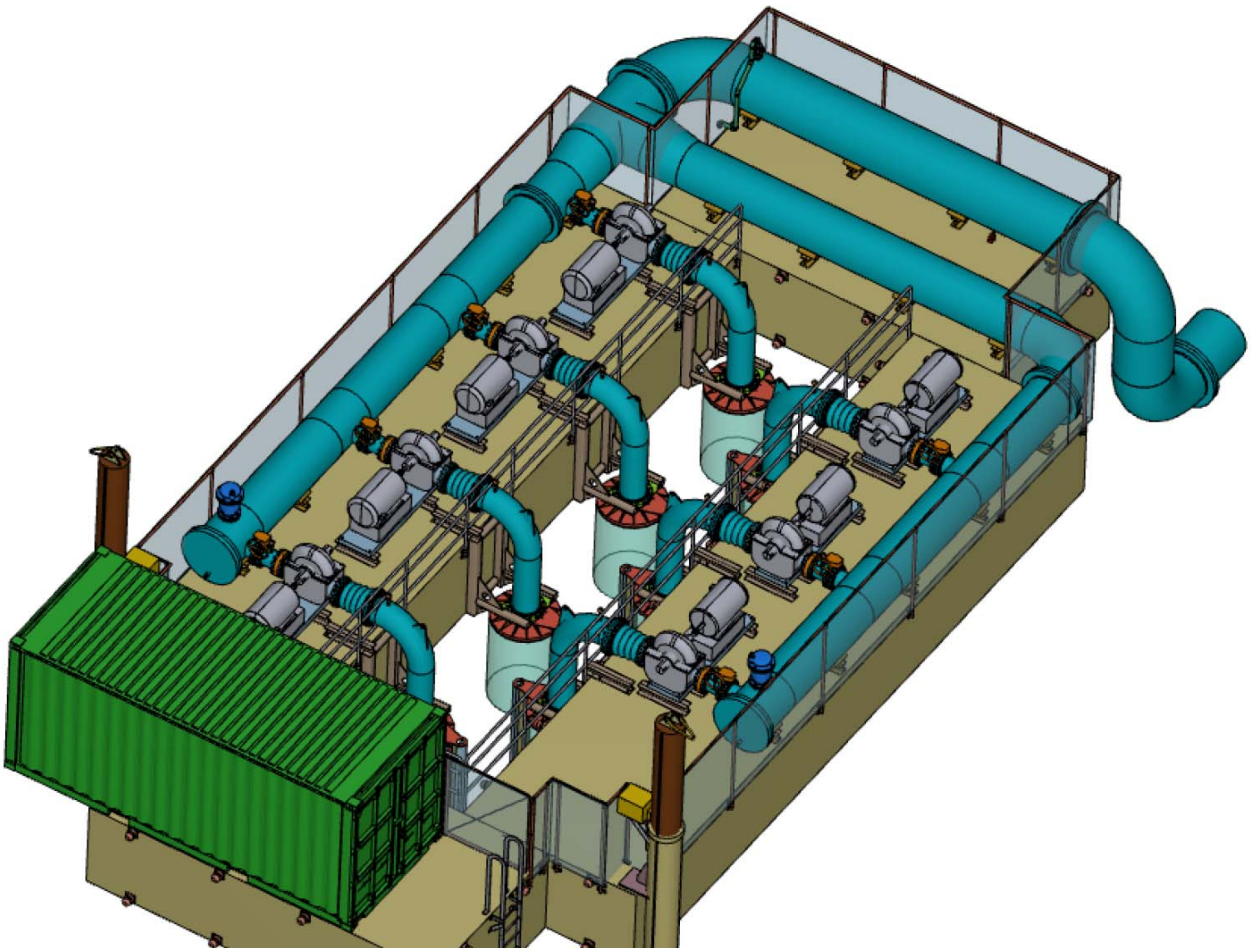


Figure 16. Pump Barge Design Model (Rotated View)

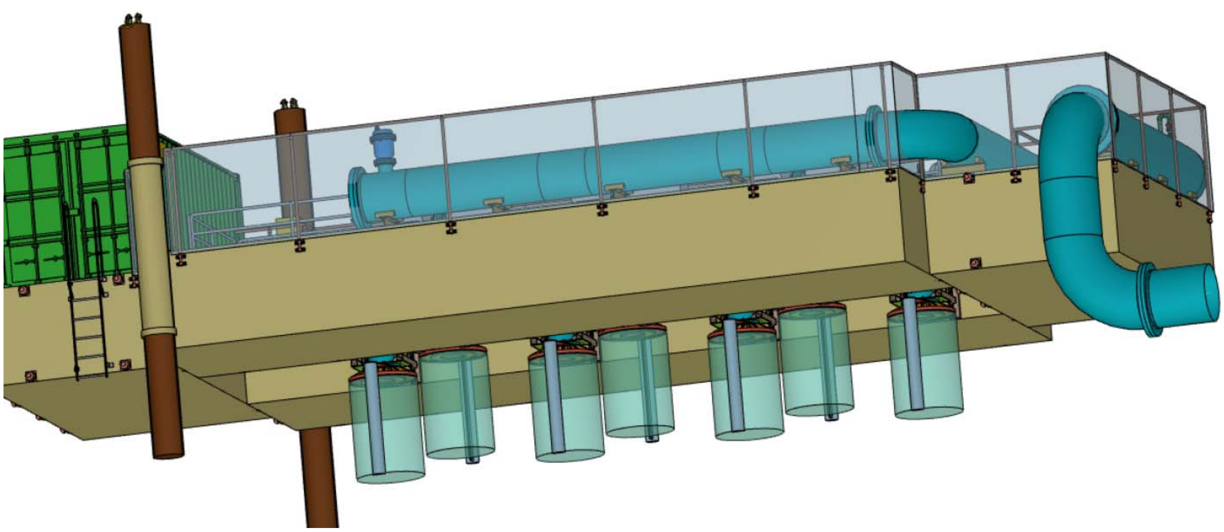


Figure 17. Underside of Pump Barge, Showing Drum Screens on Pump Suction Pipes

General Pump Barge Features

The Pump Barge will have the following general features:

- Pump Barge sections made from Flexifloat S50 Duofloat and Quadrafloat barge sections. Barge sections assembled to create pump well in the middle
- Pump Barge stabilized at each lake location using spuds.
- Steel sea container to house electrical equipment, compressors, instrumentation (flowmeter, turbidimeters, etc.). Sea container to be conditioned to maintain temperatures appropriate for all equipment.
- Automatically cleaned fish screens, individual on each pump, mounted to brackets on the barge sections.
- Steel suction and discharge piping, cement-mortar lined. 30-inch diameter headers on each pump line-up, combining into the 36-inch diameter flowmeter run and pipe connection to HDPE transmission main.
- Two 8-inch diameter air and vacuum valves, one on each 30-inch diameter header. These valves will serve to prevent the pipeline from experiencing negative surge pressure waves in the event of a sudden pump station shut-down (such as with a loss of power). Negative surge pressure wave could cause the HDPE pipeline to collapse (large diameter pipelines are susceptible to negative pressures). The use of appropriately sized and redundant air/vacuum valves addresses this concern.
- Vacuum-priming system for pumps. The pumps will vacuum prime prior to start-up. The vacuum prime system is a venture-style priming system, using compressed air (there are two compressors in the sea container) to draw a vacuum on the pump volute prior to start-up and draw the water from the lake up into the pump volute. This type of priming system is reliable and well-proven.
- 20-ft straight run of 36-inch diameter pipe to provide straight run distance to the flowmeter location so that the flowmeter accuracy is maximized.
- Safety handrail on interior pump well area
- Security fence

Maintenance Barge

A second barge will be assembled from Flexifloat S50 barge sections and placed adjacent to the Pump Barge. The second barge will have a crane on it and will be used to construct the Pump Barge as well as serve as a Maintenance Barge for the entire duration of the project. The crane on the Maintenance Barge will be able to lift each pump, or each screen and pump suction assembly for maintenance. In the event that a pump or screen needs repairs, the Maintenance Barge will allow for fast removal, repair and re-installation of the pump or screen without interruption to the other pumps and screens on the Pump Barge.

Electrical Systems

The pumps will be driven using VFDs. All pumps will be outfitted with VFDs in order to reduce inrush current to the station and limit the size of wire used as well as the impact on the utility for this facility. A general description of the electrical systems is as follows:

- General Electrical and Controls Concepts -- Redundancy
    - Each power and control system will have redundancy built in. Whether it is parallel systems such as multiple pumps or PLC processors, or alternate ways of getting the same things done.
    - Power systems will be redundant and isolated. Failure in one system, panel, cable, or VFD, will not result in loss of full operational capability.
    - Alarms will be transmitted 3 ways -- via voice grade autodialer, email, and to the COMB SCADA system.
    - PLC controls will be redundant so that processor failure is seamless and transparent. The standby PLC will be able to take over controls without interruption.
    - Manual controls – each automated system will be able to be operated manually from the barge. Pumps may be operated in hand. The power distribution system can be over-ridden and forced as needed to maintain operations.
    - Emergency power – A utility loss will be alarmed and backup power provided immediately and automatically.
    - Communications – a communications loss is treated as a critical alarm and the station will be programmed to assume a specified flow condition until over-ridden or restored. Initial set-up and communications integrity will be a top priority.
- Power Distribution and Monitoring
    - Utility power will be connected to a meter/main switchboard at a 480/277 volt level. Drawing E-2 and the load calculation may be used to order PG&E service. We recommend this voltage level even though voltage drop is a concern when running 1000 feet of cable. We were able to contain the voltage drop through the use of VFDs and parallel runs. The alternative, higher voltages, have high costs associated with them and require a much increased level of safety.
    - Power cable will be rated type W, submersible rated, 2000 volt. The cable will be operated at a very conservative ½ of its current rating, and ¼ of its voltage rating.
    - Voltage drop will be held to 5% under full load conditions. This will keep the pump motors operating within their design parameters for voltage and current.
    - Circuit breakers will include ground fault detection on each of three cable runs to the barge. Ground fault settings will be held at the minimum breaker setting for safety.
    - If any of the cable runs experience a fault, the feeder circuit breaker will trip and the loads

will be automatically shifted to an operational cable. The pump station will remain at 100% operational capacity with 2 of 3 operational cables.
  - If a second cable fails, the feeder breaker will trip, and the pump loads will be automatically shifted to the last operational cable. Capacity of the pump station will be 50% with only a single cable (1/3) in operation.
  - Power fail conditions will be monitored and a stand-by generator started automatically. The generator will be of sufficient capacity to serve maximum flow requirements as defined by the chosen scenario.
- Standby Diesel Generator:
  - The generator will be monitored for run and common alarm.
  - The fuel tank will be monitored for low fuel level that will equate to 16 hours of run time.
  - Each I/O point will be connected to the PLC for remote monitoring and alarming.
- Motor Controls
  - The pumps will be outfitted with VFDs for each motor. The VFD provides the most flexibility and versatility for operations while keeping voltage drop to a minimum.
  - Pumps can be operated locally on the barge at each VFD drive in manual mode if the control system fails or communications fails.
  - The pumps will be operated automatically and monitored for fault conditions and run status by the PLC.

Communication, Instrumentation and Controls

- Communication
  - The barge will communicate to the tower via a spread spectrum radio link. There is line-of-sight between the barge and the tower to support the radio link communication. Figure 18 shows the communication sight zone for the radio link along with the approximate locations for the barge relative to the intake tower.

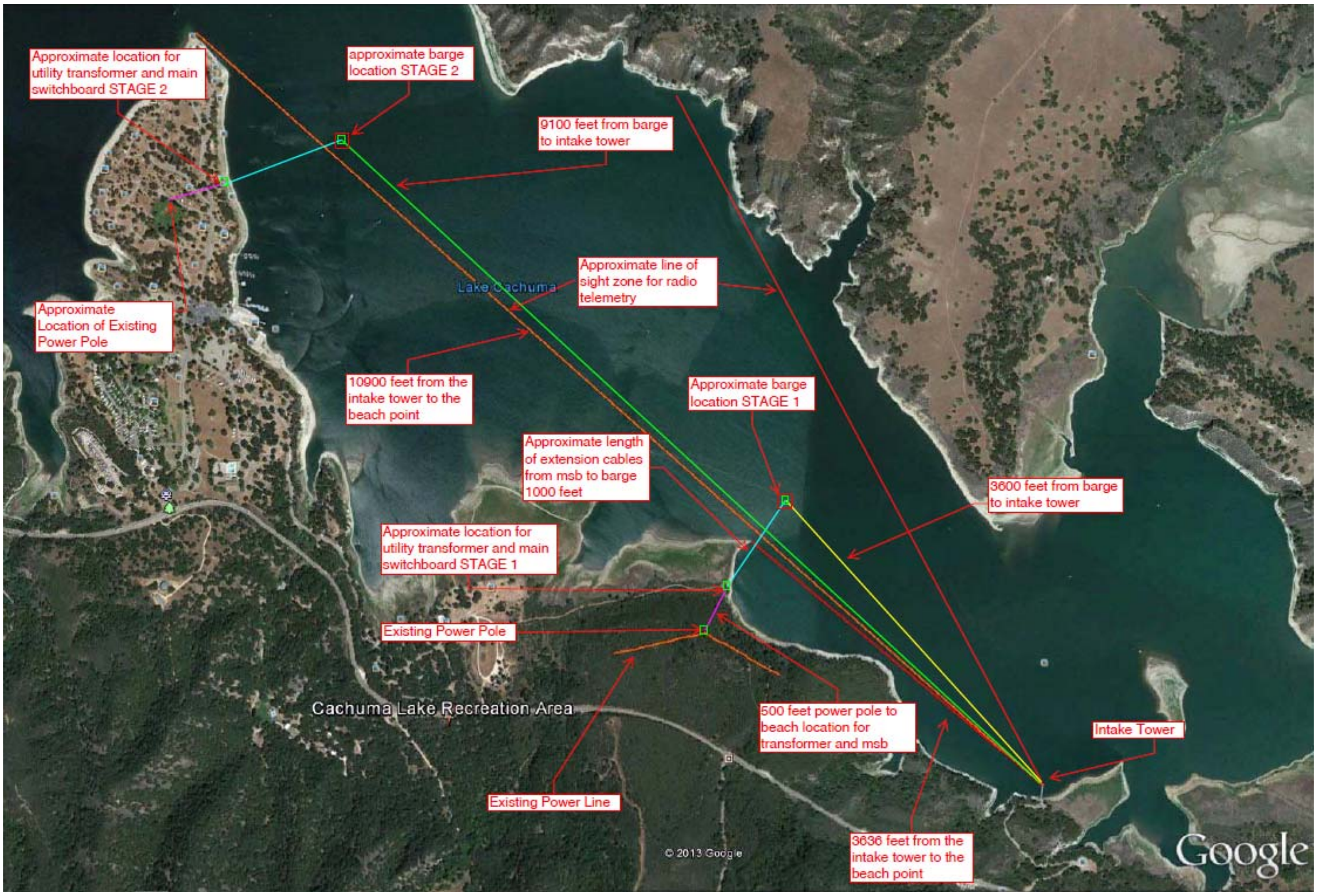


Figure 18. Communication Sight Zone for Radio Communication Between Intake Tower and Pump Barge Locations 1 and 2

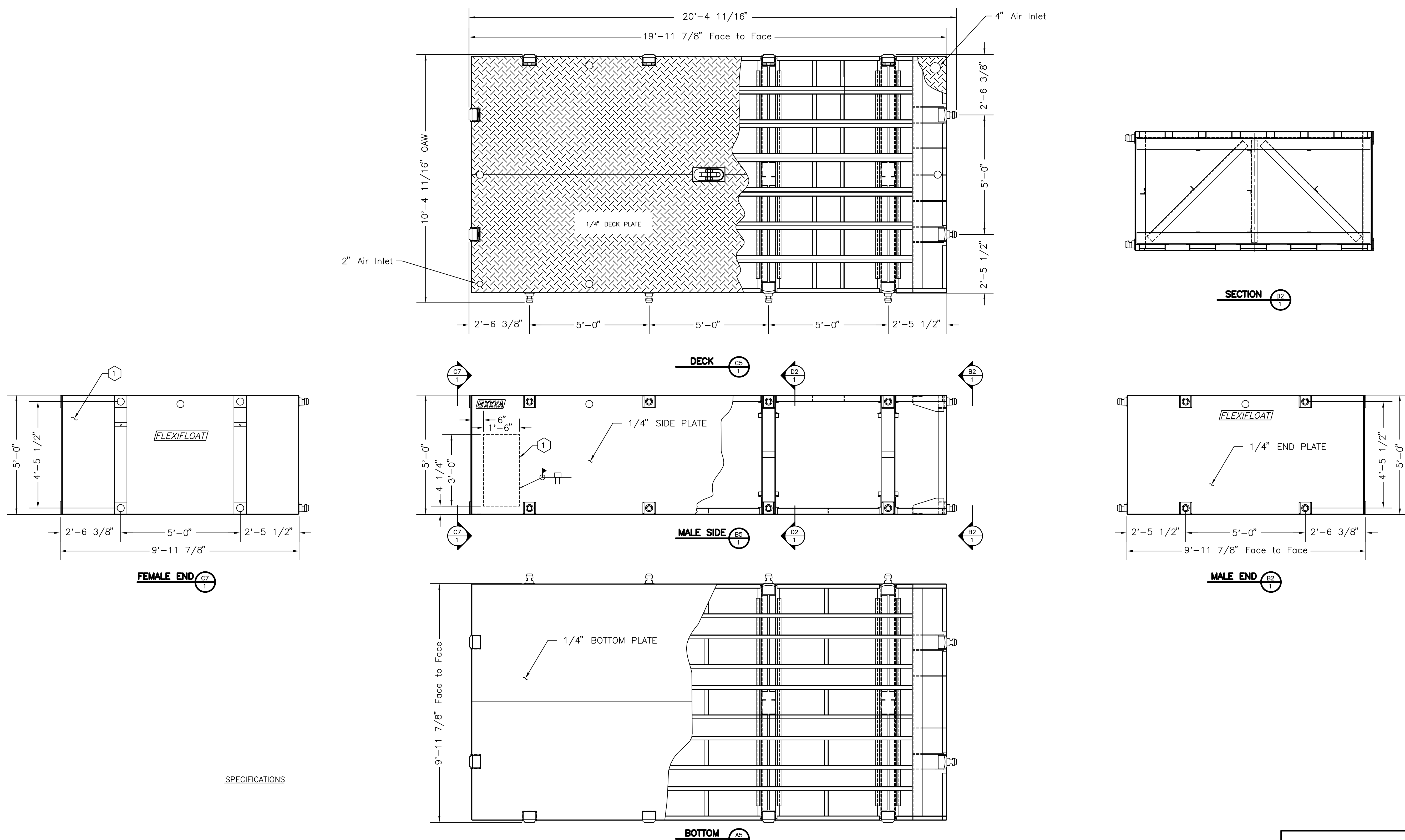
- Automated Controls
  - The barge will have a PLC panel that will control the pumps to obtain required flowrates automatically. This will be done by monitoring the level in the intake structure. The control system will call pumps and modulate speed to maintain a setpoint level in the intake structure. If COMB changes the flowrate, the level in the intake structure will be affected and the pump station will react to maintain level. In the event of communications failure, the pump station can hold the last flowrate or run to default quantity of pumps and speed as determined by COMB.
  - The barge PLC will be a dual processor in hot-standby configuration to make it as robust as possible.

- The barge PLC panel will be powered from any of the three power feeder cables and from an uninterruptible power supply. The control panel will automatically select from all available power sources.
- An operator who is located on the barge, shore, on internet, or via SCADA system will be able to monitor and control the pump station. Touchscreen operator interface panels will be provided on the barge and on the shore.
- The power distribution (shore) PLC will monitor the generator, voltage, and circuit breaker status and share that data with the barge PLC.
- The existing PLC at the intake tower will be modified to receive data from the barge PLC and forward pump station status and alarms to SCADA.
- High speed Ethernet radios will connect the intake tower PLC, the barge PLC, and the power distribution (shore) PLC.

- SCADA
  - The existing SCADA system will be modified with new screens to view the barge pump station, power distribution, and generator status. Alarms will be configured for display on SCADA.
- Alarm System
  - An autodialer will call the operator and announce the type of failure. The dialer will call for each alarm until acknowledged. The dialer will be located in the shore PLC control panel and be connected to conventional dial up phone line.
  - The SCADA system at COMB can be configured to post alarms from the barge pump station and alert COMB on-call operations if needed.
  - The Operator HMI panels will be configured for remote access. The quality of cellular or phone digital communications will be key to this working, but we will do what we can to enable remote access for operations and maintenance. This will speed troubleshooting and remedy.
- Instrumentation:
  - Flow metering
  - Turbidity
  - Intake Level
  - Priming system low air pressure
  - Utility and cable voltage monitoring
  - Circuit breaker monitoring

PRELIMINARY DESIGN DRAWINGS

Complete 3-dimensional design models of the Pump Barge and Intake Tower Connection Box have been developed in the preparation of this Proposal. Those design models have been provided as 3-dimensional .pdfs and submitted along with our proposal. They are viewable and can be manipulated (pan/zoom/spin/etc.) in Adobe Reader (available for free from www.adobe.com if not already installed on your computer). The design models have been used to develop plans and sections of both the Pump Barge and Intake Tower Connection Box. Those preliminary design drawings, along with preliminary electrical and control schematics are included on the following pages for your review.



SPECIFICATIONS

Unit Weight: 14,700 Lbs.
Rated Load Capacity @ 3.25 Ft Draft: 13.5 Tons
Horizontal Lock Spacing: 5.0 Ft.
Vertical Lock Spacing: 4.5 Ft.
Lock Strength @ 65% Yield: 45 Tons Tension/Shear
Deck Bearing Capacity: 5,000 Lbs./Ft².
Section Modulus: Transverse Section Between Trusses:
Deck in Compression: 2,646 In³.
Bottom in Compression: 2,143 In³.

GENERAL NOTES

1. TO ENTER FLOAT FOR INSPECTION OR REPAIR REMOVE FEMALE CORNER PLATES OR CUT OUT PANEL AS SHOWN. AFTER COMPLETION OF INSPECTION/REPAIR REPLACE PANEL, SEAL WELD, AND TEST FOR LEAKS AS DESCRIBED IN NOTE 2.
2. TEST FOR LEAKS BY APPLYING INTERNAL AIR PRESSURE OF 5 PSI MAXIMUM. BRUSH ALL EXTERNAL WELD SEAMS WITH WATER AND SOAP SOLUTION. LEAKS WILL BE DETECTED BY FORMATION OF SOAP BUBBLES.

OAW – Overall Width
OAL – Overall Length
REDUCTION – DO NOT SCALE

UNSPECIFIED TOLERANCES

DECIMAL:	
X.X	± .1
X.XX	± .03
X.XXX	± .001
ANGULAR:	± .50°
FRACTIONAL:	± 1/16"
METRIC:	± .001

NEXT ASSY

NO.	DATE	BY
A	2/17/09	CAM

REVISIONS

Robishaw Engineering, Inc.
HOUSTON, TEXAS

WORKING DRAWING
FLEXIFLOAT S-50 DUOFLOAT

DRAWN BY	CHECKED	DWG NO.	REV
NAME CAM	NAME	520000W	A
DATE 11/8/96	DATE	SCALE 1/2" = 1'-0"	SHEET 1 OF 1

Print Size 24 x 36 all others Not to Scale

ZBORDER 2003

REI38791

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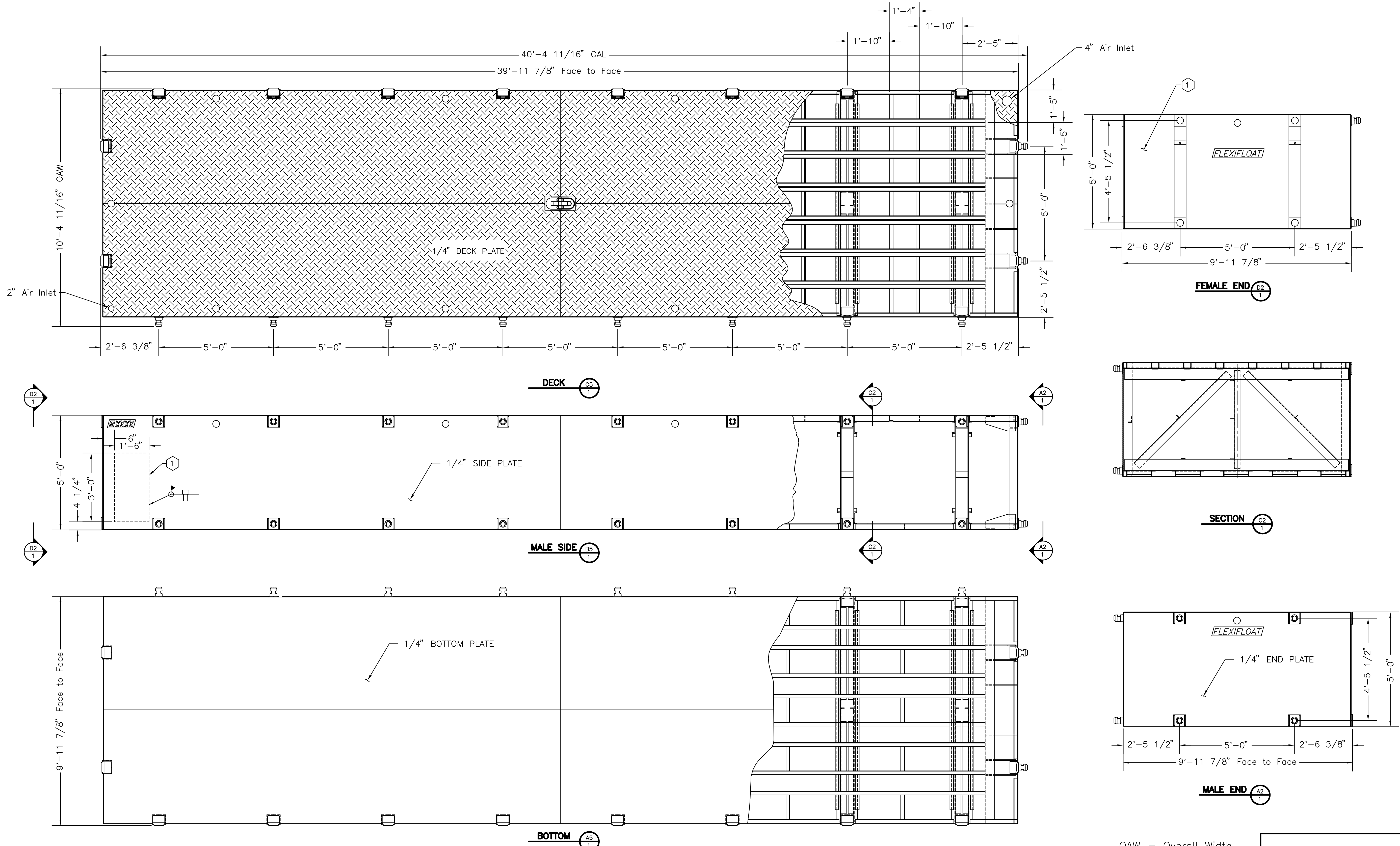

OAW – Overall Width
OAL – Overall Length
REDUCTION – DO NOT SCALE

GENERAL NOTES

1. TO ENTER FLOAT FOR INSPECTION OR REPAIR REMOVE FEMALE CORNER PLATES OR CUT OUT PANEL AS SHOWN. AFTER COMPLETION OF INSPECTION/REPAIR REPLACE PANEL, SEAL WELD, AND TEST FOR LEAKS AS DESCRIBED IN NOTE 2.
2. TEST FOR LEAKS BY APPLYING INTERNAL AIR PRESSURE OF 3 PSI MAXIMUM. BRUSH ALL EXTERNAL WELD SEAMS WITH WATER AND SOAP SOLUTION. LEAKS WILL BE DETECTED BY FORMATION OF SOAP BUBBLES.

SPECIFICATIONS

Unit Weight: 27,000 Lbs.
Rated Load Capacity @ 3.25 Ft Draft: 27 Tons
Horizontal Lock Spacing: 5.0 Ft.
Vertical Lock Spacing: 4.5 Ft.
Lock Strength @ 65% Yield: 45 Tons Tension/Shear
Deck Bearing Capacity: 5,000 Lbs./Ft².
Section Modulus: Transverse Section Between Trusses:
Deck in Compression: 2,646 In³.
Bottom in Compression: 2,143 In³.

UNSPECIFIED TOLERANCES
DECIMAL:
X.X ± .1
X.XX ± .03
X.XXX ± .001
ANGULAR: ± .50°
FRACTIONAL: ± 1/16"
METRIC: ± .001
NEXT ASSY

NO.	DATE	BY
A	2/19/09	CAM

REVISIONS

Robishaw Engineering, Inc.
HOUSTON, TEXAS

WORKING DRAWING

FLEXIFLOAT S–50 QUADRAFLOAT

DRAWN BY	CHECKED	DWG NO.	REV
NAME CAM	NAME	540000W	A
DATE 11/8/96	DATE	SCALE 1/2" = 1'-0"	SHEET 1 OF 1

Print Size 24 x 36 all others Not to Scale

ZBORDER 2003

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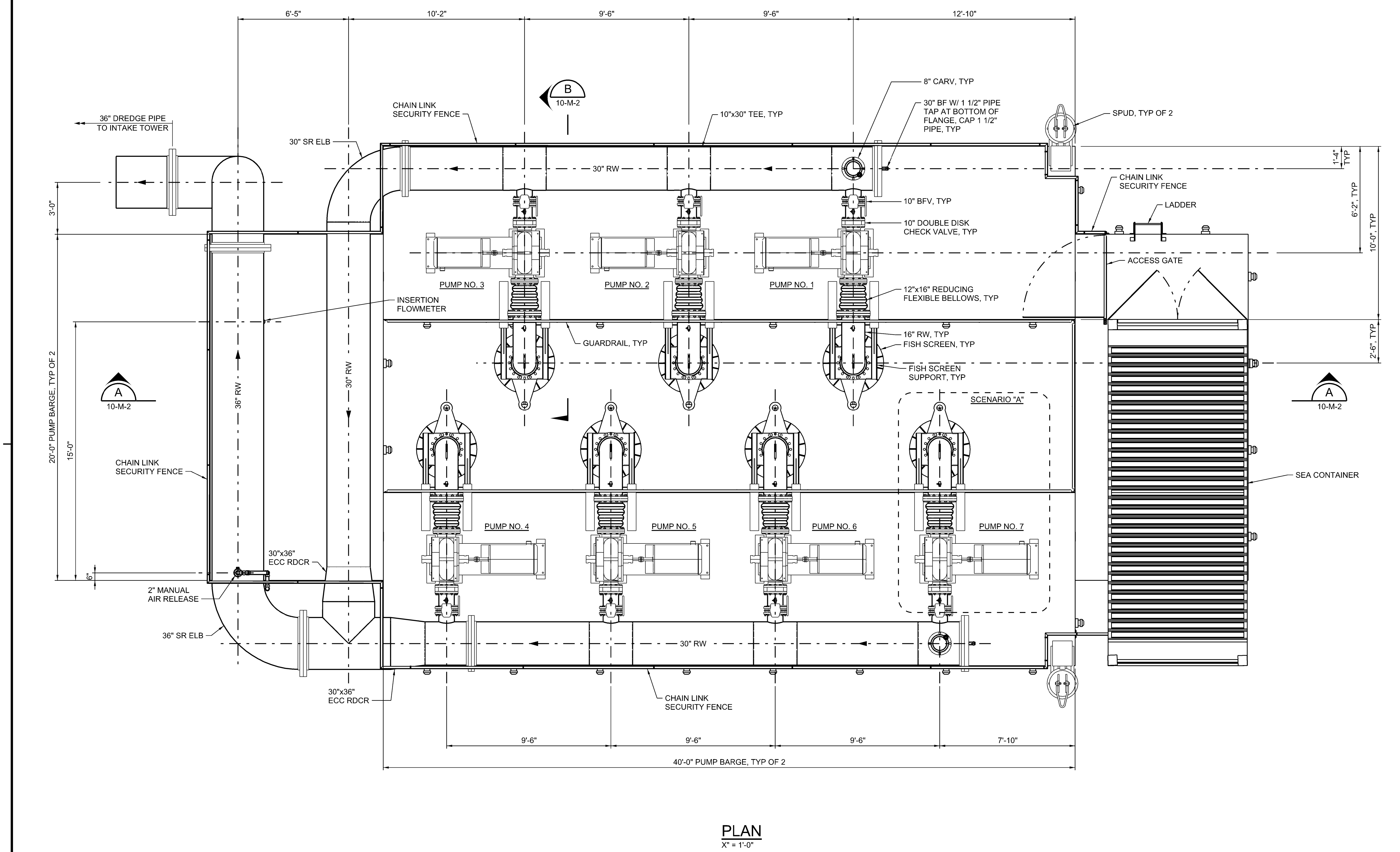


PLAN

X" = 1'-0"

SCALE 3/8"=1'-0"

DESIGNED S KADER
DRAWN C WORRALL
CHECKED S KADER
APPROVED S KADER

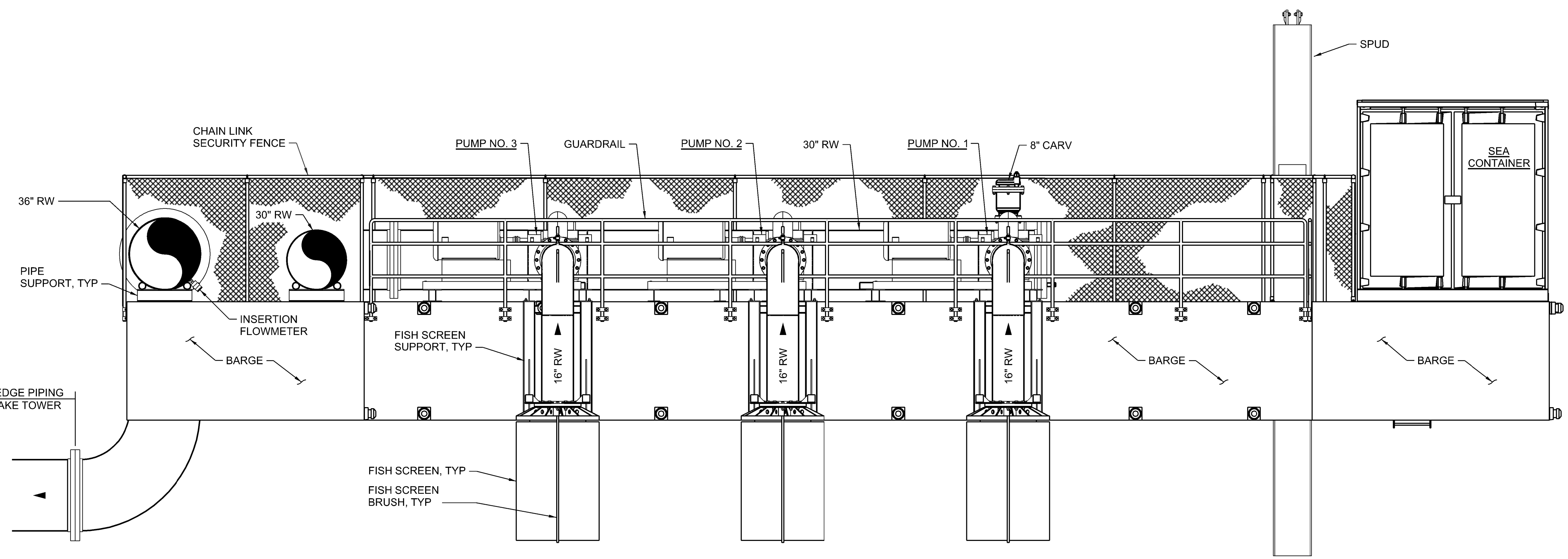
WATERWORKS ENGINEERS
1405 Victor Avenue, Suite A • Redding, CA 96003 • 530-243-2113

LAKE CACHUMA EMERGENCY PUMPING FACILITY
CACHUMA OPERATIONS AND MAINTENANCE BOARD

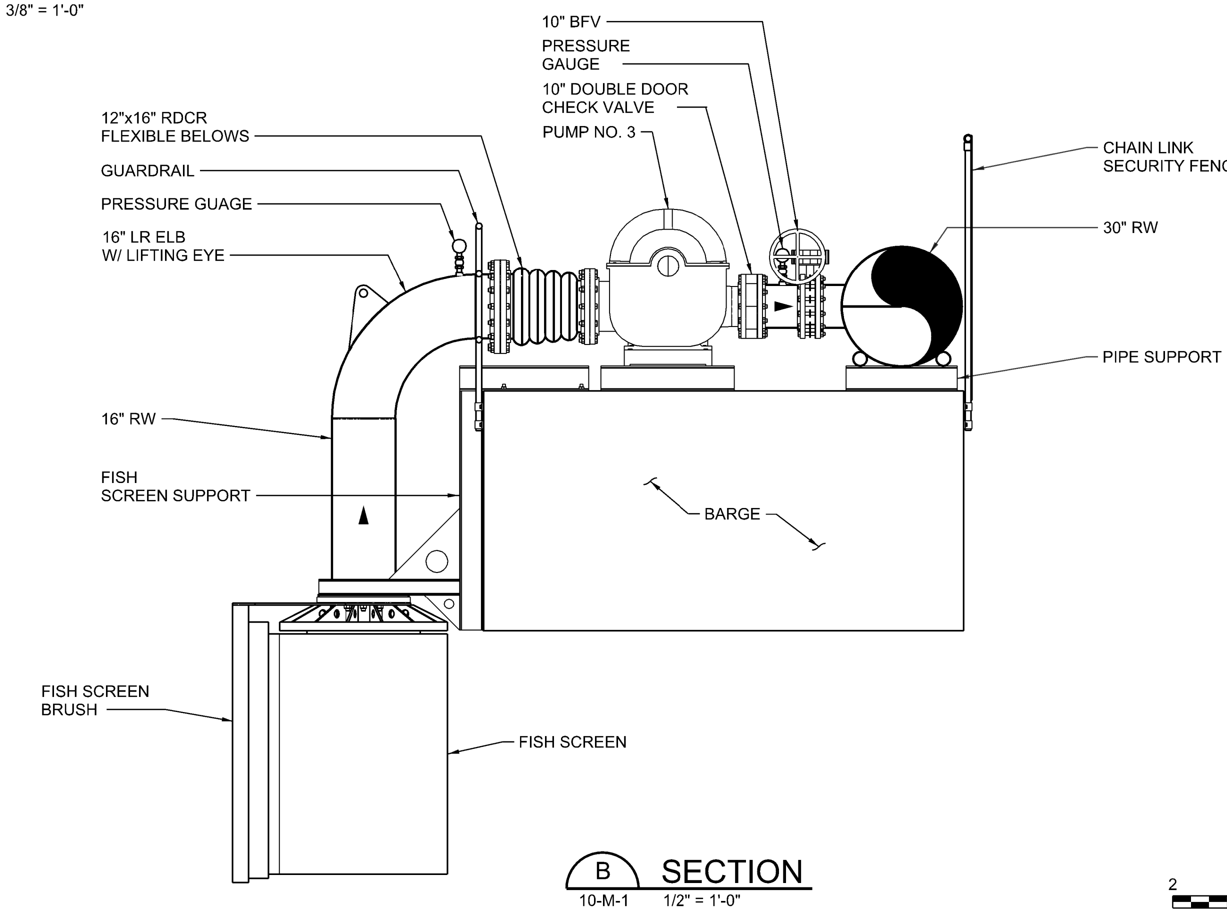
MECHANICAL
PUMP STATION BARGE PLAN

DATE APRIL 2014
PROJECT NUMBER 00-000
DRAWING NUMBER 10-M-1
SHEET NUMBER 1

FILENAME: 10-M-1.dgn PLOT DATE: 4/3/2014 1:57:48 PM



A SECTION
10-M-1 3/8" = 1'-0"



B SECTION
10-M-1 1/2" = 1'-0"

2 0 2 4 FEET
SCALE 3/8"=1'-0"

2 0 2 4 FEET
SCALE 1/2"=1'-0"

FILENAME: 10-M-2.dgn

PLOT DATE: 4/3/2014 3:12:32 PM

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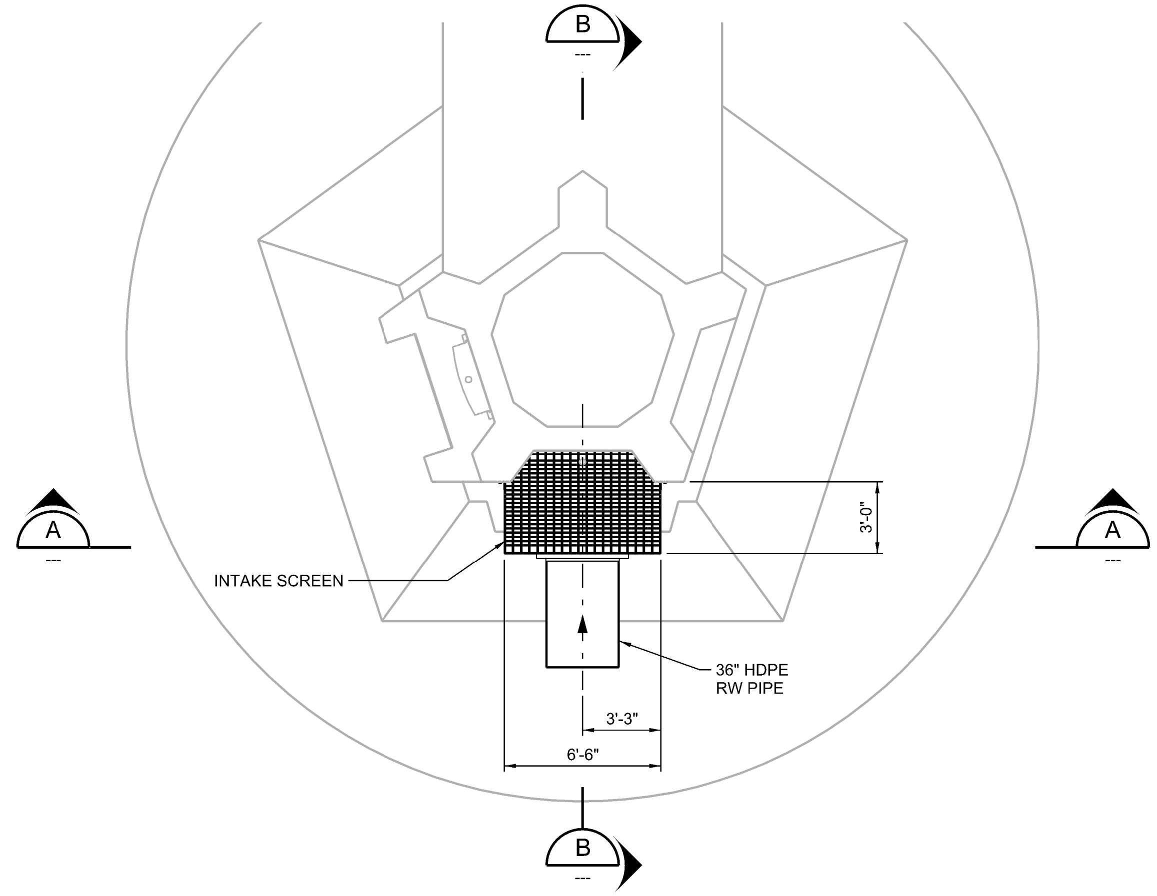
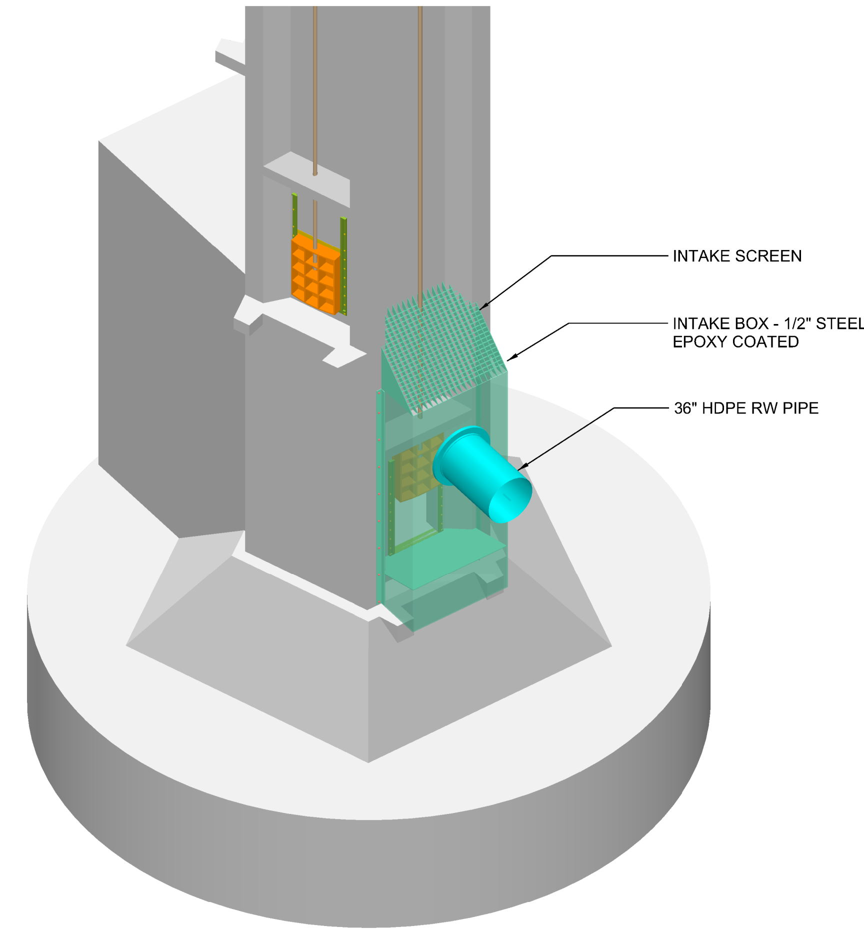
LAKE CACHUMA
EMERGENCY PUMPING FACILITY
CACHUMA OPERATIONS
AND
MAINTENANCE BOARD

MECHANICAL
PUMP STATION BARGE
SECTIONS

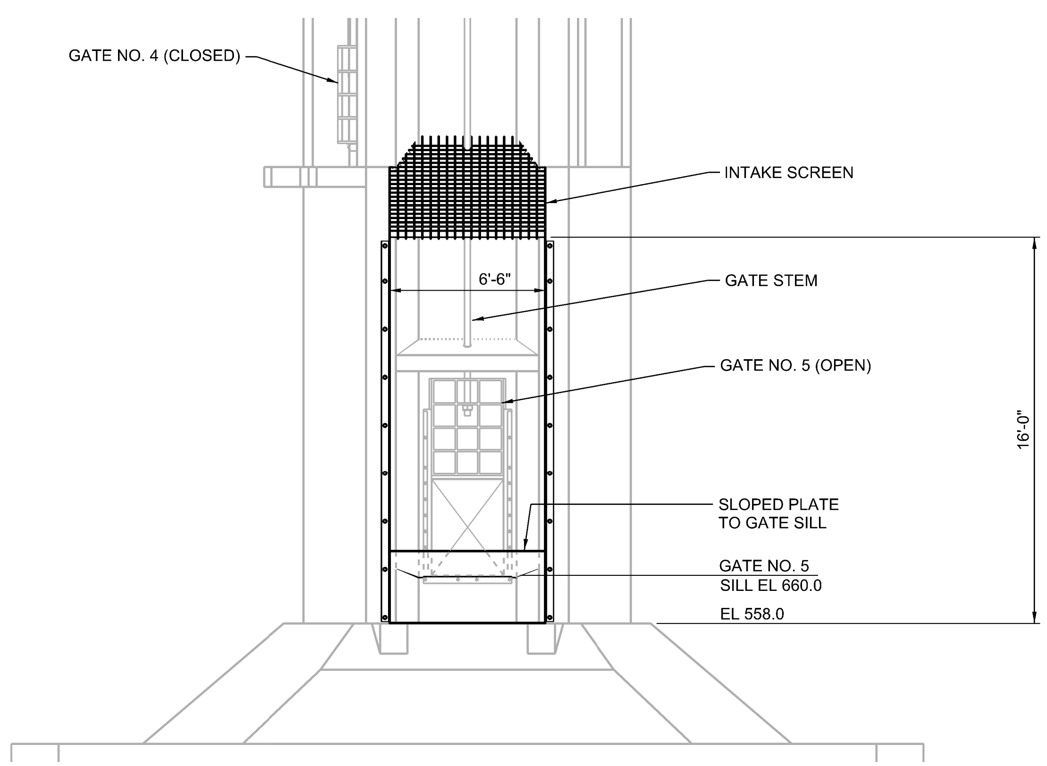
DATE
APRIL 2014
PROJECT NUMBER
00-000
DRAWING NUMBER
10-M-2
SHEET NUMBER 2



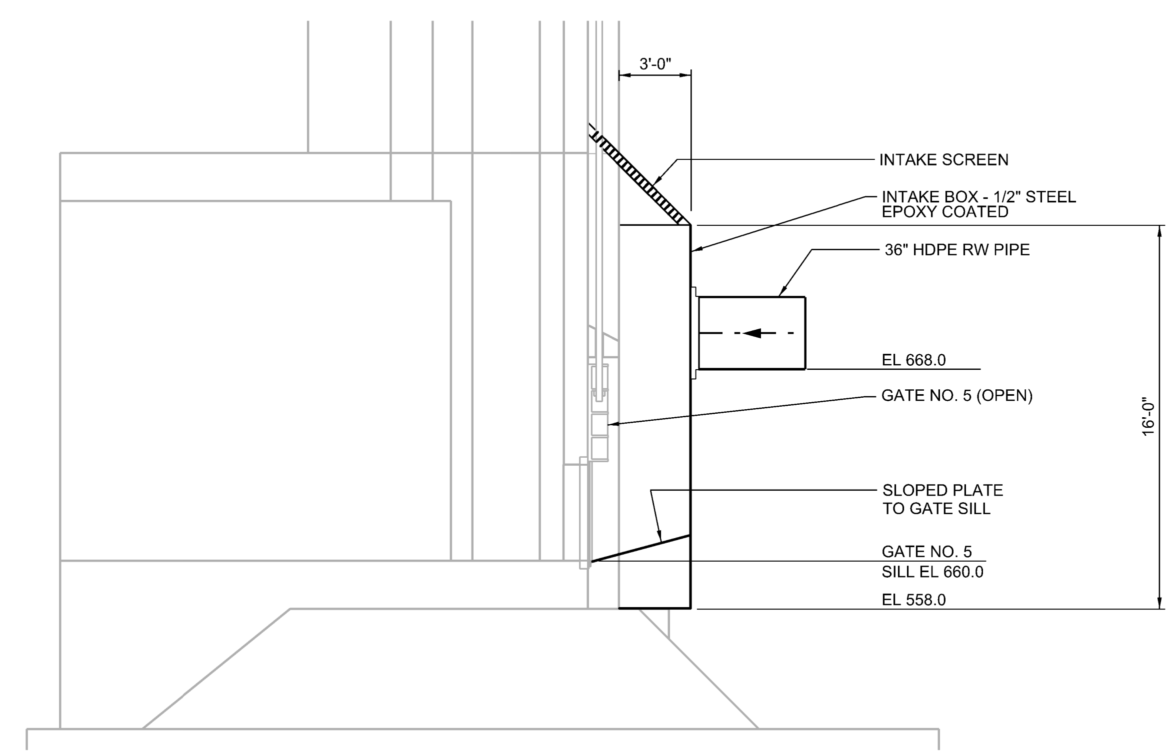
PLAN
1/4" = 1'-0"



ISOMETRIC
NTS



A SECTION
--- 1/4" = 1'-0"



B SECTION
--- 1/4" = 1'-0"

DESIGNED S KADER
DRAWN C WORRALL
CHECKED S KADER
APPROVED S KADER

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LAKE CACHUMA EMERGENCY PUMPING FACILITY
CACHUMA OPERATIONS AND MAINTENANCE BOARD

MECHANICAL
INTAKE TOWER INTAKE BOX

DATE APRIL 2014
PROJECT NUMBER 00-000
DRAWING NUMBER 20-M-1
SHEET NUMBER 1

FILENAME: 20-M-1.dgn
PLOT DATE: 4/3/2014 3:43:06 PM

1 2 3 4 5 6

COMPONENTS

SYMBOL	DESCRIPTION
RES	RESISTOR
SV	SOLENOID COIL
HTR	HEATER
	CAPACITOR
	DIODE
	DIODE, ZENER
MOV	METAL OXIDE VARISTOR
	AUDIBLE ALARM
?	3 PHASE MOTOR ? = MOTOR HP
M	3 PHASE MOTOR
M	SINGLE PHASE MOTOR
	TRANSFORMER SIZE AND VOLTAGE AS SHOWN
M	UTILITY POWER METER
	UFER GROUND
	GROUND ROD
	CURRENT TRANSFORMER RATIO AS NOTED
	DISCONNECT SWITCH SIZED PER FEEDER
PDB	POWER DISTRIBUTION BLOCK

SWITCHES – PROCESS

SYMBOL	DESCRIPTION
FS	FLOW SWITCH – CLOSES UPON INCREASING FLOW
FS	FLOW SWITCH – OPENS UPON INCREASING FLOW
LS	LEVEL SWITCH – CLOSES UPON INCREASING LEVEL
LS	LEVEL SWITCH – OPENS UPON INCREASING LEVEL
PS	PRESSURE SWITCH – CLOSES UPON INCREASING PRESSURE (DECREASING VACUUM)
PS	PRESSURE SWITCH – OPENS UPON INCREASING PRESSURE (DECREASING VACUUM)
TS	TEMPERATURE SWITCH – CLOSES UPON INCREASING TEMPERATURE
TS	TEMPERATURE SWITCH – OPENS UPON INCREASING TEMPERATURE
ZS	LIMIT SWITCH – CLOSES AT SET LIMIT
ZS	LIMIT SWITCH – OPENS AT SET LIMIT
WS	TORQUE SWITCH – CLOSES UPON INCREASING TORQUE
WS	TORQUE SWITCH – OPENS UPON INCREASING TORQUE

DEVICES – RELAY

SYMBOL	DESCRIPTION
M1	CONTACTOR OR STARTER M1
CR 1	CONTROL RELAY CR1
TR 2	TIME DELAY RELAY TR2 – ADJUSTABLE TIME DELAY RANGE & SETTING AS SHOWN
TDOE TDOD	TIME DELAY ON ENERGIZATION TIME DELAY ON DE–ENERGIZATION
107, 121	REFERENCED RELAY WITH N.O. CONTACT ON LINE 107 N.C. CONTACT ON LINE 121
CR1 (105)	NORMALLY OPEN, RELAY CONTACT – ACTUATED BY RELAY CR1 COIL LOCATED ON LINE 105
CR1	NORMALLY CLOSED, RELAY CONTACT – ACTUATED BY RELAY CR1
TR2	NORMALLY OPEN, TIME DELAY RELAY CONTACT – CONTACT CLOSES AFTER TR2 IS ENERGIZED
TR2	NORMALLY CLOSED, TIME DELAY RELAY CONTACT – CONTACT OPENS AFTER TR2 IS ENERGIZED
TR2	NORMALLY OPEN, TIME DELAY RELAY CONTACT – CONTACT OPENS AFTER TR2 IS DE–ENERGIZED
TR2	NORMALLY CLOSED, TIME DELAY RELAY CONTACT – CONTACT CLOSES AFTER TR2 IS DE–ENERGIZED
TR2	CONTACT OPENS AND CLOSES IN A TIMED REPEAT CYCLE

WIRING – CONNECTIONS

SYMBOL	DESCRIPTION
	PANEL OR EQUIPMENT WIRING
	FIELD WIRING
	CONDUCTORS – NOT CONNECTED
	CONDUCTORS – CONNECTED
	GROUND CONNECTION
	PLUG AND RECEPTACLE
	INCOMING LINE
123 123 123	TERMINAL BLOCKS WITH TERMINAL NUMBER AS SHOWN
	TERMINAL BLOCKS WITH TERMINAL NUMBER DETERMINED BY SUBMITTAL
SHIELD CONDUCTOR	SHIELDED CABLE

PLAN – SYMBOLS

SYMBOL	DESCRIPTION
	CONDUIT, EXPOSED
	CONDUIT, IN SLAB OR BELOW GRADE
	CONDUIT, CONCEALED IN WALL OR CEILING
	CONDUIT STUBBED OUT & CAPPED
	CONDUIT BENDS TOWARD OBSERVER
	CONDUIT BENDS AWAY FROM OBSERVER
	CONDUIT ENDS
J	FLEXIBLE CONDUIT CONNECTION FROM J–BOX TO EQUIPMENT
	CONDUIT CHANGE IN ELEVATION
G	BARE COPPER GROUND WIRE
G	GROUND CONNECTION BOLTED TYPE
G	GROUND CONNECTION EXOTHERMIC WELD TYPE
	DISCONNECT SWITCH
	FIELD MOUNTED DEVICE
	TELEPHONE/DATA RECEPTACLE 2 PORT TA568A, 2 CAT 6 CABLES
#	CONDUIT REFERENCE TO SCHEDULE
T	THERMOSTAT
E	EYS SEAL
J	JUNCTION BOX
	PULL BOX OF SIZE SHOWN (CHRISTY BOX SIZE MINIMUM)
A a #	LIGHTING FIXTURE # – CIRCUIT BREAKER NUMBER A – FIXTURE SCHEDULE REF. a – CONTROL SWITCH REFERENCE
WP #7 WP	DUPLEX RECEPTACLE # – CIRCUIT BREAKER NUMBER WP – WEATHERPROOF (IF SHOWN) GFI – GROUND FAULT TYPE
a M	TOGGLE SWITCH a – FIXTURES CONTROLLED 3 – 3 WAY M – MOTION DETECTOR T – TIMER SWITCH
	SPECIAL RECEPTACLE AS REQUIRED FOR EQUIPMENT TO BE CONNECTED

SWITCHES – OPERATOR

SYMBOL	DESCRIPTION
SW	TOGGLE OR DISCONNECT SWITCH
PB	PUSHBUTTON – NORMALLY OPEN, MOMENTARY ACTION
PB	PUSHBUTTON – NORMALLY CLOSED, MOMENTARY UNLESS LOS (LOCK OUT STOP) WHERE MECHANICALLY HELD
PB	PUSHBUTTON, MECHANICALLY CONNECTED, DOUBLE CIRCUIT – NORMALLY CLOSED AND NORMALLY OPEN
HAND OFF AUTO	SELECTOR SWITCH, 3 POSITION – CONTACT STATUS SHOWN EXISTS I.E. AT POSITION OF HAND, OFF, OR AUTO
	SELECTOR SWITCH, 2 POSITION – MIDDLE POSITION IS DELETED
	POTENTIOMETER

DEVICES – FRONT PANEL

SYMBOL	DESCRIPTION
X	INDICATING LIGHT, LETTER "X" INDICATES COLOR: R=RED G=GREEN, A=AMBER, W=WHITE Y=YELLOW, B=BLUE
PTT X	INDICATING LIGHT, PUSH TO TEST
ETM	ELAPSED TIME METER

DEVICES – PROTECTIVE

SYMBOL	DESCRIPTION
y xA xP xT	LOW VOLTAGE MOLDED CASE, INSULATED CASE OR POWER CIRCUIT BREAKER. RATINGS AS SHOWN IN DRAWINGS AND AS DEFINED BELOW: xA: CIRCUIT BREAKER AMERAGE xAT: AMPERAGE TRIP xAF: AMPERAGE FRAME xP: NUMBER OF POLES xT: TRIP PROTECTION MCP: MOTOR CIRCUIT PROTECTION TM: THERMAL MAGNETIC L: LONG TIME DELAY S: SHORT TIME DELAY I: INSTANTANEOUS TRIP G: GROUND FAULT A: ARC FLASH PROTECTION 100% DUTY RATED
100%	
	y: BREAKER FEATURES / OPTIONS
S	– SHUNT TRIP
K	– KIRK–KEY INTERLOCK
M	– MANUALLY CHARGED PUSHBUTTON OPERATION
E	– ELECTRICALLY CHARGED PUSHBUTTON OPERATION
OL	THERMAL OVERLOAD CONTACT
	THERMAL OVERLOAD ELEMENT
	FUSE
	MEDIUM VOLTAGE CIRCUIT BREAKER
52	TRIP FUNCTIONS PER DRAWINGS AND SPECIFICATIONS
MFR	MULTIFUNCTION RELAY PER SPECIFICATIONS

MISCELLANEOUS ABBREVIATIONS

&	AND	MTR	MOTOR
@	AT	MUX	MULTIPLEXER
A	AMBER, AMPERES	MV	MERCURY VAPOR, MEDIUM VOLTAGE
AC	ALTERNATING CURRENT	N	NEUTRAL
ACK	ACKNOWLEDGE	NC	NORMALLY CLOSED
AFF	ABOVE FINISHED FLOOR	NHC	NORMALLY HELD CLOSED
AH	AMP HOUR	NHO	NORMALLY HELD OPEN
AI	ANALOG INPUT	NIC	NOT IN CONTRACT
AIC	AMP INTERRUPTING CAPACITY SYMMETRICAL	NL	NIGHT LIGHT
AM	AMP METER	NO	NORMALLY OPEN
AO	ANALOG OUTPUT	NTS	NOT TO SCALE
AWG	AMERICAN WIRE GUAGE	(N)	NEW
ATS	AUTOMATIC TRANSFER SWITCH	OC	ON CENTER
BATT	BATTERY	OI	OPERATOR INTERFACE
(B)	PROVIDED BY OWNER – INSTALLED BY CONTRACTOR	OL	OVERLOAD
BFC	BELOW FINISHED CEILING	ORP	OXIDATION REDUCTION POTENTIAL
BOD	BIOCHEMICAL OXYGEN DEMAND	P	POLE
BPF	BAND PASS FILTER	PB	PUSHBUTTON
BYP	BYPASS	PBX	PULL BOX
C	CONDUIT	PDB	POWER DISTRIBUTION BLOCK
CAP	CAPACITOR	PF	POWER FACTOR
CB	CIRCUIT BREAKER	PFR	POWER FAIL RELAY
CKT	CIRCUIT	PH	HYDROGEN ION CONCENTRATION
COAX	COAXIAL CABLE	PLC	PROGRAMMABLE LOGIC CONTROLLER
COMM	COMMUNICATION	PM	POWER MONITOR
CR	CONTROL RELAY	PNL	PANEL
CT	CURRENT TRANSFORMER	POT	POTENTIOMETER
CS	CONSTANT SPEED	PRESS	PRESSURE
CU	COPPER	PR	PAIR, TWISTED AND SHIELDED
DC	DIRECT CURRENT	PRI	PRIMARY
DET	DETAIL	PROVIDE	FURNISH, INSTALL, AND CONNECT
DI	DIGITAL INPUT	PS	PRESSURE SWITCH
DISC	DISCONNECT	PT	POTENTIAL TRANSFORMER
DO	DIGITAL OUTPUT	PTT	PUSH TO TEST
DPDT	DOUBLE POLE DOUBLE THROW	PVC	POLYVINYLCHLORIDE
DWG	DRAWING	PWR	POWER
E–DTL	ELECTRICAL DRAWING DETAIL	REF	REFERENCE
ELEV	ELEVATION	RFI	RADIO FREQUENCY INTERFERENCE
ENET	ETHERNET	RMS	ROOT MEAN SQUARE
ETM	ELAPSED TIME METER	RTD	RESISTANCE TEMPERATURE DETECTOR
ESW	ETHERNET SWITCH	RST	RESET
(E)	EXISTING	RVAT	REDUCE VOLTAGE AUTO TRANSFORMER
FCS	FIELD CONTROL STATION	RTU	REMOTE TERMINAL UNIT
FLA	FULL LOAD AMPS	(R)	REWIRE, RELOCATE, REVISE, REUSE
FLEX	FLEXIBLE LIQUID TIGHT CONDUIT	SCH	SCHEDULE
FRP	FIBERGLASS REINFORCED PLASTIC	SEC	SECONDARY, SECOND
FS	FULL SPEED	SECS	SECONDS
FVNR	FULL VOLTAGE NON–REVERSING	SEL	SELECTOR
FVR	FULL VOLTAGE REVERSING	SFA	SERVICE FACTOR AMPS
FWD	FORWARD	SPEC	SPECIFICATION
(F)	FUTURE	SS	STAINLESS STEEL
GALV	GALVANIZED	SSRC	STAINLESS STEEL RIGID CONDUIT
GFI	GROUND FAULT INTERRUPTER	SSS	SOLID STATE STARTER
GND	GROUND	STT	START
GRS	GALVANIZED RIGID STEEL CONDUIT	STP	STOP
GRS–PVC	PVC COATED GRS CONDUIT	SV	SOLENOID VALVE
HI	HIGH	SW	SWITCH
HIM	HUMAN INTERFACE MODULE	SWBD	SWITCHBOARD
HOA	HAND OFF AUTO	SYMM	SYMMETRICAL
HP	HORSE POWER	TB	TERMINAL BLOCK
HPS	HIGH PRESSURE SODIUM	TC	TIME CLOCK
HS	HAND SWITCH	TDOD	TIME DELAY ON DE–ENERGIZATION
HTR	HEATER	TDOE	TIME DELAY ON ENERGIZATION
HZ	HERTZ	TELCO	TELEPHONE COMPANY
HZD	HAZARD	TM	THERMAL MAGNETIC
I	INTERLOCK	TEMP	TEMPERATURE
I–DTL	INSTRUMENTATION DRAWING DETAIL	TR	TIME DELAY RELAY
I/O	INPUT/OUTPUT	TRIAD	TWISTED AND SHIELDED 3 CONDUCTOR
INST	INSTANTANEOUS	TS	TEMPERATURE SWITCH
ISR	INTRINSICALLY SAFE RELAY	TSPR	TWISTED AND SHIELDED PAIR
IS	INTRINSICALLY SAFE	TVSS	TRANSIENT VOLTAGE SURGE SUPPRESSOR
J	JUNCTION BOX	TYP	TYPICAL
K	KILO, PREFIX	UG	UNDERGROUND
LA	LIGHTNING ARRESTOR	ULH	ULTRA LOW HARMONIC
LC	LIGHTING CONTACTOR	UON	UNLESS OTHERWISE NOTED
LEL	LOWER EXPLOSION LIMIT	UPS	UNINTERRUPTIBLE POWER SUPPLY
LO	LOW	V	VOLTAGE
LOS	LOCK OUT STOP	VA	VOLT AMPS
LR	LATCHING RELAY	VAR	VOLT AMPS REACTIVE
LS	LIMIT SWITCH	VFD	VARIABLE FREQUENCY DRIVE
M	MOTOR CONTACTOR	VLV	VALVE
MAG	MAGNETIC FLOWMETER	VM	VOLTMETER
MAX	MAXIMUM	VMR	VOLTAGE MONITOR RELAY
MCM	THOUSAND CIRCULAR MILS	VR	VOLTAGE RELAY
MCP	MOTOR CIRCUIT PROTECTOR	W	WATTS
MCS	MOLDED CASE SWITCH	WP	WEATHER PROOF, NEMA 3R
MH	MANHOLE	WTP	WATER TREATMENT PLANT
MIN	MINIMUM, MINUTE	WWTP	WASTE WATER TREATMENT PLANT
MODEM	MODEM	XFMR	TRANSFORMER
MOV	MOTOR OPERATED VALVE	Z	IMPEDANCE
		ZS	LIMIT SWITCH

REGISTERED PROFESSIONAL ENGINEER THOMAS P. FRISCH No. E15761 Exp. 09–30–14 ELECTRICAL STATE OF CALIFORNIA

DESIGNED T. FRISCH
DRAWN N. CONANT
CHECKED M. FRISCH
APPROVED S. KADER

FRISCH ENGINEERING, INC.
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FILE: CACHUMA-E01.DWG
DATE: MAR 27, 2014 TIME: 6:29:47PM

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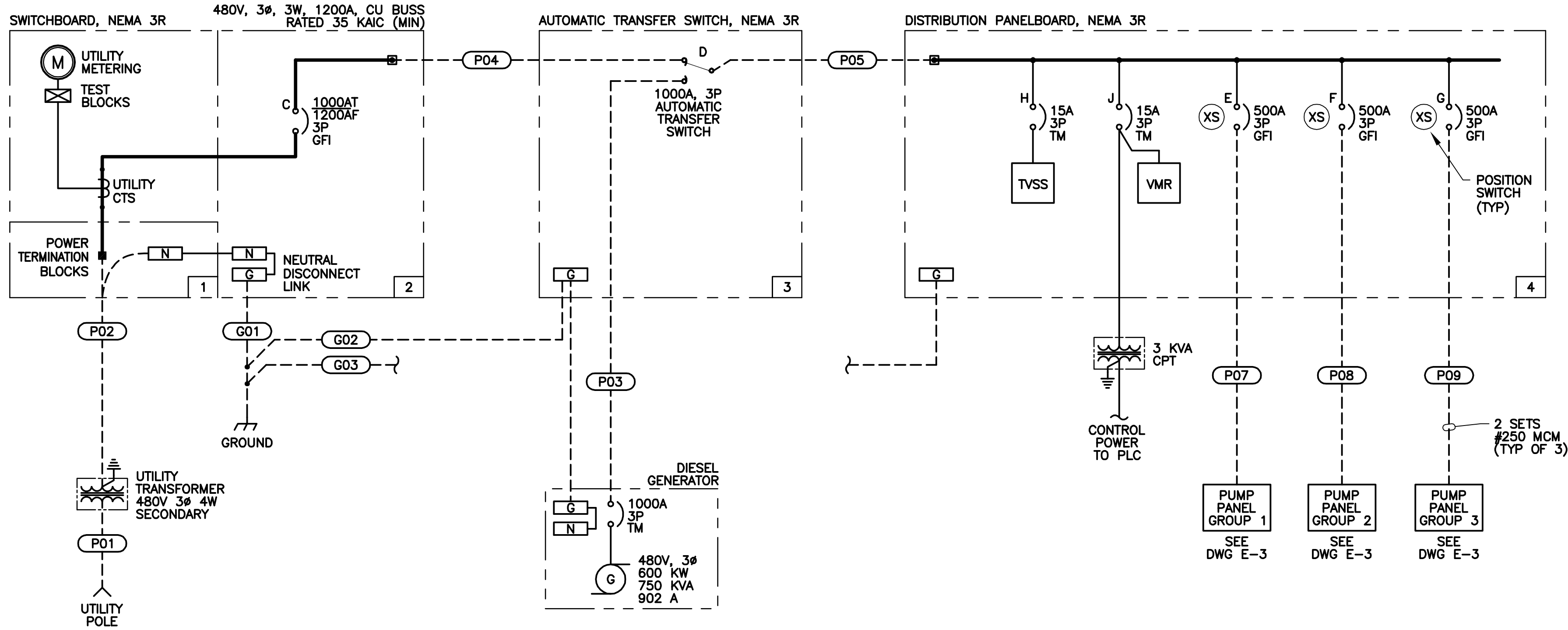
COMB CACHUMA LAKE
EMERGENCY PUMPING FACILITY
CACHUMA LAKE, CALIFORNIA

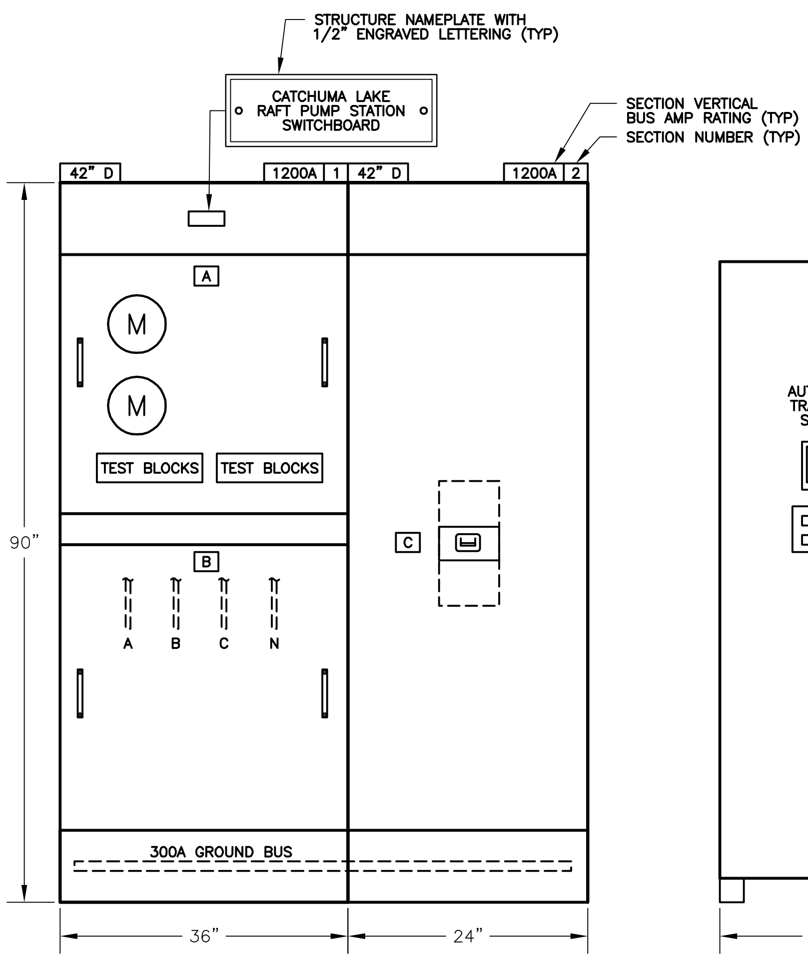
ELECTRICAL
ELECTRICAL SYMBOLS AND ABBREVIATIONS

DATE MARCH 2014
PROJECT NUMBER XX-XXX
DRAWING NUMBER E-1
SHEET NUMBER 57

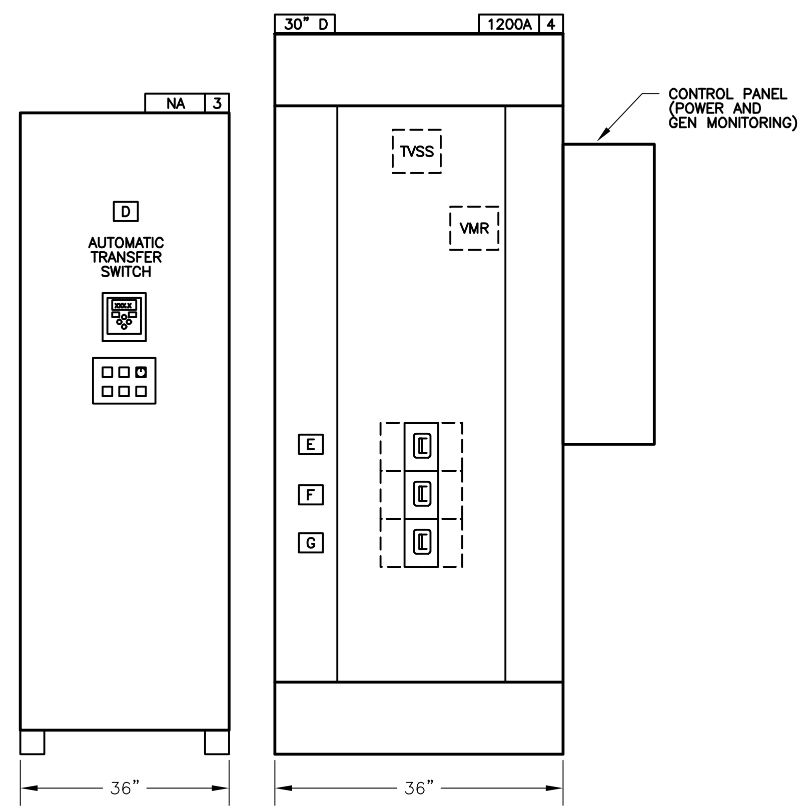
A B C D



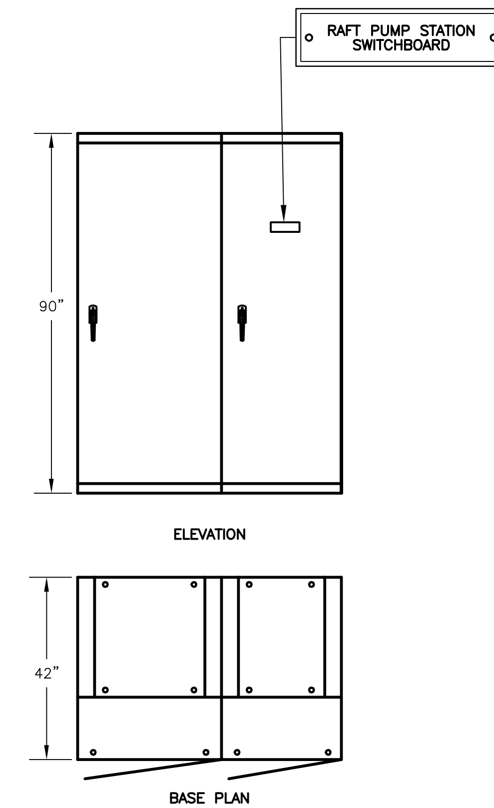
ONE-LINE DIAGRAM



METER/MAIN SWITCHBOARD ELEVATION ① ②



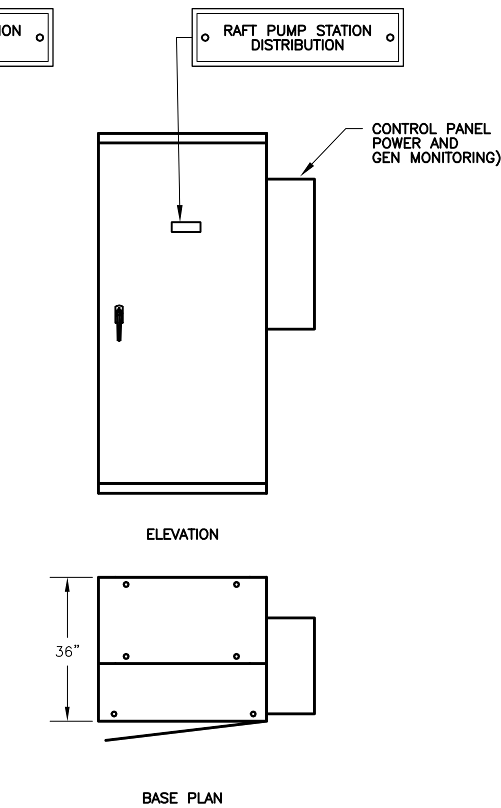
ATS AND DISTRIBUTION ELEVATION ① ②



METER/MAIN WEATHERWRAP

NOTES:

1. ALL DIMENSIONS ARE APPROXIMATE. ACTUAL DIMENSIONS SHALL BE PER MANUFACTURER APPROVED IN SUBMITTAL.



DISTRIBUTION WEATHERWRAP

NOTES:

1. ALL DIMENSIONS ARE APPROXIMATE. ACTUAL DIMENSIONS SHALL BE PER MANUFACTURER APPROVED IN SUBMITTAL.

NAMEPLATE SCHEDULE

KEY	ENGRAVING LINE 1	ENGRAVING LINE 2	LETTER HEIGHT
A	UTILITY METER		3/16"
B	UTILITY PULL	SECTION	3/16"
C	MAIN BREAKER		3/16"
D	AUTOMATIC TRANSFER	SWITCH	3/16"
E	PUMP CABLE A		3/16"
F	PUMP CABLE B		3/16"
G	PUMP CABLE C		3/16"

NOTES REFERENCED IN DRAWING:

① PROVIDE NEMA 3R ENCLOSURE

② PROVIDE NAMEPLATES PER SCHEDULE THIS PAGE.

GENERAL NOTES:

1. REAR ACCESS SHALL NOT BE REQUIRED TO SERVICE OR REPLACE SWITCHBOARD COMPONENTS.
2. EACH BREAKER SHALL HAVE A PADLOCKABLE HASP TO LOCK BREAKER IN THE OFF POSITION.
3. ALL DIMENSIONS ARE APPROXIMATE. ACTUAL DIMENSIONS SHALL BE PER MANUFACTURER APPROVED IN SUBMITTAL.

REGISTERED PROFESSIONAL ENGINEER THOMAS P. FRISCH No. E15761 Exp. 09-30-14 ELECTRICAL STATE OF CALIFORNIA

DESIGNED T. FRISCH
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APPROVED S. KADER

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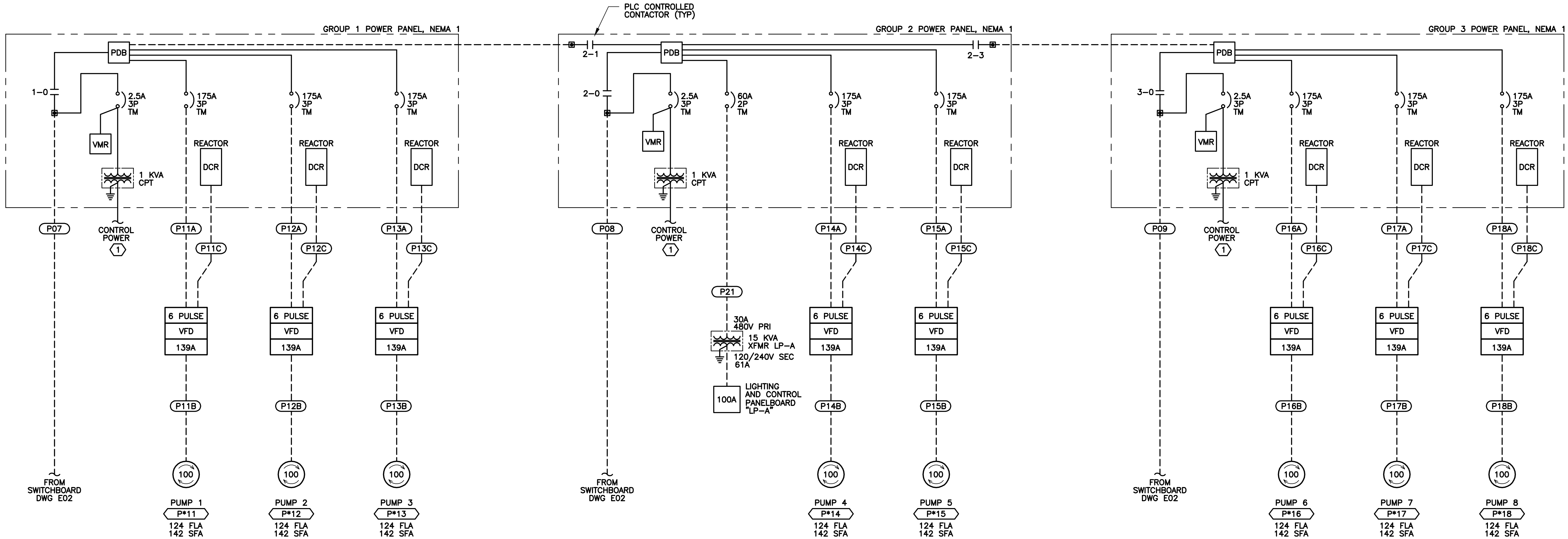
FILE: CATCHUMA-E02.DWG
DATE: MAR 27, 2014 TIME: 6:29:53PM

COMB CACHUMA LAKE
EMERGENCY PUMPING FACILITY
CACHUMA LAKE, CALIFORNIA

ELECTRICAL
SWITCHBOARD ONE-LINE DRAWING

DATE MARCH 2014
PROJECT NUMBER XX-XXX
DRAWING NUMBER E-2
SHEET NUMBER 57



RAFT PUMP STATION ONE–LINE DIAGRAM

NOTES REFERENCED IN DRAWING:

(1) CONTROL POWER CONNECTION TO PLC CONTROL PANEL. PANEL AUTOMATICALLY SELECTS FROM AVAILABLE POWERED CIRCUIT.

OPERATIONAL NOTES

1. EACH FEEDER CABLE (P07, P08, P09) FROM SHORE WILL BE SIZED FOR 50% OF CONTINUOUS DUTY LOAD. THEREFORE, A CABLE FAILURE WILL NOT INHIBIT FULL SCALE OPERATION.
2. IF TWO FEEDER CABLES ARE OFF–LINE, A SINGLE CABLE CAN POWER ANY 3 AVAILABLE PUMPS TO 50% OUTPUT OPERATION.
3. IF A CABLE FEEDER CIRCUIT BREAKER TRIPS, THE CONTROL SYSTEM WILL AUTOMATICALLY SELECT A DIFFERENT POWER SOURCE FROM THOSE STILL AVAILABLE.
4. POWER CONTACTORS ARE CONTROLLED BY PLC AND MANUAL OVERRIDE HAND SWITCH.
5. PRIMARY POWER WILL BE FROM SHORE CABLE, SECONDARY FROM ADJACENT POWER PANEL (ADJACENT SHORE CABLE).

THOMAS P. FRISCH — REGISTERED PROFESSIONAL ENGINEER — No. E15761 Exp. 09–30–14 — ELECTRICAL — STATE OF CALIFORNIA

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DRAWN N. CONANT
CHECKED M. FRISCH
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FILE: CATCHUMA-E03.DWG
DATE: MAR 27, 2014 TIME: 6:30:01PM

COMB CACHUMA LAKE
EMERGENCY PUMPING FACILITY
CACHUMA LAKE, CALIFORNIA

ELECTRICAL
RAFT PUMP STATION
ONE-LINE DRAWING

DATE: MARCH 2014
PROJECT NUMBER: XX-XXX
DRAWING NUMBER: E-3
SHEET NUMBER 57

P&ID ABBREVIATIONS

INSTRUMENTATION SYBMOLS

	FIRST LETTER		SUCCEEDING LETTERS		
	MEASURED OR INITIATING VARIABLE	MODIFIER	READOUT PASSIVE FUNCTION	OUTPUT FUNCTION	MODIFIER
A	ANALYSIS		ALARM		
B	BURNER, COMBUSTION		USER'S CHOICE	USER'S CHOICE	USER'S CHOICE
C	CONDUCTIVITY			CONTROLLER	
D	DENSITY	DIFFERENTIAL			
E	VOLTAGE		SENSOR, PRIMARY ELEMENT		
F	FLOW	RATIO			
G	GENERAL		GLASS VIEWING DEVICE		
H	HAND				HIGH, OPENED
I	CURRENT		INDICATING, INDICATOR		
J	POWER	SCAN			
K	TIME, TIME SCHEDULED	TIME RATE OF CHANGE		CONTROL STATION	
L	LEVEL		LIGHT		LOW, CLOSED
M	MOISTURE	MOMENTARY			MIDDLE
N	STATUS		STATUS	USER'S CHOICE	USER'S CHOICE
O	OPERTOR		ORIFICE, RESTRICTION		
P	PRESSURE, VACUUM		POINT (TEST) CONNECTION		
Q	QUANTITY	INTEGRATE, TOTALIZE			
R	RESET		RECORD		
S	SPEED, FREQUENCY	SAFETY		SWITCH	
T	TEMPERATURE			TRANSMITTER	TEST
U	MULTIVARIABLE		MULTIFUNCTION	MULTIFUNCTION	MULTIFUNCTION
V	VIBRATION			VAVE, DAMPER, LOUVER	
W	WEIGHT		WELL		
X	SWITCH	X AXIS	UNCLASSIFIED	UNCLASSIFIED	UNCLASSIFIED
Y	EVENT, STATE OF PRESENCE	Y AXIS		RELAY, COMPUTER, CONVERTER	
Z	POSITION, DIMENSION	Z AXIS		DRIVER, ACTUATOR, UNCLASSIFIED FINAL CONTROL ELEMENT	

P&ID ABBREVIATIONS

SWITCH IDENTIFIER

F/R	FORWARD/REVERSE	OPN	OPEN
HOA	HAND–OFF–AUTO	CLS	CLOSE
HOR	HAND–OFF–REMOTE	SEL	SELECTOR
LOS	LOCK OUT STOP	S/S	START / STOP
L/R	LOCAL / REMOTE	%	PERCENT ADJUSTMENT
MOA	MANUAL–OFF–AUTO		
OCA	OPEN–CLOSE–AUTO		
O/C	OPEN / CLOSE		
O/O	ON / OFF		

P&ID SYMBOLS

ISA SYMBOLS

SYMBOL	DESCRIPTION
XXX XXX	FIELD MOUNTED INSTRUMENT
XXX XXX	INSTRUMENT MOUNTED ON DOOR OF LOCAL PANEL, OPERATOR ACCESSIBLE
XXX XXX	INSTRUMENT MOUNTED ON DOOR OF FIELD PANEL, OPERATOR ACCESSIBLE
XXX XXX	INSTRUMENT MOUNTED WITHIN PANEL, OPERATOR INACCESSIBLE
XXX XXX	INSTRUMENT MOUNTED WITHIN FIELD PANEL, OPERATOR INACESSIBLE
I	OPERATION PERFORMED WITH LOGIC OR HARDWIRED DEVICES
MCE–XX	ASSOCIATED MOTOR CONTROL ELEMENTARY IF APPLICABLE
UNIT XXX XXX	VISUAL DISPLAY OF PLC ANALOG REGISTER SCALE TO UNITS AS SHOWN
XXX XXX	VISUAL DISPLAY OF PLC ANALOG ALARM REGISTER
XXX XXX	VISUAL DISPLAY OF PLC DIGITAL REGISTER
XXX XXX	VISUAL DISPLAY OF PLC DIGITAL ALARM REGISTER
XX XX	TAG DESCRIPTION
LA??HH	PLC I/O TAG
	PLC DIGITAL INPUT
	PLC DIGITAL OUTPUT
	ANALOG INPUT
	ANALOG OUTPUT
	AUDIBLE ALARM (BUZZER OR HORN)
X	LAMP INDICATION COLOR DENOTED BY "X" RED, BLU, GRN, WHT, AMBER
a XXXX / XXXX a	CONTINUATION TAG FROM ONE AREA TO ANOTHER AREA OF DIFFERENT DRAWINGS "a" TAG IDENTIFIER TO POINT ON DRAWING NUMBER XXXX.
I–X / I–X	CONTINUED ON DWG I–X

LINE TYPES

SYMBOL	DESCRIPTION
	PRIMARY PROCESS LINE
	SECONDARY PROCESS LINE
	ELECTRICAL SIGNAL LINE (DIGITAL OR ANALOG)
	SOFTWARE OR DATA LINK
	BOUNDARY OF EQUIPMENT PACKAGE SYSTEM
	COMMUNICATION CONNECTION

VALVES

SYMBOL	DESCRIPTION
	GATE VALVE
	CHECK VALVE
	PLUG VALVE
	BALL VALVE
	BALL CHECK VALVE
	BUTTERFLY VALVE
	ANGLE VALVE
	NEEDLE VALVE
	RELIEF VALVE
	DIAPHRAGM VALVE
	3–WAY VALVE
	FLOW CONTROL VALVE
	PINCH VALVE
S	SOLENOID VALVE (2–WAY) (S→M FOR MOTORIZED VALVE)
S	SOLENOID VALVE (3–WAY) (S→M FOR MOTORIZED VALVE)
S	SOLENOID VALVE (4–WAY) (S→M FOR MOTORIZED VALVE)
	PNEUMATIC DIAPHRAGM CONTROL VALVE
	PRESSURE SUSTAINING VALVE
	PRESSURE REGULATING VALVE
	MULTIFUNCTION VALVE
	SLUICE GATE (SG) OR SLIDE GATE (SLG)
	AIR RELIEF VALVE (ARV)
	FLOAT VALVE
	STRAINER
	BACKFLOW PREVENTER
CV	CALIBRATION VALVE
	CALIBRATION COLUMN
	ROTAMETER
	UNION

ACTUATORS

SYMBOL	DESCRIPTION
M	MOTORIZED
S	SOLENOID
S / A	PNEUMATIC OPERATOR S– SOLENOID – OPEN/CLOSE A– POSITIONER – MODULATING

PUMPS

SYMBOL	DESCRIPTION
	CENTRIFUGAL PUMP OR BLOWER
	SUBMERSIBLE SEWAGE PUMP
	VERTICAL TURBINE PUMP OR WELL PUMP
	SUBMERSIBLE WELL PUMP
	GEAR PUMP
	POSITIVE DISPLACEMENT PUMP OR BLOWER
	DIAPHRAGM PUMP
	PERISTALTIC PUMP
M M	MOTOR

SENSORS

SYMBOL	DESCRIPTION
	ORIFICE PLATE
MAG	MAGNETIC FLOWMETER
%	DENSITY METER
~	ULTRASONIC FLOWMETER
	TURBINE OR PROPELLER METER
	VENTURI TUBE
	THERMAL DISPERSION FLOWMETER OR SWITCH
	PADDLE WHEEL FLOWMETER
	FLOW SWITCH
LIT XXX	ULTRASONIC LEVEL TRANSMITTER (FLOW IF OVER FLUME OR WEIR)
LE XXX	CONDUCTANCE TYPE LEVEL ELEMENTS
LIT XXX	RADAR TYPE LEVEL TRANSMITTER
	GUIDED OPTION
LIT XXX	CAPACITANCE TYPE LEVEL TRANSMITTER

MISCELLANEOUS MECHANICAL ITEMS

SYMBOL	DESCRIPTION
	PIPE REDUCER
	RUPTURE DISC
	PRESSURE OR VACUUM RELIEF VALVE
	DIAPHRAGM SEAL
	ANNUALAR SEAL
	MIXER
F OR F	FILTER
	VENT W/CAP OR SCREEN
	FLEXIBLE HOSE OR TUBING
	SPRAY NOZZLE SYSTEM
	EXPANSION JOINT
	STATIC MIXER
	EJECTOR / EDUCTOR
	HOSE COUPLING
	PULSATION DAMPENER
	OMNI ANTENNA NON–DIRECTIONAL
	YAGI ANTENNA DIRECTIONAL

REGISTERED PROFESSIONAL ENGINEER
THOMAS P. FRISCH
No. E15761
Exp. 09–30–14
ELECTRICAL
STATE OF CALIFORNIA

DESIGNED T. FRISCH
DRAWN N. CONANT
CHECKED M. FRISCH
APPROVED S. KADER

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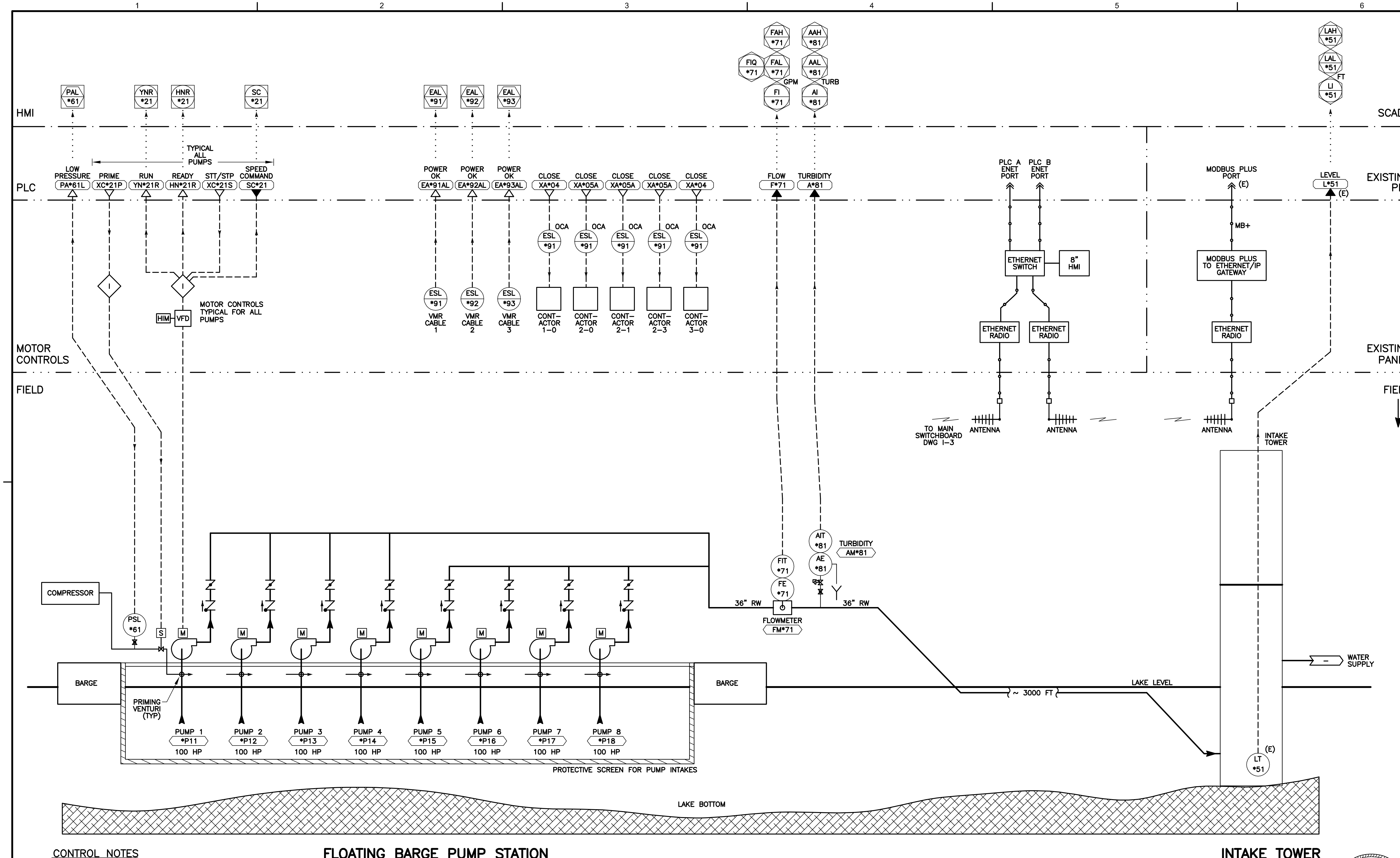
FILE: CATCHUMA-I01.DWG
DATE: MAR 27, 2014 TIME: 6:30:08PM

WATERWORKS ENGINEERS
1405 Victor Avenue, Suite A • Redding, CA 96003 • 530-243-2113

COMB CACHUMA LAKE
EMERGENCY PUMPING FACILITY
CACHUMA LAKE, CALIFORNIA

INSTRUMENTATION
INSTRUMENT SYMBOLS AND ABBREVIATIONS

DATE MARCH 2014
PROJECT NUMBER XX-XXX
DRAWING NUMBER I-1
SHEET NUMBER 57



CONTROL NOTES

1. HOT-STANDBY PLCS WILL BE FURNISHED.
2. EXISTING SCADA SYSTEM WILL BE CONNECTED AND CONFIGURED FOR ALARMS AND PUMP STATION DATA. EXISTING PLC IN INTAKE STRUCTURE WILL BE USED AS A GATEWAY TO SCADA.
3. SYSTEM WILL MAINTAIN LEVEL IN THE INTAKE STRUCTURE SO EXISTING FLOW CONTROLS MAY BE USED. TRANSPARENT TO EXISTING SYSTEM AND EASILY REMOVABLE.
4. PUMP POWER WILL BE SELECTED AUTOMATICALLY FROM AVAILABLE POWER SOURCES.

REGISTERED PROFESSIONAL ENGINEER THOMAS P. FRISCH No. E15761 Exp. 09-30-14 ELECTRICAL STATE OF CALIFORNIA

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FILE: CACHUMA-I02.DWG
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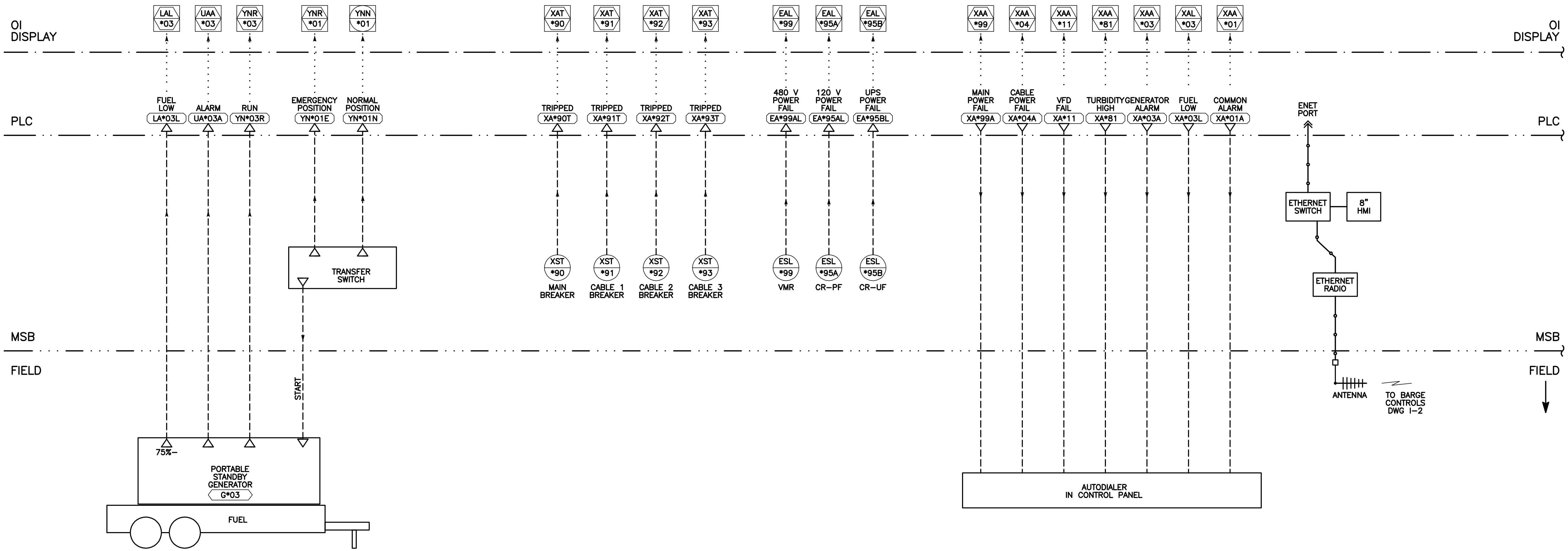
COMB CACHUMA LAKE
EMERGENCY PUMPING FACILITY
CACHUMA LAKE, CALIFORNIA

INSTRUMENTATION
RAW WATER PUMP STATION P&ID

DATE MARCH 2014
PROJECT NUMBER XX-XXX
DRAWING NUMBER I-2
SHEET NUMBER 58



MAIN SWITCHBOARD MONITORING

REGISTERED PROFESSIONAL ENGINEER
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COMB CACHUMA LAKE
EMERGENCY PUMPING FACILITY
CACHUMA LAKE, CALIFORNIA

INSTRUMENTATION
MAIN SWITCHBOARD
P&ID

DATE MARCH 2014
PROJECT NUMBER XX-XXX
DRAWING NUMBER I-3
SHEET NUMBER 59

DESIGN IMPACT OF INCREASING PEAK FLOW REQUIREMENT TO 45-MGD (SCENARIO A)

All of the design discussion in this report has been for a pump station which will pump 36-mgd maximum until April 1, 2015 at Location 1. This base scenario for our proposal is Scenario B. We will meet this design requirement using five 100-hp duty pumps with one standby pump (5+1) on the barge. Each pump will have their own intake drum screen for fish screening. Scenario A will change the peak design flow to 45-mgd at Location 1 until April 1, 2015. Scenario A will have the following impact on our design:

1. The same pumps will be used, but 6 duty and 1 standby (7 total) pumps will be used rather than 5 duty and 1 standby.
2. Each pump will still be outfitted with an individual drum screen with a propeller-driven cleaning system. Because a total of 7 pumps will be provided rather than a total of 6 pumps, 7 drum screens will be provided.
3. Appropriate modifications will be made to the electrical systems, increasing the number of VFDs provided from 6 to 7, adding appropriate equipment in the MCC, adding power feed cables, etc. as appropriate.
4. The pipeline will still be a single 36" pipe
5. **No other changes to the proposed pumping system will be made to accommodate Scenario A** (45-mgd rather than 36-mgd peak flow requirement).

CONSTRUCTION METHODOLOGY

The Pump Barge and Intake Tower Connection Box facilities will be constructed during the summer of 2014, ready to put in service by September 1st, 2014. Table 3 shows the general steps that will be taken in the construction of the facilities. See Appendix D for a detailed CPM Schedule.

Table 3. General Construction Plan

Month	Construction Activities

May	• Kick-off meeting with COMB
	  o Agree on design concepts presented in Proposal
	    ▪ Pump Barge concept
	    ▪ HDPE Transmission Pipe concept
	    ▪ Tower Connection Box concept
	  o Final acceptance on time-critical equipment and materials
	    ▪ Pumps
	    ▪ HDPE Transmission Pipe
	    ▪ Fish Screens
	    ▪ Electrical Switchgear and Feeder Wires
	  o PG&E coordination
	  o Permitting agency coordination
	• Conduct 75% design review meeting
	• Order equipment and materials
	  o Pumps
	  o HDPE Transmission Pipe
	  o Fish Screens
	  o Anchor Piles
	  o Generator
	  o Switchgear
	  o Wire
	• Mobilize equipment to establish access road and yard
	• Mobilize barge sections and crane
	• Excavate silt at Intake Tower
	• Excavate pool at Pump Barge location
	• Remove fish screen/existing pipe connection at Gate 5
	• Confirm operational status of Gate 5
	• Fabricate Intake Tower Connection Box

June	• Complete final design • Install Intake Tower Connection Box • Drive piles to anchor 36” HDPE pipeline, including safety signage • Reconfigurate Work Barge sections into Pump Barge layout • Fuse pipeline and float into place

July	• Continue to fuse pipeline and float into place • Connect pipeline to anchor piles • Deploy safety buoys • Install piping, valves, appurtenances and pumps on Pump Barge
August	• Install electrical service equipment • Install electrical switchgear on barge • Install and terminate wire • Install communication devices and wiring • Install fish screens • Test and start-up station

Cushman Contracting Corporation will mobilize to the project site in early May with a bulldozer and water truck to establish access roads and a staging yard. The perimeter of the staging yard will be fenced for security. The yard will be large enough to incorporate the PG&E power drop and transformer, an electrical container housing shore-side power and controls, a tool and spare parts storage container, and a night watchman's trailer.

By mid-May, Cushman Contracting Corporation will mobilize our Flexi-Float barge sections and our crane and work skiffs. CCC will launch and assemble the sections into a 40 x 60 foot Work Barge, at which time we will then walk the crane onto the barge. This barge assembly has been utilized by CCC on several marine projects (see Figure 19).

By the end of May Cushman Contracting Corporation will be excavating with a clam shell bucket at the Intake Tower and at the site of the pump station Location 1. The excavation at the Intake Tower will have to be coordinated with COMB to allow for a 48 hour shutdown to minimize turbidity.

Upon completion of the excavation, CCC will remove the existing modified screen at Gate 5 and confirm operational functionality of Gate 5. CCC will mobilize our dive team including our Dive Trailer, which houses the required breathing, safety, video and communications equipment, to install the Tower Intake Box from the Work Barge.

The Work Barge's next task will be to drive the pipeline Anchor Piles. As this activity proceeds we will begin the fusion of the 36" HDPE discharge pipe. The pipe will be fused on shore and fed into the water where our work skiffs will tow it into position. The discharge pipe will be secured to the Anchor Piles, safety buoys will be attached and safety signage will be installed.

When the Work Barge is completed with installing anchor piles it will be reconfigured into a smaller **Maintenance Barge** and outfitted with a smaller crane and four of the flex float sections will be configured into the Pump Barge. **The Maintenance Barge will be left in the water for the duration of the project to assist in maintenance or contingency tasks that may arise, including but not limited to pump replacement, anchor pile replacement, clam shell excavating, pipe repair, etc.**

By the end of July, we will install the following components on to the Pump Barge: pipe headers, pumps, electrical equipment container (which will by this time will have had all electrical and control gear preinstalled), suction pipe and fish screens. The Pump Barge wiring will be performed prior to adding the incidentals such as handrail, security fence, safety lighting, and signage.
Upon completion of this step the Pump Barge will be floated into position and anchored with spud piles, the 36" HDPE discharge line shall be attached to the 36" flexible hose and the submersible power cables will be installed and terminated.

Simultaneous to the Pump Barge being outfitted, the Maintenance Barge will travel to the Intake Tower Connection Box and assist the dive crew in attaching the 36" flexible hose and HDPE pipe. In addition, the communication antennae and SCADA system coordination required to incorporate the signals from the pump station will be completed.

The station will then be started tested and ready for service September 1st, 2014.

Figure 19. Cushman Contracting Company Work Barge Made From Flexi-Float Barge Sections Being Used in Ventura Harbor (2012)

OPERATING METHODOLOGY

The pumping system will be operated to maintain level in the Intake Tower. The level can be maintained at 672 in the Intake Tower so that at any time, up to 45-mgd will be available to COMB. Essentially, from COMB's perspective, the lake will be constantly at a level of 672 at all times. This allows COMB to continue operations without any change to current operating procedures. Level in the Intake Tower will be taken from the COMB SCADA system and transmitted to the Pump Barge for control of the pumps. The use of level control at the Intake Tower to control the station makes pump station operation simple, robust, and reliable.

The system will be operated via automated controls with the following general control strategy:

1. The water level at the Intake Tower will be obtained from COMB's SCADA system.
2. Water level will be transmitted to the Pump Barge using spread spectrum radio link provided as a part of this project.
3. Pump controls will start pumps one at a time and ramp up pumps and pump speeds to maintain a level setpoint in the Intake Tower
4. Pumps will be turned up/added or turned down/off to hold level in the Intake Tower.
5. If radio communication is lost, COMB will have two options for the control of the Pump Barge:
    a. The pumps on the barge could be locked in their "last known speed" and the flowrate from the barge would remain at the same flow during the entire lapse in communication.
    b. All duty pumps on the barge can be ramped up to 100% speed to provide maximum flow at the Intake Tower Connection Box. Flow that is not needed will overflow the Intake Tower Connection Box during the time that communication is suspended. The overflow will go back into the lake in the area around the Intake Tower. The overflow elevation of the Intake Tower Connection Box is 674, which will maintain the water level in the Intake Tower above 672 even at a flowrate of 45-mgd.
6. When radio communication is regained, the level control of the pumps will resume.

Inspections of the pump station will be made on a daily basis using Cushman Contracting Corporation staff who all live within 25 miles of Lake Cachuma. Cushman Contracting Corporation intends on assigning a designated individual to this project who's sole assignment will be to interface with COMB in the operation and maintenance of the pump system. In addition, Cushman Contracting Corporation intends to have a night watchman stay nights and weekends at the staging yard, this individual will be knowledgeable in basic alarms and trouble shooting of the Pump Station however his main function will be security. Cushman Contracting Corporation's main office, yard and shop are all in Goleta, approximately 20 miles from the project site. Initial inspection planning is shown in Table 4. More complete operational planning will be developed during the design process for the project and coordinated with COMB operations and operational needs.

Table 4. Initial Plan for Inspections During Operation

Frequency	Task List

Daily	• Visual inspection of station and screens
	• Check radio communication and SCADA link for proper operation
	• Observation and recording of all measurement equipment
	  o Pressure gage readings on all pumps
	  o VFD settings on all pumps corresponding to time of pressure gage reading
	  o Flowmeter reading
	  o Voltage meter reading
	  o Turbidimeter reading
	• Patrol by boat of pipeline route
	  o Visual inspection of pipeline condition and location
	  o Visual inspection of the condition of safety buoys, pipe piles, etc.
	• Meet with COMB Operations
	  o Review system operations
	  o Turn over copy of daily log

Weekly	• Inspection of barge sections • Check pump priming system for proper operation • Pump performance assessment of weekly data (pressure gages, VFD settings, flow totals).
Monthly (every 28-days)	• Generator Test (main power is shut down and transfer of pump operation to generator is observed)

Quarterly	• Dive inspection
	  o Condition of fish screens
	  o Condition of bottom of barges
	  o Condition of electrical cables
	  o Condition of HDPE connection to barge piping

CONTINGENCY PLANNING

The pump system, including the Pump Barge, Transmission Pipeline and Intake Tower Connection Box have all been designed to be extremely robust. Contingency planning has driven design decisions that have led to the system proposed. Continued contingency planning will take place during design of the system and coordinated with COMB. Initial contingency planning is summarized in Table 5.

All of the potential failure modes listed below will alarm and a skilled technician will be on-site within 30 minutes. However, it is important to note that **none of the potential failure modes will result in pump station shut-down or interruption of water delivery to the Intake Tower**. Water delivery will be continuous through all failure modes through the use of the contingency planning described in Table 5. Immediate corrective action will be taken to restore all systems to fully redundant conditions.

Table 5. Initial Contingency Planning

Potential Failure Mode	Contingency Plan
Pump Fail	• There are 6 pumps on the pump station for the 36-mgd option (7 pumps for the 45-mgd option). Only 5 are needed in order to meet the peak day design point of 36-mgd (6 for 45-mgd). The spare pump provides pump redundancy under a single pump fail scenario. The large number of duty pumps allows for continued flow at only moderately reduced flow even with multiple pump failures.
Communication Fail	• The pump station will be set up to run to 45-mgd if communication with the level sensor at the Intake Tower is lost. At that point, if demand is less than 45-mgd, water will spill at the Intake Tower Connection Box, but full flow will be provided in the Intake Tower. When communication is restored, operation of the pump station to maintain level in the Intake Tower Connection Box by varying the number and speed of the pumps will resume.
Fish Screen Fail	• There is a fish screen for each individual pump, following the same redundancy criteria as the pumps. Fish screens are automatically cleaned using a propeller-driven mechanical system to avoid algae or other debris build-up continually during operation.
Power Fail	• Operation of the station will be immediately transferred to generator power via the automatic transfer switch.
Flowrate or Pressure Issues	• The pump system has been designed so that pressure and flowrate are only informational data. Control is simply to maintain level in the Intake Tower Connection Box. Backup control is 100% speed on all duty pumps with overflow at the Intake Tower Connection Box. • Low flowrate and low pump discharge pressure will alarm and call out a technician to determine if there is a malfunction.
Water Level in Tower Too High	• The water level in the tower cannot exceed 674 (the elevation of the top of the Intake Tower Connection Box). If communication to the pump station has failed

	and the pumps continue to run, water will overflow back into the lake.
High Raw Water Turbidity	• High raw water turbidity will call a technician to investigate the operation of the station. Turbidity will be monitored daily. If turbidity is increasing as water depth at the Pump Barge is reducing, the Pump Barge can be relocated to Location 2. If the high turbidity is due to a transient condition in the lake (weather-related changes in lake quality), we will meet with COMB to discuss possible options for addressing the issue.
Noise issues	• If the pump station causes noise issues, a sound-absorbent curtain will be installed around the interior face of the fence on the barge to absorb sound.
480V Feeder Wire Failure	• There are three sets of 480V feeder wire which will run from the main switchgear on shore to the MCC on the Pump Barge. One set of feeders is entirely redundant. If a single feeder wire fails, the other two sets of feeders will be used and the failure addressed.
36" HDPE Transmission Line Break	• A 36" repair coupling will be kept on-site in the Spare Parts container in the shore-side yard. Work skiffs and the maintenance barge will be manned with a crew from Goleta and the repair coupling will be installed. A new repair coupling will be purchased and kept in the Spare Parts container.
Winter Debris	• Intense rain storms flush large amount of debris out of watershed (Cushman Contracting Corporation experienced this during the 1991 project). Work skiffs and the Maintaince barge will be manned with crew from Goleta and debris will be cleared following storm events from the discharge line preventing undue external stress.

SIGNATURE

The information provided in this proposal is true and correct and accurately describes the facilities which will be provided to the Cachuma Operations and Maintenance Board in the execution of this project.

Lee Cushman, P.E.
Secretary
Cushman Contracting Corporation

4/4/14
Date

APPENDIX A – PUMP SYSTEM DESIGN SPREADSHEET MODEL

Month	Sep-14	Oct-14	Nov-14	Dec-14	Jan-15	Feb-15	Mar-15	Apr-15	May-15	Jun-15	Jul-15	Aug-15	Sep-15	Oct-15	Nov-15	Dec-15	Jan-16	Feb-16	Mar-16	Apr-16	May-16	Jun-16	Jul-16	Aug-16	Sep-16
Required Pump Station Capacity	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25
Total Pump Statio Flow (gpm)	17361	17361	17361	17361	17361	17361	17361	17361	17361	17361	17361	17361	17361	17361	17361	17361	17361	17361	17361	17361	17361	17361	17361	17361	17361
	684							**665**												**645**					
Lake Level (ft)	684	681.3	678.6	675.9	673.1	670.4	667.7	665	663.3	661.7	660.0	658.3	656.7	655.0	653.3	651.7	650.0	648.3	646.7	645	643.3	641.7	640.0	638.3	636.7
Elevation Change to pump to el 674	**-10.0**	-7.3	-4.6	-1.9	0.9	3.6	6.3	9.0	10.7	12.3	14.0	15.7	17.3	19.0	20.7	22.3	24.0	25.7	27.3	29.0	30.7	32.3	34.0	35.7	37.3

Alternative 1

Alternative 1	Sep-14	Oct-14	Nov-14	Dec-14	Jan-15	Feb-15	Mar-15	Apr-15	May-15	Jun-15	Jul-15	Aug-15	Sep-15	Oct-15	Nov-15	Dec-15	Jan-16	Feb-16	Mar-16	Apr-16	May-16	Jun-16	Jul-16	Aug-16	Sep-16
Diameter (in) of run 1 (3500 ft)	31.51	31.51	31.51	31.51	31.51	31.51	31.51	31.51	31.51	31.51	31.51	31.51	31.51	31.51	31.51	31.51	31.51	31.51	31.51	31.51	31.51	31.51	31.51	31.51	31.51
Length (ft) of run 1	3500	3500	3500	3500	3500	3500	3500	3500	3500	3500	3500	3500	3500	3500	3500	3500	3500	3500	3500	3500	3500	3500	3500	3500	3500
number of pipes in run 1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Velocity (fps) in run 1	7.1	7.1	7.1	7.1	7.1	7.1	7.1	7.1	7.1	7.1	7.1	7.1	7.1	7.1	7.1	7.1	7.1	7.1	7.1	7.1	7.1	7.1	7.1	7.1	7.1
Diameter (in) of run 2 (6000 ft)	26.25	26.25	26.25	26.25	26.25	26.25	26.25	31.51	31.51	31.51	31.51	31.51	31.51	31.51	31.51	31.51	31.51	31.51	31.51	31.51	31.51	31.51	31.51	31.51	31.51
Length (ft) of run 2	0	0	0	0	0	0	0	6000	6000	6000	6000	6000	6000	6000	6000	6000	6000	6000	6000	6000	6000	6000	6000	6000	6000
number of pipes in run 2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Velocity (fps) in run 2	10.3	10.3	10.3	10.3	10.3	10.3	10.3	7.1	7.1	7.1	7.1	7.1	7.1	7.1	7.1	7.1	7.1	7.1	7.1	7.1	7.1	7.1	7.1	7.1	7.1
Darcy-Weisbaugh "f"	0.017	0.017	0.017	0.017	0.017	0.017	0.017	0.017	0.017	0.017	0.017	0.017	0.017	0.017	0.017	0.017	0.017	0.017	0.017	0.017	0.017	0.017	0.017	0.017	0.017
Straight run friction loss (ft)	18	18	18	18	18	18	18	49	49	49	49	49	49	49	49	49	49	49	49	49	49	49	49	49	49
Minor Losses	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%
Total friction head loss (ft)	20	20	20	20	20	20	20	54	54	54	54	54	54	54	54	54	54	54	54	54	54	54	54	54	54
Total Head Required (ft)	10	12	15	18	21	23	26	63	64	66	68	69	71	73	74	76	78	79	81	83	84	86	88	89	91
Total Head Required (psi)	4	5	7	8	9	10	11	27	28	29	29	30	31	31	32	33	34	34	35	36	36	37	38	39	39
Pump Overall Efficiency	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
Required total horsepower	53	68	83	98	113	128	143	343	352	361	370	380	389	398	407	416	425	435	443	453	462	471	480	489	498
Total kW	40	51	62	73	84	95	106	256	263	269	276	283	290	297	304	310	317	324	331	338	344	351	358	365	371
Total kW-h/day	956	1221	1486	1750	2025	2290	2555	6140	6306	6463	6630	6797	6954	7120	7287	7444	7611	7777	7934	8101	8268	8425	8591	8758	8915
Cost of electricity ($/kW)	$ 0.15	$ 0.15	$ 0.15	$ 0.15	$ 0.15	$ 0.15	$ 0.15	$ 0.15	$ 0.15	$ 0.15	$ 0.15	$ 0.15	$ 0.15	$ 0.15	$ 0.15	$ 0.15	$ 0.15	$ 0.15	$ 0.15	$ 0.15	$ 0.15	$ 0.15	$ 0.15	$ 0.15	$ 0.15
Cost per day to operate station	$ 143.39	$ 183.11	$ 222.83	$ 262.56	$ 303.75	$ 343.47	$ 383.19	$ 920.93	$ 945.93	$ 969.47	$ 994.48	$ 1,019.49	$ 1,043.03	$ 1,068.04	$ 1,093.05	$ 1,116.59	$ 1,141.60	$ 1,166.61	$ 1,190.15	$ 1,215.16	$ 1,240.17	$ 1,263.70	$ 1,288.71	$ 1,313.72	$ 1,337.26
Monthly Pump Power Costs 1 x 36	$ 4,302	$ 5,493	$ 6,685	$ 7,877	$ 9,112	$ 10,304	$ 11,496	$ 27,628	$ 28,378	$ 29,084	$ 29,834	$ 30,585	$ 31,291	$ 32,041	$ 32,792	$ 33,498	$ 34,248	$ 34,998	$ 35,704	$ 36,455	$ 37,205	$ 37,911	$ 38,661	$ 39,412	$ 40,118
Cumulatve Power Costs	$ 4,302	$ 9,795	$ 16,480	$ 24,357	$ 33,469	$ 43,773	$ 55,269	$ 82,897	$ 111,275	$ 140,359	$ 170,194	$ 200,778	$ 232,069	$ 264,111	$ 296,902	$ 330,400	$ 364,648	$ 399,646	$ 435,350	$ 471,805	$ 509,010	$ 546,921	$ 585,583	$ 624,994	$ 665,112
Total Cost of Pipe	$ 245,000	$ 245,000	$ 245,000	$ 245,000	$ 245,000	$ 245,000	$ 245,000	$ 665,000	$ 665,000	$ 665,000	$ 665,000	$ 665,000	$ 665,000	$ 665,000	$ 665,000	$ 665,000	$ 665,000	$ 665,000	$ 665,000	$ 665,000	$ 665,000	$ 665,000	$ 665,000	$ 665,000	$ 665,000
Total Cumulative Pipe+Power Cost (Alt 1 - O	$ 249,302	$ 254,795	$ 261,480	$ 269,357	$ 278,469	$ 288,773	$ 300,269	$ 747,897	$ 776,275	$ 805,359	$ 835,194	$ 865,778	$ 897,069	$ 929,111	$ 961,902	$ 995,400	$ 1,029,648	$ 1,064,646	$ 1,100,350	$ 1,136,805	$ 1,174,010	$ 1,211,921	$ 1,250,583	$ 1,289,994	$ 1,330,112

Alternative 2

Alternative 2	Sep-14	Oct-14	Nov-14	Dec-14	Jan-15	Feb-15	Mar-15	Apr-15	May-15	Jun-15	Jul-15	Aug-15	Sep-15	Oct-15	Nov-15	Dec-15	Jan-16	Feb-16	Mar-16	Apr-16	May-16	Jun-16	Jul-16	Aug-16	Sep-16
Diameter (in) of run 1 (3500 ft)	26.25	26.25	26.25	26.25	26.25	26.25	26.25	26.25	26.25	26.25	26.25	26.25	26.25	26.25	26.25	26.25	26.25	26.25	26.25	26.25	26.25	26.25	26.25	26.25	26.25
Length (ft) of run 1	3500	3500	3500	3500	3500	3500	3500	3500	3500	3500	3500	3500	3500	3500	3500	3500	3500	3500	3500	3500	3500	3500	3500	3500	3500
number of pipes in run 1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Velocity (fps) in run 1	5.1	5.1	5.1	5.1	5.1	5.1	5.1	5.1	5.1	5.1	5.1	5.1	5.1	5.1	5.1	5.1	5.1	5.1	5.1	5.1	5.1	5.1	5.1	5.1	5.1
Diameter (in) of run 2 (6000 ft)	31.51	31.51	31.51	31.51	31.51	31.51	31.51	31.51	31.51	31.51	31.51	31.51	31.51	31.51	31.51	31.51	31.51	31.51	31.51	31.51	31.51	31.51	31.51	31.51	31.51
Length (ft) of run 2	0	0	0	0	0	0	0	6000	6000	6000	6000	6000	6000	6000	6000	6000	6000	6000	6000	6000	6000	6000	6000	6000	6000
number of pipes in run 2	2	2	2	2	2	2	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Velocity (fps) in run 2	3.6	3.6	3.6	3.6	3.6	3.6	3.6	7.1	7.1	7.1	7.1	7.1	7.1	7.1	7.1	7.1	7.1	7.1	7.1	7.1	7.1	7.1	7.1	7.1	7.1
Darcy-Weisbaugh "f"	0.017	0.017	0.017	0.017	0.017	0.017	0.017	0.017	0.017	0.017	0.017	0.017	0.017	0.017	0.017	0.017	0.017	0.017	0.017	0.017	0.017	0.017	0.017	0.017	0.017
Straight run friction loss (ft)	11	11	11	11	11	11	11	42	42	42	42	42	42	42	42	42	42	42	42	42	42	42	42	42	42
Minor Losses	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%
Total friction head loss (ft)	12	12	12	12	12	12	12	46	46	46	46	46	46	46	46	46	46	46	46	46	46	46	46	46	46
Total Head Required (ft)	2	5	8	10	13	16	19	55	57	58	60	62	63	65	67	68	70	72	73	75	77	78	80	82	83
Total Head Required (psi)	1	2	3	5	6	7	8	24	25	25	26	27	27	28	29	30	30	31	32	33	33	34	35	35	36
Pump Overall Efficiency	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
Required total horsepower	13	27	42	57	72	87	102	302	312	320	330	339	348	357	366	375	384	394	403	412	421	430	439	449	457
Total kW	9	20	31	43	54	65	76	225	232	239	246	253	259	266	273	280	287	294	300	307	314	321	328	335	341
Total kW-h/day	226	491	756	1020	1295	1560	1825	5409	5576	5733	5900	6067	6224	6390	6557	6714	6881	7047	7204	7371	7538	7695	7861	8028	8185
Cost of electricity ($/kW)	$ 0.15	$ 0.15	$ 0.15	$ 0.15	$ 0.15	$ 0.15	$ 0.15	$ 0.15	$ 0.15	$ 0.15	$ 0.15	$ 0.15	$ 0.15	$ 0.15	$ 0.15	$ 0.15	$ 0.15	$ 0.15	$ 0.15	$ 0.15	$ 0.15	$ 0.15	$ 0.15	$ 0.15	$ 0.15
Cost per day to operate station	$ 33.89	$ 73.61	$ 113.33	$ 153.05	$ 194.25	$ 233.97	$ 273.69	$ 811.42	$ 836.43	$ 859.97	$ 884.98	$ 909.99	$ 933.53	$ 958.54	$ 983.55	$ 1,007.09	$ 1,032.10	$ 1,057.11	$ 1,080.65	$ 1,105.65	$ 1,130.66	$ 1,154.20	$ 1,179.21	$ 1,204.22	$ 1,227.76
Monthly Pump Power Costs	$ 1,017	$ 2,208	$ 3,400	$ 4,592	$ 5,827	$ 7,019	$ 8,211	$ 24,343	$ 25,093	$ 25,799	$ 26,549	$ 27,300	$ 28,006	$ 28,756	$ 29,506	$ 30,213	$ 30,963	$ 31,713	$ 32,419	$ 33,170	$ 33,920	$ 34,626	$ 35,376	$ 36,127	$ 36,833
Cumulative Power Costs	$ 1,017	$ 3,225	$ 6,625	$ 11,217	$ 17,044	$ 24,063	$ 32,274	$ 56,616	$ 81,709	$ 107,509	$ 134,058	$ 161,358	$ 189,364	$ 218,120	$ 247,626	$ 277,839	$ 308,802	$ 340,515	$ 372,934	$ 406,104	$ 440,024	$ 474,650	$ 510,026	$ 546,153	$ 582,986
Total Cost of Pipe	$ 350,000	$ 350,000	$ 350,000	$ 350,000	$ 350,000	$ 350,000	$ 350,000	$ 770,000	$ 770,000	$ 770,000	$ 770,000	$ 770,000	$ 770,000	$ 770,000	$ 770,000	$ 770,000	$ 770,000	$ 770,000	$ 770,000	$ 770,000	$ 770,000	$ 770,000	$ 770,000	$ 770,000	$ 770,000
Total Cumulative Pipe + Power Cost (Alt 2 -	$ 351,017	$ 353,225	$ 356,625	$ 361,217	$ 367,044	$ 374,063	$ 382,274	$ 826,616	$ 851,709	$ 877,509	$ 904,058	$ 931,358	$ 959,364	$ 988,120	$ 1,017,626	$ 1,047,839	$ 1,078,802	$ 1,110,515	$ 1,142,934	$ 1,176,104	$ 1,210,024	$ 1,244,650	$ 1,280,026	$ 1,316,153	$ 1,352,986

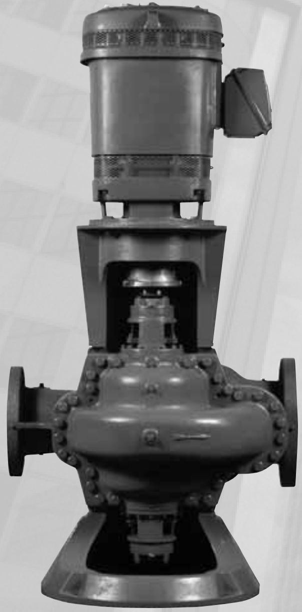
Alternative 3

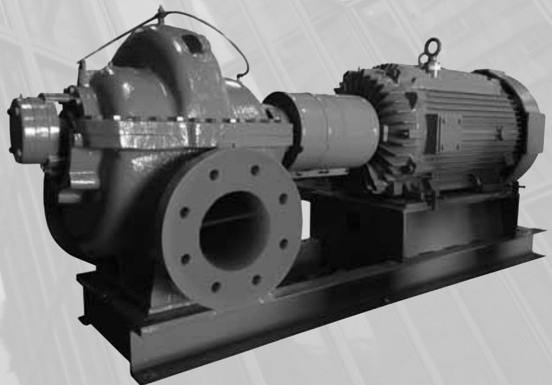
Alternative 3	Sep-14	Oct-14	Nov-14	Dec-14	Jan-15	Feb-15	Mar-15	Apr-15	May-15	Jun-15	Jul-15	Aug-15	Sep-15	Oct-15	Nov-15	Dec-15	Jan-16	Feb-16	Mar-16	Apr-16	May-16	Jun-16	Jul-16	Aug-16	Sep-16
Diameter (in) of run 1 (3500 ft)	26.25	26.25	26.25	26.25	26.25	26.25	26.25	26.25	26.25	26.25	26.25	26.25	26.25	26.25	26.25	26.25	26.25	26.25	26.25	26.25	26.25	26.25	26.25	26.25	26.25
Length (ft) of run 1	3500	3500	3500	3500	3500	3500	3500	3500	3500	3500	3500	3500	3500	3500	3500	3500	3500	3500	3500	3500	3500	3500	3500	3500	3500
number of pipes in run 1	2	2	2	2	2	2	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Velocity (fps) in run 1	5.1	5.1	5.1	5.1	5.1	5.1	5.1	10.3	10.3	10.3	10.3	10.3	10.3	10.3	10.3	10.3	10.3	10.3	10.3	10.3	10.3	10.3	10.3	10.3	10.3
Diameter (in) of run 2 (6000 ft)	31.51	31.51	31.51	31.51	31.51	31.51	31.51	26.25	26.25	26.25	26.25	26.25	26.25	26.25	26.25	26.25	26.25	26.25	26.25	26.25	26.25	26.25	26.25	26.25	26.25
Length (ft) of run 2	0	0	0	0	0	0	0	6000	6000	6000	6000	6000	6000	6000	6000	6000	6000	6000	6000	6000	6000	6000	6000	6000	6000
number of pipes in run 2	2	2	2	2	2	2	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Velocity (fps) in run 2	3.6	3.6	3.6	3.6	3.6	3.6	3.6	10.3	10.3	10.3	10.3	10.3	10.3	10.3	10.3	10.3	10.3	10.3	10.3	10.3	10.3	10.3	10.3	10.3	10.3
Darcy-Weisbaugh "f"	0.017	0.017	0.017	0.017	0.017	0.017	0.017	0.017	0.017	0.017	0.017	0.017	0.017	0.017	0.017	0.017	0.017	0.017	0.017	0.017	0.017	0.017	0.017	0.017	0.017
Straight run friction loss (ft)	11	11	11	11	11	11	11	121	121	121	121	121	121	121	121	121	121	121	121	121	121	121	121	121	121
Minor Losses	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%
Total friction head loss (ft)	12	12	12	12	12	12	12	134	134	134	134	134	134	134	134	134	134	134	134	134	134	134	134	134	134
Total Head Required (ft)	2	5	8	10	13	16	19	143	144	146	148	149	151	153	154	156	158	159	161	163	164	166	168	169	171
Total Head Required (psi)	1	2	3	5	6	7	8	62	62	63	64	65	65	66	67	67	68	69	70	70	71	72	73	73	74
Pump Overall Efficiency	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
Required total horsepower	13	27	42	57	72	87	102	781	791	799	809	818	827	836	845	854	864	873	882	891	900	909	918	928	936
Total kW	9	20	31	43	54	65	76	583	590	596	603	610	617	624	630	637	644	651	657	664	671	678	685	692	698
Total kW-h/day	226	491	756	1020	1295	1560	1825	13984	14151	14308	14474	14641	14798	14965	15132	15289	15455	15622	15779	15946	16112	16269	16436	16603	16760
Cost of electricity ($/kW)	$ 0.15	$ 0.15	$ 0.15	$ 0.15	$ 0.15	$ 0.15	$ 0.15	$ 0.15	$ 0.15	$ 0.15	$ 0.15	$ 0.15	$ 0.15	$ 0.15	$ 0.15	$ 0.15	$ 0.15	$ 0.15	$ 0.15	$ 0.15	$ 0.15	$ 0.15	$ 0.15	$ 0.15	$ 0.15
Cost per day to operate station	$ 33.89	$ 73.61	$ 113.33	$ 153.05	$ 194.25	$ 233.97	$ 273.69	$ 2,097.61	$ 2,122.62	$ 2,146.16	$ 2,171.17	$ 2,196.18	$ 2,219.72	$ 2,244.73	$ 2,269.74	$ 2,293.28	$ 2,318.29	$ 2,343.30	$ 2,366.83	$ 2,391.84	$ 2,416.85	$ 2,440.39	$ 2,465.40	$ 2,490.41	$ 2,513.95
Monthly Pump Power Costs	$ 1,017	$ 2,208	$ 3,400	$ 4,592	$ 5,827	$ 7,019	$ 8,211	$ 62,928	$ 63,679	$ 64,385	$ 65,135	$ 65,885	$ 66,592	$ 67,342	$ 68,092	$ 68,798	$ 69,549	$ 70,299	$ 71,005	$ 71,755	$ 72,506	$ 73,212	$ 73,962	$ 74,712	$ 75,419
Cumulative Power Costs	$ 1,017	$ 3,225	$ 6,625	$ 11,217	$ 17,044	$ 24,063	$ 32,274	$ 95,202	$ 158,881	$ 223,266	$ 288,401	$ 354,286	$ 420,878	$ 488,220	$ 556,312	$ 625,110	$ 694,659	$ 764,958	$ 835,963	$ 907,718	$ 980,224	$ 1,053,435	$ 1,127,398	$ 1,202,110	$ 1,277,528
Total Cost of Pipe	$ 350,000	$ 350,000	$ 350,000	$ 350,000	$ 350,000	$ 350,000	$ 350,000	$ 475,000	$ 475,000	$ 475,000	$ 475,000	$ 475,000	$ 475,000	$ 475,000	$ 475,000	$ 475,000	$ 475,000	$ 475,000	$ 475,000	$ 475,000	$ 475,000	$ 475,000	$ 475,000	$ 475,000	$ 475,000
Total Cumulative Pipe + Power Cost (Alt 2)	$ 351,017	$ 353,225	$ 356,625	$ 361,217	$ 367,044	$ 374,063	$ 382,274	$ 570,202	$ 633,881	$ 698,266	$ 763,401	$ 829,286	$ 895,878	$ 963,220	$ 1,031,312	$ 1,100,110	$ 1,169,659	$ 1,239,958	$ 1,310,963	$ 1,382,718	$ 1,455,224	$ 1,528,435	$ 1,602,398	$ 1,677,110	$ 1,752,528

APPENDIX B – PUMP CUT SHEETS AND PUMP CURVES

PACO KP, KPV

Split case pump
60 Hz





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1. Features and benefits

The Paco KP horizontal split case pump and KPV vertical split case pump are single stage, centrifugal volute pumps with high energy efficiency and low life-cycle costs.

Ease of service and long-term reliability are two of the selling features of the KP pumps. The split case design enables removal and dismantling of the internal pump parts (bearings, wear rings, impeller, and shaft seals) without disturbing the motor or pipe work. The two-bearing design means less vibration and higher reliability. The separate bearing housings allow for inspection of the seals, sleeves and bearings without removing the top half of the casing.

The double-suction design reduces axial forces by directing flow into both sides of the impeller. The double-volute design, available on most models, reduces the radial load and minimizes noise and vibration. Shaft sleeves are used to protect the shaft from corrosion and wear, thus extending the overall life of the shaft and the pump.

KP pumps cover this performance range:

- Flow rate: 60 to 12000 gpm [10 to 2700 m^3/h]
- Head: 15 to 700 ft [5 to 215 m]
- Motor (P2): 10 to 2000 hp

The pumps are non-self-priming, centrifugal volute pumps with radial suction and radial discharge ports and horizontal shaft. Impellers are hydraulically balanced.

Paco KP pumps are available in these different options:

- Pump with motor and base (see fig. 1).
- Bare shaft pump, i.e. pump without motor, with base (see fig. 2).
- Bare shaft pump, i.e. pump without motor, without base (see fig. 3).
- Or any combination requested by the customer

KPV pumps

- Same great features of KP, but in a vertical configuration for optimized space savings
- Optional lower sleeve bearing design for easier lower bearing maintenance.

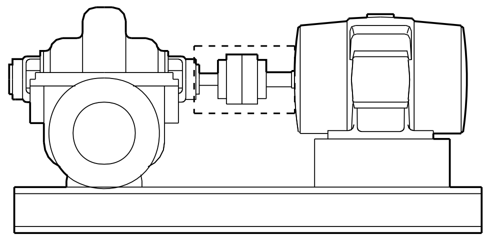


Fig. 1 KP pump with motor and base

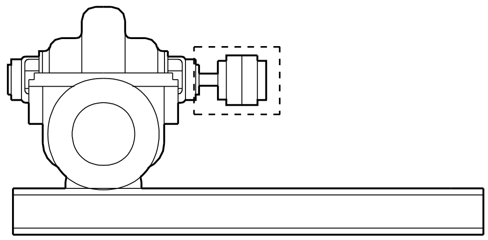


Fig. 2 KP bare shaft pump with base, coupling, and guard

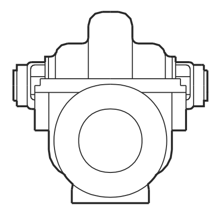
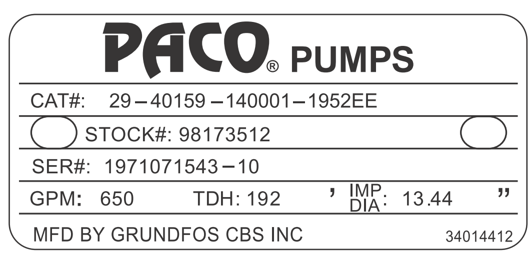


Fig. 3 KP bare shaft pump

Nameplate



2. Applications

The Paco KP pumps are used in these main fields of application:

- commercial systems
- industrial systems
- water distribution
- irrigation.

Commercial systems

Liquid transfer and pressure boosting in:

- air conditioning, primary and secondary chilled water systems
- water condensing systems and cooling towers
- boiler feed and condensate systems
- district heating plants and heating systems
- swimming pools
- fountains.

Industrial systems

Liquid transfer and pressure boosting in:

- process cooling and chilled water systems
- water condensing systems and cooling towers
- boiler feed and condensate systems
- industrial heating systems
- wash down and cleaning systems
- industrial processing systems (water, light chemicals, oils, etc).

Water distribution

Liquid transfer and pressure boosting in:

- public waterworks
- non-potable water systems.

Irrigation and aquaculture

Irrigation covers these applications:

- field irrigation (flooding)
- sprinkler irrigation
- drip-feed irrigation
- aqua farming.

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Fig. 4 KP pump used in commercial building applications

GR 2910

Fig. 5 KP pump in sprinkler irrigation

3. Product range

Pump configurations

	Standard configuration	Optional configuration
Pump casing	Cast Iron	Ductile Iron
Impeller	Bronze	• Cast Iron • Aluminium bronze • Stainless steel
Sleeve	Bronze	Stainless steel
Coupling	• Elastomeric • Grid	Spacer Coupling
Shaft seal	Mechanical seal:	Soft packing
Flange	ANSI 125	ANSI 250
Flushing line	None	• Nylon • Copper • Stainless Steel
Wear rings	Bronze	Stainless Steel
Shaft	Steel	Stainless Steel
Motor efficiency class	NEMA Premium	Others on request
Pump direction of rotation	CW - clockwise	CCW - counter clockwise

To a great extent the pumps can be adapted to the requirements of the individual customer. For customized solutions, contact your local Grundfos company.

4. Performance range

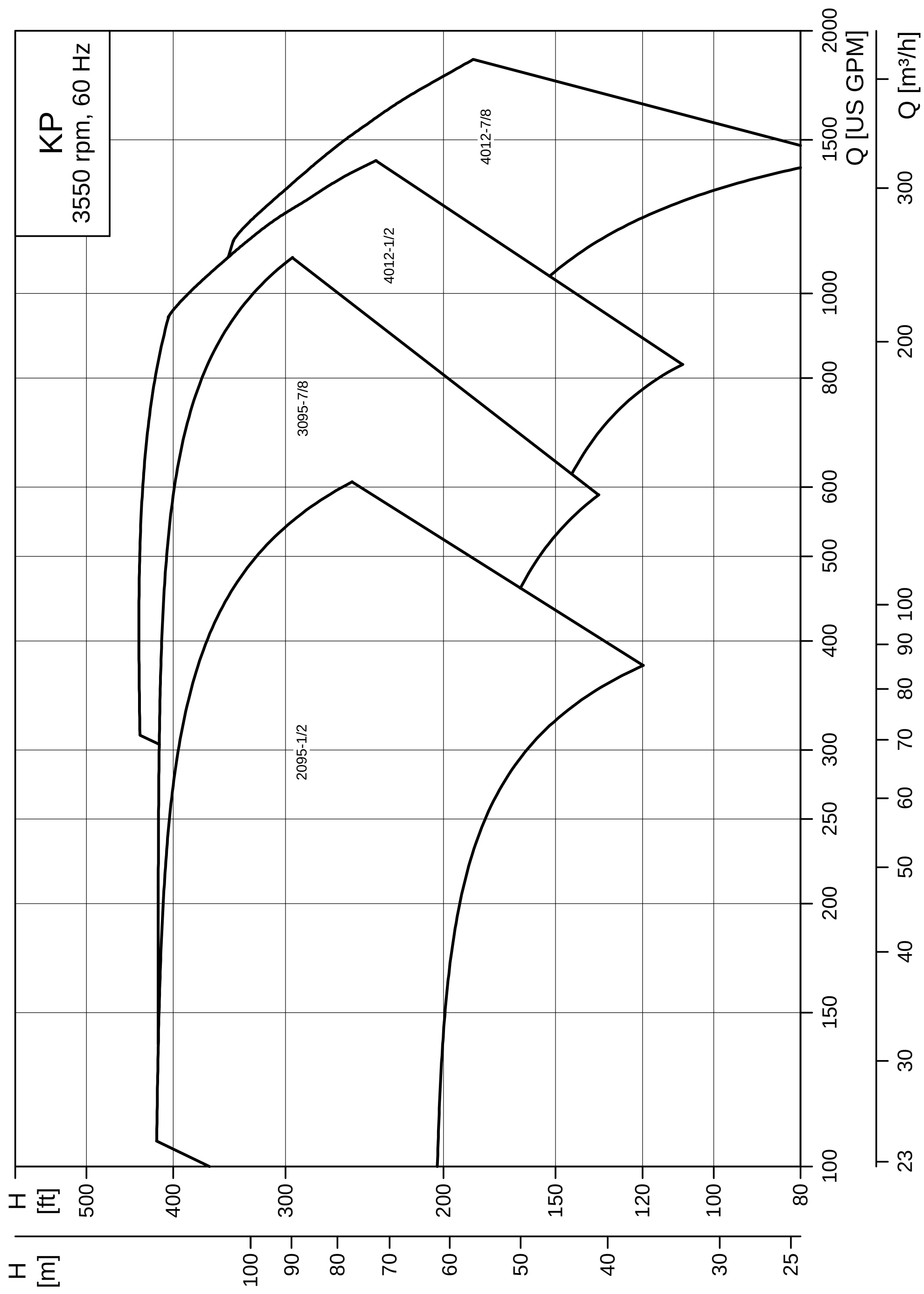
Paco KP pumps are available with 2-, 4- or 6-pole motors. 8 and 10 pole are available on request.

The next three pages show the performance range covered by these three motor types.

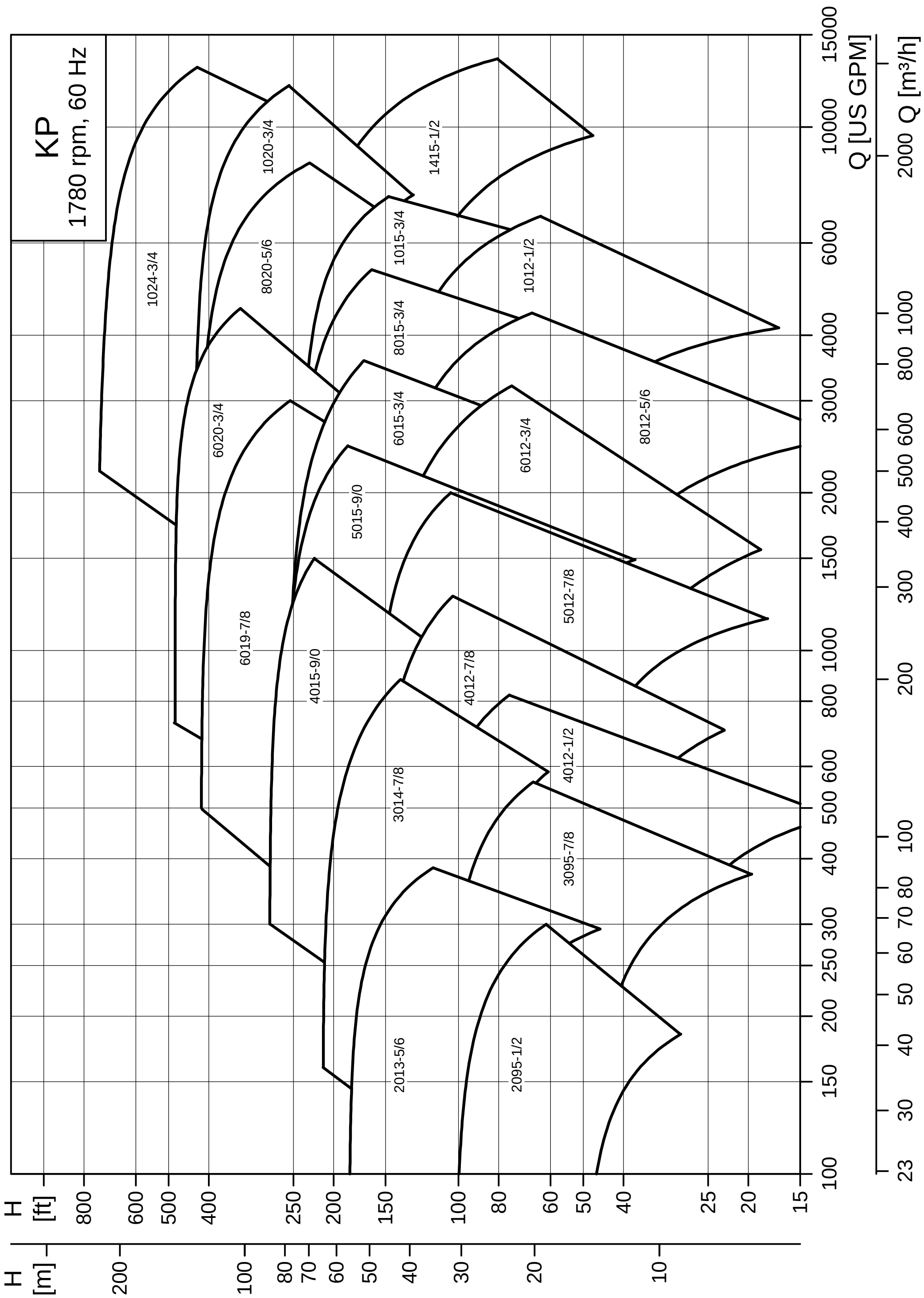
Knowing your required duty point, use the performance ranges like this:

1. Go into the relevant performance range chart.
2. Find your duty point.
3. Note which pump type covers your duty point.
4. Go to section "Product range" and then to "Performance curves and technical data" and find more detailed information on your chosen pump.

KP 2-pole



KP 4-pole



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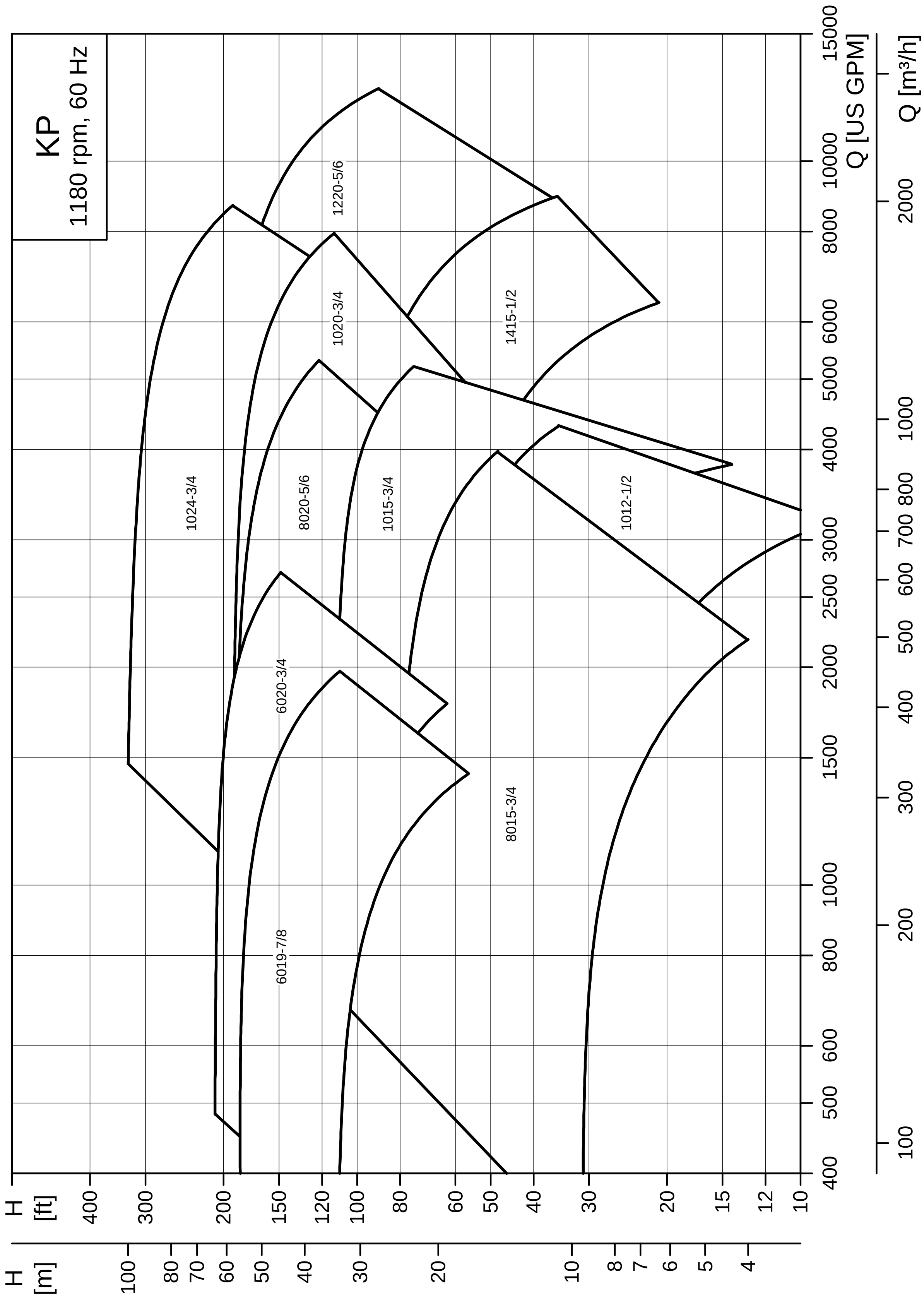
KP 6-pole



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5. Construction

Paco KP horizontal split case pumps are available in several different construction types.

KP pump, construction X2

All four construction types are available with packing as an option.

Sectional view

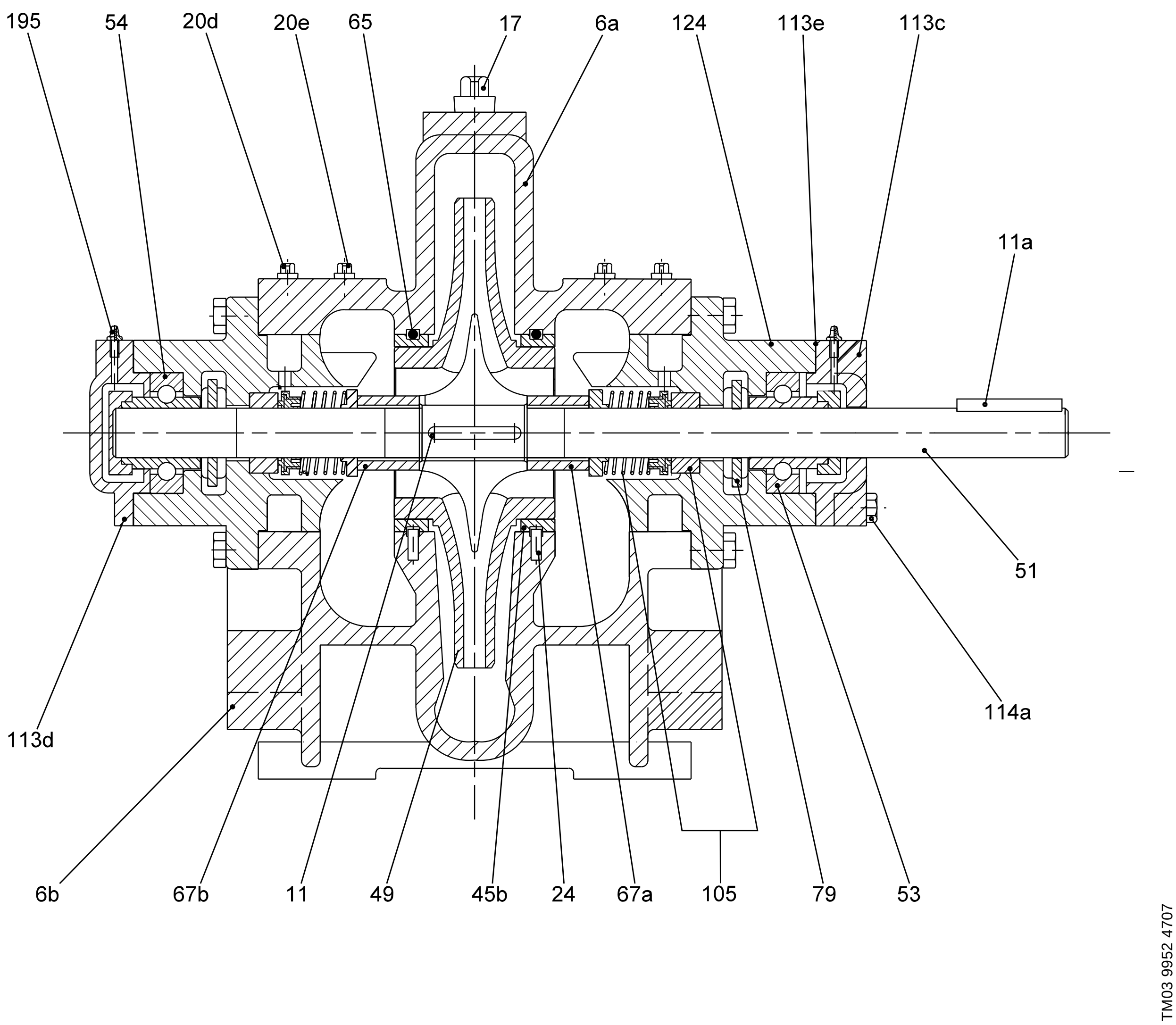


Fig. 6 Sectional view, construction X2, with mechanical shaft seals

KP pump, construction X4

Sectional view

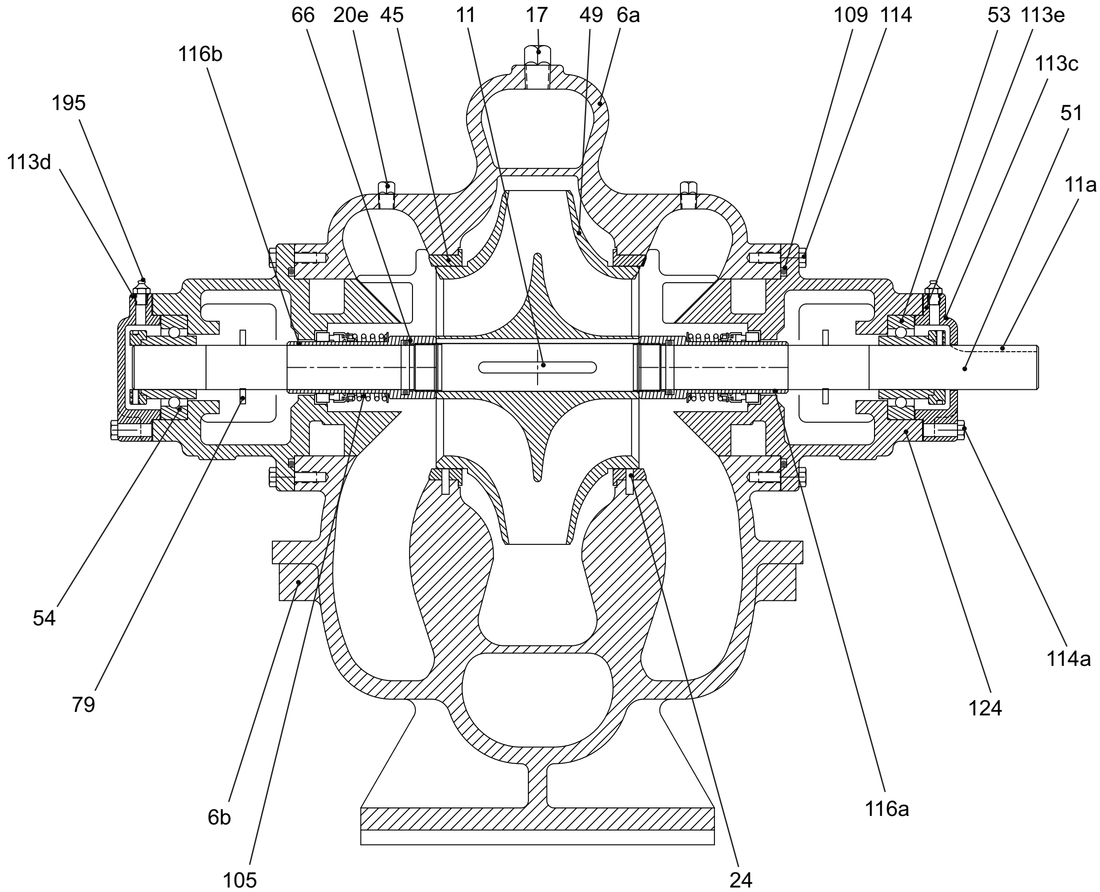


Fig. 7 Sectional view, construction X4, with mechanical shaft seals

KP pump, construction X5 and X7

Sectional view

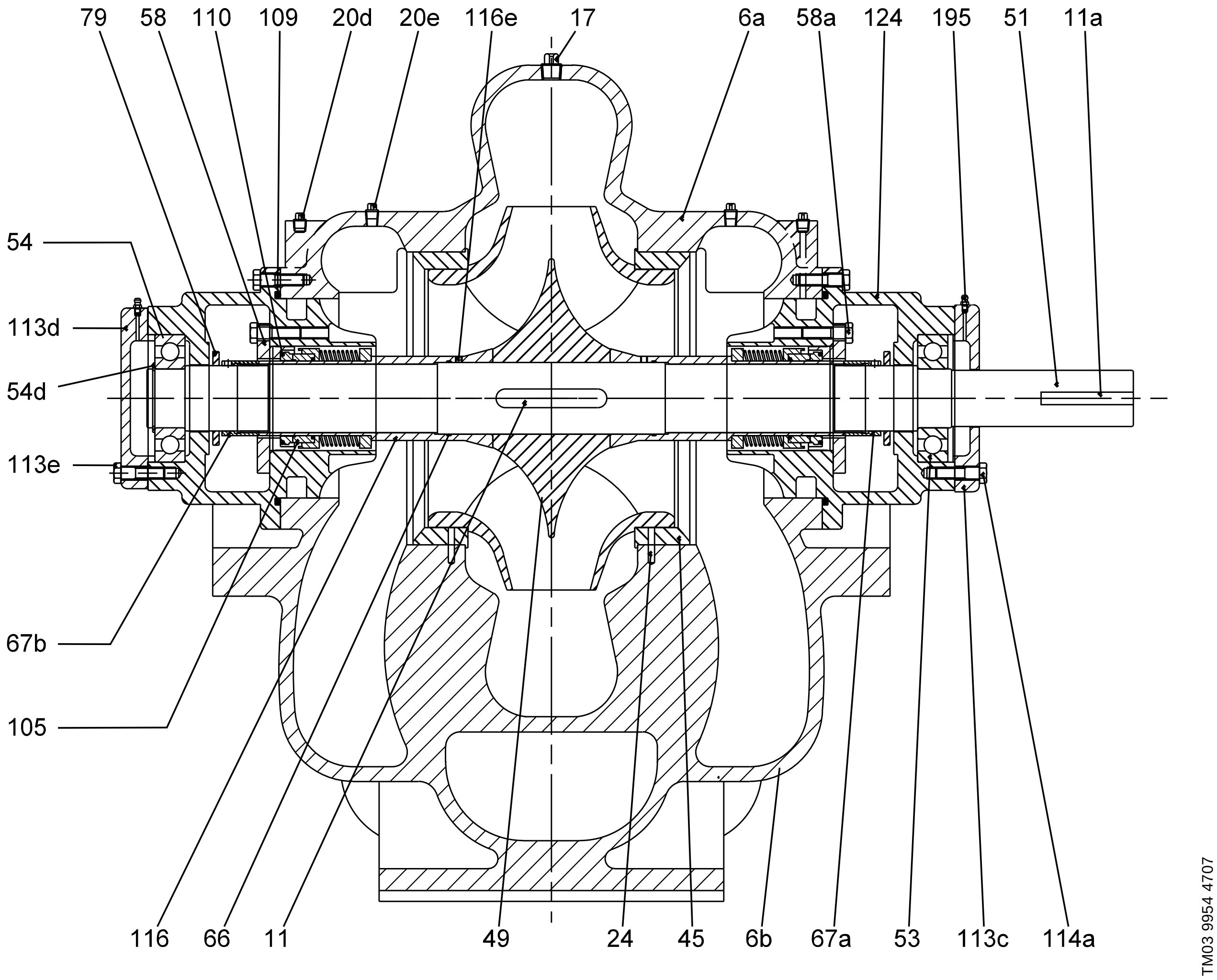


Fig. 8 Sectional view, construction X5/X7, with mechanical shaft seals

KP pump, construction XK and XV

Sectional view

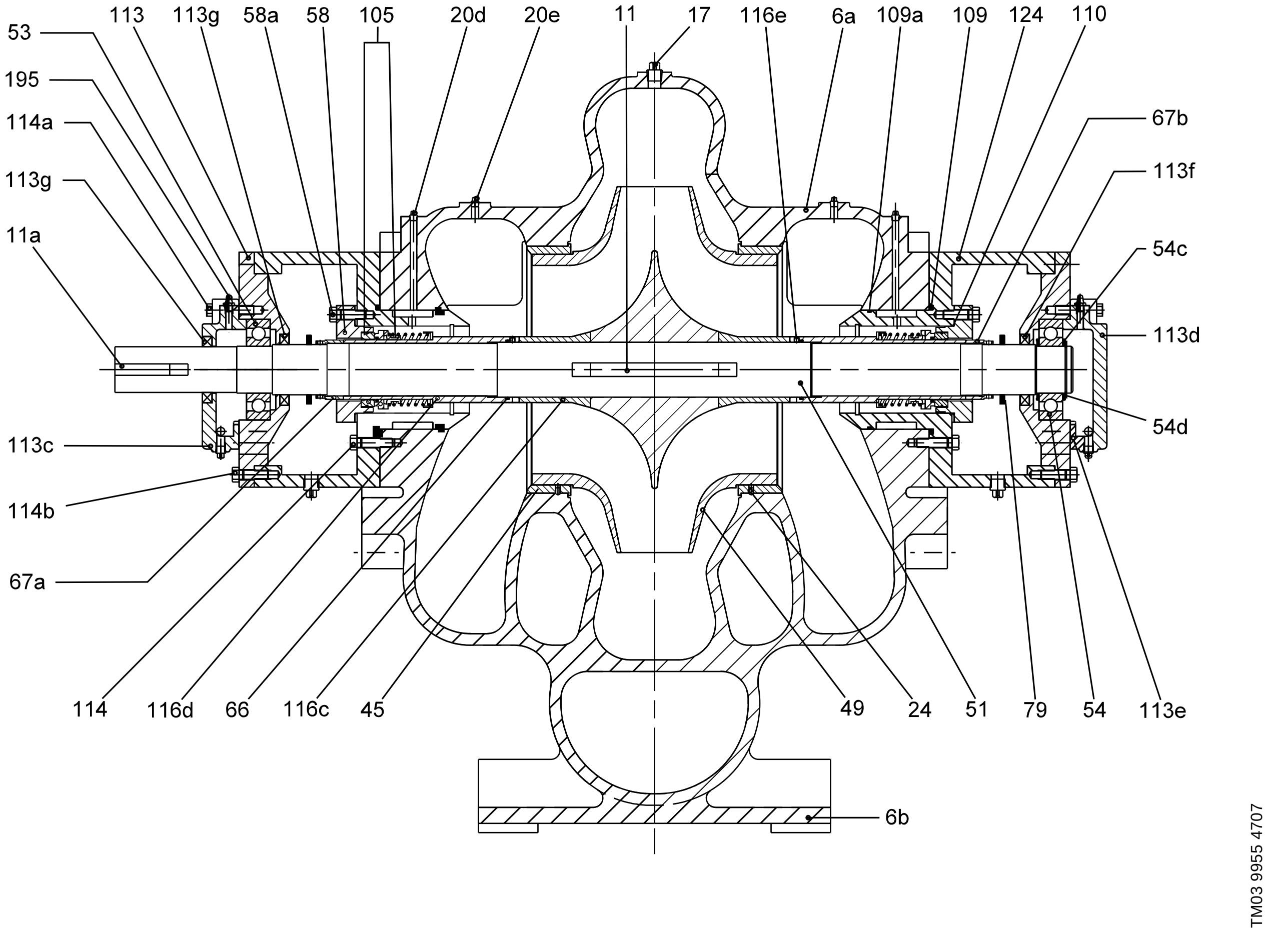


Fig. 9 Sectional view, construction XK/XV, with mechanical shaft seals

KP pump, typical end view - Horizontal

(Non-drive end)

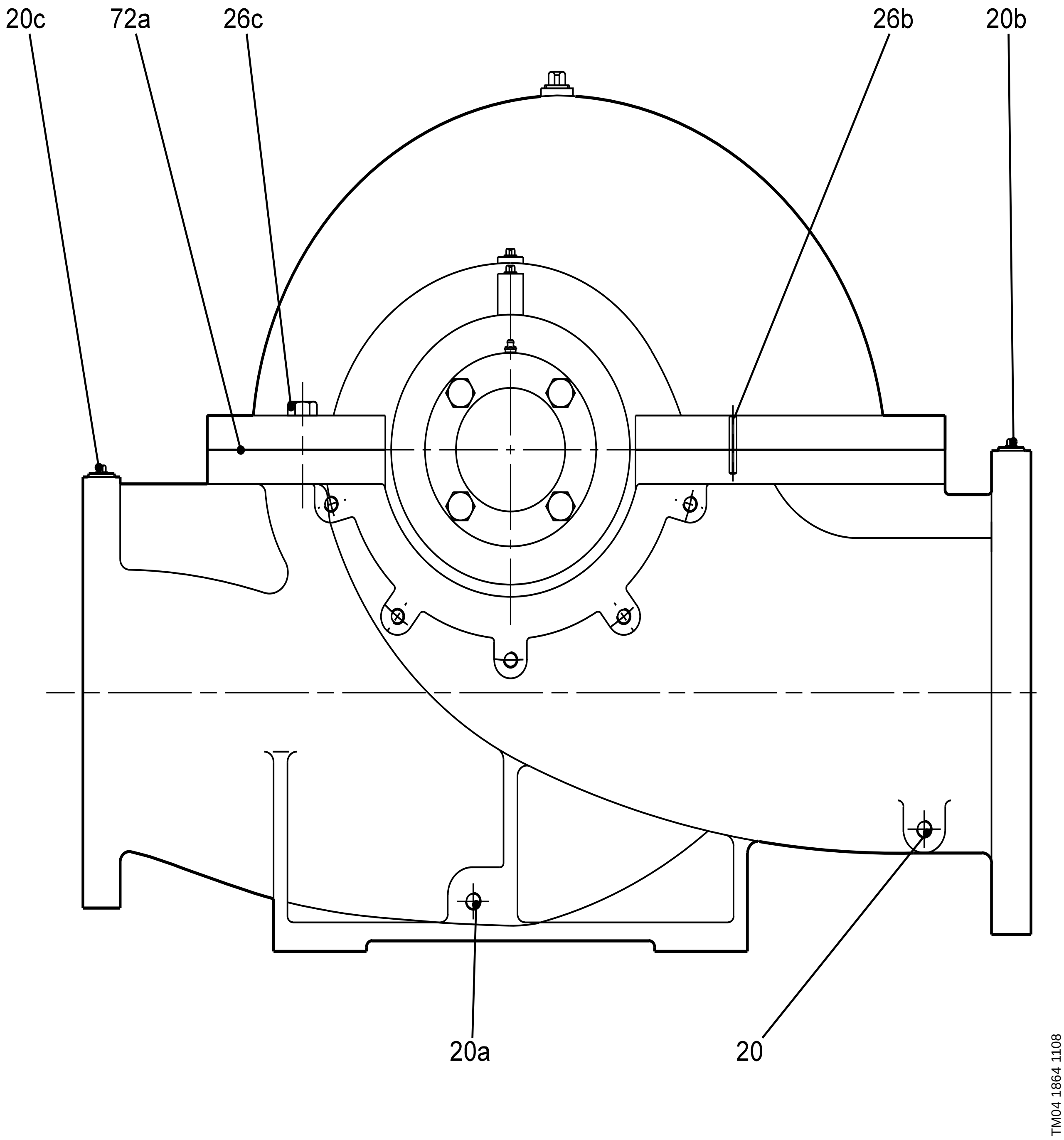


Fig. 10 Typical end view (non-drive end)

Std. components and material specification

Pos. no.	Component	Material	ASTM standard
6a	Pump casing, upper	Cast Iron	ASTM A48 CL35
6b	Pump casing, lower	Cast iron	ASTM A48 CL35
11	Key, impeller	Steel	C1018, cold drawn steel
11a	Key, coupling	Steel	C1018, cold drawn steel
17	Pipe plug	Steel	
20	Drain plug R 1/2	Steel	
20a	Plug, drain outlet	Steel	
20b	Plug, inlet	Steel	
20c	Plug, outlet	Steel	
20d	Plug, shaft seal flushing	Steel	
20e	Plug, suction chamber	Steel	
24	Locking pin, wear ring	Steel	ANSI/ASME B18.8
26b	Roll pin	Steel	ANSI/ASME B18.8
26c	Screw	Steel	
45	Wear ring	Bronze	ASTM B148, C95200
45b	Wear ring with groove for retaining ring	Bronze	ASTM B148, C95200
49	Impeller	Silicon bronze	ASTM B584, C87600
51	Shaft	Steel	AISI 1144 Stress proof
53	Ball bearing, drive end	Steel	
54	Ball bearing, non-drive end	Steel	
54c	Washer	Steel	
54d	Retaining ring	Carbon Spring Steel	SAE 1060-1090
58	Seal cover	Grey Iron	
58a	Screw	Steel	
65	Retaining ring	Stainless steel, series 303	
66	O-ring	NBR	
67a	Impeller/shaft sleeve nut, right-hand thread	Bronze	Ill932, C89835
	Impeller/shaft lock nut, right-hand thread	Stainless steel	
67b	Impeller/shaft sleeve nut, left-hand thread	Bronze	Ill932, C89835
	Impeller/shaft lock nut, left-hand thread	Stainless steel	
72a	Gasket	Vegetable fiber (HYD-401)	
76	Nameplate	Aluminum	
79	Slinger	Neoprene	
105	Shaft seal		
109	O-ring	NBR	
109a	O-ring	NBR	
110	O-ring	NBR	
113	Bearing housing	Cast iron	ASTM A48, CL30
113c	Bearing cover, drive end	Cast iron	ASTM A48, CL30
113d	Bearing cover, non-drive end	Cast iron	ASTM A48, CL30
113e	Gasket	Vegetable fiber	
113f	Lip seal, non-drive end bearing	NBR	
113g	Lip seal, drive-end bearing	NBR	
114	Screw	Steel	
114a	Screw	Steel	
114b	Screw	Steel	
116	Shaft sleeve	Bronze	III932, C89835
116a	Shaft sleeve, drive end	Bronze	I836 C89833
116b	Shaft sleeve, non-drive end	Bronze	I836 C89833
116c	Shaft sleeve, inner	Bronze	I836 C89833
116d	Shaft sleeve, outer	Bronze	I836 C89833
116e	Set screw	Steel	
124	Seal housing	Cast iron	ASTM A48 CL30
195	Lubricating nipple	Zinc coated steel	

Mechanical construction

Pump casing

The class 35 grey iron volute pump casing has radial suction port and radial discharge port.

The pumps are of the inline (symmetric) design.

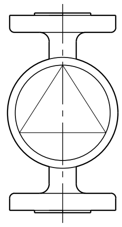


Fig. 11 Schematic drawing of an inline KP pump

Flange Drillings are in accordance with ANSI #125 or #250.

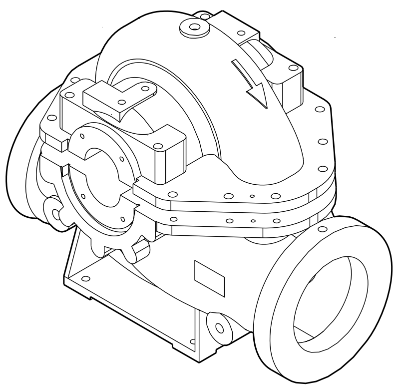


Fig. 12 Upper and lower pump casing of KP pump

Shaft

The shaft (pos. 51) is of the key and keyway type with one key for the impeller (pos. 11) and one key for the coupling (pos. 11a).
The shaft is supported by bearings at both the drive end and the non-drive end of the pump.

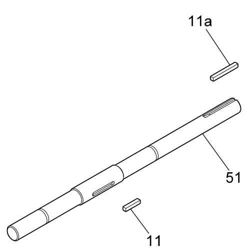


Fig. 13 KP pump shaft

Shaft sleeves are attached to the pump shaft to prevent wear of the shaft and secure the position of the impeller.

Bearings

KP pumps are fitted with two standard single-row deep-groove ball bearings. The bearings are of the open type permitting the bearings to be relubricated. The bearings are lubricated by Grundfos prior to delivery.

Seal housings

All KP pumps have two seal housings (pos. 124), one at the drive end and one at the non-drive end of the pump shaft.

A seal housing has several functions:

- Supports the pump sealing system, whether it is a mechanical shaft seal or packing
- Supports the bearing housing thus transmitting both radial and axial forces from bearing and shaft to the upper and lower pump casing
- Has a connection for the flushing pipe.
  The function of the flushing pipe is to ensure a flow of pumped liquid for cooling and lubricating the mechanical shaft seal or the packing

Impeller

The KP impeller (pos. 49) is a closed double-suction impeller. The impeller has inflow of liquid from both sides and is locked in position by a threaded sleeve arrangement.

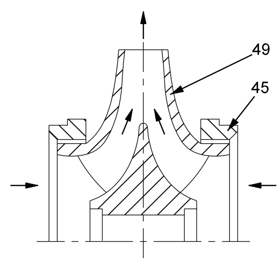


Fig. 14 Double-suction impeller

All impellers are dynamically balanced in accordance with ANSI/ISO 1940 Class G6.3 standard. Due to their design, the impellers are inherently hydraulically balanced and thus compensate for axial thrust.

All impellers are trimmed to the duty point required by the customer.

Wear rings

KP pumps have wear rings (pos. 45) between impeller and pump casing. As the name indicates, the wear rings protect the pump casing against wear. The wear rings act as a seal between impeller and pump casing.

When the wear rings become worn, the efficiency of the pump will be reduced and the wear rings should be replaced.

Coupling

As standard, KP pumps are fitted with a flexible grid coupling or elastomeric coupling, depending or motor size. The grid coupling consists of two steel flanges horizontally split coupling halves.

The coupling design assists in reducing vibrations and cushions shock loads. The design also extends the life of the coupling itself. The flexible grid is standard for VFD driven pumps.

Fig. 15 Flexible grid coupling

The elastomeric coupling has a flexible rubber section to absorb vibrations and minimizes negative affects of misalignment.

Fig. 16 elastomeric coupling

Mechanical shaft seal

The material of the standard version is Buna Carbon/ ceramic.

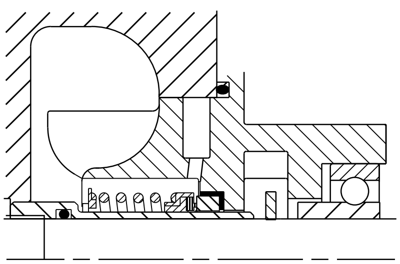


Fig. 17 Rubber bellows shaft seal

Packing

Includes graphite impregnated packing rings.

The packing rings consist of braided material which is effective for long service life for packing rings while protecting the shaft sleeve.

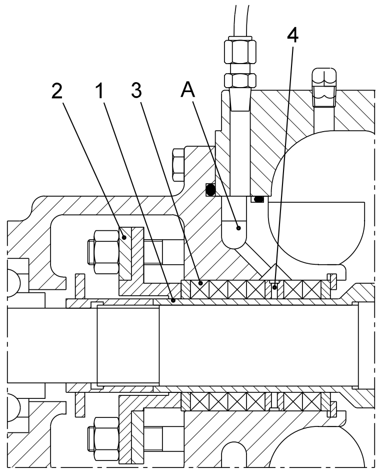


Fig. 18 Sectional view of packing with internal flushing liquid

Pos.	Description
1	Shaft sleeve
2	Gland
3	Packing ring
4	Lantern ring
A	Drilled hole for flushing liquid (pumped liquid)

Base

Pump and motor are mounted on a common base frame designed according to Hydraulic Institute standard, ANSI/HI 1.3-2000.

Painting

Prior to delivery to the customer, pump, motor and base are top coated with a blue paint (RAL 5015); coating thickness is 2 to 4 mils.The inside of the pump is primered for corrosion resistance. Standard units are not painted internally.

Test pressure

Pressure testing is made with water at ambient temperature. The standard hydrostatic test pressure is 1.5 times the flange rating pressure.

KP Case working pressure limitations at 150 °F: Flat-face flanges

Chart A

Cass material	Class 125 lb flange drilling (psi)		Class 250 lb flange drilling (psi)	
	CWP	Hydro	CWP	Hydro
Cast iron	175	265	250	375
Ductile iron	175	265	400	600

All sizes except as Chart B indicates

Chart B

Maximum case working pressure (class 125 Flange)						
Pump model number	6019	6020	8020	1020	1024	1220
Cast iron	175 psi					
Ductile iron						
Maximum case working pressure (class 250 Flange)						
Pump model number	6019	6020	8020	1020	1024	1220
Cast iron	250 psi	250 psi	234 psi	222 psi	250 psi	211 psi
Ductile iron	375 psi	375 psi	351 psi	333 psi	375 psi	317 psi

CWP: maximum Case Working Pressure based upon flange drilling. Maximum working pressure for a given application is determined by adding the maximum available suction pressure to the shut-off head of a given impeller diameter.

Hydro: Is the hydrostatic test pressure applied to the pump. Minimum hydrostatic test pressure is 1.5 times maximum allowable case working pressure.

6. Operating conditions

Ambient temperature and altitude

The ambient temperature and the installation altitude are important factors for the motor life, as they affect the life of the bearings and the insulation system.

Ambient temperature must not exceed 104 °F [+ 40 °C]. If the ambient temperature exceeds 104 °F [+ 40 °C] or if the motor is installed more than 3280 ft [1000 m] above sea level, the motor must not be fully loaded due to the low density and consequently low cooling effect of the air. In such cases, it may be necessary to use a motor with a higher output, or use a motor that is designed for the specified ambient conditions.

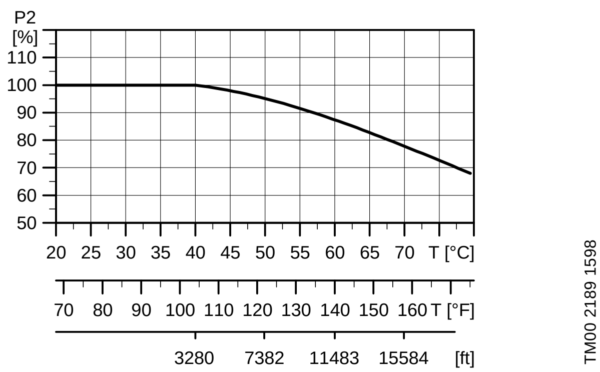


Fig. 19 Relationship between motor output (P2) and ambient temperature

Liquid temperatures and shaft seals

The maximum liquid temperature marked on the pump nameplate depends on the mechanical shaft seal used:

- Temperature range for Buna - standard):
  32 °F to 212 °F [0 °C to +100 °C].
- Temperature range for Viton
  54 °F to 212 °F [+15 °C to +100 °C].
- Temperature range for EPDM
  54 °F to 275 °F [+15 °C to +135 °C].

Shaft seal

The materials of the shaft seal types used in KP pumps have certain characteristics. These characteristics may be of importance when choosing the shaft seal for the pump.

Carbon/Ceramic

The seal has the following features:

- Brittle material requiring careful handling.
- Worn by liquids containing solid particles.
- Limited corrosion resistance, 5 < pH < 9, depending on ceramic type.
- The carbon of the seal offers properties very similar to the carbon/tungsten carbide seal. However, compared to the carbon/tungsten carbide seal, the pressure and temperature ranges are limited.

Carbon/silicon carbide

Seals with one carbon seal face have the following features:

- Brittle material requiring careful handling
- Worn by liquids containing solid particles
- Good corrosion resistance
- The self-lubricating properties of carbon make the seal suitable for use even with poor lubricating conditions (high temperatures) without generating noise. However, such conditions will cause wear of the carbon seal face leading to reduced seal life.

Buna

NBR (nitrile) rubber covers a wide range of liquids at temperatures below 212 °F [+100 °C].

- Good mechanical properties
- Standard material

Viton

FKM rubber covers a very wide range of liquids and temperatures.

- Poor mechanical properties at low temperatures
- Resistant to water up to 275 °F [+135 °C]
- Resistant to mineral oils and vegetable oils
- Not resistant to alkaline liquids at high temperatures.

EPDM

EPDM Rubber covers a wider range of liquids up to a max temperature of 275 °F [135 °C].

- Good mechanical properties.

Pressure

Maximum inlet pressure

Inlet pressure + pump pressure must always be lower than maximum pressure of the pump.

Minimum inlet pressure

The minimum inlet pressure must correspond to the NPSH curve for the pump.

Flow

Minimum flow rate

The pump must not run against a closed discharge valve, as this will cause an increase in temperature/ formation of steam in the pump. This may cause shaft damage, impeller erosion, short life of bearings, stuffing boxes with packing rings or mechanical seals due to stress or vibration.

The minimum, continuous flow rate must be at least 25% of the flow rate at best-efficiency point (BEP).

KP Impeller Max Sphere Size

Split Case Model	Max Sphere Size [inches]
2095-1/2	0.19
2013-5/6	0.16
3095-7/8	0.31
3014-7/8	0.31
4012-1/2	0.38
4012-7/8	0.75
4015-9/0	0.25
5012-7/8	0.63
5015-9/0	0.75
6012-3/4	1.00
6015-3/4	0.81
6019-7/8	0.75
6020-3/4	0.75
8012-5/6	0.88
8015-3/4	1.00
8020-5/6	1.03
1012-1/2	1.00
1015-3/4	1.25
1020-3/4	1.20
1024-3/4	1.17
1220-5/6	1.87
1415-1/2	1.25

KP model number and construction code

Example	29	60123	140001	1852
Product code	29			
Model code		60123		
Materials of construction			140001	
Motor code				1852

Production code	29
29: Split case	

Model code	60	12	3

Pump discharge
20 = 2"
30 = 3"
40 = 4"
50 = 5"
60 = 6"
80 = 8"
10 = 10"
12 = 12"
14 = 14"

Nominal maximum impeller diameter
95 = 9.5"
12 = 12"
13 = 13"
14 = 14"
15 = 15"
19 = 19"
20 = 20"
24 = 24"

Impeller design
Clockwise rotation:
1, 3, 5, 7, 9
Counter clockwise rotation:
0, 2, 4, 6, 8

Materials of construction	1	4	00	0	1

Packing or seal
3 = Standard Packing
1 = Type 21, Single Seal, Ceramic Seat, Buna
2 = Type 21, Single Seal, Tung Crbd Seat, Viton
6 = Type 21, Single Seal, Ni-Resist Seat, Viton
7 = Type 21, Single Seal, Ni-Resist Seat, Buna
8 = Type 1B, Single Seal, Ni-Resist Seat, Buna
9 = Type 21, Single Seal, Ni Resist Seat, Viton
A = Type 1, Single Seal, Ceramic Seat, Buna
B = Type 1, Single Seal, Ni-Resist Seat, Viton
C = Type 1, Single Seal, Tung Cbrd Seat, Viton
D = Type 1, Singel Seal, Ni Resist Seat, Buna
E = Type 1, Single Seal, Ceramic Seat, Buna
F = Type 1, Single Seal, Si Cbrd Seat, EPDM

ID of packing or seal
2 = 1"
3 = 1-1/4"
E = 1-1/2"
4 = 1-3/4"
5 = 2-1/4"
6 = 2-3/4"
7 = 3"
K = 3-1/2"
V = 4"

General configuration (horizontal)

Code no	Item
00	Std.
01	Dbl- wear rings
02	Oil lube brgs
03	(01) + (02)
04	(01) + (05)
05	Recirc lines
20	Dbl Ext Shaft
21	Dbl Wear Rings
22	Recirc Lines
24	(21) + (22)
30	Dbl Ext Shaft
31	Dbl Wear Rings

General configuration (horizontal)

Code no	Item
32	Recirc Lines
34	(31) + (32)
70	250 lb. Flange
71	Dbl Wear Rings
72	(71) + (73)
73	Recirc Lines
90	250 lb. Flange
91	Dbl Wear Rings

General configuration (Vertical)

Code no	Item
50	Std
51	Dbl. Wear Rings
52	Sleeve Bearing
80	250 lb. flamge
81	Dbl. Wear Rings
82	Sleeve Bearing
92	250 lb. flamge
93	Dbl. Wear Rings

Shaft/Sleeve Metallurgy
0 = Steel/Bronze
1 = Steel/S.S.
3 = S.S.l/Bronze*
6 = S.S./S.S. or S.S./no sleeves
7 = SS/Hard. SS
A = 316 SS/Ni Al Bz
X = Special

Pump Metallurgy
1 = Brz. Fitted
2 = Std. All Bronze
5 = All Iron
8 = Ductile Iron/Brz. Fitted
X = Special

Motor code	1	78	2

Enclosure
1 = ODP
2 = TECF
3 = explosion proof

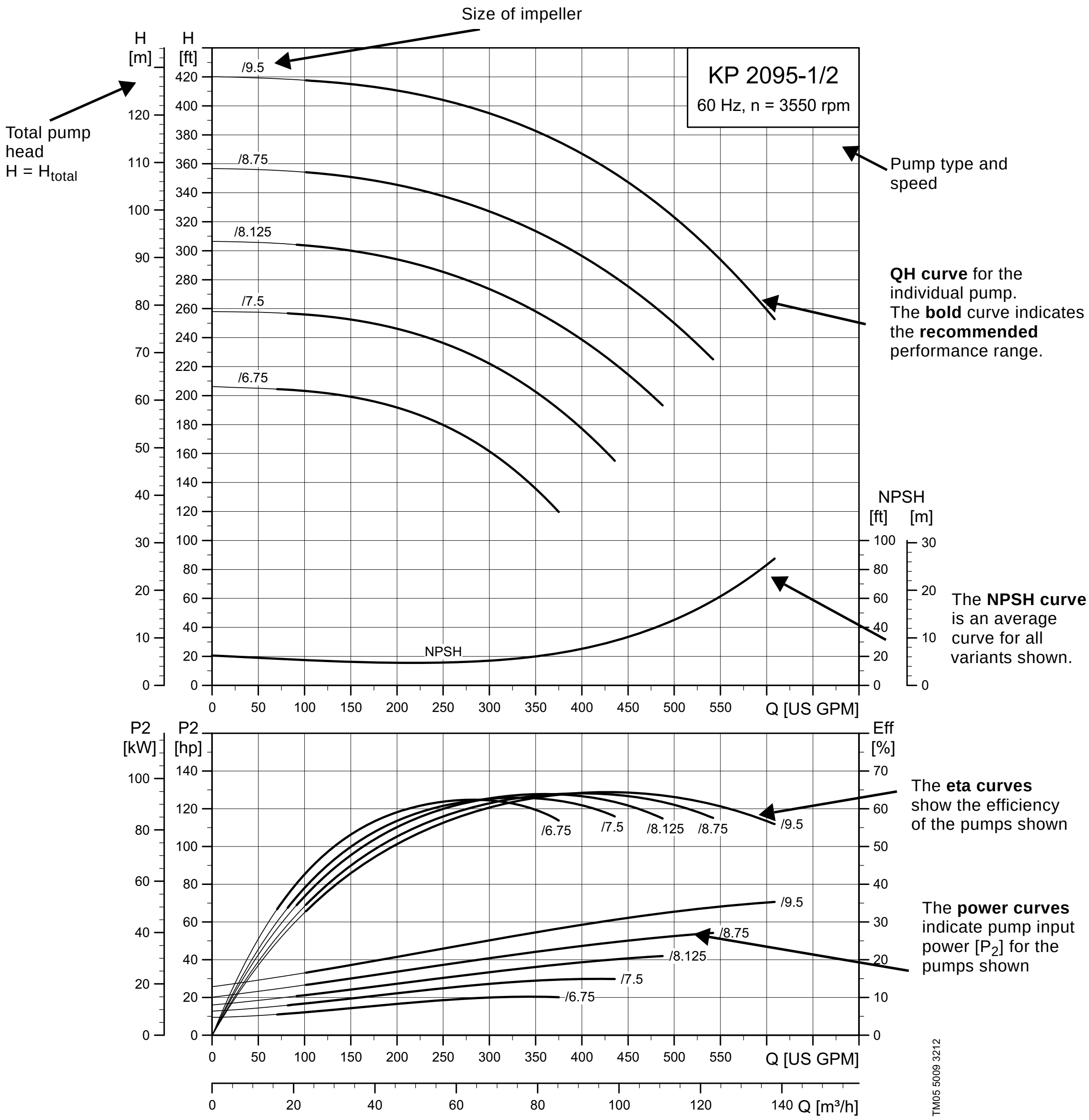
Voltage

HP	1 phase	3 phase	
	115/230 V	200 V	230/460 V
1/3	21	23	24
1/2	29	31	32
3/4	35	37	38
1	41	43	44
1-1/2	47	49	50
2	53	55	56
3	59	61	62
5	65	67	68
7-1/2	71	73	74
10	76	77	78
15	--	81	82
20	--	84	85
25	--	01	87
30	--	02	88
40	--	03	89
50	--	04	90
60	--	05	91
75	--	06	92
100	--	07	93
125	--	--	94
150	--	--	95
200	--	--	96
250	--	--	97
300	--	--	98

RPM
1 = 3500
2 = 1750
3 = 1150

7. Curve charts and technical data

How to read the curve charts



Reference the Express Suite selection tool for selections in additional speeds.

Curve conditions

The guidelines below apply to the curves shown in the performance charts.

- Tolerances according to: Hydraulic Institute.
- The curves show pump performance with different impeller diameters at the nominal speed.
- The **bold** part of the curves show the **recommended** operating range.
- Do not operate the pump along the thin parts of the curves. If your duty point lies here, you should select a smaller or larger pump type.
- Do not use the pumps at minimum flows below 0.1 x Q_{max} stated on the pump name plate because of the risk of overheating of the pump.
- The curves apply to the pumping of airless water at a temperature of 77 °F [+20 °C] and a kinematic viscosity of 1 cSt [1 mm^2/s].
- **ETA:** The lines show values of the hydraulic efficiency of the pump for the different impeller diameters.
- **NPSH:** The curves show average values measured under the same conditions as the performance curves.
  When sizing the pump, add a safety margin of at least 1.6 ft [0.5 m].
- In case of other densities than 62.3 lb/ft^3 [1000 kg/m^3] the discharge pressure is proportional to the density.
- When pumping liquids with a specific gravity higher than 1.0, motors with correspondingly higher outputs must be used.

Calculation of total head

The total pump head consists of the height difference between the measuring points + the differential head + the dynamic head.

$$H_{total} = H_{geo} + H_{stat} + H_{dyn}$$

H_{geo} :	Height difference between measuring points.
H_{stat} :	Differential head between suction and the discharge side of the pump.
H_{dyn} :	Calculated values based on the velocity of the pumped liquid on the suction and the discharge side of the pump.

Performance tests

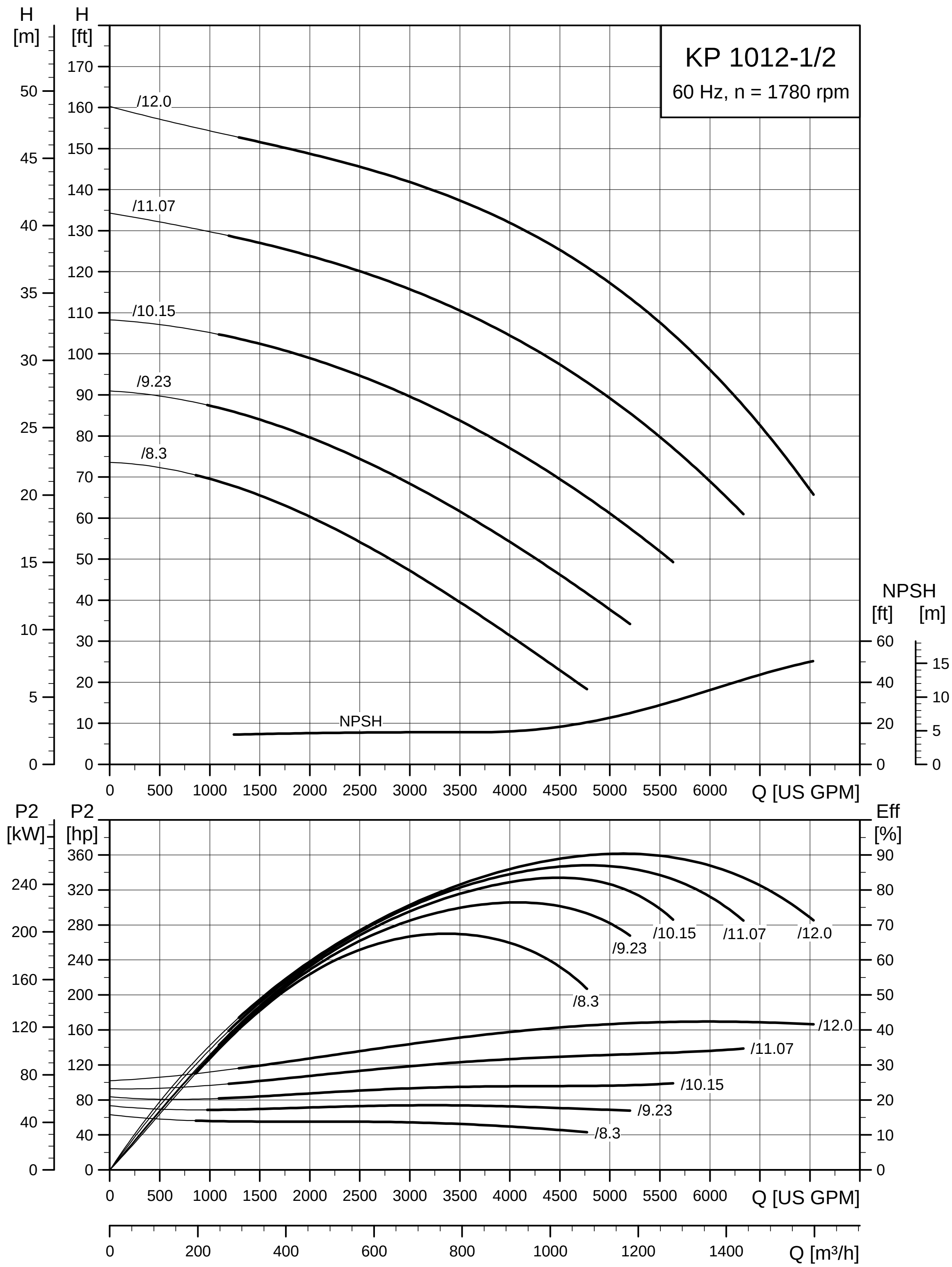
Requested tests are performed according to Hydraulic Institute. Performance tests are only completed when ordered with the pump.

Witness test

When the pumps are being tested it is possible for the customer to witness the testing procedure according to Hydraulic Institute.

If the customer wants to witness the pump test this request must be submitted with the order.

KP 1012-1/2 [4-pole]



TM05 5030 3912

Pump Performance Datasheet

Project name / location	:	Tag Number	: Default
Consulting engineer	:	Service	:
Customer	:	PACO Model	: 1012-1/2 KP
Customer ref. / PO	:	Quantity	: 1
Quote number	:	Quoted By (Sales Office)	:
Date last saved	: 03/19/2014 1:56 PM	Quoted By (Sales Engineer)	:

Operating Conditions

Flow, rated	: 5,000.0 USgpm
Differential head / pressure, rated (requested)	: 61.00 ft
Differential head / pressure, rated (actual)	: 61.11 ft
Suction pressure, rated / max	: 0.00 / 0.00 psi.g
NPSH available, rated	: Ample
Frequency	: 60 Hz

Performance

Speed, rated	: 1,780 rpm
Impeller diameter, rated	: 10.15 in
Impeller diameter, maximum	: 12.00 in
Impeller diameter, minimum	: 8.30 in
Efficiency	: 80.35 %
NPSH required / margin required	: 22.84 / 0.00 ft
-	: -
MCSF	: 1,374.7 USgpm
Head, maximum, rated diameter	: 108.2 ft
Head rise to shutoff	: 77.43 %
Flow, best eff. point (BEP)	: 4,301.3 USgpm
Flow ratio (rated / BEP)	: 116.24 %
Diameter ratio (rated / max)	: 84.58 %
Head ratio (rated dia / max dia)	: 52.02 %
Cq/Ch/Ce/Cn [ANSI/HI 9.6.7-2010]	: 1.00 / 1.00 / 1.00 / 1.00
Selection status	: Acceptable

Liquid

Liquid type	: Water
Additional liquid description	:
Solids diameter, max	: 0.00 in
Solids concentration, by volume	: 0.00 %
Temperature, max	: 68.00 deg F
Fluid density, rated / max	: 1.000 / 1.000 SG
Viscosity, rated	: 1.00 cP
Vapor pressure, rated	: 0.34 psi.a

Material

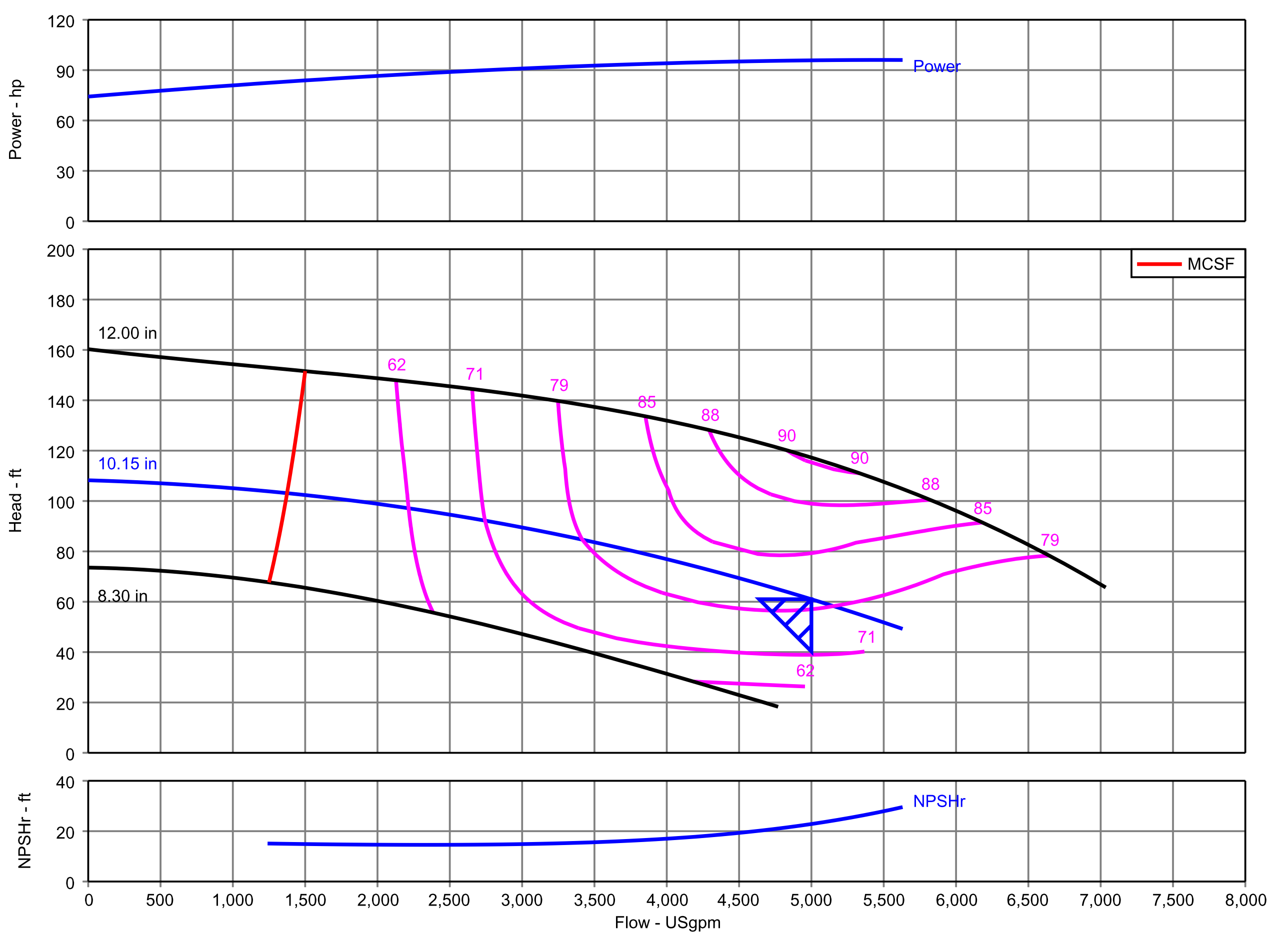
Material selected	: Cast Iron

Pressure Data

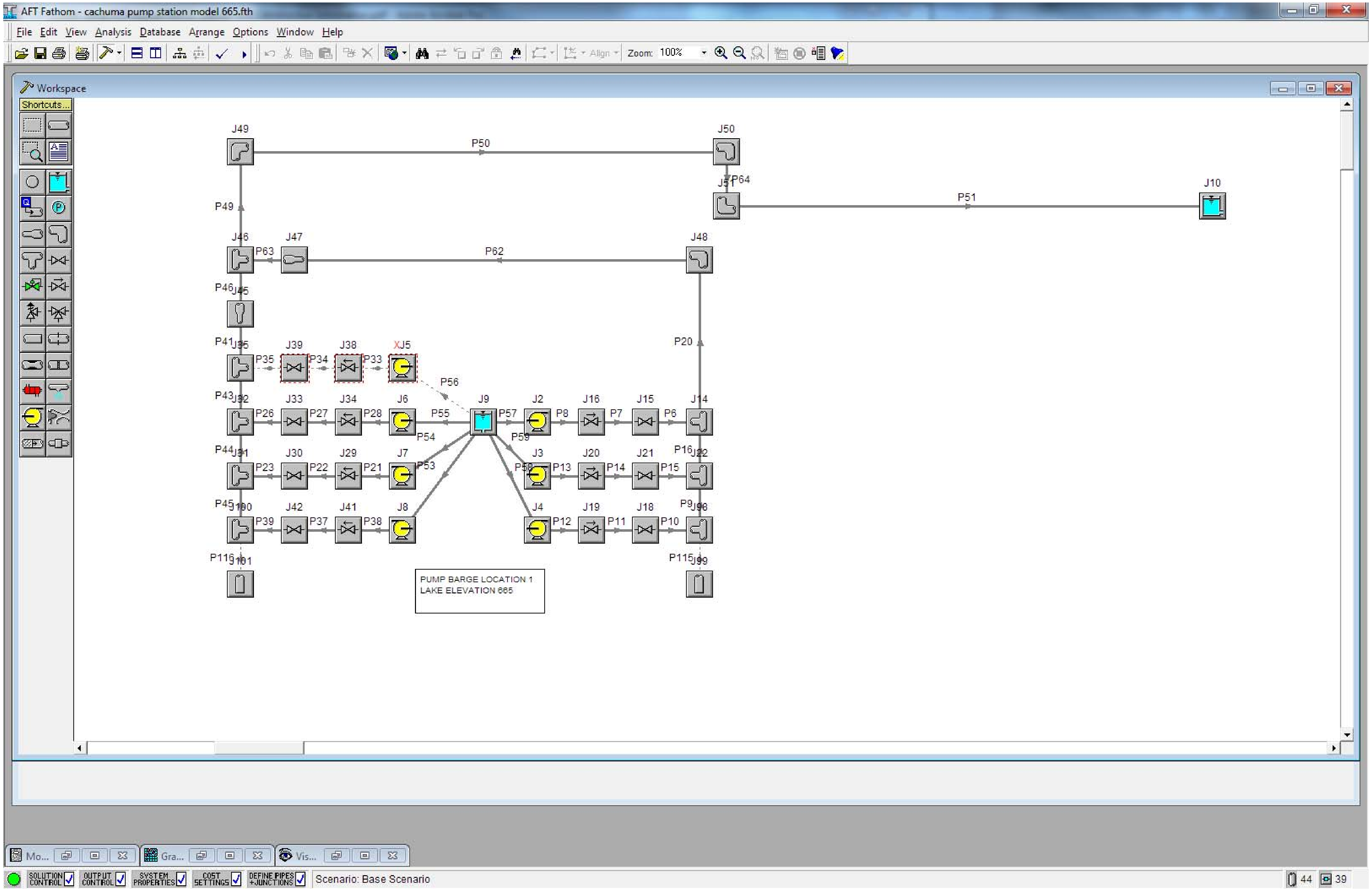
Maximum working pressure	: 46.84 psi.g
Maximum allowable working pressure	: 250.0 psi.g
Maximum allowable suction pressure	: 220.0 psi.g
Hydrostatic test pressure	: 375.0 psi.g

Driver & Power Data

Motor sizing specification	: Based on duty point (rated power)
Margin over specification	: 0.00 %
Service factor	: 1.00
Power, hydraulic	: 77.00 hp
Based on duty point (rated power)	: 95.83 hp
Non-overloading (max power)	: 96.07 hp
Nameplate motor rating	: 100 hp / 74.57 kW



APPENDIX C – AFT FATHOM HYDRAULIC MODEL


AFT Fathom - cachuma pump station model 665.fth
File Edit View Analysis Database Arrange Options Window Help
Zoom: 100%
Workspace
Shortcuts...
J49
P50
J50
P64
J51
P51
J10
P49
J46
P63
J47
P62
J48
P46
J45
P41
J35
P35
J39
P34
J38
P33
XJ5
P20
P56
P43
J32
P26
J33
P27
J34
P28
J6
P55
J9
P57
J2
P8
J16
P7
J15
P6
J14
P54
P59
P44
J31
P23
J30
P22
J29
P21
J7
P53
J3
P58
P13
J20
P14
J21
P15
P16
J22
P45
J100
P39
J42
P37
J41
P38
J8
J4
P12
J19
P11
J18
P10
P9
J98
P116
J101
P115
J99
PUMP BARGE LOCATION 1
LAKE ELEVATION 665
Mo...
Gra...
Vis...
SOLUTION CONTROL
OUTPUT CONTROL
SYSTEM PROPERTIES
COST SETTINGS
DEFINE PIPES +JUNCTIONS
Scenario: Base Scenario
44
39

AFT Fathom - cachuma pump station model 665.fth

File Edit View Analysis Database Arrange Options Window Help

Show: General, Pipes and Junctions

Output

General | Warnings | Pump Summary | Valve Summary | Reservoir Summary

Jct	Name	Vol. Flow (MGD)	Mass Flow (lbm/sec)	dP (psid)	dH (feet)	Overall Efficiency (Percent)	Speed (Percent)	Overall Power (hp)	BEP (MGD)	% of BEP (Percent)	NPSHA (feet)	NPSHR (feet)
2	Pump	7.500	723.0	22.05	50.96	77.40	96.71	86.55	6.029	124.4	27.96	12.70
3	Pump	7.500	723.0	22.06	50.97	77.40	96.71	86.56	6.029	124.4	27.96	12.70
4	Pump	7.500	723.0	22.06	50.97	77.40	96.71	86.57	6.029	124.4	27.96	12.70
X5	Pump	0.000	0.0	N/A	N/A	N/A	0.00	N/A	N/A	N/A	N/A	N/A
6	Pump	7.500	723.0	21.91	50.65	77.31	96.55	86.10	6.019	124.6	27.96	12.69
7	Pump	7.500	723.0	21.92	50.66	77.31	96.56	86.12	6.020	124.6	27.96	12.69
8	Pump	7.500	723.0	21.92	50.66	77.32	96.56	86.12	6.020	124.6	27.96	12.69

Pipes

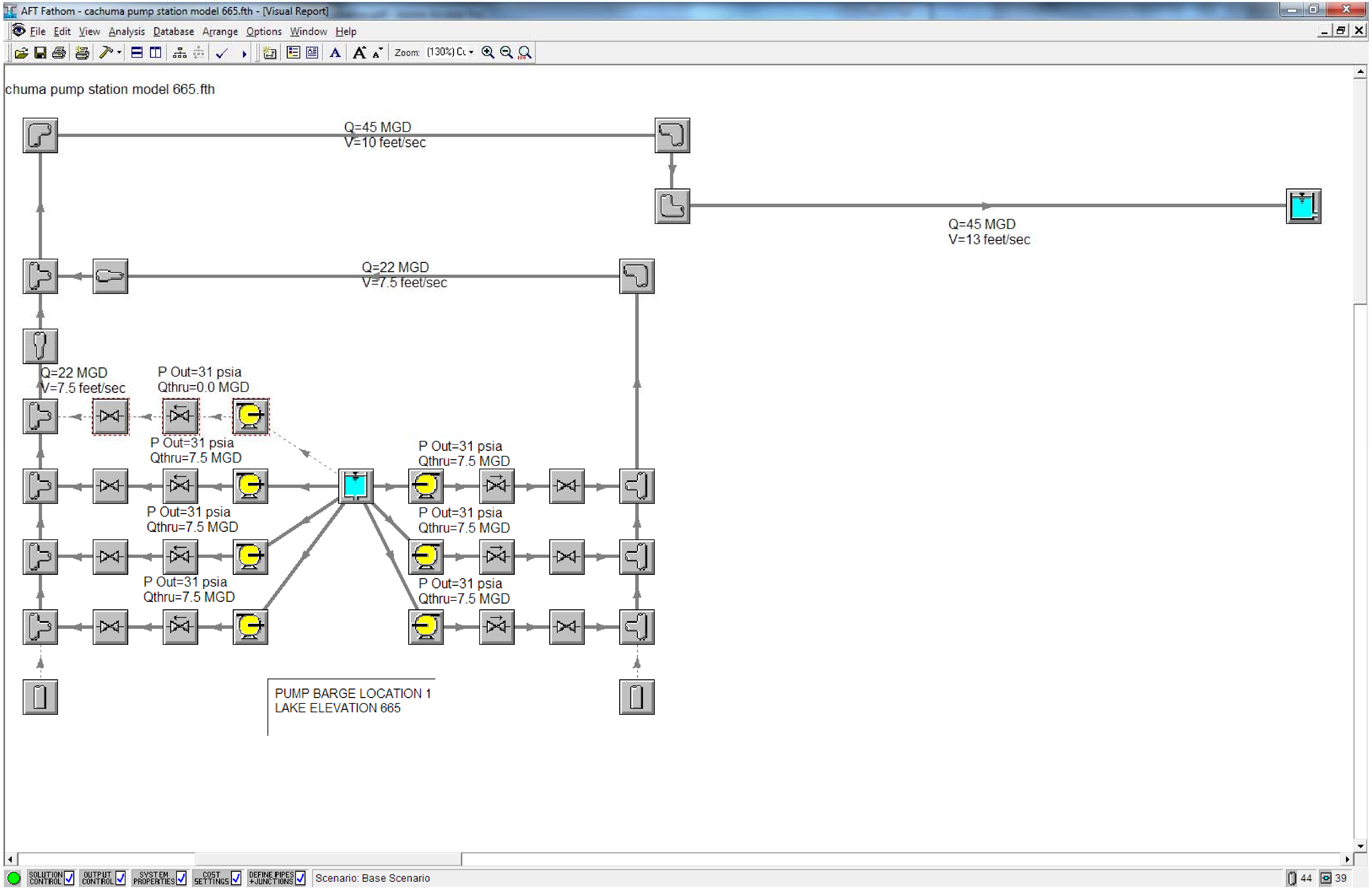
Pipe	Name	Vol. Flow Rate (MGD)	Velocity (feet/sec)	P Static Max (psia)	P Static Min (psia)	Elevation Inlet (feet)	Elevation Outlet (feet)	dP Stag. Total (psid)	dP Static Total (psid)	dP Gravity (psid)	dH (feet)	P Static In (psia)	P Static Out (psia)	P Stag. In (psia)	P Stag. Out (psia)
6	Pipe	7.500	21.191	28.33	28.06	669.5	670.0	0.267238	0.267238	0.2163	0.117610	28.33	28.06	31.35	31.08
7	Pipe	7.500	21.191	29.86	29.81	669.5	669.5	0.050890	0.050890	0.0000	0.117610	29.86	29.81	32.88	32.83
8	Pipe	7.500	21.191	31.66	31.49	670.0	669.5	-0.165459	-0.165459	-0.2163	0.117610	31.49	31.66	34.51	34.68
9	Pipe	7.500	2.487	31.05	31.04	670.0	670.0	0.001170	0.001170	0.0000	0.002704	31.05	31.04	31.09	31.09
10	Pipe	7.500	21.191	28.34	28.07	669.5	670.0	0.267238	0.267238	0.2163	0.117610	28.34	28.07	31.35	31.09
11	Pipe	7.500	21.191	29.86	29.81	669.5	669.5	0.050890	0.050890	0.0000	0.117610	29.86	29.81	32.88	32.83
12	Pipe	7.500	21.191	31.66	31.50	670.0	669.5	-0.165459	-0.165459	-0.2163	0.117610	31.50	31.66	34.52	34.68
13	Pipe	7.500	21.191	31.66	31.50	670.0	669.5	-0.165459	-0.165459	-0.2163	0.117610	31.50	31.66	34.52	34.68
14	Pipe	7.500	21.191	29.86	29.81	669.5	669.5	0.050890	0.050890	0.0000	0.117610	29.86	29.81	32.88	32.83
15	Pipe	7.500	21.191	28.33	28.07	669.5	670.0	0.267238	0.267238	0.2163	0.117610	28.33	28.07	31.35	31.09
16	Pipe	15.000	4.974	30.92	30.92	670.0	670.0	0.004319	0.004319	0.0000	0.009982	30.92	30.92	31.09	31.08
20	Pipe	22.500	7.460	30.91	30.71	670.0	669.5	-0.206982	-0.206982	-0.2163	0.021647	30.71	30.91	31.08	31.29
21	Pipe	7.500	21.191	31.52	31.36	670.0	669.5	-0.165459	-0.165459	-0.2163	0.117610	31.36	31.52	34.38	34.54
22	Pipe	7.500	21.191	29.73	29.68	669.5	669.5	0.050890	0.050890	0.0000	0.117610	29.73	29.68	32.75	32.70

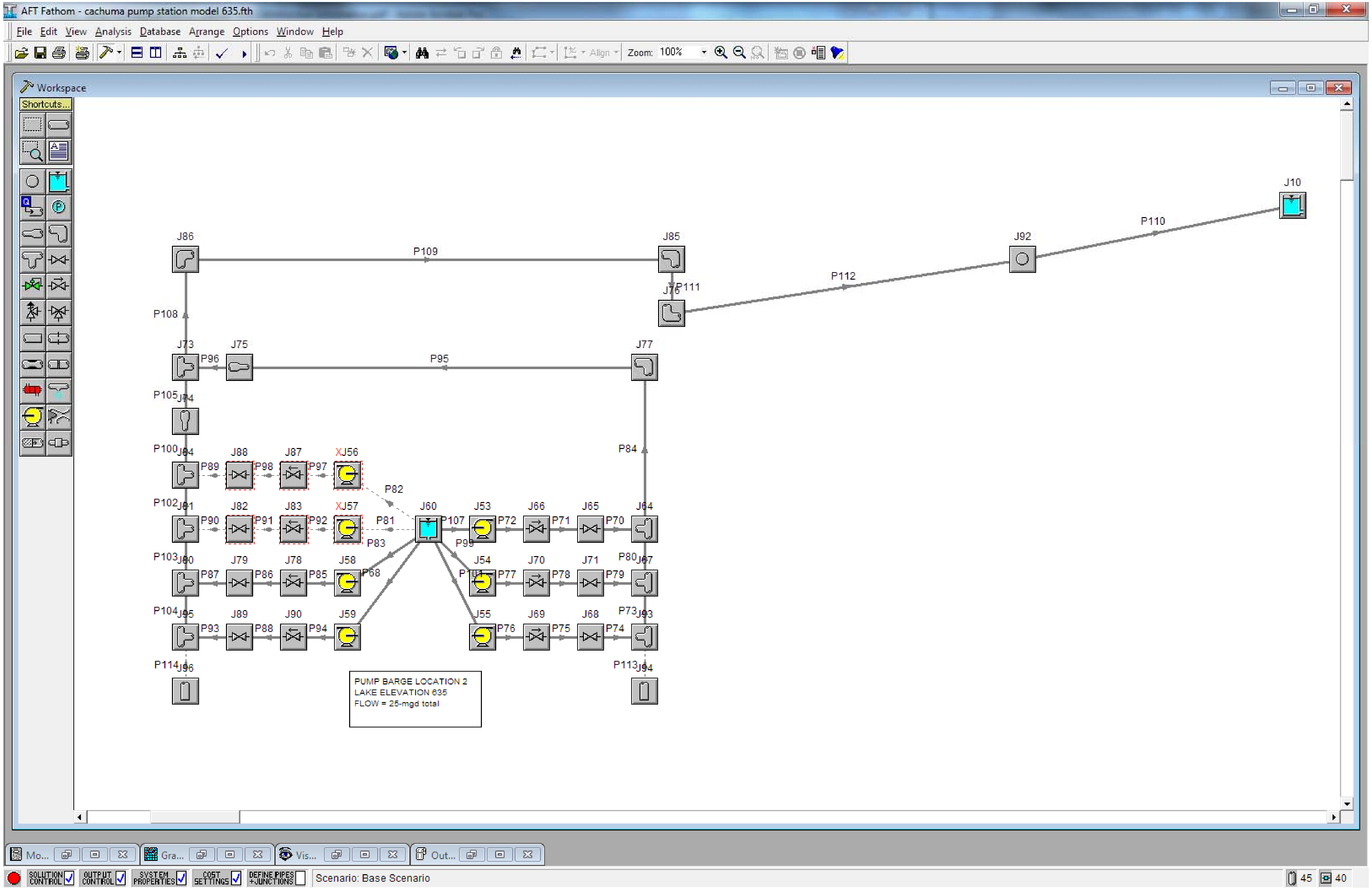
All Junctions | Area Change | Bend | Check Valve | Dead End | Pump | Reservoir | Tee or Wye | Valve

Jct	Name	P Static In (psia)	P Static Out (psia)	P Stag. In (psia)	P Stag. Out (psia)	Vol. Flow Rate Thru Jct (MGD)	Mass Flow Rate Thru Jct (lbm/sec)	Loss Factor (K)
2	Pump	11.90	31.49	12.46	34.51	7.500	723.0	0.00000
3	Pump	11.90	31.50	12.46	34.52	7.500	723.0	0.00000
4	Pump	11.90	31.50	12.46	34.52	7.500	723.0	0.00000
X5	Pump	12.53	30.94	12.53	30.94	0.000	0.0	0.00000
6	Pump	11.90	31.36	12.46	34.37	7.500	723.0	0.00000
7	Pump	11.90	31.36	12.46	34.38	7.500	723.0	0.00000
8	Pump	11.90	31.36	12.46	34.38	7.500	723.0	0.00000
9	Reservoir	14.70	14.70	14.70	14.70	N/A	N/A	0.00000
10	Reservoir	14.70	14.70	14.70	14.70	45.000	4,338.2	0.00000
14	Tee or Wye	30.24	30.24	31.08	31.08	N/A	N/A	0.00000
15	Valve	29.81	28.33	32.83	31.35	7.500	723.0	0.48965
16	Check Valve	31.66	29.86	34.68	32.88	7.500	723.0	0.59548
18	Valve	29.81	28.34	32.83	31.35	7.500	723.0	0.48965
19	Check Valve	31.66	29.86	34.68	32.88	7.500	723.0	0.59548

Mo... | Gra... | Vis...

SOLUTION CONTROL | OUTPUT CONTROL | SYSTEM PROPERTIES | COST SETTINGS | DEFINE PIPES +JUNCTIONS | Scenario: Base Scenario | 44 | 39


AFT Fathom - cachuma pump station model 665.fth - [Visual Report]
File Edit View Analysis Database Arrange Options Window Help
chuma pump station model 665.fth
Q=45 MGD
V=10 feet/sec
Q=45 MGD
V=13 feet/sec
Q=22 MGD
V=7.5 feet/sec
Q=22 MGD
V=7.5 feet/sec
P Out=31 psia
Qthru=0.0 MGD
P Out=31 psia
Qthru=7.5 MGD
P Out=31 psia
Qthru=7.5 MGD
P Out=31 psia
Qthru=7.5 MGD
P Out=31 psia
Qthru=7.5 MGD
P Out=31 psia
Qthru=7.5 MGD
P Out=31 psia
Qthru=7.5 MGD
PUMP BARGE LOCATION 1
LAKE ELEVATION 665
Scenario: Base Scenario
44
39


AFT Fathom - cachuma pump station model 635.fth
File Edit View Analysis Database Arrange Options Window Help
Zoom: 100%
Workspace
Shortcuts...
PUMP BARGE LOCATION 2
LAKE ELEVATION 635
FLOW = 25-mgd total
Scenario: Base Scenario

AFT Fathom - cachuma pump station model 635.fth

File Edit View Analysis Database Arrange Options Window Help

Show: General, Pipes and Junctions

Output

General | Warnings | Pump Summary | Valve Summary | Reservoir Summary

Jct	Name	Vol. Flow (MGD)	Mass Flow (lbm/sec)	dP (psid)	dH (feet)	Overall Efficiency (Percent)	Speed (Percent)	Overall Power (hp)	BEP (MGD)	% of BEP (Percent)	NPSHA (feet)	NPSHR (feet)
53	Pump	5.000	482.0	31.49	72.78	80.61	94.35	79.11	5.883	85.00	27.87	7.769
54	Pump	5.000	482.0	31.49	72.78	80.61	94.36	79.11	5.883	85.00	27.87	7.769
55	Pump	5.000	482.0	31.49	72.78	80.61	94.36	79.12	5.883	84.99	27.87	7.769
X56	Pump	0.000	0.0	N/A	N/A	N/A	0.00	N/A	N/A	N/A	N/A	N/A
X57	Pump	0.000	0.0	N/A	N/A	N/A	0.00	N/A	N/A	N/A	N/A	N/A
58	Pump	5.000	482.0	31.42	72.61	80.63	94.27	78.91	5.877	85.07	27.87	7.760
59	Pump	5.000	482.0	31.42	72.61	80.63	94.27	78.91	5.877	85.07	27.87	7.760

Pipes

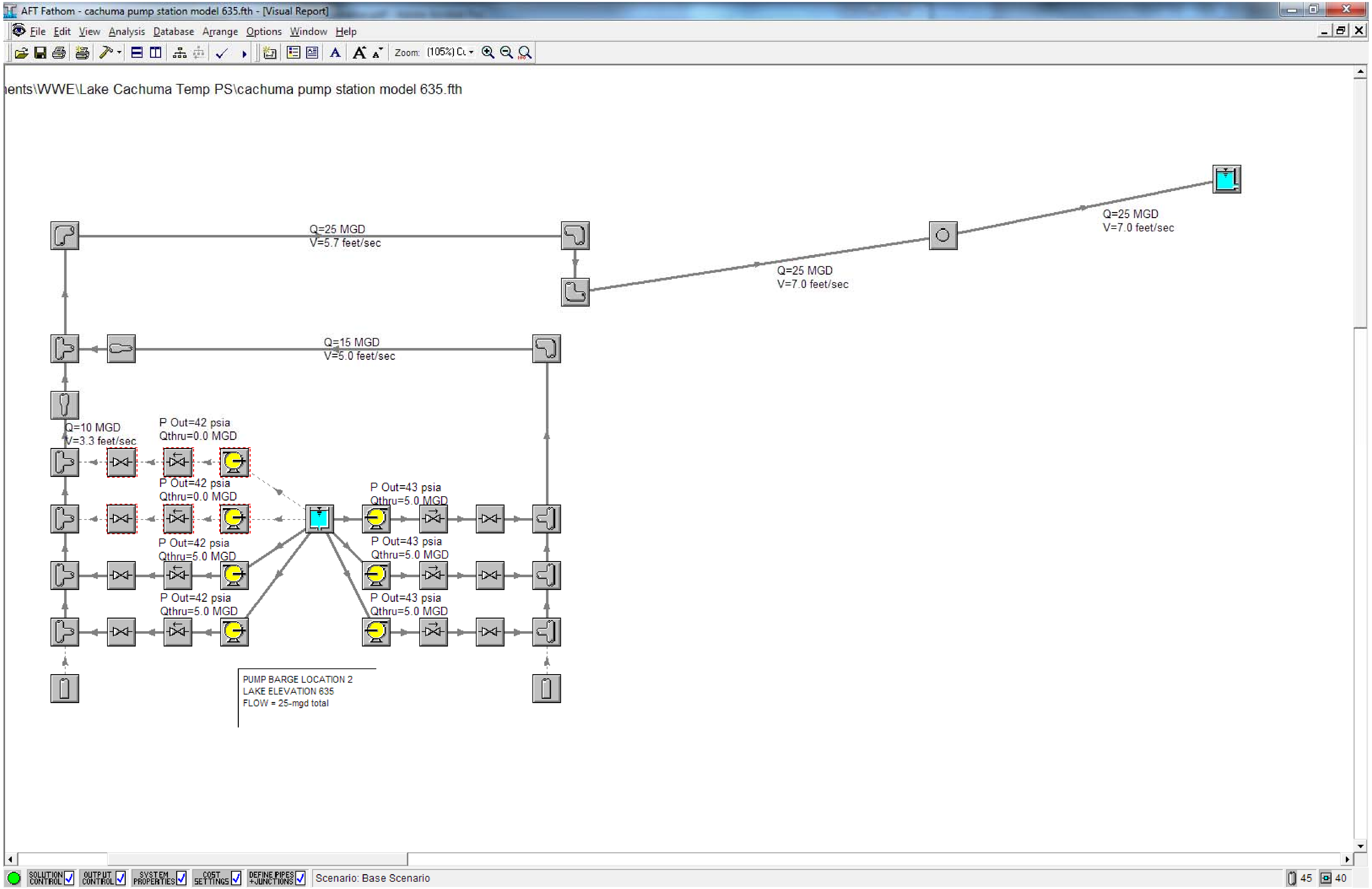
Pipe	Name	Vol. Flow Rate (MGD)	Velocity (feet/sec)	P Static Max (psia)	P Static Min (psia)	Elevation Inlet (feet)	Elevation Outlet (feet)	dP Stag. Total (psid)	dP Static Total (psid)	dP Gravity (psid)	dH (feet)	P Static In (psia)	P Static Out (psia)	P Stag. In (psia)	P Stag. Out (psia)
68	Pipe	5.000	9.850	14.04	11.77	635.0	640.0	2.2743886	2.2743886	2.1635	0.2563042	14.04	11.77	14.70	12.42
70	Pipe	5.000	14.127	41.07	41.04	640.0	640.0	0.0230701	0.0230701	0.0000	0.0533170	41.07	41.04	42.41	42.39
71	Pipe	5.000	14.127	41.75	41.72	640.0	640.0	0.0230701	0.0230701	0.0000	0.0533170	41.75	41.72	43.09	43.07
72	Pipe	5.000	14.127	42.57	42.55	640.0	640.0	0.0230701	0.0230701	0.0000	0.0533170	42.57	42.55	43.91	43.89
73	Pipe	5.000	1.658	42.37	42.37	640.0	640.0	0.0005505	0.0005505	0.0000	0.0012723	42.37	42.37	42.39	42.39
74	Pipe	5.000	14.127	41.07	41.05	640.0	640.0	0.0230701	0.0230701	0.0000	0.0533170	41.07	41.05	42.41	42.39
75	Pipe	5.000	14.127	41.75	41.73	640.0	640.0	0.0230701	0.0230701	0.0000	0.0533170	41.75	41.73	43.09	43.07
76	Pipe	5.000	14.127	42.57	42.55	640.0	640.0	0.0230701	0.0230701	0.0000	0.0533170	42.57	42.55	43.91	43.89
77	Pipe	5.000	14.127	42.57	42.55	640.0	640.0	0.0230701	0.0230701	0.0000	0.0533170	42.57	42.55	43.91	43.89
78	Pipe	5.000	14.127	41.75	41.73	640.0	640.0	0.0230701	0.0230701	0.0000	0.0533170	41.75	41.73	43.09	43.07
79	Pipe	5.000	14.127	41.07	41.05	640.0	640.0	0.0230701	0.0230701	0.0000	0.0533170	41.07	41.05	42.41	42.39
80	Pipe	10.000	3.316	42.31	42.31	640.0	640.0	0.0020068	0.0020068	0.0000	0.0046378	42.31	42.31	42.39	42.39
81	Pipe	0.000	0.000	14.70	12.53	635.0	640.0	2.1634865	2.1634865	2.1635	0.0000000	14.70	12.53	14.70	12.53
82	Pipe	0.000	0.000	14.70	12.53	635.0	640.0	2.1634865	2.1634865	2.1635	0.0000000	14.70	12.53	14.70	12.53

All Junctions | Area Change | Bend | Branch | Check Valve | Dead End | Pump | Reservoir | Tee or Wye | Valve

Jct	Name	P Static In (psia)	P Static Out (psia)	P Stag. In (psia)	P Stag. Out (psia)	Vol. Flow Rate Thru Jct (MGD)	Mass Flow Rate Thru Jct (lbm/sec)	Loss Factor (K)
10	Reservoir	14.70	14.70	14.70	14.70	25.000	2,410.1	0.00000
53	Pump	11.77	42.57	12.42	43.91	5.000	482.0	0.00000
54	Pump	11.77	42.57	12.42	43.91	5.000	482.0	0.00000
55	Pump	11.77	42.57	12.42	43.91	5.000	482.0	0.00000
X56	Pump	12.53	42.31	12.53	42.31	0.000	0.0	0.00000
X57	Pump	12.53	42.31	12.53	42.31	0.000	0.0	0.00000
58	Pump	11.77	42.50	12.42	43.84	5.000	482.0	0.00000
59	Pump	11.77	42.50	12.42	43.84	5.000	482.0	0.00000
60	Reservoir	14.70	14.70	14.70	14.70	N/A	N/A	0.00000
64	Tee or Wye	42.01	42.01	42.39	42.39	N/A	N/A	0.00000
65	Valve	41.72	41.07	43.07	42.41	5.000	482.0	0.48965
66	Check Valve	42.55	41.75	43.89	43.09	5.000	482.0	0.59548
67	Tee or Wye	42.12	42.12	42.39	42.39	N/A	N/A	0.00000
68	Valve	41.73	41.07	43.07	42.41	5.000	482.0	0.48965

Mo... Gra... Vis...

SOLUTION CONTROL | OUTPUT CONTROL | SYSTEM PROPERTIES | COST SETTINGS | DEFINE PIPES +JUNCTIONS | Scenario: Base Scenario | 45 | 40


AFT Fathom - cachuma pump station model 635.fth - [Visual Report]
File Edit View Analysis Database Arrange Options Window Help
Zoom: (105%) Ct
ents\WWE\Lake Cachuma Temp PS\cachuma pump station model 635.fth
Q=25 MGD
V=5.7 feet/sec
Q=25 MGD
V=7.0 feet/sec
Q=25 MGD
V=7.0 feet/sec
Q=15 MGD
V=5.0 feet/sec
Q=10 MGD
V=3.3 feet/sec
P Out=42 psia
Qthru=0.0 MGD
P Out=42 psia
Qthru=0.0 MGD
P Out=42 psia
Qthru=5.0 MGD
P Out=42 psia
Qthru=5.0 MGD
P Out=43 psia
Qthru=5.0 MGD
P Out=43 psia
Qthru=5.0 MGD
P Out=43 psia
Qthru=5.0 MGD
PUMP BARGE LOCATION 2
LAKE ELEVATION 635
FLOW = 25-mgd total
SOLUTION CONTROL
OUTPUT CONTROL
SYSTEM PROPERTIES
COST SETTINGS
DEFINE PIPES +JUNCTIONS
Scenario: Base Scenario
45
40

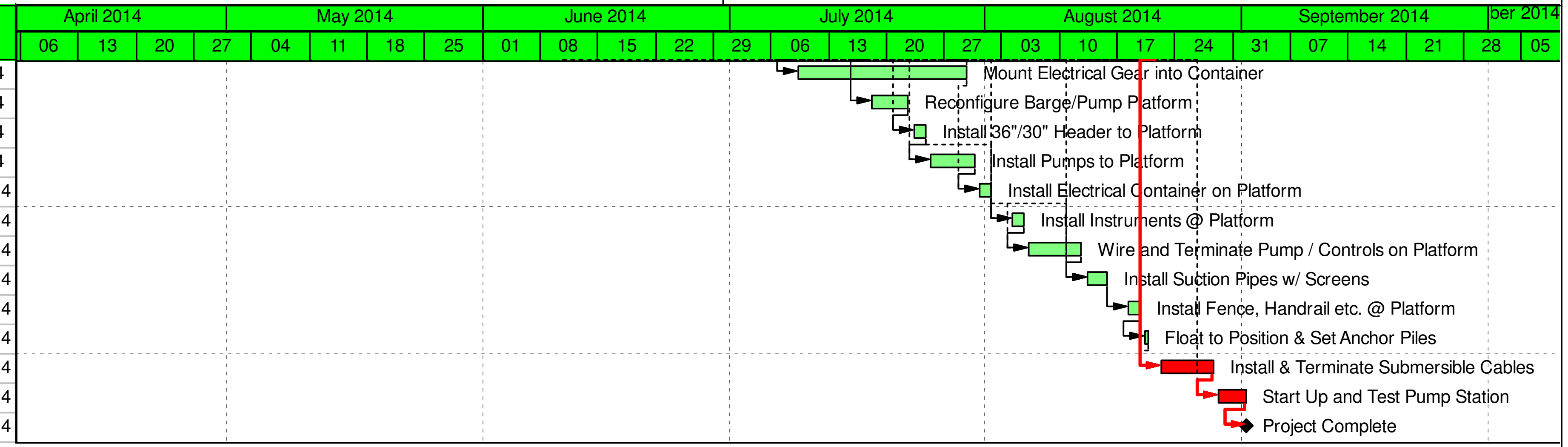
APPENDIX D – PROJECT SCCHEDULE

Activity ID	Activity Name	Original Duration	Start	Finish
	Lake Cachuma Emergency Pumping Station	102	11-Apr-14	01-Sep-14
	Administrative	26	11-Apr-14	19-May-14
02	Contract Award	0	11-Apr-14*	
03	NTP Design	0	22-Apr-14*	
09	Final Plans Approval / Meeting	0	22-Apr-14*	
10	PG & E contract (COMB)	0	22-Apr-14*	
04	Update Schedule	0	01-May-14*	
06	75% Design Approval/ Meeting	0	14-May-14*	
07	Update Schedule	0	19-May-14*	
	Engineering	14	08-May-14	28-May-14
05	75% Design	0	08-May-14*	
08	Final Plans	0	28-May-14*	
	Electrical / Staging Yard	5	22-Apr-14	28-Apr-14
22	Site Mobilization Access Roads/Yard	5	22-Apr-14	28-Apr-14
	Fabricate / Deliver	56	22-Apr-14	08-Jul-14
11	Fab Deliver 12" Anchor Piles	20	22-Apr-14	19-May-14
12	Fab Deliver Pumps	20	14-May-14	10-Jun-14
13	Fab Deliver Intake Screens	30	14-May-14	24-Jun-14
14	Fab Deliver HDPE 36" Pipe	20	14-May-14	10-Jun-14
15	Fab Deliver Electrical Gear	40	14-May-14	08-Jul-14
16	Fab Deliver Electrical Wire	20	14-May-14	10-Jun-14
17	Fab Deliver 30/36" Pipe Header	40	14-May-14	08-Jul-14
18	Fab Deliver Valves and Control	30	14-May-14	24-Jun-14
19	Fab Deliver Gate 5 Intake Box	37	14-May-14	03-Jul-14
20	Fab Deliver Instr. & Controls	30	14-May-14	24-Jun-14
21	Deliver Genset	15	14-May-14	03-Jun-14
	Tower Work	56	01-May-14	17-Jul-14
23	Mobilize Barge and Crane	5	01-May-14	07-May-14
24	Excavate Silt at Intake Tower	2	08-May-14	09-May-14
26	Remove Existing Screen at Gate5	2	15-May-14	16-May-14
27	Confirm Operation Status Gate5	1	19-May-14	19-May-14
29	Install Intake Box @ Gate5	10	04-Jul-14	17-Jul-14
	Transmission Pipe	34	20-May-14	04-Jul-14
28	Drive Anchor Piles @ 36"HDPE	25	20-May-14	23-Jun-14
30	Fuse & Float 36" HDPE Pipe	15	11-Jun-14	01-Jul-14
31	Install Safety Bouys & Signage	3	02-Jul-14	04-Jul-14
	Staging Yard	83	29-Apr-14	21-Aug-14
43	Security Fence @ Staging yard	2	29-Apr-14	30-Apr-14
44	Power to Staging Yard (PG&E / COMB)	77	29-Apr-14	13-Aug-14
48	Set Generator	1	04-Jun-14	04-Jun-14
46	Install Elec Gear Yard Container	10	30-Jul-14	12-Aug-14
45	Power Set Transformer (PG&E / COMB)	1	14-Aug-14	14-Aug-14
47	Electrical Underground @ staging Yard	5	15-Aug-14	21-Aug-14
	Pump Station #1	81	12-May-14	01-Sep-14
25	Excavate pool @ pump Station #1	3	12-May-14	14-May-14

Actual Work | Critical Remaining Work | Summary | Remaining Work | Milestone

TASK filter: All Activities

Activity ID	Activity Name	Original Duration	Start	Finish
35	Mount Electrical Gear into Container	15	09-Jul-14	29-Jul-14
32	Reconfigure Barge/Pump Platform	3	18-Jul-14	22-Jul-14
33	Install 36"/30" Header to Platform	2	23-Jul-14	24-Jul-14
34	Install Pumps to Platform	4	25-Jul-14	30-Jul-14
36	Install Electrical Container on Platform	2	31-Jul-14	01-Aug-14
38	Install Instruments @ Platform	2	04-Aug-14	05-Aug-14
60	Wire and Terminate Pump / Controls on Platform	5	06-Aug-14	12-Aug-14
37	Install Suction Pipes w/ Screens	3	13-Aug-14	15-Aug-14
39	Install Fence, Handrail etc. @ Platform	2	18-Aug-14	19-Aug-14
40	Float to Position & Set Anchor Piles	1	20-Aug-14	20-Aug-14
41	Install & Terminate Submersible Cables	5	22-Aug-14	28-Aug-14
50	Start Up and Test Pump Station	2	29-Aug-14	01-Sep-14
51	Project Complete	0		01-Sep-14



Actual Work | Critical Remaining Work | Summary
Remaining Work | Milestone

TASK filter: All Activities