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MEMORANDUM

DATE: September 20, 2024
TO: Matt Fabry, PE (City of San Mateo)
FROM: Leif Coponen, PE (CA CE #70139) and Yoshi Nakajima, EIT
SUBJECT: Marina Lagoon SDPS – Dewatering Below Elevation 95 - Alternative Analysis

Introduction

The City of San Mateo (City) contracted Schaaf & Wheeler to investigate potential short-term alternatives for lowering the Marina Lagoon water level below Elevation 95 based on the previously prepared memorandum titled "Marina Lagoon Storm Water Pump Station Study" (Schaaf & Wheeler, May 2023), which recommended the City to not operate the existing pump station below Elevation 95.

Schaaf & Wheeler has prepared four (4) conceptual alternative analysis for lowering the Marina Lagoon below Elevation 95. The purpose of this memorandum is to provide the City with an evaluation of each proposed alternative, benefits and drawbacks, and a conceptual engineer's cost estimate. The alternatives studied include:

1. Hydraulic Intake Analysis to determine if existing pumps can safely lower the water level and what hydraulic improvements are required to facilitate lowering the lagoon water level.
2. Installation of a temporary rental pump system to operate below Elevation 95.
3. Use one existing pump/gearbox/engine as a sacrificial pump with anticipated replacement.
4. Construction of a new low-flow pump station adjacent to the existing pump station.

Background

Marina Lagoon (Lagoon) water surface elevation is regulated by the City on a seasonal basis to optimize flood control, recreation, aesthetics, and ecological benefits. The Lagoon's primary water source is tidal flow from San Francisco Bay through O'Neill Slough during high tides. During the wet season, stormwater runoff from the City's drainage area can comprise a large proportion of inflow to the Lagoon.

The water level of the Lagoon is controlled using the O'Neill Slough tide gate structure on the Lagoon's south end and the Marina Lagoon Pump Station on the north end (Figure 1). During the winter months, the water level of the Lagoon is lowered by 2.0 ft from summer operating level of 96.9 ft City of San Mateo datum (CSM) to 94.9 ft CSM to provide volume for the Lagoon to receive stormwater runoff and as a protection from lowland flooding. The City additionally lowers the Lagoon by 1.5 ft to 93.4 ft CSM for a duration of a month within the winter months for "Dock Maintenance Period" (Table 1).

Figure 1 Marina Lagoon Site Plan

During the New Year's Eve storm event on December 31, 2022, the Marina Lagoon experienced higher-than-usual water levels. This was caused by the partial pump station failure consisting of clogging of the trash rack due to high inflow of sediments and debris resulting in inconsistent flow into the wet well and to the pumps, and simultaneously pump and engine failures along with SCADA system issues. As mentioned in the memorandum titled "Marina Lagoon Performance during New Years Eve 2022 storm", the computer hydraulic model results of the New Year's Eve storm event indicated that the water elevation in the Lagoon had little impact on interior flooding of the City upstream of the Lagoon, as local drainage channel capacity is seemingly the primary driver of flooding for areas that were impacted upstream of the Lagoon. However, the computer model also indicates the importance of ensuring that the Marina Lagoon Pump Station can operate as intended to mitigate flooding impacts from such extreme storms. In order to help ensure the pump station remains operational and without failure, the City is assessing the need for modification of pump station operational schemes including lowering the Lagoon water level below the acceptable pumping equipment limits.

The City contracted Schaaf & Wheeler to investigate the feasibility of operating the Marina Lagoon Pump Station below Elevation 95 on a short-term basis. However, as previously mentioned in our memorandum "Marina Lagoon Storm Water Pump Station Study", the original pump station design anticipated lagoon water levels to operate between 95.0 and 98.0 ft CSM. The mechanical systems were designed around these operating parameters and there is not much, if any, flexibility for operating outside of these parameters.

The City is currently preparing an update to the Storm Drain Master Plan. As part of the update, the City plans to conduct a detailed pump station conditional assessment to evaluate the anticipated useful life of the pump station, its components, and improvements to be considered as part of the City's future Capital Improvement Program.

Table 1 Marina Lagoon Operating Levels

Period	Level Adjustment	Elevation (ft)*	Comments
May 1 – Oct. 31	----	96.9	Summer Operating Level
Nov. 1 – Nov. 30	-1 ft	95.9	Preparing for Winter Rains
Dec.1 – Jan. 14	-1 ft	94.9	Winter Operating Level
Jan. 15 – Feb. 15	-1.5 ft	93.4	Dock Maintenance Period
Feb. 16 – Apr. 14	+1.5 ft	94.9	Winter Operating Level
Apr. 15 – Apr. 30	+1 ft	95.9	Spring Immediate Level
May 1 – Oct. 1	+1 ft	96.9	Summer Operating Level

Notes: Elevation reference is the City of San Mateo datum +100 (CSM)

Conceptual Alternatives

Schaaf & Wheeler has proposed and evaluated the four (4) conceptual alternatives mentioned above. The alternatives discussed hereon are to be considered on a short-term basis until the City determines a long-term solution to lower the Lagoon below Elevation 95. These alternatives were proposed to provide Marina Lagoon Pump Station with operational flexibility to safely lower the Lagoon below Elevation 95 throughout the year, and not only during the Dock Maintenance Period. Although not specifically discussed, the City should also consider changing the time of year the Dock Maintenance Period is administered to minimize the amount of rainfall-dependent stormwater required to be pumped from the Lagoon, to occur preferably in the late summer or early fall.

Alternative 1 – Hydraulic Intake Analysis

The concept of Alternative 1 is to perform a Hydraulic Intake Analysis of the Marina Lagoon Pump Station to determine if existing pumps can safely lower the water level and what hydraulic improvements are required to facilitate lowering the lagoon water level below 95 ft CSM.

Operation of any pumps below the pump manufacturer's recommended minimum submergence is likely to cause adverse hydraulic conditions within the wet well that can affect the pump performance due to creation of free and subsurface vortices, swirl approaching the pump impeller, flow separation at the pump bell, and a nonuniform axial velocity distribution at the suction. These hydraulic phenomena are known to cause accelerated wear and tear on pump bearings, cavitation, reduced performance, and fatigue failure. Hydraulic Institute, or HI, is a nonprofit organization that develops and publishes pump standards and guidelines. Per Hydraulic Institute (HI) / Hydraulic National Standard Institute (ANSI) 9.8 – American National Standard for Rotodynamic Pumps for Pump Intake Design, 2018 edition, there are two (2) types of hydraulic studies of intake structures and pump suction piping: (1) Physical Model Study and (2) Computational Fluid Dynamic (CFD) Model Study. Schaaf & Wheeler has evaluated each of the options and summarized below.

Option 1: Physical Model Study

Physical Model Study is a scaled modelling of an existing pump station to investigate and identify unacceptable flow patterns at the pump suction for given suction piping design. Physical Model Study is conducted to troubleshoot problems of existing facilities, confirm intake designs of new stations and existing pump station upgrades and modifications, and to optimize pump station designs. The physical model study is usually conducted by a hydraulic laboratory using personnel that have experience in modeling pump intakes. The objective of the model study is to construct a pump intake in which the pump operates as close to the factory performance testing. The model study also ensures that the final piping design generates favorable flow conditions at the inlet to the pump by deriving remedial measures to alleviate these undesirable flow conditions due to the approach upstream from the pump impeller. Considering the cost for a physical model study, HI recommends for an evaluation if one is required.

Per HI's ANSI/HI 9.8.7.1-2018, a physical hydraulic model study shall be conducted for pump intakes with one or more of the following features:

1. A suction intake arrangement with elevation relative to water level that does not provide the minimum submergence requirement of this standard, irrespective of pump manufacturer's stated submergence values.
2. The intake design is not a standard intake design presented in this standard or the geometry (such as bay width, bell clearances, sidewall angles, bottom slopes, distance from obstructions, the bell diameter, submergence, or piping changes, etc.) deviates from this standard.
3. There is no prior physical model study for the intake design considered in terms of physical features and flow rates.
4. Nonuniform or nonsymmetric approach flow to the pump sump exists.
5. Proper sump operation of a critical service or application as defined by the customer (such as a safety-related system).
6. Pump repair, remediation of a poor design, and the impacts of inadequate performance or pump failure all together would cost more than 10 times the cost of a physical model study.
7. Circular stations with four or more pumps.
8. For trench type wet wells (clear or solid-bearing liquids) the pumps have flows greater than 1,260 L/s (20,000 gpm) per pump or the total station flow with all the pumps running would be greater than 3,155 L/s (50,000 gpm).
9. Circular pump sumps (clear or solids-bearing liquids) with flows exceeding 315 L/S (5,000 gpm) per pump require a physical model study. Circular pump sumps (clear liquids) per Figures 9.8.3.3.1c and 9.8.3.3.1f with station flows exceeding 315 L/S (5,000 gpm) require a physical model study.
10. The pump of a closed bottom can intake has flows greater than 440 L/S (7,000 gpm).
11. The pumps have flows greater than 2,520 L/s (40,000 gpm) per pump or the total station flow with all pumps running would be greater than 6,310 L/s (100,000 gpm)

Following the criteria listed above, HI advises the City to conduct a Physical Model Study for the Marina Lagoon Pump Station as existing and proposed operation of the pump station meets criteria (1), (8), and (11). It is recommended to conduct this study during the project's design phase when design conditions and layouts are being determined and finalized. Typical hydraulic modifications and improvements include baffles, filets, cones and vaned cones, and surface vortex breakers.

Option 2: Computation Fluid Dynamics (CFD) Model Study

Computation Fluid Dynamics, or CFD, Model Study is a computer-based design and analytical technique simulating fluid flow behavior using the Reynolds-averaged Navier–Stokes equation, which is derived from Newton's second law to fluid motion. In a CFD model, the pump station or a device of interest is built in a three-dimensional CAD model and general fluid flow equations and related physical phenomena are applied. The CFD model of a pump station is often simulated at steady-state due to their computational efficiency, however, steady-state models are time averaged and thus cannot predict fluctuating phenomena or short-term extreme values such as transient vortex activity and fluctuations of swirl or point velocities.

Per HI's ANSI/HI 9.8.8.3-2018, a CFD model is acceptable to be used for the following features:

1. Determine the general approach flow to a sump and pump suction piping.
2. Determine the extent of the physical model and the velocity distribution needed at the physical model boundary.
3. Determine whether physical modeling a single pump bay or single suction pipe would be adequate.
4. Compare designs, to aid in the initial selection of design (or design development option) for testing using a physical model, and to better define the range of variables to be tested.

However, HI currently does not recognize CFD as an acceptable method to show compliance with ANSI/HI 9.8 acceptance criteria as it lacks correlations of CFD simulations to experimental results for the complex flow patterns near pumps. Additionally, there has been no standardization or best practice guidelines established for CFD modeling of pump intake and pump suction piping.

Summary:

A summary of the identified comparisons for each hydraulic model study option is provided below.

- Acceptance: Per HI, Physical Model Study is an acceptable method to show compliance with ANSI/HI 9.8 acceptance criteria, however, CFD Model Study is not currently recognized as an acceptable method.
- Accuracy: Results indicate that both types of models share the same accuracy when it comes to velocities and pressure. However, CFD is not likely to accurately account for

unique conditions at the Marina Lagoon Pump Station given the size and criticality of the station. Therefore, Physical Model Study is recommended.

- Accessibility: Both hydraulic model studies are conducted by hydraulic experts with experience in modeling pump intakes. The accessibility to these studies is limited.
- Schedule: CFD Modeling is typically faster than Physical Modeling. In many cases, designs resulting from a CFD model are available several weeks before similar results from a scale model.
- Cost: CFD Model studies are generally 20-40% less than a comparable physical model. This is most likely due to the labor intensity difference in model construction that influences the schedule. Also, many CFD tasks can be automated with the computer, including the design optimization process, whereas these tasks are usually completed manually with the physical model. The estimated total cost of physical modeling is $250,000.
- Storage: CFD Models are usually stored on a computer which typically has a much longer storage life and negligible space requirements. Physical models can take up considerable space in a warehouse. A benefit of the physical model after the design effort is that it can be used for training tool or as a display item. Both hydraulic model studies can be reused and re-evaluated during the design of the pump station.

Alternative 2 – Temporary Rental Pump System

The concept of Alternative 2 is to install a temporary rental pump system adjacent to the existing Marina Lagoon Pump Station along Detroit Dr. during the Dock Maintenance period when the Lagoon water elevation below 95 ft CSM is required. The temporary pumping system includes large skid-mounted pumps driven by diesel engines, fusible HDPE piping, intake screens, fuel tanks, and pump control systems, and site security measures. The pumping system requires refueling of fuel tanks and other operational oversight during pump operation.

Schaaf & Wheeler has proposed two (2) locations as shown in Figure 2 and Figure 6. For both options, two (2) rental pumps were placed parallel to each other for increased pump capacity and redundancy.

To select the appropriate rental pump that provides sufficient pump capacity for each option, a system curve was developed based on the existing topography of the area using 2017 San Mateo County LiDAR topography Digital Elevation Model (DEM) with proposed operational set points to lower the Lagoon. A system curve is comprised of static lift and dynamic head of the system and typically includes a high head and low head system curves to provide an approximate range of the operational limits at various conditions. For the proposed temporary rental pump system, the static lift depends on the level of the Marina Lagoon and tidal conditions of the San Francisco Bay, and dynamic head depends on the frictional loss through the proposed piping and minor losses of various pipe fittings from the suction to the discharge of the system (Table 2).

Table 2 System Curve Parameters

Pump	Suction Elevation	Discharge Elevation
High Head	Pump OFF Setting	MHHW
Low Head	Pump ON Setting	MLLW

To maintain the level of the Lagoon for the City's Dock Maintenance period, Schaaf & Wheeler has selected the following pump set points for Pump Start and Pump Stop at 93.4 ft CSM and 92.9 ft CSM, respectively (Table 3).

Table 3 Temporary Rental Pump

Controls and Set Points	
Pump Start Level	93.4 ft CSM
Pump Stop Level	92.9 ft CSM

Option 1: East Side of the Marina Lagoon Pump Station

As shown below, Option 1 shows the installation of the temporary rental pump system on the east side of the Marina Lagoon Pump Station (Figure 2). The rental pump system is assumed to be placed along the shoreline of the Lagoon with discharge lines installed across the Detroit Dr. adjacent to the parking space and discharged to the San Francisco Bay.

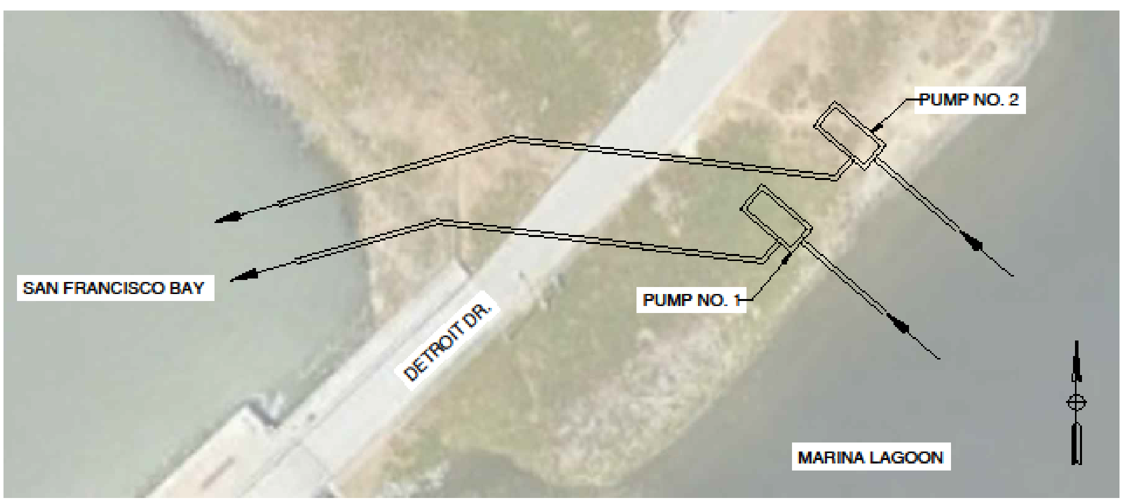

Figure 2 Option 1 - Location of Temporary Rental Pumps

Figure 3 and Figure 4 show the system curve with the selected pump curve for Pump No. 1 and Pump No. 2, respectively, based on the previously discussed system curve parameters with the configuration of the two (2) rental pumps at the controls and set points. From the pump information obtained from the pump manufacturer, the black solid line represents the pump curve, green gradient lines show the Preferred Operating Region (POR), and the red gradient lines show the Allowable Operating Region (AOR).

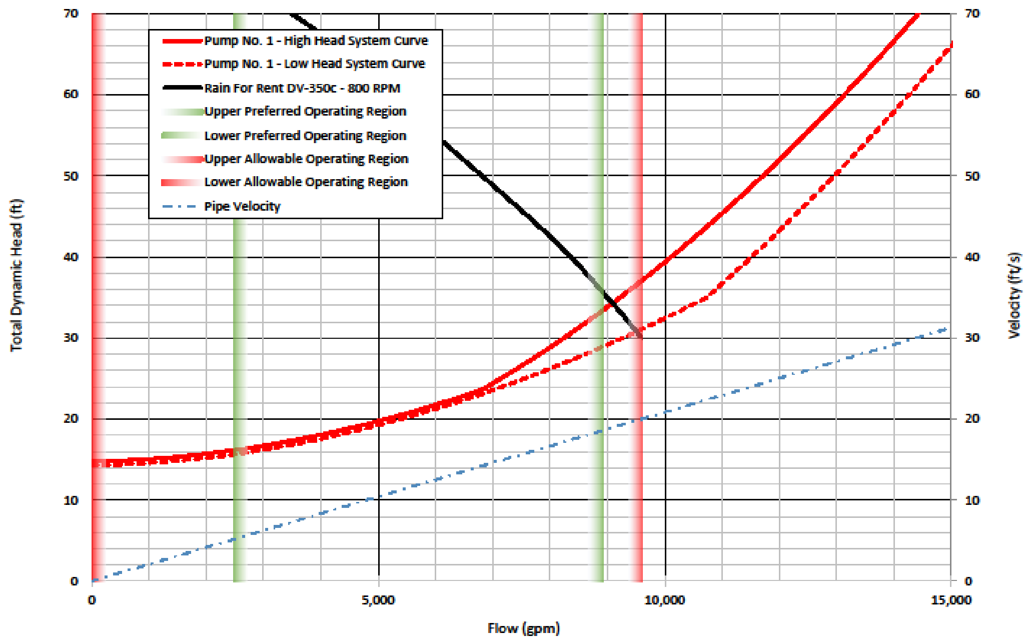

Figure 3 Pump No. 1 – Pump Hydraulics with AOR and POR

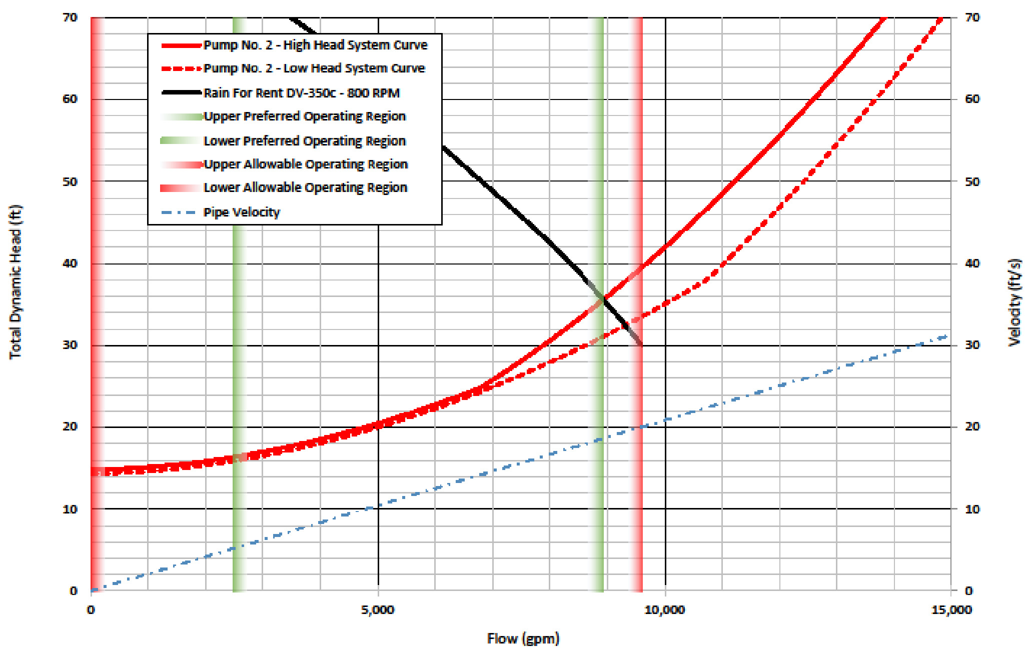

Figure 4 Pump No. 2 – Pump Hydraulics with AOR and POR

Pump No. 1 was selected to operate within the operating conditions of 9,200 gpm, or 20.5 cfs @ 34.0’ TDH with 75.2% Pump Efficiency and 9,500 gpm, or 21.2 cfs @ 31.0’ TDH with 70.8% Pump Efficiency. The proposed pump operates within the range of the pump manufacturer’s AOR; however, it is operating outside of the recommended or POR at both head conditions.

Pump No. 2 was selected to operate within the operating conditions of 8,900 gpm, or 19.8 cfs @ 35.8' TDH with 76.6% Pump Efficiency and 9,300 gpm, or 20.7 cfs @ 32.1' TDH with 71.8% Pump Efficiency. The proposed pump operates within the range of the pump manufacturer's AOR; however, it is operating outside of the recommended or POR at low head condition.

Table 4 Proposed Temporary Rental Pump

Rental Pump Specification	
Manufacturer	Rain For Rent
Model No.	DV-350c
Details	Continuous self-priming
Pump Size	14" x 14"
Suction, in.	14"
Discharge, in.	14"
Dry Weight, lbs.	13,000 lbs.
Footprint	192" x 92" (Trailer mounted)
Fuel Tank	100 gallons
Fuel Consumption	17 gph @ 1,900 RPM

All pumps must meet the Net Positive Suction Head (NPSH) required by the manufacturer. NPSH required, or $NPSH_R$, is the minimum suction head to achieve a specified performance of the pump at a specified rate of flow and to avoid cavitation of the pump. To ensure the pumps are operated as defined by the pump manufacturer and to protect the pump from cavitation, the NPSH available, or $NPSH_A$ must exceed the $NPSH_R$. $NPSH_A$ is the total suction head on the system side as the water enters the pump. Per HI's ANSI/HI 9.6.1.5.5-2017, a NPSH margin or safety factor of 1.1 to 1.3 is recommended. $NPSH_A$ is calculated from the atmospheric pressure of the location, the suction pressure or submergence of the pump, vapor pressure of the liquid, and the losses in the suction pipe. Calculated value for $NPSH_A$, $NPSH_R$, and margin of safety are summarized in Table 5.

Table 5 Option 1 - Temporary Rental Pump $NPSH_R$ and $NPSH_A$

Abbreviation	Parameters	Pump No. 1	Pump No. 2
H_{atm}	Atmospheric Pressure	33.9'	33.9'
H_{el}	Suction pressure/submergence	1.0'	1.0'
H_{vp}	Vapor pressure of liquid	0.59'.	0.59'
Headloss	Losses in the suction pipe	-	-
	$NPSH_A$	34.31'	34.31'
	$NPSH_R$	15.0'	15.0'
	Margin	2.29	2.29

Note: Atmospheric Pressure @ 0' Sea Level and Vapor Pressure of Water Temperature at 60°F

From Figure 5, the location of the proposed suction line has an estimated Lagoon invert of -3.5 to -3.0 ft NAVD88, or 91.44 to 91.94 ft CSM, with available submergence of approximately 0.96 to 1.46 ft, respectively, from the pump off set point at 92.9 ft CSM. To prevent suction of debris and sediment buildup at the bottom of the Lagoon while sufficient submergence is maintained to minimize creation of free surface vortices and to prevent damages to the pumps, the suction pipe is expected to be submerged at roughly 1.0 ft from the elevation of the water with a buoy.

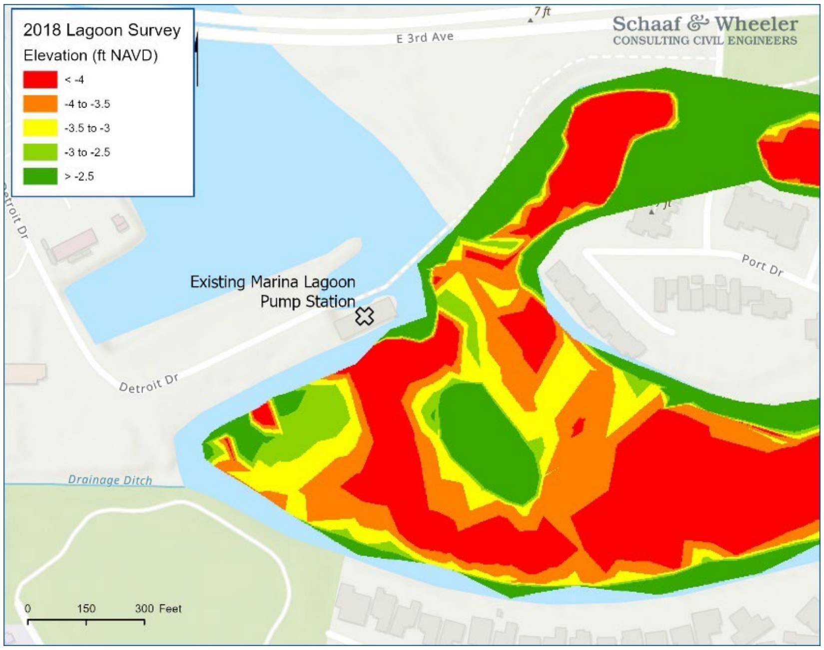

Figure 5 2018 Marina Lagoon Preliminary Dredging Assessment Survey

The two (2) proposed rental pumps at this location are expected to have a total pump capacity of 18,100 to 18,800 gpm, or 40.3 cfs to 41.9 cfs, respectively. Based on "Marina Lagoon Preliminary Dredging Assessment" (Moffatt & Nichol, 2018) and 2018 San Mateo County LiDAR topography DEM, the total volume of the Lagoon to be pumped out from 94.9 ft CSM to 92.9 ft CSM is approximately 311 acre-foot (AF), or 101,339,661 gallons (Table 6). Therefore, the two (2) pumps would be operated continuously for 90 to 93 hours to lower the Lagoon assuming no additional inflow from storm runoff.

Table 6 Volume of the Marina Lagoon per Elevation

Elevation (NAVD88)	Elevation (CSM)	Storage Volume (Acre-Foot)	Storage Volume (gal)
-2.04	92.9	201.7	65,733,306
-1.54	93.4	271.7	88,548,142
-1.04	93.9	347.4	113,195,681
-0.54	94.4	427.9	139,427,202
-0.15	94.8	494.9	161,255,529
-0.05	94.9	512.7	167,062,985

<u>Option 2: West Side of the Marina Lagoon Pump Station</u>

As shown below, Option 2 shows the installation of the temporary rental pump system on the west side of the Marina Lagoon Pump Station (Figure 6). The rental pump system is assumed to be placed along the shoreline of the Lagoon with discharge lines installed across the Detroit Dr. adjacent to the park and discharged to the San Francisco Bay from the existing paved pathway.

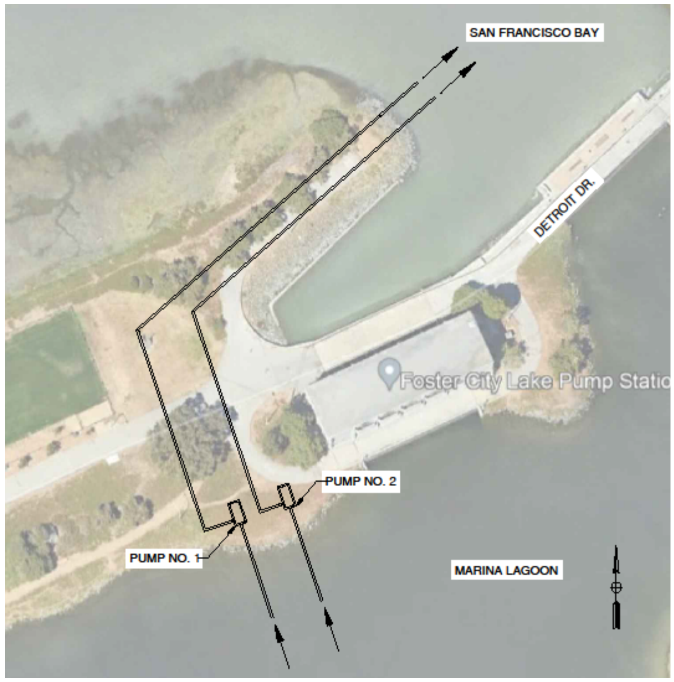

Figure 6 Option 2 - Location of Temporary Rental Pumps

Figure 7 and Figure 8 show the system curve with the selected pump curve for Pump No. 1 and Pump No. 2, respectively, based on the previously discussed system curve parameters with the configuration of the two (2) rental pumps at the controls and set points. Similarly, the black solid line represents the pump curve, green gradient lines show the POR, and the red gradient lines show the AOR.

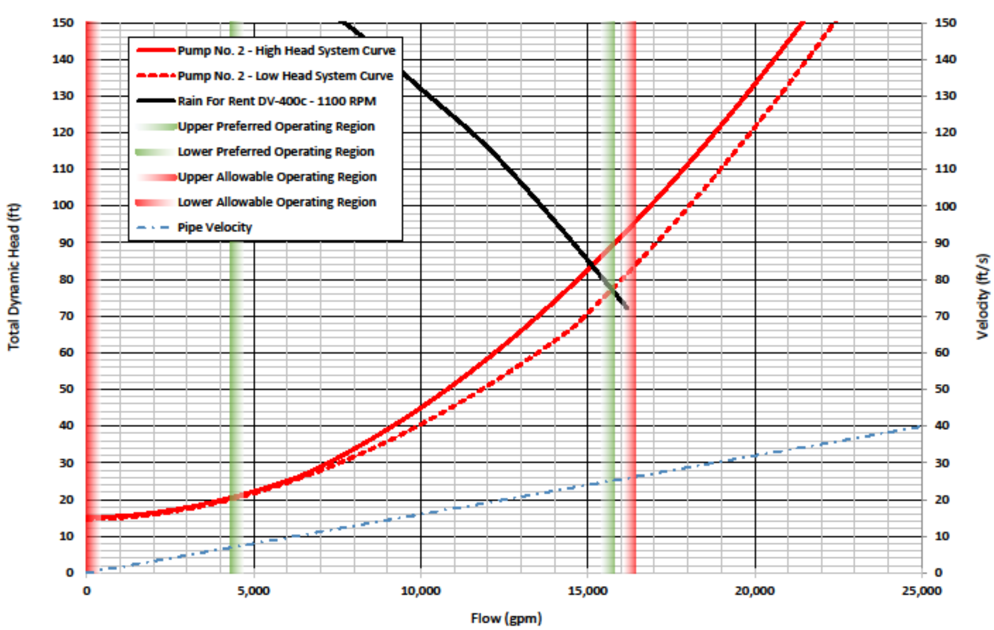

Figure 7 Pump No. 1 - Pump Hydraulics with AOR and POR

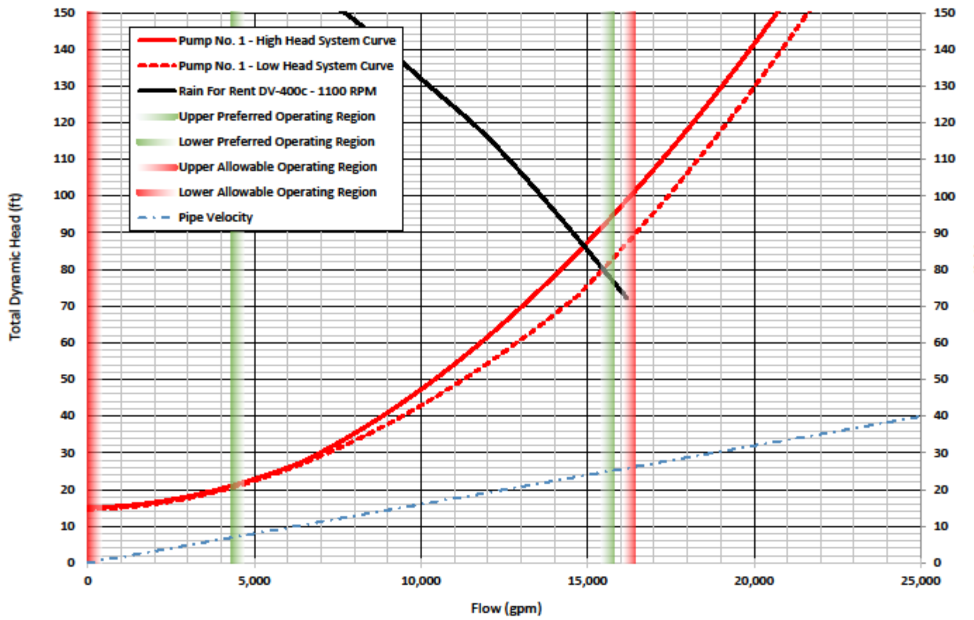

Figure 8 Pump No. 2 - Pump Hydraulics with AOR and POR

Pump No. 1 was selected to operate within the operating conditions of 14,800 gpm, or 33.0 cfs @ 86.1' TDH with 76.6% Pump Efficiency and 15,500 gpm, or 34.5 cfs @ 80.0' TDH with 76.4% Pump Efficiency. The proposed pump operates within the range of the pump manufacturer's AOR and is also within the POR at both head conditions.

Pump No. 2 was selected to operate within the operating conditions of 15,200 gpm, or 33.9 cfs @ 83.5' TDH with 76.3% Pump Efficiency and 15,800 gpm, or 35.2 cfs @ 77.0' TDH with 76.8% Pump Efficiency. The proposed pump operates within the range of the pump manufacturer's AOR and is also within the POR at both head conditions.

Table 7 Proposed Temporary Rental Pump

Rental Pump Specification	
Manufacturer	Rain For Rent
Model No.	DV-400c
Details	Continuous self-priming
Pump Size	18" x 16"
Suction, in.	18"
Discharge, in.	16"
Dry Weight	14,793 lbs.
Footprint	192" x 96" (Trailer mounted)
Fuel Tank	100 gallons
Fuel Consumption	23.4 gph @ 1,600 RPM

Similarly, to Option 1, all pumps must meet the NPSH required by the pump manufacturer. Per HI's ANSI/HI 9.6.1.5.5-2017, a NPSH margin or safety factor of 1.1 to 1.3 is recommended. Calculated value for $NPSH_A$, $NPSH_R$, and margin of safety are summarized in Table 8.

Table 8 Option 2 - Temporary Rental Pump $NPSH_R$ and $NPSH_A$

Abbreviation	Parameters	Pump No. 1	Pump No. 2
H_{atm}	Atmospheric Pressure	33.9’	33.9’
H_{el}	Suction pressure/submergence	1.0’	1.0’
H_{vp}	Vapor pressure of liquid	0.59’.	0.59’
Headloss	Losses in the suction pipe	-	-
	$NPSH_A$	34.31’	34.31’
	$NPSH_R$	31.0’	31.0’
	Margin	1.11	1.11

Note: Atmospheric Pressure @ 0’ Sea Level and Vapor Pressure of Water Temperature at 60°F

From Figure 5, the location of the proposed suction line has an estimated Lagoon invert of -4.0 to -3.5 ft NAVD88, or 90.94 to 91.44 ft CSM, with available submergence of approximately 1.46 ft to 1.96 ft, respectively, from the pump off set point at 92.9 ft CSM. To prevent suction of debris and sediment buildup at the bottom of the Lagoon while sufficient submergence is maintained to minimize creation of free surface vortices and to prevent damages to the pumps, the suction line is expected to be submerged at roughly 1.0 ft from the elevation of the water with a buoy.

The two (2) proposed rental pumps at this location are expected to have a total pump capacity of 30,000 to 31,300 gpm, or 66.8 cfs to 69.7 cfs, respectively. Based on “Marina Lagoon Preliminary Dredging Assessment” (Moffatt & Nichol, 2018) and 2018 San Mateo County LiDAR topography DEM, the total volume of the Lagoon to be pumped out from 94.9 ft CSM to 92.9 ft CSM is approximately 311 acre-foot (AF), or 101,339,661 gallons (Table 6). Therefore, the two (2) pumps would be operated continuously for 54 to 56 hours to lower the Lagoon assuming no additional inflow from storm runoff.

Summary:

A summary of the identified comparison for each of the temporary rental pump systems is provided below. For both options, the total pump capacity is less than 20% of one (1) existing pump and the rental pumps may need to operate for a longer period to keep the Lagoon low during the Dock Maintenance Period due to expected inflows with the operation of the temporary rental pump system during the wet season. The capacity of the rental pumps may not be able to handle rainstorm events.

Option 1:

- The total pump capacity of the two (2) proposed pumps is 18,100-18,800 gpm or approximately 1/8 of one (1) existing Marina Lagoon Pump Station pump.
- Require continuous operation of the temporary rental pump system for 90 to 95 hours to lower the Lagoon assuming no additional inflow from storm runoff. With the consideration of noise pollution, it is assumed that the pumps would not be operated 24/7. Therefore, it would take roughly 8 days at 12 hours per day to lower the Lagoon.
- The total length of piping required for Pump No. 1 and 2 is approximately 150 LF of 14” diameter and 170 LF of 14” diameter, respectively.
- The estimated total cost is $150,000-$175,000/month.

Option 2:

- The total pump capacity of the two (2) proposed pumps is 30,000-31,300 gpm or approximately 1/5 of one (1) existing Marina Lagoon Pump Station pump.
- Require continuous operation of the temporary rental pump system for 54 to 56 hours to lower the Lagoon assuming no additional inflow from storm runoff. With the consideration of noise pollution, it is assumed that the pumps would not be operated 24/7. Therefore, it would take roughly 5 days at 12 hours per day to lower the Lagoon.
- The total length of the piping required for Pump No. 1 and 2 is approximately 70 LF of 18" diameter and 420 LF of 16" diameter, and 71 LF of 18" diameter and 380 LF of 16" diameter, respectively.
- The estimated total cost is $175,000-$200,000/month.

Alternative 3 – Sacrifice Existing Pump with Anticipated Pump Replacement

The concept of Alternative 3 is to use one of the five existing pumps and its mechanical components as a sacrificial pump to lower the Lagoon level below Elevation 95.

Schaaf & Wheeler has evaluated the following two (2) options for this alternative.

<u>Option 1: Utilization of Existing Pump to Pump Below Elevation 95</u>

Option 1 is to operate one of the existing pumps as a permanent Lead pump when lowering the Lagoon level below Elevation 95. The pump is termed "sacrificial" as the existing pump is anticipated to be operated outside of the original designed operating parameters and risks severe damaged with the City's preference to lower the Lagoon elevation below 95 ft CSM. The Marina Lagoon Pump Station is comprised of five (5) individual pump assemblies each consisting of a diesel engine driver, right-angle gear reduction box, drive shaft, and an axial-flow pump. The five (5) main stormwater pumps have 102-inch diameter intake bell at elevation 83.0 ft CSM, 72-inch diameter pipe column, and individual 72-inch diameter flap-gated discharges with invert elevation of 97.0 ft CSM. The Marina Lagoon Pump Station was designed and constructed to operate between 95.0 and 98.0 ft CSM. Schaaf & Wheeler has previously discussed with Patterson Pump Company, pump manufacturer of the existing pumps, and was informed that the bell submergence per current ANSI/HI 9.8-2018 Intake Standard is about 15.5', or minimum submergence to 98.5 ft CSM, and an aggressive bell submergence that considers a high-quality intake design and an intake study is calculated to be bell submergence of 12.5', or minimum submergence to 95.5 ft CSM. With the current controls and setpoints, the existing bell submergence is lower than these values. Subsequently, as the Lagoon water level decreases, intake approach velocities increase and velocities across the trash rack increase. Increased velocities at the trash rack increase headloss across the trash rack and increased intake approach velocities cause structural vibration problems.

In addition, the existing mechanical components of the pump were selected to match the design of these pumps (Table 9 and Table 10) as referenced from previous memorandum titled "Marina Lagoon Storm Water Pump Station Study" (Schaaf & Wheeler, May 2023)

Table 9 Existing Diesel Drivers

Diesel Driver Specification	
Manufacturer	Cummins
Model No.	VT A28P (VTA-1710P) V-12
Rating Point	545 HP @ 1,800 RPM
Idle Speed	800 RPM
Max. No Load Speed	2,000 RPM

Table 10 Existing Right-angle Gear Drive (Pump 1 and 2)

Right-angle Gear Drive Specification	
Manufacturer	TWG Thyssen Getriebe-Und Kupplungswerke
Model No.	KBV 315/S/So
Gear Ratio:	6.3 to 1
Rating Point	520 HP @ 1,800 RPM
Details	Anti-reverse rotation mechanism Horizontal input, vertical output
AGMA Service Factor	1.25

Figure 9 shows the system curve comprised of design, high head, and low head based on the system curve parameters and controls and setpoints to lower the Lagoon to Elevation 95. From the information provided by the pump manufacturer, the black dashed line represents the existing pump curve, orange solid line represents the break horsepower (BHP) of the pump at designed 275 RPM, and orange dotted line represents the BHP required at the diesel engine. As shown in the figure, the maximum required BHP to operate at the set operating conditions is 625 HP at 135,000 gpm. The required BHP to decrease the Lagoon level to 93.4 ft CSM exceeds above the existing HP rating of both diesel engine and the right-angle gear drive box.

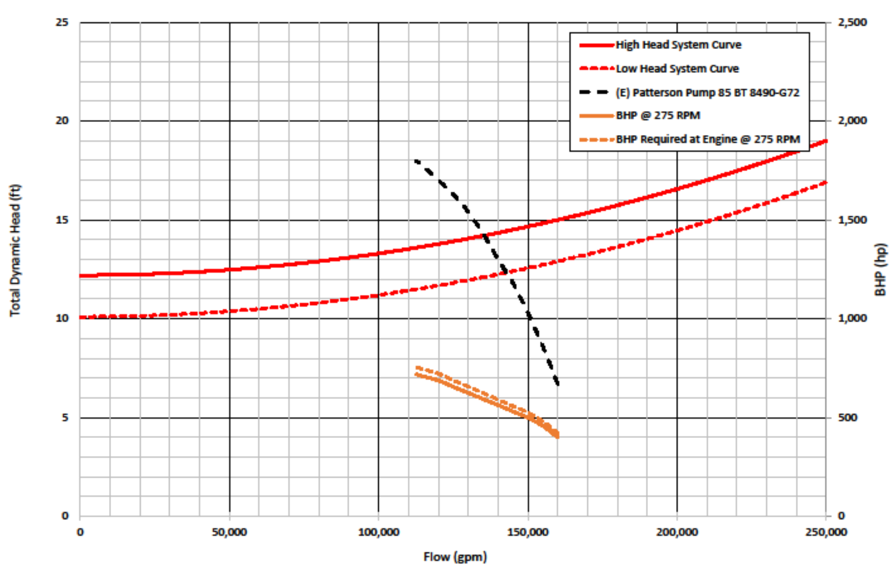

Figure 9 Existing Pump – Pump Hydraulics

Therefore, operation of the pump system outside the designed range may result in damaging the pump and its equipment due to (1) Below pump manufacturer's "aggressive" minimum submergence at 95.0 ft CSM, which may lead to formulation of surface vortices and air entrainment and result in reduced pump performance and possibly cause cavitation to the internals of the pump, and (2) Increased horsepower requirements above the rated power output of the existing engine and gear box with the increased lift to lower the Lagoon elevation would result in unnecessary stress, and wear and tear to the mechanical components. Replacement of failed equipment is expected to take at least 12 months.

<u>Option 2: Replacement of Existing Pump with Smaller New Pump</u>

Option 2 is to replace one of the existing pumps with a smaller new pump capable of lowering the Lagoon below Elevation 95 and to warehouse the existing pump and gear box as a back-up pump.

With this alternative, the existing wet well, trashrack, diesel engine, discharge pipe and outfall structure are expected to remain the same due to the constraint of time, significant financial costs, and the need for extensive design and construction to rehabilitate and/or replace the existing structures. The components to be replaced are one of five existing axial-flow pumps and its associated right-angle gear reduction box and drive shaft to match the proposed pump speed. The replacement pump would have reduced capacity to allow existing equipment to operate within preferred regions.

Based on the current configuration and setpoints at the Marina Lagoon Pump Station, Lead Pump is expected to be replaced as the pump is set at the lowest operational start point. To maintain the Lagoon below the City's preferred water elevation of 93.4 ft CSM, Schaaf & Wheeler assume the setting of the Lead Pump to be adjusted from Pump Start at 95.45 ft to 93.40 ft CSM and Pump Stop at 95.00 ft to 92.90 ft CSM (Table 11) during the Dock Maintenance Period.

Table 11 Proposed Marina Lagoon Pump Station Controls and Set Points

Pump	Pump Start (ft CSM)	Pump Stop (ft CSM)
Lead	93.40	92.90
Lag 1	95.65	95.10
Lag 2	95.85	95.20
Lag 3	96.05	95.30
Lag 4	96.25	95.40

From the As-built drawings of the Marina Lagoon Pump Station and the proposed controls and set points, a system curve consisting of design, high head, and low head was developed to select the appropriate pump that provides similar pump capacity to the existing pump but provides additional minimum submergence to lower the Lagoon below Elevation 95. At Marina Lagoon Pump Station, the static lift depends on the level within the existing wet well and tidal conditions of the San Francisco Bay, and the dynamic head depends on the frictional loss through the proposed 54-inch diameter suction pipe and existing 72-inch diameter discharge pipe, and minor losses of various pipe fittings from the intake bell to the outfall structure (Table 12).

Table 12 System Curve Parameters

Pump	Wet Well Elevation	Discharge Elevation
High Head	Pump Stop Level	Tidal Condition @ 100-year Tide EL.
Low Head	Pump Start Level	Tidal Condition @ MLLW and 72-inch Forcemain Centerline EL.
Design	Pump Start Level	Tidal Condition @ MSL and 72-inch Forcemain Crown EL.

Figure 10 shows the system curve of design, high, and low heads from the previously discussed system curve parameters and proposed pump station controls and set points. From the pump information obtained from the pump manufacturer, the black dotted line represents the existing pump curve, the black solid line represents the proposed pump curve, green gradient lines show the POR, the red gradient lines show the AOR, the orange solid line represents the pump break horsepower at 325 RPM, and orange dotted line represents the required break horsepower at the diesel engine.

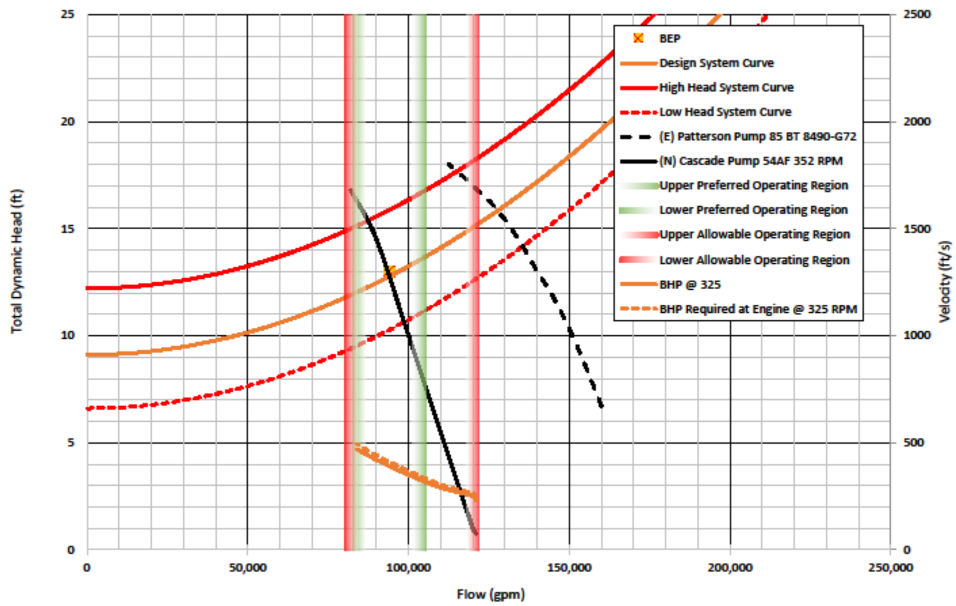

Figure 10 Existing and Proposed Lead Pump – Pump Hydraulics with AOR and POR

Lead Pump was selected to operate within the operating conditions of 88,500 gpm, or 197.2 cfs @ 15.4' TDH with 77.0% Pump Efficiency and 98,000 gpm, or 218.3 cfs @ 10.6' TDH with 73.0% Pump Efficiency. The proposed pump operates within the range of the pump manufacturer's AOR and is also within the POR of 90% and 110% from the Best Efficiency Point (BEP) at both head conditions. With the proposed pump and the existing discharge pipe, the pipe velocity is estimated at 7.2 ft/s and 8.0 ft/s, respectively, which is below the recommended limit of the upper velocity to avoid damaging the pipe surface and/or scouring the pipe lining material. At design, the proposed pump operates at 94,000 gpm, or 209.4 cfs @ 12.9' TDH with 76.7% Pump Efficiency. The maximum required BHP to operate at the set operating conditions is 447 HP at 88,500 gpm, which is less than the 545 HP rating of the existing diesel engine. The proposed pump is expected to be installed with a 11:2 ratio right-angle gear drive to match the speed of the proposed pump with the existing engine.

Table 13 Proposed Lead Pump Replacement

Proposed Pump Specification	
Manufacturer	Cascade Pump Company
Model No.	AF5420
Pump Type	Axial-flow
Driver	Diesel Engine
Speed, RPM	325
Break Horsepower, HP	470
Pump Suction, in.	54”
Pump Discharge, in.	72”

All pumps are required to maintain a minimum submergence level above the pump suction bell to avoid the creation of vortices and air entrainment. The pump manufacturer of the proposed pump requires minimum submergence of approximately 106” (8.8’) whereas the pump manufacturer of the existing pump at the Marina Lagoon Pump Station requires minimum submergence of approximately 150” (12.5’). In addition, the pump manufacturer requires adequate floor clearance between the inlet bell and the wet well structure. Excessive floor clearance increases the occurrence of stagnant zones and submerged vortices are also sensitive to floor clearance. Per HI, recommended floor clearance is 0.3 and 0.5 of inlet bell diameter. Therefore, the proposed pump has a bell diameter of 84” (7.0’) and the required floor clearance of the proposed pump is 42” (3.5’) whereas the existing pump has a floor clearance of 60” (5.0’). As a result, the proposed pump provides the City with at least 4.7 ft of additional submergence level which allows the City to decrease the pump level to the proposed 92.9 ft with the existing wet well. As shown in Figure 11, the red text indicates the existing pump level and condition, blue text indicates the proposed pump level and set points, and green indicates the tidal conditions of San Francisco Bay.

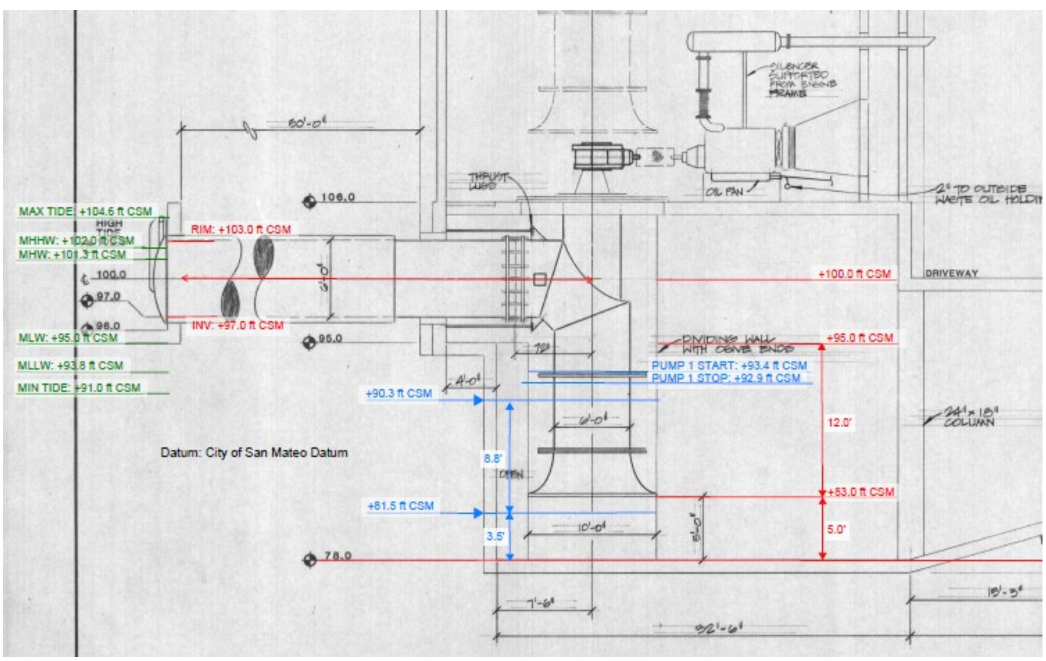

Figure 11 Existing and Proposed Pump Drawing

In addition, all pumps must meet the NPSH required by the pump manufacturer. Per HI's ANSI/HI 9.6.1.5.5-2017, a NPSH margin or safety factor of 1.1 to 1.3 is recommended. Calculated value for $NPSH_A$, $NPSH_R$, and margin of safety are summarized in Table 14.

Table 14 Proposed Lead Pump $NPSH_R$ and $NPSH_A$

Abbreviation	Parameters	Lead Pump
H_{atm}	Atmospheric Pressure	33.9'
H_{el}	Suction pressure/submergence	11.4'
H_{vp}	Vapor pressure of liquid	0.59'
Headloss	Losses in the suction pipe	-
	$NPSH_A$	44.71'
	$NPSH_R$	33.0'
	Margin	1.35

Note: Atmospheric Pressure @ 0' Sea Level and Vapor Pressure of Water Temperature at 60°F

As stated in our previously prepared memorandum titled "Marina Lagoon Performance during New Years Eve 2022 Storm" (Schaaf & Wheeler, March 2023), the Lagoon is a mapped Federal Emergency Management Agency (FEMA) Special Flood Hazard Area (SFHA) Zone AE. Therefore, Schaaf & Wheeler has also performed hydraulic modeling of the Marina Lagoon with the proposed smaller pump to ensure the modified pump station has sufficient capacity for a 100-year storm event.

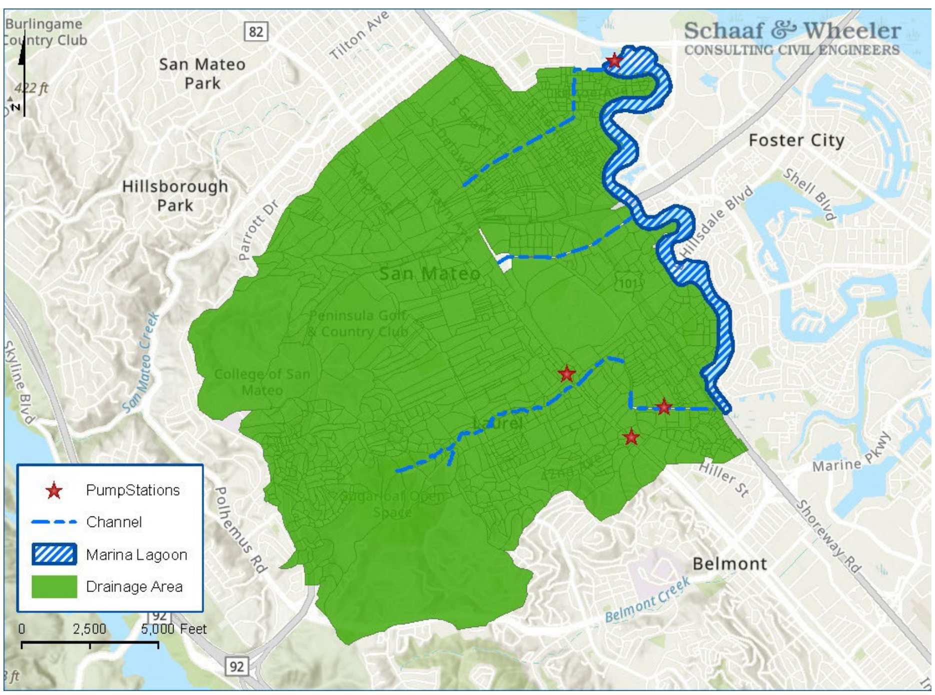

Figure 12 Study Area Overview

The methodology utilized for this study is similar to our previous memorandum mentioned above. Schaaf & Wheeler first imported existing MIKE URBAN models into MIKE+ software (three MU models were imported into a single MIKE+ model capable of modeling the entire Lagoon), then reviewed rainfall data and statistics to develop a calibrated hydrologic and hydraulic model of the entire Lagoon drainage area and tributary pipe and open channel systems. A 2-D overland model has also been developed to evaluate potential flooding from pipe systems and channels. However, prior hydraulic modeling of the Lagoon assumed water elevation below 0.0' NAVD (94.94 ft CSM) to be a dead storage. With the anticipation of lowering the Lagoon to 93.4 ft CSM, Schaaf & Wheeler has composited and updated the topography and bathymetry of the Lagoon. The revised hydraulic model was set to prioritize the use of updated bathymetry beneath elevation -0.5' NAVD88 and to prioritize LiDAR above elevation 0' NAVD88. Once those were composited together, missing data between the two surfaces were interpolated to create a continuous surface for the model.

From our revised hydraulic modeling, it was concluded that the replacement of the existing Lead pump with the proposed smaller pump does slightly increase the water elevation of the Lagoon during a 100-year storm event but does not require re-mapping the existing 2015 FEMA Flood Zone Map. The City would have the ability to lower the Lagoon below Elevation 95 during winter months but is not required to maintain FEMA mapped Flood Zones.

Summary:

- The existing wet well, trash rack, diesel engine, discharge pipes, and outfall structure remain the same. The components replaced are the axial-flow pump, right-angle gear reduction box, and drive shaft.
- The total pump capacity of the one (1) proposed pump is 88,500-98,000 gpm or approximately 3/5 of one (1) existing Marina Lagoon Pump Station pump.
- The proposed pump operates within the pump manufacturer's AOR and POR at all operating conditions.
- The proposed pump requires less minimum submergence level than the existing pump and provides the operational capability to operate the Marina Lagoon Pump Station to the Dock Maintenance Period level of 92.9 ft CSM.
- The proposed pump has sufficient $NPSH_A$ to meet the $NPSH_R$ by the pump manufacturer with a safety factor of 1.35.
- The proposed pump requires BHP of 447 HP, which is less than the 540 HP rating of the existing diesel engine. The proposed pump is installed with a 11:2 ratio right-angle gear drive to match the speed (325 RPM) of the proposed pump with the existing engine.
- From the hydraulic modeling results, replacement of the existing Lead pump with the proposed smaller pump does slightly increase the water elevation of the Lagoon during a 100-year storm event but does not require re-mapping the existing 2015 FEMA Flood Zone Map.
- The estimated total cost is $1.5-$2.0 Million.

Alternative 4 – Construction of a New Low-flow Pump Station

The concept of Alternative 4 is to construct a new low-flow pump station adjacent to the existing Marina Lagoon Pump Station. The new pump station is anticipated to include two (2) new electric pumps with a combined pump capacity of approximately one (1) existing pump capable of lowering the Lagoon below Elevation 95.

Proposed Wet Well Configuration

With the construction of the new pump station, Schaaf & Wheeler has preliminarily outlined the structure of the facility in accordance with HI's ANSI/HI 9.8.7.1-2018. The HI provides standards for pump intakes and wet wells for rotodynamic pumps based on a unitized design criterion. The document outlines standard intake configuration based on specified criteria for a free surface intake, distinguishing between clear liquids and solid bearing liquids. Overall objectives for the standard include mitigation/elimination of submerged vortices, free surface vortices, pre-swirl, nonuniform velocity distribution, and entrained air or gas bubbles as these hydraulic phenomena have been identified to adversely affect the performance of pumps. A typical plan and section following HI's unitized pump standards are provided in Figure 13 and Figure 14 for reference. Varying from HI's recommended unitized pump standards may be acceptable, however, variations typically either require increased submergence to mitigate unsteady flow conditions or scale modeling to demonstrate acceptability.

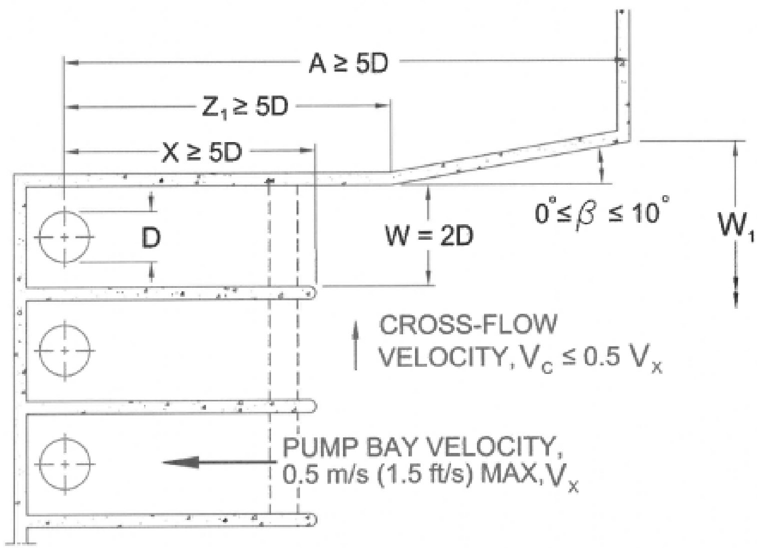

Figure 13 HI Standards Plan View

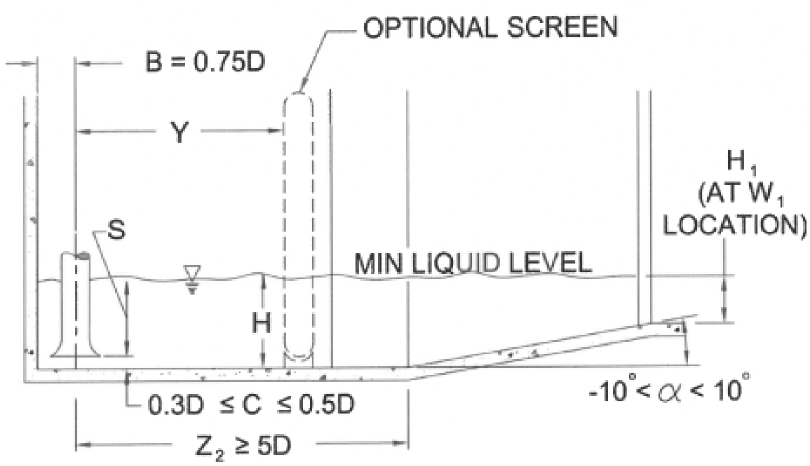

Figure 14 HI Standards Section View

Per HI Standards, Schaaf & Wheeler has proposed the construction of the new pump station adjacent to the existing Marina Lagoon Pump Station on the west side as shown below in Figure 15. The intake structure requires adequate flow depth to limit velocities in the pump bays and to reduce the potential for formulation of surface vortices. Adequate pump bay width and length is also required to limit the maximum pump approach velocities while maintaining channel flow uniformity towards the pumps. In addition, The wet well configuration was designed with the consideration of Lagoon's intake invert elevation, trash rack design, the minimum submergence level, and floor clearance.

Figure 15 Location of New Pump Station

<u>Proposed Trash Rack Assessment</u>

Per U.S. Department of the Interior – Bureau of Reclamation "Design Standards No. 6 Hydraulics and Mechanical Equipment – Chapter 12: Trashracks and Trashrack Cleaning Devices", an important aspect of the design of trash rack is the headloss caused by the blockage accumulated debris. Most trash rack structures are sized to provide a maximum approach velocity of 1 to 2 ft/s for normal flows.

From our preliminary design of the new pump station, the trash rack headloss and velocity were calculated at blockage of 0%, 50%, and 75%. At 0% blockage, minimal trash rack headloss was observed and maximum approach velocity of 1.29 ft/s. At 50% blockage, the maximum headloss is 0.109 ft and maximum approach velocity of 2.59 ft/s with both pumps running. At 75% blockage, the maximum headloss is 0.541 ft and the maximum approach velocity of 5.18 ft/s with both pumps running.

Therefore, our preliminarily proposed trash rack design meets the standards and design requirement and is adequate for the new pump station. Based on our evaluation, it is recommended for the City to maintain the proposed trash rack below 50% blockage as above this threshold may introduce approach velocity above the preferred design condition. At higher approach velocities, typically greater than 5 ft/s and observed with 75% blockage, the velocity may cause vibration of the trash bar and trash rack panels and ultimately cause structural concerns to the pump station.

Proposed Controls and Setpoints

The objective of the new pump station is to operate during the Dock Maintenance Period and to lower and maintain the Lagoon below the City's preferred water elevation of 93.4 ft CSM. Schaaf & Wheeler has proposed to set the controls and set points of the two (2) new pumps at the following settings (Table 15).

Table 15 Proposed Pump Station Controls and Set Points

Pump	Pump Start (ft CSM)	Pump Stop (ft CSM)
Pump No. 1	93.40	92.90
Pump No. 2	94.40	93.90

Proposed Pump Selection

Similarly, to Alternative 3, a system curve consisting of design, high, and low heads was developed to select the appropriate pump for the new pump station. The static lift depends on the level within the proposed wet well and tidal conditions of San Francisco Bay, and the dynamic head depends on the frictional losses through the proposed 54-inch diameter suction and discharge pipes, and minor losses of various pipe fittings from the intake bell to the outfall structure (Table 16).

Table 16 System Curve Parameters

Pump	Wet Well Elevation	Discharge Elevation
High Head	Pump Stop Level	Tidal Condition @ 100-year Tide EL.
Low Head	Pump Start Level	Tidal Condition @ MLLW and 54-inch Forcemain Centerline EL.
Design	Pump Start Level	Tidal Condition @ MSL and 54-inch Forcemain Crown EL.

Figure 16 and Figure 17 show the system curve with the selected pump curve for Pump No. 1 and Pump No. 2, respectively, based on the previously discussed system curve parameters with the configuration of the two (2) proposed pumps at the controls and set points. From the pump information obtained from the pump manufacturer, the black solid line represents the pump curve, green gradient lines show the POR, and red gradient lines show the AOR.

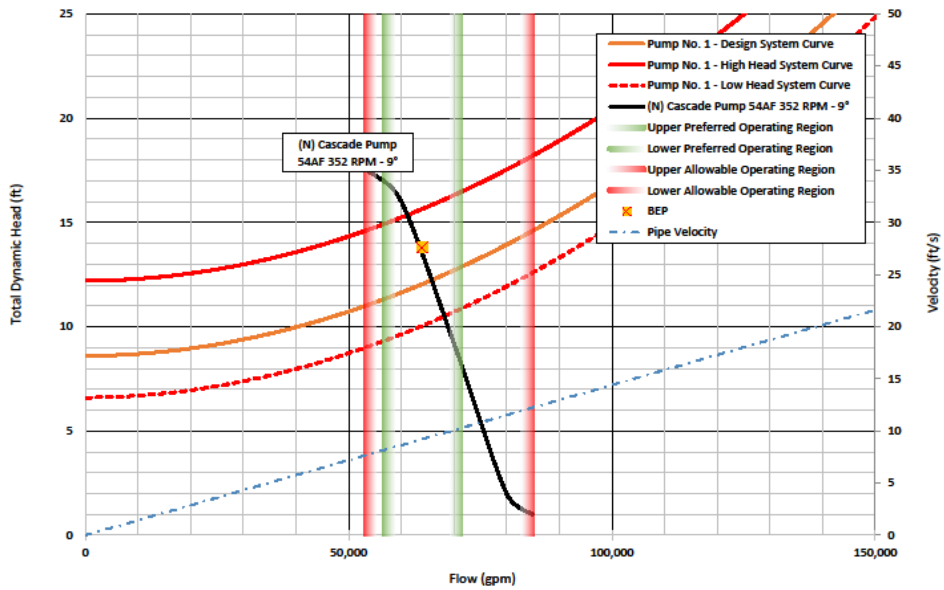

Figure 16 Pump No. 1 – Pump Hydraulics with AOR and POR

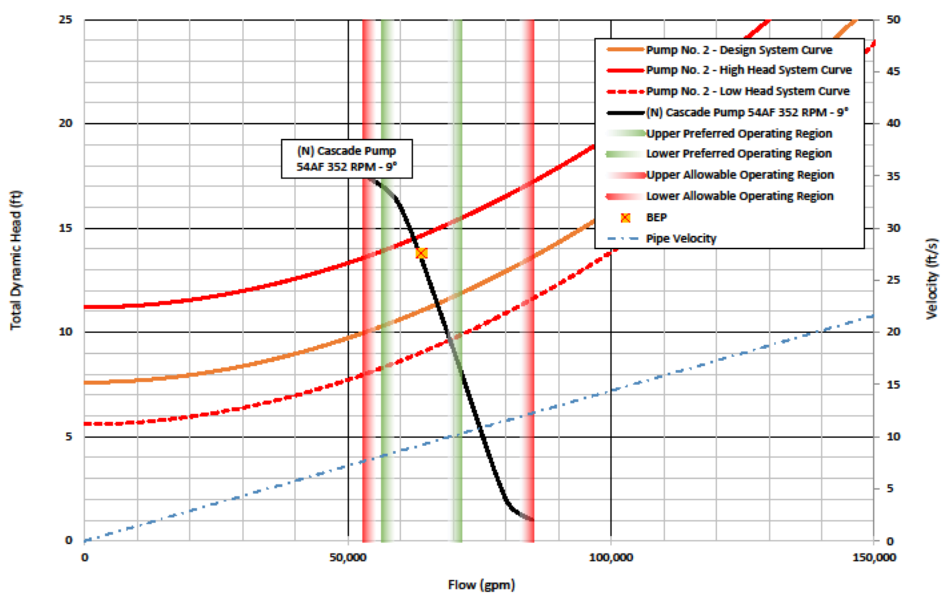

Figure 17 Pump No. 2 – Pump Hydraulics with AOR and POR

Pump No. 1 was selected to operate within the operating conditions of 61,000 gpm, or 135.9 cfs @ 15.1’ TDH with 75.9% Pump Efficiency and 68,500 gpm, or 152.6 cfs @ 10.3’ TDH with 72.9% Pump Efficiency. The proposed pump operates within the range of the pump manufacturer’s AOR and is also within the POR of 90% and 110% from the BEP at both head conditions. With the proposed pump and the proposed 54-inch diameter discharge pipe, the pipe velocity is estimated at 9.2 ft/s and 9.9 ft/s, respectively, which is below the recommended limit of the upper velocity of 10.0 ft/s. At design, the proposed pump operates at 66,000 gpm, or 147.0 cfs @ 12.2' TDH with 74.5% Pump Efficiency.

Pump No. 2 was selected to operate within the operating conditions of 63,000 gpm, or 140.4 cfs @ 14.3' TDH with 76.6% Pump Efficiency and 69,500 gpm, or 154.8 cfs @ 9.5' TDH with 72.5% Pump Efficiency. The proposed pump operates within the range of the pump manufacturer's AOR and is also within the POR of 90% and 110% from the BEP at both head conditions. With the proposed pump and the proposed 54-inch diameter discharge pipe, the pipe velocity is estimated at 9.6 ft/s and 10.0 ft/s, respectively, which is below the recommended limit of the upper velocity of 10.0 ft/s. At design, the proposed pump operates at 67,000 gpm, or 149.3 cfs @ 11.2' TDH with 75.0% Pump Efficiency.

Table 17 Proposed Lead Pump Specification

Proposed Pump Specification	
Manufacturer	Cascade Pump Company
Model No.	AF5420
Pump Type	Axial-flow
Driver	Electric Motor
Speed, RPM	355
Break Horsepower, HP	315
Pump Suction, in.	54"
Pump Discharge, in.	54"

The two (2) proposed pumps at this location are expected to have a total pump capacity of 124,000 gpm to 138,000 gpm, or 276.3 cfs to 307.5 cfs, respectively. The estimated pump capacity is approximately 9/10 of one (1) existing pump capacity at the Marina Lagoon Pump Station.

Furthermore, all pumps are required to maintain a minimum submergence level above the suction bell and minimum floor clearance. Per pump manufacturer, the minimum submergence level is approximately 90" (9.5') and minimum floor clearance is approximately 42" (3.5'). The proposed wet well configuration was designed with the consideration of these pump design criteria.

Simultaneously, the proposed must meet NPSH required by the pump manufacturer. Per HI's ANSI/HI 9.6.1.5.5-2017, a NPSH margin or safety factor of 1.1 to 1.3 is recommended. Calculated value for NPSHA, NPSHR, and margin of safety are summarized in Table 18.

Table 18 Proposed Lead Pump $NPSH_R$ and $NPSH_A$

Abbreviation	Parameters	Pump No. 1	Pump No. 2
H_{atm}	Atmospheric Pressure	33.9'	33.9'
H_{el}	Suction pressure/submergence	7.9'	7.9'
H_{vp}	Vapor pressure of liquid	0.59'	0.59'
Headloss	Losses in the suction pipe	-	-
	$NPSH_A$	41.21'	41.21'
	$NPSH_R$	26.0'	26.0'
	Margin	1.59	1.59

Note: Atmospheric Pressure @ 0' Sea Level and Vapor Pressure of Water Temperature at 60°F

Summary:

- Construction of a new low-flow pump station with a total pump capacity of 124,000-138,000 gpm.
- The new pump station is designed in accordance with HI's ANSI/HI 9.8.7.1-2018.
- The proposed pump provides the operational capability to operate the Marina Lagoon Pump Station to the Dock Maintenance Period level of 92.9 ft CSM.
- All pumps are expected to be electrical motor pumps.
- The proposed pump operates within the pump manufacturer's AOR and POR at all operating conditions.
- The proposed pump has sufficient $NPSH_A$ to meet the $NPSH_R$ by the pump manufacturer with a safety factor of 1.59.
- The estimated total cost is $15-$20 Million.

Benefits and Drawbacks

Schaaf & Wheeler has evaluated all four (4) conceptual alternatives and listed the benefits and drawbacks of each alternative. The referenced conceptual cost estimate of each alternative is attached as Appendix A.

Alternative 1:

Benefits

- Utilizes the existing Marina Lagoon Pump Station as the basis of hydraulic improvements with the existing wet well, trash rack, diesel engines, axial-flow pumps, discharge pipes, and outfall structure.
- Evaluates operational capability of the existing five (5) axial-flow pumps at the Marina Lagoon Pump Station and provides confirmation of new designs and existing pump station upgrades and modifications.
- Provides supported remedial measures to alleviate undesirable flow conditions to operate the pumps as close to the optimal performance.
- The existing pump station is beneficial for future operation, not just for pumping low Lagoon levels.

Drawbacks

- Conducted by hydraulic experts with experience in modeling pump intakes. Accessibility to the hydraulic study is limited.
- Require extensive time to build the physical model, conduct hydraulic analysis, and implement the improvements at the Marina Lagoon Pump Station. The expected lead time is 1-2 years.
- The hydraulic improvements may extend the life of the equipment by a few years, but the pump station is already nearing the end of its useful life with

many of the mechanical systems more than 35 years old. Pump station will need full rehabilitation in coming years.

- Required to dewater the wet well to install the hydraulic improvements.
- The estimated total cost for physical modeling is $250,000. Depending on the actual improvements at the Marina Lagoon Pump Station, the improvement costs may be $250,000-$2.0 Million.

Alternative 2:

Benefits

- Requires the least amount of time to deploy and physically install the temporary rental pump system on-site.
- Requires the least amount of time to begin the operation of dewatering the Lagoon compared to other Alternatives. The expected lead time is 8 weeks.
- Flexibility with the location of the temporary rental pump system.
- The estimated total cost of the project is $150-$200K/month. Requires the lowest amount of financial cost out of all the alternatives, assuming short-term implementation only. The estimated cost includes pumping units, piping, fuel tanks, pump control system, required diesel fuel, maintenance cost, and mobilization/demobilization.

Drawbacks

- The total pump capacity is 20% of one (1) existing pump and the rental pumps may need to operate for a longer period to keep the Lagoon low during the Dock Maintenance Period due to expected inflows with the operation of the temporary rental system during the wet season. The capacity of the rental pumps to handle storm events is uncertain.
- Operation and maintenance of the temporary rental pump system is extremely labor intensive as the City staff is required to manually operate the pumps, continuously monitor, and refuel during the duration of the operation.
- Requires the City staff to be present during the operation of the temporary rental pump system from approximately 5 to 8 days depending on the selected configuration of the pumps. The estimated time duration is with an assumption of no additional inflow from storm runoff.
- Rental pumps are expected to be operated 12 hours per day to lower the Lagoon. The local residents in the area may experience significant noise pollution during the temporary pumping operation.
- Requires the City staff to perform sediment and debris removal to avoid clogging of the temporary bypass pumps. City should review feasibility of installing suction and discharge piping near the existing pump station structure to minimize impacts from the temporary pumping operation.
- There is a limited number of rental pump companies that are capable of supplying the temporary pumping system. Therefore, the City may experience challenges with pump availability and/or may need to reserve the

rental pumps for longer than anticipated duration to ensure and secure pump availability.

- Sunk cost as no permanent improvements to the existing pump station.

Alternative 3:

Benefits

- The existing wet well, trash rack, diesel engine, discharge pipes, and outfall structure remain the same.
- The proposed pump requires less minimum submergence level than the existing pump and provides the operational capability to operate the Marina Lagoon Pump Station to the Dock Maintenance Period level of 93.4 ft CSM.
- Replace one (1) existing pump with the proposed new smaller pump. The lifecycle of the diesel engine and other mechanical components is extended.
- Rehabilitate and warehouse the existing axial-flow pump and gear box as a back-up, if needed.

Drawbacks

- The pump capacity of the existing axial-flow pump is minimized by 40% from 150,000 gpm to 86,500-98,000 gpm. The overall pump station capacity is reduced by 8%.
- Require extensive time to deliver and replace the existing pump, right-angle gear reduction box, and drive shaft with the proposed custom pump and associated mechanical components. The expected lead time is at least 12 months.
- The estimated total cost of the project is $1.5-$2.0 Million.

Alternative 4:

Benefits

- The estimated total pump capacity of the pump station is approximately 9/10 of one (1) existing pump capacity at the Marina Lagoon Pump Station.
- The new pump station provides an additional 18% pump capacity to the existing Marina Lagoon Pump Station and assists with the FEMA’s requirement of 100-year storm event.
- Designed in accordance with HI standards and to operate within the operating conditions to lower the Lagoon to the Dock Maintenance Period level.
- Provides redundancy for the existing Marina Lagoon Pump Station. Allows for maintenance and/or replacement of the gearboxes, electrical controls, and other major components of one existing pump while maintaining equivalent pumping capacity.
- Reconfigure to utilize the new pump station as the lead pump station prior to the operation of the existing Marina Lagoon Pump Station to extend the life span of the existing five (5) axial-flow pumps.

Drawbacks

- Require extensive time and financial cost to design and construct the new pump station. The expected lead time is 5-10 years.
- The estimated total cost of the project is $15-$20 Million. Requires the highest amount of financial cost out of all the alternatives.

Conclusion

Based on our evaluation, Schaaf & Wheeler recommends that the City consider a combination of Alternative 3 and 4 as short- and long-term options for the Marina Lagoon Pump Station to lower the Marina Lagoon water Elevation below 95.

As previously mentioned in our memorandum titled “Marina Lagoon Storm Water Pump Station Study” (Schaaf & Wheeler, May 2023), the pump station is nearing the end of its useful life with many of the mechanical systems more than 35 years old. As Marina Lagoon Pump Station is a critical infrastructure to control and maintain the Lagoon level throughout the year, our recommendations prioritize reliability and operability of the pump station. Therefore, Schaaf & Wheeler recommends the following short- and long-term planning for the pump station in lieu of previously provided recommendations.

Short-term Recommendation

With the City’s preference to lower the Marina Lagoon water level below Elevation 95, Schaaf & Wheeler recommends Alternative 3, specifically Option 2, as a short-term plan for the Marina Lagoon Pump Station.

This alternative utilizes the existing infrastructure and mechanical equipment of the pump station and only replaces one of five axial-flow pumps and associated right-angle gear drive. The proposed pump will be designed to retrofit to the existing diesel engine and discharge pipe. The total pump station capacity is reduced by 8%, however the proposed pump provides the City with an operational capability to operate the pump throughout the year and allows the Lagoon to be lowered to the “Dock Maintenance Period” level of 93.4 ft CSM. However, this alternative does not address the existing concerns with the life span of the existing equipment near its useful life at the pump station. Therefore, Schaaf & Wheeler also recommends the City to consider Alternative 4 as a long-term plan for the Marina Lagoon Pump Station.

Long-term Recommendation

This alternative requires extensive time and financial cost to design and construct a new low-flow pump station. The expected lead time is 5-10 years. However, the new pump station provides an addition 18% pump capacity to the existing Marina Lagoon Pump Station, designed to operate at the City’s preferred “Dock Maintenance Period” level, redundancy for the existing Marina Lagoon Pump Station to allow for maintenance and/or replacement of existing equipment of concern, and prolongs the life span of the existing and replaced equipment at the Marina Lagoon Pump Station if reconfigured to operate these two (2) new smaller pumps before the larger 150,000 gpm axial-flow pumps are operated. The existing Marina Lagoon Pump Station already provides capacity for a 100-year storm event, but construction of a new low-flow pump station provides the City with additional safety factors to meet FEMA’s requirements. The new low-flow pump station provides the City flexibility as it rehabilitates the existing station, allowing the existing station to be taken offline during summer months to perform rehabilitation work in the future.

Schaaf & Wheeler also recommends the City investigate the feasibility of revising the timeframe, duration, and/or frequency of the Dock Maintenance Period to more efficiently conduct the operations. The Dock Maintenance Period is currently performed annually during the rainy season and lowering of the Lagoon below Elevation 95 with additional storm water inflows represents a higher-degree of adverse conditions for a pumping system compared to dry-season operation.