2015

Design of Proposed Improvements to Southwest Stillwater

FINAL DESIGN REPORT

1 MAY, 2015

HARPOON & ASSOCIATES | 207 Engineering South, Oklahoma State University

HARPOON & ASSOCIATES

May 1, 2015

Selection Committee
723 S. Lewis Street
Stillwater, OK 74074

RE: Final Design of Booster Pump Station and Pipeline

Dear Members of the Selection Committee:

Since the summers of 2011 and 2012, the residents of the Southwest Pressure Zone of Stillwater have been facing low pressure and low flows. Of the proposed improvements to the infrastructure, we at Harpoon & Associates feel that it is well within our talents and abilities as an engineering firm to successfully redesign the Booster Pump Station at Highway 51 and Country Club (51/CC BPS) and the transmission main between the pump station and the water tower at Range Rd and 19^{th} St. It is the goal of our staff to not only meet the state and local requirements, but to provide exceptional service to the Southwest Pressure Zone of Stillwater.

For this work project, the site selection for the pump is imperative to future growth of the city, and our firm is dedicated to considering all the variables surrounding this decision. Going forward with the land acquisition will be a delicate system of events, as dealing with the property owners can be tedious. At Harpoon, our number one priority is the satisfaction of the surrounding locale, and we take great pride in accommodating all parties involved. Preliminary designs are among the specialties of the work group, understanding the needs of the facility and taking the future growth into account. Meetings will evolve from these designs to discuss possible efficiency options to better provide for the needs of the city. These meetings will lead to the final design phase, requiring approval of the city, state, and DEQ regulatory demands, which will then give way to the construction phase of the job.

It is well understood that simply building a facility and pump station are not enough, but the ease of operation and maintenance are of key importance as well. The need for repairs is inevitable, however with our design staff, it does not have to be like pulling teeth. By making all units and junctions easily accessible, two employees can reassemble the entire unit competently.

Sincerely,

Harpoon and Associates

Aiden M Carmichael, Project Manager

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1.0 Executive Summary

The proposed project focuses on the insufficient water pressure being delivered to the southwest region of Stillwater, Oklahoma. Town regulations require the pressure to be at a minimum of 25 PSI: a standard that is currently being undershot. With the projected expanse of the city and the growth its populous, it has become increasingly imperative every day to improve on this system.

To adequately improve on the water delivery, it is necessary to redevelop the whole pump series within the region. Getting new pumps means a need for new pipes, new hydrological and hydraulic analysis, new construction, and a new pump house. The first step is to determine how long it is suppose to be sufficient for the city's needs, and as time goes on, what those needs are. The demand can be obtained from the water company, who keeps track of historical usage and quantity. These numbers allow us to figure out how large the pumps will need to be in the future, and also how large the pipes will need to be to transport it.

From there, it is important to put these specific needs into an operating system to run scenarios and determine pipe diameter, resulting pressures from those diameters, right-of-way for the piping system, and even determine the location of the pump house. The specific placement of the pump house should also take elevations into account to optimize all necessary water runoff information, and environmental concerns such as historical significance, endangered species population, and cultural significance. With physical placement of the pump house and adequate pipelines drawn to deliver sufficient water pressure, we needed to check for clearance of said pipes as they are put in the ground, select pumps that can operate at the designed horsepower, and then model the pump house to fit the number of pumps chosen.

A vertical alignment study is conducted which shows the pipeline at its full length in relationship to the surface elevation while taking other utility lines that have been buried into account. After all interference has been avoided and the minimum depth requirement is met, the "plan and profile" can be produced, which simply shows the vertical alignment in a easy-to-read fashion, complete with surveying stations, or checkpoints, that correspond with their location on a map.

The pump house design is pretty straight forward in its conceptual needs. It has to be able to house to determined numbers of pumps, have a space open for future implementation of pumps, and provide space for control panels for ease of operation and maintenance. The exterior is designed to be rather pleasing in appearance without any implication of the building's use. With the developed size of the pump house, it is important to conduct a rainwater runoff analysis, or hydrograph study, to determine if the resulting construction will cause flooding with the next 25 year rainfall. The runoff difference is used to design a catch basin that will drain the same way the pre-construction area is accustomed.

Before there can be any kind of ground breaking, the actually foundation of the pump house has to be selected to keep the building down when there is a strong gust. With the system designed, the pumps chosen, the pump house developed, environmental, hydrologic, and hydraulic studies conducted, and city requirements met, the water requirements for the town have been addressed, including cost estimation for all parts with annual payment plans.

2.0 Project Information

2.1 Existing Conditions

The project in question pertains to the water supply being distributed to the southwest region of Stillwater, Oklahoma. As it is currently, water pressures throughout the disbursement area are dropping below city standards. The minimum pressure requirement for Stillwater at any given point within the main is 25 PSI, and the current facility is failing to keep up with the expansion of the cities populous. The pump station currently resides at the northwest corner of Highway 51 and Country Club Road.

2.2 Project Scope

The proposed solution for the water pressure needs by Harpoon and Associates was to install larger pumps, in a new pump station. The pump station required selecting a site within the southwest region, between the water tower, which is south of Highway 51 on Range road, and the existing water main junction near 51 and Western. With the site selection in hand, the projected population is required for water demand needs in the future. With the future population water demand, pipe sizing and pressure modeling is needed to maintain city standards. Vertical alignment is required to make sure the new piping can avoid interfering with other pipes and utilities in the proposed dig sites, and the plan and profile are needed for ease of job translation to the contractors.

When sizing the actual pumps, decisions must be made about a quantity, overall power, diameter, and size with optional emergency backups. With the size of the enclosure items, the pump house can be built to fit. The new pump house must be designed to shelter, not only the pumps, but the control panels which operate the pumps. Besides the operational purposes of the house, it must also be relatively visually aesthetic to compliment the inevitable growth in the land around it. So as not to affect natural water flow within the region, hydrographs must be constructed for the area.

3.0 Pipeline

3.1 Route and Layout

We propose that our pipeline tie into the existing transmission main around the location of the existing booster station (Highway 51 and Country Club). From there, it will run west along the north side of Highway 51 until just east of Range Road, bore under Highway 51 into our pump station, bore under Range Rd, and run south along the west side of Range Rd to the water tower. The route is shown in Figure 3.1-1 below.

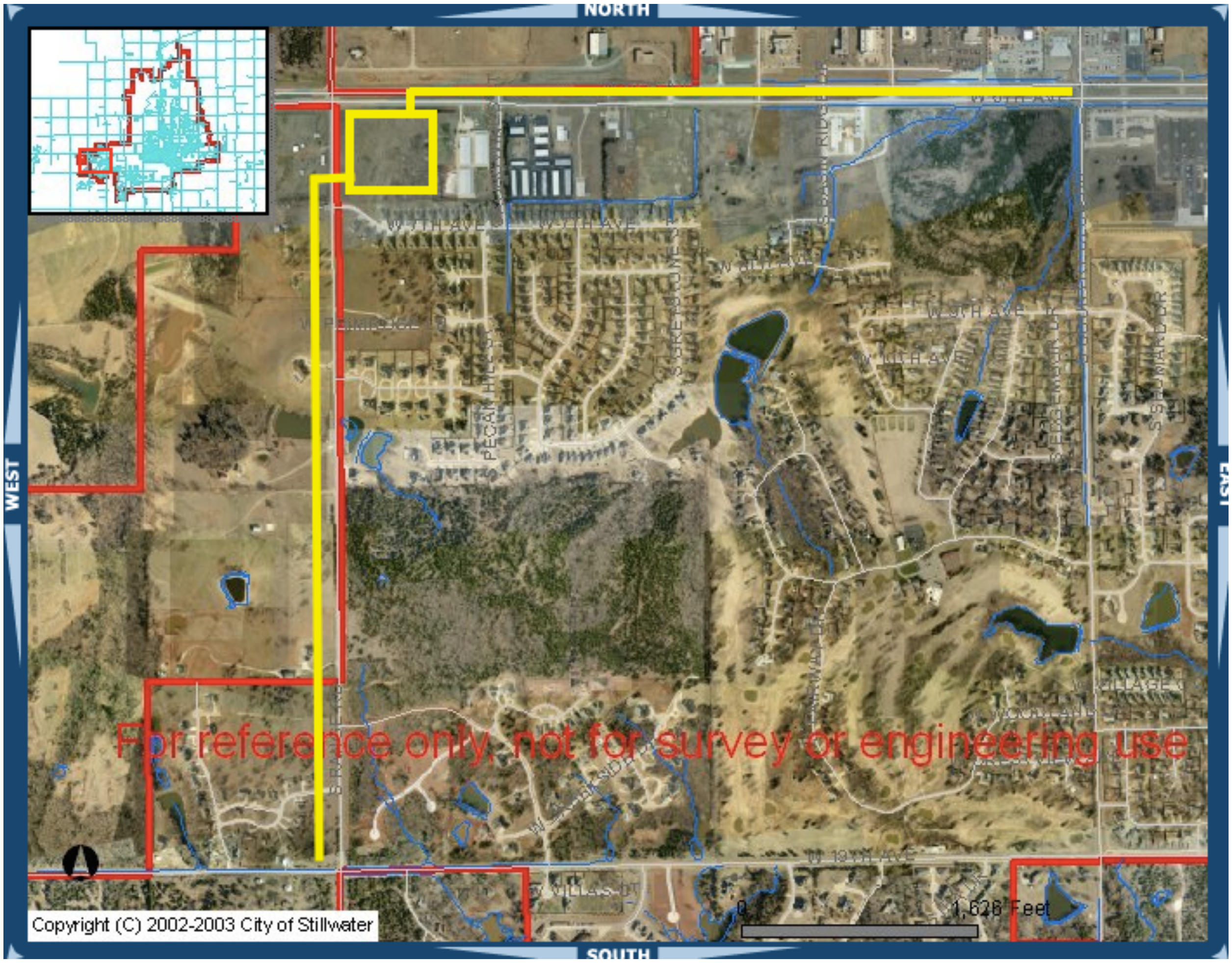


Figure 3.1-1: Proposed pipeline route. The yellow square represents the site of our booster station, and the yellow line represents our pipeline route.

To lay the pipe, we will need to dig a trench that is 4 ft wide and 6 ft deep.

In the realm of industry, there are always going to be new ways to accomplish tasks that better the community. One of the most inventive ways of hiding and protecting some of these innovations at the same time is to simply bury them. There are all sorts of things buried in the ground that benefit people and they may never even know it, but if you are going to add something to the super highway of utilities in the ground, you have to know what is down there already.

When burying the water pipes, a vertical alignment assessment was needed to run interference. For starters, Stillwater regulations dictate that the pipes must be buried a minimum of 3.5 feet, so that is where the depth starts. Since the elevation throughout the city changes so drastically, this alignment was used to determine depth of the pipe all along the street.

Once the elevations, sizes, and materials are determined for the network of pipes, it is important that it can be presented in a understandable way. The profile can most easily be described as the vertical alignment, in tangent with the plan view of the project (birds eye view) with the technical surveying station. The point is ease of conveyance of all materials in the project and where they are located.

3.2 Material

We elected to use 24" PVC pipe in our suction line, and 20" PVC pipe for our discharge line. PVC piping was chosen over ductile iron for several reasons.

The first reason is simply the cost of the material. PVC was cheaper than ductile iron in the sizes we are using, so it was the more cost effective of the material choices.

The second reason is the city's experience with the material. In a similar project to this one, PVC pipe was used, so contractors are familiar with the material. This can be an important consideration in the final cost of the project. If the contractor is unfamiliar with a certain material, the learning curve associated with learning about the material can cost time and therefore money. This potential issue is avoided by using PVC.

The third reason for choosing PVC is based on its material properties. Because PVC is plastic, it does not rust. Thus, it will not erode over time due to hard water. Ductile iron, on the other hand, has a tendency to corrode as it sets in the ground, due to water and soil properties both. PVC pipe will not erode, giving the pipes a longer lifetime.

The final reason is the flexibility of the material. Although it is not recommended, PVC pipe can be bent slightly to compensate for an incorrect grade of the trench should the need arise. Ductile iron does not give as much flexibility.

3.3 Boring

We will need to bore under two roads in Stillwater. First, we will bore from the north side of Highway 51 to the south to bring the suction line of our pipe into the booster station. After the discharge pipe exits the station, we will need to bore under Range Rd from the east side to the west.

3.4 Alternatives

We did consider one alternative for the pipe route and layout. We originally planned to have the pipeline run along the south side of Highway 51 and then down the east side of Range Rd, as shown in Figure 3.4-1 below. We discarded this alternative primarily due to lack of data. When we received survey data from the City of Stillwater, we only received data for the north side of Highway 51 and the west side of Range Rd. We did not have access to survey equipment, so we altered our alignment to ensure we had an accurate vertical alignment.

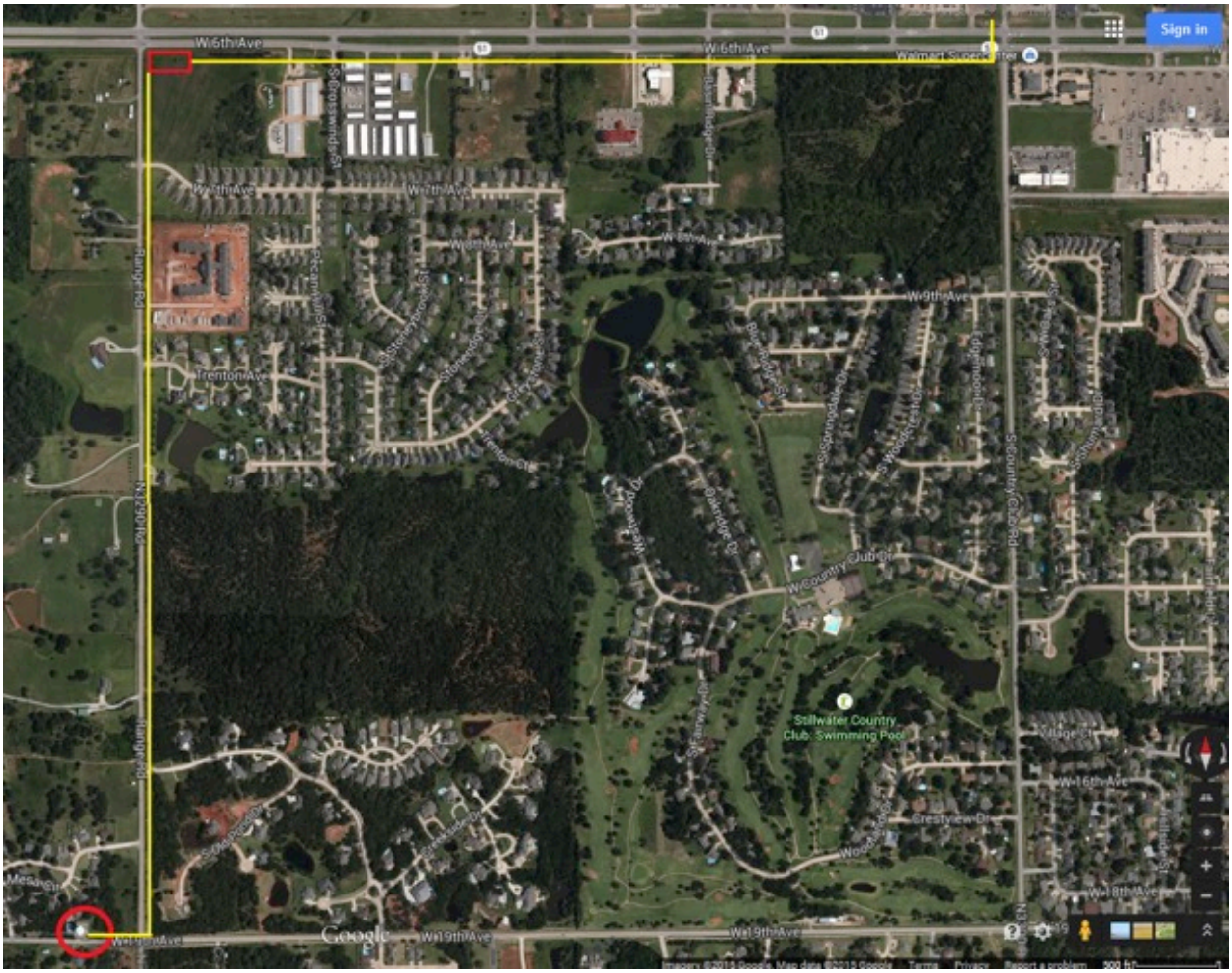


Figure 3.4-1: Preliminary pipeline alignment.

3.5 Capacity

The necessary capacity of the pipes was calculated based on a population projection. The city is expanding mostly toward the southwest, which is the region that our pump station will serve. We project a population of 18,700 residents by the year 2040 in the southwest region alone. Using an average of 150 gallons per person per day, and a peaking factor of 2.2, we project a total demand of 6.2 million gallons per day (MGD), or approximately 4300 gallons per minute. Using WaterCAD, we found that a 24" suction line would be sufficient (see Appendix E for more information).

One of the primary problems with the existing pump system is the low water pressure throughout the system. The pressure is already too low in many locations in Stillwater, and this does not include project growth patterns and water needs. If the proposed pumps take into account all of the water needs for the next 20 years with some safety factors calculated in for good measure, then the next step is to check elevations, sizing, and material types for the pipes that will be carrying this water.

Using Bentley WaterCAD, a model of the Stillwater area was developed and the new pipelines were added in. By setting the elevations for the pipe junctions, setting their diameter according to availability and overall cost, and picking the desired material type best fitting for the task, simulations could be run that detail results and further necessary adjustments to the proposed model. After setting these parameters through a system of trial and error, the pressure reached a desirable 30 PSI across the city with plenty of pressure to spare over the minimum. The pipes were selected to be made of PVC, with a diameter along Range Road of 20" and along Highway 51 of 24". The elevations of the pipes and their junctions can be seen in Appendix E.

3.6 Valves

For this project, we consider using 3 type of valves for different events, which are check valve, isolation valve and air release valve.

The purpose of choosing check valve is make sure flow in element is moving in one direction, and it will prevent from flowing in reversed direction. Hence we will place check valve near pump to make sure water will not flowing backward and damaging pumps and pipe system. We have 3 pumps in pump station, for each pump, 2 check valves placed on each side of pump will be a good idea. For the pipe system, every junction should have 1 check valve to prevent interval between junctions from reversed water flow.

Isolation valve is design for the situation that the valves need to be open and close manually. We will place isolation valve in both sides of pump in case there are something wrong going. Isolation valve allow crews control water system manually when emergency occurs.

For our project, we will use plug valve. Plug valve provide isolation and will rarely affected by pressure drop. In contract, gate valve, which is an isolation valve as well, can only handle low pressure situation.

Air release valve is for the event that negative pressure exists in water system. For example, for a pump if the elevation of discharge side is lower than intake side, a siphon will occurs. This situation requires air release valve. However, in our design, there is no negative pressure exist air release valve is not mandantory.

3.7 Environmental and Permits

Our site is located at the following coordinates: Latitude: 36° 6'53.30"N, Longitude: 97° 8'22.27"W

Using these coordinates, a "Level II" environmental analysis was performed.

Water is a very important element to people and to processes in their homes. People wash their clothes, dishes, and bodies with it, and it is also used in our toilets and sinks. When analyzing an area for possible improvements, it is necessary to know if there are any bodies of water that are readily affected by the work. Even if surrounding homes do not draw from those bodies of water for their water needs, there is always a concern to not affect it in any negative way for environmental preservation purposes. There is a chance that the construction causes more runoff to go to local water bodies, possibly causing overflow, which could even affect nearby homes. According to wetland mapper, there are 2 freshwater ponds and 1 freshwater forested/ shrub wetland in this area. As a safety factor, the range of view was expanded to well over a mile from the job site location, but none of these three bodies will suffer any consequence from the work construction and will not be affected by the work. Figure 3.7-1 below shows the results of our search.

Figure 3.7-1: Results of "Waters of the US" search.

When selecting an area, it is wise to look, not only at the elevation and availability of the area, but who else the work might affect. There may not be people at the location, but there are most assuredly animals. There is no way of knowing to the naked eye if there are any animal species dwelling in the small patch of grass southeast of Range and Highway 51, Before breaking any ground at this location, analysis must be done. By checking with online databases of animal species in the area, we can determine if there are than are endangered on a species capacity by the proposed pump house in that location. Figure 3.7-2 below shows the lack of endangered species in our area.

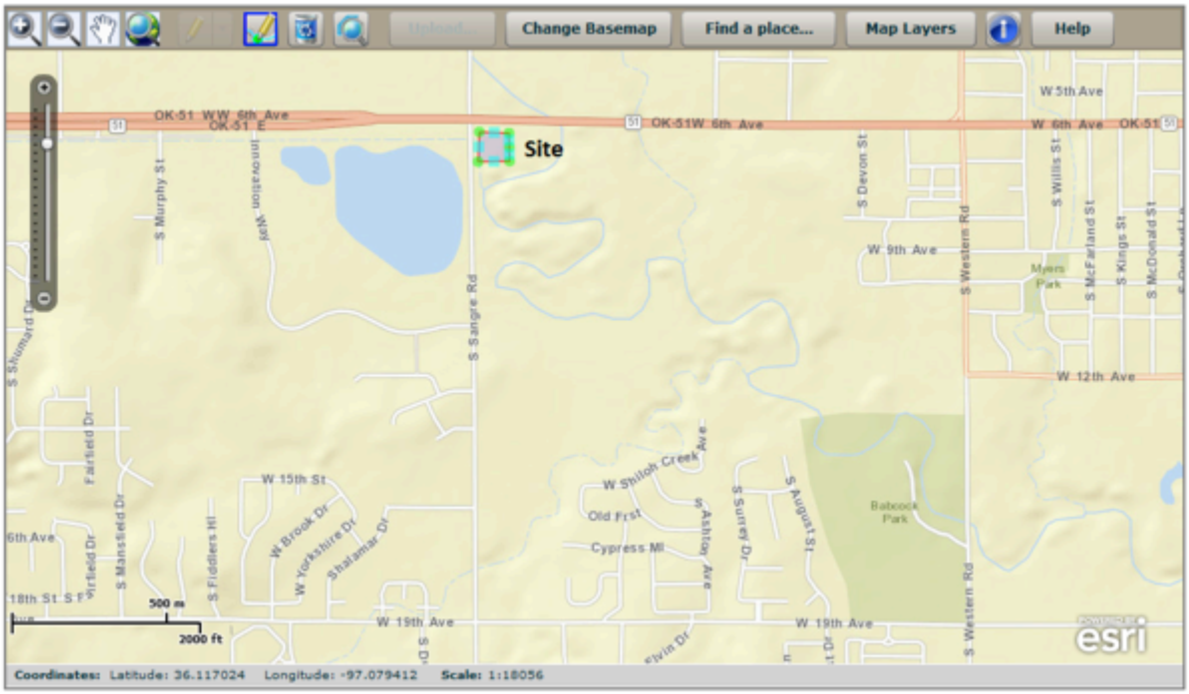


Figure 3.7-2: Results of endangered species search.

A silt of threatened birds in this area is found in Table 3.7-1 below.

Table 3.7-1: List of endangered birds in our area.

Species Name	Bird of Conservation Concern (BCC)	Species Profile	Seasonal Occurrence in Project Area
Bald eagle (*Haliaeetus leucocephalus*)	Yes	species info	Year-round
Bell's Vireo (*Vireo bellii*)	Yes	species info	Breeding
Chestnut-collared Longspur (*Calcarius ornatus*)	Yes	species info	Wintering
Dickcissel (*Spiza americana*)	Yes	species info	Breeding
Fox Sparrow (*Passerella liaca*)	Yes	species info	Wintering
Golden eagle (*Aquila chrysaetos*)	Yes	species info	Wintering
Harris's Sparrow (*Zonotrichia querula*)	Yes	species info	Wintering
Hudsonian Godwit (*Limosa haemastica*)	Yes	species info	Migrating
Lark Bunting (*Calamospiza melanocorys*)	Yes	species info	Breeding
Least Bittern (*Ixobrychus exilis*)	Yes	species info	Breeding
Little Blue Heron (*Egretta caerulea*)	Yes	species info	Breeding
Loggerhead Shrike (*Lanius ludovicianus*)	Yes	species info	Year-round
Mississippi Kite (*Ictinia mississippiensis*)	Yes	species info	Breeding
Painted Bunting (*Passerina ciris*)	Yes	species info	Breeding
Prothonotary Warbler (*Protonotaria citrea*)	Yes	species info	Breeding
Red-headed Woodpecker (*Melanerpes erythrocephalus*)	Yes	species info	Year-round
Rusty Blackbird (*Euphagus carolinus*)	Yes	species info	Wintering
Scissor-tailed Flycatcher (*Tyrannus forficatus*)	Yes	species info	Breeding
Short-eared Owl (*Asio flammeus*)	Yes	species info	Wintering
Snowy Plover (*Charadrius alexandrinus*)	Yes	species info	Migrating

A list of threatened species in this area is shown in Figure 3.7-3 below.

Endangered Species Act Species List (USFWS Endangered Species Program).

There are a total of **5** threatened, endangered, or candidate species on your species list. Species on this list should be considered in an effects analysis for your project and could include species that exist in another geographic area. For example, certain fishes may appear on the species list because a project could cause downstream effects on the species. Critical habitats listed under the **Has Critical Habitat** column may or may not lie within your project area. See the **Critical habitats within your project area** section below for critical habitat that lies within your project area. Please contact the designated FWS office if you have questions.

Species that should be considered in an effects analysis for your project:

Birds	Status		Has Critical Habitat	Contact
Least tern (*Sterna antillarum*) Population: interior pop.	Endangered	species info		Oklahoma Ecological Services Field Office
Piping Plover (*Charadrius melodus*) Population: except Great Lakes watershed	Threatened	species info	Final designated critical habitat Final designated critical habitat	Oklahoma Ecological Services Field Office
Red Knot (*Calidris canutus rufa*) Population:	Threatened	species info		Oklahoma Ecological Services Field Office
Sprague's Pipit (*Anthus spragueii*) Population:	Candidate	species info		Oklahoma Ecological Services Field Office
Whooping crane (*Grus americana*) Population: except where EXPN	Endangered	species info	Final designated critical habitat	Oklahoma Ecological Services Field Office

Don't see a species you expect to see?

Figure 3.7-3: List of endangered species in our area.

Along with environmental destruction, it is also necessary to survey the area for any historical significance before diving in. For all the same reasons that one would examine the local inhabitants in the area, historic pieces there would hold significant importance as well.

This is list of all national register of historic places in Stillwater:

Stillwater	Berry, James E., House	502 S. Duck St.
Stillwater	Campus Fire Station	600 W. University Ave.
Stillwater	Citizens Bank Building	107 E. 9th St.
Stillwater	Cottonwood Community Center	NW of Stillwater
Stillwater	Cross, Hamilton, House	1509 W. 9th
Stillwater	Frick, William, House	1016 S. West St.
Stillwater	Hoke Building	121 W. 7th Ave.
Stillwater	Long Branch Creek Bridge	1/8 mi. N. of jct. of N3300 & E0540
Stillwater	Magruder Plots	Oklahoma State University
Stillwater	Murphy House	419 S. Monroe
Stillwater	Oklahoma A & M College Agronomy Barn and Seed House	2902 W. 6th St. Building #610
Stillwater	Old Central, Oklahoma State University	Oklahoma State University campus
Stillwater	Payne County Courthouse	606 S. Husband St.
Stillwater	Pleasant Valley School	1901 S. Sangre Rd.
Stillwater	Reifsnyder, Josephine, Lustron House	2119 Sherwood
Stillwater	Selph Building	119 W. 7th Ave.

Stillwater	Stillwater Santa Fe Depot	400 E. 10th St.
Stillwater	Walker Building	117 W. 7th Ave.

Luckily, none of these historic sites is within the given area.

The same online resources that cleared the area for work with regards to animals and historic sites also tells us if there is any significant cultural resource in the area. These elements include religious, racial, or regarding the arts or heritage of a people that may be affected by the proposed job. Luckily, there are no cultural resources present in the designated area.

The ongoing project will not have any affect on the surrounding environment.

There are several permits that we need in order to construct the station and the pipeline. First, we need an Earth Change permit from the City of Stillwater since we are disturbing more than 1 acre of land. Second, we need a Stormwater Runoff permit from ODEQ. Third, we need a permit from ODOT to bore under Highway 51. Fourth, we need a permit from the City of Stillwater to bore under Range Rd. Fifth, we need yet another permit from the City of Stillwater for temporary street closures. Finally, we need permits to construct the building, both from the City and ODEQ.

4.0 Booster Station

4.1 Layout

Our station will be located on the southeast corner of Highway 51 and Range Road, as shown in Figure 4.1-1 below.

Figure 4.1-1: Booster station location. The red lines are Stillwater city limits, and the yellow square is the site of the station. Range Road runs along the west side of the station, and Highway 51 runs along the north side.

We chose this site for several reasons. First, it is open land that is relatively flat, which should make construction simpler. Second, there are no existing buildings around it with tenants that might be disturbed during construction, increasing public favor for the project. Third, the existing infrastructure is in close proximity, making connecting the new pipeline straightforward.

Other sites were in consideration for our location, but they were rejected for various reasons. One alternative that was considered is shown in Figure 4.1-2 below. It is located on 5th Ave and Country Club, just north of Highway 51. It is behind the On Cue gas station. This location was rejected primarily because of its proximity to other existing buildings. Construction would likely be difficult with little to no room to maneuver the equipment. Additionally, construction at this location would disrupt existing utilities in the area. To summarize, the location was cluttered with other buildings and utilities, which is why we chose not to locate our pump station there.

Figure 4.1-2: Alternative #1 for our pump location site. This alternative was rejected because it was deemed too cluttered with existing buildings and utilities.

The other alternative considered was the northwest corner of Range Rd and Highway 51, the corner opposite of our site, shown as "Proposed location #3" in Figure 4.1-3 below. Harpoon & Associates went to investigate this site, and we noticed a large pond. If this site had been chosen, we would have had to purchase a significant amount of fill soil to grade the site. This would have been a significant cost to the City of Stillwater, and we elected to avoid that particular one.

Figure 4.1-3: Alternatives #2 and #3 for our pump location site. Alternative #2 was chosen as our official site, and alternative #3 was rejected due to poor existing grading on the site.

We plan on purchasing 5000 square feet of land (50' X 100'); this includes room for the building itself, the parking lot, and the rights to a temporary 10 ft construction easement all the way around the site. The building itself will be 40 ft wide by 60 ft long, and the layout is shown in Figure 4.1-4 below.

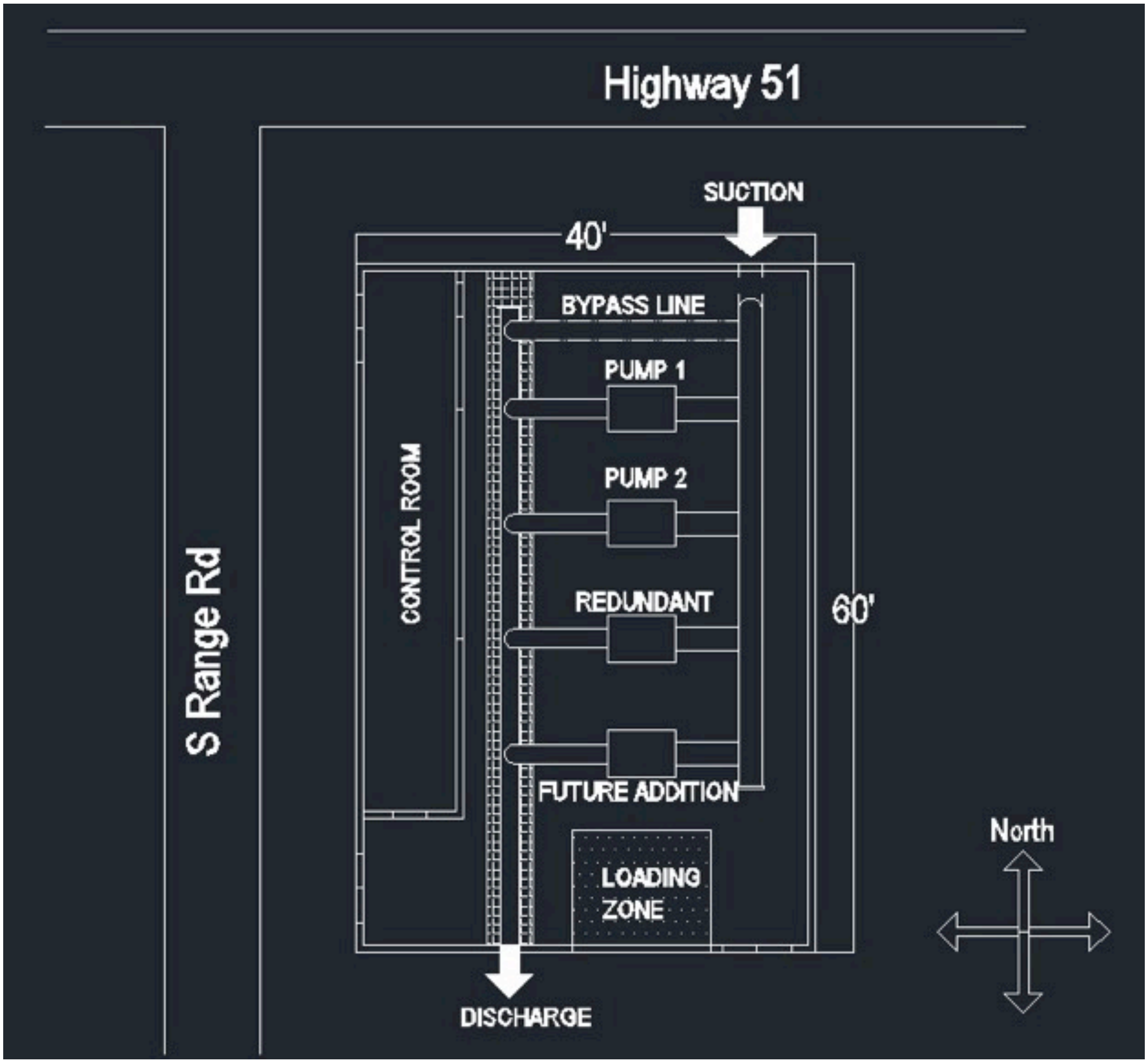


Figure 4.1-4: Booster station layout plan view. The building includes 4 pumps total, as well as suction piping above ground on the east side of the building, the underground discharge piping in a trench on the west side of the building, and an electrical control room on the west side of the building.

Figure 4.1-5 shows an isometric drawing of our pump station, complete with pipes and the roof trusses.

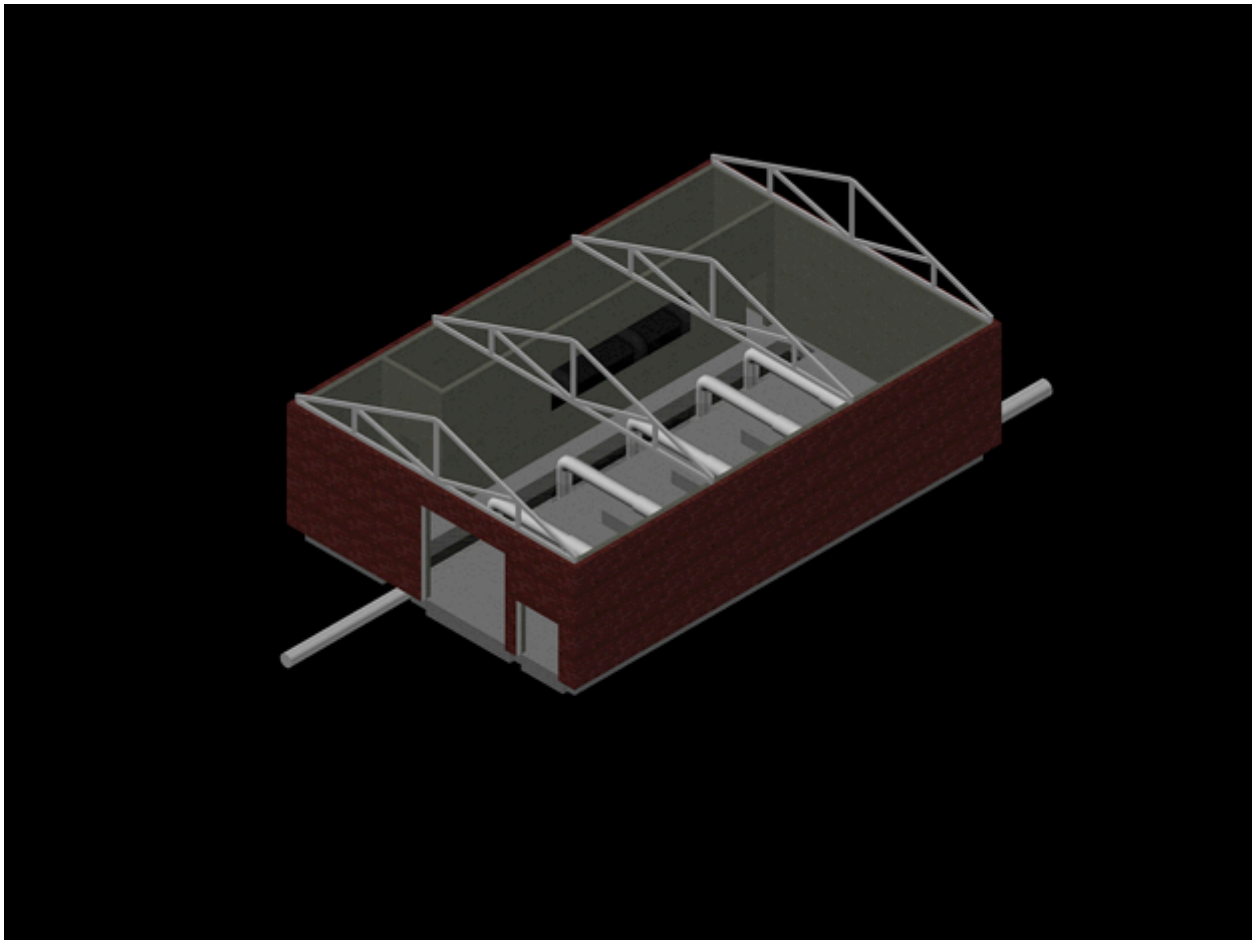


Figure 4.1-5: Isometric drawing of pump station.

Figure 4.1-6 below shows the truss that we are using for our roof support. The total span is 40 ft wide, the length of the building. The end bays are 8 ft wide, and the middle bays are 12 ft wide. The truss is 7 ft tall at its peak, and it uses a 4/12 pitch.

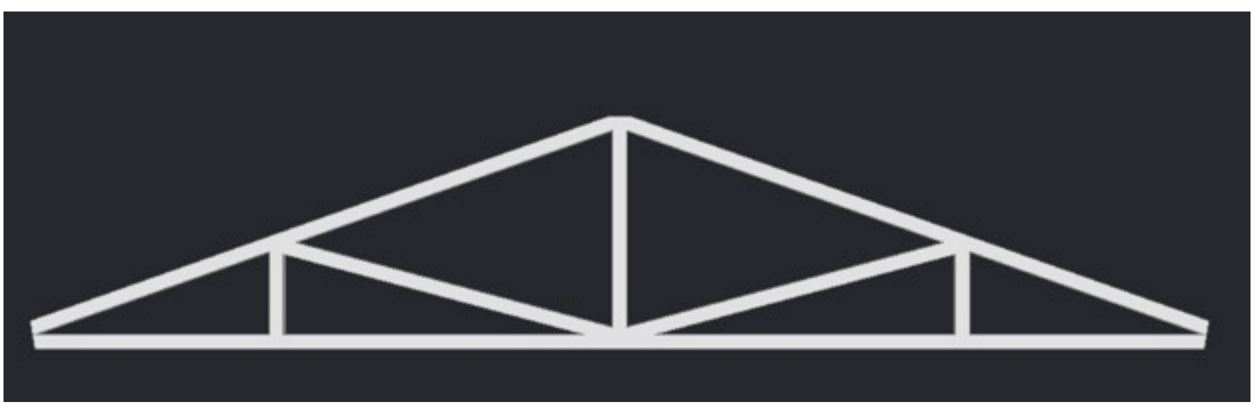


Figure 4.1-6: Roof truss.

The site also includes an underground detention facility, but that will be detailed in section 4.6 of this report.

4.2 Structure

Our pump station will be constructed using eight inch, reinforced CMU blocks with a brick veneer. These materials were preferred by our client and have been used to construct other pump stations throughout Stillwater. The roof will be a series of trusses with asphalt shingles. We chose asphalt, rather than corrugated tin, for aesthetic purposes. Our site is located near various housing additions and the combination of brick veneer and asphalt shingles will allow our pump station to remain inconspicuous when future development occurs in that area. For the truss system we used a roof pitch of 4/12 which left us with a maximum height of 7 feet and a slope angle of 19 degrees.

When choosing the type of crane and its supports, we took into consideration the complaints of our client with the crane system placed in the most recently built pump station located on 12th and Perkins. The support columns were located too close to the pipe system running throughout the station and made maintenance difficult. To prevent any difficulties for maintenance we chose to place the support columns in each corner of the building flush against our CMU walls. The reason we chose not to tie the support columns inside the CMU wall was to prevent large loading of the CMU blocks by the weight of the crane when it is transferring pump equipment or piping. The crane we have selected also provides a wide range of motion to provide ease of maintenance. Figure 4.2-1 below shows a general idea of how our crane system might look.

Figure 4.2-1: Crane system.

The loadings used in the design and analysis of our pump station were the dead and wind. The dead loads were an accumulation of the weights of our truss system, asphalt shingles, CMU blocks, reinforcing, and mortar. We used Method 1 – Simplified Procedure found in ASCE 7-05 and a design wind speed of 90 mph for 3 seconds to come up with our wind loading on our pump station. To use this method, our building had to meet several criteria. It is a simple diaphragm building, meaning there are no structural separations. The crane is a separate structure, but it will not be carrying any wind loads. The building has a mean roof height of 18 ft, making it a low-rise building. The building has no openings other than doors, meaning it is an enclosed building. It is a regularly shaped building, and it is not flexible. The roof has a pitch of less than 45 degrees. Because of these criteria, we were able to use the simplified procedure to calculate our wind loads.

These wind loads came out to be 22.5 psf and -36.8 psf. Using tributary area, we calculated the loads on the columns to size our members.

4.3 Foundation and Soils

We chose a shallow foundation, spread footing, because it is easier to construct and common to be used for pump station houses. Also, the cost of it is affordable. We used the log of boring of the site and BCSF4, software developed by Dr. Garry H. Gregory to calculate the allowable net bearing capacity and we got an approximate value of 5000 psf. There are two foundations to be installed, one is at the exterior walls, and the other one is under the pipe trench. The footings dimensions were measured in accordance with the International Building Code 2012.

We calculated the surcharge load because there is an excavation used for the pipe trench, which causes a lateral pressure to act on the system in addition to the basic earth pressure, lateral pressure at rest. The lateral pressure caused by earth is 24,000 psf. There is no water table in the system, so that makes it easier to avoid the other loads. There is no live load applied to the foundation, and the dead load due to the slab is 150 lb/cubic ft. The pumps weigh 1950 lb each, and they are treated as point loads on the slab. Therefore, the net allowable load is approximately 20,000 lb/ft

4.4 Utilities

This pump station needs electricity to run the pumps and controls. The pump motors themselves need power, the variable frequency drives (VFDs) need power, and all the instrumentation and control processes need power to function. We plan on bringing in 3-phase power for a total of 480 V and a maximum of 400 A. We likely only need 220 V, so we are bringing 480 V into the station. This also serves to light the building and control the HVAC system in the station.

Power is the only utility that we need to bring into the station. We will tie into the local electric grid at existing power lines, and we recommend an on-site generator for redundant power. In case of electric failure, the generator will turn on to keep water flowing to the residents of the southwest region of Stillwater.

4.5 Pumps

Based on previous population calculation, we can determine the demand of water at this point.

$Q = 781\ gpm\ per\ pump = 1.74\ cfs\ per\ pump$

From elevation of pump station and water tower, we can determine the static head:

$Static\ head = 1063 - 930 = 133\ ft$

For dynamic head:

$$h_f = \frac{fL}{D} * \frac{v^2}{2g}$$

$$h_f = 0.021 \times \frac{6000}{1.33} \times \frac{1.74^2}{2 \times 32.2}$$

$$h_f = 4.5\ ft$$

v Here is velocity of flow,

$$v = \frac{Q}{A} = \frac{1.74}{\frac{\pi}{4} \times 1.33^2} = 1.74\ \frac{ft}{s}$$

Total head loss is$133 + 4.5 = 137.5\ ft$, use$140\ ft$.

Thus operating point for our pump is 780 gpm and 140 ft.

Based on this information, we determine to use pump $6 \times 4 \times 14L$ 8000 series with 12.0 inches impeller. The pump curve for the pump we chose can be found in Appendix G.

The pumps will also use a variable frequency drive (VFD) to adjust the speed with the variations in the flow. The specifications for these can also be found in Appendix G.

In addition to the VFDs, we will also install pressure transmitters to control the VFDs. Flowmeters will also be installed. These will send data to our program logic control (PLC) panel, which will control the VFDs. The data will also be sent to the city via a SCADA system installed at the station.

4.6 Detention Facility

Construction serves as a tool for the betterment of civilization and has innumerable applications. The positive affects of engineering require no explanation and are extraordinarily apparent, however altering the environment from its original state can also carry negative affects as well. One of the major concerns with the cut and fill of soil in an area for grading and setting groundwork is the increase in rainfall runoff due to the removal of obstacles and permeable surfaces. The results of this increase in runoff consist of disasters like flooding in the area, washout of affected soils, and water damage to the planned project.

To prevent any of these occurrences, it is important to develop a hydrograph of the watershed area in question, which will determine both pre and post construction runoff. The pre construction runoff is simply how the water will run off of the area without any construction being performed on the area. The importance of determining the post construction runoff is that the runoff difference from pre construction is the amount of water that will accumulate due to the "dirt work" in the area.

The area selected for the pump station has a rather lazy slope of roughly 4% and the actual area of the construction work is only 5,000 square feet. The actual runoff time of the water is so small that it is less than the smallest values in the given hydrograph charts. By rounding all of the values up to the nearest decimal, this inherently adds a safety factor to the resulting runoff volume. The project requires a detention pond to be able to sustain a 25-year storm, however, with these conservative numbers, the pond is more likely to handle a 100 year storm. The total storage volume required for this land is 2,391 ft^3. The values for the area in question as laid out in the Hydrographs can be examined in Appendix D.

The detention basin was set up underneath the parking lot section of the pump house. It is 1.2 foot deep, and has an area of 2,000 ft^2. To match the outflow of the water to that of the pre construction flow, a pipe needs to be installed that runs from the storage to the trench along the road. In sizing the outflow pipe, the required orifice size is smaller than that of the lowest value for this type of installment, so the lowest value is used, 4 inches, which is a conservative upsizing from what the value would have been.

5.0 Budget

We project that this project will cost $1.7 million as a capital cost. The breakdown of cost by facility is shown in Table 5.0-1 below.

Table 5.0-1: Capital cost of this project.

Facility	Total Cost
Pipeline	$ 459,104.83
Trench	$ 525,542.52
Building	$ 348,612.73
Electric	$ 52,291.91
Pumps	$ 148,852.55
Contingency	$ 153,440.45
Total	$ 1,687,844.99

In our initial budget, we projected the cost into terms of annual payment. We estimated that the city would pay nearly $800,000 every year for this project. This is a vast overestimate. Our material costs were inaccurate, and almost all of them were rule-of-thumb values. This estimate was much more refined, constructed using RSMeans.

6.0 Project Schedule

We set an initial schedule for the design phase at the beginning of this project, and we have mostly held to our schedule. Table 6.0-1 below outlines our schedule for the design phase.

Once we had all of the components sized and designed, we were able to build a schedule for the construction phase. Table 6.0-2 below details this preliminary schedule.

Table 6.0-1: Schedule for Design Phase

Projected Design Schedule: Harpoon & Associates																	
	Week 1: 12-Jan	Week 2: 19-Jan	Week 3: 26-Jan	Week 4: 2-Feb	Week 5: 9-Feb	Week 6: 16-Feb	Week 7: 23-Feb	Week 8: 2-Mar	Week 9: 9-Mar	Week 10: 17-Mar	Week 11: 23-Mar	Week 12: 30-Mar	Week 13: 6-Apr	Week 14: 13-Apr	Week 15: 20-Apr	Week 16: 27-Apr	Week 17: 4-May
Teams Formed	■																
RFP Received	■																
Respond to RFP		■	■														
Selection Interviews			■														
Teams Finalized				■													
Survey & Land Acquisition			■	■													
Geotechnical Investigation				■													
Permitting				■													
Begin CAD Modeling				■													
Foundations					■												
Utilities/Hydraulics					■	■	■										
Environmental						■											
First Quality Check					■	■											
30% Design Review						■											
Hydrology							■										
Storm Water Management							■	■									
Structures								■	■								
Second Quality Check							■	■									
50% Design Review									■								
Spring Break										■							
Set Pump Controls											■						
Finalize Design											■	■					
Prepare Final Presentation												■	■	■	■		
Estimates and Scheduling													■	■			
Final Quality Check														■	■		
Final Design Presentation																■	
Project Wrap-Up																	■

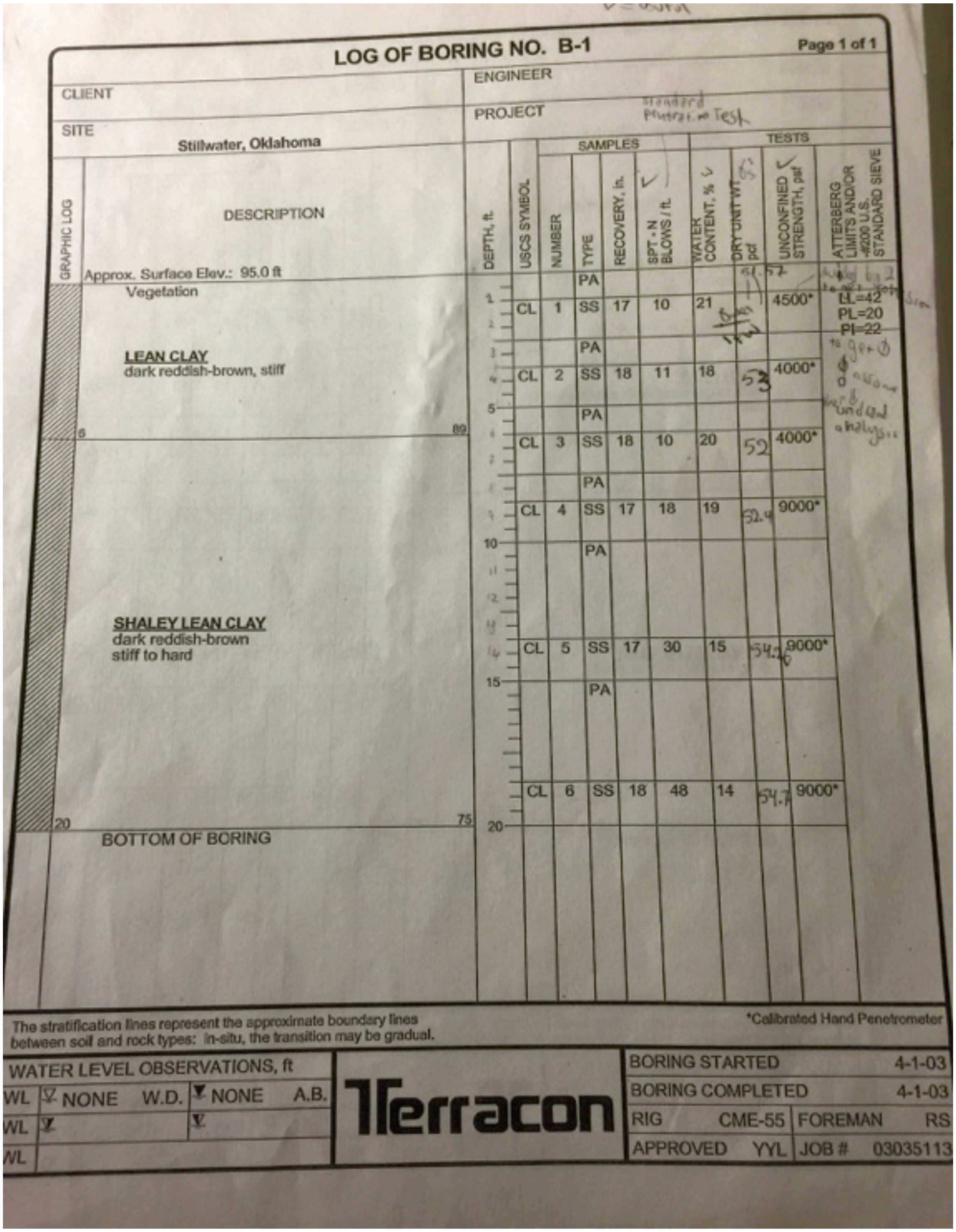
Table 6.0-2: Preliminary Construction Schedule

Projected Construction Schedule: Harpoon & Associates

	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	Week 7	Week 8	Week 9	Week 10	Week 11	Week 12	Week 13	Week 14	Week 15	Week 16	Week 17	Week 18	Week 19	Week 20	Week 21	Week 22	Week 23	Week 24	Week 25
Contract out for Bid	■																								
Award Contract		■																							
Gather Materials and Suppliers Lists		■	■																						
Order Materials			■	■																					
Pipework Trenching					■	■	■																		
Site Grading					■	■																			
Boring Tunnels						■		■			■														
Lay Bedding					■	■	■																		
Pipe Installation									■	■	■	■	■	■	■										
Backfill									■	■	■	■	■	■	■										
Excavation for Detention Facility								■	■	■															
Install Detention Facility										■	■														
Install Utilities															■	■	■								
Lay Foundation										■	■														
Construct Pump House												■	■	■	■	■	■								
Crane Installation																■	■	■							
Pump Installation																			■	■	■				
Install Controls																			■	■	■				
Pipe Installation																			■	■	■				
Site Cleanup																						■	■		
Start Up																								■	
City Approval																									■

Appendix A – Plan and Profile Sheets

Appendix B – Soil Boring Logs



LOG OF BORING NO. B-1 — Page 1 of 1

CLIENT	ENGINEER
SITE: Stillwater, Oklahoma	PROJECT: Standard Penetration Test

Approx. Surface Elev.: 95.0 ft

Description	Depth, ft.	USCS Symbol	Number	Type	Recovery, in.	SPT - N Blows / ft.	Water Content, %	Dry Unit Wt. pcf	Unconfined Strength, psf	Atterberg Limits and/or -#200 U.S. Standard Sieve
Vegetation				PA						
LEAN CLAY dark reddish-brown, stiff		CL	1	SS	17	10	21		4500*	LL=42 PL=20 PI=22
				PA						
		CL	2	SS	18	11	18	53	4000*	
	5			PA						
6 — 89		CL	3	SS	18	10	20	52	4000*	
SHALEY LEAN CLAY dark reddish-brown stiff to hard				PA						
		CL	4	SS	17	18	19	52.4	9000*	
	10			PA						
		CL	5	SS	17	30	15	54.[illegible]	9000*	
	15			PA						
		CL	6	SS	18	48	14	54.7	9000*	
20 — 75 BOTTOM OF BORING	20									

The stratification lines represent the approximate boundary lines between soil and rock types: in-situ, the transition may be gradual.

*Calibrated Hand Penetrometer

WATER LEVEL OBSERVATIONS, ft				
WL	NONE	W.D.	NONE	A.B.
WL				
WL				

Terracon

BORING STARTED	4-1-03		
BORING COMPLETED	4-1-03		
RIG	CME-55	FOREMAN	RS
APPROVED	YYL	JOB #	03035113

Appendix C – Foundation Sample Calculations

Foundation Design

Types of pressure: Active pressure, Passive pressure, & @ Rest

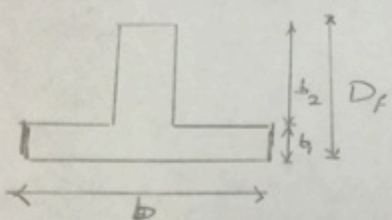
$\gamma'_{sat} \approx 125$ pcf

effective unit wt of soil $= \gamma' = 125 - 62.4 = 62.6$ pcf

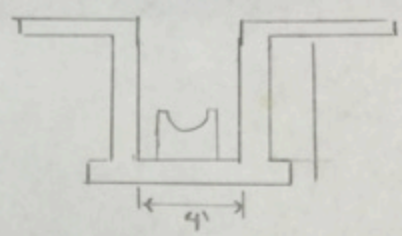
Factor of safety = 3

Soil cohesion $= \frac{4500}{2}$ (Unconfined strength) $= 2250$ psf

Shapes of footings:



"under walls"

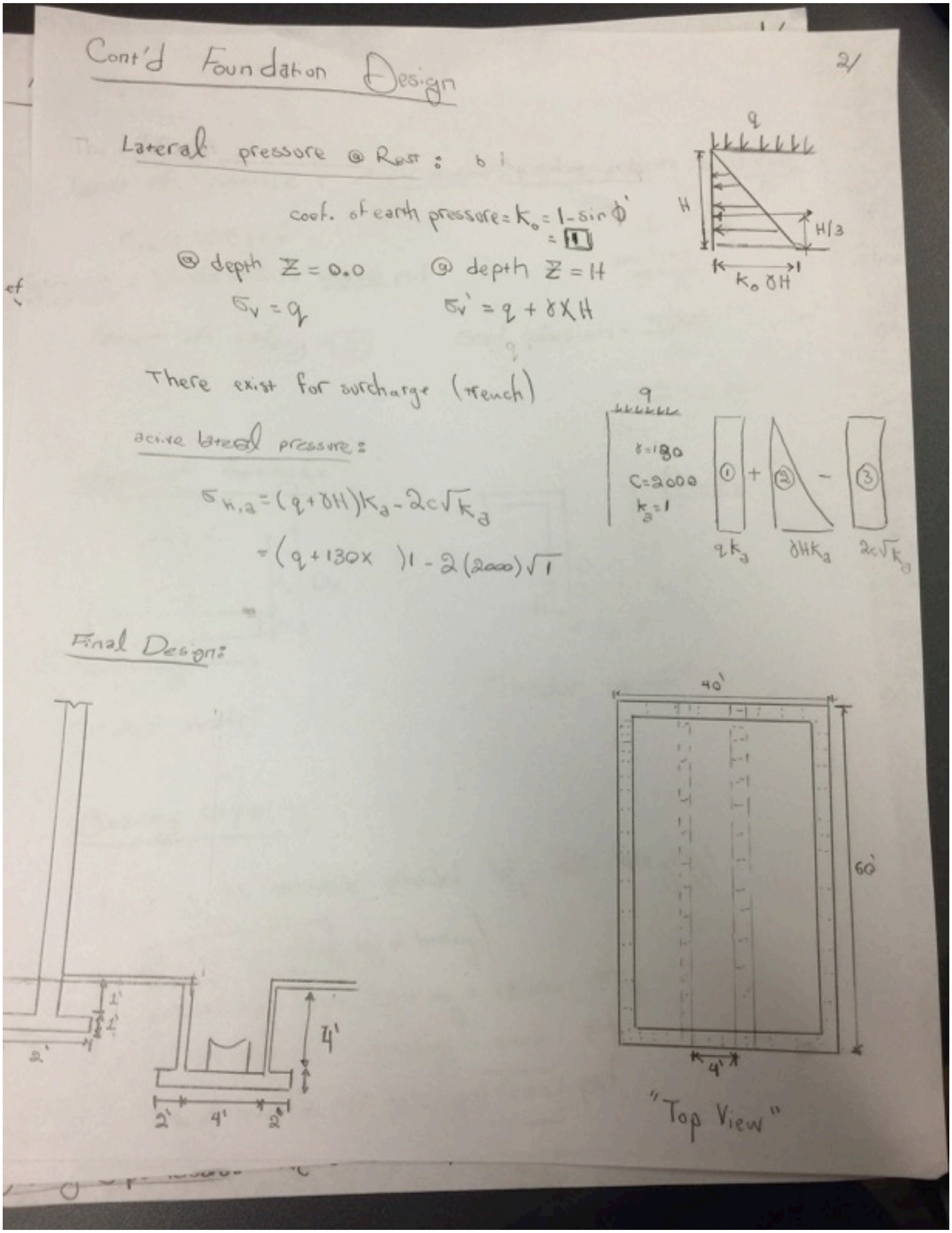


"under trench"

Bearing capacity:

By using the software provided by Dr. Gregory:

- No ground table (log of boring)
- Ultimate Gross Bearing = 15,000 psf
- Allowable Gross Bearing = 5000 psf
- Allowable net Bearing = 5000 psf



Bearing capacity of shallow foundation by Vesic Method. The software was written and provided by Garry H. Gregory, Ph.D., P.E.:

*****PROGRAM BCSF4*****

WRITTEN BY GARRY H. GREGORY, Ph.D., P.E. ((c)September 2011) - UNAUTHORIZED USE PROHIBITED

****BEARING CAPACITY OF SHALLOW FOUNDATIONS BY VESIC METHOD****

Harpoon & Associates

DATE OF RUN: 04/28/2015   TIME OF RUN: 20:41:14.71

Soil Friction Angle (Degrees) = 0.00   Soil Cohesion = 2250.00(psf)

Moist Unit Weight = 125.00(pcf)   Saturated Unit Weight = 130.00(pcf)

Depth to Water Table = 0.00(ft)   Load Inclination (Degrees) = 0.00   F.S.= 3.00

Number of Widths = 3   Number of Depths = 3

Initial Width =   2.00(ft)   Initial Length =   60.00(ft)   Initial Depth =   1.00(ft)

Vesic Bearing Capacity Factors

NC =   5.14   NQ =   1.00   NY =   0.00

Vesic Correction Factors (Fqi by Meyerhof Method)

B =   2.00(ft)

Df(ft):   1.00 2.00 3.00

Fcs =   1.006 1.006 1.006

Fqs =   1.000 1.000 1.000

Fys =   0.987 0.987 0.987

Fcd =   1.200 1.400 1.393

Fqd =   1.000 1.000 1.000

Fyd =   1.000 1.000 1.000

Fci =   1.000 1.000 1.000

Fqi =   1.000 1.000 1.000

Fyi =   0.000 0.000 0.000

B =   3.00(ft)

Df(ft):   1.00 2.00 3.00

Fcs =   1.010 1.010 1.010

Fqs = 1.000 1.000 1.000

Fγs = 0.980 0.980 0.980

Fcd = 1.133 1.267 1.400

Fqd = 1.000 1.000 1.000

Fγd = 1.000 1.000 1.000

Fci = 1.000 1.000 1.000

Fqi = 1.000 1.000 1.000

B = 4.00(ft)

Df(ft): 1.00 2.00 3.00

Fcs = 1.013 1.013 1.013

Fqs = 1.000 1.000 1.000

Fγs = 0.973 0.973 0.973

Fcd = 1.100 1.200 1.300

Fqd = 1.000 1.000 1.000

Fγd = 1.000 1.000 1.000

Fci = 1.000 1.000 1.000

Fqi = 1.000 1.000 1.000

Ultimate Gross Bearing Capacity				
Width(ft)	Length(ft)	Depth(ft)	qu(psf)	Qu(lb/ft)
2	60	1	14039.9	28080
2	60	2	16436.2	32872
2	60	3	16423.7	32847
3	60	1	13306.2	39918
3	60	2	14931.2	44794
3	60	3	16556.3	49669
4	60	1	12958	51832

4	60	2	14197.5	56790
4	60	3	15437	61748

Allowable Gross Bearing Capacity FS **= 3.00**				
Width(ft)	Length(ft)	Depth(ft)	qa(psf)	Q (lb/ft)
2	60	1	4680	9360
2	60	2	5478.7	10957
2	60	3	5474.6	10949
3	60	1	4435.4	13306
3	60	2	4977.1	14931
3	60	3	5518.8	16556
4	60	1	4319.3	17277
4	60	2	4732.5	18930
4	60	3	5145.7	20583

Allowable Net Bearing Capacity FS **= 3.00**				
Width(ft)	Length(ft)	Depth(ft)	qna(psf)	Qna(lb/ft)
2	60	1	4657.4	9315
2	60	2	5433.7	10867
2	60	3	5407	10814
3	60	1	4412.9	13239
3	60	2	4932	14796
3	60	3	5451.2	16354
4	60	1	4296.8	17187
4	60	2	4687.4	18750
4	60	3	5078.1	20312

Appendix D – Hydrology Sample Calculations

The hydrology calculations were performed using the method outlined in the TR-55 document.

Worksheet 5a: basic watershed data

24 hr rainfall P (in) 8.46

	1	2	3
Length	225	225	50
height	10	10	2
slope (ft/ft)	0.044	0.044	0.0400
velocity (ft/s)	3.4	3.4	3.2
trvel time (s)	66.18	66.18	15.63
travel time (hr)		0.0184	0.0043
Drainage area Am (mi2)	0.000404	0.000404	8.968E-05
Time of Conc. Tc (hr)	0.0184	0.0184	0.0227
Travel Time through subarea Tt	-	0.0184	0.0043
Downstream Subarea names	2, 3	3	-
Travel time summation to outlet	0.0227	0.0043	-
Pre-const. CN	83	83	83
Pre-const. Runoff Q (in.)	6.39	6.39	6.39
Am-Q (mi2-in)	0.00258	0.00258	0.00057
Initial Abstraction Ia	0.41	0.41	0.41
Ia/P	0.04846	0.04846	0.04846

	1	2	3		
Length	225	225	50		
height	10	10	1		
slope (ft/ft)	0.044	0.044	0.02		
velocity (ft/s)	3.4	3.4	1.5		
trvel time (s)	66.18	66.18	33.3333		
travel time (hr)		0.0184	0.00926		
Drainage area Am (mi2)	0.000404	0.000404	8.968E-05	total drainage area	0.000897
Time of Conc. Tc (hr)	0.0184	0.0184	0.0276		
Travel Time through subarea Tt	-	0.0184	0.0093		
Downstream Subarea names	2, 3	3	-		
Travel time summation to outlet	0.0276	0.0093	-		
Post-const. CN	83	83	98		
Post-const. Runoff Q (in.)	6.39	6.39	8.26		
Am-Q (mi2-in)	0.00258	0.00258	0.00074		
Initial Abstraction Ia	0.41	0.41	0.041		
Ia/P	0.04846	0.04846	0.00485		

Worksheet 5b: basic watershed data

Time of Conc. Tc (hr)	0.0184	0.0184	0.0227
Time to outlet ΣTt (hr)	0.0227	0.0043	-
Ia/P	0.04846	0.04846	0.04846
Am-Q (mi2-in)	0.00258	0.00258	0.00057

Time of Conc. Tc (hr)	0.0184	0.0184	0.0276
Time to outlet ΣTt (hr)	0.0276	0.0093	-
Ia/P	0.0485	0.0485	0.0048
Am-Q (mi2-in)	0.0026	0.0026	0.0007

Note: numbers are so small across the bored, units will be rounded up to .1, thus the water control will be overdesigned.

Note: The hydrograph hours window will be spread to be sure to include the largest quantity

Pre Construction

hydrograph times in hours	11	11.3	11.6	11.9	12	12.1	12.2	12.3	12.4	12.5	12.6	12.7
	24	34	53	334	647	1010	623	217	147	123	104	86
Tt=0.0 hr, Ia/P= .1, Tc=.1												
Area 1	0.0619	0.0877	0.1367	0.8613	1.6684	2.6044	1.6065	0.5596	0.3791	0.3172	0.2682	0.2218
Area 2	0.0619	0.0877	0.1367	0.8613	1.6684	2.6044	1.6065	0.5596	0.3791	0.3172	0.2682	0.2218
Area 3	0.0138	0.0195	0.0304	0.1914	0.3707	0.5788	0.3570	0.1243	0.0842	0.0705	0.0596	0.0493
	0.1375	0.1948	0.3037	1.9139	3.7075	5.7875	3.5699	1.2435	0.8423	0.7048	0.5959	0.4928
	21	29	43	134	267	520	847	701	378	224	157	122
Tt=0.1 hr, Ia/P= .1, Tc=.1												
Area 1	0.0542	0.0748	0.1109	0.3455	0.6885	1.3409	2.1841	1.8076	0.9747	0.5776	0.4048	0.3146
Area 2	0.0542	0.0748	0.1109	0.3455	0.6885	1.3409	2.1841	1.8076	0.9747	0.5776	0.4048	0.3146
Area 3	0.0120	0.0166	0.0246	0.0768	0.1530	0.2980	0.4854	0.4017	0.2166	0.1284	0.0900	0.0699
	0.1203	0.1662	0.2464	0.7679	1.5300	2.9797	4.8535	4.0169	2.1660	1.2836	0.8996	0.6991
	18	25	35	61	110	215	418	704	702	486	312	209
Tt=0.2 hr, Ia/P= .1, Tc=.1												
Area 1	0.0464	0.0645	0.0903	0.1573	0.2836	0.5544	1.0779	1.8153	1.8102	1.2532	0.8045	0.5389
Area 2	0.0464	0.0645	0.0903	0.1573	0.2836	0.5544	1.0779	1.8153	1.8102	1.2532	0.8045	0.5389
Area 3	0.0103	0.0143	0.0201	0.0350	0.0630	0.1232	0.2395	0.4034	0.4023	0.2785	0.1788	0.1198
	0.1031	0.1433	0.2006	0.3495	0.6303	1.2320	2.3952	4.0341	4.0226	2.7849	1.7878	1.1976

Post Construction

hydrograph times in hours	11	11.3	11.6	11.9	12	12.1	12.2	12.3	12.4	12.5	12.6	12.7
	24	34	53	334	647	1010	623	217	147	123	104	86
Tt=0.0 hr, Ia/P= .1, Tc=.1												
Area 1	0.0619	0.0877	0.1367	0.8613	1.6684	2.6044	1.6065	0.5596	0.3791	0.3172	0.2682	0.2218
Area 2	0.0619	0.0877	0.1367	0.8613	1.6684	2.6044	1.6065	0.5596	0.3791	0.3172	0.2682	0.2218
Area 3	0.0178	0.0252	0.0393	0.2474	0.4792	0.7481	0.4615	0.1607	0.1089	0.0911	0.0770	0.0637
	0.1416	0.2005	0.3126	1.9699	3.8160	5.9569	3.6744	1.2799	0.8670	0.7254	0.6134	0.5072
	21	29	43	134	267	520	847	701	378	224	157	122
Tt=0.1 hr, Ia/P= .1, Tc=.1												
Area 1	0.0542	0.0748	0.1109	0.3455	0.6885	1.3409	2.1841	1.8076	0.9747	0.5776	0.4048	0.3146
Area 2	0.0542	0.0748	0.1109	0.3455	0.6885	1.3409	2.1841	1.8076	0.9747	0.5776	0.4048	0.3146
Area 3	0.0156	0.0215	0.0319	0.0993	0.1978	0.3852	0.6274	0.5192	0.2800	0.1659	0.1163	0.0904
	0.1239	0.1710	0.2536	0.7903	1.5747	3.0669	4.9956	4.1345	2.2294	1.3211	0.9260	0.7195
	18	25	35	61	110	215	418	704	702	486	312	209
Tt=0.2 hr, Ia/P= .1, Tc=.1												
Area 1	0.0464	0.0645	0.0903	0.1573	0.2836	0.5544	1.0779	1.8153	1.8102	1.2532	0.8045	0.5389
Area 2	0.0464	0.0645	0.0903	0.1573	0.2836	0.5544	1.0779	1.8153	1.8102	1.2532	0.8045	0.5389
Area 3	0.0133	0.0185	0.0259	0.0452	0.0815	0.1593	0.3096	0.5215	0.5200	0.3600	0.2311	0.1548
	0.1062	0.1474	0.2064	0.3598	0.6488	1.2681	2.4653	4.1521	4.1404	2.8664	1.8402	1.2327

Peak Outflow Discharge	Qo	5.7875	0.97156758
Peak Inflow Discharge	Qi	5.9569	

Note: highest quantity available on chart is .8, therefore .8 will be used.

Storage Volume	Vs	0.139
Runoff Volume	Vr	

Runoff Volume 0.395024284

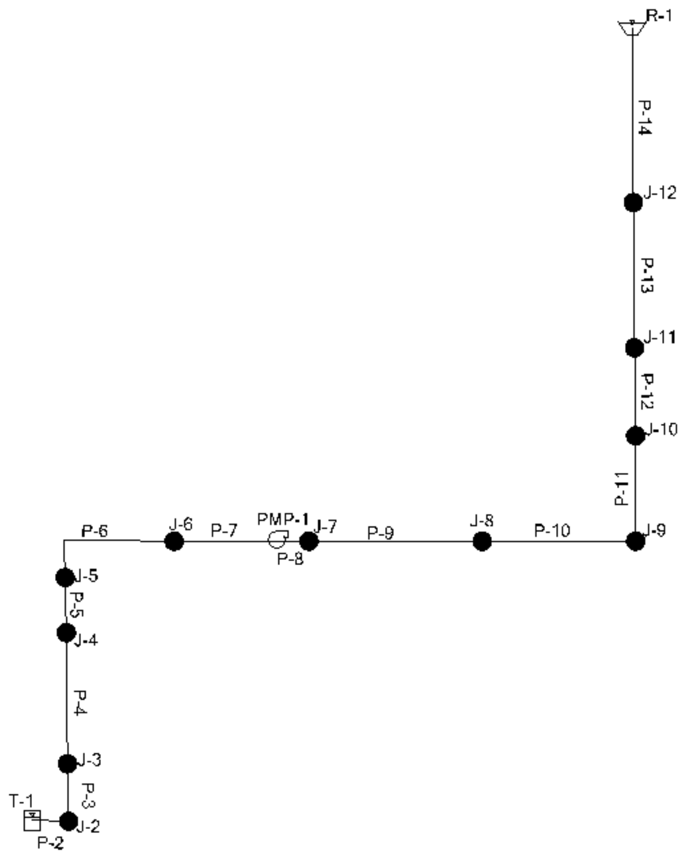
Storage Volume 0.054908375 acre-ft
2391.808836 ft3

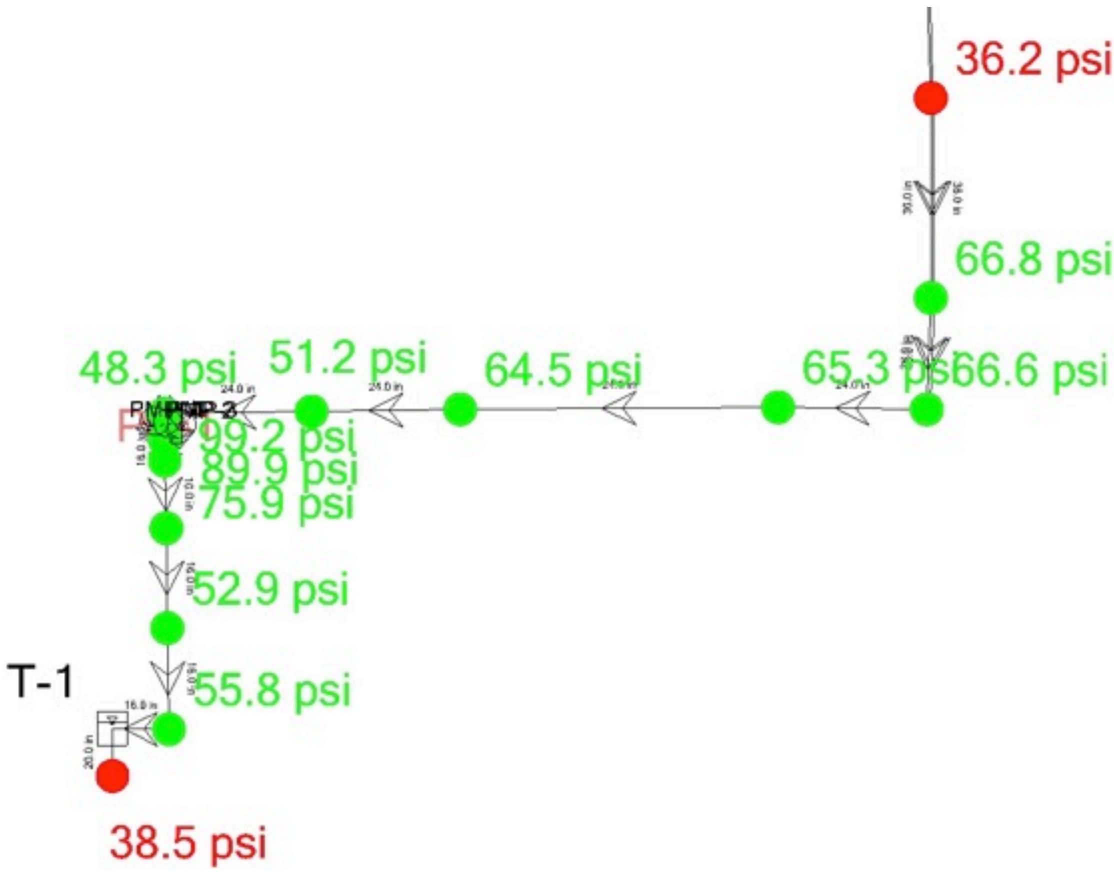
detention basin = area*depth

volume	2391.80884	1.195904418 ft depth
area	2000	

Appendix E – Hydraulic Tables from WaterCAD

The following images show the layout of the WaterCAD model used to calculate the hydraulic needs of the system. The first image shows the preliminary layout, and the second one shows the finalized layout with pressures at each junction.





The next few images are the FlexTables generated from WaterCAD. The first is the pressures in the 24" suction line into the station. The next is the pressures in all of the junctions, including in the 20" discharge line to the water tower. The final one is the pipe flex table, showing the flow in each pipe.

ID	Label	Elevation (ft)	Zone	Demand Collection	Demand (gpm)	Hydraulic Grade (ft)	Pressure (psi)
35	J-4	890.00	<None>	<Collection: 1 items>	4,937	1,043.99	66.6
37	J-5	890.00	<None>	<Collection: 1 items>	2,032	1,040.88	65.3
39	J-6	890.00	<None>	<Collection: 1 items>	302	1,038.97	64.5
41	J-7	920.00	<None>	<Collection: 0 items>	0	1,038.31	51.2
43	J-8	926.00	<None>	<Collection: 0 items>	0	1,037.65	48.3

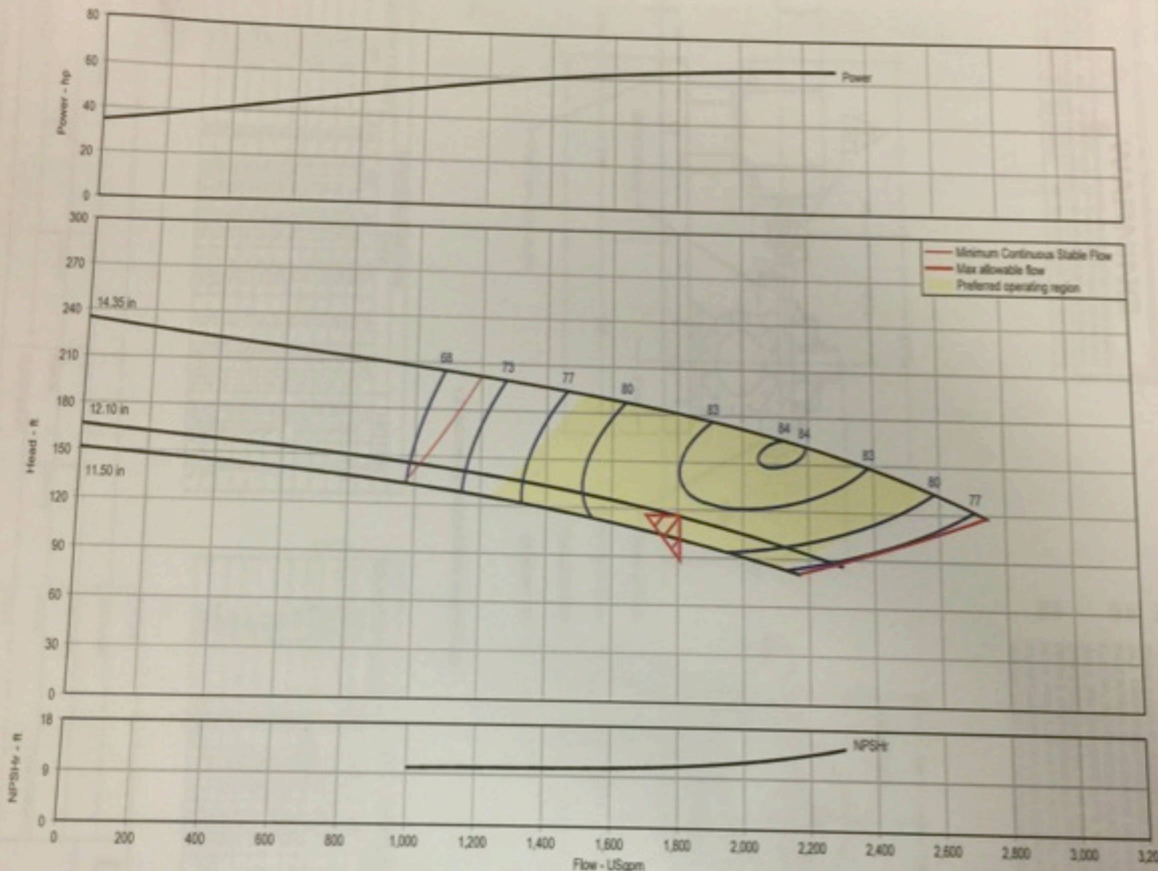
ID	Label	Elevation (ft)	Zone	Demand Collection	Demand (gpm)	Hydraulic Grade (ft)	Pressure (psi)
29	J-1	930.00	<None>	<Collection: 0 items>	0	1,052.73	53.1
31	J-2	963.00	<None>	<Collection: 1 items>	2,571	1,046.64	36.2
33	J-3	890.00	<None>	<Collection: 1 items>	11,593	1,044.38	66.8
35	J-4	890.00	<None>	<Collection: 1 items>	4,937	1,043.99	66.6
37	J-5	890.00	<None>	<Collection: 1 items>	2,032	1,040.88	65.3
39	J-6	890.00	<None>	<Collection: 1 items>	302	1,038.97	64.5
41	J-7	920.00	<None>	<Collection: 0 items>	0	1,038.31	51.2
43	J-8	926.00	<None>	<Collection: 0 items>	0	1,037.65	48.3
45	J-9	950.00	<None>	<Collection: 0 items>	0	1,157.74	89.9
47	J-10	980.00	<None>	<Collection: 0 items>	0	1,155.54	75.9
49	J-11	1,020.00	<None>	<Collection: 1 items>	1,563	1,149.02	55.8
53	J-12	1,060.00	<None>	<Collection: 1 items>	0	1,149.00	38.5
58	J-15	1,040.00	<None>	<Collection: 0 items>	0	1,079.78	17.2
67	J-18	930.00	<None>	<Collection: 0 items>	0	1,159.27	99.2
83	J-19	1,030.00	<None>	<Collection: 0 items>	0	1,152.30	52.9

Label	Length (Scaled) (ft)	Start Node	Stop Node	Diameter (in)	Material	Hazen-Williams C	Flow (gpm)	Velocity (ft/s)	Length (User Defined) (ft)
P-2	204.47	J-1	J-2	36.0	PVC	150.0	11,619	3.66	5,398.42
P-3	132.15	J-2	J-3	36.0	PVC	130.0	10,334	3.26	2,489.02
P-4	73.62	J-3	J-4	36.0	PVC	130.0	4,537	1.43	1,943.72
P-5	98.10	J-4	J-5	24.0	PVC	130.0	4,138	2.93	2,590.04
P-6	209.81	J-5	J-6	24.0	PVC	130.0	2,105	1.49	5,539.40
P-7	98.10	J-6	J-7	24.0	PVC	130.0	1,803	1.28	2,590.04
P-8	96.74	J-7	J-8	24.0	PVC	130.0	1,803	1.28	2,554.13
P-10	44.66	J-9	J-10	16.0	PVC	130.0	1,803	2.88	1,179.11
P-12	37.39	J-11	T-1	16.0	PVC	130.0	240	0.38	400.00
P-13	31.48	T-1	J-12	20.0	PVC	40.0	0	0.00	40.00
P-15	10.85	R-1	J-15	50.9	PVC	130.0	23,239	3.66	286.51
P-16	907.96	J-15	J-1	36.0	PVC	130.0	11,619	3.66	23,969.79
P-22	13.81	J-18	J-9	16.0	PVC	130.0	1,803	2.88	824.27
P-23	8.16	J-8	PMP-1	16.0	PVC	130.0	601	0.96	20.00
P-24	9.25	PMP-1	J-18	16.0	PVC	130.0	601	0.96	20.00
P-25	10.45	J-8	PMP-2	16.0	PVC	130.0	601	0.96	20.00
P-26	12.25	PMP-2	J-18	16.0	PVC	130.0	601	0.96	20.00
P-27	11.11	J-8	PMP-3	16.0	PVC	130.0	601	0.96	20.00
P-28	13.07	PMP-3	J-18	16.0	PVC	130.0	601	0.96	20.00
P-29	907.75	J-15	J-1	36.0	PVC	130.0	11,619	3.66	23,969.79
P-30	204.85	J-1	J-2	36.0	PVC	130.0	11,619	3.66	5,398.42
P-31	132.87	J-2	J-3	36.0	PVC	130.0	10,334	3.26	2,489.02
P-32	74.65	J-3	J-4	36.0	PVC	130.0	4,537	1.43	1,943.72
P-33	66.00	J-10	J-19	16.0	PVC	130.0	1,803	2.88	1,742.61
P-34	66.82	J-19	J-11	16.0	PVC	130.0	1,803	2.88	1,764.10

Appendix F – Pump and VFD Specifications

Customer :
Project name : Default

Pump Performance Curve
Encompass 2.0 - 15.1.1.0



Item number	: 003	Size	: 6" 28x3C	Flow, rated	: 1,807.0 USgpm
Service	:	Stages	: 1	Differential head / pressure, rated	: 116.0 ft
Quantity	: 1	Speed, rated	: 1,780 rpm	NPSH required	: 11.03 ft
Quote number	: 278120	Based on curve number	: 6-28x3C-1800-J6H1C1	Fluid density, rated / max	: 0.999 / 0.999 SG
Date last saved	: 27 Apr 2015 8:33 AM	Efficiency	: 82.22 %	Viscosity	: 1.00 cP
		Power, rated	: 64.26 hp	Cq/Ch/Ce/Cn [ANSI/HI 9.6.7-2010]	: 1.00 / 1.00 / 1.00 / 1.00

HAYNES EQUIPMENT COMPANY, LLC.
117 N W 132ND - OKLAHOMA CITY, OK 73114-8115

PHONE: - FAX:

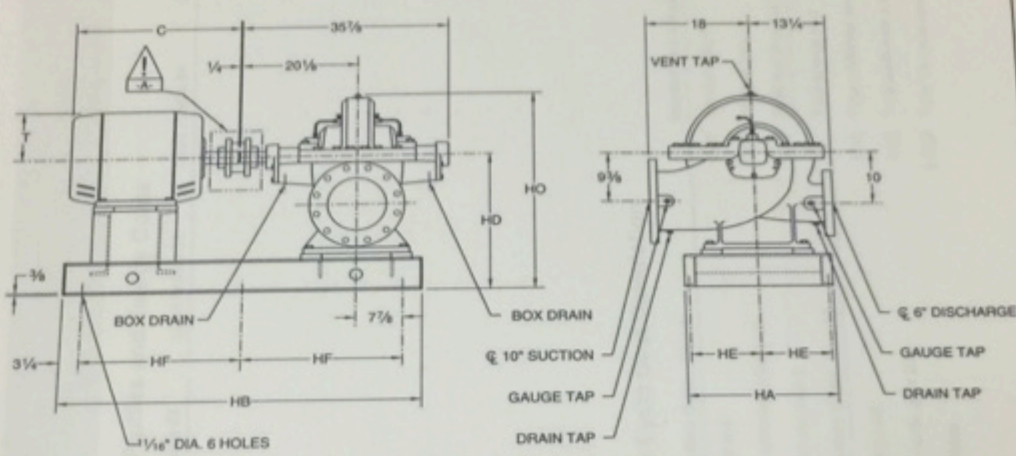
⚠ WARNING

DO NOT OPERATE THIS MACHINE WITHOUT PROTECTIVE GUARD IN PLACE. ANY OPERATION OF THIS MACHINE WITHOUT PROTECTIVE GUARD CAN RESULT IN SEVERE BODILY INJURY.

-A- SUPPLIED BY FMPC -B- SUPPLIED BY OTHERS

NOTES:

(1) ALL FLANGES ARE STANDARD 125# ANSI DRILLING. OPTIONAL 250# ANSI FLANGES ARE AVAILABLE.
(2) ALL DIMENSIONS ARE IN INCHES UNLESS NOTED.
(3) ROTATION IS ALWAYS VIEWED FROM THE DRIVER END. FOR C.C.W. ROTATION, SUCTION AND DISCHARGE POSITIONS WILL BE ON OPPOSITE SIDES OF THAT SHOWN ABOVE AND DIMENSIONS IN THE END VIEW WILL BE REVERSED.
(4) BASES ARE DESIGNED TO BE COMPLETELY FILLED WITH GROUT.
(5) NOT FOR CONSTRUCTION, INSTALLATION, OR APPLICATION PURPOSES UNLESS CERTIFIED. DIMENSIONS SHOWN MAY VARY DUE TO NORMAL MANUFACTURING TOLERANCES.



CLOCKWISE ROTATION SHOWN (3)

UNIT DIMENSIONS								
MOTOR FRAME SIZE	BASE						MOTOR	
	HA	HB	HD	HE	HF	HO	C	T
256T	19	54½	25¾	8¾	24	37 1/16	22⅜	6⅜
284TS	19	54½	25¾	8¾	24	37 1/16	22⅛	7
284T	19	54½	25¾	8¾	24	37 1/16	23½	7
286TS	19	54½	25¾	8¾	24	37 1/16	23⅝	7
286T	19	54½	25¾	8¾	24	37 1/16	25	7
324TS	19	54½	25¾	8¾	24	37 1/16	24⅝	8
324T	19	60½	25¾	8¾	24	37 1/16	26⅛	8
326TS	19	60½	25¾	8¾	27	37 1/16	26⅛	8
326T	19	60½	25¾	8¾	27	37 1/16	27⅝	8
364TS	25	60½	25¾	11¾	27	37 1/16	26⅝	9¼
364T	25	60½	25¾	11¾	27	37 1/16	28¾	9¼

UNIT DIMENSIONS								
MOTOR FRAME SIZE	BASE						MOTOR	
	HA	HB	HD	HE	HF	HO	C	T
~~365TS~~	~~25~~	~~60½~~	~~25¾~~	~~11¾~~	~~27~~	~~37 1/16~~	~~27½~~	~~9¼~~
365T	25	60½	25¾	11¾	27	37 1/16	29¾	9¼
~~404TS~~	~~25~~	~~60½~~	~~25¾~~	~~11¾~~	~~27~~	~~37 1/16~~	~~29⅝~~	~~10¼~~
404T	25	60½	25¾	11¾	27	37 1/16	32⅝	10¼
405TS	25	60½	25¾	11¾	27	37 1/16	31⅛	10¼
405T	25	66½	25¾	11¾	30	37 1/16	34⅛	10¼
444TS	25	66½	25¾	11¾	30	37 1/16	34⅛	11¼
444T	25	72½	25¾	12	33	37 1/16	37⅞	11¼
445TS	25	66½	25¾	11¾	30	37 1/16	36⅛	11¼
445T	25¾	72½	27¾	12	33	39 1/16	39⅞	11¼

CUSTOMER		P.O. NO.	Fairbanks Morse Pump Corporation
JOB NAME		TAG NAME	SETTING PLAN 6" 2823A & C OPTIONAL STRUCTURAL BASE
PUMP SIZE AND MODEL	GPM / TDH / RPM	ROTATION	
MOTOR / HP	FRAME / PHASE / HERTZ	VOLTS / ENCLOSURE	
CERTIFIED FOR	CERTIFIED BY	DATE	DWG NO 2820S049 / REV NO 0

PENTAIR

Customer :
Project name : Default

Life Cycle Cost Datasheet

Encompass 2.0 - 15.1.1.0

Item number	: 003	Quantity	: 1	Size	: 6" 28x3C
Service	:	Quote number	: 278120	Stages	: 1
		Date last saved	: 27 Apr 2015 8:33 AM	Speed, rated	: 1,780

Load Profiles and Energy Costs

Expected pump life: 20 years	Load Profile #1	Load Profile #2	Load Profile #3	Load Profile #4	Load Profile #5	Total
Flow: (USgpm)	1,807.0	-	-	-	-	-
Operation: (hours per year)	8,760	-	-	-	-	8,760
Energy cost, present value ($ per kWh)	0.1000	-	-	-	-	-
Speed, rated (rpm)	1,780	-	-	-	-	-
Head (ft)	115.9	-	-	-	-	-
Efficiency (%)	82.22	-	-	-	-	-
Power, rated (hp)	64.26	-	-	-	-	-
Motor efficiency (%)	100.00	-	-	-	-	-
Drive/gear efficiency (%)	100.00	-	-	-	-	-
System curve		-	-	-	-	-
Energy, total (kWh)	8,395,691.1	-	-	-	-	8,395,691.1
Energy cost, per year	$ 41,978.46	-	-	-	-	$ 41,978.46
Energy cost, total present value	$ 629,608.77	-	-	-	-	$ 629,608.77

Life Cycle Cost Calculation

Additional Annual Costs			Additional One-time Costs, Year 0			Interest and Inflation Rates		
Routine maintenance cost	:	0.00	Initial investment cost	:	0.00	Interest rate, %	:	6.00
Repair cost	:	0.00	Installation and commissioning cost	:	0.00	Inflation rate, %	:	3.00
Operating cost	:	0.00	Other one-time costs, year 0	:	0.00	**Total Net Present Value Costs**		
Downtime cost	:	0.00	**Additional One-time Costs, Year 20**			Total energy cost	:	$ 629,608.77
Environmental cost	:	0.00	Decommissioning cost	:	0.00	Total additional annual cost	:	$ 0.00
Other annual costs	:	0.00	Other one-time costs, year 20	:	0.00	Total additional one-time cost	:	$ 0.00
Total, present value	:	$ 0.00	Total, present value	:	$ 0.00	Total life cycle cost	:	$ 629,608.77

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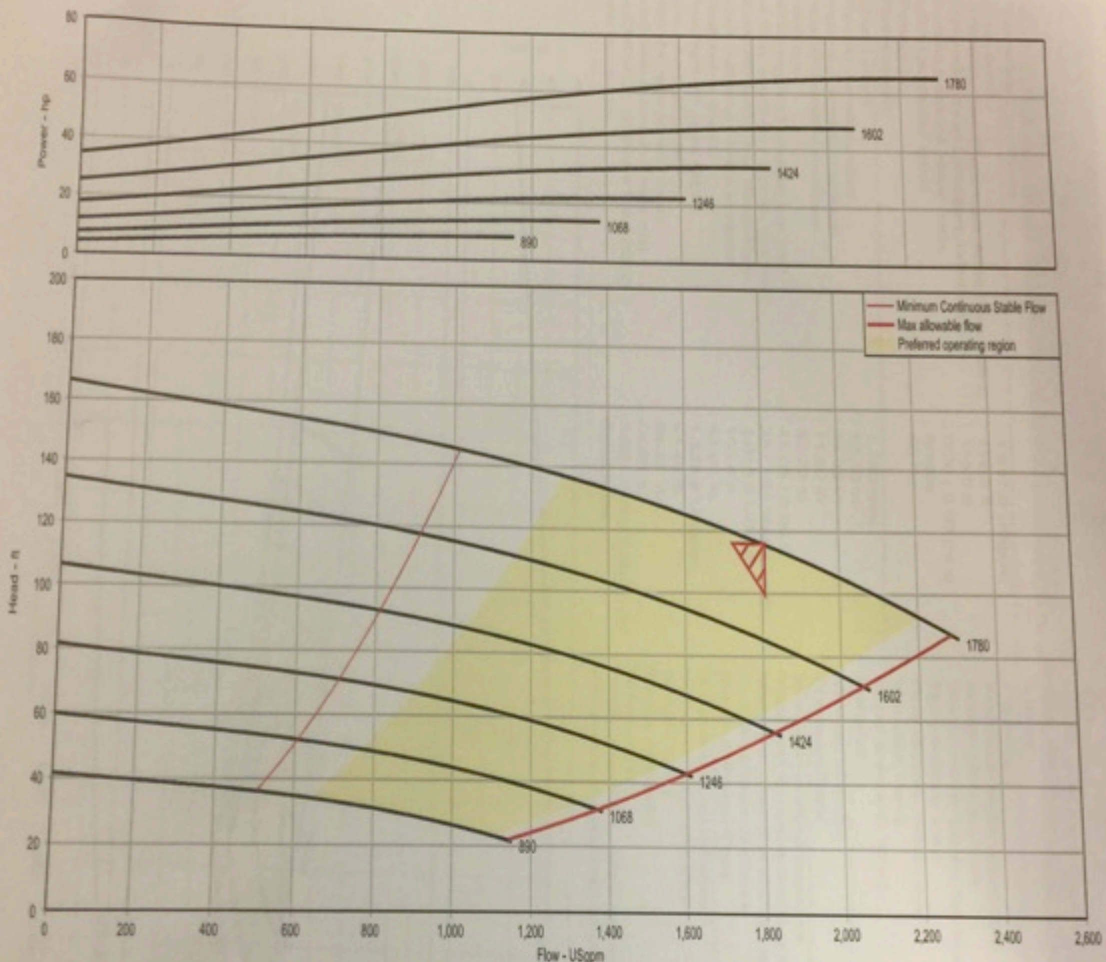
Customer :
Project name : Default

Multi-Speed Performance Curve

Encompass 2.0 - 15.1.1.0



Item number	: 003	Size	: 6" 28x3C	Flow, rated	: 1,807.0 USgpm
Service	:	Stages	: 1	Differential head / pressure, rated	: 116.0 ft
Quantity	: 1	Speed, rated	: 1,780 rpm	NPSH required	: 11.03 ft
Quote number	: 278120	Based on curve number	: 6-28x3C-1800-J6H1C1	Fluid density, rated / max	: 0.999 / 0.999 SG
Date last saved	: 27 Apr 2015 8:33 AM	Efficiency	: 82.22 %	Viscosity	: 1.00 cP
		Power, rated	: 64.26 hp	Cq/Ch/Ce/Cn [ANSI/HI 9.6.7-2010]	: 1.00 / 1.00 / 1.00 / 1.00
				Impeller diameter, rated	: 12.10 in

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PENTAIR

Customer :
Project name : Default

Pump Performance Datasheet

Encompass 2.0 - 15.1.1.0

Item number	: 003	Size	: 6" 28x3C
Service	:	Stages	: 1
Quantity	: 1	Based on curve number	: 6-28x3C-1800-J6H1C1
Quote number	: 278120	Date last saved	: 27 Apr 2015 8:33 AM

Operating Conditions

Flow, rated	: 1,807.0 USgpm
Differential head / pressure, rated (requested)	: 116.0 ft
Differential head / pressure, rated (actual)	: 116.6 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	: 12.10 in
Impeller diameter, maximum	: 14.35 in
Impeller diameter, minimum	: 11.50 in
Efficiency	: 82.22 %
NPSH required / margin required	: 11.03 / 0.00 ft
nq (imp. eye flow) / S (imp. eye flow)	: 25 / 164 Metric units
Minimum Continuous Stable Flow	: 1,015.0 USgpm
Head, maximum, rated diameter	: 166.4 ft
Head rise to shutoff	: 43.65 %
Flow, best eff. point (BEP)	: 1,835.8 USgpm
Flow ratio (rated / BEP)	: 98.43 %
Diameter ratio (rated / max)	: 84.32 %
Head ratio (rated dia / max dia)	: 64.03 %
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	: 0.999 / 0.999 SG
Viscosity, rated	: 1.00 cP
Vapor pressure, rated	: 0.34 psi.a

Material

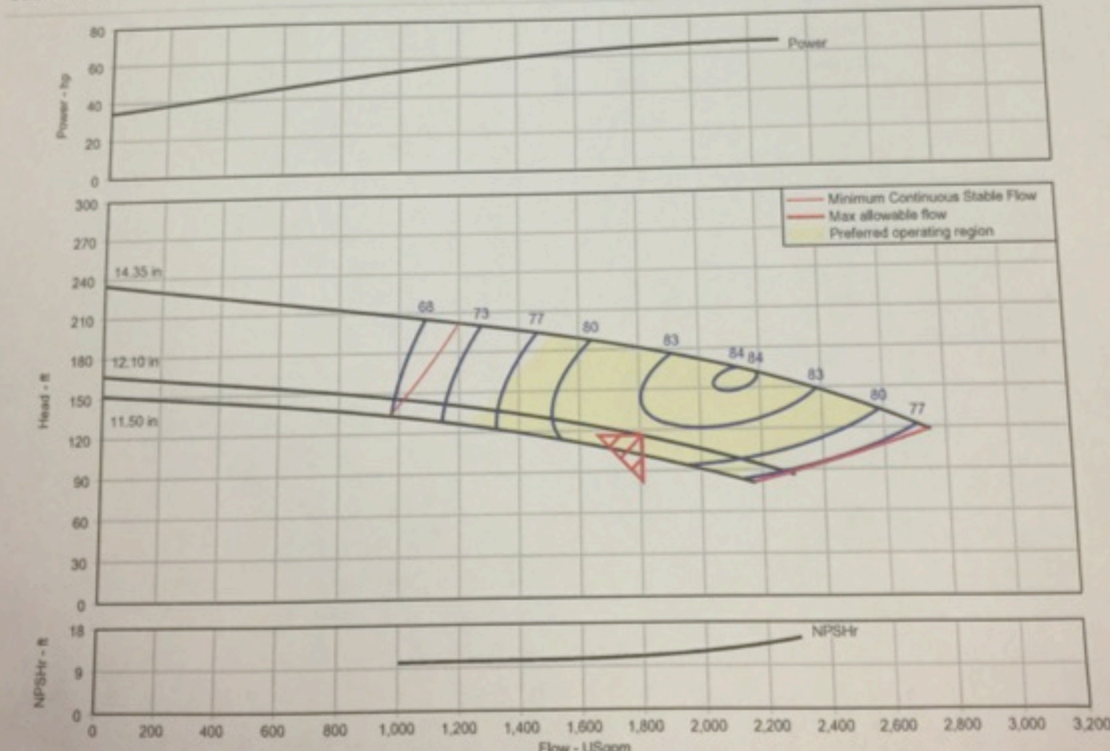
Material selected	: Standard

Pressure Data

Maximum working pressure	: 72.01 psi.g
Maximum allowable working pressure	: 300.0 psi.g
Maximum allowable suction pressure	: N/A
Hydrostatic test pressure	: N/A

Driver & Power Data

Driver sizing specification	: Maximum power
Margin over specification	: 0.00 %
Service factor	: 1.00
Power, hydraulic	: 52.84 hp
Power, rated	: 64.26 hp
Power, maximum, rated diameter	: 65.85 hp
Minimum recommended motor rating	: 75.00 hp / 55.93 kW



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