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FirstEnergy Bay Shore Power Plant
Integrated Reversed Louver
Fish Diversion System

Concept Design Evaluation

April 20, 2011

Kinectrics Report No: K-409054-CDE-0001-R02

Bob Reesor, David Marttila, Paul Patrick

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1.0 INTRODUCTION

Extensive research has been conducted on various fish protection systems in an attempt to reduce both entrainment (E) and impingement (I). Since the technology for impingement reduction is often different from entrainment technologies, integrated systems are often used to address the different life history stages of fish, notably larvae, juvenile and adult fish.

A preliminary evaluation of various mitigation options for reducing fish impingement and entrainment at Bay Shore Power Plant was conducted by Kinectrics in 2008 (Ager and Lin 2009). At that time, a reversed louver system with a culvert bypass offered maximum predicted reduction for impingement. A follow-up study suggested that further modifications to the louver (smaller slat angle, smaller open spacing and placement of a solid bottom overlay) and a fine mesh angled screen placed behind the louver may offer further entrainment and impingement reductions (Lin and Patrick 2010).

A pilot project was conducted at the Bay Shore intake channel using an angled reversed louver array and a sample angled fine mesh screen to determine its effectiveness in reducing I/E. The pilot project was installed in April 2010 with data collection and evaluations commencing in May and continuing throughout the summer and early fall periods. The pilot louver was designed to test the louver performance with respect to I/E and fish response and give guidance for operational issues. The pilot louver was installed at an angle of approximately 20-22 degrees to the channel shoreline and extended 140 feet in length with 7 sections of 20 feet each. The louver terminated at about 50 feet perpendicular to the shoreline at a depth of about 14 feet which was nearly 25% of the distance across the channel.

In order to extend this reverse louver design to a full scale application at Bay Shore, a preliminary engineering design report was prepared (Kinectrics Report No: K-409054-001-DR-0001-R02) to define the major issues to be addressed for the design of an integrated fish diversion system (i.e. "the Fish Diversion System", FDS). The integrated FDS will consist of the following components:

1. Trash Diversion/Handling System
2. Reverse Louver Array
3. Fish Pump and Fish Return System
4. Fine Mesh Traveling Screens

The objective of this engineering design review report is to present and evaluate conceptual FDS designs. The evaluation of the conceptual designs is based on the following:

1. Ability to meet the design criteria compiled in Kinectrics Report No: K-409054-001-DR-0001-R02
2. Cost estimation of the components
3. Cost estimation for construction and installation
4. Long term performance
5. Maintenance and regulatory requirements.

2.0 GENERAL SYSTEM DESCRIPTION

It is necessary for Bay Shore Power Plant to meet the proposed OEPA guidelines for entrainment and impingement reductions as per their NPDES Permit:

- Entrainment- 60% (eggs and larval fish)
- Impingement- 80% (juvenile and adult fish)

Operational experience shows that single mode system for fish diversion systems do not generally meet the proposed guidelines for both entrainment and impingement reduction and survivability.

As noted above, integrated systems are generally used to address the different life history stages of fish, notably larvae, juvenile and adult fish. For example, at the Brunswick Plant in North Carolina, mitigation technologies include a fish diversion structure (9.4 mm mesh screens) at the mouth of the intake channel to reduce impingement of large organisms, 1mm fine-mesh traveling screens to reduce entrainment of larvae, a fish return system to return impinged organisms back to the estuary, and by using flow minimization to reduce impingement and entrainment (Thompson 2000).

To meet NPDES Permit targets to reduce impingement by 80% and entrainment by 60% with optimal survival a multi-component integrated fish diversion system has been developed for Bay Shore Power Plant. The flow diagram presented in Figure 1 shows the integrated multi-mode fish diversion system to be considered for installation at Bay Shore Power Plant (Figure 1).

The multi-component integrated fish diversion system design for Bay Shore is composed of the following systems.

1. Trash Diversion/Handling System
2. Reverse Louver Array
3. Fish Pump and Fish Return System
4. Fine Mesh Traveling Screens - will be reviewed and assessed by Kinectrics to provide a summary of the available suppliers and an assessment of screens able to safely handle eggs, larval fish and adult fish.

COMPONENT 1

The first component of the Bay Shore Power Plant integrated fish diversion system is the debris handling system. The primary function of the debris handling system is to divert trash and debris entering the intake channel away from the louver array and fine mesh traveling screens to an area where it can be removed easily and disposed of. The debris boom may also aid in passively directing larval fish and/or eggs in the upper water column towards the east shore line closer to the fish bypass pumps and hence optimize survival. Juvenile and adult fish may also be diverted, although the expected diversion efficiency is expected to be low.

COMPONENT 2

The second stage of the fish diversion system is a reversed louver array which is installed downstream of the debris diversion system. The function of the reversed louver array is to increase the survival of fish by diverting them in the intake channel away from the station and the traveling screens where fish are subjected to different types of stresses associated with high flows, physical abrasion, and handling off a vertical traveling screen. The solid overlay on the bottom will also be effective in diverting a proportion of fish eggs and larvae based on Pilot Project results (Ager et al. 2011), and literature results.

The reverse louver array will be installed at an angle of 22° to the current flow. As the fish encounter the array they will travel along it towards the fish pump bypass or swim back out the channel. Some residual fish passage through the louver array is expected to occur. The fish accumulating at the fish pump will be pumped back to the Maumee River downstream from the Bay Shore intake channel entrance.

COMPONENT 3

The third stage of the system is the transport system where the fish, larvae and eggs will be transported unharmed to an environmentally preferred location (Maumee River). In an earlier design the intent was to have a small channel where the water coming off the end of the reverse louver would flow past the plant intake and into the discharge channel. During the course of the project it was found the delta temperature in the immediate discharge vicinity was higher than some fish species could tolerate (5° F), which would add stress resulting in increased mortality. After significant discussion and evaluation, it was concluded that the best location for the fish to be transported to was back to the Maumee River. The other major part of the transport system is the fish pumps which are designed to safely move fish from one location to another. The pump station is integral to the end of the louver array. The fish transport system has been designed to operate effectively with varying water heights and fish loading scenarios.

COMPONENT 4

The final component of the Bay Shore Power Plant fish diversion system is a series of fine mesh traveling screens to be installed in the existing screen house of the plant. Larval fish and eggs and residual juvenile fish that inadvertently make it past the debris and louver array will end up on the fine mesh traveling screens where they will be washed off the screen into a fish trough and diverted back into the fish pump station to be transported back to the Maumee River and eventually to Lake Erie.

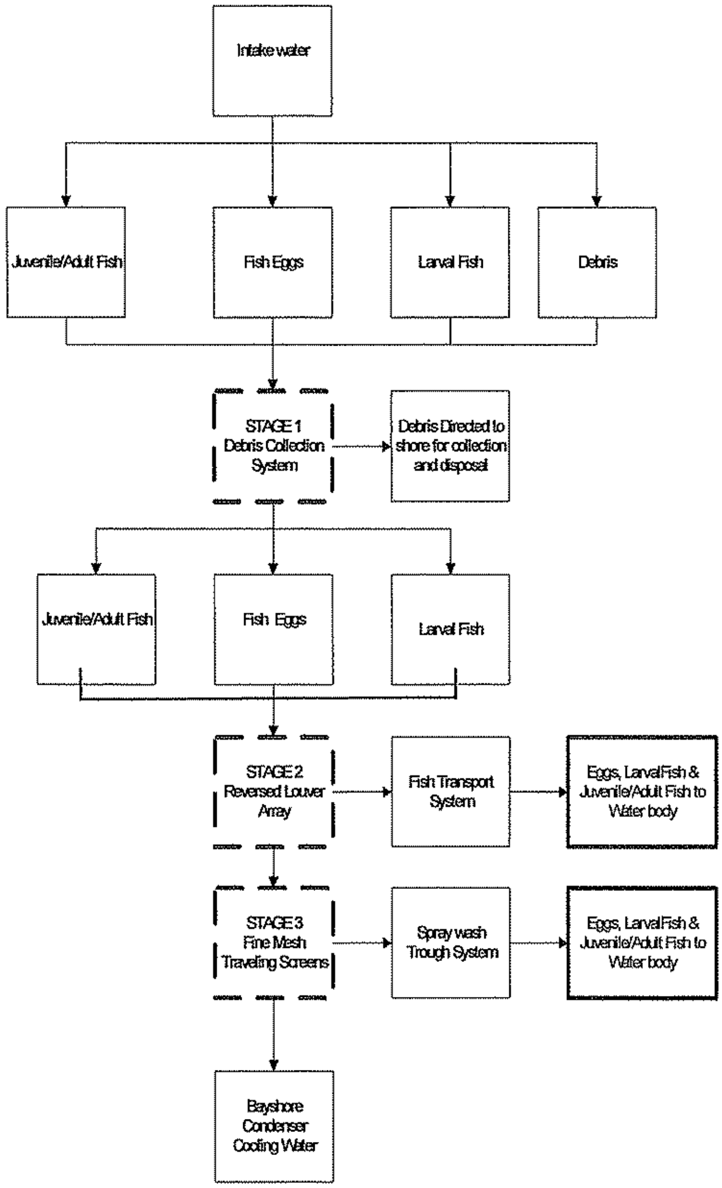


Figure 1. Process flow diagram of the multi-component integrated fish diversion system designed for Bay Shore Power Plant.

2.1 Codes and Standards

- CAN/CSA-S16-01 "Limit States Design of Steel Structures"
- All HDPE piping to comply with AWWA C906
- All permanent structures to comply with Ohio Building Codes
- Investigate the need for a NPDES permit for HDPE discharge pipe
- Ohio electrical codes

3.0 CONSTRUCTION AND INSTALLATION PLAN

The process flow diagram shows the suggested construction steps for the installation of the fish diversion system at Bay Shore. The layout of the proposed integrated fish diversion system is shown in K-409054-GA-0001.

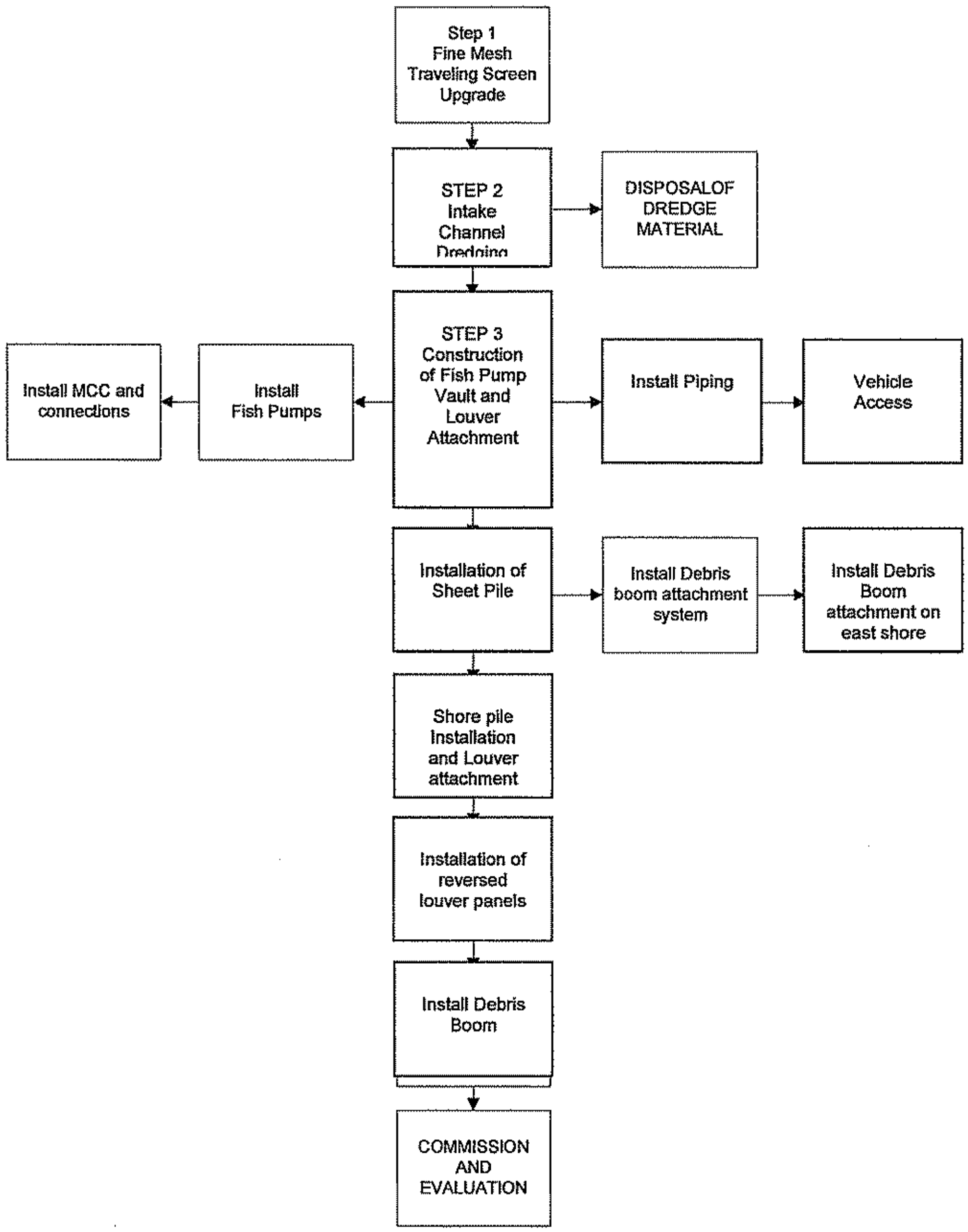


Figure 2. Construction and installation process flow diagram

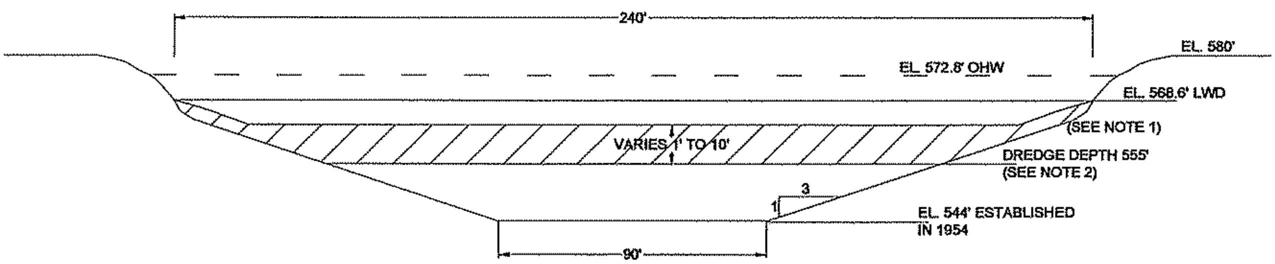
The installation of the integrated fish diversion system shall be carried out in such a way as to ensure that maximum station water flow into the intake structure is not interrupted and routine construction procedures can be followed. Construction and dredging methodology will require special attention to sediment suspension, fish spawning periods, and plant cooling water turbidity.

1. The proposed plan requires the installation of fine mesh traveling screens on two screen houses and installation of fish troughs to move fish from the fine mesh screens to the fish pump station for safe transport to the Maumee River. The additional fine mesh travelling screens will be scheduled for installation as the operating schedule permits.

2. Dredging of the intake channel is required to provide a base level from which to install the louver panels. The dredging operation and the disposal of the dredged material will be done with the USACOE and the Port Authority cooperation.

   The condition of the intake channel bottom will be considered to determine the degree of dredging that may be required to support the foundations for the system. Historical and plant "as built" dredging details were reviewed to try to determine the approximate length of time between dredging. A set of existing bathymetry measurements and sediment probes were conducted in November 2010 and the results are documented in the Appendix 1. The design basis for flow velocities will be the existing channel profile before any future dredging. It is estimated from the data available to date that an average of 7' (2.1m) of sediment will be required to be removed from approximately 200' width of channel and from the bridge to the County drain which is about 400' of channel. This is about 21,000 yd^3 or 16,000 m^3.

   Estimates were obtained of suction dredging from \$14-19/m^3 and up to \$20,000 for additional mobilization and demobilization. This did not include disposal, only pumping to a disposal site on shore. **The budgetary estimate for dredging without disposal would be \$244-324,000. This should be considered conservative as the 7' sediment depth was on the high side of the average.**



TOLEDO EDISON
INTAKE CHANNEL
TYPICAL CROSS
SECTION

NOTES
1. PRESENT CHANNEL BOTTOM VARIES FROM EL. 564.3' TO 555'
2. DREDGE DEPTH APPROXIMATELY EL. 555'
3. CHANNEL APPROXIMATELY 4,800 LINEAR FEET LONG TO BE DREDGED TO MAINTAIN WATER SUPPLY ENTIRE LENGTH FROM TOLEDO SHIPPING CHANNEL TO TOLEDO EDISON Co. BAYSHORE STATION
4. CHANNEL SHOULD BE DREDGED FROM BAR RACKS TO COUNTY DRAIN ENTRANCE IN CHANNEL

Figure 3. General dredge plan

(See Appendix 1 for dredging profiles)

3. The fish pump station will be installed.
4. The pumps, MCC and power connections will be made.
5. The piping for transporting fish will be installed including the discharge into the Maumee River. HDPE piping connection made to the fish pump station and exit from the fish pump station.
6. The HDPE piping will be installed along the east shore to allow vehicle access for debris removal from the debris boom.
7. Installation of the shore line sheet piles – the sheet piles removes the slope grade to the bottom of the channel and this provides a base starting point for the installation of the louver array and debris screen.
8. Louver attachment slider systems will be installed on the completed fish pump station vault and shore line pile.
9. A debris boom attachment system will be installed on the shore pile and existing east shore sheet pile wall.
10. The louver array will then be installed in the channel.
11. The debris boom will then be installed.
12. Commissioning and evaluation

The system operates in a passive manner except for the fish pumps and its effectiveness can only be determined by sampling after the system has been in operation. There are no special commissioning requirements for the system except for the standard operating conditions and start up for the fish pumps. A standby pump will be planned but the actual requirement should be accessed during the detailed engineering phase. It will need to be assessed to determine if two pumps could allow for maintenance to be performed without the need to rely on a complete system shutdown. Any one of the two pumps or any two of the three pumps may be capable of running the fish transport system.

The process of cleaning the debris and bio-fouling in and around the FDS should be considered part of the evaluation process. The debris will be diverted by the FDS to a location that will be amenable to the removal of the debris from the channel by a mechanism that would operate in all four seasons. At worst case the barrier cleaning process shall be capable of being handled by standard materials handling equipment similar to what is done at the plant at present. The debris removal mechanism will need to be operated intermittently and seasonally as debris builds up. It is desirable not to have debris build up in the vicinity of the fish pumps. The debris handling system shall not result in increased bank erosion or flow turbulence to create increased bottom sediment erosion.

The major requirement of the fish diversion design, construction and installation is to prevent any disruption to the stable supply of cooling water to the plant at full operating conditions.

Procedures for fine mesh screen and louver cleaning shall ensure that the risk of diver activity around the intake is minimal. Most routine pump maintenance can be accomplished without diver support.

The debris booms, louver arrays, fine mesh screens and fish pumps and bypass piping will be inspected at regular intervals during the prime operating season. The design of the system will accommodate inspection by a combination of divers and plant personnel.

The FDS should be inspected as soon as practical after major rain storm event, after the ice thaw in the spring or after the fall debris flows which tend to coincide with storms.

4.0 FISH DIVERSION COMPONENT DESCRIPTION AND FUNCTIONAL CRITERIA

4.1 Debris Diversion System (DDS)

The debris diversion system is the first component of the fish diversion system. The system is designed to divert the floating debris in the channel away from the face of the reverse louver and the trash racks at the plant intake channel so it can be removed from the water and placed onshore for disposal. The reverse louver is designed to divert debris as well but due to the low cost of the floating debris boom it was seen as a cost effective approach for keeping debris away from the louver and fish pump station. Although part of the FDS system, the debris may be handled completely separate from the louver, fish transport system and fine mesh traveling screens. The proposed removal of debris at the old coal unloading dock keeps the bridge over the intake free of obstruction, allows easy truck access, and provides a large enough area to stock pile debris for periodic removal. The routing of the HDPE pipe from the fish pump station would travel along the east shoreline and the debris would need to be removed from the water and placed in trucks across this location on the east shore. A crossover with concrete support footings will be required to drive a clamshell and trucks across the HDPE pipe.

Although not absolutely mandatory if it is decided not to employ the separate debris boom than the debris removal from the fish pump station trash rack should be reviewed and an automated debris removal system should be considered or a more vigorous maintenance schedule should be implemented to ensure debris does not block or interfere with the fish pumps. If a floating louver array is chosen to be the best option for the reverse louver than the number of pilings in the center of the channel should also be reviewed if a debris boom is not in place. The assumptions made for debris loading on the floating louver array were that only moderate loading would occur with up to 1 foot deep layer of debris. The expected loading on the floating reverse louver would be higher as all floating debris would be stopped by the array and would work its way to the fish pump station.

Debris should not enter the fish pumping system because of concerns of fish mortality while being transported long distances with debris. There may be operational issues with the fish pumps due to excessive debris loading. Smaller debris that still manages to enter the screen house would exit off the screens to the discharge channel by a separate pipe.

Functions of the debris system include the following:

1. Prevent/reduce debris from entering the fish pump intake but at the same time not hinder fish from accessing the fish pump entrance.
2. Prevent/reduce debris from blocking the reverse louver array.
3. Prevent/reduce debris from impacting on the fine mesh traveling screens.
4. Provide some passive diversion of fish eggs and larvae away from the traveling screens and towards the fish pump.
5. Divert some juvenile and adult fish immediately towards the fish pump.

The debris handling system will rise and fall with varying daily and seasonal water heights. Many different commercially available debris boom companies were contacted (web site, phone, presentation). The short list of three suppliers (Slickbar, Fleet Technologies and Tuffboom) was narrowed down to a preferred supplier based on the following criteria;

- engineering design
- quality, durability of product.
- constructed of non-corroding and anti biofouling materials.
- abundant history of boom fabrication over many years.
- positive OPEX for similar environmental conditions.
- customer service, willingness to incorporate customer design requirements and site specific needs.
- local, well respected manufacturer.
- minimum scheduled delivery time.

The floating debris boom that displayed the highest level of operating experience, durability, reliability and remained cost-effective was Tuffboom (Worthington Products, located in Canton, Ohio). This product has an extensive list of installations in hydro electric dam sites and municipal water supplies. Key features of this product include the following:

- constructed of high density UV resistant polyethylene having a closed cell foam core
- galvanized steel framework, each section 130" in length
- heavy duty galvanized connecting hardware
- designed to connect under slung mesh or solid panels of varying depth
- floatation of 700 lbs per section
- flexible rubber sheathing overlaps panel seams
- slider assembly at anchorage ends to compensate for water level fluctuations
- optional boat gate, functions without disconnecting boom.
- acts as a partial ice control boom

This boom can be equipped with robust sliders on each end to allow for substantial changes in water levels. The boom can extend underwater from 1 ft to 10 ft in depth. Most commercially supplied systems for debris are made between 1 and 4 ft. The deflector can be a solid wall or a HDG mesh screen and requires virtually no cleaning or maintenance. This boom does not need to be removed in the winter and is made for heavy freeze thaw conditions. Once the end pilings are installed, the installation is very quick as the whole system comes assembled and can be craned into the water and floated into place for connection. Due to the floating nature of the boom it will also divert pack and frazil ice and any extreme ice build up will push under the boom. The boom is deployed with 6-8 % slack in the cable to allow for some flexibility to debris build up and ice flows. The debris boom will be installed at an angle of approximately 40-50° to the shore line. This will allow for sideways downstream movement of the debris along the boom to the corner near the shore. The debris can then be removed by the standard clam shell attachment on an excavator and loaded in a truck when enough debris is accumulated. The whole intention of the debris boom is to be a robust barrier capable of being banged around by human and natural elements, requiring next to no maintenance and having a long life expectancy.

4.2 Reversed Louver Array (RLA)

The reversed louver array is designed to address a significant portion of the impingeable fish and to a lesser extent the reduction of entrainment of larvae and eggs prior to entering the screen house. The function of the reversed louver array is threefold:

1) To remove potentially vulnerable species such as shiners and gizzard shad early in the channel prior to entering the plant screen house, and therefore improve survivability.

2) The diverted fish (larvae and eggs) along the solid overlay and louver itself are transported via a fish pump back into the Maumee River unharmed.

3) To divert or minimize debris which will impact performance of fish, egg and larval survivability on the traveling screens, and thereby improving survivability.

The specific features which determine the effectiveness of louver to divert fish are frame angle, slat angle, slat length, slat spacing and a bottom overlay fish guide. Fish avoidance responses are expected from large schools encountering the louver since the entire school would respond as a single unit, and would not tend to pass through the louver slats opening in the reversed mode. In addition, avoidance behavior is also expected based on the slat length which is selected to create a space perception cue to the fish.

The louver array will be angled at approximately 21-22 degrees. This is to allow for maximum sweep velocities along the louver array under standard operating conditions of the plant.

The reverse louver will need to be treated with a coating for bio-fouling or it will require cleaning frequently during each season to avoid zebra mussel build up. Treatment options that were considered for bio-fouling include the following:

1. Copper cladding of the louver system
2. Fine copper wire embedded in the HDPE slats
3. Silicon Based coatings
4. Copper based coatings
5. In water diver cleaning with no treatments

The louver system was considered as a permanent structure that is similar to a set of bar racks. However, with issues relating to ice flows and changing water levels, the cost of such a rigid structure was estimated to be extremely high. The next option considered was a hinged approach where the louver was supported from above with a head rail and the bottom of the louver would be free to move if extreme pressures were to build up (e.g. water heads from blockages or ice flows or extreme debris flows). In this case the bottom guiding wall would be fixed to the hinged panels. The last option considered was a floating louver array where the louver could be suspended from a set of floats and where the louvers hang below the floats and the guiding wall would be hinged off the bottom of the louver. In this configuration the louver would move up and down with the water level and the guiding wall would hinge or collapse out of the way. This way the louver would always be in the water column and the guiding wall would be fully extended in average to high water levels but be reduced during low water periods.

It was decided that either the hinged approach or the floating louver would be the most practical and cost effective. Further analysis suggested that the floating louver array is recommended and would be constructed in a very similar fashion to the commercially available debris screen. A proven commercially available floatation structure would be used to suspend the louver and guiding wall. The array would be supported every 100' with a pipe piling and a sliding attachment to allow for varying water heights. The HDPE slats have neutral buoyancy and would assist with the floatation. The guiding wall would have a HDPE cover which is neutral as well.

Key features of the Floating Reverse Louver System include the following:

- Worthington's Boatbuster 20 is constructed with dual side by side floats connected by a heavy duty galvanized steel framework
- Each 130" section has 1500 lbs floatation
- This system can accommodate under slung HDPE reverse louver sections
- Hinged guiding wall sections can be supported below the louver sections
- Slider assemblies at appropriate 100' intervals will allow the system to fluctuate with the water level elevation changes
- Flexible rubber sheathing overlaps the panel seams to prevent fish passage
- A deflector on the surface would prevent fish from going over if the buoyancy of the system created the floatation to be lower in the water column.
- Floating arrays will be assembled on shore and can be craned into location

4.3 Fish Transport System (FTS)

The fish pump and transport system is used to transport fish diverted away from the station to the Maumee River. Factors considered in the design of the fish transport system include location, type of pump, size, impeller speed, fish density, sweep velocity along louver to pump, attraction velocity (if required), and quantity of flow.

The fish transport system uses three Hidrostal pumps. Two pumps will run continuously at any one time and all three pumps are operated in the rotation selected. The two operating pumps will increase bypass flow along the last few sections of the louver array and pass both fish and flow to the Maumee River through a 42" diameter HDPE pipe which would run parallel to the existing intake channel towards the Maumee River. The length of the transport system is estimated to 5,000 feet. A standby pump will be planned but the actual requirement should be assessed during the detailed engineering phase. It will need to be assessed to determine if two pumps could allow for maintenance to be performed without the need to rely on a complete system shutdown. Any one of the two pumps or any two of the three pumps may be capable of running the fish transport system.

Factors considered in the selection of the discharge location include the following:

1. delta temperature from the intake to the discharge point of the HDPE pipe
2. icing conditions of the routing of the HDPE pipe
3. direction of river flow when fish pump is operating
4. under water route versus on land

5. elevation change from the fish pump to the discharge location and its route
6. cost of the installation and type of installation required
7. location of the fish pump station in the channel

Factors considered when choosing the size and type of transport pipe include the following:

1. UV resistance
2. time fish are in the pipe
3. velocity of fish in the pipe
4. inside surface of the pipe
5. corrosion resistance
6. flexibility during the installation
7. method of entry to the water

Factors considered when choosing the fish pumps include the following:

1. size of fish to be transported
2. type of fish
3. type of operation, seasonal or continuous
4. total displacement head required
5. function required, to move fish or water and fish
6. depth of water around fish pumps
7. debris loading at the pump station
8. rpm versus survivability
9. varying water levels vs tdh
10. operating experience with existing species

After consideration of many options for fish discharge and fish pump station locations, the option selected was to recommend the use of three 12" hidrostal pumps contained in a fish pumping station on the east side of the intake channel in front of the caisson piling on the east side of the existing bridge. From the pump station, a 42" DR26 HDPE pipe will exit the fish pump station and be installed on the shoreline along the existing intake channel out to the east side of the intake entrance from the Maumee River.

4.4 Fine Mesh Traveling Screens

Due to the inability of reverse louver arrays to effectively handle entrainment it was determined that the 60% target of entrainment reduction could not be achieved without the use of an additional technology to compliment the reverse louver arrays. Preliminary results with the louver array with bottom overlay suggest that 25-28% of the larvae could be diverted based on a depth preference for the lower depths (Ager et al. 2011). A much lower effectiveness (possibly up to 10%) would likely occur with eggs since egg distribution is more uniform within the water column based on preliminary field data.

Initially, fine mesh screens were considered to be installed behind the reverse louver arrays which would have required substantial maintenance to avoid total blockage. Several techniques were considered to release the "impinged" eggs and larvae along these fine mesh static screens to the pumping station for transport back to the river. After looking at water pumps, bubblers and compressed air nozzles it was determined that it would be difficult for the eggs and larvae to move along the fine mesh screens towards the fish pumping station without being damaged. At this point the decision was made to focus on fine mesh travelling screens (2 mm) that can be installed at the existing plant pump house. The main function of the fine mesh traveling screen component of the integrated system is to collect and divert organisms which include eggs and larvae unharmed towards the fish trough transport system. This is an expensive but necessary option to remove eggs and larvae. The main advantage of these travelling screens is that they can be maintained on a continuous basis and eggs and larvae can be removed in a fashion that will optimize their survivability. These screens have been designed to effectively separate the debris from the eggs and larvae, and recently there has been OPEX in the lab and in the field on the performance of some manufacturers.

Thru-Flow and Dual-Flow screen systems were both considered for Bay Shore to reduce both entrainment and impingement losses. Dual flow screens use an "outside-to-inside" flow pattern to ensure that debris is always maintained on the upstream side for a given channel width, dual flow screens generally offer greater surface area and lower head losses and thus lower average through screen velocities because both sides of the screen are filtering flow. The issue again comes down to price and fish survival. Is the added cost of the dual flow screens required to meet the target entrainment reductions (and survival)? It is difficult to answer this question strictly based on fish survival and USEPA316B issues so other benefits are being considered.

A major additional advantage of the dual-flow over the thru-flow screens is the improved debris and fish separation, and less debris carryover. If more carry-over occurs, there would be more loss of biological material (eggs, larvae, and juvenile fish) which would result in a lower survivability. Debris and fish separation will be very important in larval and juvenile fish survival. It also expected to be important for eggs and larval fish.

The design specifications for both types of the screen systems require a water supply of 746 MGPD to the plant, and 2mm or lower fine mesh screens. The fish handling system includes fish buckets as well as different sprays systems for separation of debris and fish. During low water level periods the dual flow screens have a larger screening area and would be more successful in operating during heavy debris and/or fish runs.

5.0 CONCEPTUAL DESIGNS FOR THE INTEGRATED FISH DIVERSION SYSTEM

Two conceptual designs have been generated for review by Bay Shore Power Plant. The conceptual designs have the same layout and common components that do not change between the two concepts. The only difference would be in the reverse louver array which can be a static hinged design or a floating concept. The following components are common to both designs:

1. Debris Handling System
2. Fish Transport System
3. Fine Mesh Traveling Screens

The two options being considered for the reversed louver array include:

1. Static hinged louver system and
2. Floating louver design.

Both options will accommodate the design requirements of the reverse louver array. Both approaches will allow for severe water level variations, ice loads and cleaning options. The floating louver array is more cost effective in that it can be assembled on shore and most of the construction can be done off-site. The only issue with the floating louver array is that the materials of construction for the louver slats must be HDPE in order for it to be buoyant enough for reasonable floatation. A static hinged approach would allow for the slats to be manufactured from steel which would reduce the capital costs for the louver panels. However the louver construction costs will be substantially lower for the floating louver than for the piling and structural framework required for the static hinged louver approach. Both approaches are expected to perform similarly in terms of biological effectiveness.

The biological effectiveness of the fish diversion system using either the floating or static louver array is expected to meet the fish diversion (survival) requirements as set out by the OEPA (i.e. 80%).

The key design constraint considered in the FDS solution is the "**security of the cooling water supply to the plant at full capacity**". Both of the louver concepts will accomplish this key issue as they are both designed to allow water past in a blockage situation or low water conditions.

All pricing in this section includes a 25% contingency. It assumes all standard deliveries and no provision for rush or shortened delivery times. In most cases it does not assume transportation to site with the exception of the fish pumps.

5.1 Fish Diversion System General Layout

The general layout of the Bay Shore Power Plant fish diversion system is shown in Figure 4 (see Kinectrics Drawing number K-409054-GA-0001).

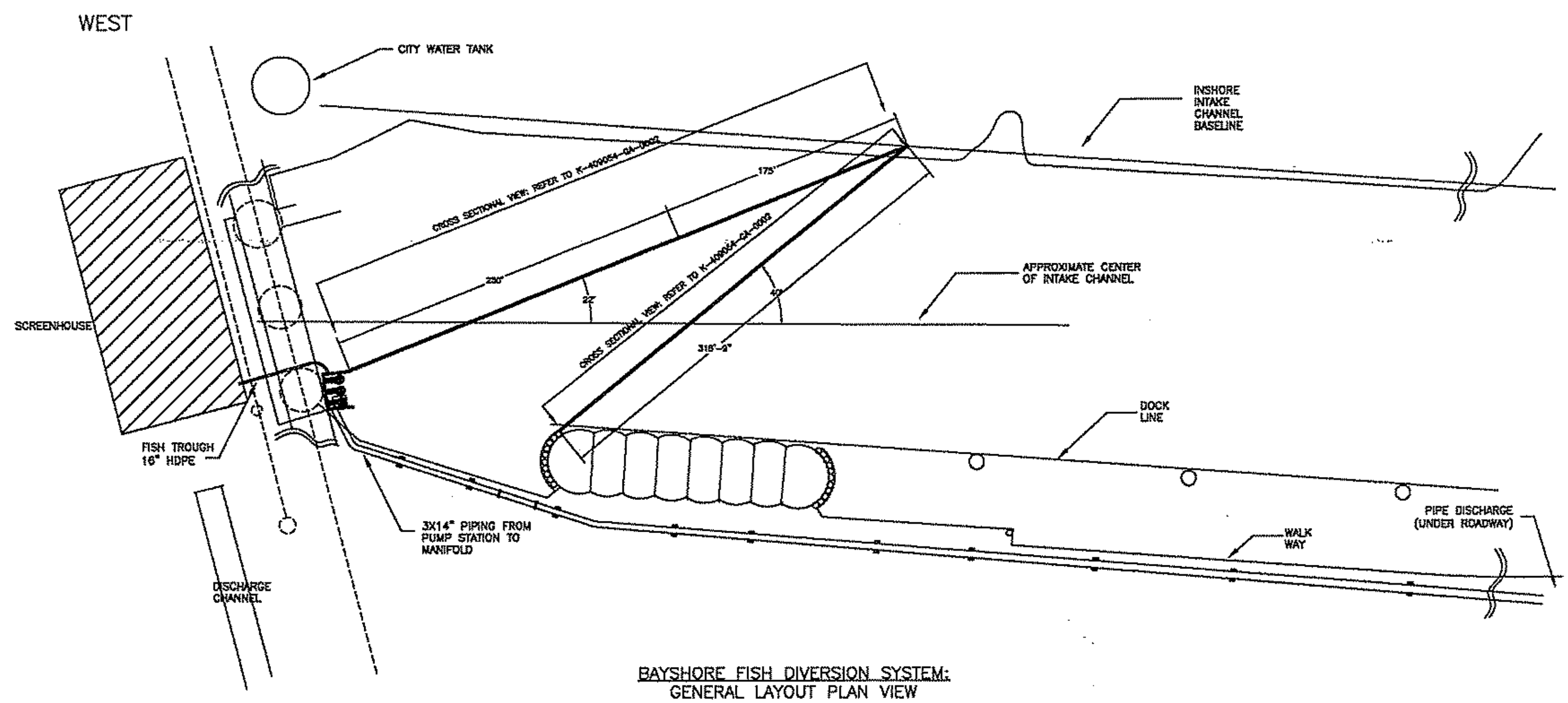


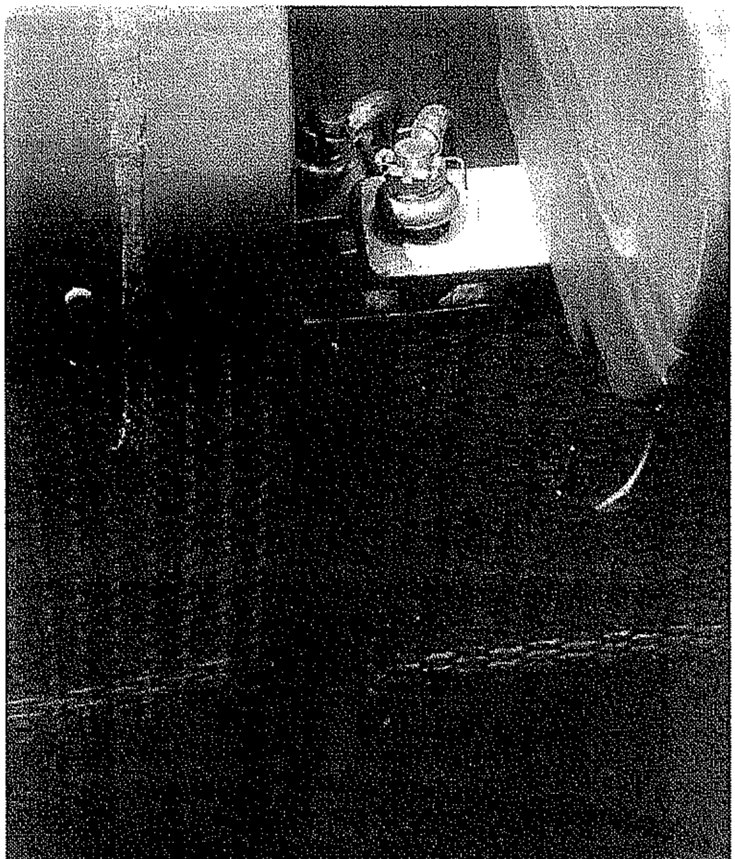
Figure 4. Fish diversion system general arrangement drawing (Kinectrics Drawing number K-409054-GA-0001)

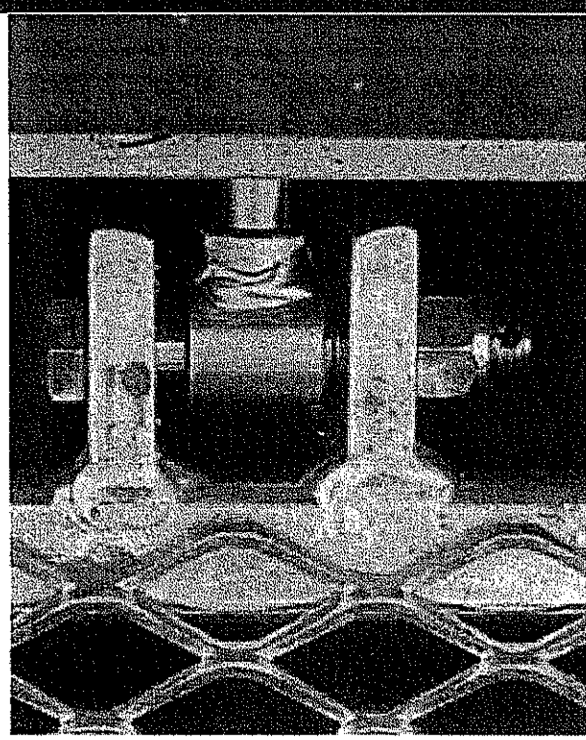
5.2 Debris Handing System

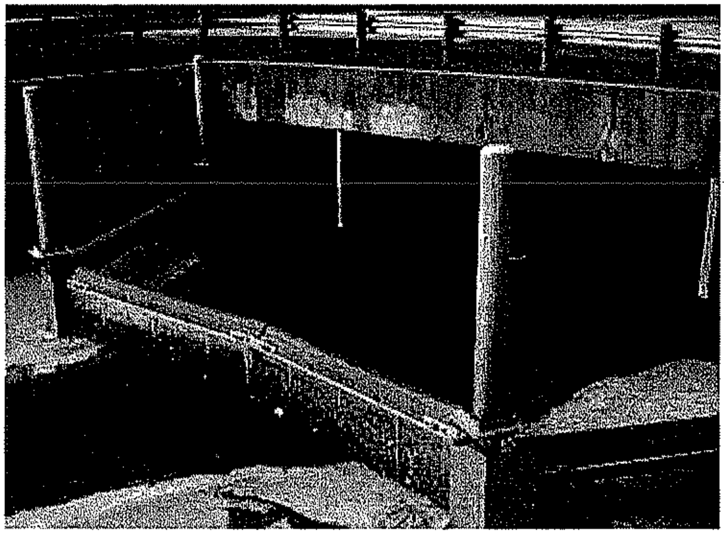
The debris handling system consists of a series of floats in a steel framework with short panels hanging approximately 48" below the float. The debris handling system is installed on a 40-50° angle to the intake flow. The debris handling boom will be attached to shore pilings via a cable attachment to a sliding rail supplied as part of the system. The shore attachments are equipped with a sliding rail to allow the floating boom to move up and down with the water column. Excessive loading such as ice flows will result in the debris boom flexing and allowing passage. Any debris floating down the intake channel will be diverted along the debris system and work its way to shore. The recommended debris boom and all of its attachments are commercially available and are modular to allow for easy expansion or replacement if required. The function of the design is to divert as much floating debris as possible in a cost-effective manner from the water intake channel to the shore line. The debris screen needs to withstand winter conditions especially freezing and ice flows. The conceptual design and photos are below.
Each screen attaches easily and securely to the underside of the TUFFBOOM barrier via two specially modified connector lugs shown in Figure 5 below. Individual screen sections are connected together, Figure 5, via chain to form a durable underwater barrier to sub-surface debris. Tuffboom debris screens are made from rigid tubular steel framing and include a choice of facing materials including: open ¾" diamond pattern metal mesh, sheet metal, solid rubber sheeting, or HDPE sheet.

The properties of construction are:

- Heavy-wall impact resistant polyethylene with max. UV resistance.
- Unsinkable solid internal core of non-water absorbing foam fill. Maintains buoyancy even when punctured.
- High load bearing internal steel channel provides strength and ballast, resists horizontal and vertical loads.
- Load-rated galvanized safety shackle connections permit full movement with minimal wear.
- Fully-interchangeable connection hardware.
- Connections are designed for continuous motion and heavy loads
- Option of Mold-in Graphics™ with standard or customized warnings.
- Exceptional debris load capacity.
- Available in International Orange, Safety Yellow, Log Boom Brown, Forest Green, Black, White, Red, Navy, Gray, Sand Tan.
- High Visibility, high buoyancy for maximum freeboard visibility
- Weight: Approximately 141 lbs (64 kg) per unit
- Center to Center Length: 136 in (3.45m)
- Float Unit Length: 120 in (3.05)
- Buoyancy: approximately 700 lbs (317 kg) per unit.







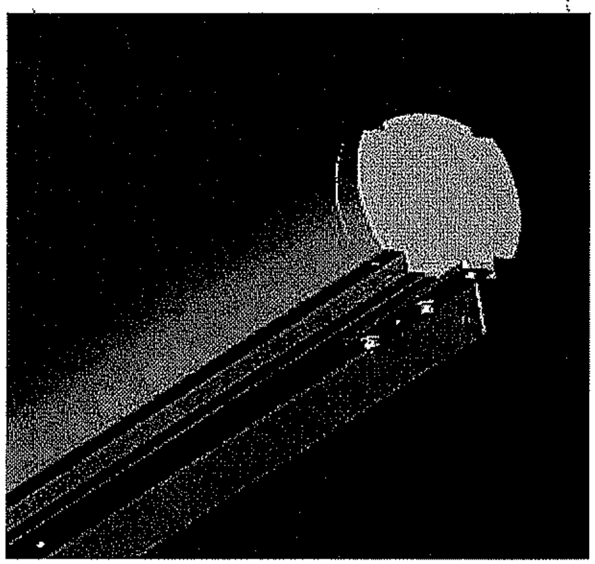


Figure 5. Debris handling system details.

Budgetary Pricing for the Debris Screen

The debris screen and its sliding shore attachments are commercially available off the shelf with no extra detailed engineering required. The budgetary price for this equipment is **$65-75,000 with delivery at about 8 weeks. The price is about $40-48,000 for the debris boom panels and $23,500 for the two end slider rails. A boat gate if required would be about an additional $10,000-12,000.** This would only be required if boat access is necessary behind the debris screen or in front of the louver.
The system can be installed with very little effort once the shore attachments are in place. The installed budget for the entire debris system would be about **$100,000.**

5.3 Fish Transport System

The function of the fish transport system is to move as efficiently as possible all the fish, eggs and larvae that come off the reverse louvers and the fine mesh travelling screens to a biologically preferred location away from the plant without inflicting any additional damage to the organisms and with the least level of stress. The discharge point must have a water temperature not more than 5° F higher or lower than the intake water temperature at the fish pumping station. The approximate temperature distribution for intake and channel discharge sections for November is shown in Figure 6. The main component of this system is a pump specifically designed to transport fish. Detailed specifications of the fish pump are summarized in Appendix 2. The hidrostal fish pumps and impellers are specially designed to operate at lower rpm.

The design of the fish transport system takes into account the following factors:

1. Pump speed compensation for fluctuating water levels to maintain suitable bypass flow during changing Total Displacement Head (TDH).
2. Transport the fish, eggs and larvae to a discharge location where there is less than a 5°F increase in the discharge temperature from the intake temperature.
3. Maximum fish spherical circumference of 8" diameter.

Pumps:

Each Hidrostal pump model L12V-H will operate at 500-600 rpm. The pump motor is 60 Hp and is rated for 75 amps full load at 460V/3/60 will incorporate a variable frequency drive interlocked to the intake water level to automatically maintain the pump RPM at about 520.

The electrical requirements of the pumps will require an electrical room, connection to the grid, switch gear, transformers, etc.

The pump station drawing (Figure 7, drawing K-409054-GA-0005) shows the requirements for the pump control and operation. The following components are referenced:

1. MCC model/manufacturer
2. Interface required from MCC to station control for remote control and alarm
3. Variable frequency drives
4. Ultra sonic depth transducer

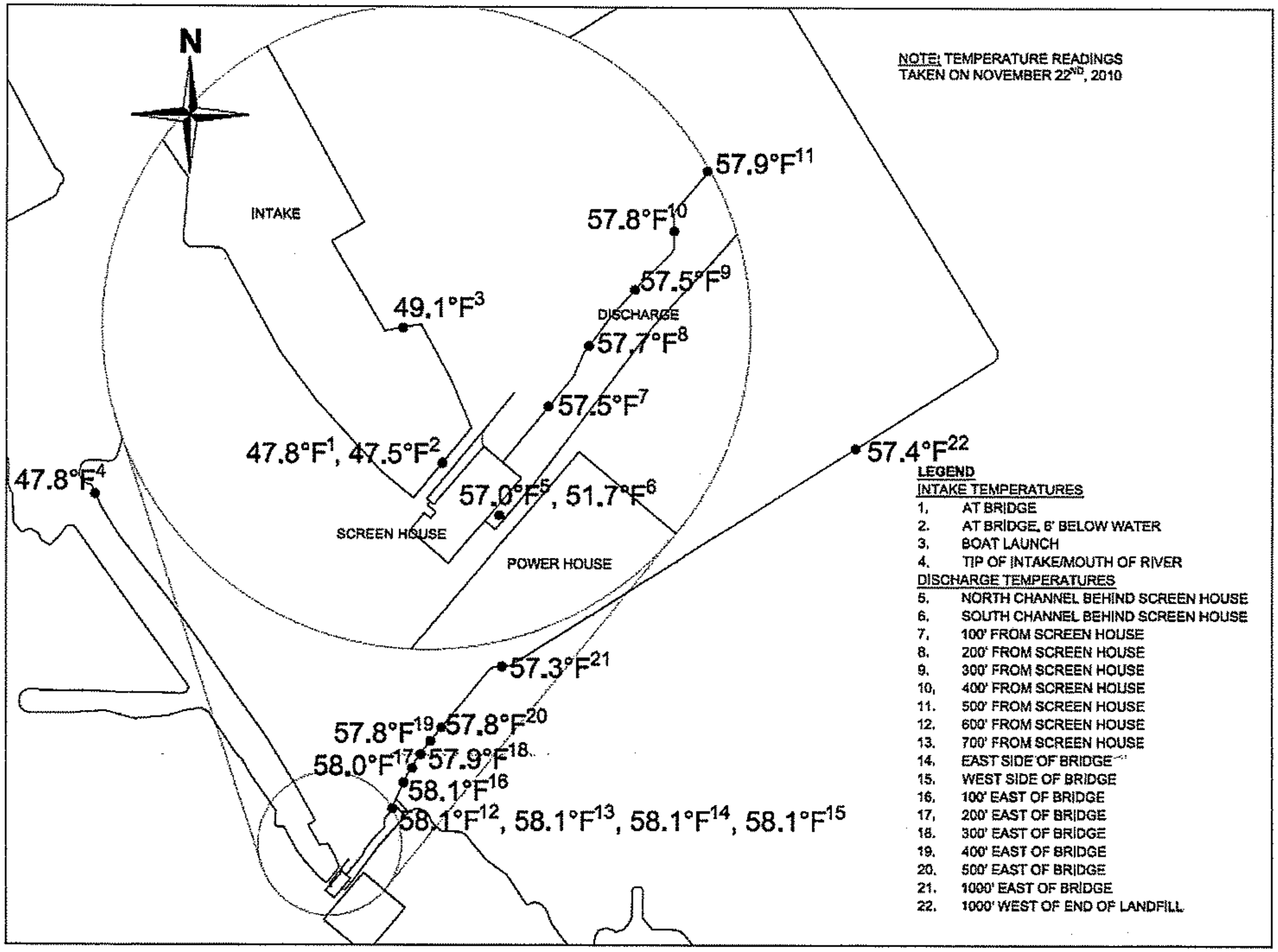


Figure 6. Temperature distribution from the intake to discharge of plant (Nov 22, 2010).

The fish will generally approach the louver and will make their way along the louver following the sweep of the water generated by the reversed louver slats. The fish will end up in the corner in front of the fish pump station. The draw from the fish pumps will eventually pull the fish through a trash rack in front of the fish pump station to the inside of the pumping station. To avoid the accumulation of fish at the end of the louver the fish are moved by the fish pumps to the smooth walled HDPE pipe.

1. Each pump will deliver 4000-5000 USGPM. Based on the performance curve the pumps will be set at 520 rpm for 25ft TDH. The water level used for the maximum head was the minimum normal water of 568'. During the commissioning phase the pump speed and control will be adjusted to optimize the pump operation and fish survival.

2. The pumps will be controlled with a variable frequency drive to ensure they are running in the right part of the pump efficiency curve during high and low water levels. An ultra sonic sensor will be used for feedback control of the pump speed to maintain a uniform water flow in the transport pipe.

3. The fish transport pipe will be 42" IPS DR26 HDPE, resulting in an I.D.of 38.575".

4. The water flow in the discharge pipe with the following:
   a. Three pumps running would be about 4.1 ft/sec in the pipe (16,000 gpm). This velocity may result in slightly increased fish mortality.
   b. Two pumps running the flow rate would be about 2.8 ft/sec in the pipe (10,000 gpm)

5. The fish pump(s) will provide capacity to pump 400 ton/hr of fish based on 50/50 water to fish by volume. This data was provided by Weir Canada as a conservative estimate of the track record from fish farms and unloading boats for fisheries.

6. The 12" pumps will pump a fish with a girth up to 8 3/8" and have a 26 5/8" impeller. The trash racks in front of the pumps will ensure that fish with a girth in excess of 7"-7.5" will not enter the pump.

7. The suction inlet of the pumps will be 16" and 26" with the suction bell.

8. The exit from the fish pump station to the 42" HDPE pipe will have a 12x18" increaser, then 18" pipe. long radius elbow is preferred to connect the 18" to the 42" HDPE pipe

9. The variable frequency drive changes automatically with the water height and it is using a 4-20 mA signal from the ultrasonic level sensor.

HDPE Pipe:

The water velocity in transport pipes is designed to have a normal flow that is less than 3 ft /s. The piping for the fish transport system is proposed to be a 42" IPS DR26 HDPE pipe with a length of approximately 5000 ft along the east side of the existing intake channel. The size of the pipe chosen was based on a compromise between flow rate in the pipe and fish residence time in the pipe. Obviously the least time in the pipe the better for fish survival however to accomplish this the flow rate needs to be high. The residence time in a 48 " pipe would have increased to about 40 minutes from the 30 minutes projected for the 42" pipe. It is necessary to keep the velocity down to about 3 ft/s if possible to ensure fish are not damaged in transport. The pipe should have all smooth inside surfaces to avoid any fish damage during the ride back to the river and no 90° elbows but should incorporate a Tee near the discharge end of the pipe before the entrance to the Maumee River for access and sampling. During the fusion process to connect the 50' lengths of pipe the inside fusion welds will need to be scrapped smooth. The fish will be discharged below the water level about 80 feet from shore on the down river side of the intake channel entrance from the Maumee River. The pipe will need to be installed at grade following the installation guidelines of Appendix 4.

There must be a concrete road crossover for the pipe at the east sheet pile wall to access the debris removal area of the debris boom east shore termination point. This will allow a clam shell excavator to pass over the pipe to get to the waters edge to reach the debris in the channel. Trucks will also need to access this area to remove any debris lifted to shore. It is important that the crossover has a concrete footing to provide radial support to avoid future crushing of the pipe.

The pipe will need to be buried to grade past this location. From this point to the end of the intake the pipe can be at grade until it crosses under the road at the end of the intake channel to enter the river below grade to avoid ice pack damage to the pipe.

Fish Station:

The fish station must be able to house three 12" fish pumps and will have a footprint dimension of about 5 meters wide by 4.5 meters deep. The top elevation of the fish pump station would be at 575'. The pumps must be mounted on a concrete base and the base elevation must provide a minimum of 10 feet of water depth for the pumps to operate without them encountering suction/cavitation problems. The final pump station will be designed during the detailed engineering phase and will be constructed of concrete or sheet piling with structural steel support. The back wall of the station will need to be concrete to provide support for a guide rail that is used for routine or emergency pump maintenance.

The pumps must be elevated from the channel bottom to avoid sediment build up in the fish pump station. The fish pump station will have trash racks on the entire front face of the station with openings about 6" wide to allow for fish passage but prevent large debris from entering the pump area.

Fish Trough:

The fish trough return system from the fine mesh traveling screens will be directed to the fish pump station as well. This fish trough should be an enclosed HDPE pipe. This pipe should have minimal changes in direction, be smooth inside and no elbows. It can be a 16" DR 26 HDPE pipe with an I.D. of 14.7". The fish trough pipe will need to transition from the fish trough exit from the fine mesh travelling screens and continue under the existing roadway/bridge from the plant in a curved fashion around the east roadway support caisson to an open water discharge inside the pumping station. The exit from the fish trough pipe should discharge at the 575' elevation to avoid any potential for it to become frozen. It will be self draining and a gravity discharge with no pressure except gravity.

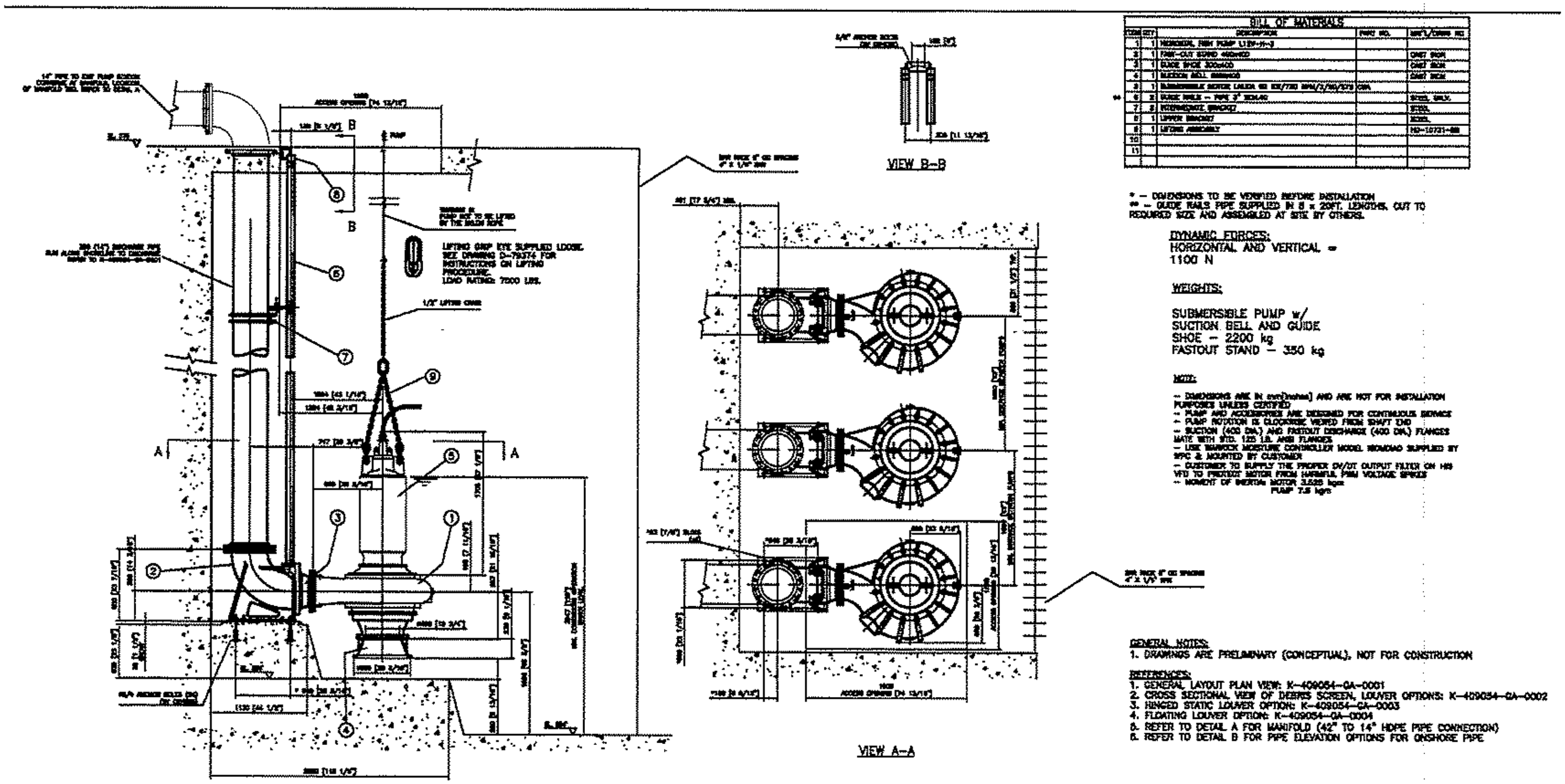


Figure 7. Fish pump assembly drawing (drawing K-409054-GA-0005)

Budgetary Pricing for the Fish Pumps

The budget pricing given by the manufacturer for three Pumps, fast-out elbows, guide rails and brackets, lifting chains, ultra sound water level sensors, motor control centers with VFD's for indoor installation, start-up supervision and freight to site is about ***$1,000,000 with delivery at about 30 weeks.***

Budgetary Pricing for the discharge fish transfer pipe and on-site assembly

Static and Surge Pressure for DR26 HDPE pipe
Working pressure (WPR): 64 psi
WPR & dynamic Surge: 96 psi
WPR & Occasional Dynamic Surge: 128 psi

<u>OPTION 1:</u>

Pipe size and specifications:

42" Ø IPS DR26 HDPE pipe (Supplied in 50ft lengths)
OD: 42.00" / 1066.80mm
ID: 38.575" / 979.81mm
Cost: $127/ft x 5000ft = $635,715

42" Ø IPS DR 26 HDPE Tee (1)
Cost: $8,975

42" Ø five segment elbows
Cost: $ 9,450 ea x 2 = $18,900

42" Ø IPS HDPE Flange Assembly
(Includes Stub end and Ductile Iron Ring)
Cost: $3,755 ea x 2 = $7,510

Estimated time for on-site fusion/day
Cost: $4,500 x 15 = $67,500

Estimated travel and mobilization
Cost: $6,000

TOTAL COST: $744,600 delivery estimated at 12 weeks

In pipe water velocity (assumes 10,000 USGPM flow, two pumps operating) will be 2.80 ft/sec (0.86 m/sec) with an estimated head loss of 2.4 ft over 5000 feet and 4.1 ft/sec (1.28 m/sec) with all three pumps operating. All three pumps would be considered for operation during spawning season. This would only be considered for periodic operation and not on a continual basis.

The estimated time for fish to be in this pipe before discharge will be about 30 minutes.

OPTION 2:

Pipe size and specifications

1200mmØ metric DR26 HDPE pipe (Supplied in 50ft lengths)
OD: 47.38" / 1066.80mm
ID: 43.519" / 979.81mm
Cost: $158/ft x 5000ft = $790,000

1200mmØ metric DR26 HDPE Tee (1)
Cost: $9,135

1200 mm Ø five segment elbows
Cost: $10,450 x 2 = $20,900

1200mmØ metric DR26 HDPE Flange Assembly
(Includes Stub end and Ductile Iron Ring)
Cost: $7,425 x 2 = $14,850

Estimated time for on-site fusion/day
Cost: $4,500 x 15 = $67,500

Estimated travel and mobilization
Cost: $6,000

TOTAL COST = $899,250 delivery estimated at 12 weeks

In pipe water velocity (assumes 10,000 USGPM flow, two pumps operating) will be 2.1 ft/sec (0.66 m/sec) with an estimated head loss of 1.4 ft over 5000 feet and 3.1 ft/sec (0.96 m/sec) with all three pumps operating. All three pumps would be considered for operation during spawning season. This would only be considered for periodic operation and not on a continual basis.

The estimated time for fish to be in this bigger pipe before discharge will be about 40 minutes.

5.4 Reversed Louver Array

The reversed louver array has two conceptual design options the floating louver array or the static hinged louver array. Table 1 summarizes the design parameters of the static hinged and floating louver designs. Table 2 summaries the performance requirements of each louver design.

Table 1. Design Parameter comparison

Design Parameter	Static Hinged Louver	Floating Louver
Louver Approach Velocity:	Same	Same
Louver Sweep or Bypass Velocity:	Same	Same
Louver Slat Velocity:	Same	Same
Louver Slat Angle	Same	Same
Louver Slat Spacing:	Same	Same
Current Velocity:	Same	Same
Louver Frame Angle:	Same	Same
Pressure Gradient	Same	Same
Turbulence:	Same	Same
Space Perception Cues:	Same	Same
Bottom Overlay/Guiding Wall	**Fixed** height 25% of minimum water depth. About 4' in height and fixed	**Variable** from 5% at minimum water depth to 25% at maximum water depth

Table 2. Design Performance Requirements

Performance Requirement	Static Hinged Louver	Floating Louver
Divert and process river debris	Same	Same
Sediment Control	Same	Same
Pack and Frazil Ice Flows	Same	Same
Biofouling	Same	Same
Varying Water Levels	Louver flow increases with lower water levels	Louver flow stays constant with lower water levels
Varying Plant Operating Levels	Louver water flow increases with plant operating levels	Louver water flow increases with plant operating levels

Taking into consideration the performance requirements and design parameters; the floating louver system offers the most flexible design to ensure consistent louver effectiveness and capability to ensure water flow to the plant. The construction/installation costs would be lower for the floating array as the piling and steel support structures are minimal compared to the static hinged array. This louver array will have less impact from silt build up covering/burying the guiding wall than a static array.

The louver array will start from the west shore near the County drain and connect to the fish pump station at the east side of the intake channel near the road crossover. The louver frame is installed at a 20-22^0 angle to the intake flow or centerline of the channel. The shore installation of the sheet pile sections is identical for both louver concept designs. The sheet pile wall will cover the entire water column. The attachment mechanism is shown in Figure 8 and is a 5" schedule 80 pipe with commercially available sliding floats. Figure 9 shows the louver slat design for both the floating and static louver panels. Figure 10 shows the shoreline attachment and wedge installation.

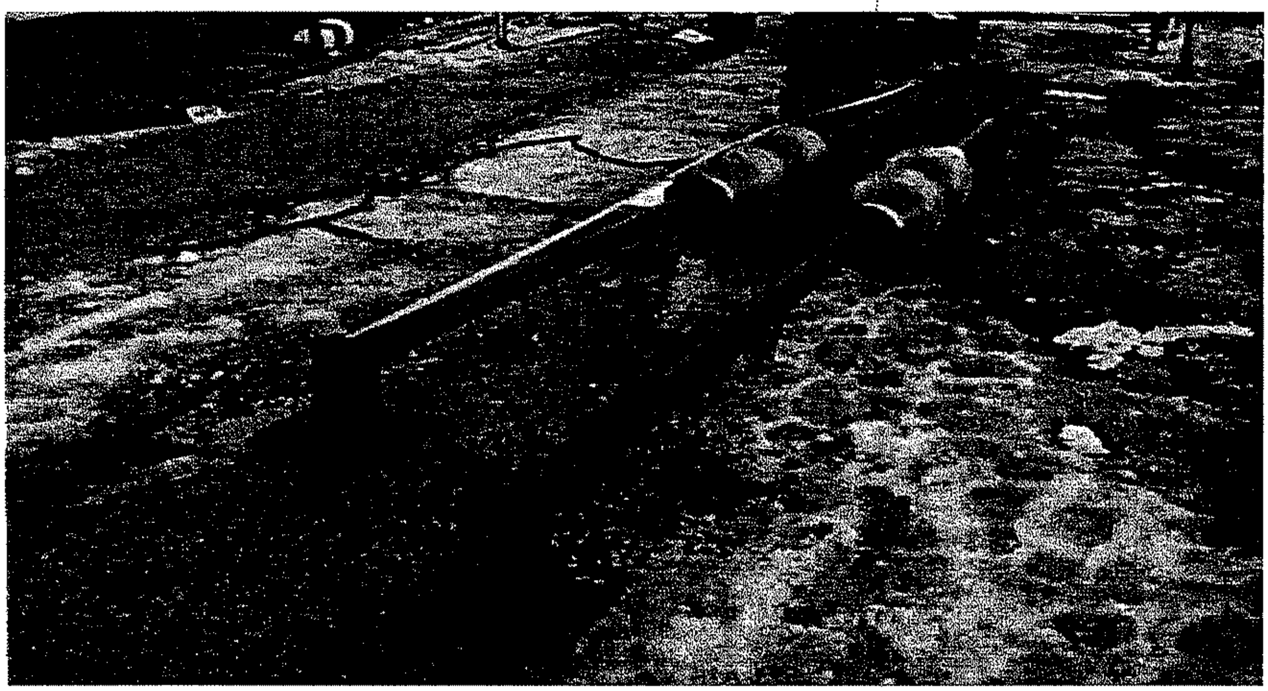
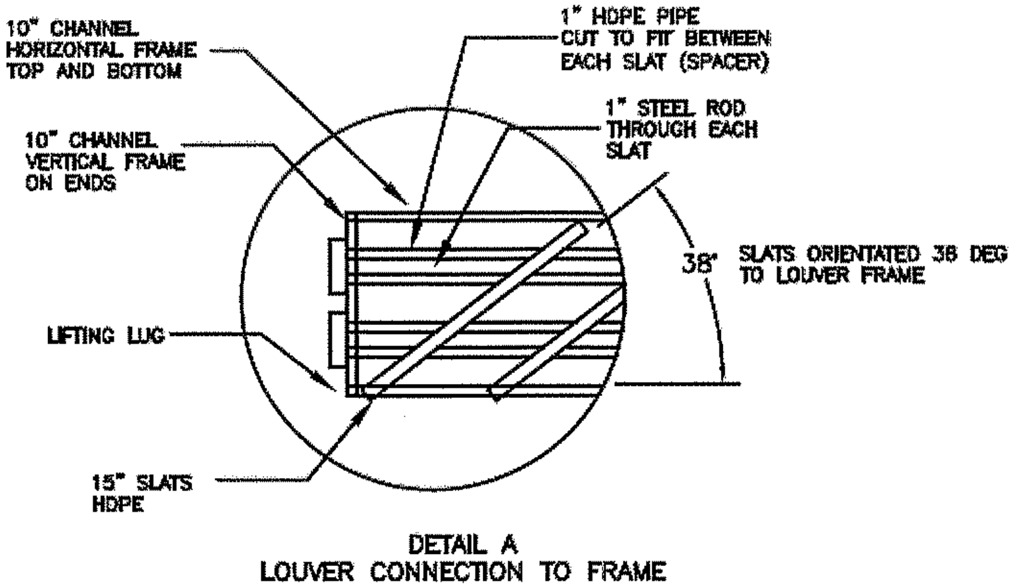


Figure 6. Shore line pile and fish station attachment system for the louver array



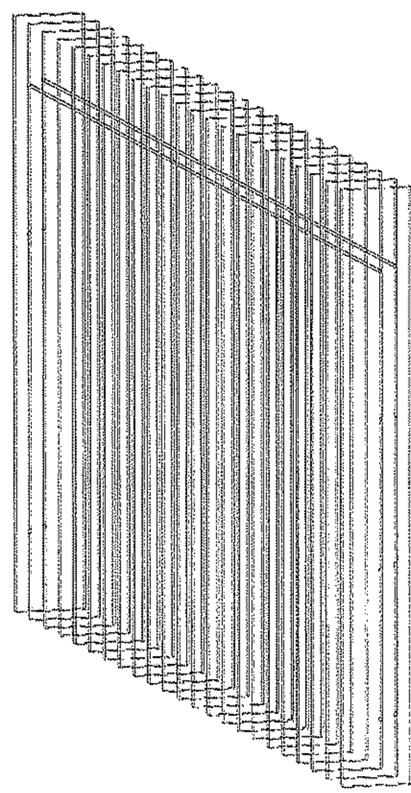


Figure 7. Louver design and slat layout

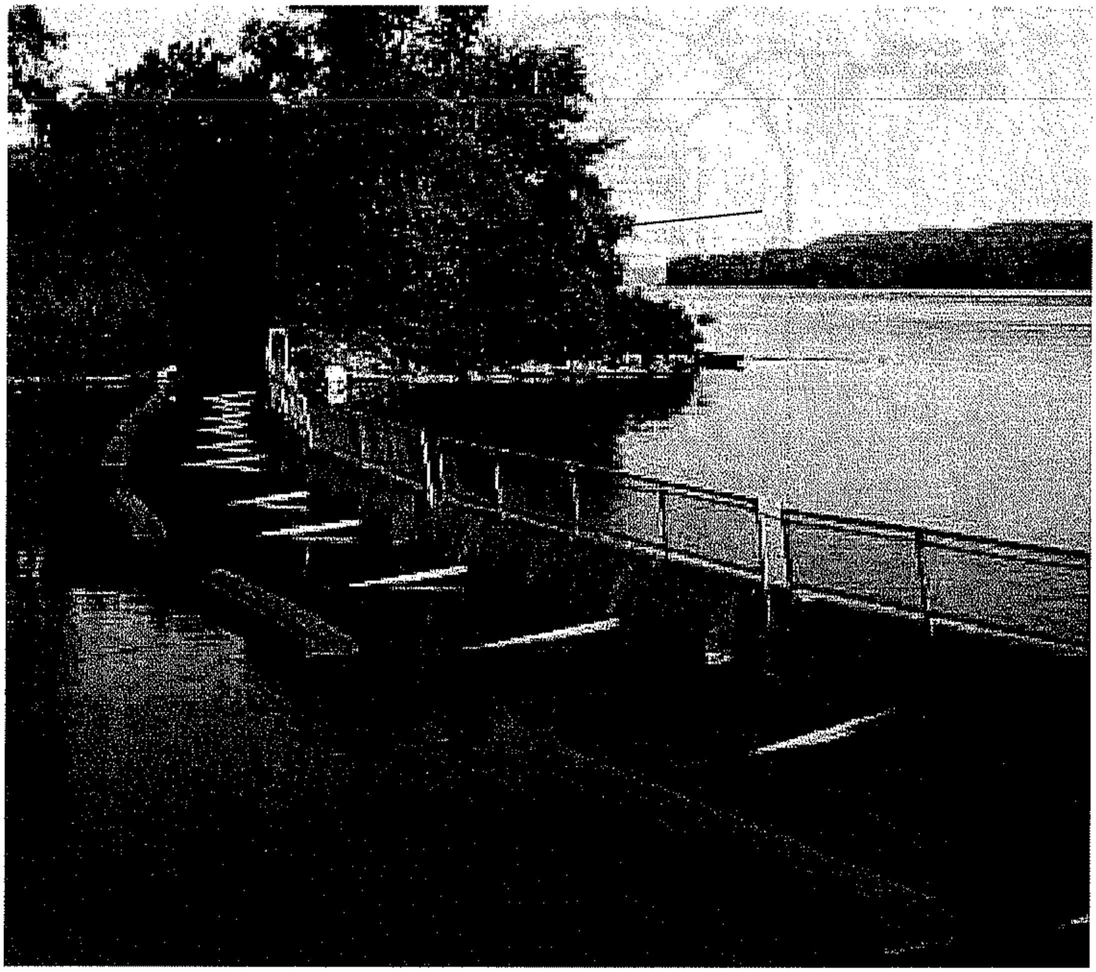


Figure 8. Shore line attachment and wedge installation

5.4.1 Static Hinged Reversed Louver Array (SHRL)

Figure 11 shows the static hinged reversed louver array in cross-sectional view. Once the shore line piles are installed, the static reversed louver array requires the installation of a series of 16" (1/2" wall) steel piles spaced 20' apart (Figure 12).

When the piles are completely installed the fish guide wall sections are installed by sliding the panel down each pair of piles starting from pile #1 to the pump station (Figure 13). These guiding walls are stationary and will be subject to siltation. As silt builds up in front and behind the guiding wall its effectiveness as a fish diversion tool will be reduced substantially. The guiding wall is 4' in height and will increase the flow rate locally of the water through the louver slats

When the fish guide wall installation is complete the pile caps (Figure 14) are attached to the piles. The pile caps are used to attach the 12" wide flange "H" beams (50 lb/ft) to the pile. The span beam supports the louver panels and provides the hinge point for the louver arrays (Figure 15).

The gap between the louver panels will be filled with flexible rubber sheet seals to prevent fish passage between the panels.

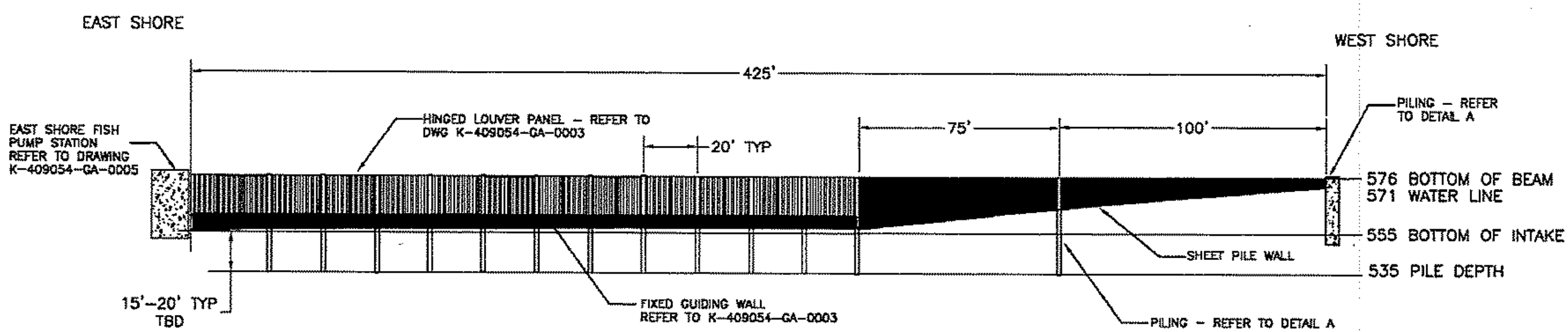


Figure 9. Static Hinged louver profile

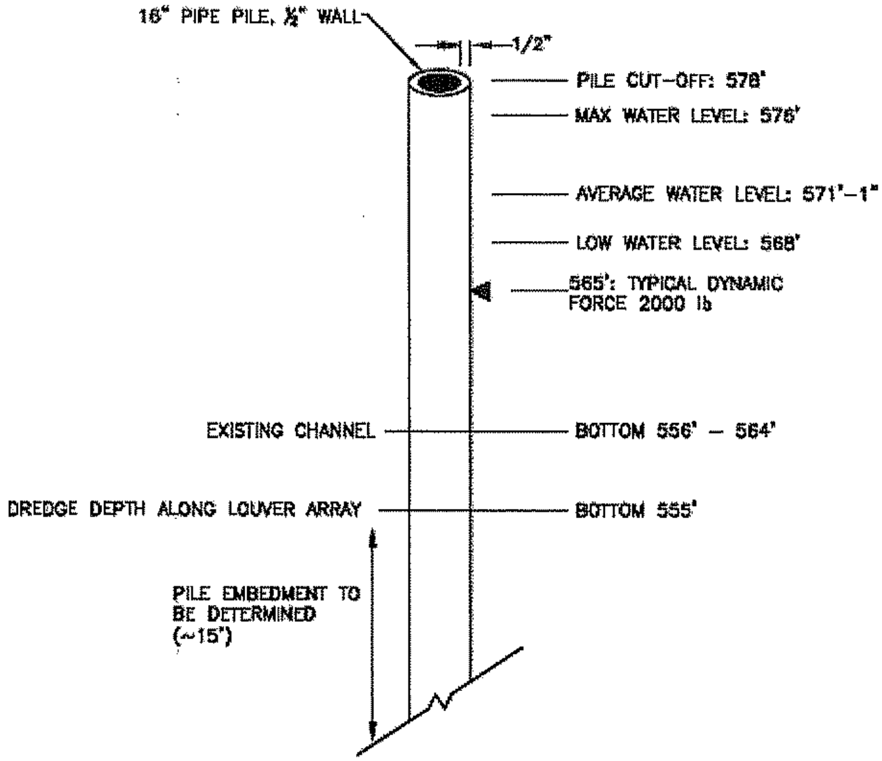


Figure 10. Louver pile

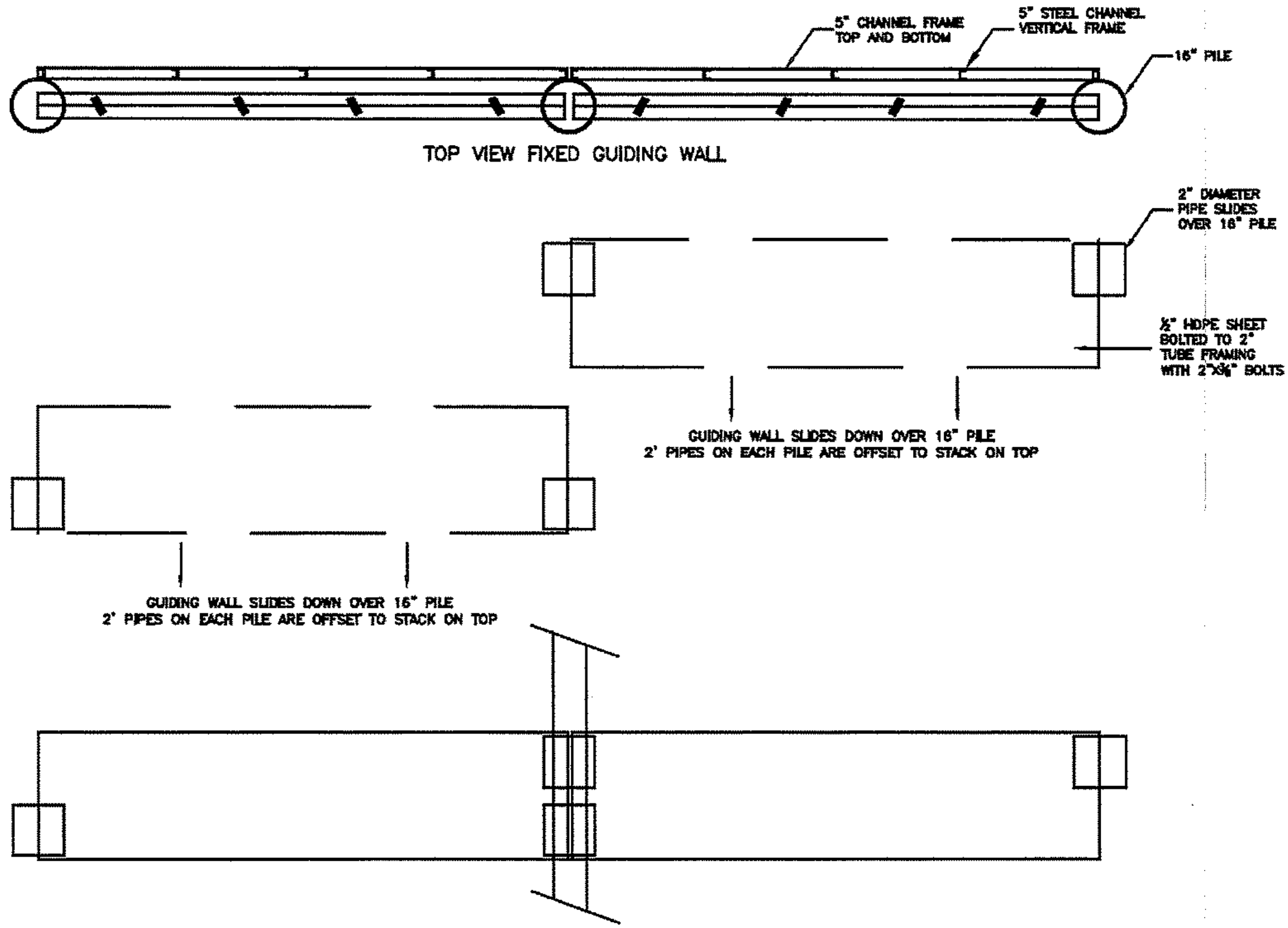


Figure 11. Static Hinged Louver fish guiding wall

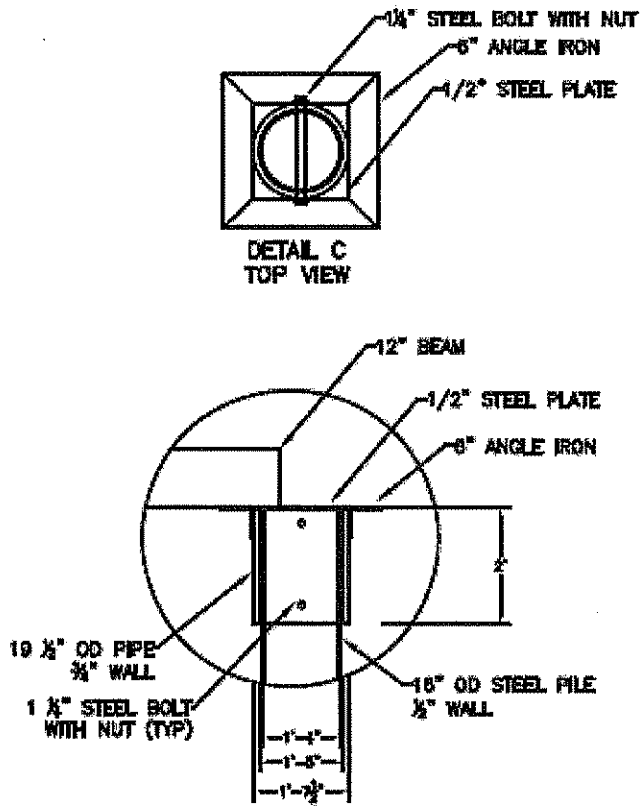


Figure 12. **Static Hinged Louver pile cap arrangement.**

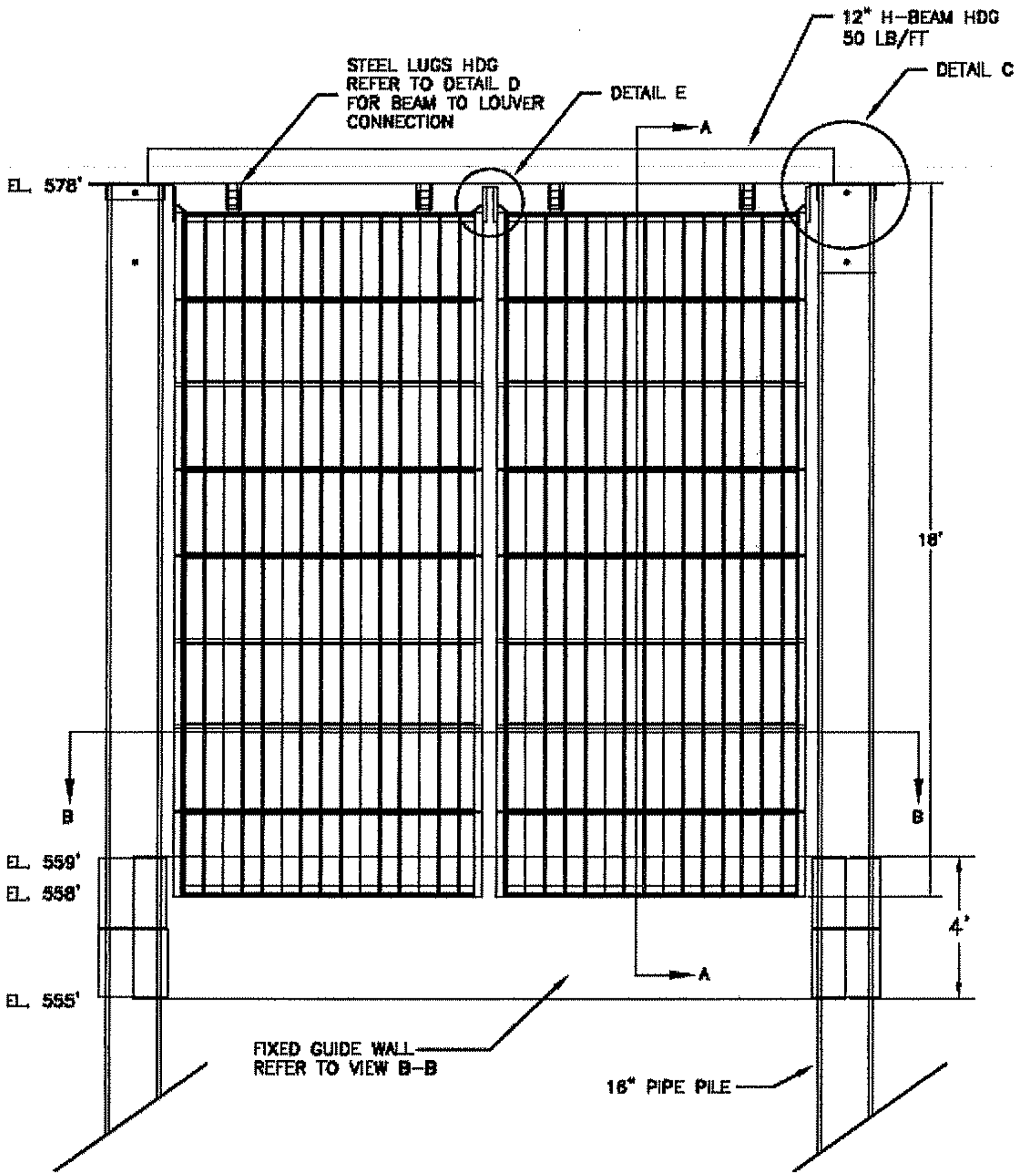


Figure 13. Static louver design

Static Hinged Louver specifications and budget pricing

9ft 6in x 18ft HDPE Slat Assembly
¾" x 15" x 18 ft slat construction c/w copper imbedded both sides
Cost: $75,400 ea

9ft 6in x 18ft HDPE Slat Assembly
¾" x 15" x 18 ft construction c/w **NO** copper imbedded both side
Cost: $45,900 ea

- HDG Steel frames for above HDPE slat arrays and assembly with rubber gaskets are each at $9,060 with assembly (25 required)
- HDG bottom static guiding wall with HDPE covering will be $8,300 each (13 required)
- 16" Pipe pilings (0.5" wall) , 45 ' length each $2,700 (13 required)
- 12" H beams 20' long (50 lb/ft) HDG fabricated each $3,900 (13 required)
- HDG Pile caps each $1,800 (13 required)
- 2x150' feet of 1/4"x 20' sheet pile wall($0.9/lb) 60,000 lbs= $54,000 , installation $4/ft^2 x 6000 =$24,000, hardware and mobilization =$20,000, Total=$98,000

The static hinged array will consist of 25 panels with a total cost estimated at ***$2,426,600*** with the copper wire antifouling treatment and ***$1,689,100*** without copper wire antifouling.

The same static hinged louver array can also be constructed from ¼" plate steel slats and structural steel frame rather than HDPE slats and steel frame. This hinged steel version of the above with a silicon based coating for anti fouling protection would be **$ 1,243,600** and without any anti fouling protection the budgetary price of would be **$991,600**. It is expected that this anti fouling coating would need to be replaced every 3-5 years in order to be effective.

5.4.2 Floating Reversed Louver Array

Figure 16 shows the cross-sectional view of the floating reversed louver. The shore line piles are installed in the same manner as the static louver. The floating louver array requires only two additional piles at 100' intervals. When the piles are installed the floating louver array can be installed.

The gaps between each set of the floating louver panels are covered with rubber sheeting (Figure 17) to avoid passage of small fish, eggs and larvae.

The louver panels and the fish guide wall are combined into one panel that is attached to a floating framework (Figure 18). Starting from the west shore and the sheet pile wall termination, the first floating louver section is attached to pile #1. The 100' floating section is then attached to pile #2 which are both equipped with a slider which allows the louver section to move up and down with the intake water level. Each floating section is attached to the next until the louver reaches the pump station. At the pump station the floating louvers are also attached to a slider fastened to the pump station wall. Again the slider allows the entire floating louver to move with the fluctuating water levels of the intake channel.

The floating louver is held in place by cables attached to the sliding devices mounted to each set of pilings.

The floating louver array moves with the water level of the intake. At the attachment points of each 100' section the array is attached to a float guide that allows the louver array to move up and down with the water level. At the lowest water level (566') the water would be about 12' in the center of the channel and the louver would be 100% of the water column and there would be essentially no guiding wall. If no debris boom is chosen as an option than the 100' spacing between pilings should be reviewed as the debris loading at any particular point in time would be considered much higher.

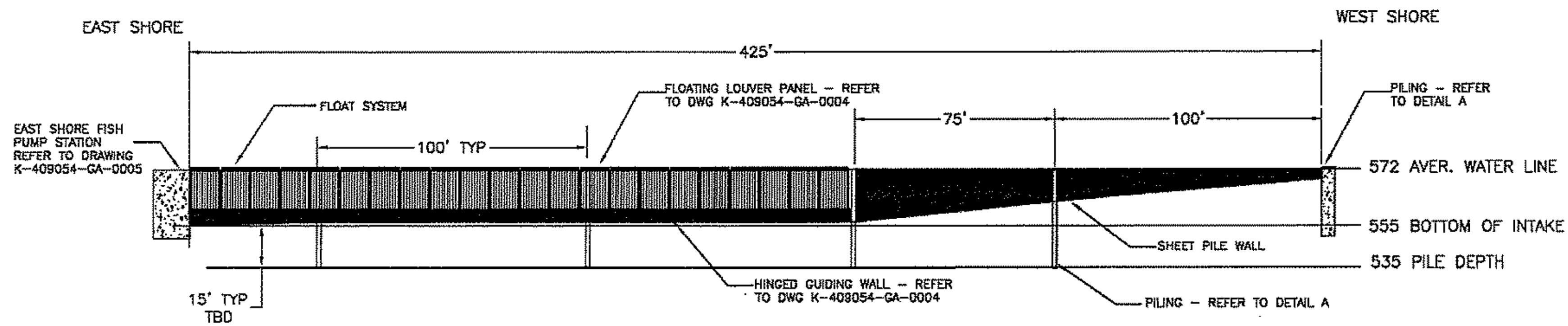


Figure 16. Floating louver profile

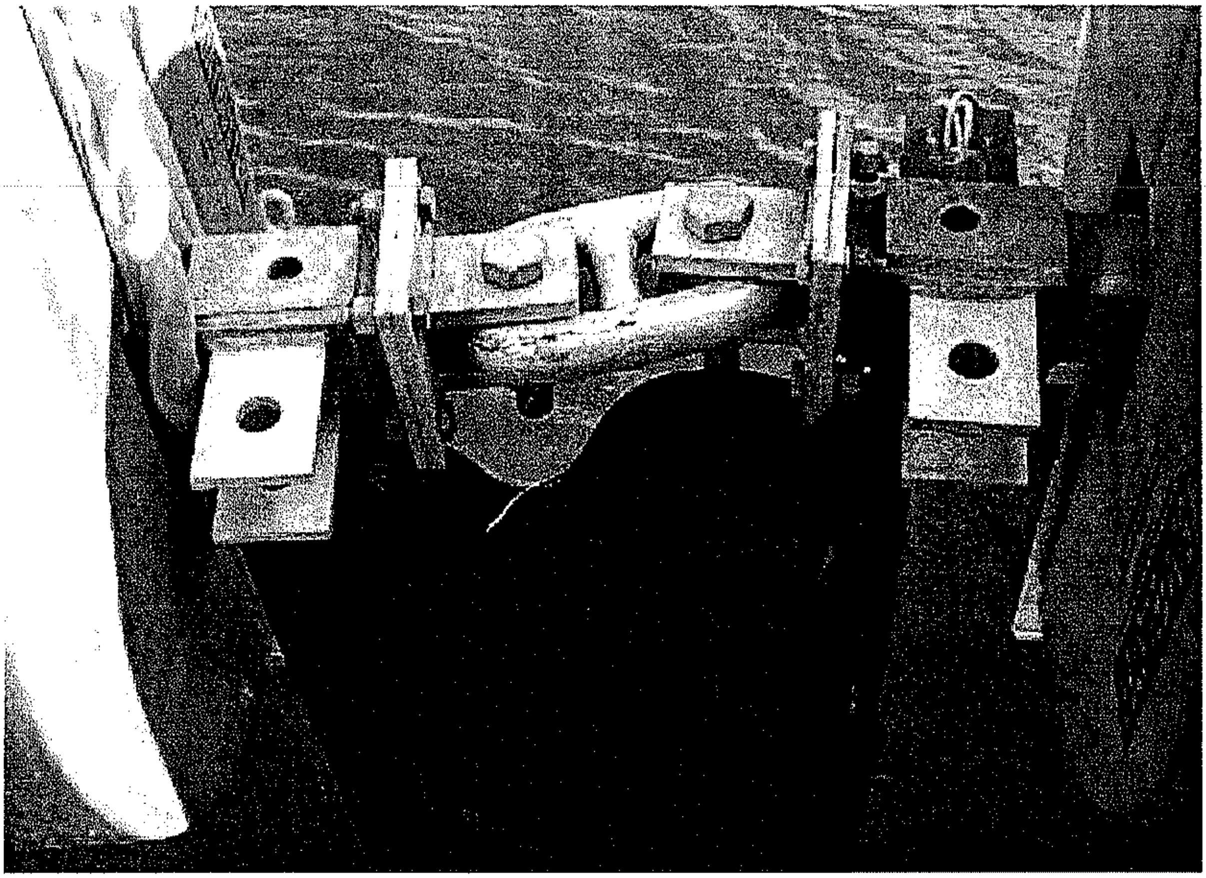


Figure 17. Floating Louver Rubber Gap Covers

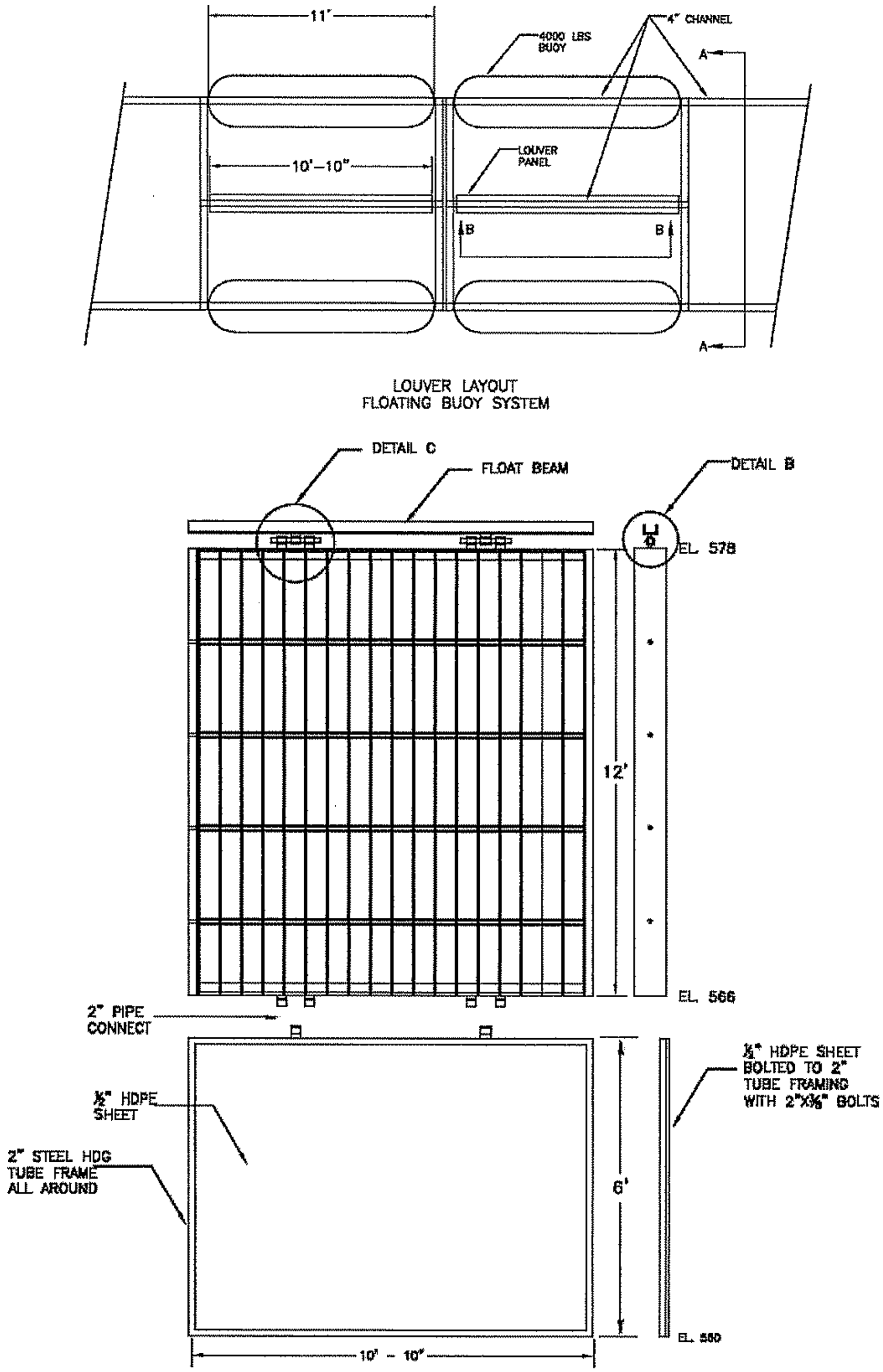


Figure 18. Floating Louver design

Floating Louver budget pricing

10ft 10in x 12ft HDPE Slat Assembly
¾" x 15" x 12 ft slat construction c/w copper imbedded both sides
Cost: $57,450 ea

10ft 10in x 12ft HDPE Slat Assembly
¾" x 15" x 12 ft construction c/w <u>**NO**</u> copper imbedded both side
Cost: $34,900 ea

- HDG Steel frames for above HDPE slat arrays and assembly are each at **$8,060** with assembly and

- The HDG folding guiding wall with HDPE covering will be **$6,500 each.**
- 2x150' feet of 1/4"x 20' sheet pile wall ($0.9/lb) 60,000 lbs= $54,000 , installation $\$4/ft^2$ x 6000 =$24,000, hardware and mobilization =$20,000, Total=$98,000

Each flotation unit for the louver array will cost ***$11,000 ea***

The total floating array will consist of 23 panels with a total materials cost estimated at ***$2,007,230*** with the copper antifouling treatment and ***$1,488,580*** without copper antifouling.

5.4.3 Recommended Louver Design Option

Table 3 summarizes the construction of the two louver concepts. Based on feasibility and ease of installation it is recommended that the floating louver array be installed.

Table 3. Construction and Installation

Construction & Installation	Static	Floating
Piles	13	4
Shore Attachment	1	1
Sheet Pile Shore	1	1
Fish Pump Crib Attachment	1	1
Louver Panels	Fixed Position	Moves with Water Level
Fish guide	Fixed Position	Moves with Water Level
Varying Intake Water Levels	Fixed Position	Moves with Water Level

5.5 Fine Mesh Traveling Screens

1. At Bay Shore TGS screens 1 and 9 are permanently shut down.
2. The site has 2 sets of stop logs to block water flow, one is in each bay 1 and 9.
3. Bay Shore has requested that 1 and 9 should be replaced first.
4. Bay Shore screen bays 1 to 6 are of different width than bays 7 to 9. As a result the stop logs are not interchangeable. Screens 1 to 6 are physically much closer together above floor grade than the others.

The screen suppliers are to supply a new fish trough to exit from screen house. The trough is to be connected to the fish transport system via a 16" HDPE DR26 pipe.

FirstEnergy - normal operating head differential is 5' and up to 15' on start up.

FirstEnergy - The design criteria is considered normal at a water level at 571-572' with a thru screen velocity of 1 ft/s and at low water level at 568' a thru screen velocity of 1.5 ft/sec.

FirstEnergy - based on 80% screen blockage the 746 MGPD flow must be maintained. This would result in a flow of 1.13 ft/sec and 5" of head loss.

Kinectrics considered both "thru-flow" and "dual-flow" systems from both an engineering and biological perspective. Several criteria were reviewed including demonstrated effectiveness for both entrainment and impingement survival, what fine mesh screens are available, debris/ fish separation and carryover, and operating experience (OPEX). Kinectrics held discussions directly with two vendors Intralox and OVIVO on the two different alternatives. Kinectrics also participated on discussions with two other vendors Atlas and Superior. In addition FirstEnergy issued an RFQ where Kinectrics carry out evaluations on the responses to this RFQ. Three of the vendors provided a "thru-flow" design (either carbon steel- SSI or engineered polymer-Hydrolox, Superior), and two vendors (OVIVO and Atlas) considered and proposed "dual-flow" screens for this project. It should also be noted that both Atlas and OVIVO can provide a thru-flow design screen but did not.

The expected USEPA316b Rule will likely recommend fine mesh screen sizes 2 mm or smaller (Table 4). Still, a 2-mm mesh size will not be 100% effective in reducing larval and egg passage through the mesh. In field studies conducted on the Great Lakes, nets with 500 microns (or 0. 5mm) are typically used in scientific larval tow studies. However, such nets are not always effective in collecting all species of fish eggs (Auer 1982, 2009). A 0.5 mm mesh or smaller is not feasible at Bay Shore. The proposed 2 mm mesh will be partially clogged under some operating conditions at Bay Shore, and will likely be closer to 1 mm. Based on recent EPRI (2009) lab studies, both Hydrolox (not slotted) and OVIVO screens have shown high survival for a 1.78 and 2 mm mesh under laboratory conditions (in addition tests were conducted under ideal conditions with no debris, Table 4). Survival typically exceeded 80% for 12 mm larvae. With debris, a lower survival performance would be expected.

Essentially for eggs and larvae survival, the lower the through screen velocity the better. There have been lab based tests (EPRI 2009) conducted up to 1.5 ft/sec (0.5, 1.0 and 1.5 fps) but there is no comparative OPEX above 1.5 ft/sec. A screen with a higher screen area is also expected to have less impact on eggs and larvae. The actual upper limit is not well defined number. Still, SSI proposes a through-screen velocity of 1.6 fps which is an unknown, and hence a risk to the station. Kinectrics does not believe a through-screen velocity is critical if less than 1.5 ft/sec which most vendors are (possible exception of SSI). Above this number it is less clear.

One of the disadvantages of the Hydrolox/Superior screen is that, the HDPE mesh is not square but slotted with slot sizes ranging up to 19 mm (e.g. 1. 78 mm x 19 mm) within the screen matrix. This will result in a further loss in performance in egg and larvae survival (the slotted mesh was not evaluated in the 2009 EPRI lab studies since prototype systems provided from each of the vendors were small relative to proposed field installations).

Hydrolox, Superior, SSI, OVIVO and Atlas have all shown or claim high survival for fish impingement (Table 4). However, studies are limited, and there are no recent studies where both a thru-flow design from one vendor is compared to another with dual-flow at the same plant, especially for fine mesh screens. It should be noted that there is considerable variability in power plant design, water intake body, flows and velocities, and species impinged, so that 1-2 studies would still not be statistically robust to compare performance of one system over another.

Still, one of the major advantages of the dual-flow over the thru-flow screens is the improved debris and fish separation, and less debris carryover (Table 4). If more carry-over occurs, there would be more loss of biological material (eggs, larvae, and juvenile fish) which would result in a lower survivability. Debris and fish separation will be very important in larval and juvenile fish survival. The claimed reduction of carry- over would also reduce the maintenance requirement on condenser tube cleaning which is a significant additional advantage to the plant. Hydrolox polymeric screens claim to outlast steel mesh screens by 2-5 times and require less maintenance but we have not found enough operating experience or long enough track record to validate these two claims.

Another important component of any of the screen systems is the fish bucket design (Table 4). All vendors have claimed fish friendly bucket designs; although OVIVO has more design experience based on Fletcher's (1984) earlier work on hydraulics. The fish buckets incorporate what is referred to as a stalled fluid zone, protecting the fish until they are flushed out by water at 5 to 10 psi. This occurs when the buckets are at a 45 degree angle at the top of the system and are introduced to a fish trough. A high pressure spray is introduced on the down side of the system to remove debris and clean the screens. A separate trough removes debris.

Wash Water Requirements

For fish handling for dual-flow systems, it is unclear why Atlas proposes a three (3) spray system- fish removal, fish survival and debris. The pressures for the fish removal and survival are identical (115 GPM @ 10-15psi). The water required for the debris removal is proposed as 500GPM @ 40psi. The total water requirement is 730 GPM/screen but at a lower water pressure than the others. There is some concern with the depth of water in the fish return trough proposed by Atlas (Table 4). A 2" plus water depth is proposed which is too low for fish return systems. The 4"plus water depth suggested by OVIVO is standard and more adequate for fish survival. Atlas does use the highest level of spray water.

For the OVIVO dual flow screens, they propose 350 GPM @ 5 to 10 psi for the fish boxes and another 150 GPM @ 80 psi for the debris wash. This is a total water requirement of 430GPM/screen. This does not include any water for the fish trough.

For fish handling for thru-flow systems, the Hydrolox screens from Intralox and Superior claim to require about 102 GPM @ 40 psi for the fish trough and 270-290 GPM @ 100 psi for the separate debris trough. This results in a total minimum water requirement of 372 GPM; however, there was no water requirement stated for the fish troughs but was discussed that it could be supplied by low pressure plant water supply.

The SSI screens claim to require 270 GPM @20psi for the fish sprays/trough and 230GPM @80-100 psi for the debris sprays which results in a total water requirement of 500GPM.

In summary, vendors with dual-flow designs are preferred over Hydrolox, SSI and Superior thru-flow designs for both entrainment and impingement survival and from both engineering and biological perspectives. A major disadvantage of the Hydrolox/Superior design is the slotted mesh which could result in passage of eggs and larvae, and hence survivorship. The new 1.78mm Hydrolox mesh design has not yet been used at a plant and hence has no track record. If FirstEnergy were to choose the Hydrolox screens from Intralox or Superior it should be considered the prototype installation which carries many operational and performance risks.

Aside from the delivery uncertainty as many of the components have not been manufactured yet, also operationally the fish/debris separation efficiency and the clean ability during high fish and debris loading periods have not been proven. With no operating experience on their fine mesh screens, it is difficult to recommend the Hydrolox screens for the first two screens as they will be a core component of supplying cooling water at Bay Shore. If these screens were to be purchased as back up screens or the last two screens being purchased and would be part of a rotation there would be less risk as any operational problems could be resolved without affecting core plant capacity.

Considering the poor status of the existing screens at Bay Shore it is difficult to select a screen that is new to the market even though there is a good track record for the existing Hydrolox screen at Bay Shore (with the larger mesh size). A first step could be to replace the existing 6mm mesh on the existing Hydrolox screen with the new 1.78mm slotted mesh and monitor its performance. If substantial problems arose the mesh could be changed back in a couple days without major disruptions. Even if it was found that the Hydrolox screen was the most efficient for fish, eggs and larvae survivability (although doubtful given their slotted design), it would be too risky to recommend this screen given the poor status of the existing screens at Bay Shore.

Therefore the OVIVO and Atlas designs are recommended for consideration because of their dual-flow characteristics. The advantages of the higher surface screening area, more uniform mesh size, lower debris carry over, inherent lower plant maintenance for the condenser tube cleaning, lower head operation and ability to operate during higher fish and debris runs make the dual flow screens a safer choice for a fine mesh traveling screen. Since fine mesh screen compliance will likely be important in the revised USEPA316B Rule, the manufacturer with the most successful operating experience is the safest choice.

Of the dual flow systems, OVIVO is the preferred technical system based on information submitted and OPEX (e.g. fine mesh lab trails) but there are obvious concerns with price and delivery. With the information received to date the OVIVO screens have much higher levels of OPEX. If Atlas could supply some additional operating experience than they could be considered more seriously as they are substantial cheaper and have a more acceptable delivery schedule. Still, Atlas has to provide OPEX on fish handling at an operating facility.

We further recommend that FirstEnergy seriously consider the cost effectiveness of refurbishing 1-2 of the existing screens until there is more operating experience for some of the vendors, and there is a clearer direction from the EPA on their 316B requirements.

Table 4. FINE MESH (2 mm or less) SCREENS FOR FISH PROTECTION- ENGINEERING AND BIOLOGICAL CRITERIA FOR CONSIDERATION AT BAY SHORE FOR THROUGH FLOW AND DUAL FLOW SYSTEMS

CRITERIA	THRU FLOW (STRAIGHT THRU FLOW)- all water passes from one side to the other through both the ascending and descending sides of the moving screen	DUAL FLOW (OUT TO IN FLOW)- mesh panels move more parallel to flow from both ascending and descending sides of the band. Water passes through and exits at back of screen
	Potential Vendor-Hydrolox, Superior, SSI	*Potential Vendors-OVIVO, Atlas
Flow Patterns	Single pass	Dual flow
OPEX (Operating Experience)	Limited since new fine slotted mesh polymer technology for Hydrolox and Superior has yet to be manufactured commercially or installed in the field	Extensive (including international- OVIVO e.g. most plants in UK and France use dual flow)
Debris Carry-over	Some (twigs, sticks, leaves, fish, algae, mussels) by pass the screen into the plant	No. Still occurs but reduced considerably. Design prevents debris by-pass with lower thru screen velocities.
Debris and fish separation	Hydrolox claims to have good debris/fish separation with 372 GPM of water in separate troughs. SSI talk about a deflector for debris and sprays for fish, unclear as to whether it is truly designed for 316B although there appear to be separate troughs.	Dual flow screen design and different spray pressures result in better debris/fish separation and less debris carry over OVIVO- two sprays (fish, debris) Atlas- three sprays (fish removal, fish survival, debris)
Fine mesh size(s) available	1.78 mm wide (not square)- no OPEX for field trails. Slot lengths vary from 6 mm to 19 mm.	0.5mm, 1.0mm, 2.0mm and higher (0.5 and 1.0 OPEX- field OVIVO trails ongoing)
EPA Rule for Screens (expected)	Definitely < 2mm possibly as low as 1 mm in freshwater bodies (may be issue for Hydrolox/Superior if 1 mm)	Definitely < 2mm possibly as low as 1 mm in freshwater bodies
Demonstrated IMPINGEMENT survival (Lab and/or Field)- coarse mesh.	Yes- (performance species specific (typically over 90% for robust species but considerably lower (<50%) for some pelagic schooling species).	Yes- performance species specific (typically over 90% for robust species but considerably lower (<50%) for some pelagic schooling species).

	Hydrolox LAB tests- Alden (2006)- >85% for robust species Hydrolox FIELD- Barrett Plant (2008)- 6.8 to 100% range. Robust species exceed 90%. SSI none reported.	OVIVO FIELD- Dunkirk Plant (2000) -variable with species ranging from about 18 to 100%. Robust species exceed 90%. ATLAS FIELD- claim 90-94%(no supporting documentation provided)
Recently demonstrated ENTRAINMENT reduction- fine mesh (LAB)-	Yes (EPRI 2009)- LAB (1.78 mm not square). Hydrolox only. Post collection survival (survival off screens)- exceeded 80% for larvae > 12 mm. In some replicates, survival considerably higher (100%). Screen velocity up to 1.5 fps had no or minor effect on post-collection survival. However, tests conducted under "clean" water conditions. With debris, survival expected to be lower.	Yes (EPRI 2009)- LAB (2.0 mm)- OVIVO only Post collection survival (survival off screens)- exceeded 80% for larvae > 12 mm. In some replicates, survival considerably higher (100%). Screen velocity up to 1.5 fps had no or minor effect on post-collection survival. However, tests conducted under "clean" water conditions. With debris, survival expected to be lower. For this reason, dual flow is a preferred option.
Fish handling system including fish buckets	Yes, all 3 vendors claim separate fish and debris buckets but the separation efficiency and technique are unclear.	Yes- S.I.M.P.L.E. system with improved design over thru flow (OVIVO). Better bucket design (OVIVO) for fish survival and capture. Atlas reports the standard Ristroph bucket with no enhancements for fish survival or capture Trough- 4" or higher OVIVO Trough- 2" or higher Atlas

***Both Atlas and OVIVO can provide thru-flow but are recommending dual-flow for Bay Shore**

6.0 ENGINEERING CALCULATIONS

6.1 Load Calculations on Static Louver Array

The purpose of this section is to calculate the dynamic force created by the movement of water into the louver panels.

Assumptions:

Assuming the louver panels across the channel provide complete blockage (100% clogged), results in a drag coefficient of 2. This analysis will give you the force on the panels created when water approaches the panels with a certain velocity, and then comes to a complete stop (stagnation pressure). In reality, the water will flow through the panels while creating some dynamic flow effects in front and behind the panels such as eddy's, and will therefore have a drag coefficient of something less than 2. However, this is the force caused by current only, and assumes there is no elevation difference from one side of the panels to the other. In addition, this approach does not address ice forces, dynamic forces caused by wave or storm action, effect of eddy's in front or behind, or any other related forces that may be presented to the system.

Parameters:
Flow velocity in channel (V1) = 0.75m/s, uniform top to bottom and across Width of louver = 61m (200 ft) Depth of channel = 5m (average of deepest point in each 25ft cross section is approx 4.6m) Cross section profile is rectangular (61m x 5m cross sectional area) Assume drag coefficient of 2 (Cd=2) Assume flow stops at wall, V2=0 Assume elevation difference = 0

Drag force Fd= 1/2 x Cd x V^2 x A x density
Fd=1/2 x 2 x (0.75^2 m2/s2) x 61m x 5m x 1000kg/m3
Fd=171,563 N
Fd=38,567 lbsf

For reference:
Determine the elevation difference to develop an equivalent static force Fs= 1/2 x density x gravity x width x height^2
Fs=1/2 x 1000 kg/m3 x 9.81 m/s2 x 61m x h^2
Fs=299,205 x h^2
To develop 171,563N, h=0.75m = 2.5 ft (across entire width)

6.2 Load Calculations on Floating Louver Array

6.3 Load Calculations on Debris Screen

The debris boom manufacturer was given the conditions in the channel of 1.5 fps flowrate of water and to assume a safety factor of 2 times for the calculation. The debris screens recommended are 48" deep in the water column and the boom would be oriented 40-50° to the flow of water in the channel. The worst case assumption of 2 feet of ice cover could generate up to 51,000 lbs of force on the boom cable. This force would be mostly applied to the upstream piling or anchor. The force on the upstream anchor could be up to 32,100 lbs and 18,900 lbs on the downstream anchor.(reference is Paul Meeks, Worthington Products Inc.).

In more typical conditions where there is little to no ice flows or normal debris flows the expected loading on the upstream anchor would be 6250 lbs and 3700 lbs on the downstream anchor. Assuming a safety factor of 2 again the resulting normal peak design load with no ice would be 12,500 lbs on the upstream anchor and 7,400 lbs on the downstream anchor.

7.0 BILL OF MATERIALS AND COST SUMMARY WITH INSTALLATION ESTIMATES

All pricing in this section includes a 25% contingency. It assumes all standard deliveries and no provision for rush or shortened delivery times. In most cases it does not assume transportation to site with the exception of the fish pumps.

7.1 Debris Boom

Table 5. Materials – Debris Boom

Component	Quantity	Unit Cost	Total Cost
floating debris boom modules with 4' submerged screen panels, 320 ft	320	$ 125.00	$ 40,000.00
end sliders	2	$ 11,500.00	$ 23,000.00
boat gate optional	1	$ 12,000.00	$ 12,000.00
Total			**$ 75,000.00**

Floating Debris Boom Installation:

1. Install two shoreline sliders attachments (2 days, work boat required)
2. Crane debris boom modules into the water and make boom to boom connections (2 days, 80 ton hydraulic crane and workboats required)
3. Boat gate installation (1 day, 80 ton hydraulic crane and workboat required)

Estimated to require 4-5 days of time and cost about $21,500.

7.1 Floating Louvers with Guiding Wall

Table 6. Materials – Floating Louvers with Guiding Wall

Description	Component	Quantity	Unit Cost	Total Cost
Materials (Option 1)	10' 10" wide x 12' high HDPE Slat Assembly c/w copper imbedded wire both sides, 3/4" x 15" x 12' HDPE slats	23	$ 57,450.00	$ 1,321,350.00
Materials (Option 2)	10' 10" wide x 12' high HDPE Slat Assembly bare w/no copper imbedded wire , 3/4" x 15" x 12' HDPE slats	23	$ 34,900.00	$ 802,700.00
Materials (all options)	10' 10" wide x 12' high HDG steel frames to contain HDPE arrays with rubber sheeting gaskets	23	$ 8,060.00	$ 185,380.00
Materials (all options)	10' 10" wide x 12' high HDG folding guiding wall, tube construction with HDPE covering	23	$ 6,500.00	$ 149,500.00
Materials (all options)	Commercially available floatation unit to carry the louver array	23	$ 11,000.00	$ 253,000.00
Materials (all options)	175 linear feet of sheet piling, 1/4" x 20' sheets, lbs	70,000	$ 0.90	$ 63,000.00
Materials (all options)	hardware	1	$ 2,000.00	$ 2,000.00
	Total Materials (Option 1)			**$ 1,974,230.00**
	Total Materials (Option 2)			**$ 1,455,580.00**

Floating Louver Installation:

1. The first step for the floating louver installation is the shore connections. The sliding float attachment must be installed on the sidewall of the fish pump station.
2. The 175' of sheet pile wall must be laid out and started from the west shore. The wall will be anchored on each end with a 16" pipe pile. The pipe pile on the west shore should be installed and then the 175' of wall. The wall will be finished with another 16" pipe pile.
3. At the end of the sheet pile wall and on the second pile a floatation slider must be installed on the pipe pile. The slider can be installed on an "H" pile attached to the pipe pile.
4. Another 16" pipe pile must be installed near the center of the channel.
5. Two additional floatation sliders must be installed on this pipe pile using "H" beams. This will result in three separate sets of floatation louvers at about 100' in length. Each will float independently on its own set of sliders. Each module will be attached to each other using rubber sheeting to seal the gaps between modules.
6. Each set of floating louver modules can be assembled on shore and craned into the water. Once floating in the water the modules can be connected to each other and attached to their respective sliders between each set of pilings and the fish pump station.

This installation including the sheet pile wall will require about 3-4 weeks and cost approximately $30-35,000 for the sheet pile wall and $63-75,000 for the other two pilings, module assembly and installation in the channel.

7.3 Static Louver Assembly with Guiding Wall

Table 7. Materials – Static Louver Assembly with Guiding Wall

Description	Component	Quantity	Unit Cost	Total Cost
Materials (Option 1)	9' 6" wide x 18' high HDPE Slat Assembly c/w copper imbedded wire both sides, 3/4" x15" x18' HDPE slats	25	$ 75,400.00	$ 1,885,000.00
Materials (Option 2)	9' 6" wide x 18' high HDPE Slat Assembly bare no copper imbedded wire, 3/4" x15" x18' HDPE slats	25	$ 45,900.00	$ 1,147,500.00
Materials (Option 3)	9' 6" wide x 18' high HDG plate steel (1/4") Slat Assembly with Si coating	25	$ 28,080.00	$ 702,000.00
Materials (Option 4)	9' 6" wide x 18' high HDG plate steel (1/4") Slat Assembly with no bio fouling coating	25	$ 18,000.00	$ 450,000.00
Materials (all options)	9' 6" wide x18' high HDG steel frames to contain HDPE arrays with rubber sheeting gaskets	25	$ 9,060.00	$ 226,500.00
Materials (all options)	20' x4' HDG static bottom guiding wall, tube construction, with HDPE covering	13	$ 8,300.00	$ 107,900.00
Materials (all options)	16" pipe pilings(0.5" wall), 45' length	13	$ 2,700.00	$ 35,100.00
Materials (all options)	12" H beams 20' long(50 lb/ft) HDG fabricated to attach to pile caps with hinges	13	$ 3,900.00	$ 50,700.00
Materials (all options)	HDG pile caps with mounting hardware	13	$ 1,800.00	$ 23,400.00
Materials (all options)	175 linear feet of sheet piling, 1/4" x 20' sheets, lbs	70000	$0.9/lb	$ 63,000.00
Materials (all options)	hardware	1	$ 2,000.00	$ 2,000.00
	Total Materials Option 1			**$ 2,393,600.00**
	Total Materials Option 2			**$ 1,656,100.00**
	Total Materials Option 3			**$ 1,210,600.00**
	Total Materials Option 4			**$ 958,600.00**

Static Hinged Louver Installation:

1. The first step for the static hinged louver installation is the same as the floating louver which is the shore connections.
2. The 175' of sheet pile wall must be laid out and started from the west shore. The wall will be anchored on each end with a 16" pipe pile. The pipe pile on the west shore should be installed and then the 175' of wall. The wall will be finished with another 16" pipe pile.
3. At this point 16 " pipe piles will need to be installed every 20' until the fish pump station is reached. The piles need to be installed with a reasonable good level of accuracy. Once complete they can all be cut off to the correct elevation.
4. After the piles are all cut to length the fixed guiding walls can be slide over the piles and slid down to the bottom. Divers will need to check for obstructions to ensure the guiding walls are on bottom.
5. The pile caps can all be installed on the top of the piles.
6. The 12" "H" beams can then be bolted to the pile caps.
7. Once the entire structure is in place with the guiding wall in place, the hinged louver panels can be craned into place and fixed to the top rail

This installation including the sheet pile wall will require about 6-8 weeks and cost approximately $30-35,000 for the sheet pile wall and $185- 195,000 for the other 13 pilings, the guiding wall, pile caps, and "H" beam hinge rails. The louver panels depending on whether they are constructed from steel or HDPE will require $85-165,000 for mounting as a barge and crane would be required for the steel louvers.

7.4 Pumps and Piping

Table 8. Materials – Pump and Piping

Description	Component	Quantity	Unit Cost	Total Cost
Materials	three pump package fast-out elbows, guide rails and brackets, lifting chains, ultra sound water level sensors, motor control centers with VFD's for indoor installation, start-up supervision and freight to site.	1	$ 1,000,000.00	$ 1,000,000.00
Materials	42" IPS DR 26 HDPE pipe	5000	$ 127.00	$ 635,000.00
Materials	42" IPS DR 26 HDPE pipe Tee	1	$ 8,975.00	$ 8,975.00
Materials	42" IPS DR 26 HDPE pipe five segmented elbows	1	$ 9,450.00	$ 9,450.00
Materials	42" IPS DR 26 HDPE pipe flange assembly	2	$ 3,750.00	$ 7,500.00
Materials	42" steel pipe end blind flange, HDG and fabricated	1	$ 2,650.00	$ 2,650.00
Materials	14"IPS DR 17 HDPE pipe flange assembly	6	$ 275.00	$ 1,650.00
Materials	14"IPS DR 17 HDPE pipe	300	$ 28.00	$ 8,400.00
Materials	14" IPS DR 26 pipe smooth radius 90	3	$ 1,200.00	$ 3,600.00
Materials	12" to 14" IPS DR 26 increaser	3	$ 600.00	$ 1,800.00
	Total Materials			**$ 1,679,025.00**

<u>Fish Pumping Station and Pump Installation:</u>

1. Install Coffer dam sheet pile wall for de watering the fish pump station location and install the 16" pipe piling against the fish pump station for louver connection.
2. De- water the inside of the coffer dam
3. Remove silt down to the original clay bottom at about 544' elevation
4. Prepare the base and pour the new concrete base for the fish pump station
5. Pour the concrete for the back wall
6. Mount the trash rack for the fish station entrance
7. Mount the fast out elbows and guide rails to the concrete base for the fish pump attachment
8. Install the fish pumps
9. Provide electrical and control connection to the pumps from the plant
10. Install the 14" piping connections from the fish pump discharges to the 42" HDPE end blank flange plate on shore
11. Install the 16 " HDPE pipe from the screen house fish troughs to the fish station under the roadway to the top of the fish pump station
12. Remove the front of the coffer dam to allow water to enter the fish pumping station

Total time for installation assuming no scheduled downtime and good site access with reasonable weather would be 6-8 weeks. The estimated cost for installation would be $187,000.

<u>42"HDPE Pipe and Discharge Installation:</u>

1. Prepare the site from the plant to the discharge location with a bull dozer to remove debris and provide a uniform base for the pipe installation
2. The pipe needs to be routed along the east sheet pile wall until the wall protrudes out into channel then the pipe should continue on land only buried4 feet below grade until the pipe passes the debris removal area. A proper road crossing will need to be constructed above the pipe until it passes this area. Then, a shallow 30" deep trench should be excavated for the entire length of the pipe before it goes underground for the discharge back into the river
3. The 50' pipe lengths can then be fused together beside the trench on site
4. The pipe should be pushed into the trench and the backfill cover cap can be placed on the pipe for the entire length from the station until it reaches the point at the end of the intake channel. Some additional loads of fill may be required to properly cover the pipe with fill to avoid future erosion.
5. At the end of the existing intake channel a 42" pipe tee must be installed before the pipe is routed under the roadway to the water. The trench must be dug under the existing road at the end of the intake channel and the 42" pipe must be routed into the river under the bank and along the river bottom so as to avoid ice damage to the pipe in the future. The pipe must be buried and armor stone must be put back along the bank to avoid ice packs from pushing the pipe where it enters the water. The 42" pipe sections must be fused on shore and put in place beside the trench to prepare to be towed into place with a small tug boat. The pipe would then be sank to the right location on the river bottom and installed and backfilled correctly as per Appendix 4. Gambian stone must be placed in piles on top of the pipe underwater to hold it in location. The entrance around the underwater pipe discharge point must be surrounded with Gambian stone to support the pipe discharge from movement and vibration.
6. The pipe would be routed from a straight run along the side of the intake channel to a gentle curve after the tee to an easterly direction under the dike roadway and into the river. This will require on site fusion as the trench is being excavated to the water.

This installation is estimated to require 6-8 weeks with reasonable non winter weather and is expected to cost about $75,000 for the fusion welding and $83,000 for the pipe installation on land and $93,000 for the in water installation.

7.5 Fine Mesh Screen Installation

Detailed proposals were received by vendors which outlined the equipment costs but left the installation costs up to FirstEnergy. It has been estimated that it would require 2-4 weeks to install 2 screens. The external costs to remove an existing screen and install a screen would depend which screen was selected as some screens require some modifications to the screen house structure and roof. More detailed installation costs can be estimated in the detailed engineering phase when the screen vendor has been selected. At the very least a 160 ton hydraulic crane will be required for 2-3 weeks which will cost about $25-35,000.

8.0 PREDICTED MORTALITY ASSOCIATED WITH DIFFERENT COMPONENTS OF AN INTEGRATED FISH PROTECTION SYSTEM

Predicted mortality for both entrainment and impingement associated with different components of an integrated fish protection system is shown in Tables 9 and 10, respectively. These estimates are based on several assumptions some of which are unknown since there is no OPEX to verify these mortalities. For example, while there are references on fish survival passage through a fish pump and transport system (Patrick and Sim 1985, Rodgers and Patrick 1985, Helfrinch et al. 2007), there appears to be no data for entrainment organisms including eggs and larval fish. These estimates are therefore based on Best Professional Judgment (BPJ) concerning the technology as well as from discussions with other professional staff. These estimates also assume all entrained organisms and fish are alive and healthy prior to being impinged or entrained. It also assumes that results from field studies will be similar to that found in the lab (especially for larvae).

ENTRAINMENT- The predicted overall mortality for larval fish and eggs associated with the integrated system is 25%, or a survival rate of 75%. This estimate is based primarily on data available from larval fish (not eggs), and is assumed that mortality for eggs is similar to that of larval fish. Much of the information is also based on lab studies (e.g. survival), and large differences in survival are expected for the different species entrained at Bay Shore (likely in the range from 20 to 100%).

The predicted results clearly indicate the importance of the fine mesh screens where most of the mortality is expected to occur (20%). **The fine mesh screen mortality estimate assumes a dual flow system with no carryover.** If carryover occurs, there likely will be additional mortality associated with the screen design. Losses associated with a through-flow fine mesh screen may add at a minimum, 10% or more mortality with passage or carryover on some entrainment events. For example, collection efficiency in lab based tests for various flow-through systems averaged 84% for all species for flows of 1 and 1.5 fps (i.e. 16% loss of larvae which were not collected, EPRI 2009). The "uncollected" larval fish were attributed to gaps between panels, seals, etc. which is essentially "carryover". Off-screen survival for impinged eggs and larvae may still reach 80% for through-flow screens but losses will occur for entrained organisms through or around the screens as "carryover". Therefore, it is critical that dual flow screens are considered at Bay Shore for entrainment survival. If not, survival rate would be lower (and likely closer to the 60% OEPA guideline; i.e. estimated dual flow survival of 75% minus 10% loss of carryover).

The 75% survival estimate with dual flow screens should meet OEPA's guidelines, but will not likely meet USEPA316b guidelines if cooling towers or equivalent (90%) are proposed in their revised Rule. Other changes will also be required such as operational flow changes during the "peak" periods when entrainment occurs.

IMPINGEMENT- The predicted overall mortality for juvenile and adult fish associated with the integrated system is 11.5%, or a survival rate of 88.5%. This estimate is based on available literature (e.g. Griffiths 1984, Patrick and McKinley 1987, EPRI 2001), BPJ and expected performance of the louver array in diverting fish towards the fish pump and transport system (Ager et al. 2011). It is likely a conservative estimate since it does not include any fish diversion from the debris boom, or fish diverted by the louver which may eventually back out the channel towards the river. The approach velocities are very low in the channel.
The mortality estimate assumes a dual flow system with no carryover. If carryover occurs, there likely would be additional mortality but it would be considered insignificant. Since only 15% of

the fish are expected to pass though the louver array towards the screens, differences in mortality between through-flow and dual flow screen designs would not be expected to be large. Therefore, it is not critical that dual flow screens are be considered at Bay Shore if a louver array is in place for impingement survival.

Based on this analysis, an integrated fish diversion system consisting of the following components is recommended for Bay Shore Power Plant:

1. Trash Diversion/Handling System
2. Reverse Louver Array
3. Fish Pump and Fish Return System
4. Fine Mesh Traveling Screens

It is likely not critical that dual flow screens are required to meet OEPA's guidelines for impingement mortality. However, a dual flow fine mesh screen is recommended to reduce entrainment mortality.

Table 9. Predicted Entrainment Losses (Mortality) Associated with Different Components of an Integrated Fish Protection System at Bay Shore.

TECHNOLOGY COMPONENT	MORTALITY (%)	CUMULATIVE MORTALITY (%)	CUMULATIVE SURVIVAL (%)
Debris Boom	0	0	100
Louver	25% larvae diverted towards fish pump and transport system (Ager et al. 2011). Assume 10% mortality (pump-5%, pipe transport- 5%)	2.5	97.5
Fine Mesh Screen (2 mm)*	75% larvae pass though louvers towards pumphouse. Assume overall 20% mortality (80% survival-EPRI 2009) or 15% mortality based on expected % larvae x expected mortality rate (75 x 0.2).	17.5	82.5
Fish Pump	Assume no carryover, and 75% pass from screenhouse to pump. Assume 5% mortality associated with pumps or 3.75% mortality based on expected % larvae x expected mortality rate (75 x 0.05)	21.25	78.75
Fish Transport System	Assume 5% mortality associated with pipe transport or 3.75% mortality based on expected % larvae x expected mortality rate (75 x 0.05)	25	75

*assumes dual flow with no carryover. If through-flow used, an additional loss of at least 10% mortality associated with carryover (i.e. entrained), although off-screen survival may still be 80%.

Table 10. Predicted Impingement Losses (Mortality) Associated with Different Components of an Integrated Fish Protection System at Bay Shore.

TECHNOLOGY COMPONENT	MORTALITY (%)	CUMULATIVE MORTALITY (%)	CUMULATIVE SURVIVAL (%)
Debris Boom	0	0	100
Louver	85% fish diverted towards fish pump and transport system. Assume 10% mortality (pump-5%, pipe transport- 5%)	8.5	91.5
Fine Mesh Screen (2 mm)*	15% fish pass though louvers towards pumphouse. Assume overall 10% mortality (90% survival-Barrett 2008, Dunkirk 2000 or 1.5% mortality based on % expected fish x expected mortality (15 x 0.1).	10	90
Fish Pump	Assume no carryover, and 15% pass from screenhouse to pump. Assume 5% mortality associated with pumps. 0.75% mortality based on % expected fish x expected mortality (15 x 0.05)	10.75	89.25
Fish Transport System	Assume 5% mortality associated with pumps. 0.75% mortality based on % expected fish x expected mortality (15 x 0.05)	11.5	88.5

*assumes dual flow with no carryover. If through-flow used, some additional loss may occur with carryover but is not expected to be significant since only 15% of the fish will likely enter the screen house. The screen survival will likely still be 90%.

9.0 REQUIREMENTS FOR THE PERMISSION TO INSTALL(PTI) APPLICATION

The following is a list of the requirements for the application document for the permission to install:

1. Complete Ohio EPA Form A Permit-to-Install/Plan Approval Application.
2. Complete Ohio EPA Division of Surface Water Anti-Degradation Addendum.
3. Assemble Plans (prepared by others) into a package to be submitted to Ohio EPA. Plans are to include the following per OEPA Guidance for Section 316(b)Part VIII (F)(3) Site Specific Technology Plan:
    a. A narrative description of the design and operation of all existing and proposed design and construction technologies.
    b. An engineering estimate of the efficacy of the proposed and/or implemented design and construction technologies.
    c. A demonstration that the proposed and/or implemented design and construction technologies achieve an efficacy that is as close as practicable to the applicable performance standards.
    d. Design and engineering calculations, drawings, and estimates prepared by a qualified professional to support the elements of a Site-Specific Technology Plan.
4. Relevant reports are:

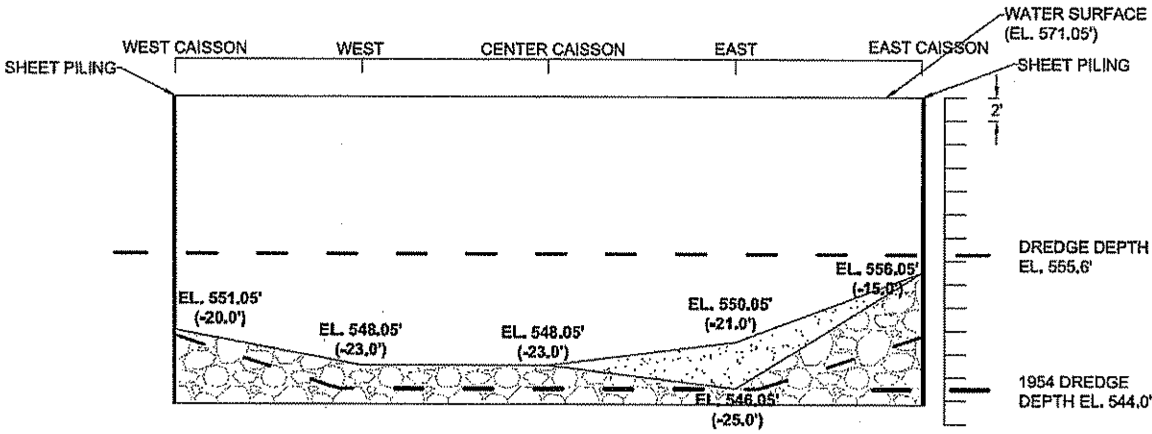
"Modeling of Options to Address Entrainment and Impingement Reductions at Bay Shore" Kinectrics Report No. 409025-001-RA-0001-R00, dated January 2010.

"FirstEnergy Bay Shore Power Plant Integrated Reversed Louver Fish Diversion System, Concept Design Evaluation" Kinectrics Report No. K-409054-CDE-0001-R01, dated March 18, 2011.

5. Coordinate questions regarding specifics of items 1-4 with First Energy, Kinectrics, and the Ohio EPA.
6. Submit draft of items 1-3 to First Energy and Kinectrics by June 1, 2011 for review and comment.
7. Submit Final of items 1-3 to Ohio EPA by July 1, 2011.

Appendix 1: Existing Bottom Condition Profiles

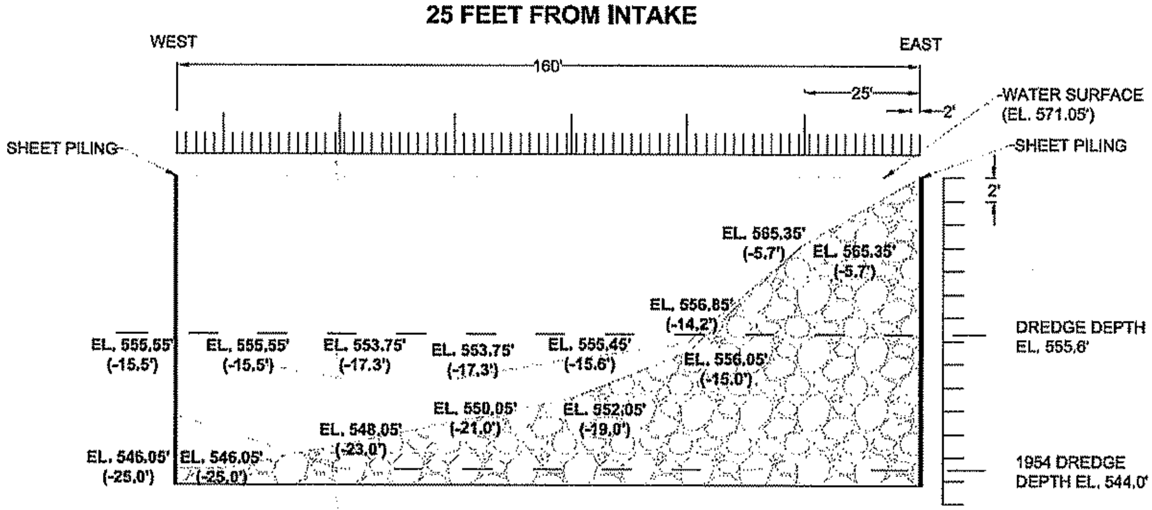
ACROSS INTAKE



ASSUMPTIONS
1. DREDGE DEPTHS CONSTANT THROUGHOUT CHANNEL
2. DEEPEST PORTION OF 1954 DREDGE DEPTH IS CENTERED WITHIN CHANNEL

LEGEND
- SOFT SEDIMENT
- FIRM BOTTOM

25 FEET FROM INTAKE



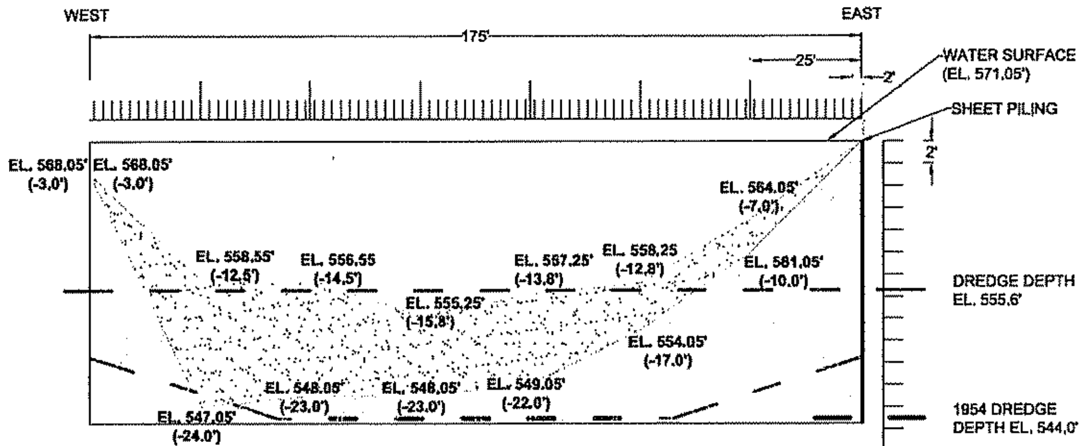
ASSUMPTIONS
1. DREDGE DEPTHS CONSTANT THROUGHOUT CHANNEL
2. DEEPEST PORTION OF 1954 DREDGE DEPTH IS CENTERED WITHIN CHANNEL

NOTE: HORIZONTAL SCALE IS 40% OF VERTICAL SCALE

LEGEND
- SOFT SEDIMENT
- FIRM BOTTOM

Appendix 1 (Cont'd)
Existing Bottom Condition Profiles

50 FEET FROM INTAKE

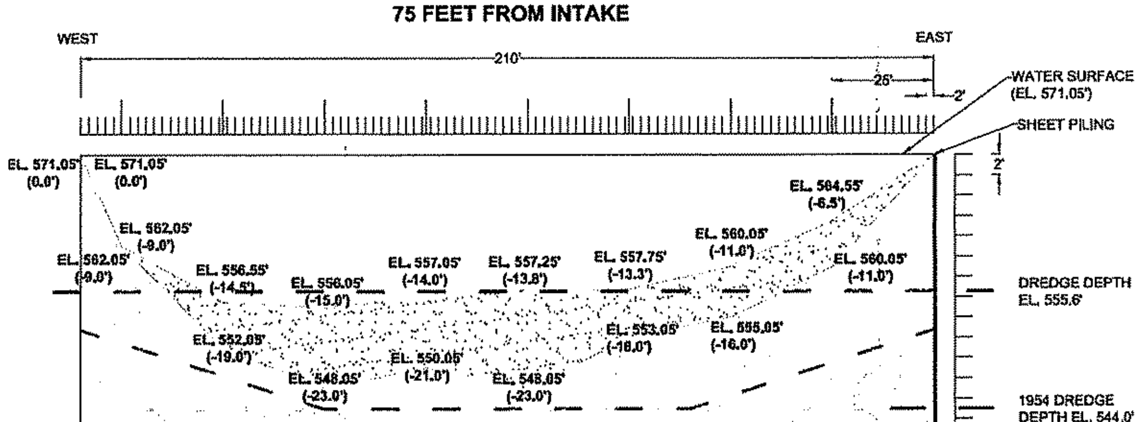


ASSUMPTIONS
1. DREDGE DEPTHS CONSTANT THROUGHOUT CHANNEL
2. DEEPEST PORTION OF 1954 DREDGE DEPTH IS CENTERED WITHIN CHANNEL

NOTE: HORIZONTAL SCALE IS 40% OF VERTICAL SCALE

LEGEND
- SOFT SEDIMENT
- FIRM BOTTOM

75 FEET FROM INTAKE



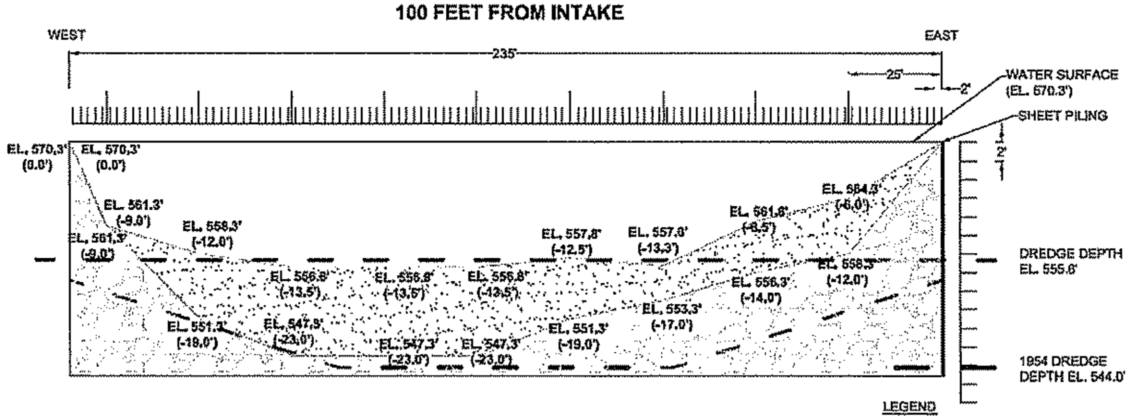
ASSUMPTIONS
1. DREDGE DEPTHS CONSTANT THROUGHOUT CHANNEL
2. DEEPEST PORTION OF 1954 DREDGE DEPTH IS CENTERED WITHIN CHANNEL

NOTE: HORIZONTAL SCALE IS 40% OF VERTICAL SCALE

LEGEND
- SOFT SEDIMENT
- FIRM BOTTOM

Appendix 1 (Cont'd)
Existing Bottom Condition Profiles

100 FEET FROM INTAKE

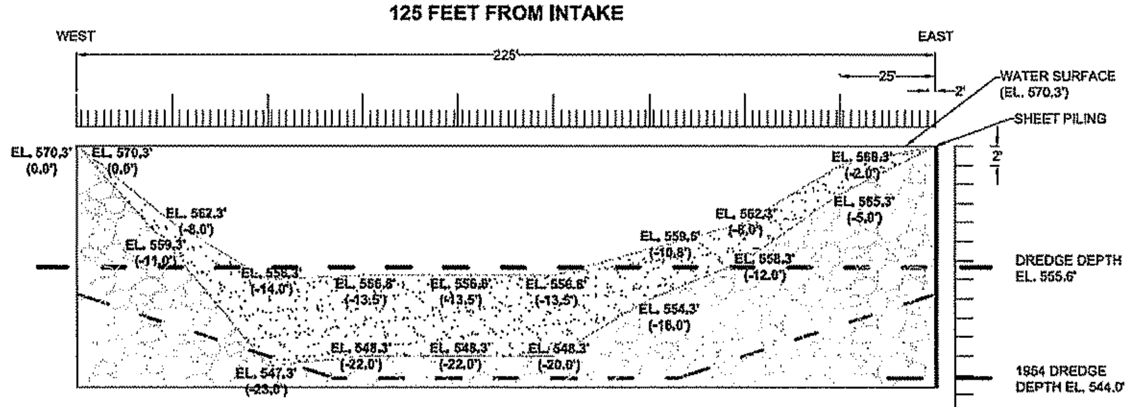


ASSUMPTIONS
1. DREDGE DEPTHS CONSTANT THROUGHOUT CHANNEL
2. DEEPEST PORTION OF 1954 DREDGE DEPTH IS CENTERED WITHIN CHANNEL

NOTE: HORIZONTAL SCALE IS 40% OF VERTICAL SCALE

LEGEND
SOFT SEDIMENT
FIRM BOTTOM

125 FEET FROM INTAKE

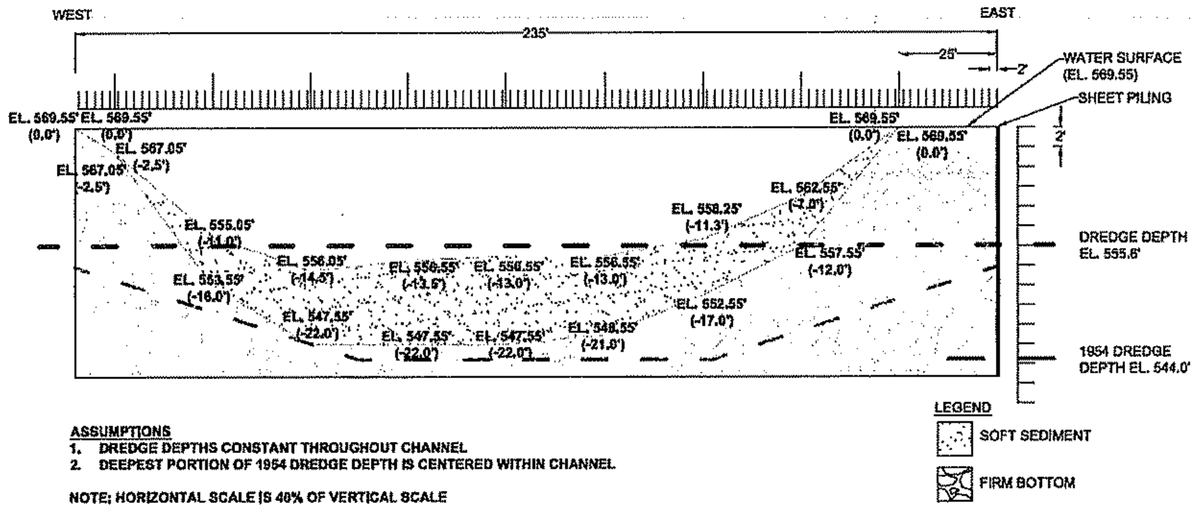


ASSUMPTIONS
1. DREDGE DEPTHS CONSTANT THROUGHOUT CHANNEL
2. DEEPEST PORTION OF 1954 DREDGE DEPTH IS CENTERED WITHIN CHANNEL

NOTE: HORIZONTAL SCALE IS 40% OF VERTICAL SCALE

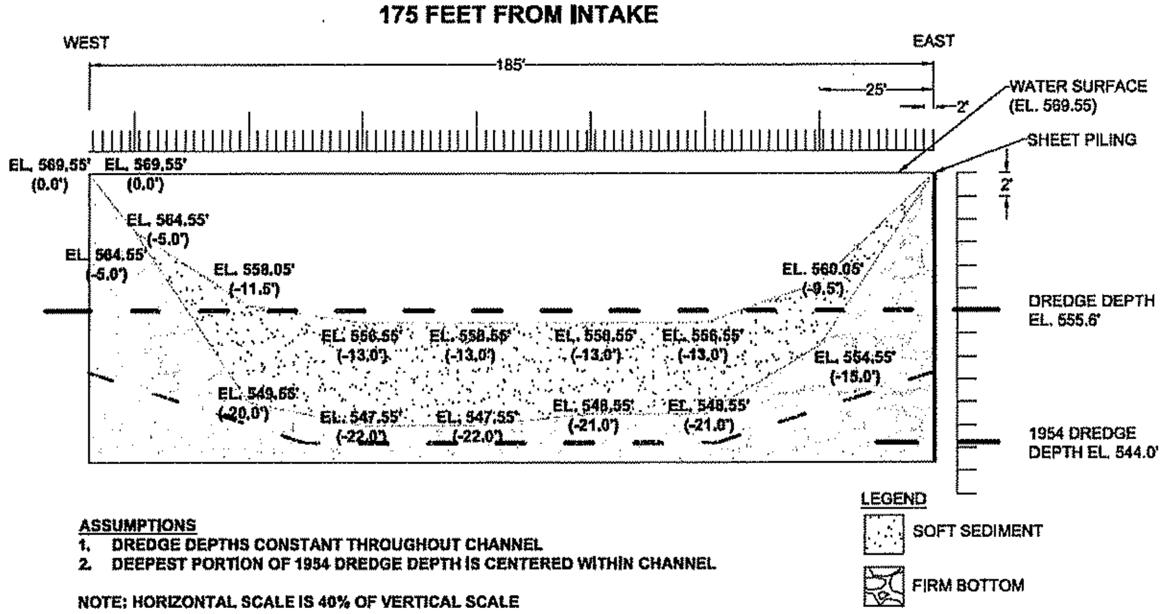
LEGEND
SOFT SEDIMENT
FIRM BOTTOM

Appendix 1 (Cont'd)
Existing Bottom Condition Profiles



ASSUMPTIONS
1. DREDGE DEPTHS CONSTANT THROUGHOUT CHANNEL
2. DEEPEST PORTION OF 1954 DREDGE DEPTH IS CENTERED WITHIN CHANNEL

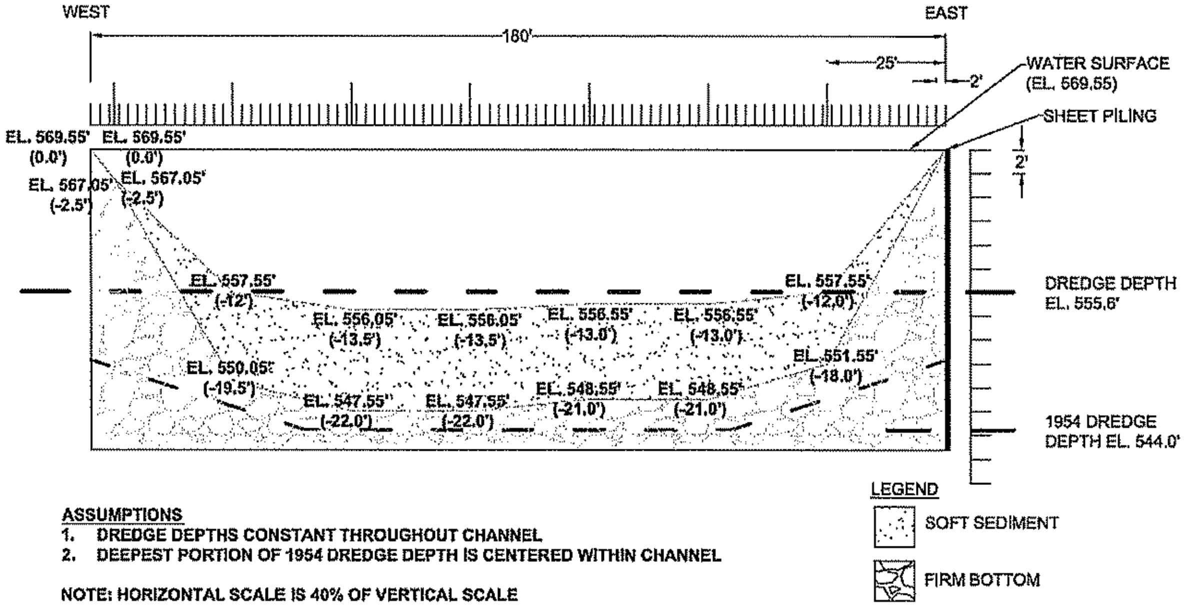
NOTE: HORIZONTAL SCALE IS 40% OF VERTICAL SCALE



ASSUMPTIONS
1. DREDGE DEPTHS CONSTANT THROUGHOUT CHANNEL
2. DEEPEST PORTION OF 1954 DREDGE DEPTH IS CENTERED WITHIN CHANNEL

NOTE: HORIZONTAL SCALE IS 40% OF VERTICAL SCALE

Appendix 1 (Cont'd)
Existing Bottom Condition Profiles



ASSUMPTIONS
1. DREDGE DEPTHS CONSTANT THROUGHOUT CHANNEL
2. DEEPEST PORTION OF 1954 DREDGE DEPTH IS CENTERED WITHIN CHANNEL

NOTE: HORIZONTAL SCALE IS 40% OF VERTICAL SCALE

Appendix 2: Hidrostal Specifications

PART 1 GENERAL

1.01 There shall be supplied as shown by the plans K-409054-GA-0001 wet pit screw centrifugal submersible pumps specifically designed to pump live fish with a survival rate not less than 95%. The Engineer and/or owner may at their discretion, request from the pump manufacturer actual survival rate tests, conducted on different fish species.

1.02 QUALITY ASSURANCE

A. All pumping equipment furnished under this Section shall be of a design and manufacture that has been used in similar applications and it shall be demonstrated to the satisfaction of the Owner that the quality is equal to equipment made by that manufacturer specifically named herein. Manufacturers shall provide evidence of at least five (5) installations with contact names, in which the proposed pumps have provided satisfactory performance for a minimum of five (5) years in a similar application. No consideration will be given to an individually sized pump that hasn't been commercially available for fifteen (15) years.

B. To insure a consistent high standard of quality, the manufacturer of this pumping equipment shall comply with the requirements of the ISO 9001 Quality System, and such compliance shall be verified by an independent certification agency approved by the International Organization for Standardization. Documentation shall be submitted for approval showing compliance with this requirement, and the equipment will not be released for shipment until approved.

C. Unit responsibility. Screw centrifugal pump, complete with submersible motor, fast out and lifting cable or pump base, and all other specified accessories and appurtenances shall be furnished by the pump manufacturer to insure compatibility and integrity of the individual components, and provide the specified warranty for all components.

D. The screw centrifugal pumps specified in this section shall be furnished by and be the product of one manufacturer.

1.03 PERFORMANCE

A. The pumps shall be designed for continuous operation and will be operated continuously under normal service. To minimize operation power costs, the hydraulic efficiency shall be 70% minimum, and must be guaranteed by the manufacturer.

B. OPERATION CRITERIA

	Flow GPM	TDH FT	Max. Pump RPM	Pump Efficiency %	Brake HP Required	Min. Shut-Off TDH	Nominal Motor HP	Max. Motor RPM
Design Condition	4,000	25	500	70	36	50	60	580
Secondary Condition	5,000	30	570	70	54	64	60	580

C. PUMP CRITERIA

1. Minimum suction diameter 16"
2. Minimum discharge diameter 12"
3. Minimum non-compressible solids passage 8.375"

PART 2 PRODUCTS

2.01 A. PUMPS

1. Design

a. The basic design shall be a single-passage, clog-free pump, utilizing a screw-centrifugal impeller. The overall pump design shall combine high efficiency, low required NPSH and a large solid passage.

b. The hydraulic design of the impeller shall combine the action of a positive displacement screw with the action of a single-vane centrifugal impeller to provide a single, non-bifurcated flow stream with only gradual changes in flow direction.

1) The impeller vane shall be designed specifically for the fishing industry, to assure efficient, damage and stress free live fish transportation. The impeller will be enclosed with the proper vane leading edge to maintain the specified fish survival rate.

2) The impeller flange or impeller shall contain a spiral groove on the rear face so that any solids in the pumped media are discharged from the space between the back plate and the rear of the impeller.

c. In order to maintain optimum running clearances along the entire length of the impeller to maintain design hydraulic efficiencies, the geometry of the impeller vane and suction piece shall be conical, so any axial adjustment of the impeller will cause the clearance between the impeller and suction piece to change uniformly along the entire length of the impeller. Designs incorporating curved, or combination curved/conical impeller and suction piece are not acceptable because in such designs clearances cannot be adjusted uniformly over the full length of the impeller.

d. Suction and discharge flanges shall be drilled to meet ANSI 125 lb. bolting.

e. Sealing. All mating surfaces in pump casing and in motor housing shall be machined and fitted with nitrile O-rings for watertight seal.

2. Materials of Construction

a. Cast Iron Construction

1) The pump volute, back plate, and suction piece shall be of closed-grained cast iron, ASTM A 48-CL30.

2) The impeller shall be of stainless steel, ASTM A 743, and shall be both statically and dynamically balanced.

3) The suction piece or impeller shall be externally adjustable to compensate for wear by means of shims or regulating screws so that the necessary running clearances between the liner and impeller can be maintained for optimum hydraulic efficiency.

B. SUBMERSIBLE MOTOR

1. Design

a. Motors shall be non-explosion proof design.

b. The motors shall be of the submersible type, suitable for full-load, continuous operation fully submerged in the pumped liquid of up to 65 foot depths. Motors shall be of the "air-filled" type, to optimize efficiency, with stator and rotor housed in a watertight chamber containing only air. Motors of the "oil-filled" type, with stator and rotor immersed in oil or motors which circulate the pumped media through internal cooling media channels, ports, or jackets are not acceptable.

c. Motor excess heat shall be dissipated directly from the exposed stator housing to surrounding pump liquid for adequate motor cooling at any continuous power output up to and including rated power in ambient of 40°C.

d. Motor stator windings and leads shall be insulated with moisture-resistant Class F insulation for operation at temperatures up to 155 degrees Celsius.

e. Motors shall have the stator varnish applied by the "vacuum-pressure impregnation" method to ensure thorough and complete varnish penetration. The stator shall be heat-shrink fitted into the stator housing.

f. Motor cable-entry sealing assembly shall consist of the following five components to ensure a positive, redundantly watertight seal:

1) The sealing components shall be mechanically isolated from cable strains by a two-piece restraining clamp, which will securely grip the cable above the moisture-sealing components and bear any mechanical forces applied to the cable.

2) The cable moisture seal shall consist of an elastomer grommet, prevented from extruding past the cable by stainless-steel retaining washers on either side. The grommet shall be compressed tightly against the cable outside diameter (and the entry assembly inner diameter) by a screwed follower gland.

3) Each individual conductor shall be interrupted by a solid-copper isolation dam to prevent wicking of moisture through the conductor strands.

4) The cable insulation shall be sealed by an epoxy poured into the cable entry and totally encapsulating the stripped-back insulation and the individual copper dams. This poured epoxy seal shall also function as a redundant seal for the cable outside diameter.

5) The cable free end shall be sealed from moisture-entry during shipping, storage, and prior to connection to the control panel by a plastic sleeve securely clamped over the cable end.

g. Motors which use only a compress-grommet gland, or only a poured epoxy seal, without benefit of redundancy of both types together are not equal or acceptable.

h. Shaft sealing shall be by independently-mounted, tandem mechanical seals contained in an oil chamber that is formed as an intrinsic part of the motor frame and allows the seals to be completely submerged in and lubricated by the oil bath.

1) The mechanical seal nearest the bearing shall utilize carbon/ceramic faces, and shall isolate the seal cooling oil from the motor frame.

2) The mechanical seal nearest the impeller shall be a stainless steel or rubber bellows-type construction firmly attached to the rotating face and clamped to the shaft, to prevent contaminants from contacting the stainless-steel spring which loads the seal face. The seal faces shall be a solid tungsten-carbide rotating face running against a solid silicon-carbide stationary face. Seals with both faces of similar materials, or seals with bonded, soldered, or converted face surfaces are not equal or acceptable.

3) The mechanical seal nearest the impeller shall be contained in a seal chamber formed by the impeller flange and a recess cast into the motor frame. To prevent debris from entering the chamber and to prolong the mechanical seal life, a flush port shall be provided so that an optional external water flush can be supplied directly into the seal chamber.

4) The mechanical seal nearest the impeller shall be isolated from contaminants in the pumped media by a labyrinth-fit between the backside of the impeller and the back plate, as well as by pump-out grooves cast into the impeller back shroud and into the back plate, to minimize debris reaching the shaft seal.

5) Both inner and outer seals shall be dimensionally interchangeable with standard off-the-shelf, inch-size, John Crane mechanical seals, or equal, to allow second-source availability of seals from local distributors for emergency repairs.

i. The thrust bearings shall be designed to take the full axial load of the impeller.

j. Motors shall be submersible, 3 phases, 60 cycles, with HP, RPM, and voltage as follows:
60 HP, 600 RPM, 460 Volts

k. The submersible power and instrumentations cables shall be____ ft. long.

2. Protection Devices. The motor shall be provided with the following protection devices:

a. Two normally closed thermal sensors embedded in the stator windings, wired in series, will open a protective circuit if winding temperature exceeds rated operating temperature. These sensors automatically reset when winding temperature has cooled to a safe operating temperature.

b. A conductivity probe to monitor the moisture content of the oil in the chamber between the outer and the inner mechanical seals. The probe shall be wired to a separate protective circuit, which, when connected to a conductivity-sensitive relay in the control panel, will trip an alarm if moisture content of the oil indicates a failure of the outer mechanical seal. The pump supplier shall supply the necessary monitor for each pump, to be installed in the MCC by the contractor.

C. MOUNTING

Fast Out. The manufacturer shall provide a fast-out fixture which shall be permanently mounted in the wet well as shown by the plans. The fixture shall cantilever the entire pump volute and motor from the volute discharge flange, providing an unobstructed sump floor under the pump; The fixture shall include 90 degree cast-iron piping elbow to connect to vertical piping, and shall provide mounts for two galvanized steel rails of standard schedule 40 pipe (provided by others), which will guide the pump into position. The pump shall be supported by a positive metal-to-metal interlocking flange, which is additionally sealed by a leak proof nitrile rubber ring pressed against the fixture flange by the weight of the pump.

Anchor bolts. The contractor shall supply Stainless steel anchor bolts as recommended by the pump manufacturer.

Pump lifting: The pump manufacturer shall supply the necessary lifting device including shackles, chain, rope and eye grip for use with the customer's crane.

INTERNAL FINISH

The outside impeller shroud and internal passage shall be polished smooth to protect fish from discaling, eye and fins injury, etc.
The casing volute shall be ground smooth form any sharp surfaces and epoxy coated. The suction cover shall also be machined smooth.
The fast out elbow internal passage shall be ground smooth form any sharp surfaces and epoxy coated.

Appendix 3: HDPE Pipe Water Flow Data

48 INCH METRIC SCLAIRPIPE

VELOCITY, VELOCITY HEAD AND HEAD LOSS / 1000 FEET; (HAZEN WILLIAMS FORMULA)

DESIGN STRESS = 800 PSI
COEFFICIENT C = 150 CONSTANT

	DR 32.5 I.D.=44.302			DR 26 I.D.=43.526			DR 21 I.D.=42.616		
FLOWS USGPM	VEL FPS	VEL HD FEET	HD LOSS FT/1000	VEL FPS	VEL HD FEET	HD LOSS FT/1000	VEL FPS	VEL HD FEET	HD LOSS FT/1000
1000	0.2	0.00	0.00	0.2	0.00	0.00	0.2	0.00	0.00
2000	0.4	0.00	0.01	0.4	0.00	0.01	0.5	0.00	0.01
3000	0.6	0.01	0.03	0.6	0.01	0.03	0.7	0.01	0.03
4000	0.8	0.01	0.04	0.9	0.01	0.05	0.9	0.01	0.05
5000	1.0	0.02	0.07	1.1	0.02	0.07	1.1	0.02	0.08
7000	1.5	0.03	0.12	1.5	0.04	0.14	1.6	0.04	0.15
9000	1.9	0.06	0.20	1.9	0.06	0.22	2.0	0.06	0.24
11000	2.3	0.08	0.29	2.4	0.09	0.31	2.5	0.10	0.35
13000	2.7	0.11	0.39	2.8	0.12	0.43	2.9	0.13	0.47
15000	3.1	0.15	0.51	3.2	0.16	0.56	3.4	0.18	0.62
17000	3.5	0.20	0.64	3.7	0.21	0.70	3.8	0.23	0.78
19000	4.0	0.25	0.79	4.1	0.26	0.86	4.3	0.29	0.96
21000	4.4	0.30	0.95	4.5	0.32	1.04	4.7	0.35	1.15
23000	4.8	0.36	1.13	5.0	0.39	1.23	5.2	0.42	1.37
25000	5.2	0.43	1.31	5.4	0.46	1.43	5.6	0.50	1.59
29000	6.1	0.57	1.73	6.3	0.61	1.89	6.5	0.67	2.10
33000	6.9	0.74	2.20	7.1	0.80	2.40	7.5	0.87	2.66
37000	7.7	0.93	2.72	8.0	1.00	2.96	8.4	1.09	3.29
41000	8.6	1.14	3.28	8.9	1.23	3.58	9.3	1.34	3.98
45000	9.4	1.38	3.90	9.7	1.48	4.26	10.2	1.61	4.73
50000	10.4	1.70	4.74	10.8	1.83	5.17	11.3	1.99	5.75
55000	11.5	2.06	5.66	11.9	2.21	6.17	12.4	2.41	6.86
60000	12.5	2.45	6.65	13.0	2.63	7.25	13.6	2.87	8.06
65000	13.6	2.87	7.71	14.1	3.09	8.41	14.7	3.37	9.35
70000	14.6	3.33	8.84	15.1	3.58	9.65	15.8	3.91	10.72
76000	15.9	3.93	10.30	16.4	4.22	11.23	17.2	4.60	12.49
82000	17.1	4.57	11.85	17.7	4.91	12.93	18.5	5.36	14.37
88000	18.4	5.27	13.51	19.0	5.66	14.74	19.9	6.17	16.38
94000	19.6	6.01	15.27	20.3	6.46	16.65	21.2	7.04	18.51

THE HEAD LOSSES CAN BE CORRECTED FOR OTHER C VALUES BY MULTIPLYING THE HEAD LOSS BY THE FOLLOWING CORRECTION FACTORS:

C	CORRECTION FACTOR	C	CORRECTION FACTOR
150	1.00	120	1.51
140	1.14	110	1.77
130	1.30	100	2.12

42 INCH IPS SCLAIRPIPE

VELOCITY, VELOCITY HEAD AND HEAD LOSS / 1000 FEET; (HAZEN WILLIAMS FORMULA)

DESIGN STRESS = 800 PSI
COEFFICIENT C = 150 CONSTANT

	DR 32.5 I.D.=39.261			DR 26 I.D.=38.576			DR 21 I.D.=37.760		
FLOWS USGPM	VEL FPS	VEL HD FEET	HD LOSS FT/1000	VEL FPS	VEL HD FEET	HD LOSS FT/1000	VEL FPS	VEL HD FEET	HD LOSS FT/1000
800	0.2	0.00	0.00	0.2	0.00	0.00	0.2	0.00	0.00
1600	0.4	0.00	0.01	0.4	0.00	0.02	0.5	0.00	0.02
2400	0.6	0.01	0.03	0.7	0.01	0.03	0.7	0.01	0.04
3200	0.8	0.01	0.05	0.9	0.01	0.06	0.9	0.01	0.06
4000	1.1	0.02	0.08	1.1	0.02	0.09	1.1	0.02	0.10
5600	1.5	0.03	0.15	1.5	0.04	0.16	1.6	0.04	0.18
7200	1.9	0.06	0.24	2.0	0.06	0.26	2.1	0.07	0.29
8800	2.3	0.09	0.34	2.4	0.09	0.37	2.5	0.10	0.41
10000	2.7	0.11	0.43	2.8	0.12	0.47	2.9	0.13	0.53
12000	3.2	0.16	0.61	3.3	0.17	0.66	3.4	0.19	0.74
14000	3.7	0.22	0.81	3.9	0.23	0.88	4.0	0.25	0.98
16000	4.2	0.28	1.03	4.4	0.30	1.13	4.6	0.33	1.25
18000	4.8	0.36	1.29	5.0	0.38	1.40	5.2	0.42	1.56
20000	5.3	0.44	1.56	5.5	0.47	1.71	5.7	0.52	1.90
22000	5.8	0.53	1.87	6.1	0.57	2.03	6.3	0.62	2.26
25000	6.6	0.69	2.36	6.9	0.74	2.58	7.2	0.81	2.87
28000	7.4	0.86	2.92	7.7	0.93	3.18	8.0	1.01	3.53
31000	8.2	1.06	3.52	8.5	1.14	3.84	8.9	1.24	4.27
34000	9.0	1.27	4.18	9.4	1.37	4.56	9.8	1.49	5.06
37000	9.8	1.51	4.88	10.2	1.62	5.33	10.6	1.77	5.92
41000	10.9	1.85	5.91	11.3	1.99	6.44	11.8	2.17	7.16
45000	11.9	2.23	7.02	12.4	2.40	7.66	12.9	2.61	8.51
49000	13.0	2.65	8.22	13.5	2.84	8.96	14.1	3.10	9.96
53000	14.1	3.10	9.50	14.6	3.32	10.37	15.2	3.63	11.52
57000	15.1	3.58	10.87	15.7	3.85	11.86	16.4	4.19	13.18
62000	16.5	4.24	12.71	17.1	4.55	13.86	17.8	4.96	15.41
67000	17.8	4.95	14.67	18.4	5.31	16.00	19.3	5.79	17.79
72000	19.1	5.71	16.76	19.8	6.14	18.28	20.7	6.69	20.32
77000	20.4	6.53	18.98	21.2	7.02	20.70	22.1	7.65	23.01

THE HEAD LOSSES CAN BE CORRECTED FOR OTHER C VALUES BY MULTIPLYING THE HEAD LOSS BY THE FOLLOWING CORRECTION FACTORS:

C	CORRECTION FACTOR	C	CORRECTION FACTOR
150	1.00	120	1.51
140	1.14	110	1.77
130	1.30	100	2.12

Appendix 4: Buried Pipe Installation

BURIED PIPE INSTALLATION

Introduction

In any below grade piping application, the quality of the installation is one of the key factors in the long-term performance of piping materials. In many applications SCLAIRPIPE offers several unique qualities that can aid in safer and faster installation. These qualities are enhanced by proper design considerations and installation procedures.

This section offers a guide to good underground installation of SCLAIRPIPE and should serve to supplement the specifying engineer's knowledge of local conditions. Other guides to below grade piping installations are contained in publications such as ASCE/WPCF Manuals of Practice and ASTM Standard D2321 - "Standard Recommended Practice for Underground Installation of Flexible Thermoplastic Sewer Pipe."

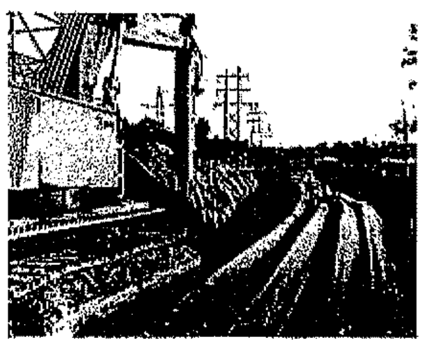
Excavation of Trench

The trench should be dug to the required alignment and depth shown on the contract drawings, or as directed by the supervising engineer, and only so far in advance of pipe laying as he permits. The recommended trench opening for the installation of continuous lengths of pipe assembled above the trench is shown in Table 6. Where space or ground conditions do not permit the minimum specified trench openings, joining and laying may be conducted in the trench, using the joining machine or flange connections. In special cases where trench sidewalls are sloped, shorter trenches may be used.

The flexibility and light weight of SCLAIRPIPE, together with its ability to be thermally fused into long lengths above ground, permit the use of installation techniques which are different from those used for rigid piping materials.

Joining the pipe above ground allows the use of narrower trench widths where ground conditions permit. Slot trenches excavated by rotary trenchers, back-hoes or bucket shovels are ideal.

FIGURE 9 - Trench Excavation



At fittings, service connections and similar work locations where it is necessary to descend into the trench, the trench should be braced and drained so that the construction crew can work safely and efficiently as required by local safety codes and regulations.

TABLE 6

TRENCH OPENING FOR THE INSTALLATION OF JOINED LENGTHS OF POLYETHYLENE PIPE

Nominal Pipe Size (inches)	Depth of Trench (feet)						
	3	5	7	9	11	13	15
1/2 - 3	8	10	11	11	12	12	12
4 - 8	13	16	19	21	23	24	25
10 - 14	17	21	25	28	30	32	34
16 - 22	21	27	31	35	39	42	44
24 - 40	28	36	43	48	53	57	61
42 - 63	36	46	54	61	67	73	78

NOTE: The values in this table are based on installation conditions at 73°F. They are given as a guide only, and are calculated using the largest pipe in each group.

Trench Widths

Since flexible pipe has to support, at most, only the weight of the "prism" or vertical column of soil directly over the pipe, the precaution of keeping the trench as narrow as possible is not the concern that it is for a rigid pipe which can be subjected to the weight of the soil beside the prism as well as the prism itself. With PE pipe, widening the trench will generally not cause a loading greater than the prism load on the pipe. Trench width in firm, stable ground is determined by the practical consideration of allowing sufficient room for the proper preparation of the trench bottom and placement and compaction of the pipe embedment materials, and the economic consideration of the costs of excavation and of imported embedment materials.

Trench width in firm, stable ground will generally be determined by the pipe size and compacting equipment used. The following table gives minimum trench width values. The trench width may need to be increased over the values in Table 3 to allow for sufficient clearance between the trench sidewalls and the pipe for compaction equipment. Typically for large diameter pipe (18" and larger), this required clearance will vary from 12 to 18 inches. If two or more pipe are laid in the same trench, sufficient space must be provided between the pipes so that embedment material can be compacted. When the pipe is installed by trenching or ploughing, the trench width may be less than that given in Table 7 since the trenching machine or plough typically shapes the trench bottom to provide appropriate haunching for the pipe.

TABLE 7 - **Minimum Trench Width in Stable Ground**

Nominal Pipe Size (in.)	Minimum Trench Width (in.)
3 to 16	Pipe O.D. + 12
18 to 42	Pipe O.D. + 18
48 and larger	Pipe O.D. + 24

Ground conditions may not permit sharp trench profiles in sandy, silty areas. The trench walls may be sloped at an angle of 45 degrees or the angle of repose of the material. When wide trenches are necessary, the initial bedding material should be compacted in order to withstand the final earth burial load.

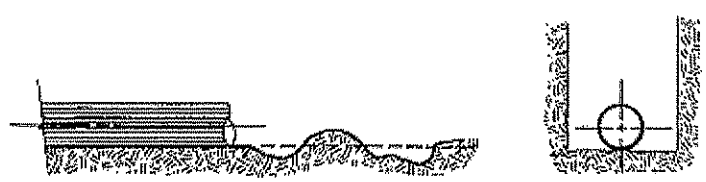
Preparation of Trench Bottom

For pressure systems such as watermains, sewage forcemains, or long distance transmission lines, the accurate levelling of trench bottoms is not essential unless specified in the drawing. For pressureless systems such as gravity drainage systems, the slope should be graded as evenly as it would be for other piping materials.

Flat Trench Bottom

Bedding is not necessary if the bottom of the trench is reasonably smooth and straight and the soil is essentially free of rock. An undisturbed bottom meeting these requirements is ideal. When trench bottoms must be disturbed, they should be compacted to a density at least equal to the density of the surrounding bedding material. Large rocks, stones and boulders should be removed to provide a minimum of 6 inches of clear bedding material on each side of and below all pipe and accessories. Excavations below subgrade should be filled and levelled with suitable material approved by the supervising engineer. Generally smooth stones no larger than two inches in any dimension are acceptable if mixed with sandy soil or clay. All sizes of SCLAIRPIPE will accomodate themselves to trench bottoms that are somewhat uneven. Sharp-edged rocks or hard shale, however, can create overstressed areas in the pipe wall which can damage the pipe when it is backfilled. (see figure 10)

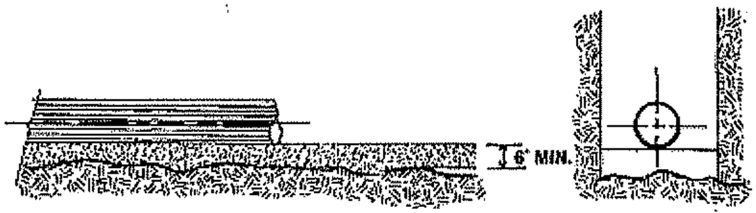
FIGURE 10 - **Flat Trench Bottom**



Excavation in Shale and Loose Rocky Soil

To avoid "point contacts" with loose rock, and to provide a uniform bed for the polyethylene pipe to rest on, the trench should be excavated at least six inches deeper than grade. The trench bottom should then be filled to grade with selected fill approved by the supervising engineer, tamped to 90 per cent Standard Proctor Density or greater. (see figure 11)

FIGURE 11 - Improved Trench Bottom



Excavation in Solid Rock

Bedding should be prepared in the same manner as for "Excavation in Shale and Loose Rocky Soil". In cases where the excavated trench slopes sharply and ground water flows through it, the trench bottom should be filled with coarse crushed stone (1 inch minus) and compacted to 90 per cent Standard Proctor Density or greater in order to help prevent the washing out of the bedding and the subsequent settlement of the pipeline.

Soils Requiring Special Treatment

Unstable soils, such as wet clay and sandy soils with poor bearing strength, should be excavated 4 to 6 inches deeper than specified for the pipe invert. The trench bottom should be refilled with selected imported or excavated material (gravel, crushed stone, etc.) to provide uniform support for the polyethylene pipe, as already discussed in this section. In unstable organic soils, where the ground water table can cover the pipe at its installed elevation, extra weight may be added to impart negative buoyancy to the pipe, if specified by the supervising engineer. The weights should be designed to not exceed the bearing strength of the foundation material.

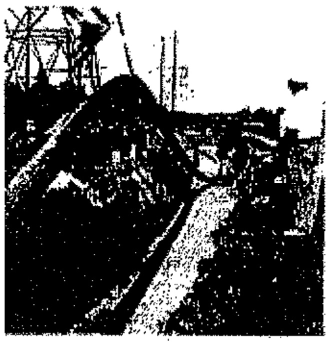
Placing the Pipe in the Trench

Pipe and accessories should be inspected for defects prior to their lowering into the trench. Under no circumstances should they be dropped, dumped or rolled into the trench. All foreign matter or dirt must be removed from the interior and ends of the pipe and accessories before they are lowered into the position in the trench. Pipe should be kept clean by means approved by the supervising engineer before, during and after laying.

Pipe is usually joined above ground and laid out above the right-of-way before or during excavation. It may be placed in the trench as the digging progresses, thereby keeping a minimum amount of trench open behind the digger. In special circumstances, the pipe may be prejoined into lengths of approximately 500 feet, stored in an assembly area, and then pulled to the installation site. There they can be either thermally fused or mechanically connected together.

V

FIGURE 12 - **Placing Pipe in the Trench**



Pipe sizes up to 6 in. nominal diameter may be moved manually into the trench. All larger pipe, fittings, valves, hydrants and accessories should be lowered carefully using suitable mobile equipment in a manner that will prevent damage to pipe and fittings. Typical equipment used to place pipe into the trench would include back-hoes, cranes and telescoping lifting equipment. For lifting long lengths of joined pipe, band or nylon rope slings are mandatory to minimize damage to the pipe. It is recommended that slings be used when handling pipe of any length.

Assembly of Final Pipe Connections

Fused Joints

Pipe to be joined in the trench by thermal fusion should be joined in the same manner as for pipe joined outside the trench. Consult the "Joining Procedure" section for a more detailed description of this process. Lengths of pipe should be allowed to cool to the ambient soil temperature before any joining is performed.

Flanged Joints

Connections to metal fittings, valves, tanks, pumps, or other pipe materials are generally made by flange assemblies. They may also be used to connect lengths of polyethylene pipe, where fusion is impractical.

Where necessary to eliminate galvanic corrosion, insulating sleeves can be used to separate the bolt from the metal slip-on flange. Alternatively, 8-mil polyethylene film "tubing" may be pulled over the flange assembly and tightly taped to the pipe on each side with plastic tape. The length(s) of pipe to be connected should be made longer and allowed to cool to ambient soil temperature before making up the joint. The faces to be joined must be properly aligned and, if possible, installed so that one face is in compression against the other. **Under no circumstances** should the bolts be used **to pull up the mating faces** to overcome an evident gap or misalignment. These bolted joints should be left exposed for a minimum of 8 hours and then retightened prior to pressure testing.

Installation of Fittings and Valves

All fittings should be carefully inspected and cleaned before being carefully lowered into the trench. Well compacted (90 per cent Standard Proctor Density or greater) crushed stone or gravel should be applied in 6 in. layers (extending to the trench walls) at all elbows, tees, wyes and other fittings so that the fittings are encased in stable backfill. The compacted material should extend a minimum distance of three pipe diameters beyond the ends of the fitting unless the same compaction has been specified by the supervising engineer for the remainder of the pipeline.

All geared valves, and any other valves designated, should be set in masonry valve pits, unless otherwise specified by the supervising engineer. The wrench nuts should be readily accessable for operation through the manhole opening. Pits should be constructed in a manner that will permit minor valve repairs and afford protection for the pipe against impact or settlement where the pipe passes through the pit walls. Cast-iron valve boxes should be firmly supported prior to backfilling and compacted to the finished grade to prevent tilting or tipping.

Joints at Fittings and Structures

Relative movement between polyethylene pipe, fittings and other rigid structures should be prevented at flanged joints. This may be done by either: ensuring that the soil bearing the pipe will provide equal, long-term support for the pipe and the fitting; or by supporting the fitting and the length of pipe (support equal to at least five times the length of the fitting) by means of continuous longitudinal timber(s) or a concrete cradle centered under the fitting.

Where polyethylene pipe is connected to flanged pipe or fittings **fixed in a rigid structure**, such as a valve pit or manhole, a reinforced concrete pad should be poured under the pipe and the flange, and the pad connected to the structure by means of a reinforcing rod. This support should extend from the flanged joint: a minimum of one pipe diameter for pipe larger than 12 in. nominal; or a minimum of one ft. for smaller pipe. In such cases, assemblies similar to those shown in figures 13(a) and 13(b) have proven to be effective in preventing damage to the connections. Alternatively, in stable, well compacted soils where settlement is unlikely, a retaining device can be clamped to the pipe embedded in the wall. Where SCLAIRPIPE extends through a wall, as in a manhole for example, anchor assemblies similar to figure 13(c) should be used to avoid movement of the pipe through the wall.

FIGURE 13 - **Buried Connections to Rigid Structures**

13 a)

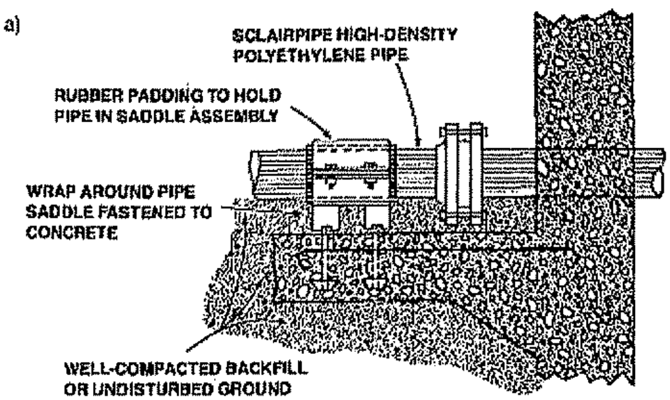
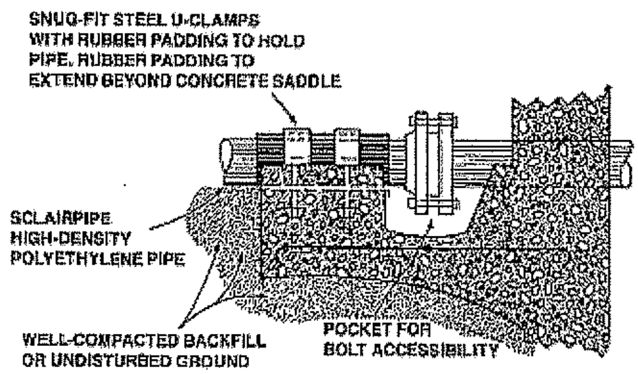
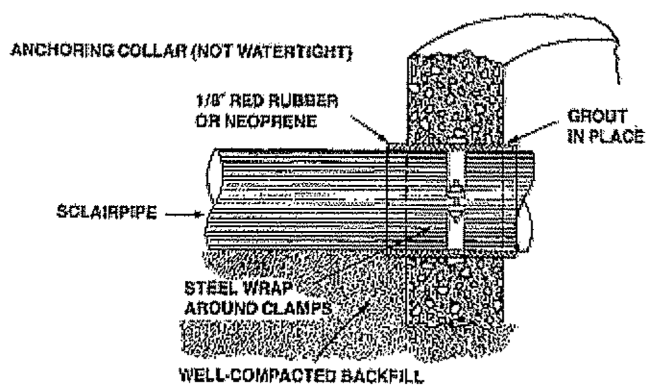


FIGURE 13 - **Buried Connections to Rigid Structures** (cont'd)

13 b)



13 c)

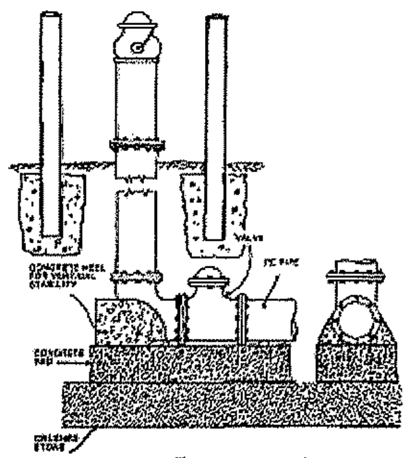


NOTE: For methods of watertight entry to a manhole see figure 24 (Pg. 34)

Setting of Hydrants

Hydrants should be inspected, lowered into the trench and joined to SCLAIRPIPE as specified in the preceding sections. Bearing pads should be provided as detailed in figure 14. Where required the barrel drain should be clear for adequate drainage. Hydrants should be positioned to provide complete accessibility while minimizing the possibility of damage from vehicles or injury to pedestrians. All hydrants should be independently supported prior to backfilling to ensure that excessive torquing or bending stressses are not placed on the flange connections and that the hydrants continue to stand plumb. Each hydrant should be connected to the main and controlled by an independent gate valve unless otherwise specified by the supervising engineer.

FIGURE 14 - **Hydrant Connection**



Pressure Testing of SCLAIRPIPE

Pressure testing with air is **not** recommended for SCLAIRPIPE high density polyethylene pipe under any circumstances. Water is the recommended pressure medium for the pressure testing of SCLAIRPIPE piping systems. Testing can be done before or after the pipe is in the trench. If the pipe must be backfilled before it is tested, the mechanical joints should be left open for visual inspection during testing.

Basic Procedure for Pressure Testing

When pressurized, SCLAIRPIPE exhibits a relatively rapid rate of initial deformation (i.e. noticeable radial expansion), followed by a slower, more constant rate of deformation with time. As the pipe expands, the pressure decreases and more water must be pumped into the system to maintain the pressure. If a leak exists in the system, the amount of water required to maintain the pressure will be considerably more than this pre-determined amount of make-up water. The pressure test involves pressurizing the pipe and adding make-up water until the pipe has reached its initial deformation. This level of deformation is usually attained after 3 to 4 hours depending on the size of the pipe. It is characterized by a noticeable reduction in the amount of make-up water required to return the piping system to the test pressure. It is at this time that the actual test period begins. Its duration can be 1 to 3 hours. At the end of the test period, a measured amount of make-up water should be added to return the pipe to the test pressure. The amount of make-up water should not exceed the allowance given in Table 8.

The amount of expansion taking place during the pressure testing of SCLAIRPIPE is also dependent on the temperature of the pipe during testing. The temperature of the pipe can be taken as an average of the temperature of the water pumped into the pipe and the temperature of the empty pipe immediately before testing (ambient air temperature). When testing the pipe at temperatures below 73.4°F, the amount of make-up water shown in Table 8 should be multiplied by the appropriate correction factor taken from figure 15.

FIGURE 15 - **Correction Factor for Pressure Testing**

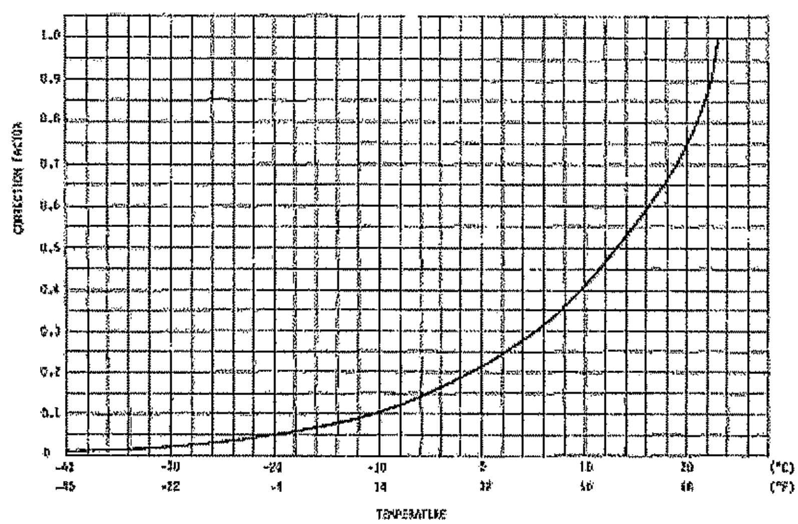


TABLE 8

ALLOWANCE FOR EXPANSION UNDER TEST PRESSURE*

Allowance for Expansion [U.S. gal per 100 ft. of pipe] at 73.4°F

Nominal Pipe Size (in.)	1 hour Test	2 hour Test	3 hour Test
3	0.10	0.15	0.25
4	0.13	0.25	0.4
6	0.3	0.6	0.9
8	0.5	1.0	1.5
10	0.7	1.3	2.1
11	1.0	2.0	3.0
12	1.1	2.3	3.4
14	1.4	2.7	4.2
16	2.7	3.3	5.0
18	2.2	4.3	6.5
20	2.7	5.5	8.0
22	3.5	7.0	10.5
24	4.5	8.9	13.3
28	5.5	11.1	16.7
32	7.0	14.3	22.5
36	9.0	18.0	27.0
40	11.0	22.0	33.0
42	12.5	25.0	37.5
48	16.0	32.0	48.0
54	20.5	41.5	62.0
63	28.0	60.0	86.0

*Those allowances refer to the actual Test Period.

Testing Outside the Trench

If agreed to by the supervising engineer; pressure testing with water can be conducted after joining is complete, before laying the pipe into the trench. The pipe should be subjected to a maximum hydrostatic test pressure of 1.5 times the rated pressure of the pipe (1.5 x the Standard Pressure Rating as obtained from Table 9) for a maximum period of 3 hours. The pipe can be maintained at the "Test Pressure" by the periodic addition of make-up water.

As the lines pressure-tightness is determined by visual examination, it is not necessary to calibrate the make-up water for the initial stretching of the pipe. The fused joints should be examined for leakage and any joints showing leakage must be removed from the pipeline. The pipe should then be rejoined, and the system retested.

NOTE: It is the responsibility of the Contractor to ensure that normal safety precautions are observed for above ground hydrostatic pressure tests.

TABLE 9

STANDARD PRESSURE RATING

Hydrostatic Design Basis	Standard Pressure Rating (DR) [psig @ 73.4°F]									
	32.5	26	21	17	15.5	13.5	11	9	7.3	6.3
800 psi	50	64	80	100	110	128	160	200	250	300

Pressure testing in the Trench

After the pipeline has been laid it can be filled with water and subjected to a hydrostatic pressure test. The "Test Pressure" should be 50 per cent greater than the rated pressure of the pipe **at the lowest elevation of the system** for a particular pressure rating of pipe. When in the opinion of the supervising engineer, local conditions require that the trenches be backfilled immediately after the pipe has been laid, the pressure test may commence: after the backfilling has been completed and at least 7 days after the last concrete bearing pad has been cast.

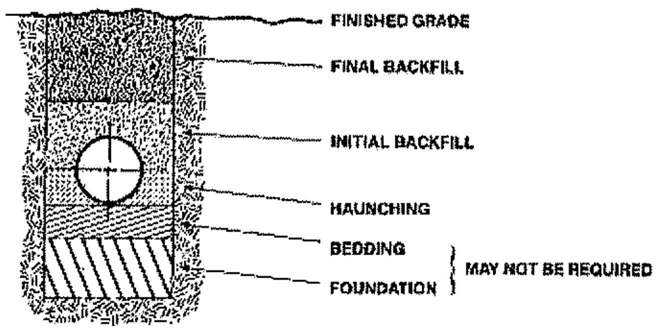
The test procedure consists of two steps: the initial expansion phase and the test period. In order to accomodate the initial expansion of the pipe under test, sufficient make-up water is added to the system at hourly intervals, returning the piping system to the Test Pressure. This repressurization is repeated 3 times after the original pressurization of the pipe. After the completion of the initial expansion phase, (eg. 3 hours after initially pressurizing the piping system under test) the actual test period will begin. The Test Period **must not exceed 3 hours.** After this Test Period, a measured amount of make-up water should be added to return the piping system to the Test Pressure. The amount of make-up water **should not** exceed the allowance given in Table 8.

NOTE: Under no circumstances should the total time under test exceed eight (8) hours at 1.5 times the pressure rating. If the test is not completed due to leakage, equipment failure or any other reason within this time period, the test section should be permitted to "relax" for an additional eight hour period prior to starting the next testing sequence.

Backfilling and Tamping

The backfilling should be carried out according to one of the following methods: with reference to one of the following sub-sections; as required by the drawings; or as otherwise specified by the supervising engineer. The terms referred to throughout this section are those shown in Figure 16.

FIGURE 16 - **Backfilling and Tamping**



Unless otherwise specified by the supervising engineer, the "Haunching" and "Initial Backfill" should be completed prior to the leakage test, with the remainder of the backfill completed after the completion of a satisfactory test. In all cases the Haunching and Intial Backfill material must be placed and compacted to provide support as specified by the supervising engineer.

The particular material used for backfilling will vary according to local conditions, the type of application and the specific requirements of the supervising engineer. In general, three types of backfill material have been found acceptable for the installation of SCLAIRPIPE. Full details on these bedding materials can be found in these basic reference works : (1) WPCF - "Manual of Practice" #FD-5; (2) "Standard Handbook of Plant Engineering", McGraw-Hill Inc.; (3) ASTM D2321, "Underground Installation of Flexible Thermoplastic Sewer Pipe"; (4) PPI No.TR31, "Underground Installation of Polyolefin Pipe".

The following includes a number of process materials and soil classifications listed under the "Unified Soil Classification System."

CLASS I - Angular 1/4 in. to 1-1/2 in. graded stone, including a mumber of materials that may be available locally such as coral,crushed slag, crushed stone and crushed shells.

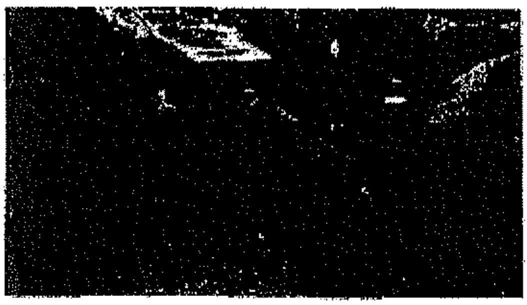
CLASS II - Coarse sands and gravels having a 1-1/2 in. maximum particle size, including variously graded sands and gravels containing small percentages of fines, generally granular and non-cohesive, either wet or dry. Soil types GW, GP, SW and SP are included in this class.

CLASS III - Fine sands and clay gravels, including fine sands; sand-clay and gravel-clay mixtures. Soil types GM, GC, SM and SC are included in this class.

Haunching and Initial Backfill

The requirements for Haunching and Initial Backfill using Class I, Class II and Class III materials are given in ASTM D2321. The specific compaction requirements may vary from job to job but, in general, Haunching and Initial Backfill should be compacted to 90 percent Standard Proctor Density as determined by the "American Association of State Highway Officials Method: T99". In certain non-critical applications, a lower level of compaction can be specified by the supervising engineer. Compaction should be carried out in 6 in. layers until the top of the pipe is reached. Compaction directly over the pipe should be avoided with less than one foot of cover on top of the pipe.

FIGURE 17 - **Haunching Small Diameter Pipe**



Final Backfill

Final backfill to finished grade may be excavated material or other soil. This material must be unfrozen, free from voids, lumps of clay, stones and boulders over 8 in. in their longest diameter. In all cases the supervising engineer should judge the suitability of the material for use as backfill. Under certain conditions, the type of final backfill material may be important to the design of the piping system and methods for applying the Initial Backfill should apply.

Final Backfill Under Roads

Trenches in the right of way of a road should be backfilled to finished grade with an approved grannular material to a compaction of 90 percent Standard Proctor, or to a compaction density specified by the supervising engineer.

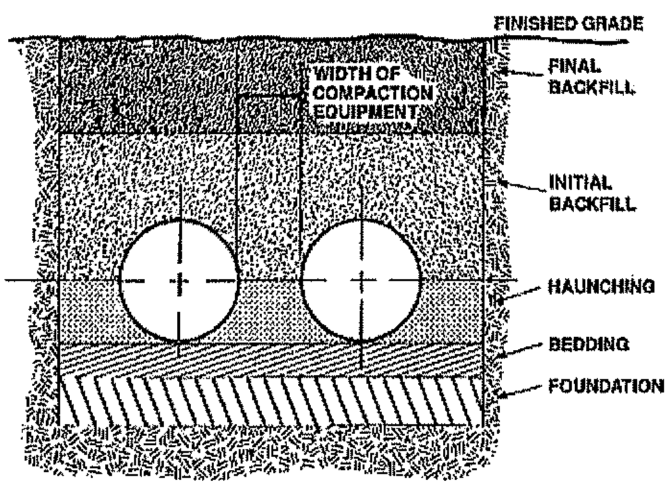
NOTE: Where the pipe crosses a road or right of way, the supervising engineer should consider the use of a culvert or casing for easier accessability to the pipeline (e.g. removing the pipe from the culvert to change pipe size).

FIGURE 18 - Multiple Pipes In a Trench

Two or More Pipes In a Common Trench

In the case of multiple pipes in the same trench, the requirements previously outlined apply in all cases. Care must be taken in the spacing of pipes to allow for full and adequate compaction of the Haunching and Initial backfill, around each pipe, using conventional compaction equipment, as shown in Figure 19. The supervising engineer should examine each particular application to decide whether an embankment condition applies when designing a support for the soil around the pipe.

FIGURE 19 - Two or More Pipes In a Common Trench



SURFACE INSTALLATION

Introduction

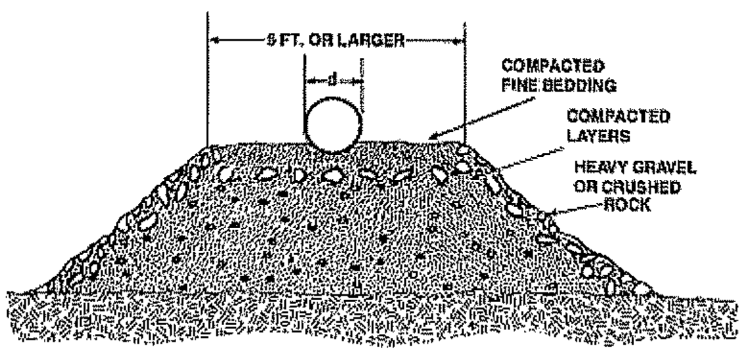
Although for practical and traditional reasons most pipelines are installed below ground, sometimes for a number of reasons, an above ground installation could be a better choice. An above ground installation may be necessary because of environmental or other factors (e.g. an abrasive slurry line requiring periodic rotation; areas of difficult installation in unstable ground as in bogs or permafrost; or areas where excavation is impractical as in areas of solid rock.) Surface installations also permit easy access to the pipeline in the event of line blockage and can simplify line relocation (e.g. relocation of tailings, dredging and temporary water supply lines).

Surface Preparation

The proposed pipeline route should be carefully surveyed to ensure that proper grading can be achieved and that the pipe will not be bent to greater extent than its minimum bending radius, either horizontally or vertically.

The pipe bed should not be located directly adjacent to a roadway where it could be damaged by passing traffic or snowplows. The pipe bed should be constructed in a manner similar to that used in constructing an unpaved secondary road. The bed should be formed in layers, each compacted to 90 percent Standard Proctor Density, to support the weight of the pipe and limited traffic along the top of the bed. The sides of the bed should be covered with "rip-rap" or a minimum of 2 in. gravel or crushed rock to prevent erosion. (see Figure 20)

FIGURE 20 - **Typical Pile Bed**



If the pipe bed runs close to a watercourse, it should be protected with large "rip-rap" or sand/cement bags. Where it crosses a watercourse, the bed should be perforated with culverts of suitable dimensions, with the entrances protected against erosion.

The dimensions and slope of the bed depend on local conditions. In most situations, an adequate top width should be allowed for both stability and access to the pipeline and to accomodate its thermal expansion or contraction. The surface of the bed should be compacted smoothly so that the pipeline is continuously supported. Sharp rocks must be removed to avoid point loading on the pipe should pipe movement occur.

FIGURE 21 - **Typical Surface Installation**

Minimum Permanent Bending Radius

SCLAIRPIPE because of its flexibility, can be field bent during installation, often eliminating the need for bends of 45 degrees or less. Sweeping directional changes larger than 45 degrees can also be made but minimum bending radii must be observed.

Table 10 gives multipliers for calculating the minimum permanent bending radii for SCLAIRPIPE in both pressure and non-pressure service. The minimum permanent bending radius (in inches) is equal to the nominal pipe diameter (in inches) times the appropriate multiplier.

TABLE 10

MULTIPLIERS FOR MINIMUM BENDING RADII

Application	Multiplier
Pressure Pipe	50
Non-Pressure Pipe	35

Where space will not permit the use of the minimum bending radius, standard fabricated polyethylene fittings should be used.

Connections to Fittings and Structures

As in connections made in buried installations, relative movement between the polyethylene pipe, fittings and other rigid structures should be prevented at flanged joints. Please refer to the following sections in the BURIED INSTALLATION chapter of this document for more specific information on assembly and connections to rigid structures for surface installations: "Assembly of Final Pipe Connections"; "Installation of Fittings and Valves"; "Joints at Fittings and Structures".

There are some special considerations, however, for surface piping systems. When fittings are installed on the surface, you must prevent potential movement by ensuring that the haunching is firmly compacted beneath the pipe and fittings. Where bearing strength of the soil is inadequate to support heavy fittings, valves or clusters of fittings, concrete bearing pads, large enough in area to provide a stable support, should be used.

Where polyethylene pipe is to be connected to flanged pipe or to fittings fixed in a rigid structure, a reinforced-concrete pad should be poured under the pipe and the flange and the pad should be connected to the structure by means of a reinforcing rod. This connection is quite similar to the ones discussed in the BURIED INSTALLATION chapter. For details on the differences in connections between buried and surface installations compare Figure 13 (Buried) with Figure 22 (Surface). Alternatively, in stable well-compacted soils where settlement is unlikely, a retaining device should be welded to the pipe embedded in the wall. Figure 23 describes some of the several methods that have been used to provide a watertight entry at a manhole.

FIGURE 22 - **Surface Connections to Rigid Structures**

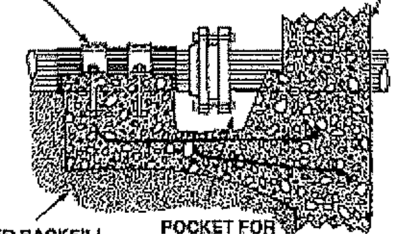
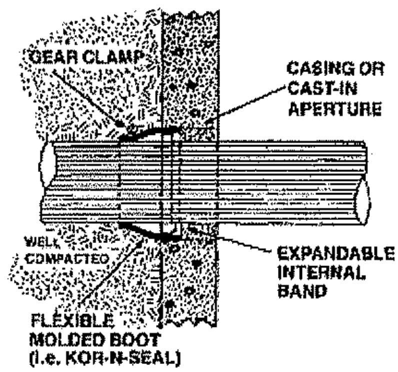
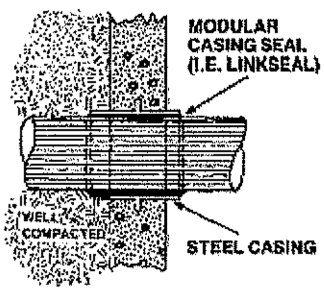


FIGURE 23 - Methods of Watertight Entry at a Manhole

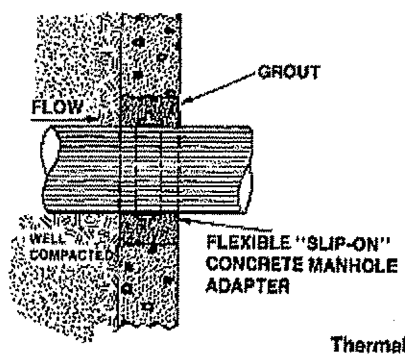
23 a)



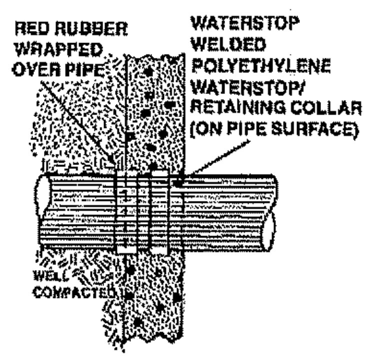
23 b)



23 c)



23 d)



Thermal Effects

SCLAIRPIPE high density poyethylene pipe has a relatively high coefficient of linear expansion when compared to steel pipe. Taken by itself, this factor might cause concern about longitudinal stresses in the piping system. However, there are other factors offsetting the expansion factor. One factor is that SCLAIRPIPE has a relatively low modulus of elasticity. Another factor is that stress relaxation occurs in most typical installations, rapidly at first, and then more gradually.

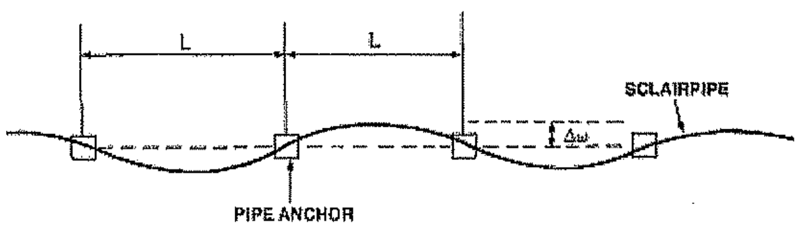
As a result, although thermal expansion should be a consideration in the design and construction of a SCLAIRPIPE piping system, generally, no special procedures are required. Day-to-day variations in ambient air temperatures will cause unrestrained SCLAIRPIPE to contract or expand. During installation, when the pipe is empty, this effect is more pronounced and must be taken into account when joining pre-determined lengths of pipe. During normal operation, movement of the pipe is generally much lower because of the relatively constant temperature of the fluid in the pipeline.

The coefficient of thermal expansion for SCLAIRPIPE high density polyethylene pipe is approximately 0.1 in./100 ft. per degree F. Accordingly, 100 ft. of unrestrained SCLAIRPIPE can shrink or expand longitudinally about 1.0 in. for every 10°F change in temperature. Because SCLAIRPIPE exhibits a lower modulus of elasticity (apparent modulus) as compared to rigid or conventional pipe, the stresses induced in the pipe when restrained, and the force transferred to the restraining device are relatively low. As a result, the pipeline is normally allowed to move laterally as temperatures change. The pipe is restrained only in areas where pipe movement is likely to cause damage to pipe itself, to attached or surrounding structures, or make access to the right of way difficult.

Lateral Movement

The pipe, when laid on a prepared bed, may be allowed to move laterally. Normally the pipe should be anchored at intervals along its length allowing the pipe to deflect laterally between the anchors. (see Figure 24) This method is the simplest where adequate space on the bed is available to accomodate this deflection. On normal straight runs, the spacing of the anchors depends on the allowable lateral displacement and the degree of curvature of the pipeline. The lateral displacement depends on the expected temperature change. If the pipeline is installed in mid-summer, the displacement will be the largest; as the temperature drops, the displacement will decrease as the pipe contracts.

FIGURE 24 - **Lateral Deflection Due to Thermal Movement**



Where the pipe diameter is small in relation to the length between anchors, the amount of lateral deflection can be calculated as follows:

$$\Delta w = B \times L \sqrt{\Delta T}$$

Where - Δw = lateral deflection of the pipe (ft.)
L = length of pipe between anchors (ft.)
ΔT = temperature variation (°F)
B = coefficient for consistency in units
[B = 0.0067 (for ft. and °F)]

TABLE 11

LATERAL DEFLECTION OF ANCHORED PIPE

Temperature Change	Anchor Spacing			
(°F)	25	50	75	(Feet)
20	0.75	1.50	2.20	
40	1.10	2.10	3.20	
60	1.30	2.60	3.90	
80	1.50	3.00	4.50	

NOTE: These deflections are theoretical maximums; actual deflections will generally be less due to the pipe's stiffness and the friction between the pipe and the ground.

This relationship can be used to calculate both expansion and contraction. If the pipe is installed at the warmest time of year, it can be deflected during installation in such a way that when the temperature drops the deflection will decrease. The equation can also be used to calculate, for various anchor spacings, the amount of deflection that will occur as the pipeline expands at warmer temperatures.

It is not necessary to provide for a single bend between anchors. The deflection may be achieved by "snaking" the pipe so that the sum of the individual defections is equivalent to the Δw, above. However, care should be taken not to exceed the minimum bending radius. Anchors should be used on sharp bends to prevent all pipe movement from concentrating in this area. Similarly, anchors should be used to prevent the pipe from moving up against an existing structure or rock outcrop, or from moving itself off the pipe bed or trestle.

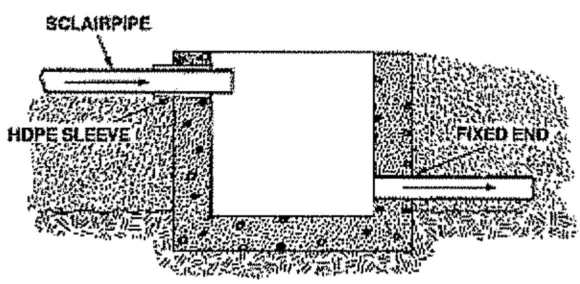
Longitudinal Movement

When lateral deflection is unacceptable, thermally induced movement may be accomodated by several types of sliding joints. Because of friction the actual amount of movement will be less than that calculated using the coefficient of thermal expansion and contraction. However, the coefficient calculation will provide expansion length that can be used for the design of the sliding joint.

When the length of the pipe is long in relation to the pipe diameter (in excess of 100 : 1), it may be necessary to restrain the pipeline laterally to ensure that the thermal movement is taken up by the sliding joint and not by snaking. This can be accomplished by installing guide posts or hoops at approximately 10 ft. intervals for pipe sizes up to 12 in. diameter, or at 20 ft. intervals for all larger sizes. Alternatively, the pipe can be placed in a wooden trough to reduce friction.

Gravity sliding joints can be fabricated on-site. For example, it may be feasible to accomodate thermal movement by allowing the pipe to slide in one side of a drop box or manhole as shown in figure 25.

FIGURE 25 - **Sliding Connection at a Manhole**



Restrained Pipelines

The forces developed in SCLAIRPIPE high density poyethylene pipe due to changes in temperatures are very low when compared to metal pipe. It is often feasible to restrain or partially restrain the pipe in locations where it will be subject to temperature changes. The method used to restrain the pipeline will vary according to the temperature change expected, the steepness of the pipeline grades and the soil upon which the pipeline is laid. Design of the pipe restraints and calculation of the allowable loads imposed on them should be left to the engineer designing the piping system. For additional information or technical assistance on piping system design, please contact your KWH Pipe representative.

Probably the most common and most cost-effective method of anchoring or restaining the pipeline is a strategically placed pile of soil, or a continuous berm. A berm also offers other advantages: it will reduce the temperature variations in the pipeline; minimizes the occurence of freeze-up even in cases where the frost penetration in the berm reaches the level of the pipeline; and also provides protection against damage.

The height and dimensions of the berm or embankment will vary with the purpose given to it and the nature of the material used to construct it. It is always recommended that the pipe be placed on a well compacted bottom layer. Also, the material supporting the pipe laterally should be compacted in a manner similar to that for a buried installation. (see Figure 26)

FIGURE 26 - **Typical Berm or Embankment**

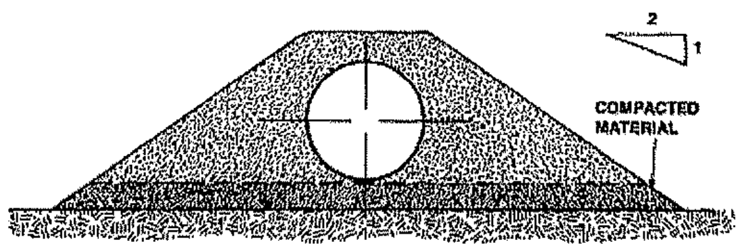
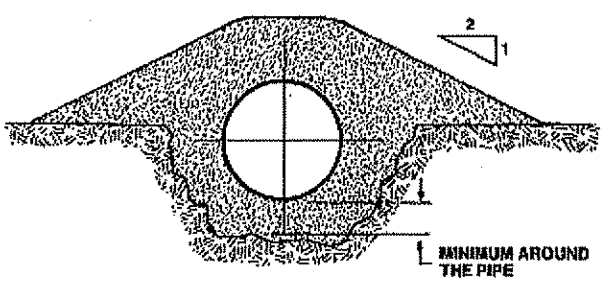
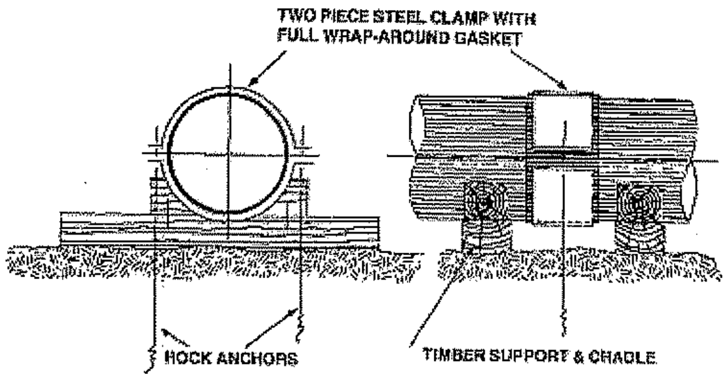


FIGURE 27 - **Typical Berm for Semi-Buried Installation**



In areas where soil cover is minimal, or for installations directly on rock surfaces, a cradle support with specially designed rock anchors can be used. (see figure 28)

FIGURE 28 - **Anchoring System for Rock Installation**



Cast in place or bolt-on concrete blocks are a simple, but somewhat expensive, alternative of restraining the pipe in areas of unstable soil (see figures 29 and 30). Where the bolt-on anchors or bands are used, their width should be at least as large as the outside diameter of the pipe and may, in some cases, require a rubber blanket between the anchor and the pipe.

FIGURE 29
Cast-In-Place Concrete Block

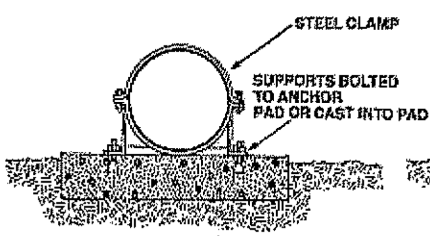
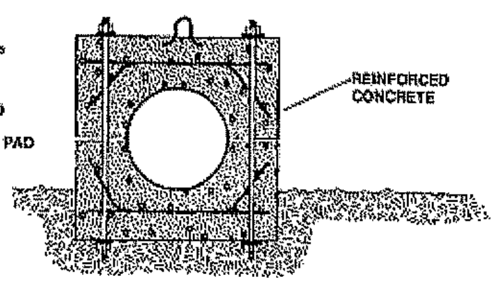


FIGURE 30
Bolt-on Concrete Block



A very effective and often used way of anchoring the pipe is the use of wooden sleepers and strapping (see figures 31 and 32). In effect the steel strapping acts as a relief mechanism because of their tendency to break loose if the lateral loads reach unusually high levels. This method is not designed to restrain longitudinal movement of the pipeline.

FIGURE 31
Bolt-on Wooden Blocks

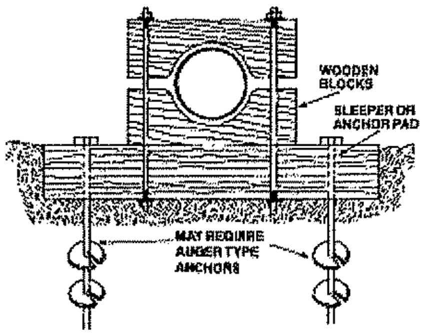
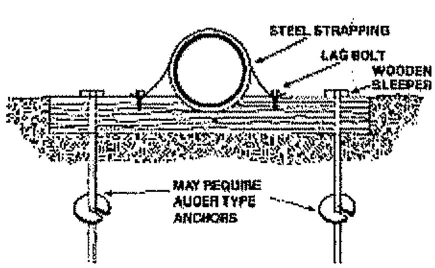


FIGURE 32
Wooden Sleeper and Strapping



Mechanical restraints can also be used for trestle or bridge crossing applications. Anchors can be placed at the ends of a pipeline or at intermediate points. Those placed on the pipeline ends should restrain both longitudinal and lateral movement. Normally those at intermediate points are designed primarily to restrain lateral movement. Poorly designed anchors may themselves become the source of future problems. Accordingly, they should be designed to eliminate "stress risers" and they must be firmly bedded to prevent them from sinking.

Worthington Products, Inc.
TUFFBOOM Barrier System

Canadian Specifications

DETAILS OF CONSTRUCTION

Floatation Log Booms.

Floatation logs shall be new boom logs not previously used for any other purpose and shall be supplied by a manufacturer with not less than 5-years experience providing logs booms for the specified purpose. Floatation logs shall consist of an external encasement (A), internal foam fill (B) and internal structural steel member (C) through which all external interboom connections are attached. Each floatation log shall be cylindrical in shape and shall include recessed longitudinal ribbing to provide impact strength and load resistance. The nominal diameter shall be 16-inches as measured with a 16-inch diameter circle template placed at one end of the flotation log. Flotation logs shall be 120-inches in length. The assembled length of each floatation log as measured from center of interboom connector to center of interboom connector on the opposite end of the boom log shall be 135-inches in length plus/minus 2-inches. The average total dry weight of each floatation log with the bottom steel connector plate shall be 140 pounds. Each flotation log shall be designed to maintain its original buoyancy when supplied with underwater screen attachments. This buoyancy shall not be reduced even if the floatation unit is structurally damaged or punctured.

Encasement "A". shall be rotationally molded using rotationally molding grade linear low density polyethylene or linear medium grade polyethylene. Polyethylene encasement shall have a minimum density of 0.935 g/cm³ as determined by ASTM D1505-68 and be UV-stabilized for long-term environmental exposure. The nominal wall thickness of the polyethylene encasement shall be 0.170-inch. The standard encasement color shall be yellow (FS-13655) per Transport Canada requirements unless alternate colors are requested.

Internal Foam "B". Polystyrene shall meet the requirements of ASTM C-578 and shall have a minimum in-place density of 0.9 pounds per cubic foot and a maximum in-place density of 1.2 pounds per cubic foot. Water absorption of polystyrene shall not exceed 3% by volume as tested per ASTM C-272. Polystyrene shall be unable to support combustion without an external heat source. Polystyrene fill shall take up a minimum of 95% of the interior volume of the boom. Under no circumstances will the percentage of foam fill be less than 90% of the interior volume of the boom. Polystyrene shall be produced by a manufacturer who has been continuously engaged in the production of styrene foam for flotation for a minimum of five years. The buoyancy of the floatation unit will not be reduced as long as the foam remains in place.

Internal Structural Steel Member "C". Each floatation log shall be fabricated with a structural steel channel according to ASTM A572-Grade 50 structural steel, with a 4" minimum external channel width and a minimum ultimate tensile strength of 57,000 pounds. The weight of each channel shall not be less than 5.4-pounds per foot. Material certification shall be made available by the manufacturer on request. The structural channel shall be located such that it is on the interior of each floatation log, centered across the width and positioned on the bottom interior surface to provide anti-rolling features to the boom unit. The internal channel must be positively secured in place such that it cannot separate from the boom encasement nor can it rotate independently from the encasement material. Manufacturer shall warrant that the internal steel shall not rotate independently from the encasement. Materials that are molded in place or through wall mold-in channels or bars are not permitted due to the different thermal properties of steel and polyethylene and the resulting risk of physical separation of material in the field. All load bearing connections between floatation logs shall de designed such that the load is distributed through this channel.

Interboom Connection Hardware

All connecting hardware between floatation units shall consist of bottom steel connector plates (item "A"), load-rated galvanized safety shackles (item "B") and load-rated galvanized weldless links (item "C"). The strength of the connection assembly is essential to the long term performance of the boom line. Therefore, the Manufacturer must provide certified test results of the load capacity of connection assembly . The connections between flotation units shall be engineered to minimize wear and maximize load-bearing capacity. All external connecting hardware must be of galvanized steel construction. The use of non-metallic materials, such as pvc belting, or other materials that can be cut, ripped, torn or are subject to environmental degradation shall not be acceptable. (See note below for corrosive water environments).

Worthington Products, Inc.
TUFFBOOM Barrier System

Canadian Specifications

Item "A". Bottom steel connector plates shall be fabricated from structural steel plate according to ASTM A572, Grade 50, "Specification for Structural Steel". Connection plates or bars must be tested to assure they meet or exceed the breaking strength of the shackles and links. Bottom plates shall be factory assembled to the floatation units prior to shipment.

Item "B". Connection shackles shall have a minimum pin diameter of ¾-inch, be of a safety type with a heavy-hex style castle nut, lock washer and galvanized cotter pin. Connection shackles must be hot dipped galvanized for corrosion resistance and have a WLL (Working Load Limit) of not less than 4-3/4 tons stamped on the body. The WLL rating shall be clearly identified on the body of each shackle. The minimum average tensile breaking strength of each shackle shall be 60,000 lbs and be certified to be proof tested to 57,000 pounds working capacity. Manufacturer is responsible for providing testing certificate attesting to load capability of connectors upon request. Each shackle shall be supplied with a galvanized steel straight cotter pin to prevent the safety bolt from coming loose. "R" type cotter pins shall not be acceptable.

Item "C". Weldless links shall be ¾-inch, be hot-dipped galvanized for corrosion resistance and have a WLL (working load limit) of not less than 4-3/4 tons. The WLL rating shall be clearly identified on the body of each shackle. The minimum average tensile breaking strength of each shackle shall be 60,000 lbs and be certified to be proof tested to 57,000 pounds working capacity. The weldless link may be substituted with alternate connectors in order to achieve a wider gap between floatation units. Where any alternate connector is utilized it must exceed the 57,000 pound proof tested working capacity of the weldless link.

Testing: Manufacturer must provide certification of test results from an independent certified laboratory validating the load bearing capacity of the entire connection assembly. For purposes of definition, the connection assembly consists of the steel member attached to the boom, shackles and links. Testing shall consist of a standard pull test to breaking point of an entire connection assembly.

Color: The default color of the floatation log booms shall meet Transport Canada requirements for safety yellow per FS-13655. Alternate colors are available on request. Where an alternate color is desired, the color choice shall be clearly stated in the final specification and on the purchase requisition..

OPTIONAL/ANCILLIARY ITEMS:
The items shown below may be specified by the owner as additional items to be included in the scope of supply. Where such items are included in the scope of supply, the relevant specification shall apply.

Graphics/Lettering:
Graphics shall be the millennium type mold-in graphic. Standard graphics shall be black lettering using 4" high Arial font type graphic. Standard graphic panels shall be placed on the upstream face of the each boom and shall read: <> DAM AHEAD KEEP AWAY <>. Alternate wording/symbols may be specified by the project owner prior to commencement of production.

Debris Screens:
Debris screens shall be fabricated from structural steel tubing and shall consist of an outer rectangular frame with vertical support tubes spaced on approximately 30" centers. An expanded metal wire mesh overlay shall be welded to the support frame. Unless otherwise specified, the expanded metal shall be a ¾" expanded metal mesh in a diamond pattern. Screens shall be attached to the booms on both ends in such a manner as to minimize the spacing between the top of the screen and the bottom of the boom while simultaneously permitting the booms to swivel or tilt independently from the booms. Screens shall include a chain or cable that affixes the bottom of each screen to the next screen unit. The screen length shall be such that there is not more than a 6" gap between screen units when installed.

The floating barrier shall be equivalent or superior to the TUFFBOOM system as Manufactured by Worthington Products, Inc. (1-800-899-2977) of Canton, Ohio or approved equal.

FirstEnergy®

Oregon, Ohio

Bay Shore Generating Plant

Intake Channel - Fish Diversion System Project

ENGINEERING SUMMARY REPORT

June 27, 2011

Prepared by:

CHEMSTRESS CONSULTANT COMPANY
CHEMSTRESS PROJECT No. 5802

Chemstress Consultant Company
39 South Main Street
Akron, Ohio 44308

FirstEnergy Generation Corp

Oregon, Ohio

Bay Shore Plant

Intake Channel – Fish Diversion System Project

ENGINEERING SUMMARY REPORT

PROJECT PURPOSE

FirstEnergy Generation Corporation is currently in the construction document phase for the building of a new fish diversion system for the intake channel at the Bay Shore Plant in Oregon, Ohio. This new system will reduce the amount of debris entering the existing water intake structure, and more importantly the amount of fish being impinged or entrained at the same intake structure for the plant.

The existing intake structure takes in water directly from the intake channel which is fed directly from the Maumee Bay and River. The intake structure currently has an exterior screening process which stops debris at the mouth of the intake allowing for sometimes large quantities of debris. Within the intake structure there are screens which separate off small immature fish which are many times pulled into the facility and then transported through a fish trough to the existing outlet channel. The new diversion system is being designed to divert the fish from ever entering the intake structure to and also return extremely small fish and eggs that may enter back to a fish pumping station that will transport the diverted fish back the river waters and ultimately to the Maumaee Bay.

The following is being provided as an engineering summary report for the Bay Shore Plant Fish Diversion System and will provide information regarding Design Basis, Design Parameters, Start-Up Plan, and Compliance Schedule:

DESIGN BASIS

The Preliminary Engineering Report was prepared by Kinectrics North America and is dated April 20, 2011. The new system has been designed in accordance with the said report. The basis for the design was established to meet several parameters:

- The diversion wall or screens should provide a natural egress to the transportation pumps without endangering the population by causing an abruptness of travel path.
- Transport pipe will provide an approiate volume of water to allow for stability of the ambient water temperatures and chemical make up for the fish to be transported without negatively affecting the population.

- Provide appropriate flow velocities to allow the fish to move towads the ultimate discharge point but not too much as to negatively affect the population.

- The transport system should allow for the ability to sample the population to assure effective operation.

- Maintain 750 MGPD of intake flow to the plant.

- The system shall result in a reduction in impingement of 80% and 60% in entrainment.

The new Fish Diversion System is being provided to allow for the above mentioned needed modifications in order to meet the requirements established by the in-place NPDES Permit. The entire system wil include the following:

- Trash Diversion/Handling System is being provided to divert trash and debris entering the intake channel away from the louver array and fine mesh traveling screens to an area where it can be removed easily and disposed of. The debris boom may also aid in passively directing larval fish and/or eggs in the upper water column towards the East shore line closer to the fish bypass pumps. Juvenile and adult fish may also be diverted, but this effect will not be significant.

- Reverse Louver Array is being provided as the main fish diversion system. This system is a reversed louver arraywhich is installed downstream of the debris screens or diversion system. The function of the fish diversion louvers is to increase the survival of the fish by diverting them in the intake channel away from the station and traveling screens where the fish are subjected to different types of stresses associated with high flows, physical abrasion, and handling off a vertical traveling screen. The solid portion of the louver along the bottom will also be effective in diverting a proportion of fish eggs and larvae.

- Fish Pump and Fish Return System will transport the fish, larvae and eggs unharmed to an environmentally preferred location in the Maumee River and ultimately in Maumee Bay. This will be achieved with the installation of new transport pumps designed to safely move fish from one location to another. This pump station is integral to the end of the fish diversion louver. The transport pipe being provided is a 42 inch diameter pipe to allow for enough volume of water as to allow for the preferred environment for the survival of the fish, larvae and eggs.

DESIGN PARAMETERS

The potential flows to be received by the Intake Structure are expected to be 750 MGPD. The proposed trash screen and fish diversion louver will allow for these flows to be provided at any water level that the intake channel has historically reached.

The water levels are expected to reach an extreme elevation of approximately 578 feet while dropping to a minimum elevation of around 563 feet. The trash louvers will screen debris to a point approximately four feet below the water's surface, and the fixed diversion louver will allow minimally uninhibited flows for any water above elevation 559 feet. The channel bottom is approximately at 555 feet with some variations in silted bottom elevations.

The allowable velocities to accommodate the diverted fish will be between 2 fps and 3 fps at any one time. These velocities are deemed sufficient enough to keep the fish moving towards the discharge while providing a comfortable velocity for the fish.

The system is designed to allow a smooth transition back into the waters.

The system has been set up to allow for grab samples as indicated in the NPDES. Two sampling structures will be provided to allow for these samples to be taken from and the fish collected will be transported and stored in a holding tank for observation to determine the condition of the diverted population. These structures could also be used to mechanically isolate areas of the pipe for maintenance reasons as well.

START-UP PLAN

The following is a summary of anticipated start-up situations and expected adjustments to the process over a period of time to establish accurate information to evaluate accurately the quality of the discharge waters in terms of recovered fish population. The anticipated start-up plan is as follows:

General Start-Up: March 1, 2013 to April 1, 2013

This stage of the start-up will involve the operation of the equipment and instrumentation for the fish transport pump system. This process will involve the setting of the valves and establishing propoer operation of the pumps and instrumentation. The General Start-Up will include testing of the operations and establish initial settings of the new level controls and evaluate the flows provided to the discharge transportation piping.

Final Start-Up: April 1, 2013

OPERATION & MONITORING SCHEDULE

The following is provided as representation of FirstEnergy Generation Corp. plan for performing adequate sampling of final effluents, and establishment of a Operation and Monitoring Plan to achieve compliance with established criteria by the City of Massillon and the OEPA:

1. Begin Construction: March 1, 2012
2. Complete Construction: March 1, 2013
3. Complete Start-Up,Testing, & Training: April 1, 2013
4. Begin Operation: April 1, 2013
5. Potentially Begin Sampling: May 1, 2013

Upon completion of the two year time period for establishing an accurate representation of the effluent, meetings will be held as required with the OEPA to anaylize the sampling results and if the effluent is not in compliance with established criteria an Action Plan will be mutually agreed upon. If the system is determined to be in compliance with the requirements in place, the sampling procedures will continue as a period operation to assure continued compliance. .

BOWSER-MORNER, INC.

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419-691-4800

Engineering Service Report

Client: Chemstress Consultant Co.
Attention: Bradley W. Lightfoot, P.E.
39 South Main Street
Akron, Ohio 44308

Project: SOIL EXPLORATION,
First Energy Bay Shore,
Fish Diversion Project,
Oregon, Lucas County, Ohio

Job No.: 154944
Date of Service: June 24, 2011

Report No.: 154944-0611-2933
Engineer: J. Richard Hoppenjans, P.E., F. ASCE, D. GE
Report Consists of 8 Pages

Ladies and Gentlemen:

In accordance with your instructions, Bowser-Morner, Inc. has begun to perform engineering services to identify site soil and groundwater conditions relative to the installation of a 42-inch discharge pipe which will run from the Bay Shore Power Plant Screen House northward and into Maumee Bay. We are performing these services in anticipation of detailed test borings and laboratory tests, which are pending.

Bowser-Morner has performed dozens of test borings at the Bay Shore Power Station over the last 35 years. We are also the Geotechnical Engineer of Record for the Confined Disposal Facilities in the Bay. Geologically, the site is situated in a glacial till deposit which consists of an unsorted, unstratified mixture of clay, silt, sand, and coarser fragments deposited by glacial ice. Bedrock at the plant site is on the order of 120 to 130 feet deep. Attached with this report is a site plan with representative test boring locations indicated. Also attached are the boring logs for these four borings. We have also attached a cross-section of soil test boring data that was performed in 1966 for the construction of a portion of the existing power plant.

If there are any questions, please contact us.

Respectfully submitted,

BOWSER-MORNER, INC.

This document was originally issued by J. Richard Hoppenjans, P.E., F. ASCE, D. GE. on 6/24/11. This document is not considered a sealed document. This document has been produced from material that was stored and/or transmitted electronically and may have been inadvertently altered. Rely only on final hard-copy materials bearing the consultant's original signature.

J. Richard Hoppenjans, P.E., F. ASCE, D. GE
Vice President, District Manager, Chief Engineer

JRH:mlj

LOG OF BORING NO. 1

Demineralized Water Storage Tank, Toledo Edison Bay Shore Station, Toledo, OH

BORING LOCATION: As shown on boring location plan **DATE STARTED:** 11/13/84

SURFACE ELEVATION: 580.5 ± **DATE COMPLETED:** 11/13/84

STRATUM	DESCRIPTION OF MATERIAL	SAMPLE NO. & TYPE	SAMPLE DEPTH	BLOWS PER 6" ON SAMPLER	"N" BLOWS /FT. OR CORE REC.
0.0'	(FILL) Topsoil				
6"	Very stiff brown & gray clay, some silt, trace of sand - moist	1A	1.0- 2.5	6-9-10	19
5.0'		1C	4.0- 6.0		24"
		1B	6.0- 7.5	6-9-13	22
	(Becomes very stiff at 7.5')				
10.0'	(Becomes medium stiff with thin sand partings at 10.0')	2A	9.0-10.5	4-5-5	10
		2C	12.0-14.0		17"
14.0' / 15.0'	Soft gray clay, some silt, trace of sand, trace of gravel - moist	3A	14.0-15.5	1-2-2	4
19.0' / 20.0'	Very soft gray clay, some silt, some sand, trace of gravel - moist	4A	19.0-20.5	1-1-2	3
		3C	22.0-24.0		
		5A	24.0-25.5	3-5-6	11
25.0'	(Becomes stiff at 25.5')				
30.0'		6A	29.0-30.5	4-6-7	13
	Bottom of boring at 30.5'				

METHOD: Hollow Auger

TECHNICIAN: BK/PF

JOB NO.: 39006

WATER OBSERVATIONS

INITIAL DEPTH: 6.5 med, 9.0 Hvy.

COMPLETION DEPTH: None*

DEPTH AFTER: ____ HRS. ____

TYPE SAMPLER:

X A. SPLIT SPOON

X B. Liner

X C. SHELBY TUBE

2B15

*Taken in augers

BOWSER – MORNER

LOG OF BORING NO. 1

DEVELOPMENT OF DRY FLY ASH STORAGE AREA NEAR BAY SHORE STATION - TOLEDO, OHIO

BORING LOCATION: As shown on boring location plan **DATE STARTED:** 11-24-81

SURFACE ELEVATION: 581.3' (I.G.L.D.) **DATE COMPLETED:** 11-24-81

STRATUM	DESCRIPTION OF MATERIAL	SAMPLE NO. & TYPE	SAMPLE DEPTH	BLOWS PER 6" ON SAMPLER	"N" BLOWS /FT. OR CORE REC.
0.0'	(FILL) Gravel				
0.5'	(FILL) Hard brown and gray clay, some silt, some sand, trace of gravel, moist	1A	1.0- 2.5	12-18-24	42
	(Becomes very stiff at 4.0')	2A	3.5- 5.0	8-11-16	27
5'					
	(Becomes medium stiff at 8.5')	3A	8.5-10.0	3- 4- 5	9
10'					
12.0'	Medium dense gray sand and silt, wet	4A	13.5-15.0	4- 8- 4	12
13.5'	Stiff gray organic silt and clay, moist				
15'					
		5A	18.5-20.0	3- 3- 5	8
19.0'	Medium stiff gray clay and silt, traces of sand and gravel, moist				
20'					
		6A	23.5-25.0	4- 4- 5	9
25'					
		7A	28.5-30.0	2- 4- 5	9
	Bottom of boring at 30.0'				

METHOD: Hollow Auger

TECHNICIAN: BC and RF

JOB NO.: 33737 (jl)

WATER OBSERVATIONS

INITIAL DEPTH: 13.0' (medium)

COMPLETION DEPTH: 13.0'

DEPTH AFTER: 6.0 HRS. None

TYPE SAMPLER:

X A. SPLIT SPOON

___ B.

___ C. SHELBY TUBE

BOWSER – MORNER
TESTING LABORATORIES, INC.

LOG OF BORING NO. 2

DEVELOPMENT OF DRY FLY ASH STORAGE AREA NEAR BAY SHORE STATION – TOLEDO, OHIO

BORING LOCATION: As shown on boring location plan **DATE STARTED:** 11-24-81

SURFACE ELEVATION: 581.7' (I.G.L.D.) **DATE COMPLETED:** 11-24-81

STRATUM	DESCRIPTION OF MATERIAL	SAMPLE NO. & TYPE	SAMPLE DEPTH	BLOWS PER 6" ON SAMPLER	"N" BLOWS /FT. OR CORE REC.
0.0'	(FILL) Gravel				
0.5'	(FILL) Hard brown and gray clay, some silt, some sand, trace of gravel, moist	1A	1.0- 2.5	15-18-20	38
	(Becomes very stiff with a gray sand seam at 4.0')	2A	3.5- 5.0	15-10-14	24
5'					
9.0'		3A	8.5-10.0	2- 2- 3	5
10'	Soft gray clay and silt, trace of sand, moist				
		4A	13.5-15.0	2- 2- 5	7
15'					
		5A	18.5-20.0	2- 2- 3	5
20'					
23.5'	Medium stiff gray clay, some silt, some sand, trace of gravel, moist	6A	23.5-25.0	3- 3- 5	8
25'					
		7A	28.5-30.0	4- 4- 5	9
30'					

METHOD: Hollow Auger

TECHNICIAN: BC and RF

JOB NO.: 33737 (jl)

WATER OBSERVATIONS

INITIAL DEPTH: 39.0' (medium)

COMPLETION DEPTH: None

DEPTH AFTER: ____ HRS. ____

TYPE SAMPLER:

X A. SPLIT SPOON

___ B.

___ C. SHELBY TUBE

BOWSER – MORNER
TESTING LABORATORIES, INC.

LOG OF BORING NO. 2 - continued

DEVELOPMENT OF DRY FLY ASH STORAGE AREA NEAR BAY SHORE STATION - TOLEDO, OHIO

BORING LOCATION: As shown on boring location plan **DATE STARTED:** 11-24-81

SURFACE ELEVATION: 581.7' (I.G.L.D.) **DATE COMPLETED:** 11-24-81

STRATUM	DESCRIPTION OF MATERIAL	SAMPLE NO. & TYPE	SAMPLE DEPTH	BLOWS PER 6" ON SAMPLER	"N" BLOWS /FT. OR CORE REC.
30'					
35'	(Becomes very stiff at 34.5')	8A	33.5-35.0	8- 8-11	19
40'		9A	38.5-40.0	5- 7-11	18
45'	(Becomes hard at 43.5')	10A	43.5-45.0	14-20-17	37
50'		11A	48.5-50.0	11-23-29	52
		12A	54.5-55.0	11-21-23	44
	Bottom of boring at 55.0'				

METHOD: Hollow Auger

TECHNICIAN: BC and RF

JOB NO.: 33737 (jl)

WATER OBSERVATIONS

INITIAL DEPTH: 39.0' (medium)

COMPLETION DEPTH: None

DEPTH AFTER: ____ HRS. ____

TYPE SAMPLER:

X A. SPLIT SPOON

__ B.

__ C. SHELBY TUBE

BOWSER – MORNER
TESTING LABORATORIES, INC.

LOG OF BORING NO. 3

DEVELOPMENT OF DRY FLY ASH STORAGE AREA NEAR BAY SHORE STATION - TOLEDO, OHIO

BORING LOCATION: As shown on boring location plan — DATE STARTED: 11-24-81

SURFACE ELEVATION: 581.9' (I.G.L.D.) — DATE COMPLETED: 11-24-81

STRATUM	DESCRIPTION OF MATERIAL	SAMPLE NO. & TYPE	SAMPLE DEPTH	BLOWS PER 6" ON SAMPLER	"N" BLOWS /FT. OR CORE REC.
0.0'	(FILL) Gravel				
0.5'	(FILL) Very stiff brown and gray clay, some silt, some sand, trace of gravel, moist	1A	1.0- 2.5	9-11-15	26
		2A	3.5- 5.0	5- 7-10	17
5'	(Possible original soil at 5.0')				
10'		3A	8.5-10.0	1- 3- 7	10
13.5'	Medium stiff brown and gray silt and sand, moist	4A	13.5-15.0	2- 2- 4	6
15'					
18.5'	Stiff gray clay, some silt, some sand, trace of gravel, moist	5A	18.5-20.0	6- 7- 8	15
20'					
25'		6A	23.5-25.0	3- 5- 8	13
		7A	28.5-30.0	5- 7- 8	15
	Bottom of boring at 30.0'				

METHOD: Hollow Auger

TECHNICIAN: BC and RF

JOB NO.: 33737 (jl)

WATER OBSERVATIONS

INITIAL DEPTH: None

COMPLETION DEPTH: None

DEPTH AFTER: 5.0 HRS. None

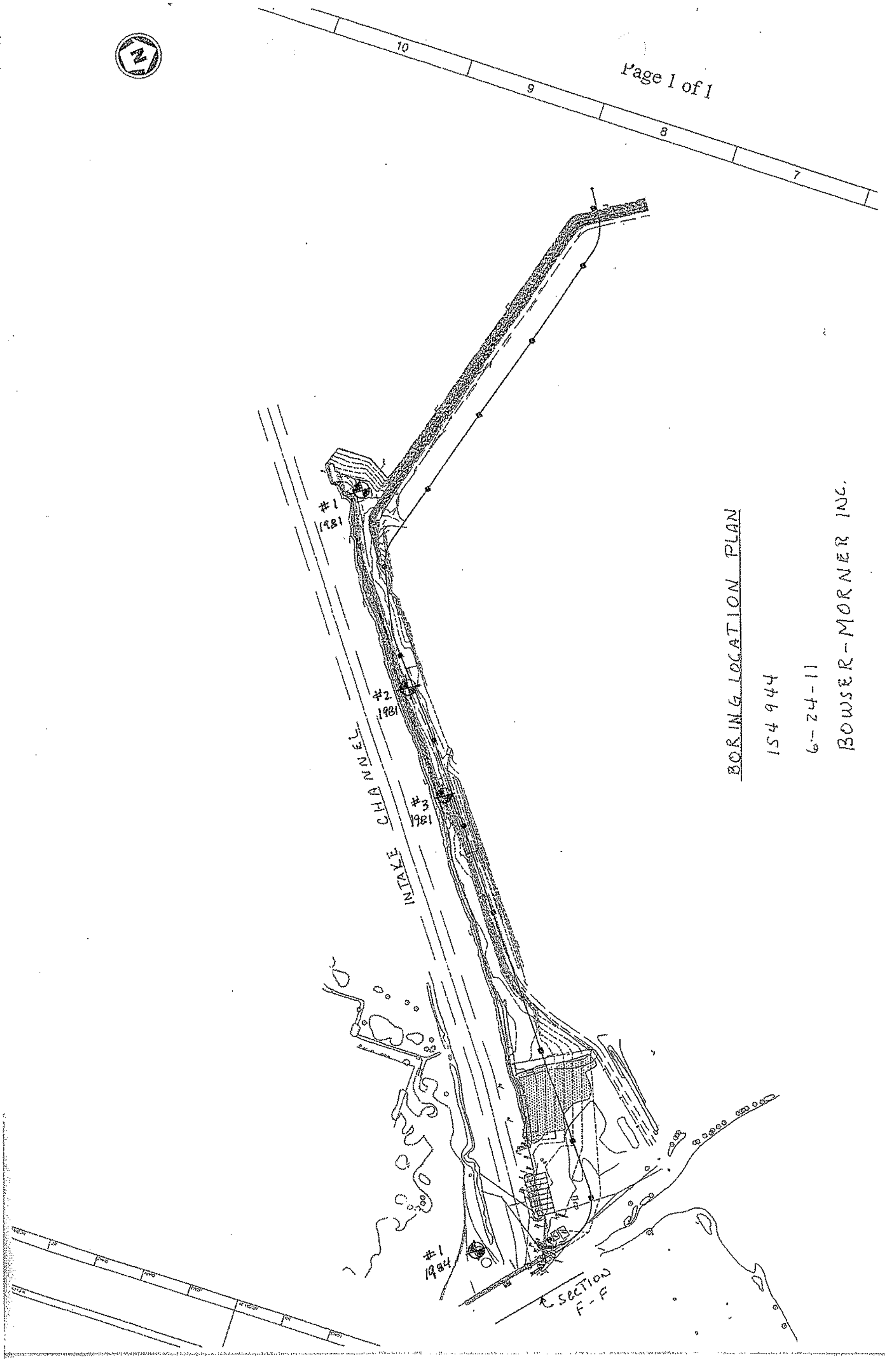
TYPE SAMPLER:

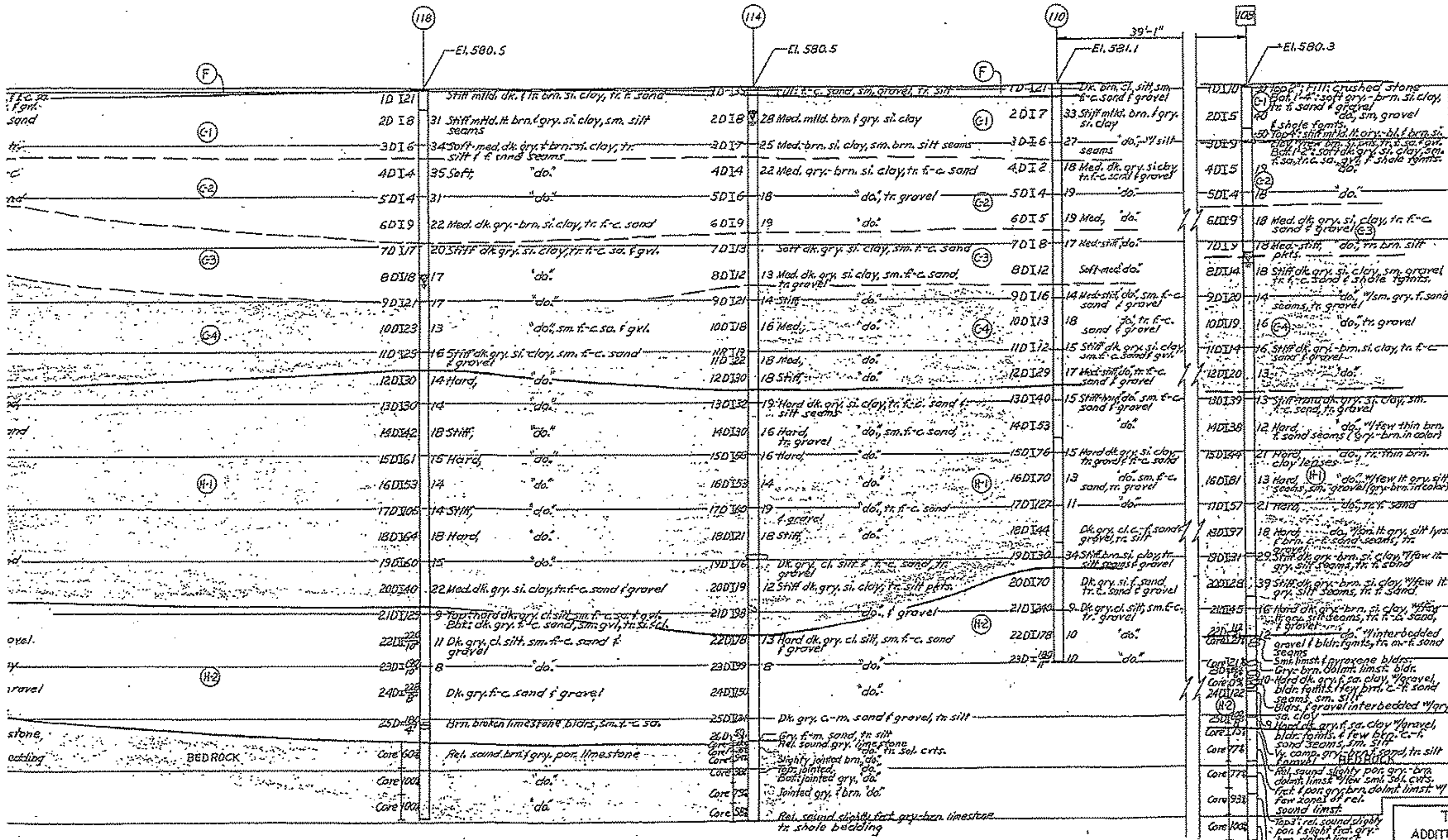
X A. SPLIT SPOON

B.

C. SHELBY TUBE

BOWSER – MORNER
TESTING LABORATORIES, INC.


N
10
9
8
7
#1 1981
#2 1981
#3 1981
#1 1984
INTAKE CHANNEL
SECTION F-F
BORING LOCATION PLAN
154944
6-24-11
BOWSER-MORNER INC.



GENERAL STRATA DESCRIPTIONS

- (F) - Fill: Sand, gravel, silt, clay, cinders and brick
- (C-1) - Medium to stiff mottled brown and gray silty clay with thin silt seams.
- (C-2) - Medium gray to gray brown silty clay, trace sand and gravel.
- (C-3) - Medium to stiff dark gray silty clay, trace sand and gravel.
- (C-4) - Stiff to hard dark gray silty clay, trace sand and gravel.
- (H-1) - Hard dark gray silty clay, trace sand, gravel and silt packets.
- (H-2) - Very compact gray clayey silt to fine to coarse sand, gravel and boulders.
- BEDROCK - Fractured and porous to sound gray brown dolomitic limestone.

NOTES

1. For Boring Location Plan and Abbreviations for Soil Sample Descriptions see Dwg. Nº GS-1.
2. For General Notes and Boring Legend see Dwg. Nº GS-2.

Bowser-Morner Inc.
154944
6-24-11

R LEVEL OBSERVATIONS

	TIME	DEPTH HOLE	DEPTH CASING	DEPTH WATER	ELEV. WATER
5	1600	131'-0"	95'-0"	39'-0"	542.0
5	1430	140'-0"	110'-0"	37'-5"	543.1
5	0700	95'-0"	9'-5"	6'-0"	574.5
5	1700	140'-4"	0'-0"	2'-6"	578.0
5	1700	140'-3"	0'-0"	6'-5"	574.1
5	1115	Not Known	0'-0"	4'-5"	576.1
5	0730	81'-6"	9'-0"	17'-11"	563.2
5	1600	110'-11"	0'-0"	0'-0"	581.1

SECTION F-F

GRAPHIC SCALES
Vertical 0' 5' 10' 20' 40'
Horizontal 0' 5' 10' 20' 40' 80'

TOLEDO EDISON COMPANY
ADDITIONAL UNITS, BAY SHORE STATION
TOLEDO OHIO

GIBBS & HILL, INC.
CONSULTING ENGINEERS
NEW YORK NEW YORK

MUESER · RUTLEDGE · WENTWORTH & JOHNSTON
CONSULTING ENGINEERS
415 MADISON AVE. NEW YORK 17, N.Y.

SCALE	MADE BY	DATE	FILE NO.
As Shown	PLH	1-14-66	3235
	CHK'D BY MFC	DATE 1-14-66	

GEOLOGIC SECTION F-F — DRAWING NO. GS-3

FIRST ENERGY - BAY SHORE PLANT
OREGON, OHIO
FISH DIVERSION PROJECT
CHEMSTRESS PROJECT NUMBER: P5802
PROJECT BUDGET ESTIMATE REV 1 - 6/27/11

DESCRIPTION	QUANTITY	UNITS	UNIT COST	COST
FISH DIVERSION CONSTRUCTION				
FLOATING DEBRIS SCREEN				
MOBILIZATION	1	LS	$5,000.00	$5,000
PIPE PILES	150	LF	$250.00	$37,500
FLOATING DEBRIS BOOM INCL. APPURTENANCES	320	LF	$150.00	$48,000
SHEET PILE END WALLS	4200	SF	$35.00	$147,000
DOCK EXCAVATION AND BACKFILL STABILIZATION	975	CY	$20.00	$19,500
OVERHEAD AND PROFIT	1	LS	$51,400.00	$51,400
FLOATING DEBRIS SCREEN TOTAL				**$308,400**
FIXED DIVERSION LOUVER SYSTEM				
MOBILIZATION	1	LS	$5,000.00	$5,000
PIPE PILES	750	LF	$250.00	$187,500
SHEET PILE END WALLS	9750	SF	$35.00	$341,250
SHEET PILE BASE WALL	7000	SF	$35.00	$245,000
FIXED LOUVER SYSTEM (GALVANIZED STEEL)	5600	SF	$50.00	$280,000
MISCELLANEOUS STRUCTURAL STEEL	20000	LBS	$3.50	$70,000
OVERHEAD AND PROFIT	1	LS	$225,750.00	$225,750
FIXED DIVERSION LOUVER TOTAL				**$1,354,500**
FISH TRANSPORT SYSTEM				
MOBILIZATION	1	LS	$5,000.00	$5,000
DEBRIS REMOVAL & DREDGING	1400	CY	$10.00	$14,000
PIPE PILES	150	LF	$250.00	$37,500
COFFERDAMS	3200	SF	$35.00	$112,000
PUMP VAULT CONCRETE BASE SLAB	26	CY	$750.00	$19,500
PUMP VAULT CONCRETE WALLS	25	CY	$1,250.00	$31,250
PUMP VAULT CONCRETE TOP SLAB	14	CY	$1,250.00	$17,500
PUMP VAULT ACCESS HATCHES	3	EA	$5,000.00	$15,000
PUMP VAULT DEBRIS GRATE SCREENS	360	SF	$50.00	$18,000
ELECTRICAL & INSTRUMENTATION	1	LS	$50,000.00	$50,000
TRANSPORT PUMP & APPURTENANCES	3	EA	$350,000.00	$1,050,000
12 INCH HDPE FUSED PIPING (OPEN CUT)	150	LF	$100.00	$15,000
12 INCH GATE VALVES	3	EA	$2,500.00	$7,500
12 INCH CHECK VALVES	3	EA	$2,500.00	$7,500
18 INCH HDPE PIPING (CONCRETE ENCASED)	120	LF	$200.00	$24,000
42 INCH HDPE FUSED PIPING (DIRECTIONAL BORE)	3620	LF	$650.00	$2,353,000
72 INCH VALVE CHAMBERS	3	EA	$15,000.00	$45,000
72 INCH SAMPLING CHAMBERS	2	EA	$15,000.00	$30,000
42 INCH SUBMERGED HEADWALL	1	EA	$5,000.00	$5,000
OVERHEAD AND PROFIT	1	LS	$771,350.00	$771,350
FISH TRANSPORT TOTAL				**$4,628,100**
FISH DIVERSION BUDGET TOTAL				**$6,291,000**

Chemstress Consultant Compa
39 South Main Street
Akron, Ohio 44308
Project No. 5802

FirstEnergy
Fish Diversion Project
Drawing List
June 27, 2011

Drawing List

Drawing	Rev.	Title
SK-1	2	Title Sheet
SK-2	2	Site Notes
SK-3	2	Structural Notes
SK-4	2	Overall Site Plan
SK-5	5	Pump Chamber, Diversion and Debris Screen Plan
SK-6	3	Diversion and Debris Screen Elevations
SK-7	3	Diversion Screen Details
SK-8	5	Plan and Profile Sheet 1
SK-9	4	Plan and Profile Sheet 2
SK-10	4	Plan and Profile Sheet 3
SK-11	4	Plan and Profile Sheet 4
SK-12	4	Plan and Profile Sheet 5
SK-13	4	Plan and Profile Sheet 6
SK-14	2	Plan and Profile Sheet 7
SK-15	3	Plan and Profile Sheet 8
SK-16	2	Plan and Profile Sheet 9
SK-17	2	Cross Sections