Homer Tidal Power and Marine Instrument Test Station Design

Senior Design Project

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Sponsored by the City of Homer, Alaska

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Executive Summary

The purpose of the Homer Tidal Power Incubator design project was to develop a design for a tidal generator and marine instrument test station. This project was initiated by the following groups: Homer Tidal Energy Incubator Working Group, Homer City Council members, tidal power proponents, local political leaders, and industry professionals. These groups met to discuss the potential of utilizing the Homer Deep Water Dock as a tidal generator testing station. This testing station would allow tidal generator manufacturers and researchers to test their designs under real world conditions. With the recommendation of Dr. Orson Smith, dean of the University Of Alaska Anchorage School Of Engineering, a group of senior engineering students were selected to develop a design for a tidal generator and marine instrument test station at the Homer Deep Water Dock. Following submission of an interim report detailing several alternative concepts for the design, a dock-mounted generator test station was selected by members of the Homer Tidal Energy Incubator Working Group. The dock-mounted generator test station design was then brought to 35% design completion by the UAA student design team.

The preliminary design encompasses the requirements of the initiating parties and explores several options to appeal to potential tidal generator and marine instrument developers. The selected design of the structural support would require additional connection reinforcement and construction of new decking, as well as provide a shelter for equipment and personnel. The cradle mechanism system for raising and lowering tidal generators will accommodate multiple design configurations. The test station will include an instrumentation system consisting of site monitoring, oceanographic, and electrical characteristic instrumentation that will be interfaced with a computer system and data logger.

A cost estimate of the 35% design, which includes the above mentioned features, is included in this report in Appendix A. The costs include $212,269.94 for the electrical installation, $109,200.00 for the structural installation, and $205,124.60 for the rail and cradle system installation. With contingencies the total estimated cost estimate for the project is $701,035.74.
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Before the project continues to the next phase of development it is recommended that the following are completed: a site characterization to include a water velocity profile and geotechnical details at the project location, monitoring of the biological activity in the immediate area, and a complete site and structural inspection performed by a licensed Professional Engineer.

1. Introduction

1.1. Project Context

The Homer Tidal Power Incubator project was initiated by the Homer City Council in the fall of 2012. During the course of several meetings which took place over the following months, Dr. Orson Smith and a group of senior engineering students from the University Of Alaska Anchorage School Of Engineering were enlisted to begin a preliminary design of the tidal incubator. With the City of Homer as the sponsor, the student group began work on the tidal generator incubator to 35% design completion as the goal.

1.2. Project Team Organization

The team was comprised of seven senior engineering students from the University of Alaska Anchorage with Dr. Orson Smith as the faculty advisor. The team included two civil engineering students, two mechanical engineering students, and three electrical engineering students. This project served to fulfill requirements of each respective degree program as part of the A438 capstone design course.
Following the selection of the team members, the team was organized into four technical teams: structural, cradle mechanism, instrumentation, and power. A project management organization chart is shown below.

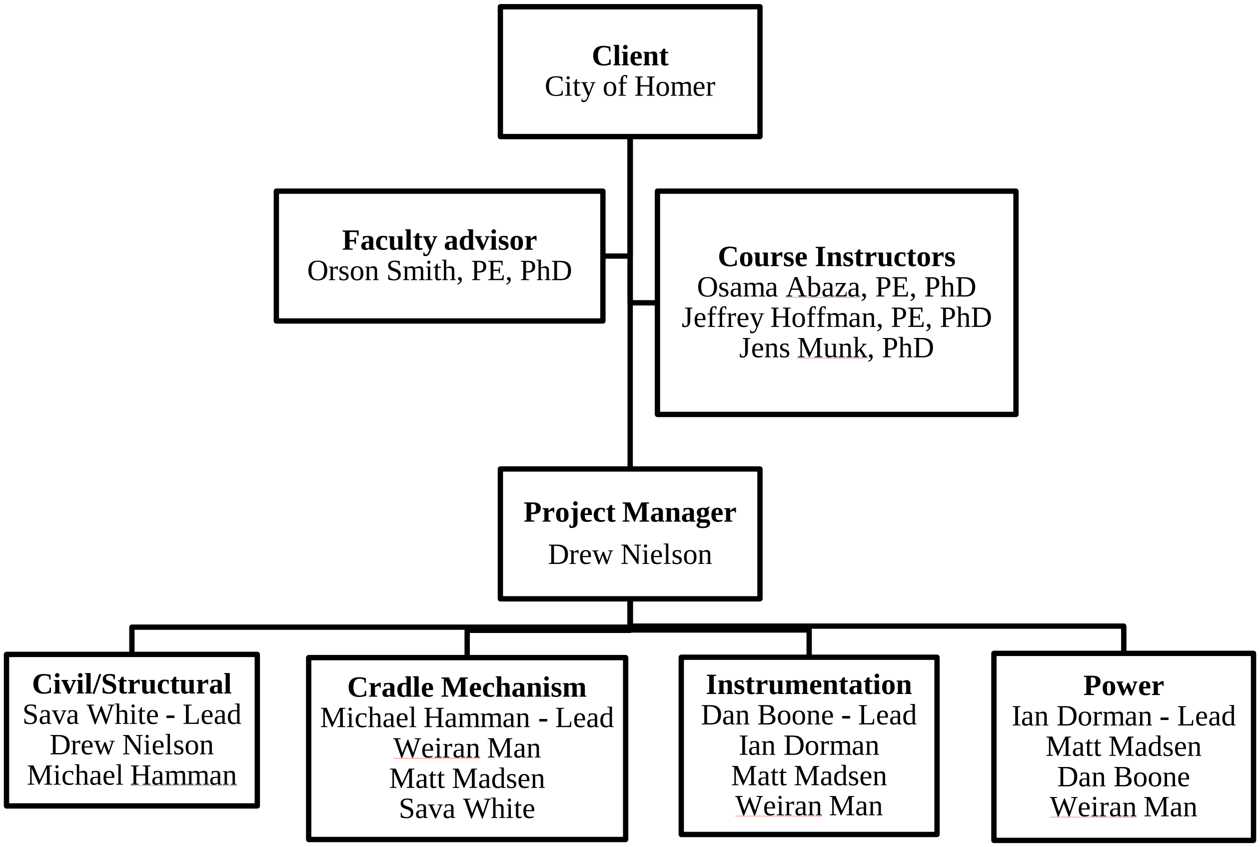

Figure 1: Project organization chart

Civil/ Structural

The location of the proposed dock-mounted test station is located between two piles installed for the purpose of supporting a previously used conveyor system which delivered wood-chips to the end of the dock. These piles are connected to the trestle by dual steel beams attached to the sides of the piles and to the concrete pile cap at the trestle. In order to determine if the piles and beams are suitable for supporting the test station, the structural capabilities will need to be determined. The purpose of the civil/structural engineering team is to provide engineering expertise to these aspects of the project. The team will be analyzing the structural capabilities of the existing dock, designing reinforcement for an additional deck to support the cradle mechanism mount, and designing the shelter. In addition, the team will be charged with creating a computer model which will enable a structural engineering to quickly determine the strength of the system.

Cradle Mechanism

Since tidal generators extract kinetic energy from the current, the energy dissipated across the device is proportional to the cube of the velocity change over the device. By measuring the velocity differential and the mechanical output of the device researcher can develop empirical equations for the efficiency of their device. To accomplish this goal, the hydrokinetic device must conveniently be placed and retracted from the flow for monitoring and maintenance procedures. This not only implies the design of adequate mechanical devices for vertical mobility, but also the structural stability of the mounting system in order to withstand drag loads on the system.

Instrumentation

When testing a prototype tidal generator at any location, three primary areas of operation should be monitored. First, the performance of the tidal generator, including power output and efficiency, is monitored in order to determine the devices electrical power generation viability. Second, measurements are made of how well the tidal generator endures within the testing environment. Lastly, the effect of the tidal generator on the surrounding environment is also observed. The above measurements are made using a system of instrumentation consisting of a series of strategically placed instruments, a data collection and storage device, a user interface computer with software able to display and control the various instruments, and a data transmission system. Additionally, some aspects of generator durability may be made using direct visual observation of the tidal generator itself.

Power

The power generated by the tidal generators will need to be safely dissipated or be stored. This will be accomplished by the use of a load bank with a possibility of an electrical interconnection to the HEA utility grid.

All options detailed within this report will require the use of a load bank. The load bank not only dissipates the energy but can simulate different load conditions. Thus the customer will be able to subject their prototype design to numerous simulated conditions. An electrical interconnection is not necessary for the overall success of the project but can offer a novel amenity to the proposed facility.

Of the alternatives listed in this report the dock mounted option will accommodate the largest range of tidal generators and is the only alternative that will accommodate an interconnection with the utility. However these advantages may not be important to the market, especially when one considers that the floating option can accommodate small scale prototypes just as well if not better than the dock mounting alternatives. The interconnection and wiring methods are governed by various standards and guides.

1.3. Acknowledgements

The following sponsors are gratefully acknowledged for their contributions to the project:

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Katie Koester, Community and Economic Development Coordinator City of Homer

Bryan Hawkins, Harbor Master City of Homer

Carey Meyer, PE

Homer City Council

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2. Tidal Energy Overview

2.1. Overview of Tidal Energy

A Hydrokinetic device is a device that converts the kinetic energy of a flowing body of water into a more usable form such as mechanical and/or electrical energy. Hydrokinetic devices have long been employed to improve humanity's overall quality of life. In recent times, high energy prices have initiated interest in the development and utilization of small scale hydrokinetic devices to offset the reliance on high price oil or natural gas. These devices are characterized by low power generation, which is due to low kinetic energy and current hydrokinetic technology. These devices are referred to as unconventional systems (Khan, Bhuyan, Iqbal & Quaicoe, 2009). The demand for alternate sources of electric power generation and available hydro resources has drawn researchers and developers to pursue further hydrokinetic development.

One particular research group surveyed the findings of 76 researchers and developers (Khan, Bhuyan, Iqbal & Quaicoe, 2009). This is not an exhaustive list, but does show the current effort placed into bringing this technology forward. This interest is important since technological advancement is needed in this areas to make unconventional generation possible (Johnson, 2010).

The positioning of Alaska is promising in reference to hydrokinetic energy potential. Alaska has 40% and 90% of U.S. river energy and tidal energy resources (Johnson, 2010). To put this in perspective, this amounts to 1,250,000,000 MWh/yr for southern Alaska.

Currently there are a wide variety of hydrokinetic device designs under development. Figure 2 and 3 show several turbine variations and one non turbine (f) of the Sea-snail design. The turbine types (a)-(e) employ drag or lift forces on their blades for power generation and Sea-snail (f) employs drag forces on the hydrofoils (Khan, Bhuyan, Iqbal & Quaicoe, 2009). Other designs exist but for brevities' sake only designs specific to Figure 2 and 3 are represented. The orientations of many designs can be accommodated and accurately tested in a slightly different geometric orientation. For example the rigid mooring can be tested upside down from its design orientation. The orientations of many designs can be accommodated and accurately tested in slightly different geometric orientations from production use.

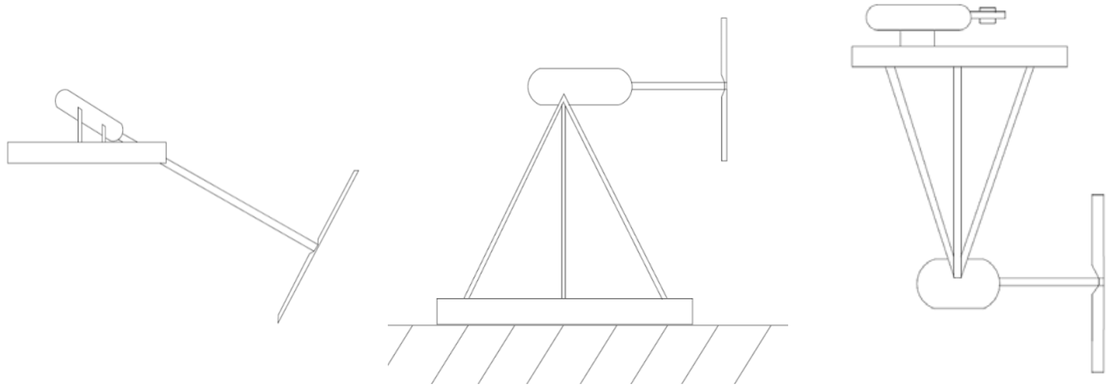

Figure 2: (from left to right) (a)Inclined axis, (b)rigid mooring, (c)and non-submerged generator

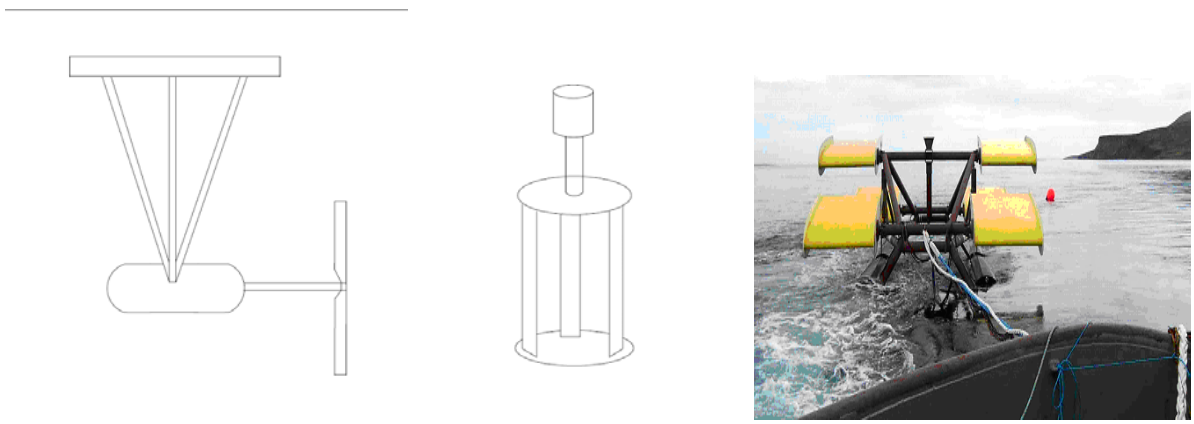

Figure 3: (from left to right) (d)Submerged generator, (e)squirrel cage, (f)sea-snail

2.2. Tidal Power Test Station Opportunities and Implications

The purpose of initiating the tidal power incubator project is to provide manufacturers with a venue for testing tidal generators and marine instruments. This project presents an opportunity for the City of Homer to be a provider of tidal generator testing services to tidal generator manufacturers from around the world. The test station will provide the Port of Homer, and City of Homer, with increased revenues from the provisions from the tidal generator developers/manufacturers. A secondary purpose of the tidal incubator will be to provide the City of Homer with preliminary data of the effectiveness and practicality of implementing tidal power in the Kachemak Bay.

3. Site Characterization

The project is located at the end of the Homer Spit at the Deep Water Dock. The Homer Spit is a 4.5-mile long spit separating the inner Kachemak Bay from Lower Cook Inlet (Figure 4). The Kachemak Bay has an average depth of 150 feet, with the deepest part south of the Homer Spit at about 576 feet (Field, and Walker). Kachemak Bay is the site of one of the world's largest tidal ranges, with an average vertical tidal range of 18 feet.

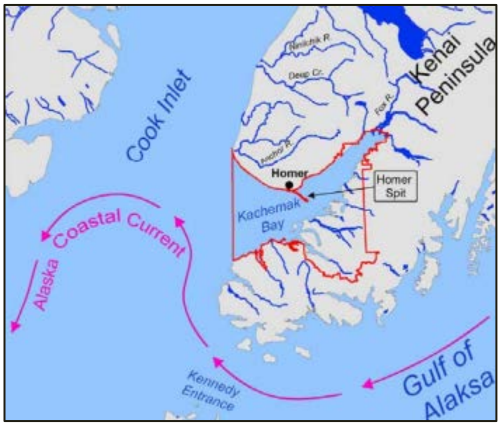

Figure 4: Kachemak Bay

Currents in the Kachemak Bay are influenced by both the tidal range variation and the Alaska Coastal Current (Field, and Walker). Although site specific current data is unavailable, an estimate was made based on extrapolating data from the NOAA testing station in Seldovia. The NOAA current station in Seldovia has measured the average current to be 1.3 knots during the flood tide and 1.0 during the ebb tide. Although, according to a US Army Corps of Engineers Environmental Assessment (USACE, 2007), tidal currents may reach 3 to 5 knots near constrictions (USACE, 2007). Therefore, a conservative current estimate at the Deep Water Dock is 2 knots.

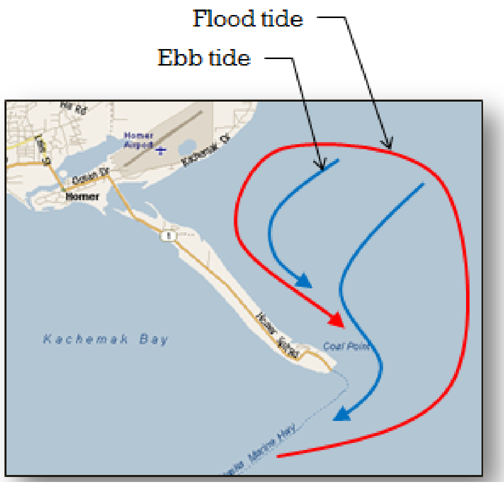

Figure 5: Typical tidal current flow at the Homer Spit

Kachemak Bay is home to a variety of marine mammals and fish. Otters and seals are a common sight on and around the small boat harbor and Deep Water Dock. According to the Kachemak Bay Ecological Characterization, Kachemak Bay is home to otters, minke whales, harbor porpoises, Steller's sea lions, and harbor seals (Field, and Walker).

3.1. Site Visit

On February 22, 2013, the UAA Tidal Energy Incubator Project design team accompanied by Dr. Orson Smith traveled to Homer, Alaska to perform a site visit and discuss various issues and ideas with members of the Homer community. Upon arrival in Homer, the design team met with Community and Economic Development Coordinator, Katie Koester, Port director/Harbormaster, Bryan Hawkins and Public Works Director, Carey Meyer. At this meeting, Mr. Hawkins provided the team with a brief history of the harbor and its current mission in serving the City of Homer.

Mr. Hawkins reiterated that both sides of the Homer Deep Water Dock would be unavailable for use as potential locations for the tidal generator incubator project as these areas are used to moor vessels. Mr. Hawkins pointed out two large beams left over from the wood chip conveyor system. The beams are currently adjacent to, but not attached to the deep water dock and extend from the dock roadway. These two beams would be in a prime location to site the tidal generator project as they are located along the dock roadway furthest from the shore and above the deepest available water, as well as on the correct side of the roadway to receive the incoming tidal stream with little interference from the roadway piles. Mr. Hawkins also told the team that the tide at the deep water dock flows in the same direction - roughly southeast - for both incoming and outgoing tides.

Mr. Hawkins also provided the team with the available as-built structural and electrical documents for the deep water dock and dock roadway. These documents were photographed by team members as necessary. Following this discussion, the design team split into two groups to view the deep water dock and roadway from above and below. Mr. Hawkins and Mr. Meyer escorted one of the groups onto the dock roadway to give team members a top side view of potential project site locations.

Team members observed the two beams previously described by Mr. Hawkins as well as the availability of utility services along the dock roadway. Team members also took pictures of the deep water dock and roadway in order to maintain an accurate picture of the site details. The second group was taken by Port Maintenance Supervisor, Aaron Glidden in the harbormaster patrol vessel to observe the underside of the dock roadway from sea level. During this aspect of the site visit, the dock piles were closely examined, the undersides of the two beams were observed, and the northwest face of the dock roadway was looked over for potential advantages and disadvantages related to designing the tidal generator project. Additional pictures were also taken. The groups then switched places to allow each group a complete view of the site potential.

Upon returning from the visit to the deep water dock, the team met with HEA Engineer, Mike Tracy. Mr. Tracy indicated that connecting the prototype tidal generators to the HEA electrical grid through an intertie would likely not pose any problems for HEA.
At 1:00 p.m., the UAA design team met with the Homer Tidal Energy Incubator Working Group and other community members at Homer City Hall. The design team gave a brief presentation to the working group outlining the project in its current state. The presentation consisted of the organizational structure of the design team, a timeline of how the team planned to move forward with the project including a list of deliverables for the working group, and various design possibilities for the tidal energy incubator project. Following the presentation, a general discussion of the project took place between the working group and team members. At this time, Kachemak Bay Research Reserve Manager, Terry Thompson offered to provide the team with any data his organization had available concerning the conditions at the potential project site. Additionally, Public Works Director, Carey Meyer offered to provide structural and loading information about the deep water dock and dock roadway.

3.2. Existing Site Conditions

Existing site conditions were evaluated during a field trip conducted on February 15, 2013. The extent of the evaluation was a visual determination of the conditions and not a full site inspection.
As-builts provided to the team are included in Appendix D. The visual inspection and input received from stakeholders revealed that two additional 24-inch diameter piles were added next to the dock trestle for previous operations of a conveyor belt. The two additional piles each support two W26x194 beams, spanning from the existing trestle and terminating at the ends of the piles. Measurements of the addition were collected by the Harbormaster's office and provided to the team. A wood-framed, single-story building was also installed on the deck, but was determined that it would not interfere with the installation and operation of the tidal power incubator project.
During the site visit, the team assessed the existing electrical equipment. The current electrical service to the dock is fed by a 24.9Y/14.4 kilovolt (kV) primary to 480Y/277 Volt (V) secondary 150 kilovolt-amperes (kVA) rated pad mount transformer feeding a 600 Amp (A) rated switchboard NEMA 4X/3R type. This switchboard is the main distribution panel and named 'MDS'. Both the transformer and MDS are located at shore. The MDS provides power to the dock via a 225A rated circuit breaker feeding a two inch rigid metal conduit with four #4/0 AWG XHHW conductors. This conduit is routed on the north side of the trestle. These conductors land on the line side terminals of another switchboard rated for 400A named 'DS'. This switchboard is located on the dock itself and provides the power for all loads on the dock and the heat trace for the main water pipe serving the dock.

3.3. Marine Fauna and Flora

Studies have shown that fish have a high chance of surviving a turbine blade collision. A study was done by Steve Amaral, Greg Allen, and George Hecker, on the mortality of fish regarding interaction with power turbines. They reference that fish injuries are usually caused by pressure waves from collapse of gas bubbles from turbine, shear stresses on fish from turbine blade, large pressure gradients that hurt fish as they swim through, and blade strike (Amaral, Allen, and Hecker 2009).

For gas bubbles to be a potential danger there must be a reduction in pressure at or below vapor pressure causing cavitation. This they said, however, will not happen unless the water pressure drops below 60% of the ambient pressure, which would be very unlikely for a turbine immersed in a large body of water (Amaral, Allen, and Hecker 2009). Shear stresses in the area of the turbine may endanger fish as well, although this is mainly a result in conventional hydroelectric turbines where fish are forced through a small area with fast running current and many sharp edges from the turbines. As with the gas bubbles, pressure gradients would be minimal compared with conventional hydroelectric turbines where this is not a significant issue (Amaral, Allen, and Hecker 2009).

Blade strike may be the most variable condition of a test station utilizing many different kinds of turbines and is the area where Amaral, Allen, and Hecker studied the most. When they put fish through a narrow area with a turbine, they found a large correlation between blade length to width ratio and strike speed concerning fish survival rate. Also, the length of the fish played an important role in its survival as well. After sending the fish through the turbine, they put them in a tank for 96 hours to determine what the total survival rate was. For their pilot scaled turbine running at 240 rpm, the survival rate for most fish was over 90% for fish upwards in length of around 8 inches (Amaral, Allen, and Hecker 2009).

More research would need to be done on the density of fish using the deepwater dock channel to determine if the turbine would cause any significant environmental impacts. Also, more research on the effect of turbines on larger salmon of at least 24 inches may need to be completed as the immediate survival rate decreases the longer the fish is (Amaral, Allen, and Hecker 2009).

Research regarding the interaction between whales and large subsurface marine structures is limited. However, there are a few ongoing studies, including one conducted by ORPC Alaska investigating the interaction between marine mammals and tidal energy devices. A presentation made by the U.S. Department of Energy (www1.eere.energy.gov), discussed implementing technology to acoustically monitor whale interactions, which is another potential use for the Homer Tidal Incubator Test Station.

4. Test Station Design Alternatives

4.1. Design and Evaluation Criteria

The following criteria were developed in order to rank and determine the optimum selection of a tidal power test station:

- Functional Performance
  - System must accommodate multiple hydroelectric generator designs.
  - Lifting system must conveniently deploy hydroelectric generators.
  - Must simulate most field conditions and constraints.
  - Must not adversely affect the Deep Water Dock operations.
- Structural Stability
  - Must withstand vertical and horizontal dynamic and static loading in conjunction with corrosion, fatigue, and fracture fail modes.
  - Must provide for protection of instrumentation and data collection devices.
  - Must not adversely affect the structural stability of Deep Water Dock.
- Economical Profitability
  - Operation and Installation costs must be minimized so that facility is affordable for research and developmental use.
- Environmentally Safe
  - System must not leak environmental pollutants.
  - Hydrokinetic devices must not adversely affect the marine life surrounding the test station.

4.2. Summary of Alternative Concepts

The design team held several meetings where alternative concepts were formulated. The initial concept was a facility placed somewhere on the deep water dock. Much of the space along the dock was eliminated in consultation with the Harbormaster and Public Works Director. The end of the dock was eliminated because it is still in use for mooring large vessels, and the shallower end of the trestle was eliminated because the water needs to be deep enough to accommodate prototype tidal generators. During the team's site visit, two beams that protrude out near the end of the trestle were pointed out by the Harbormaster, and have been selected as the most practical location for the testing facility on the dock.

The design team also formulated the concept of having a floating facility that could be moored at the dock so testing could take place either at the dock or at some other location. The team formulated two alternatives for this concept. Either the facility could be built on a large barge that would be more seaworthy, or it could be built on a smaller pontoon barge that would be more mobile.

The alternative concepts are summarized below:

- A permanent facility built at the deep water dock on the two beams protruding out near the end of the trestle.
- A floating facility built on a large barge.
- A floating facility build on a smaller, more mobile pontoon barge.

4.3. Alternatives Analysis

The following section discusses the remaining alternatives that were deemed practical by the constraints of the project.

4.3.1. Alternative 1 - Dock Mounted

The structural support for the trestle mounted cradle system and the instrumentation with system auxiliary equipment housing would be placed on the empty beam sections. These beams are left over from the wood chip exportation project where the conveyor belt loading system rested.

A setup such as a rack and pinion system as depicted in Figure B.1 (see Appendix B) could be used to deploy the testing devices. The system would be equipped with instrumentation and sensors to sense the changing tides. This would allow the system to automatically raise and lower the cradle system in sequence with the tide. The option of deploying the system at a set distance above the bay floor would also be included.

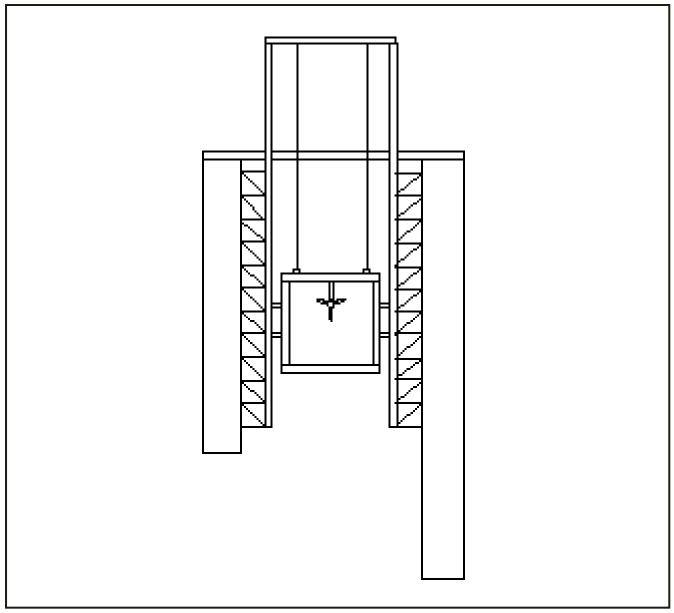

Figure 6: Dock extension from the sawdust operation. These unused beams would ideal for the location of a Hydro Test Station to be mounted on the trestle.

4.3.1.1. Advantages

Revenue: An advantage of attaching the cradle mechanism to the dock is that the revenue generated will be confined to the City of Homer. Researchers who desire to test their devices in the unique conditions of Kachemak Bay can be charged for the time they take to complete their experiments and for the use of the site location that is within Homer's jurisdiction. By attaching the cradle to the dock, the city of Homer could potentially add new employment options for its citizens. The mechanism itself will require maintenance and repairs, both of which can be done by Homer businesses or by the City of Homer.

Interconnection compatibility: A dock mounted system allows for interconnection of the tidal generator output to the city of Homer's electrical grid system. The customer's prototypes could be allowed to run for a period of several months. This free electrical energy is a minor benefit to HEA. The real appeal of a grid interconnection to the project is that it gives the customer a proof of design capability. If a tidal generator was left in place for an extended duration, the power generated could potentially be used for supplementing power to the ice plant.

Use of existing electrical components: The transformer for the dock is serving no other loads and can therefore be utilized as an isolation transformer for the site. This means that the dock mounted option can accommodate a tidal generator with a peak output of around 150 KW without the need for installation of a new transformer. In addition, the main distribution panel is rated for 600A which can accommodate a wide range of possible designs.

Enclosure options: The physical elements of the coastal and ocean environment dictate the protection of instrumentation, data collection system, and the cradle mechanism system. The unused beams of the dock offer simple accommodation by either employing a connex or a simple frame structure. The enclosure would be similar to the existing building located on the trestle.

Secondary use as an ocean sensor test facility: Long-term monitoring of oceanographic conditions is a mission of the Kachemak Bay Research Reserve, based in Homer. This NOAA funded monitoring would be an advantage to vendors of oceanographic instrumentation who want to test new sensor systems in comparison to well-maintained systems operated by the Reserve. The features that would accommodate monitoring of conditions and performance of tidal generators are compatible with this secondary use of a test station fixed at the Deep Water Dock.

Available structure for mounting instruments: The in-place dock structure provides additional options when deciding upon instrument placement and orientation. These additional placement options may allow for better monitoring of site conditions, environmental impact, and generator performance than would be reasonably available with the mobile floating test site option.

Available electrical power: Reliable power is accessible from the HEA grid to provide electricity for the facility and instrumentation system.

Long term monitoring of site conditions: Instruments can be put in place on a permanent or semi-permanent basis, allowing for long term monitoring of the site conditions. This monitoring will take place during tidal generator testing, but can also be performed separate from a tidal generator test in order to increase the baseline data available for the test site. This additional baseline data may be a positive marketing characteristic for potential clients.

Protected location with known site conditions: The project site next to the deep water dock is in a protected location with known environmental conditions. Thus, choosing appropriate instruments and calibrating them for these conditions will be easier than doing the same for the changing environmental conditions found with the floating test site option.

Adding further instruments: If a client or the City of Homer deems it necessary to enhance the existing instrumentation system, placing additional instruments at the test site would be feasible. Additional power would be available, and the existing dock structure along with the deployed instrumentation system would allow for an uncomplicated deployment of further instruments.

Data collection, storage, and transmission: The permanent and land based nature of the project location at the dock allows data generated by the instrumentation system to be collected, stored and analyzed in a protected and in an easily accessible environment. A client would have the ability to observe the testing data in real time as it is being collected and analyzed by the instrumentation computer in the sheltered laboratory. The client could also extract data for further transmission or analysis at any time. Additionally, if further transmission of data is required by a client, internet access at the dock site is readily available.

Site conditions: One of the benefits for researchers in testing their designs in application type conditions is for design flaws and weaknesses to be analyzed. This permits the researcher to alter the design until satisfactory test results are obtained; saving capital that would have been lost if the flawed design had been marketed. In order for testing facilities to attract researchers they must simulate actual operating conditions. In tidal power generation the velocity, direction, and sediment content of tidal currents is of crucial importance. Since Kachemak Bay has a significant silt content and seasonal presence of frazil and brash ice it is not a mitigating decision factor in the stationary and mobile test station options. The above variable conditions are ideal for testing devices in a real world environment.

4.3.1.2. Disadvantages

Moderate and unidirectional current: The location of the Deep Water Dock produces a unidirectional flow with a peak mid-tide velocity of around two knots. Two knots (one meter per second) is generally considered the minimum current velocity necessary for testing hydrokinetic devices (Johnson, 2010). The low velocity current with the dock mounted option leaves uncertainty as to whether or not significant interest in testing devices at the dock is realistic. On the other hand, rural coastal communities that install micro-hydropower systems of 100kW or less to supplement other power generation mechanisms may be well-represented by the conditions at the Deep Water Dock.

Higher freeboard: Kachemak Bay has a tidal range of approximately 18 ft. This relatively large tide range makes the Bay an attractive place to test tidal power generators and also presents additional difficulties in the design of the mounting system for testing devices. The testing devices must be kept beneath the trough of the waves, and preferably at a consistent relative position to either the water surface (floating systems) or the seabed (bottom-mounted systems). Testing floating systems requires that the mounting system be capable of fluctuating with the tide change. In addition to this challenge, the full extension of the cradle mechanism for yearly low tides requires a larger system to accommodate the reach.

Instrumentation maintenance: Permanently deployed instruments would require significant effort to calibrate and replace. Some instruments may be placed underwater either at the dock or some distance away. These instruments would be less accessible for maintenance than the equivalent instruments in a floating test site system.

4.3.2. Alternative 2 - Floating

This is a major alternative with two variations: flat-deck barge and pontoon barge. Both could be kept afloat and be moored at the Dock for testing there or moved to a location with stronger tidal currents or other conditions different from those at the Dock. The pontoon variation might even be designed for disassembly and transport by truck for use at a river site.

A floating system based at the dock would have a cradle mechanism and instrumentation housing implemented on a watercraft that could be towed to other locations. The cradle mechanism on the floating option would keep the test tidal generators at a consistent depth below the waterline as the craft's vertical position relative to the water would not change.

4.3.2.1. Advantages

Use of trestle electrical interconnection system at Homer only: By implementing a marine electrical connection system the floating option could utilize the interconnection to the Homer power grid allowing for the respective inherent benefits of the dock mounted option. However, this benefit would be restricted to the vicinity of the deep water dock, and limited by the length of the marine electrical connection system.

Transportation: To accommodate additional research conditions and locations, the floating designs would be capable of sea transportation.

Instrumentation access: Periodically instrumentation needs to be calibrated and repaired or replaced. Because the floating design options will require a method of deploying and retrieving the in-water instrumentation, required maintenance will be easier to perform.

4.3.2.2. Disadvantages

Generator system required: Due to the remote nature of the floating options, portable electrical generation will be required. Electrical power is necessary to run the monitoring devices for the testing system and testing equipment for the proposed testing facility. Both floating options would only be able to utilize HEA power at the Deep Water Dock, and would require an onboard power generation system. For the addition of the generator system, fuel transportation and explosion prevention design considerations must be made.

Anchoring system: To properly and safely anchor a barge so that operations and testing of equipment may begin, the barge must be both stable and able to retain a specific position and orientation as determined by the needs of the tester. Anchoring systems for barges vary only slightly from well-established anchoring systems for small boats. If a barge were to be anchored in the traditional single anchor method, the position and direction would be set by the currents and wind. With the layout and orientation restraints of the cradle mechanism, the preferred method of anchoring would be to either use a two-anchor or four-anchor anchoring configuration.

Unknown site conditions: Because of the lack of continuity at a testing location the site condition would only be moderately known. Repeated testing at one site, such as the deep water dock, will build up a collection of site condition data. This data would enable the clients to know exactly what conditions their prototype tidal generator will encounter. Of course the floating option could be taken to the same locations repeatedly, but site condition data taken at a few sites will be less accurate than repeated testing at just one site.

Deploying/retrieving instruments: Just as the floating option has an advantage in being able to readily deploy and retrieve instruments, it also has some disadvantages. Every time the floating facility is moved, the instruments will need to be retrieved, stored, and then deployed at the new site. The instruments could remain in place at a permanent facility, only needing to be moved when necessary. Retrieving and deploying instruments also entails attaching some mechanism to the floating facility to do the work, which adds complexity to the design.

Data storage/collection: Data collected by the instrumentation will need to be stored and retrieved by the clients. This system is a challenge because the data will either need to be stored while the test is taking place and later retrieved or transmitted from the floating facility to an onshore computer. If the data is to be retrieved it would entail either the client visiting the floating facility at regular intervals to download the data, or downloading it after the test is complete. There may be issues with this method because while the facility is out at sea, a problem could occur with the test that would render the data unusable. Transmitting the data from the facility presents a large design challenge, and would require access to a network of some type that may not be available throughout the Cook Inlet.

Long term testing: The client may want to test their prototype tidal generator over an entire lunar cycle to expose it to a variety of tidal conditions. This presents a challenge for the floating option because it will need to remain at sea and anchored in place through a large range of weather and sea conditions. If the conditions get too bad a long term test may need to be aborted in order to protect the vessel and tidal generator from being damaged.

4.3.3. Barge

A typical flat deck ocean barge would be retrofitted to secure an excavator for deploying hydrokinetic devices and marine instrumentation. A connex retrofitted for housing instrumentation and data collection and a marine grade generator with a fuel tank would be placed on the barge opposite from the excavator. The dredge barge in Figure 7 represents the barge testing station with the placement of the instrumentation housing and power generation system substituting the rock collection.

A bracket system would be attached to the excavator arm in the place of the bucket. The testing devices would be deployed using the existing excavator controls. The instrumentation and power feeds would be secured along the excavator's arm from the devices to the onboard processing center.

Figure 7: Dredge Barge with Excavator for cleaning Channel; similar to the cradle mechanism the for barge option. Retrieved from www.hcmm.com.my.

4.3.3.1. Advantages

Stability: Though most barges are used in river and lake environments, coastal barges also see some degree of success. When anchored near the shore, the flat-bottomed design of the barge provides enough stability to prevent it from capsizing. Likewise, due to the large size of the hull, the barge offers more carrying capacity in comparison to the pontoon, which lacks storage capacity and has an increase chance of capsizing in rough waters. Also, most barges were designed to ride the waves instead of crashing into them, which when added to their already structurally sound design, provides stable platforms upon which research can be completed.

Excavator utilization: The flat deck barge option allows for the simplification of the cradle mechanism design by utilizing an excavator to deploy the hydrokinetic device and instrumentation as depicted in Figure 6. This is done simply by positioning the excavator on the end of the barge to lower the testing device into the tidal current with the excavator arm.
Use of trestle electrical interconnection system at Homer only: By implementing a marine electrical cabling system the flat deck barge option could utilize the interconnected to HEA's would be restricted to the vicinity near the deep water dock and limited by the length of the

marine electrical cabling scheme.

Barge application flexibility: A barge outfitted with a cradle mechanism may serve a larger purpose than just testing tidal generators. In the event that tidal generator manufacturers find the incubator less popular than expected, the barge may be used for alternative purposes in areas of academic research. Also, the flexibility of a barge to be used for various purposes allows purchased used barges to be refitted for the purpose of the project.

4.3.3.2. Disadvantages

Barge availability: Though barges are common, it may be difficult to find the correct size and type of barge for the project in Alaska. A seller for this type of barge could eventually be found if a used barge is preferred. Transportation from another part of the world may be necessary to obtain a barge, which would add a significant cost to the project in time and fuel. A larger barge found locally would also be an extra expense and would also take up precious dock space as large barges are usually not capable of effective grounding for storage purposes. Depending on the size and availability of barges available for sale, a custom barge may have to be commissioned. A custom barge would enable the team to design specific requirements for the size and function. In any case, an existing barge can also be modified to meet the requirements of the design.

4.3.4. Pontoon

The pontoon option would resemble a catamaran style flat deck barge with the center open to allow for the deployment of the cradle system as depicted below in Figure 8. This pontoon would be custom designed to meet the design constraints and objectives. The cradle system could be mounted directly over the void in deck and could resemble the rack and pinion system in Figure B.1, see Appendix B.

Figure 8: Model of pontoon testing setup.

4.3.4.1. Advantages

Symmetric loading: The separation of the pontoons in the catamaran design is convenient for the implementation of the cradle mechanism for mounting the testing devices. The position of the cradle mechanism and attached device in conjunction with the identical pontoons yields symmetric loading. This system provides excellent stability and requires fewer complicated design calculations.

Land transportation: In addition to being transported by sea, the pontoon could be designed to be disassembled and trucked to river locations throughout the state on the road system for testing.

4.3.4.2. Disadvantages

Custom fabrication: The cost of custom manufacturing versus production manufacturing is drastically more expensive. In this case the design constraints of the pontoon barge would increase project cost.

Spatial weight challenges: The placement of fuel and the generator creates potential spatial weight challenges with meeting the size limitations of a river testing operation. These spatial weight challenges may also be detrimental to the general stability of the craft.

5. Test Station Final Design

5.1. Design Assumptions

For the purposes of the preliminary design, several conservative assumptions were made with regards to hydroelectric generator size, geometric profile, and weight. The design assumptions are as follows:

- Circular Cylindrical body orientated with circular cross-section perpendicular to direction of flow.
- Maximum diameter = 10ft.
- Maximum length = 10ft

5.2. Structural Support

In conjunction with the cradle mechanism, the structural support must be able to withstand the additional loads placed upon it by the testing of a tidal generator. These loads include dead weight of the generator and cradle frame, live load due to current flow, load due to ice buildup, live load due to wave action, load due to harmonic motion of the generator, as well as loads such as buoyancy and debris impact. The following assumptions were made in order to accommodate multiple tidal generator designs and allow for the maximum range of designs.

- Maximum vertical load = 30,000 lbs
- Maximum horizontal load = 14,000 lbs

Using finite element analysis, the team was able to build a model of the existing dock and determine whether the existing conditions provided the required load resistance. This finite element model was constructed using a program called SAP 2000. Following analysis and several discussions with faculty advisors, it was determined that only minimal loads due to the addition of the tidal power incubator facility were to be transferred to the existing trestle and dock.

Taking into consideration that the dock modification could not obstruct traffic, it was determined that a deck would have to be constructed atop the existing beams in order to allow room for the shelter as well as provide a working surface for tidal generator experiments. In addition, it was determined that a cantilever extension would have to be added to the ends of the beams to allow extra working space. The cantilevered extension was designed to withstand the same loads as those placed atop the beams. The cantilevered extension would have to be constructed of steel c-type channel and welded to the existing dual W36x194 beams. The beam connections were analyzed and it was determined that a gusset plate would be required to connect the existing beams to the added cantilever c-type channels.

Following an investigation of the existing connection details, it was determined that the connections that currently exist to support the extended W36x194 beams do not have adequate capability to support the additional weight of a deck, let alone a cradle mechanism structure and live loads such as foot traffic and forklift operations. It is recommended that a full structural inspection be completed and additional bracing be provided to the existing connections.

Weighing the available options, and comparing them to the design criteria, it was decided that the easiest approach to adding decking would be to use the same type of pre-stressed concrete decking on the trestle and extend it outward atop the beams to allow working space. The pre-stressed concrete decking is measured at 4’-0” in width and would need to span the distance of 35’-0” (identical to the existing trestle width and span).

It is required that the testing station provide a shelter where equipment testing and monitoring would take place. A conceptual sketch of a shelter is provided in the drawings in Appendix C.

Figure 9: Extended beams previously used to support conveyor system

5.2.1. SAP 2000 Model

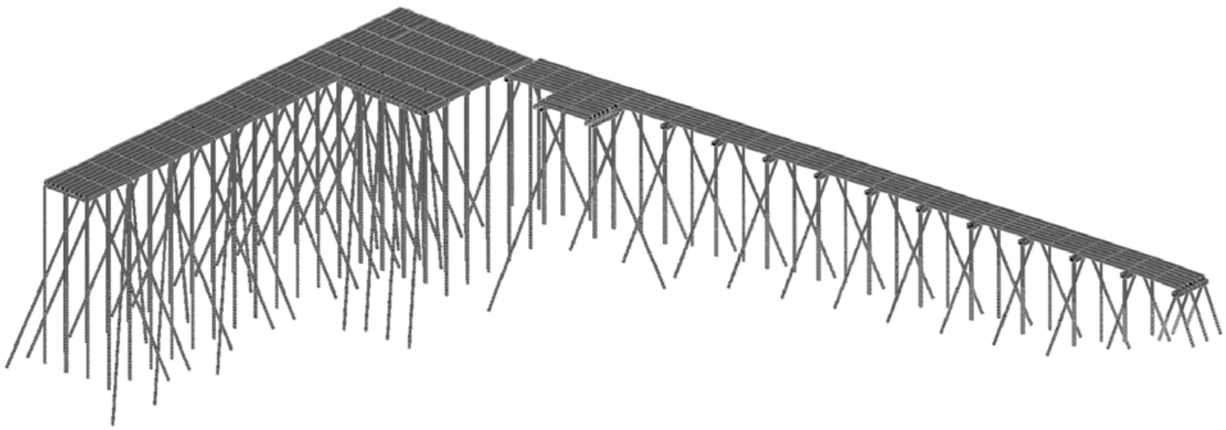

Figure 10: SAP 2000 Model of the Deep Water Dock

A SAP2000 model was built to determine if the extra loads from the test station and tidal generators would adversely affect the structural integrity of the dock. For this model of the structural components of the dock, components were kept as close to real as possible with the entire dock considered. The as-builts were used to model the dock in 3D and to define elements as realistically as possible.

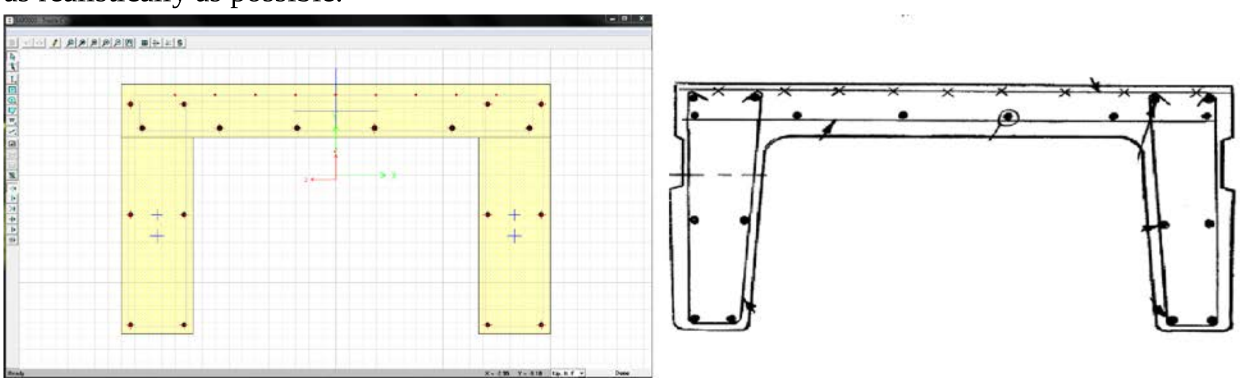

Figure 11: Comparison of defined model cross section vs. the as-built cross section trestle concrete C beams.

After the structure elements were modeled and defined, it was necessary to apply boundary conditions to simulate stiff soil, rigid connections, and other various physical properties of the Homer Deep Water Dock. Boundary conditions are necessary in order for the dock to behave realistically under applied loads and representative element internal stresses to be determined. Element mid-lines had to be matched up with the center of area midpoint of each element so that forces would transfer properly. Joint constraints were used in tandem with very stiff connecting elements to simulate structure connections when the area midpoints did not align.

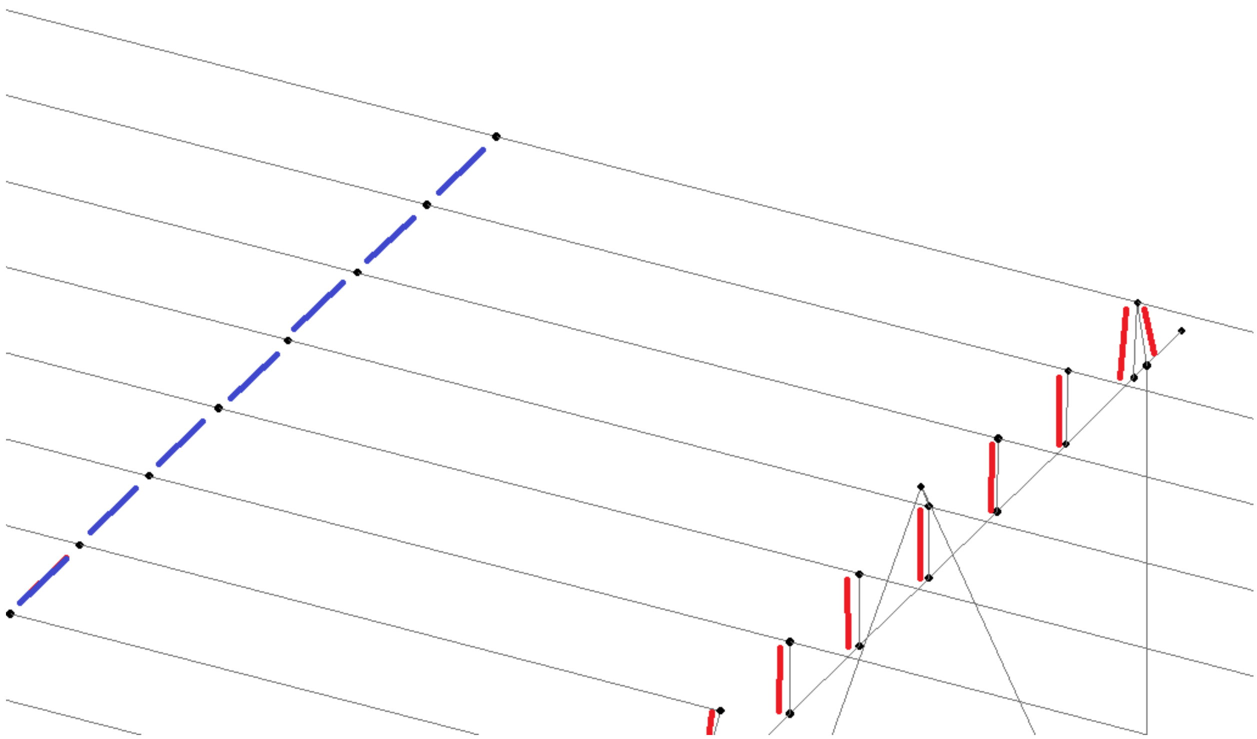

Figure 12: Joint constraints (blue lines) are not graphically shown in the model yet ensure that the distance and rotation between nodes (black dots) does not change and are the most accurate method of implementing element (grayscale lines) connections. Very stiff elements (parallel with red lines) are slightly less accurate than joint constraints and it is much more efficient to create the model utilizing this method of connecting elements.

Load cases were assigned utilizing ASCE-7 Load Resistance Factor Design load combinations 2 and 5, modified to include fendering energy from the dock fenders, current, breaking wave, ice, and cradle mechanism to find the increase of force intensity of stress on the dock from the cradle mechanism vertical and horizontal loads. SAP2000 influence lines were utilized to determine the most significant area to place forklift and truck loads. Included loads on the structure considered include dead, fendering, live, ice, breaking wave, current, forklift, earthquake, and cradle mechanism loads.

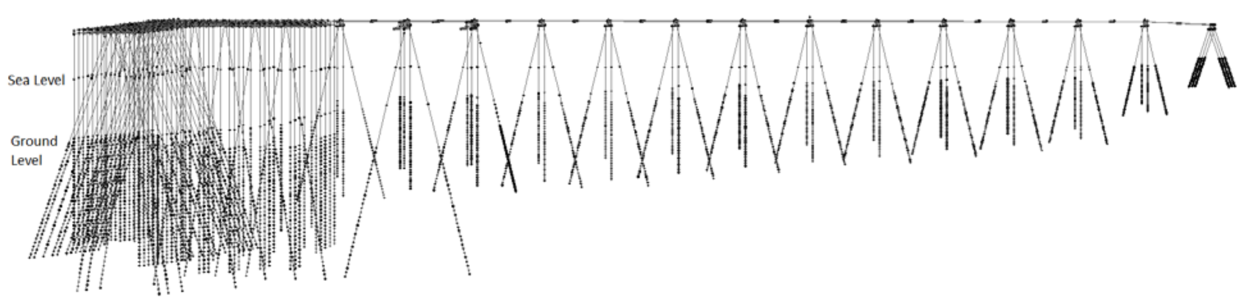

Figure 13: Side view of the SAP2000 model with Sea Level and Ground Level nodes

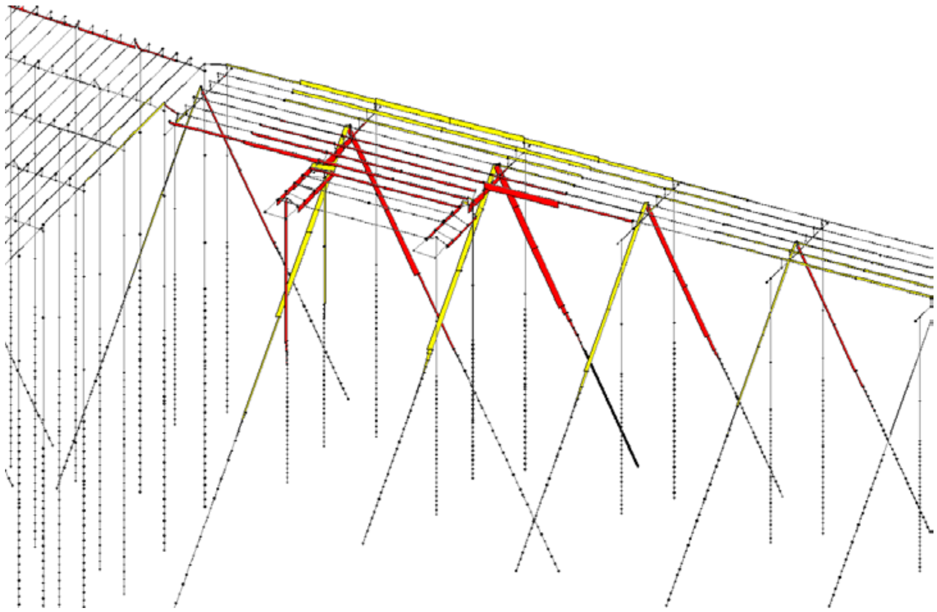

Figure 14: Axial force from only the cradle mechanism load case. Axial is the force that pushes or pulls along the axis of the element and stretches or crushes the piles.

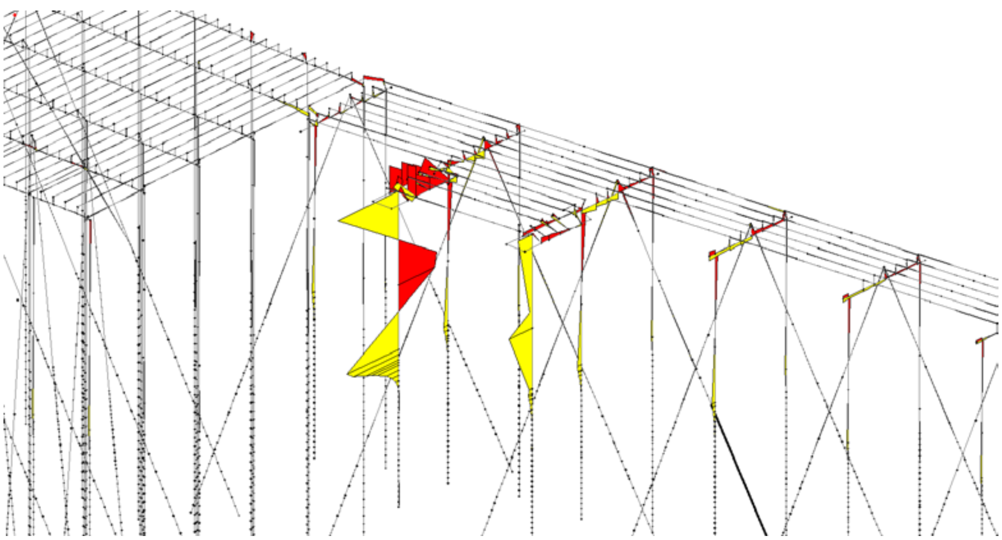

Figure 15: Bending moment force around one axis from only the cradle mechanism load case. Bending moment is the force that bends the inside of the element outward.

After the analysis was completed, differences in force between each load combination with and without the cradle mechanism load were found. These differences were divided by the cross-sectional area multiplied by the strength;

$$\%\ Increases\ Relative\ to\ Nominal\ Strength\ of\ Element = \frac{(Increase\ in\ load)}{Fy * A}$$

where Fy = Strength of Material and A = Cross Sectional Area of Frame

Maximums of each type of element were considered with this method for bending moment forces in both directions and axial force. Vertical pile % Increases did not exceed 5%, diagonal pile % increases did not exceed 2.5%, and trestle C beam % increases did not exceed 2.5%. These are very low values in comparison with the strength of each element and it is unlikely that a complete overhaul of the Homer Deep Water Dock for the increased load from the test station would be required. However, this analysis did not consider the connection from the metal piles to the concrete beams or potential local stresses on each element from the cradle mechanism. Therefore, it is highly recommended that a licensed structural engineer consider issues like this to ensure the structural integrity of the dock.

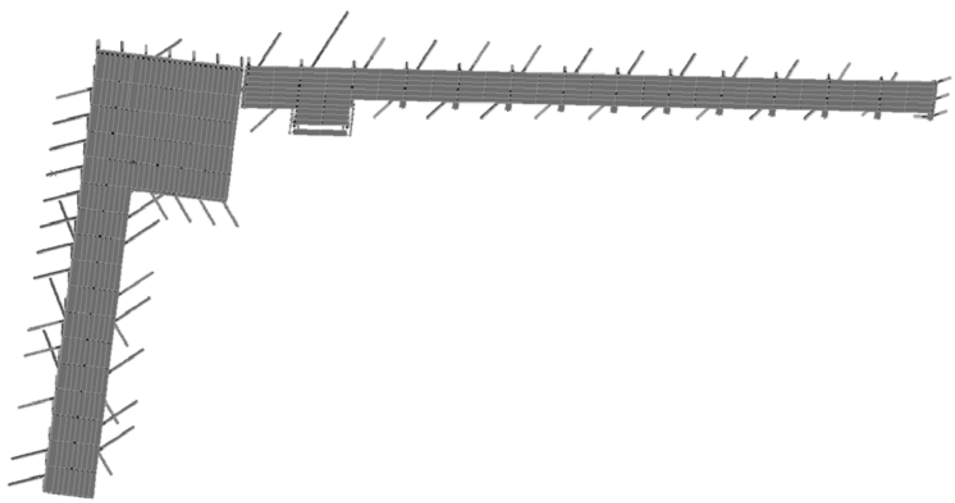

Figure 16: Aerial extruded view of the SAP2000 Homer Deep Water Dock model.

5.3. Cradle Mechanism

5.3.1. Cradle Mechanism Design Alternatives

The wave currents surrounding piles at the selected testing site produce drag forces that prevent testing devices from operating properly without structural support. Two design scenarios were proposed to meet this performance need and were evaluated. One option was a rail system attached by webbing to the existing piles which will be referred to as the ‘Static Rail System’, where the cradle would slide vertically into and out of testing position. The second option was a collapsible rail system (Sliding Rail System) which would extend and contract with the deployment of hydrokinetic generators. Figures 11 and 12 provide descriptions of the Sliding and Static Rail Systems respectively.

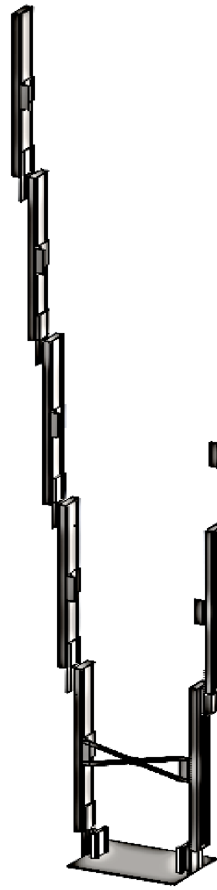

Figure 17: Sliding Rail System.

Since bearing and wheel systems are susceptible to failure from both corrosion and suspended sediment prevalent in Kachemak Bay, low friction contact pads were selected to provide for vertical translation. This allows for the use of standard steel channel sections for the rail system.

5.3.2. Static Rail Description

The Static Rail System utilizes welded webbing to support the rails in which the cradle's Teflon pads slide. The rails are aligned vertically with great precision and the web is placed and varied as required for alignment. Evaluation of the rail system design's characteristics yielded the following advantages and disadvantages:

- Advantages
  - Simple Construction.
  - Structural Stability, limited effects of vortex shedding.
  - Minimization of material use.

- Disadvantages:
    - Permanent subsurface structure
    - Underwater construction.
    - Slight obstruction on surface activity.

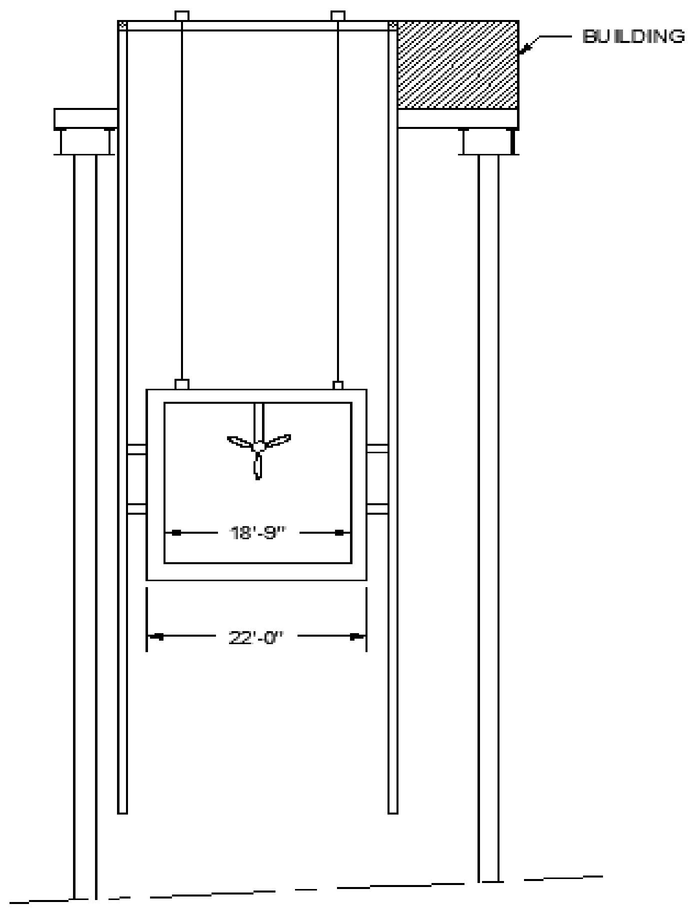

Figure 18: Front elevation of cradle and static rail system.

5.3.3. Sliding Rail System Description

The Sliding Rail System is cantilevered from above the testing station deck and extends into the tidal flow. The system is composed of several interdependent sliding sections. When fully extended it spans approximately 50 feet into the tidal flow. The stress is translated along the individual sections and concentrated above on the station's main structural support.

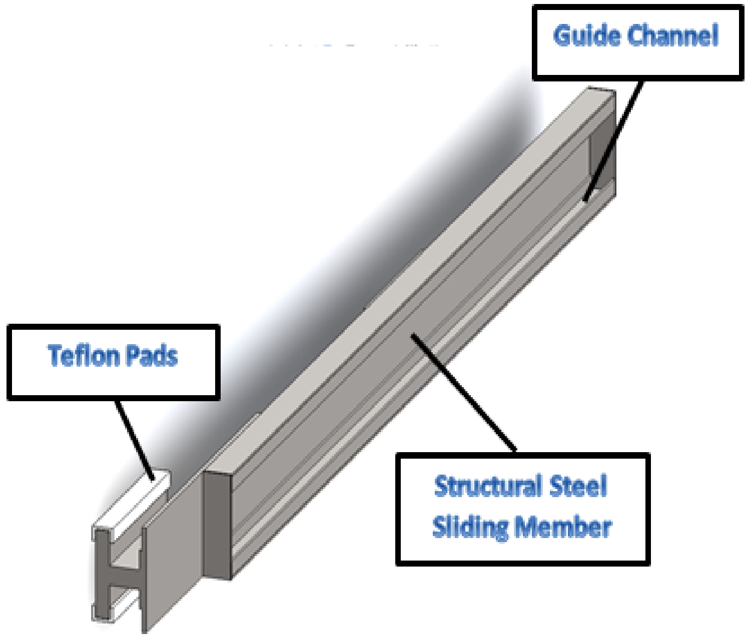

Figure 19: Solidworks model of sliding system's rail member.

While evaluating the Sliding Rail System's characteristics the following advantages and disadvantages were produced:

- Advantages
    - No underwater construction.
    - Convenient maintenance of entire system.
    - Simple construction.
- Disadvantages
    - Complex design.
    - Vortex shedding presents a limited risk
    - Requires complex analysis.
    - Restricts testing device variability.
    - Requires large safety factor.

5.3.4. Option Selection

Since actual research and development designs can potentially come in any geometric profile this makes the calculation and modeling of harmonic loading extremely complicated. The time for performing this harmonic loading analysis is not available so designing the Sliding Rail System would require increased material usage for preventing system failure. This increase in material increases both the construction and operation costs. Because of the effects of harmonic loading the Sliding Rail System design was eliminated. The Static Rail System was chosen for its simplistic design characteristics.

5.3.5. Cradle Design

The cradle on which the perspective hydrokinetic devices would be deployed spans approximately 25-feet. For design purposes the maximum vertical device load on the cradle was assumed to be 30,000-lbs since literature searches yielded no realistic basis for the design load. The cradle system has the potential for multiple device configurations either mounting from the upper or lower beams.

As seen in Figure 13 the cradle's main frame section is a design of 14"x14"x5/8" square beam section with welded joints. The Teflon bearing system is connected with a linear plain bearing for dissipating any moments that would cause stress concentrations on the Teflon pads. The bearing mount is custom design using Solidworks since no suitable mounting system is available on the market. The bearing mount is designed to disassemble for maintenance convenience using a bolt design that permits disassembly while the cradle is operation position.

The cradle frame, Teflon bearing, and bearing mount were analyzed for stress concentrations using Solidworks Simulation Software. Based on the analysis results the components' designs were optimized for structural integrity and material optimization.

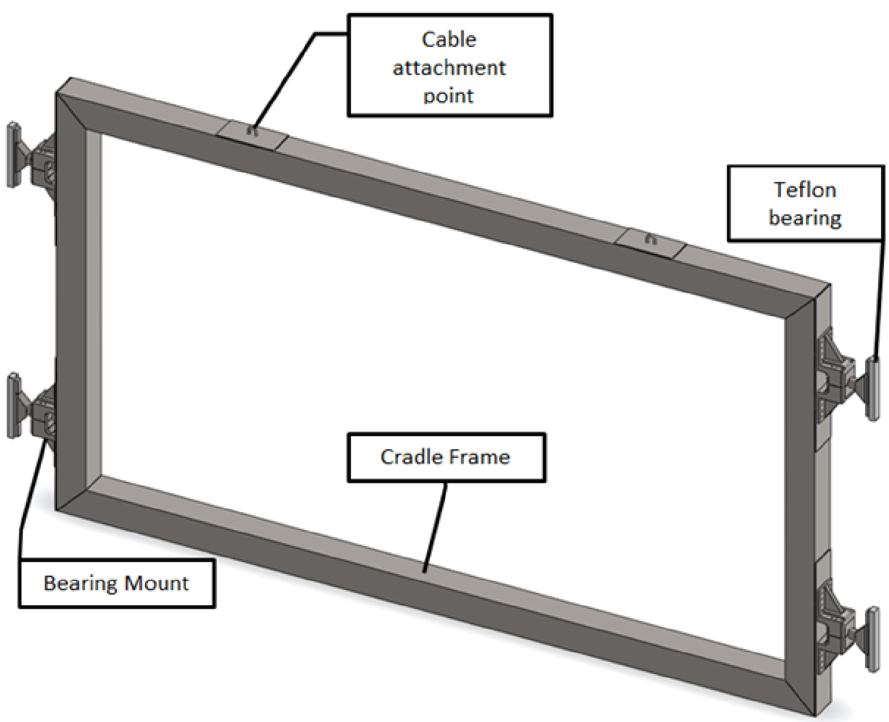

Figure 20 - Solidworks cradle model.

5.3.6. Rail Design

The rail static rail system was designed based on a Finite Element Analysis performed using Solidworks Simulation. The rail members are to be constructed of W 5x19 I beams to allow for webbing connection to the flanges on one side of the I beam web. Opposite from the flange webbing connections the slide support operates in the I beam's channel as shown in figure 17.

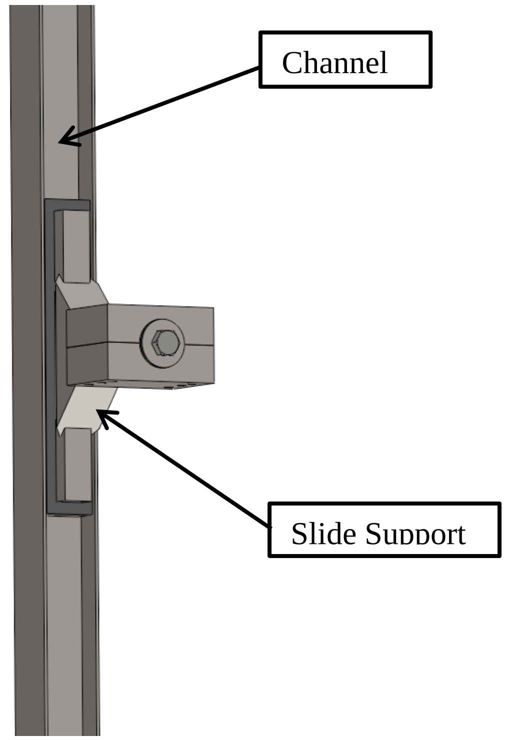

Figure 21: Soldworks model of Slide Support with I beam section channel; cradle rail system.

5.3.7. Cradle and Rail System

The complete assembly model of the Cradle and Rail System minus the webbing support is given below in figure 19. The cradle slides vertically up and down the rail via the slide supports fastened to the cradle frame. The rail itself is attached to the dock piers, where the existing structure will provide added stability. The winch system provides the vertical displacement.

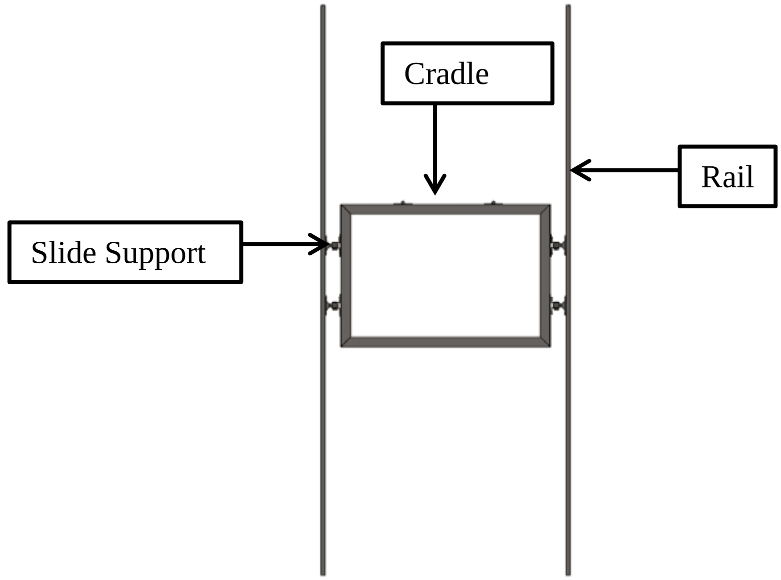

Figure 22: Solidworks model of cradle and rail system.

5.3.8. Cradle Winch System

In terms of winch design, there are three main options available to the consumer; electric drive winches, electro-hydraulic winches, and hydraulic drive winches. Each winch has its own advantages and disadvantages.

The electric drive winch is a relative newcomer to the market, and already has proven to be a viable alternative to electro-hydraulic and hydraulic winch systems. Consisting of components such as variable frequency drives, AC induction motors, reduction gearboxes, sensor feedback and control systems, the electric drive winch is much preferred by newly constructed science and commercial fishing vessels. This is due to the electric winch's propensity to reduce energy consumption and the need for maintenance in its lifespan. Furthermore, electric winch systems are relatively quiet, and are the least likely to disturb marine life in their native habitats. Leakage of hydraulic oil is also not an issue, further reducing the chance of pollution within the environment.

- Advantages
  - Reduced energy consumption
  - Reduced maintenance
  - Less noise
  - Precision control
  - No hydraulic fluids
  - High efficiency
  - Lightweight
- Disadvantages

- Less spare parts to be found for repair
- Requires trained electrician to perform periodic inspections
- Limited to specific suppliers

In contrast to the electric drive winch, the electro-hydraulic winch is a veteran in the field of marine exploration. It is preferred by many companies due to its reliability and adaptability to various operating conditions. In addition, the electro-hydraulic winch is simple to maintain and operate, while still possessing the precision control necessary for it to compete with electric winches. Most electro-hydraulic drives compose of a hydraulic power unit (HPU), a hydraulic motor, a sensor feedback and control system, along with cooling and braking system.

- Advantages:
  - Reliable
  - Adaptable to various operating conditions
  - Simple to operate and maintain
  - Precision control
- Disadvantages:
  - Low efficiency
  - High energy consumption
  - High installation costs
  - Potential leakage of hydraulic fluids

The final option, the hydraulic drive winch, is similar to an electro-hydraulic drive in almost every way. The only major difference is that a hydraulic winch uses one HPU to power various hydraulic motors, whilst the electro-hydraulic winch powers only one. This has led to the hydraulic winch possessing less system volume and mass than its hybrid counterpart.

- Advantages
  - Reliable
  - Cheaper to install than hydraulic winch
  - Easy to maintain
- Disadvantages
  - Noisy
  - Heavy
  - Potential leakage of hydraulic fluids
  - Total system mass is higher than the other two options

All factors considered; we believe that an electric winch would work best with our cradle mechanism. The combination of low cost, reliability, and low environmental impact ultimately swayed our decision.

We looked at a variety of suppliers for potential winch selections. We decided on a few that looked the most promising and chose them based on the criterion shown below.

Homer Marine Hydrokinetics and Instrumentation Testing Station - Winch Selection							
Decision Matrix							
Manufacturer	Load Ability	Lift Speed	Braking System	Motor	Safety Features	Estimated Cost	
David Round	3	3	3	3	3	1	**16**
Allied Power Products	3	2	3	3	3	1	**15**
Appleton Marine	3	2	2	1	3	2	**13**
Blue Ocean Tackle	1	2	2	1	2	3	**11**
Coastal Marine	2	2	3	1	3	2	**13**

Poor	Nominal	Good
1	2	3

Figure 23: Winch selection decision matrix.

We chose our criterion based off the projected specifications for the winch. The load ability was how close the winch could lift our estimated load of 30,000 lbs. The lift speed was determined on the basis if it would fit our desired speed of lower than 1 foot per minute. The braking system is necessary to prevent the cradle from freefalling. An efficient, powerful motor was desired, along with various safety features that made the winch safe to use and of less risk to its crew. Finally, an estimated cost was done based on the winch and its various components.

Suggested Winch: David Round 203 Series

- Custom built and specifically designed for its intended project.
- Can be fitted to a wide variety of circumstances.
- Utilizes a highly efficient electric motor.
- Safety mechanisms such as motor brakes come prebuilt.
- Motor brakes to hold suspended loads.
- Other safety devices available for the client to select.
- Single line capacities from ¼ to over 50 tons.
- Capable of lifting loads at various speeds.

A general cost estimate for the 203 Series is hard to come by. This is due, in no small part, to the fact that these types of winches are custom made for specific clients. Thus, it is extremely hard to find a range of set values for these winches. However, research done on similar winches yielded a price tag of several tens of thousands of dollars, assuming that all components, including nonessential ones are added. If a bare kit is what is deemed more suitable for the project, then the cost will be significantly less.

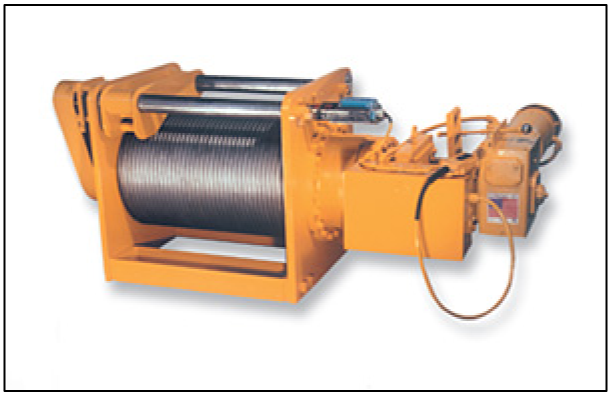

Figure 24: David Round 203 Series Marine-grade Winch.

5.4. Power and Electrical

Perhaps the most challenging aspect for designing the interconnection was the lack of a specific tidal generator. In general an interconnection will be designed with an exact generator source in mind because each type of generator will have different electrical signal characteristic and will need different power conditioning. Therefore the interconnection design seeks to meet the most general requirements in hopes of providing for the needs of the widest range of possible tidal generators.

5.4.1. Power Rating of Interconnection

In order to determine the design requirements of the interconnection it was necessary first to calculate a theoretical maximum power output at the site. The Institute of Electrical and Electronics Engineers (IEEE) provides design guidelines for renewable resource interconnection up to a maximum capacity of 10 Megawatts (MW) (IEEE, 2003, p. 2). An interview with a HEA power engineer lowered this figure to 1 MW. The reason was that 1 MW is the capacity of the distribution network from the utility substation to the Homer Spit (Tracy, personal communication, February 22, 2013). This capacity, however, is far over the working groups proposed perimeter's for the facility.

In order to reduce capital costs to both HEA and the City of Homer the existing onsite transformer will serve as an isolation transformer for the interconnection. The transformer has a capacity of 150 kVA; therefore the maximum rating of the interconnection was further reduced to match this capacity. A design was undertaken to accommodate that capacity.

A further analysis of the Kachemak bay tidal ebb and floods concluded that a maximum current at the deep water dock in units of meters per second (m/s) is $v \approx 1.03\ (m/s)$. The theoretical energy flux of flowing water in units of Watts per square meter (ψ) can be calculated as…

$$\psi = \frac{1}{2}\rho v^3 = \frac{1}{2} * 1029 * 1.03^3 = 562.21\ (W/m^2)$$

… Where the average density of sea water in units of kilograms per cubic meter is $\rho \approx 1029\ (kg/m^3)$.

The distance between sea floor and the Mean Lowest Low Water (MLLW) in meters at the proposed generator cradle apparatus on the Deep Water Dock is $B = 5.4864\ (m)$. The lowest historical observed water level in the bay in meters is $L = 1.588\ (m)$ below MLLW. The area 1.5 m above the sea floor is not suitable for a tidal generator due to the likelihood that it will encounter high sediment levels. Therefore the maximum height available for a tidal generator in meters at the dock can be calculated as…

$$h = B - L - 1.5 = 5.486 - 1.588 - 1.5 = 2.398\ (m)$$

The cradle mechanism is designed to accommodate a 10 foot wide generator or $w = 10\ (ft) = 3.048\ (m)$ wide device. Therefore the total area available for power generation in square meters is, (A)…

$$A = h * w = 2.398 * 3.048 = 7.309\ (m^2)$$

…and the theoretical maximum energy (E_{max}) in Watts that can be produced is…

$$E_{max} = \psi A = 562.21 * 7.309 = 4109\ (W)$$

Thus the interconnection was designed to accommodate at a minimum this value. HEA currently restricts the maximum rating of an interconnection to 25 kVA. The theoretical maximum is below this range therefore it is in compliance with HEA's requirements.

5.4.2. Interconnection Components

The electrical signals produced by tidal generators are similar in characteristics to power signals produced by wind turbines. Thus the design of this interconnection utilizes wind turbine interconnection technologies. A wide variety of inverters and rectifiers are available on the market that will meet the design and functional requirements of the facility. Provided with this report are examples of such devices, and the justifications for these particular models will follow in the report.

The functional requirements of the interconnection are defined by three main publications: HEA's "Electric Service Requirements (Service Assembly Guide) 2009" (HEA, 2009) which for the most part is derivative of IEEE standards 1547 and Underwriters Laboratory (UL) standard 1471 (IEEE, 2003; UL, 1999) . Both latter publications list numerous design requirements which are not applicable to an interconnection of this limited size and simplicity. The main focus of these publications is to limit the impact of the distributive resource (the tidal generator) on the local electrical grid.

The proposed design seeks to satisfy these requirements. Appended to this report is a proposed electrical one-line diagram (see Appendix C) where in electrical connection of the interconnection devices are shown. The following lists various points on the one line (as indicated by hex note symbols on the drawing) and what functional requirements are met at those points:

1) Site Transformer:
The Equipment Grounding Conductor from the inverter must be physically connected to the grounding electrode system at the site transformer. This installation requirement insures that the utility and facility grounding schemes are integrated; which insures that the overcurrent and ground fault protection systems of the facility and the utility will operate correctly (IEEE, 2003, p. 6). The Site Transformer also serves no other load besides the facility, this fulfills HEA's requirement for a dedicated distribution transformer (HEA, n.d., p. 5).

2) Manual Disconnects and Bi-directional Meter:
HEA requires the installation of a bi-directional meter (HEA, n.d., p. 3). HEA personal will need to periodically work on the service meter, therefore a manual disconnect that is lockable in the open position will be installed between the differing types of meters (HEA, n.d., 2) . This will isolate any power that may happen to be generated from the tidal generator from appearing at the service meter. HEA personal will also need to work on the bi-directional meter. Therefore an additional disconnect will be installed on the generator side of the bi-directional meter (Hibberd, personal communication).

3) Inverter:
The Inverter fulfills many design requirements and is the main 'workhorse' of the interconnection. The inverter specified in this report is UL 1471 listed and operates by line-commutation (White, personal communication). The main function of the inverter is to provide a clean power signal to the grid. A clean signal has the following characteristics: Output voltage to be maintained within ±5% of the nominal voltage (IEEE, 2003, p. 6); frequency to be maintained within 60.5 to 59.3 Hertz (Hz) (IEEE, 2003, p. 8); DC injection current not to exceed 0.5% of full rated output current of the tidal generator (IEEE, 2003, p. 9); total harmonic distortion not to exceed 5% (IEEE, 2003, p. 9); the power factor must be maintained to a value no less than 0.9 (HEA, 2009, p. 22).
If HEA loses power the tidal generator must not put power onto the utility electrical grid. Because the inverter is line commutated it is not capable of inadvertently energizing the utility electric grid. A line commutated inverter requires a source voltage signal in order to operate. If HEA loses power the inverter will lose its voltage signal for synchronization and disconnect the generator power from the utility grid.
When HEA power is restored it is required that the tidal generator not be reconnect to the electrical grid until that power has been maintained for a minimum of 5 minutes (HEA,

n.d). The inverter is programmable via a software package. Through this program a re-closure delay of 5 minutes will be specified (White, personal communication).
The suggested device for the inverter is the Power-One Aurora PVI-5000-OUTD-US-W. The distinguishing characteristic of this inverter is its turn on voltage is very low at 50 VDC. This will accommodate generators near the lower power output range will still accommodating the higher range near the theoretical maximum.

4) Optional Load Bank Connections
   The customer utilizing the facility may not want to connect the prototype to the electrical grid; therefore the system can be configured to isolate from the inverter and operation exclusively with a customer supplied load bank. Therefore connection points for a load bank are included in the design. Both AC and DC load banks can be connected to the system.

5) AC or DC generators:
   DC or 3-phase AC generation is the most common throughout industry. Therefore this design seeks to accommodate both types in an effort to appeal to the largest portion of the possible market. If in AC machine is being tested its output will be connected to a 3-phase rectifier before being sent to the inverter. This is necessary to achieve the correct characteristics before interconnection with the utility grid. If a DC machine is connected it need only be connect directly to the inverter.

5.4.3. Other Possible Considerations

IEEE 1547.1 specifies all commissioning test requirements for an interconnection (IEEE, 2005). These commissioning analysis costs are not included in the cost estimate provided in this report. Before a customer using the proposed facility can connect a tidal generator to the utility gird they will be required to give HEA 45 days of advanced notice and provide extensive documentation (HEA, 2009, p. 22). This may deter perspective customers.

5.5. Instrumentation

5.5.1. General Instrumentation

5.5.1.1. Computer System

A standard desktop computer system will be needed to analyze and report the data collected from both the power and oceanographic instrumentation systems. The computer system will be required to operate multiple sophisticated software packages in order to perform this data analysis. Thus choosing a computer system with more advanced specifications will be required. Additionally, choosing a more advanced system will allow the computer to operate effectively as software updates and expansions are added in the future.

Suggested Device: Dell XPS 8500 Desktop System (http://www.dell.com/)

- Dual 24 inch HD Monitors allow for simultaneous viewing of the data analysis software and the live underwater camera feed.
- Win TV-HVR 2250 PCIe Dual TV Tuner Card supports the video input from the camera.
- 2-Port PCI RS-232 Serial Adapter Card supports two Campbell Scientific CR3000 Microloggers.
- Dual hard drives allow for regular data backup.
- Backup battery system allows the system to continue data collection and analysis in the event of temporary power loss.

5.5.1.2. Data Logger

A data-logger is a device that is able to process and store signals produced by multiple and various sensors before passing the data to a standard computer. The data-logger software allows the user to write unique programs to process the signals produced by each sensor. The data from the multiple sensors can then be organized into a variety of formats that allow for straightforward reading by the user.

Suggested Device: Campbell Scientific CR3000 Micrologger (http://www.campbellsci.com/cr3000)

- Device has a large input capacity, capable of handling the current number of instruments as well as allowing for expansion of the instrumentation system.
- Device is compatible with RS-232 serial cables for data communication making it compatible with each of the suggested instruments.
- An optional backup battery is available to allow for continued data collection in the event of temporary power loss.
- Device is able to read the input voltage ranges produced by each of the suggested devices.

5.5.2. Oceanographic Instrumentation

The strategy for monitoring the effects of the tidal generator on the surrounding environment consists of measuring several oceanographic properties. Measuring the effect of the tidal generator on the surrounding environment is necessary for environmental permitting purposes as well as fully understanding the performance and efficiency of the tidal generator.

The environmental properties that should be monitored are:

- Water velocity – the overall movement of the water
- Water depth at the test site
- Water temperature
- Water conductivity - used to determine water salinity
- Water turbidity – the cloudiness of the water
- Size of particulates suspended in the water
- Scouring of the seafloor beneath the hydrokinetic device
- Noise produced by the hydrokinetic device
- Cetacean activity near the test site
- Other wildlife activity near the test site
- Capability to extract water samples for further laboratory testing

Because a collection of instruments and the associated cabling could significantly reduce the ability of the hydrokinetic device cradle mechanism to house a variety of hydrokinetic devices, the oceanographic instrumentation system has been largely designed to operate separately from the cradle mechanism. The oceanographic instrumentation system will measure water conditions near the hydrokinetic device, but the instruments will not interfere with the mounting and deployment of the device via the cradle mechanism. The oceanographic instruments will be hard wired to the datalogger/computer system to allow for continuous and real time data gathering. Power will also be provided through this cabling to prevent the need for battery replacement or recharging of the underwater instruments. The cabling will be placed along the seafloor away from the test area and weighted to prevent cable migration and possible entanglement in the hydrokinetic device.

The oceanographic instrumentation wiring design is shown in Figure 25. Many of the instrument connection cables shown in the figure are proprietary and will be procured from the instrument manufacturer along with the specific instrument.

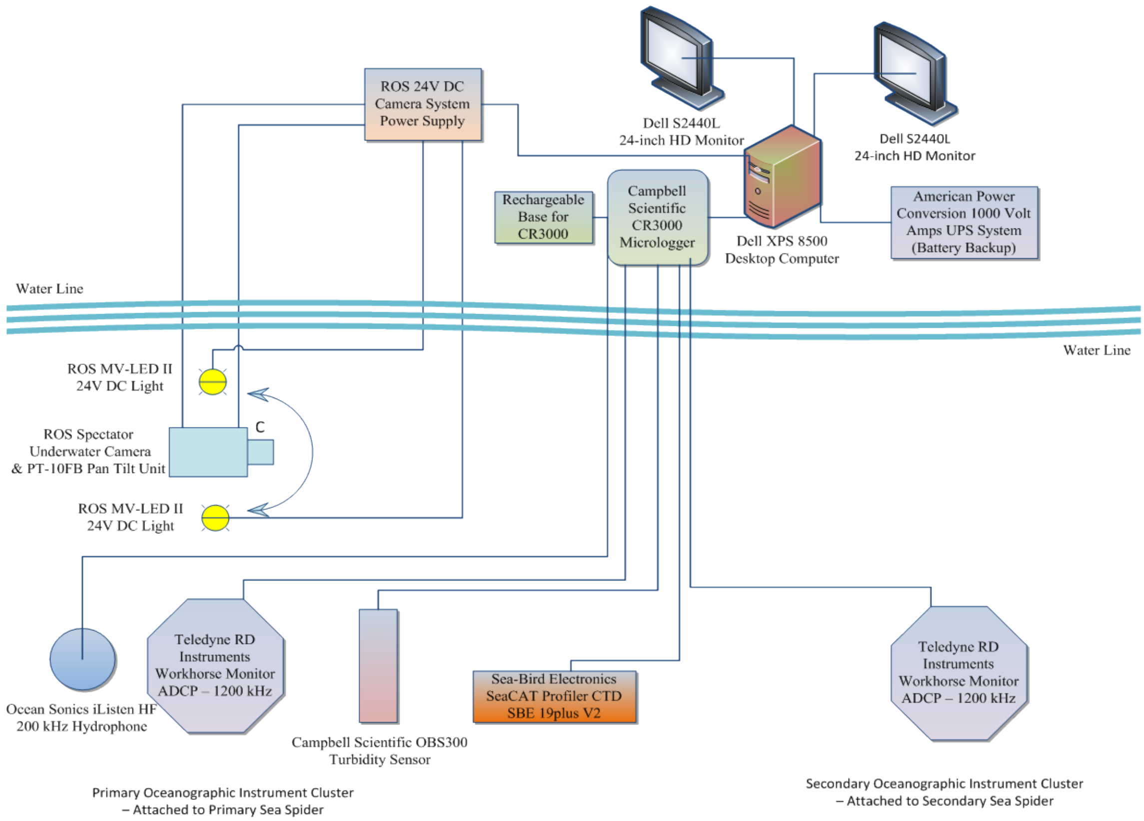

Figure 25: Oceanographic Instrumentation Wiring Design

5.5.2.1. Ocean Floor Mounting System

Suggested Device: Oceanscience Sea Spider
(http://www.oceanscience.com/Products/Seafloor-Platforms/Sea-Spiders.aspx)

Figure 26: Oceanscience Sea Spider during deployment. Retrieved from http://www.oceanscience.com

The Sea Spider, manufactured by Oceanscience (see Figure 26), is a three-legged fiberglass instrument mounting system. Multiple instruments and sensors can be attached to the Sea Spider in a variety of configurations. Two Sea Spiders will be used for instrumentation mounting; one centered at 10 feet directly upstream of the hydrokinetic device cradle mechanism, and the second centered at 30 feet downstream of the first. The Sea Spider is of sufficiently low profile at 21 inches to keep the instrumentation system from interfering with the tidal flow moving toward the hydrokinetic device. The dual instrumentation mounting system will allow for testing of tidal properties both before and after the hydrokinetic device. Additionally, each Sea Spider will have the ability to house additional instruments, allowing for straightforward expansion of the instrumentation system. The Sea Spider uses ballast weights attached to each foot to maintain its position on the ocean floor. With adequate cable lengths for each attached instrument, the Sea Spider will be able to be raised and lowered as a unit to perform instrument maintenance. Alternatively, the Sea Spider can be left in place and commercial divers can retrieve each instrument individually to perform necessary maintenance.

5.5.2.2. Acoustic Doppler Current Profiler (ADCP)

"The energy flux contained in a fluid stream is directly dependent on the density of the fluid, cross-sectional area, and fluid velocity cubed" (Khan, 2009). Thus, the water velocity contains the majority of the energy in a tidal stream. Measuring the water velocity over the entirety of the affected water column both upstream and downstream of the generator is of high importance. "Acoustic Doppler Current Profiler (ADCP) instruments are used to measure the speed of water across an entire water column" (Hydro International, 2007).

Two ADCP devices will be used in order to best quantify the interaction of the tidal with the hydrokinetic device. A primary ADCP will be attached to the primary Sea Spider and set on the seafloor with the main instrument cluster ten feet directly upstream of the cradle mechanism. This ADCP will measure the tidal flow prior to any interaction with the hydrokinetic device. A secondary ACDP will be attached to a second Sea Spider set on the seafloor twenty feet directly downstream from the cradle mechanism to measure the tidal flow following the water's interaction with the hydrokinetic device. These two current measurements can be used to aid in determining the energy production efficiency of the hydrokinetic device.

Suggested Device: Teledyne RD Instruments Workhorse Monitor – 1200 kHz (http://www.rdinstruments.com/monitor.aspx)

- Device can send data and receive power through an RS-232 serial cable, thus not requiring battery power.
- 1200 kHz model allows for more accurate current profiling at the small distances found in near shore waters.
- Device is designed for real time data transmission and long term deployment (up to five years).
- Teledyne ADCP devices have been shown to be compatible with the Campbell Scientific Dataloggers (http://s.campbellsci.com/documents/ca/case-studies/46florida-ocean.pdf)

5.5.2.3. Turbidity Sensor

The measurement of turbidity, or the amount of sediment suspended within the water, is crucial when monitoring a tidal generator test site. High sediment levels may cause significant wear on a tidal generator. Test site clients will want accurate turbidity data to compare with the deterioration observed on the tested tidal generator. Optical backscatter sensors (OBS) "measure the amount of light transmission of water to give a measurement of the suspended solids in that water" (Campbell Scientific, 2013). An optical backscatter sensor coupled with water sampling will provide sufficient suspended sediment data for the test site. One turbidity sensor will be used to monitor the sediment levels present in the tidal current. The turbidity sensor will be attached to the primary Sea Spider with the main instrument cluster upstream from the cradle mechanism.

Suggested Device: Campbell Scientific OBS300 (http://www.campbellsci.com/obs300)

- The turbidity of lower Kachemak Bay ranges from 2-5 Nephelometric Turbidity Units (NTU) (Cook Inlet Regional Citizens Advisory Council, 2010). Under these conditions this device will measures from 0 to 250 ± 0.5 NTU.
- Data and power are both sent over vendor provided cable.
- Device output is directly compatible with CR3000 Micrologger.

5.5.2.4. Conductivity and Temperature Probe

Water conductivity, temperature and depth are typically monitored using a device called a CTD. "The device's primary function is to detect how the conductivity and temperature of the water column changes relative to depth. Conductivity and temperature information is valuable because the salinity (the concentration of salt) of the seawater can be derived from these two variables" (NOAA, 2006). The salinity of the seawater contributes to its overall density. As stated above, the energy present in a tidal stream is dependent on the water density (Khan, 2009), thus measuring this quantity is important for determining the efficiency of the tidal generator. This CTD probe will be mounted to the primary Sea Spider upstream from the hydrokinetic device.

Suggested Device: Sea-Bird Electronics SEACAT Profiler CTD SBE 19plus V2 (http://www.seabird.com/products/spec_sheets/19plusdata.htm)

- Device has conductivity and temperature measurement ranges large enough to encompass the full range of conditions found at the test site.
- Device is programmable to allow for moored (stationary) sampling.
- Real time data collection is possible with the addition of a Sea-Bird Electronics SBE Deck Unit and Power and Data Interface Module.
- Device can be powered over in place cable for long term deployment.

5.5.2.5. Hydrophone

A tidal generator consists of moving parts which may generate sounds audible to local cetaceans, including orcas, endangered humpback whales, and protected Cook Inlet beluga whales (Terry Thompson, personal communication, April 24, 2013). Due to the protected status of these marine mammals, environmental permitting will not allow a hydrokinetic device at the test site to significantly disrupt the whales' behavior. The use of a hydrophone (underwater microphone) capable of monitoring the full audible frequency range of these whales will detect sounds produced by the hydrokinetic device that may be disturbing to the whales found in Kachemak Bay. This hydrophone can also be used observe the behavior of whales in Kachemak Bay as they travel near the tidal generator test site.

At this point the level of wildlife activity at the test location is not well understood. By performing wildlife surveys and gaining a better understanding of wildlife activity at the test location, the level of necessary hydrophone monitoring will be better understood. Additionally, hydrophones tend to record a significant amount of noise (unwanted sound) when placed in moving water (Monty Worthington, personal communication, March 2013). Due to the consistent movement of tidal water this will be an issue with any hydrophones placed at the test location. Creating hydrophone systems that are able to remove this noise through hydrophone placement or software filtering requires a high level of expertise. Further evaluation by a professional experienced in the use of hydrophones in moving water along with the collected wildlife survey information will be necessary to complete an adequate hydrophone system. Under the current design, one hydrophone will be attached to the primary Sea Spider.

Suggested Device: Ocean Sonics icListen HF 200 kHz (http://oceansonics.com/products/iclisten-hf/)

- Device has a recording spectrum (10 Hz to 200 kHz) at nearly the full marine mammal audible spectrum (7 Hz to 180 Hz) (Washington State DOT, 2013).
- Data able to be transmitted over RS-232 serial cable.
- Data is filtered and processed by the device before transmission.

5.5.2.6. Water Sampling System

Extracting water samples from the test site for further analysis by an external laboratory may be desired by a client. Examining the test site sea water for the size breakdown of suspended solids, the presence of microscopic organisms or chemical contaminants, as well as additional laboratory tests will allow a client to further understand the environment in which the hydrokinetic device is operating. For client convenience, the water sampling system will have the ability to take samples without the use of a boat or diver and the capability of extracting samples from any depth within the water column.

Suggested Device: LaMotte Dissolved Oxygen/Temperature Sampler with Calibrated Line & Weight (http://www.lamotte.com/component/option,com_pages/mid,/page,161/task,item/)

- Device can be used by the client to obtain a water sample without leaving the trestle roadway/laboratory road deck.
- Calibrated line allows for the extraction of water samples at specific depths.

5.5.2.7. Underwater Camera System

An underwater video camera with the appropriate features (lighting, zoom, tilt, and pan capabilities) will allow the client to visually observing the behavior of a hydrokinetic device in real time, while it operates in the tidal flow. This will provide one more source of information for the client to combine with the tidal monitoring data to evaluate the behavior of the hydrokinetic device.

A hydrokinetic device can cause significant changes to water flow can cause scouring of the seafloor in a shallow ocean environment. This seafloor scouring can affect sea life present on the ocean floor beneath the tidal generator, and over the long term, change the floor contour. This underwater camera system appears to be the most reasonable and cost effective method for observing seafloor scouring.

Surveillance of other sea life at the tidal generator site may also be desirable. Salmon returning to the Homer Spit ‘Fishing Hole’ pass near the test site each spring and

summer. Observing these salmon as they pass near and interact with the test tidal generator is most effectively accomplished with the underwater camera which is already in place to view the behavior of the tidal generator itself.
The underwater camera system, including the camera, lighting, and computer controlled pan and tilt device will be mounted to the primary Sea Spider upstream from the hydrokinetic device. By directing the camera downstream, the camera lens will be kept clear of tidal swept sediment and debris.

Suggested Device: Remote Ocean Systems (ROS) Spectator 36:1 Color Zoom Camera (http://www.rosys.com/oceanographic/spectator-ocean/)

- Cameral has 36X optical zoom and 12X digital zoom for a total of 432X zoom.
- Camera operates under low illumination – 1.4 Lux typical minimum illumination.
- Video is transmitted through the ROS power supply to the computer for viewing and recording.

Suggested Device: ROS MV_LED II (DC) Underwater LED Spotlight (http://www.rosys.com/oceanographic/mv-led-ocean/)

- Spotlights consist of ultra-high intensity white LED array.
- Spotlight dimming is controlled from the computer through RS-485 serial cable.

Suggested Device: ROS PT-10-FB RS-485 Computer Controlled Pan & Tilt Unit (http://www.rosys.com/oceanographic/pt-10-ocean/)

- Unit has full 360 degree horizontal and +/- 90 degree vertical pan capabilities.
- Unit is controlled from the computer through RS-485 serial cable.

5.5.3. Power Instrumentation

Initially the strategy for measuring the power developed in the system was to supply a portable power meter with the ability to measure DC and AC at a variety of frequencies, as well as calculate several power parameters. A decision was made to instead supply measurement devices that will be permanently installed in their own housing so the client will not be required to open the electrical housing equipment to attach the meters voltage and current probes.

The current strategy for monitoring the power produced by the tidal generator involves making time stamped measurements of the voltage and current at multiple stages in the facility. The stages that the voltage and current will be measured at are: stage 1, at the generator; stage 2, after the rectifier; and stage 3, after the inverter (see figure 14). This will allow the client to know how much power the generator is producing as a function of the water velocity, that each of the systems stages are working correctly, and, according to the IEEE Standard 1159: Recommended Practice for Monitoring Electric Power Quality, they will be able to derive parameters from the voltage and current data in post processing such as:

- Current total harmonic distortion
- Voltage total harmonic distortion
- Frequency
- RMS Voltage
- RMS Current

In some cases not all of the stages in the system will be utilized. For example, if a DC generator is being tested at the facility the rectifier will not be utilized, and only measurements at stages 2 and 3 will be necessary. The power instrumentation system is designed so that, in any case, the appropriate power measurements can be made without requiring significant changes to the system (see Appendix C for a one line diagram of the system, and Appendix B for a sketch showing the location of the system components in the facility).

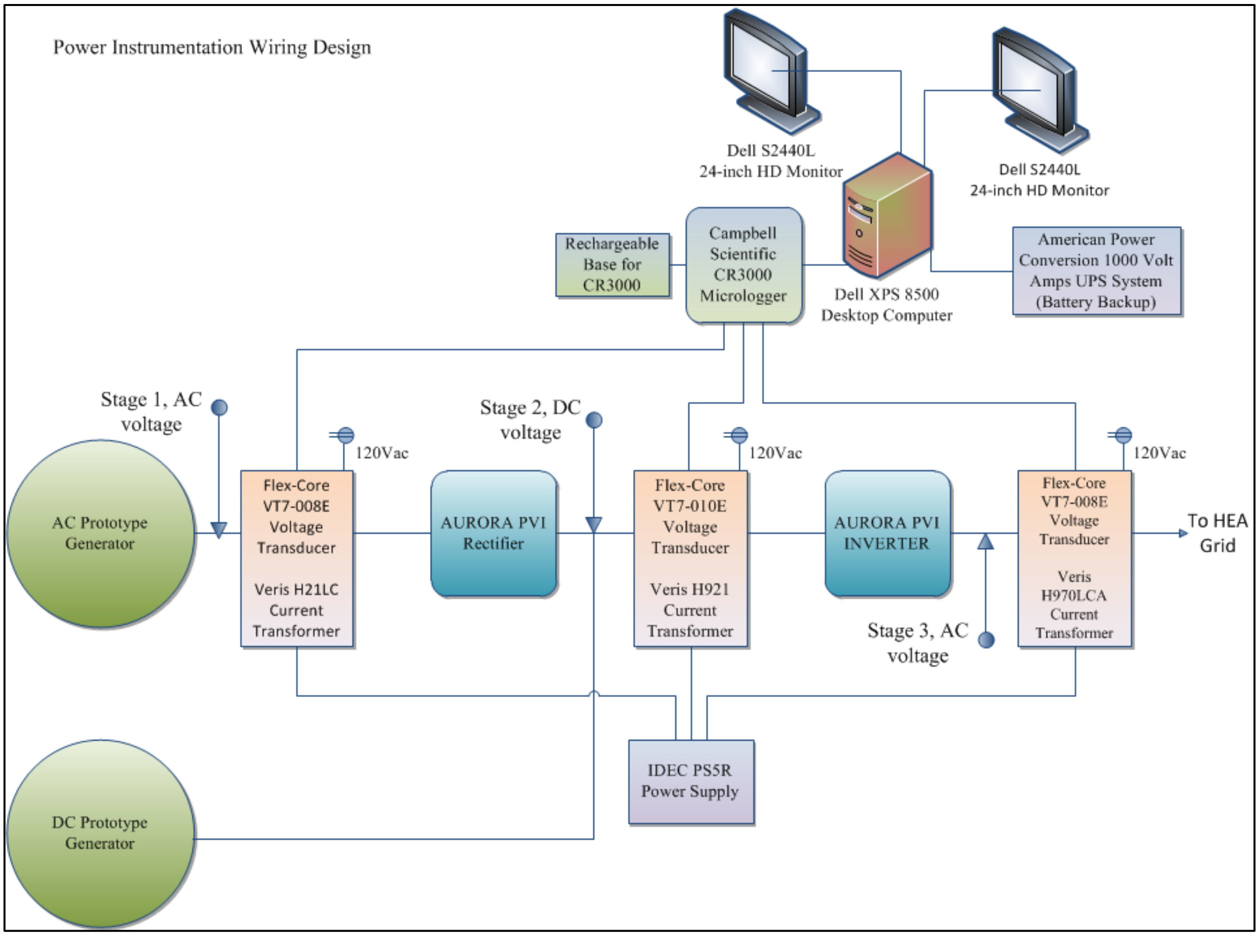

Figure 27: Stages 1-3 of the system.

5.5.3.1. Voltage Transducer

A voltage transducer is a device that measures a voltage and outputs a signal scaled according to the magnitude of the measured voltage. At all of the stages of the system there are constraints on what the voltage can be based off what the devices connected at each stage are rated for. The voltage ratings are summarized below:

- Stage 1: The rectifiers rated input voltage is 0-400V AC at 0-600Hz
- Stage 2: The rectifiers rated output voltage is 0-600V DC
- Stage 2: The inverters rated input voltage is 0-600V DC
- Stage 2: The load banks rated input voltage is 0-500V DC
- Stage 3: The inverters output voltage is known to be 277V AC at 60Hz

Several voltage transducers will be used in order to measure the voltages at each of the stages, and will be selected so that they can handle the maximum rated voltage of the devices connected at that stage. At stage 1, the voltage transducers need to be able to measure the voltage of up to three phases in the range of 0-400V and at a wide range of frequencies; at stage 2, the voltage transducers need to be able to measure 0-600V DC; and at stage 3, the voltage transducers need to be able to measure 277V AC at 60Hz.

Suggested Device: Flex-Core VT7 (http://flex-core.com/pdf-files/VT7.pdf)

- Measures frequencies ranging from 0-10kHz
- Output of 4-20mA which is compatible with the CR3000
- Option 008E with a range of 0-400V for stage 1
- Option 010E with a range of 0-600V for stage 2
- Option 007E with a range of 0-300V for stage 3
- Requires a 120Vac power supply

5.5.3.2. Current Transformer

A current transformer is a device that takes either a DC or AC current and outputs a signal scaled according to the magnitude of the measured current. As in the case of the voltage, there are constraints on what the current can be based off what the devices connected at each stage are rated for. Those current ratings are summarized below:

- Stage 1: The rectifiers rated input current is 16.6A RMS
- Stage 2: The inverters rated input current is 36A
- Stage 2: The load banks rated input current is 120A
- Stage 3: The inverters rated output current is 27A

Several current transformers will be required to measure the current at each of the different stages, and will be selected so they can handle the maximum current rating at each stage with the exception of the load bank rating, as the current is not expected to reach 120A under normal operating conditions. At stage 1, a current transformer rated for 0-20A will be required; at stage 2, a current transformer rated for 0-40A will be required; and at stage 3, a current transformer rated for 0-30A will be required.

Suggested Device: Veris H21LC, H921, and H970LCA (http://www.veris.com/Category/Current-spcMonitoring/Current-spcTransducer/4-20mA-spcOut.aspx)

- All devices have a 4-20 mA output that is compatible with the CR3000
- H721LC will be used for stage 1 AC current measurement
- H921 will be used for the stage 3 AC current measurement
- H970LCA will be used for the stage 2 DC current measurement
- Requires a 24Vdc power supply

6. Summary of Final Design

The final design of the Homer Tidal Power and Marine Instrument Test Station encompasses all the requirements of the client and explore several options to appeal to potential tidal generator entrepreneurs and manufacturers.

The selected design of the structural support would require additional connection reinforcement and construction of new decking, as well as providing a shelter for equipment and personnel. The selected final rail system will consist of braced static channels on which the cradle mechanism would operate. The frame in which the prospective generator would sit spans approximately 22-feet. The cradle system has the potential for multiple device configurations either mounting from the upper or lower beams. The cradle system would be lowered and raised via a dual winch system.

The theoretical maximum output of a prospective tidal generator is below 4109-W, and is therefore in compliance with HEA's requirements. The electrical signals produced by tidal generators have many of the characteristics of wind turbines thus the design of this interconnection utilizes wind turbine interconnection technologies.

The instrumentation that would accompany the system includes a computer and a data-logger. Oceanographic instrumentation that is recommended to accompany the system is consisted of an acoustic Doppler current profiler, turbidity sensor, conductivity and temperature probe, hydrophone, and an underwater camera system with an underwater LED spotlight.

A cost estimate for the project was prepared and is attached at the end of the report in Appendix A. The cost estimate consisted of three separate estimates for the structural, cradle mechanism, and electrical components of the project. Each estimate includes the costs of labor, material, and any other required expenses. The cradle mechanism estimated cost is $205,124.60, the structural estimated cost is $109,200.00, and the electrical estimated cost is $212,269.94 giving the base cost of $526,594.54 for the project. An additional 12% was added for contingency in the design and 21% for contingency in construction. The project total comes to a total of $701,035.74 in 2013 dollars.

7. Conclusion & Recommendations

A tidal power test station location at the Deep Water Dock at the City of Homer is an ideal location for entrepreneurs to test conceptual and preliminary generators and marine instruments. The preliminary design provided in this report and accompanying material seeks to provide the client with the capability to proceed with the completion of the design.
It is recommended that the City of Homer invest in completing a site characterization of the area around the Deep Water Dock. This report made a reasonable assumption of the water velocity of the area, but several factors may have a significant impact on this assumption. The site characterization should also include some consideration for monitoring biological activity in the local area. It is also recommended that a complete site and structural inspection be performed prior to proceeding with a final design.

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Appendix A – Cost Estimate

Cradle and Rail System Cost Estimate

Task Break down	Quantity	Unit	unit price ($)	hours	Rate $/hr.	Sub total	Total
			Rail				
Labor							
Welding				228	85.00		$19,380.00
Underwater welding				92	120.00		$11,040.00
General steel				463	75.00		$34,725.00
Engineering				183	150.00		$22,500.00
Equipment operator				131	85.00		$11,135.00
Subtotal							**$98,780.00**
Material							
I beam	6.00	20ft beam	380.00				$2,280.00
2" gal.	9.00	10ft	27.20				$244.80
2" gal.	9.00	16 ft.	43.52				$391.68
2" gal.	9.00	11.5 ft.	32.64				$293.76
2" gal.	18.00	4 ft.	10.88				$195.84
Plate	18.00	1'x1'x.5"	20.00				$3,406.08
Subtotal							**$6,812.16**
Equipment							
Welding				320.00	30.00		$9,600.00
Crain				NA	8000.00		$8,000.00
Misc.				100.00	50.00		$5,000.00
Subtotal							**$22,600.00**

Cradle and Rail System Cost Estimate

Task Break down	Quantity	Unit	unit price ($)	hours	Rate $/hr.	Total
			Cradle			
Material						
Horizontal Member	2	2000	$4,000.00	3	100	$4,600.00
Side member	2	1300	$2,600.00	3	100	$3,200.00
Backing Plate	4	120	$480.00	2	100	$1,280.00
Slide support	4	250	$1,000.00	2	100	$1,800.00
Stress Plate	2	50	$100.00	1	100	$300.00
Attachment Ring	2	20	$40.00	1	100	$240.00
Teflon Pad	4	400	$1,600.00	4	100	$3,200.00
L Bracket	8	50	$400.00	1	100	$1,200.00
The Bearing Mount	8	100	$800.00	5	100	$4,800.00
Outer Washer	8	100	$800.00			$800.00
Retaining Washer	4	200	$800.00			$800.00
FW .75	48	0.32	$15.36			$15.36
9.75"x.75" Mount Bolt	24	4.07	$97.68			$97.68
HHNUT 1.000-8-B-C	24	0.41	$9.84			$9.84
Selefed Narrow FW 1.062	40	0.63	$25.20			$25.20
HHSBOLT 1.500-6x 2x2-N	40	5	$200.00			$200.00
HHSBOLT 1.2500-7x 1.5x1.5-S	4	4.84	$19.36			$19.36
FLS48 (Sleeve Bearing)	4	50	$200.00			$200.00
Assembly	1		$0.00	24	200	$4,800.00
Shipping	1		$0.00		NA	$2,000.00
Subtotal						$29,587.44

			Winch System			
David Round 203 Series Winch x2	2		$20,000			$40,000
Flex-X 19 Class Bright Wire Rope 1 inch diameter	150	LF	$22.30			$3,345
Labor				30	150	4500
Subtotal						**$47,845**

Cradle and Rail System Total **$205,624.60**

Structural Cost Estimate

Task Break down	Quantity	Unit	unit price ($)	hours	ate $/hı	Total
Site Inspection						
Structural engineer x2	60	Hourly	$ 200.00			$ 12,000.00
Travel	1	Lump sum	$ 2,000.00			$ 2,000.00
Design						
Structural engineer x2	80	Hourly	$ 200.00			$ 16,000.00
Material						
Pre-cast, pre-stressed concrete beams	138	Linear foot	$ 250.00			$ 34,500.00
Steel C-channel	24	Linear foot	$ 300.00			$ 7,200.00
Steel connections/ misc.	1	Lump sum	$ 2,500.00			$ 2,500.00
Prefabricated shelter	1	LS	$ 20,000.00			$ 20,000.00
Labor						
Construction manager x1	20	Hourly	$ 180.00			$ 3,600.00
Welder x2	20	Hourly	$ 150.00			$ 3,000.00
Laborer x2	20	Hourly	$ 120.00			$ 2,400.00
Equipment (forklift and crane) x2	2	Daily	$ 3,000.00			$ 6,000.00
Subtotal						**$ 109,200.00**

Structural Total	**$ 109,200.00**

Electrical Cost Estimate

Component	Device Specifics	Quantity	Cost per Unit	Total Cost
Computer System				
Dell XPS 8500 Desktop Computer	Intel Core i7 processor 12 GB RAM Windows 7 OS Intel SRT solid state hard drive (32GB)	1	$1,300.00	$1,300.00
Hauppauge Computer WinTV-HVR-2250 PCIe Dual TV Tuner	Video card for video input from camera	1	$107.00	$107.00
Startech.com 2-Port PCI RS232 Serial Adapter Card	Serial card for data input from datalogger	2	$32.00	$64.00
Dell S2440L 24-inch Full HD Monitor with LED		2	$260.00	$520.00
American Power Conversion 1000 Volt Amps UPS System	Battery backup for computer	1	$146.00	$146.00
Datalogger				
Campbell Scientific CR3000 Micrologger		1	$2,875.00	$2,875.00
Campbell Scientific CR3000 Rechargeable Base		1	$360.00	$360.00
Campbell Scientific CR3000 Wall Charger	With 6 foot cable	1	$70.00	$70.00
Campbell Scientific Datalogger Support Software		1	$599.00	$599.00
Subtotal				**$6,041.00**

Instrument Mounting System				
Oceanscience Sea Spider Fiberglass Seafloor Platform	Includes 3 x 50 lb lead ballasts	2	$2,880.00	$5,760.00
Oceanscience Sea Spider Gimbal	For use with acoustic Doppler profiler	2	$625.00	$1,250.00
Oceanographic Instruments				
Teledyne RD Instruments Workhorse Monitor ADCP*	1200 kHz model	2	$35,000.00	$70,000.00
Ocean Sonics icListen HF Hydrophone	Rated to depth of 200 meters	1	$10,185.00	$10,185.00
Ocean Sonics Lucy Software	For use with icListen HF Hydrophone	1	$4,199.00	$4,199.00
Campbell Scientific OBS300 Turbidity Sensor	With titanium body for use in seawater	1	$1,290.00	$1,290.00
Campbell Scientific OBS300 Sensor Cable	Custom length cable (in feet)	200	$7.25	$1,450.00
Sea-Bird Electronics SeaCAT Profiler CTD SBE 19plus V2*		1	$500.00	$500.00
Sea-Bird Electronics CTD Cable*	Custom length cable (in feet)	200	$1.00	$200.00
LaMotte Dissolved Oxygen/Temperature Sampler	For extracting water samples at depth	2	$192.00	$384.00
Water Sampler Calibrated Line & Weight	20 meter line with weight	2	$57.00	$114.00
Remote Ocean Systems Underwater Camera System				
Spectator 36:1 Color Zoom Camera	Underwater camera	1	$5,995.00	$5,995.00
Camera Clamp	Mounting clamp for camera	1	$305.00	$305.00
MV-LED II 24V DC Lights	Underwater lighting	2	$1,350.00	$2,700.00
Light Clamp	Mounting clamp for lights	2	$95.00	$190.00
PT-10FB 24V DC Pan & Tilt Unit	Underwater pan & tilt unit	1	$8,995.00	$8,995.00
Pan & Tilt Unit Bracket	Mounting bracket for pan & tilt unit	1	$345.00	$345.00
Power supply	Power supply for the camera system	1	$220.00	$220.00
Underwater Cable with DB-9 (RS-232) Connection	75 foot cable	3	$2,008.00	$6,024.00
Subtotal				**$120,106.00**

Power Quality Monitoring			
Current transformers 60Hz AC - Veris H921-AH01	1	$120.00	$120.00
Current transformers Var Hz AC - 3 * Veris H720-AH01 10-80HZ	3	$543.75	$1,631.25
Current transformers DC - Veris H970LCA-AH01	1	$220.00	$220.00
Instrument Power Supply - PS24-15W	1	$122.00	$122.00
Voltage transducers, AC Gen - 3*VT7-008E	3	$1,515.00	$4,545.00
Voltage transducers, DC Gen/Rect - VT7-010E	1	$505.00	$505.00
Voltage transducers, AC Inv output - VT7-007E	1	$505.00	$505.00
			$0.00
Electrical Enclosures			$0.00
CR3000 & A547 enclosure - ENC16/18 w/ -VC & -NM options	1	$310.00	$310.00
12"X12"X6" enclosure	2	$23.97	$47.94
			$0.00
Power Components			$0.00
3ϕ disconnect - DU321RB	1	$293.00	$293.00
DC 40A Fused Disconnect - DH162NRK	1	$345.00	$345.00
Manual Transfer Switch AC Gen/DC Gen - DTU362	3	$1,245.00	$3,735.00
manual disconnect - DU221RB	1	$177.00	$177.00
lockable manual disconnect - DU221RB	1	$177.00	$177.00
customer meter socket - URTRS101B	1	$123.00	$123.00
Power-One Aurora Wind PVI-WIND-INTERFACE	1	$451.35	$451.35
Power-One Aurora Wind PVI-5000-OUTD-US-W	1	$2,126.23	$2,126.23
SQUARE D # 8538SCG14V02S Motor Combo Starter 10HP	1	$1,327.00	$1,327.00
XHHW #8 AWG Conductor 1000'	3	$1,027.29	$3,081.87
AC 12/2 100'	5	$61.73	$308.65
RMC 1" - 10'	30	$21.49	$644.70
EMT 1" - 10'	20	$7.45	$149.00
Various Fittings	1	$2,000.00	$2,000.00
Subtotal			**$22,944.99**

Labor				
Commercial Diver	Work hours	80	$102.00	$8,160.00
Instrumentation Technician/Electrician	Work hours	300	$152.73	$45,817.95
Instrumentation/Computer Programmer	Work hours	80	$115.00	$9,200.00
subtotal				**$63,177.95**

***Price estimate is based on that of a similar device**

Electrical Total	**$212,269.94**

Project Cost Estimate Summary

Item	Total
Electrical	$212,269.94
Structural	$ 109,200.00
Rail and Cradle System	$205,624.60
Design Contigency	$63,251.34
Construction Contingency	$110,689.85
Total	**$701,035.74**

Appendix B – Sketches

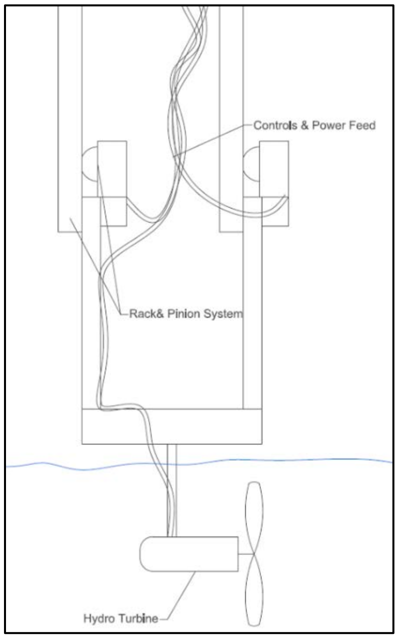


Figure B.1: Sketch of rack and pinion cradle system.

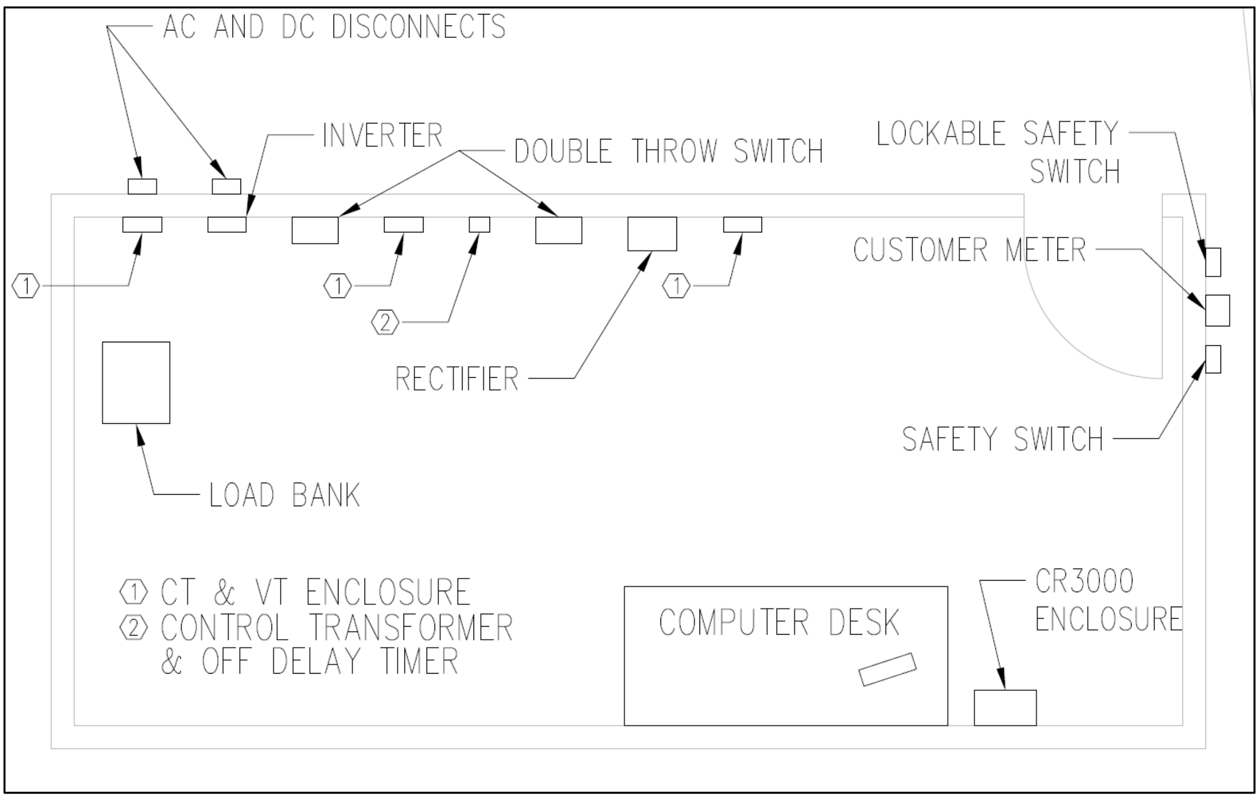
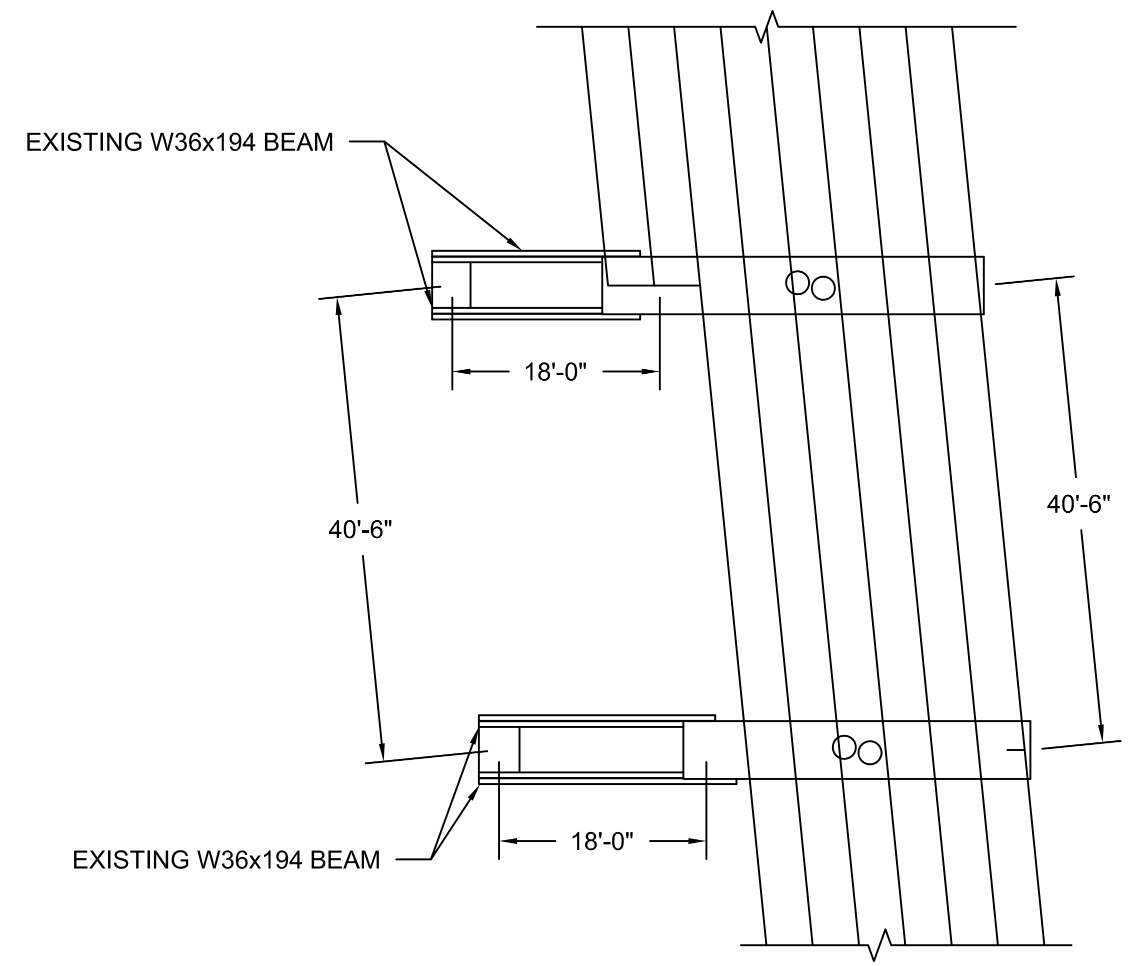


Figure B.2: Sketch of the lab facilities electrical layout.

Appendix C – Drawings



EXISTING DOCK PLAN
SCALE: 1:200

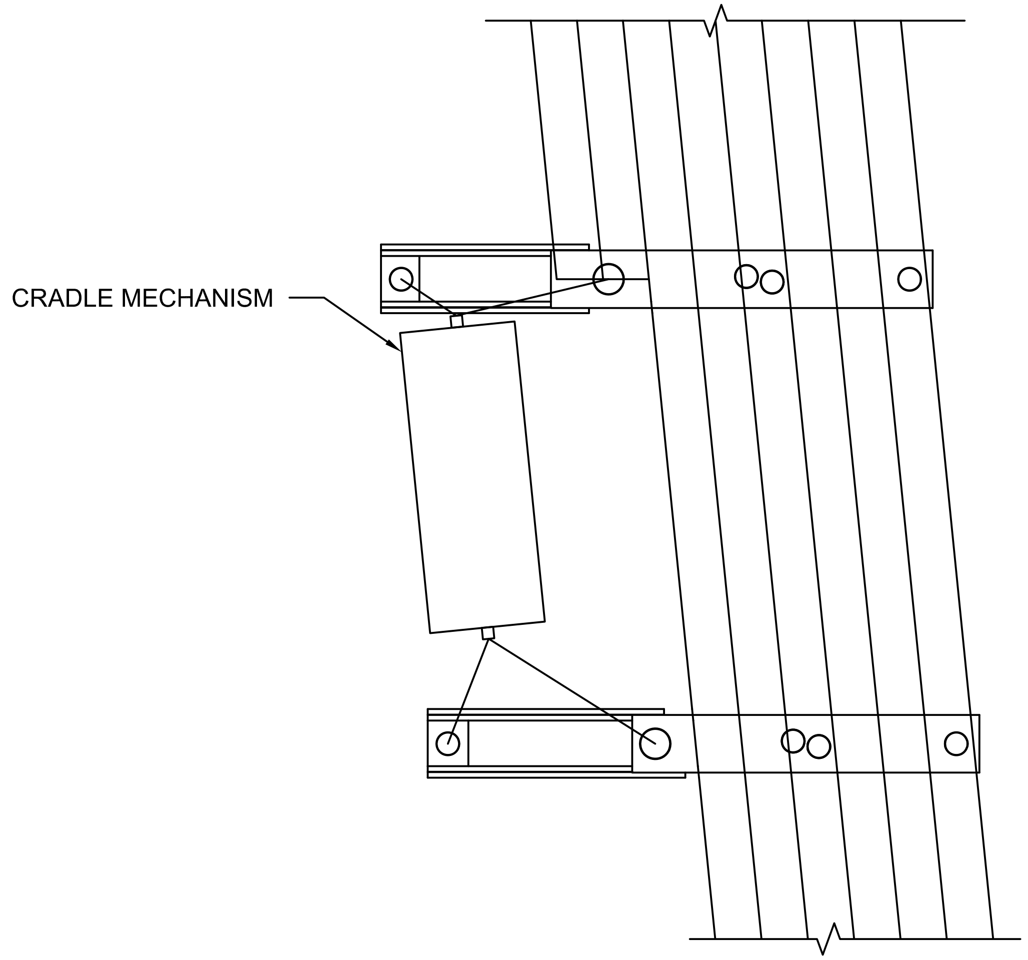
General Notes

No.	Revision/Issue	Date

Homer Tidal Turbine Incubator Design Project

UAA School of Engineering

Project A438
Date 4/19/2013
Scale As Noted
Sheet 1



CRADLE MECHANISM PLAN
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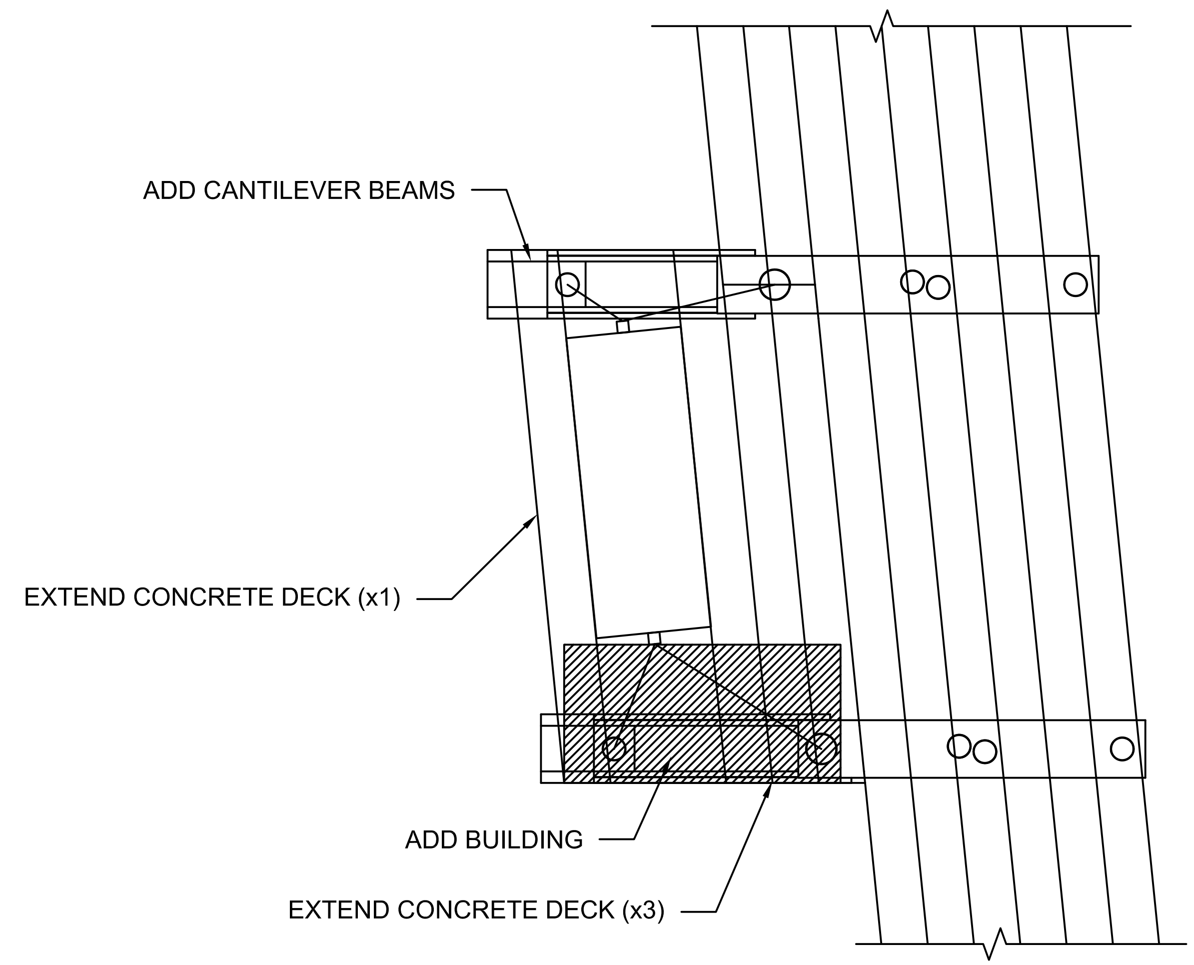


DECK ADDITION PLAN
SCALE: 1:200

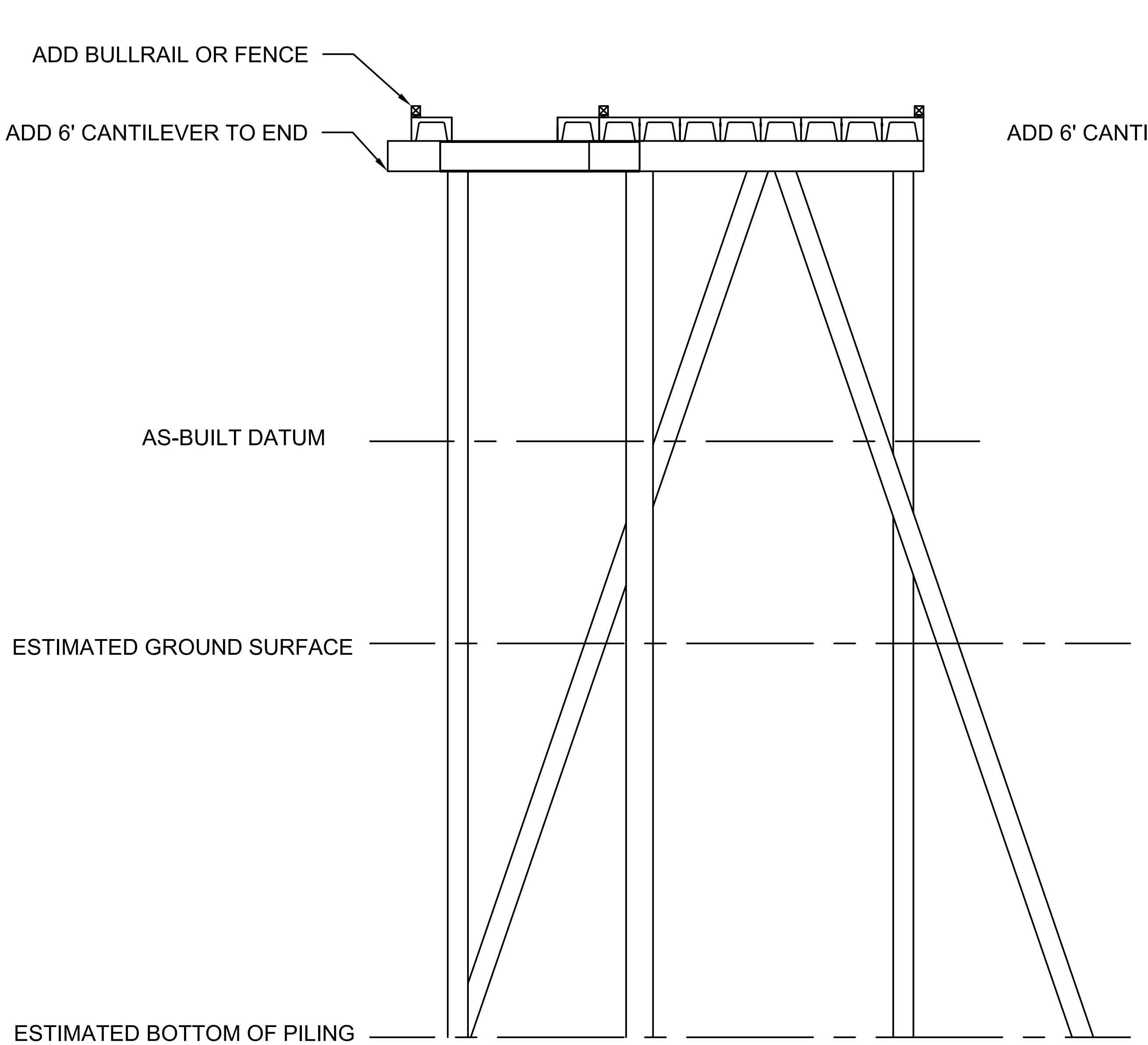
General Notes

No.	Revision/Issue	Date

Homer Tidal Turbine Incubator Design Project

UAA School of Engineering

Project: A438	Sheet: 2
Date: 4/19/2013	
Scale: As Noted	



NORTH SECTION
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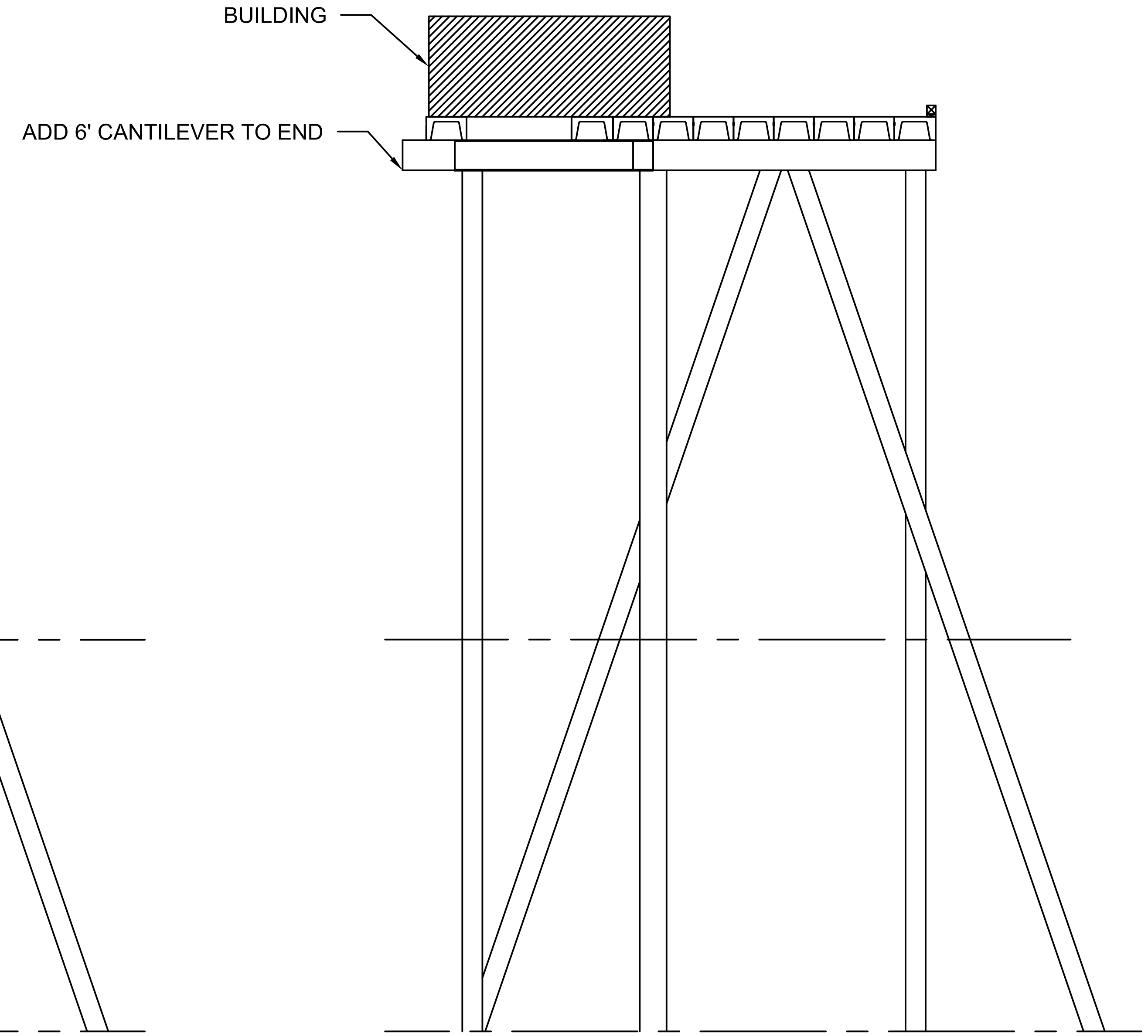

SOUTHSECTION
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General Notes

No.	Revision/Issue	Date

Homer Tidal Turbine Incubator Design Project

UAA School of Engineering

Project A438	Sheet 3
Date 4/19/2013	
Scale As Noted	

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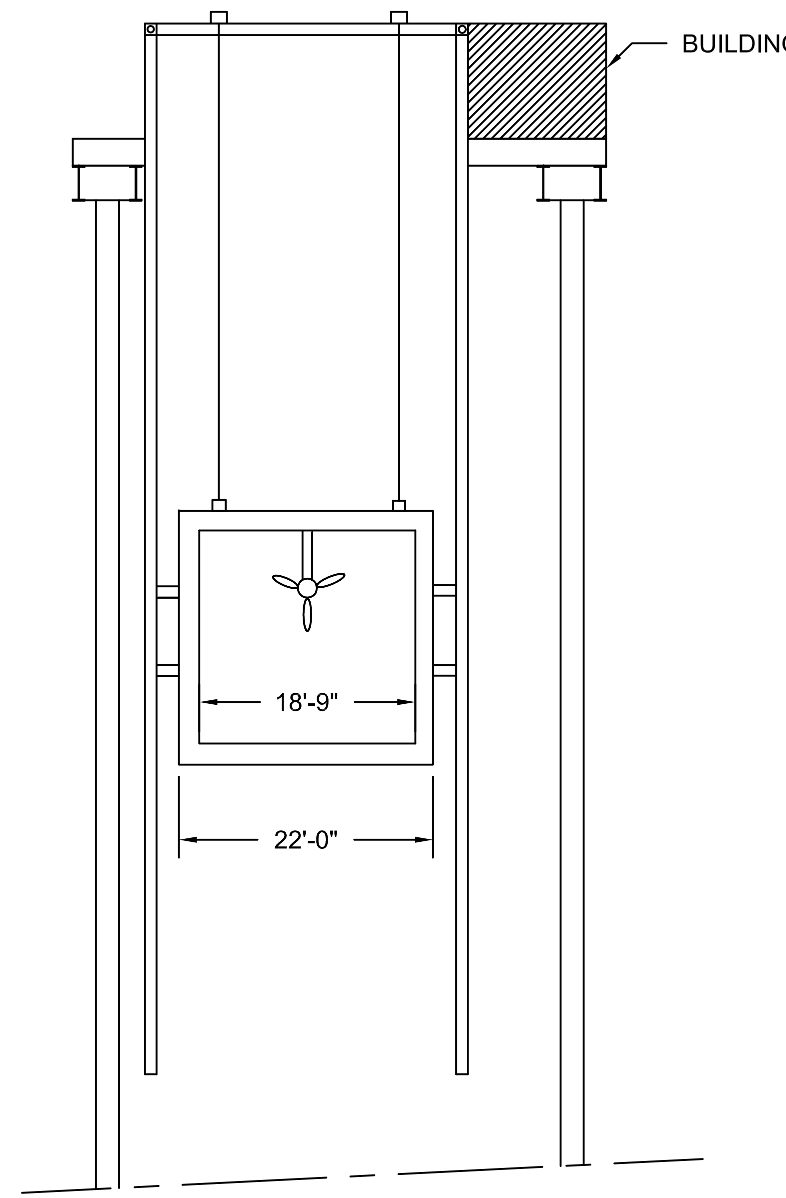


FRONT ELEVATION
SCALE: 1:200

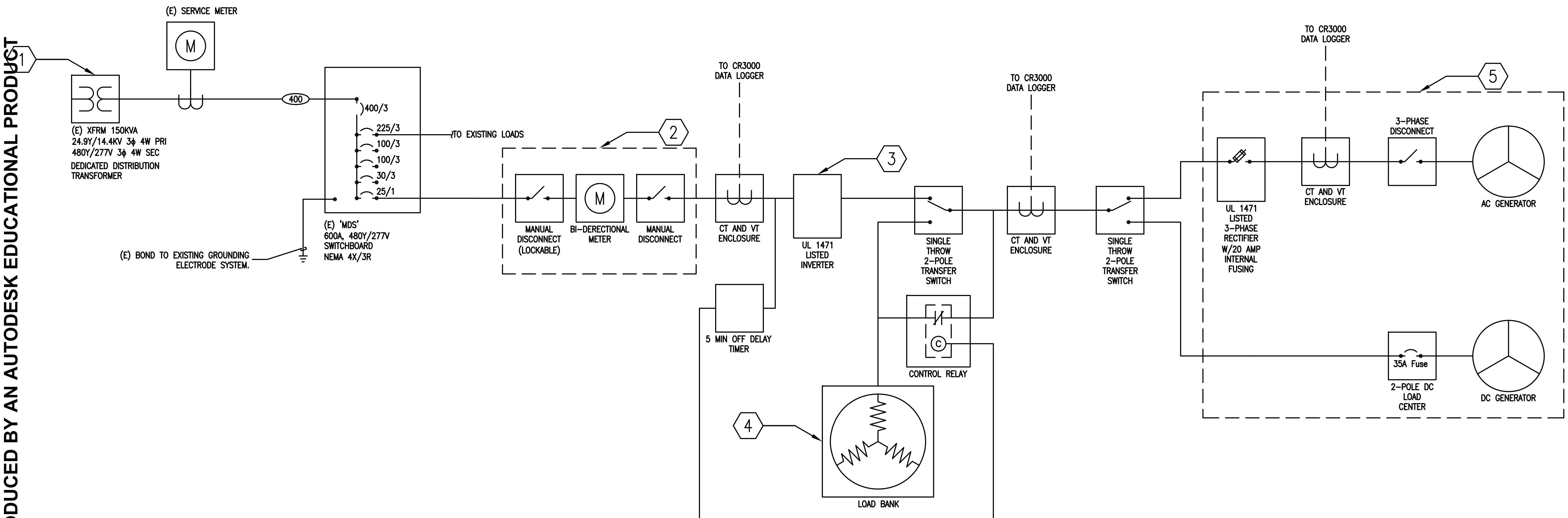
General Notes

No.	Revision/Issue	Date

Homer Tidal Turbine Incubator Design Project

UAA School of Engineering

Project A438	Sheet 4
Date 4/19/2013	
Scale As Noted	



ELECTRICAL ONE-LINE

SCALE: NTS

General Notes

No.	Revision/Issue	Date

Homer Tidal Turbine Incubator Design Project

UAA School of Engineering

Project: A438

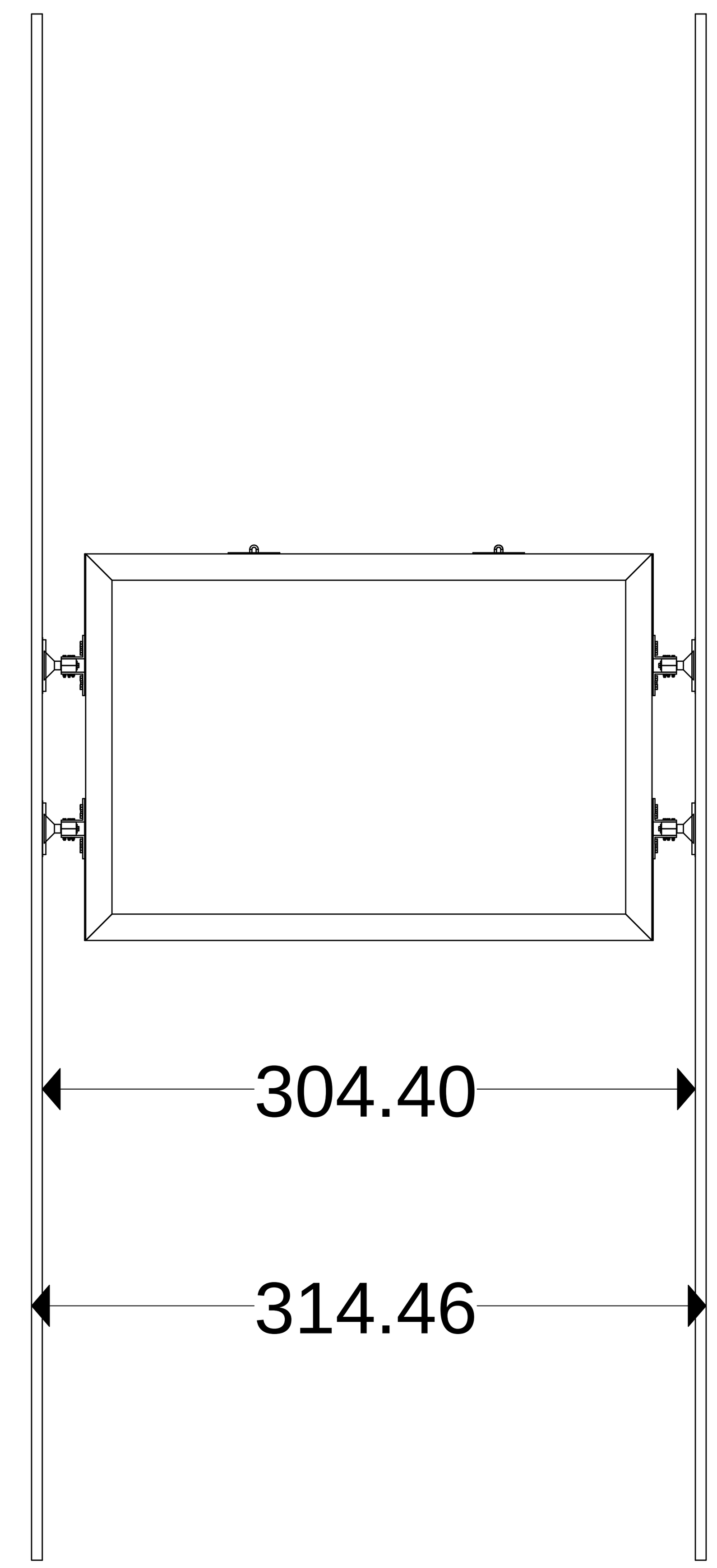
Date: 4/19/2013

Scale: As Noted

Sheet: 5

ITEM NO.	PART NUMBER	DESCRIPTION	QTY.
1	T&B Section	Cradle top and bottom members	2
2	Side Section	Cradle side members	2
3	Backing Plate	Support for bearing assembly mounting	4
4	FLS48	Sleeve bearing	4
5	Slide support	Vertical bearing system	4
6	Stress Plate	Stress backing for cable attachment points	2
7	Attachment Ring	Cable attachment	2
8	Teflon PTFE	Bearing pads	4
9	Bracket	Bearing Mount Assembly	8
10	Rail Member Section	W 5x19 I Beam	2
11	Outer Washer	PTFE coated wash	8
12	Retaining Washer	Retaining washer for Slide Mount	4
13	FW 0.75		48
14	9.5"x.75" Mount Bolt		24
15	HHNUT 0.7500-10-B-C		24
16	Selected Narrow FW 1.062		40
17	HHSBOLT 1.5000-6x2x2-N		40
18	HHSBOLT 1.2500-7x1.5x1.5-S		4

ITEM NO.	PART NUMBER	DESCRIPTION	QTY.
1	L Bracket		1
2	The Bearing Mount		1



Loads:

- Maximum static load of device on system (30 kips), Load is applied at midpoint of cradle.
- Maximumdrag load of device on system(15 kips), Load is applied at center of cradle.
- UseAISI 4340 Normalized Steel.
- Design corrosion protection system.
- Perform all welds with applicable AWS standards.

Homer Tidal Power and Marine Instrumentation

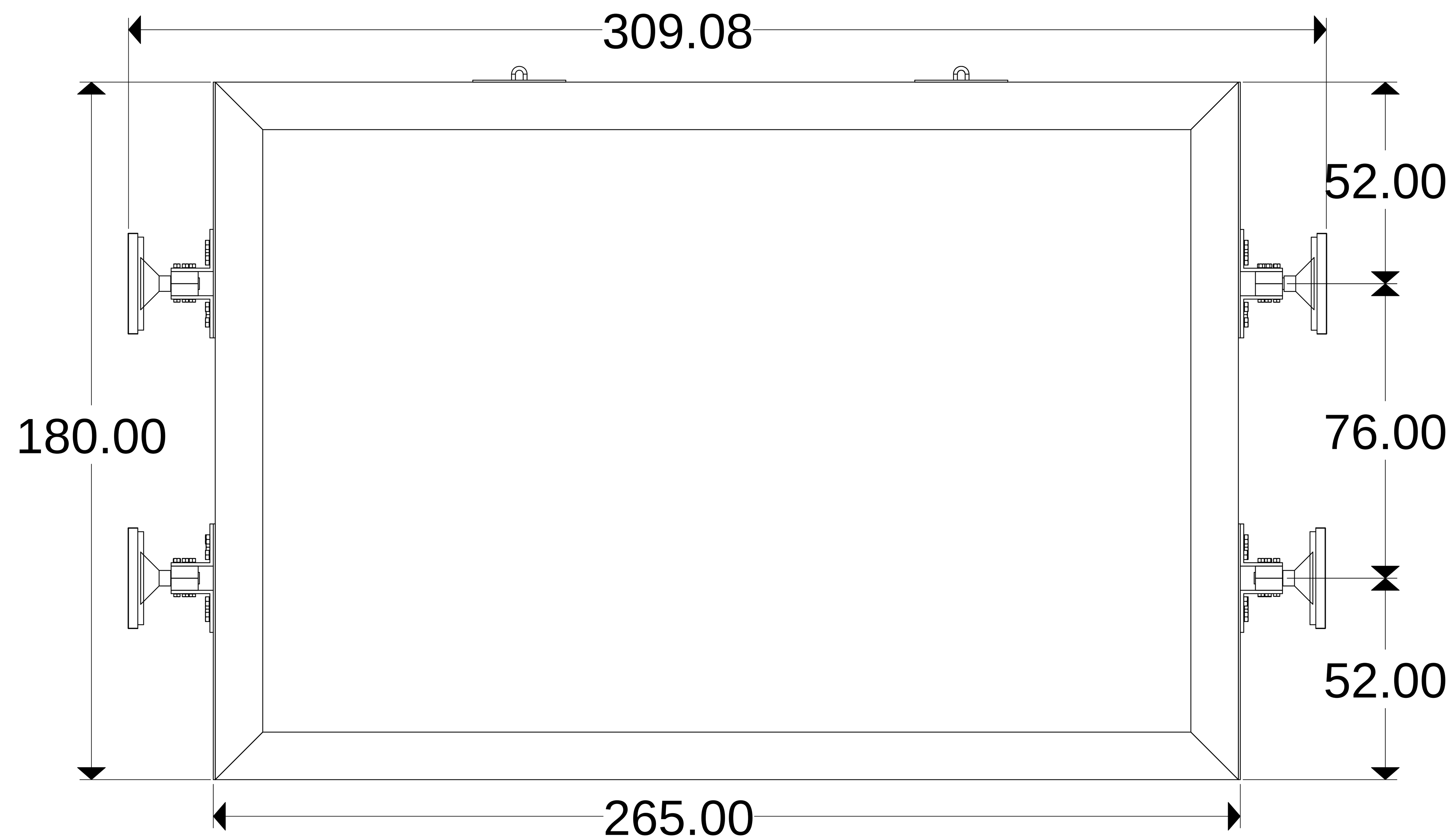
Seawolf Engineering

TITLE:

Schedule of Parts

SIZE D DWG. NO. Sheet_ 1of 7 REV

SCALE: 1:64 WEIGHT: SHEET 1 OF 7



Homer Tidal Power and Marine Instrumentation

Seawolf Engineering

TITLE:

Cradle Assembly

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D	Sheet_2 of 7	

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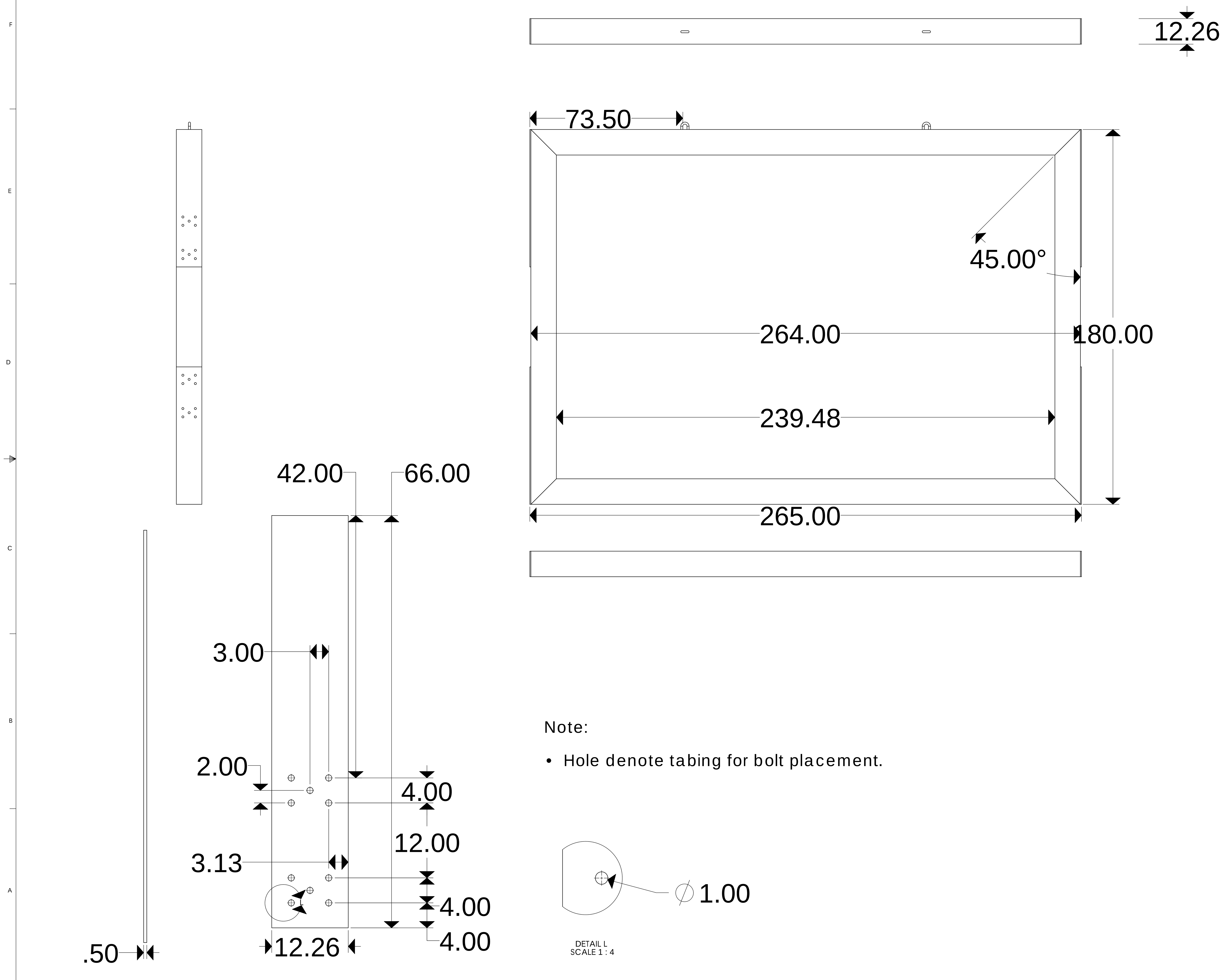
Cradle and Rail Assembly



Note:

- Hole denote tabing for bolt placement.

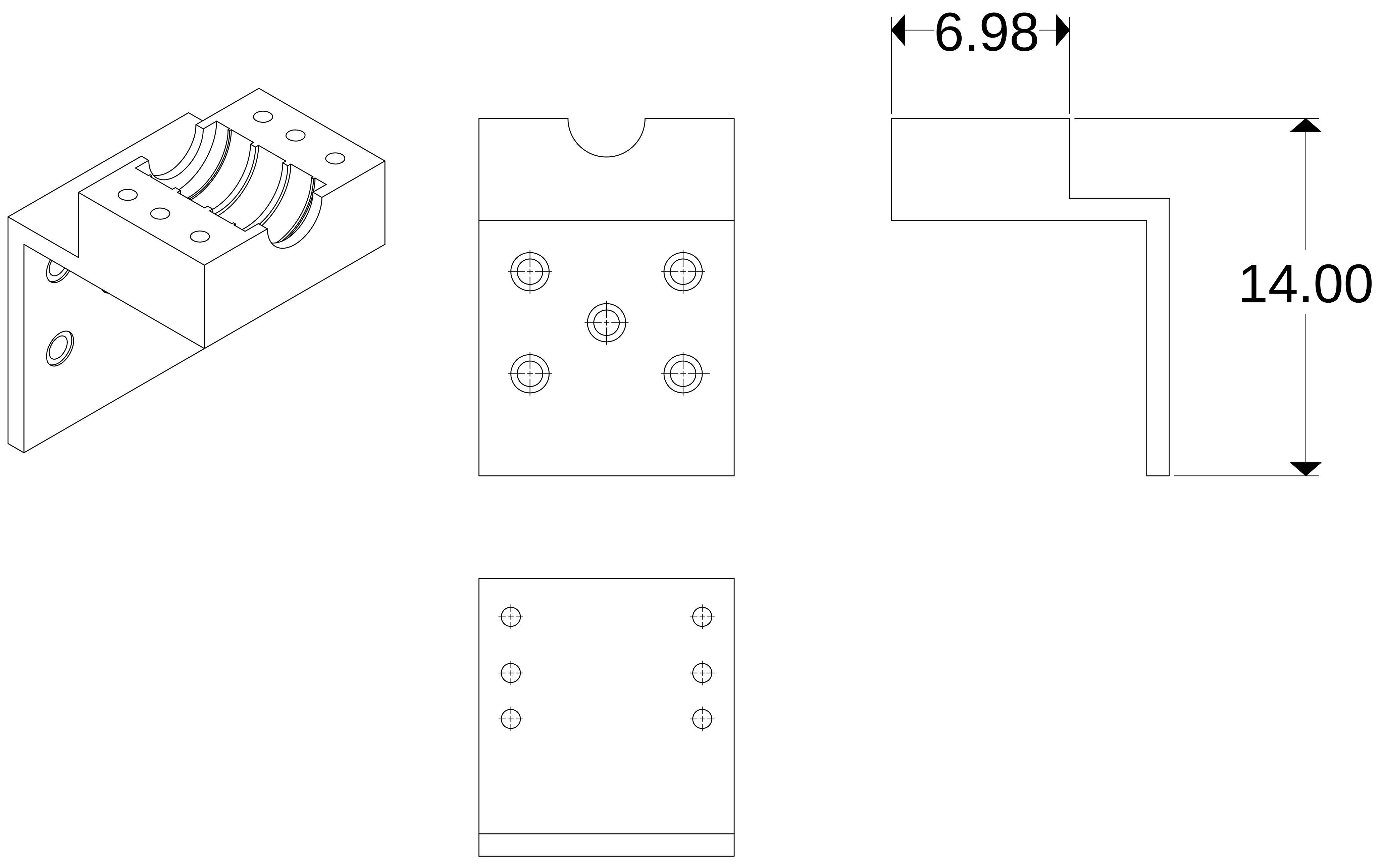
Homer Tidal Power and Marine Instrumentation

Seawolf Engineering

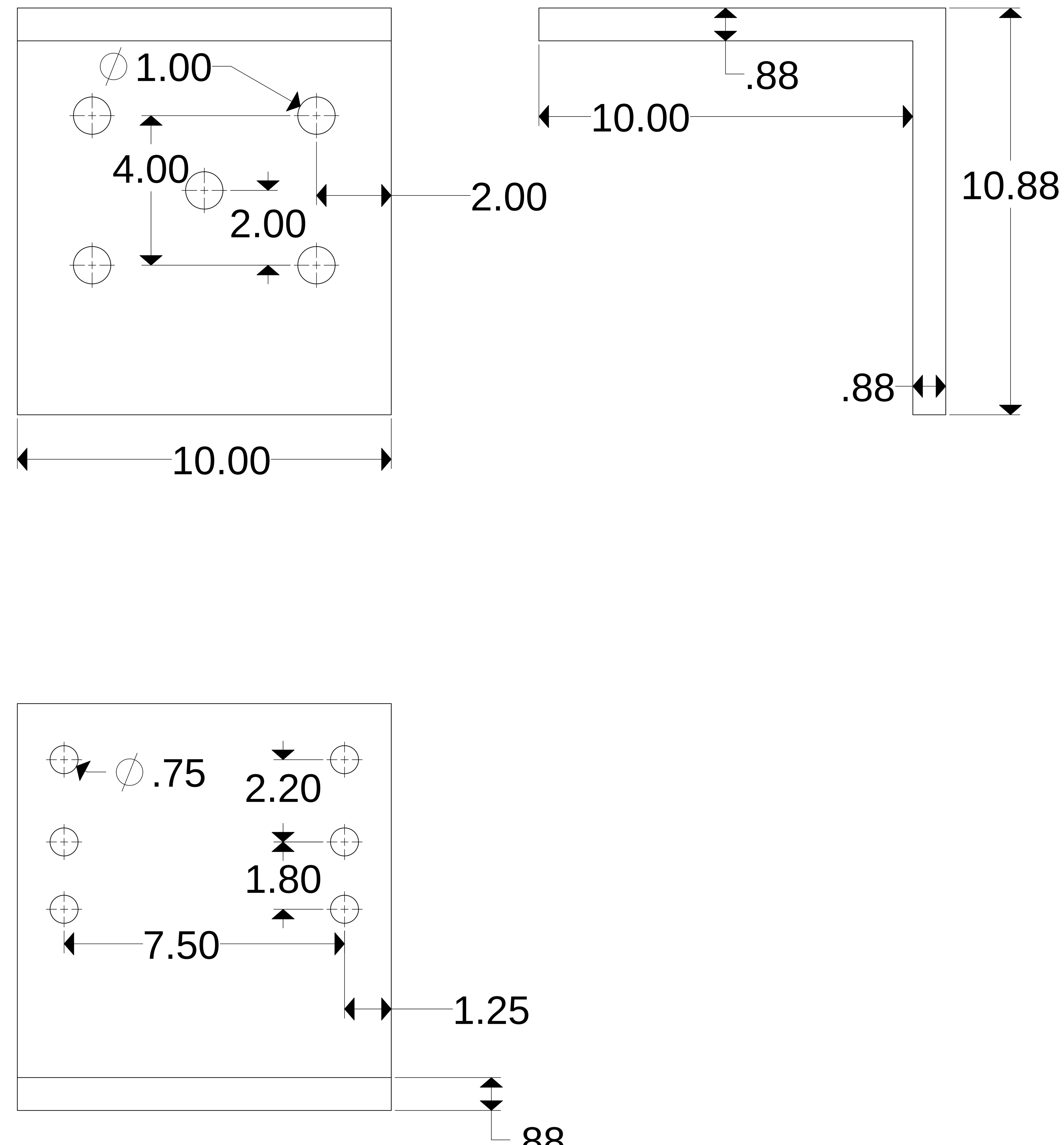
TITLE: Cradle

SIZE D | DWG. NO. Sheet_3 of 7 | REV

SCALE: 1:24 | WEIGHT: | SHEET 3 OF 7



Bearing Mount
Assembly



L Bracket

Homer Tidal Power and Marine Instrumentation

Seawolf Engineering

TITLE:
Bearing Mounting System

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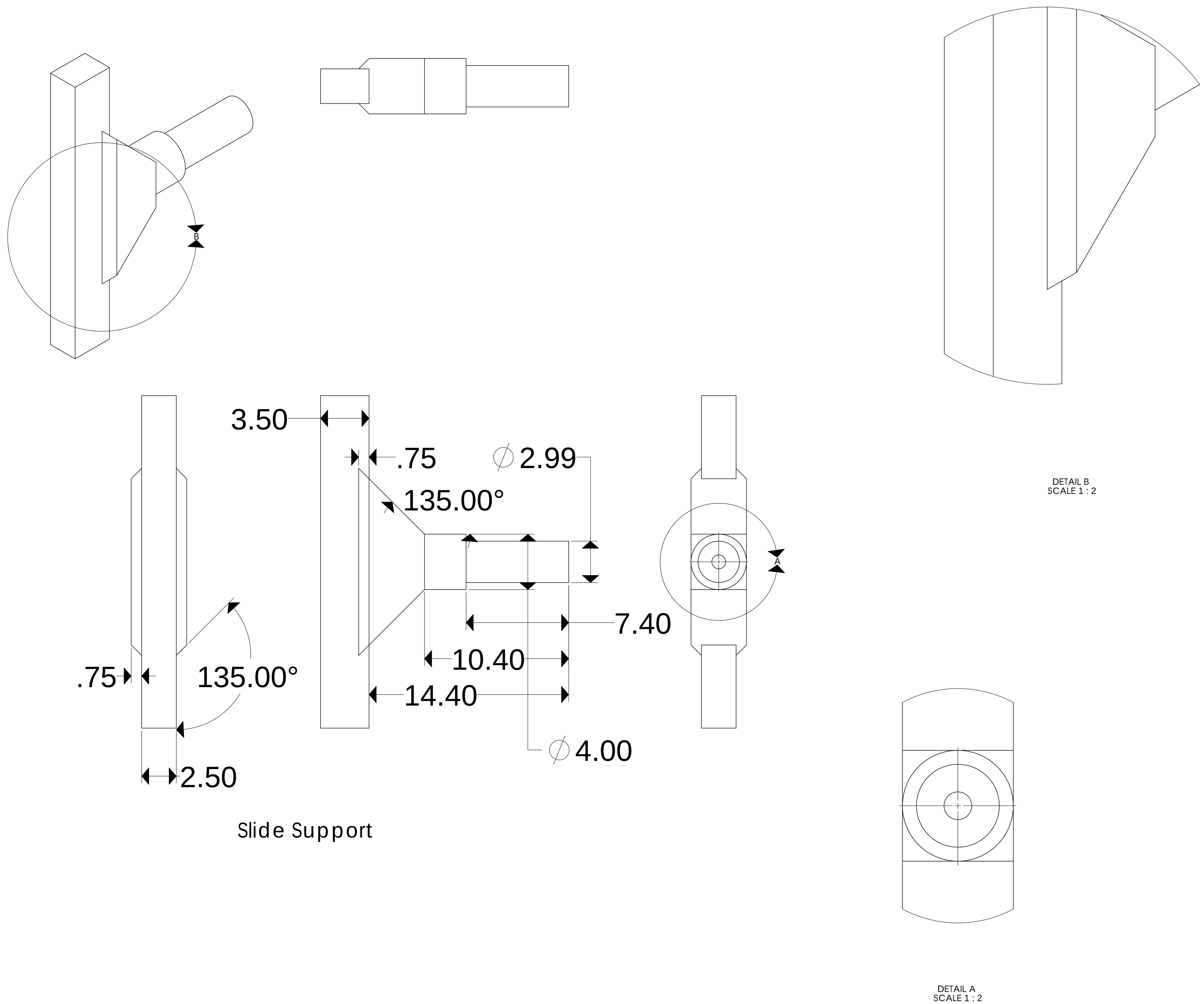


Homer Tidal Power and Marine Instrumentation

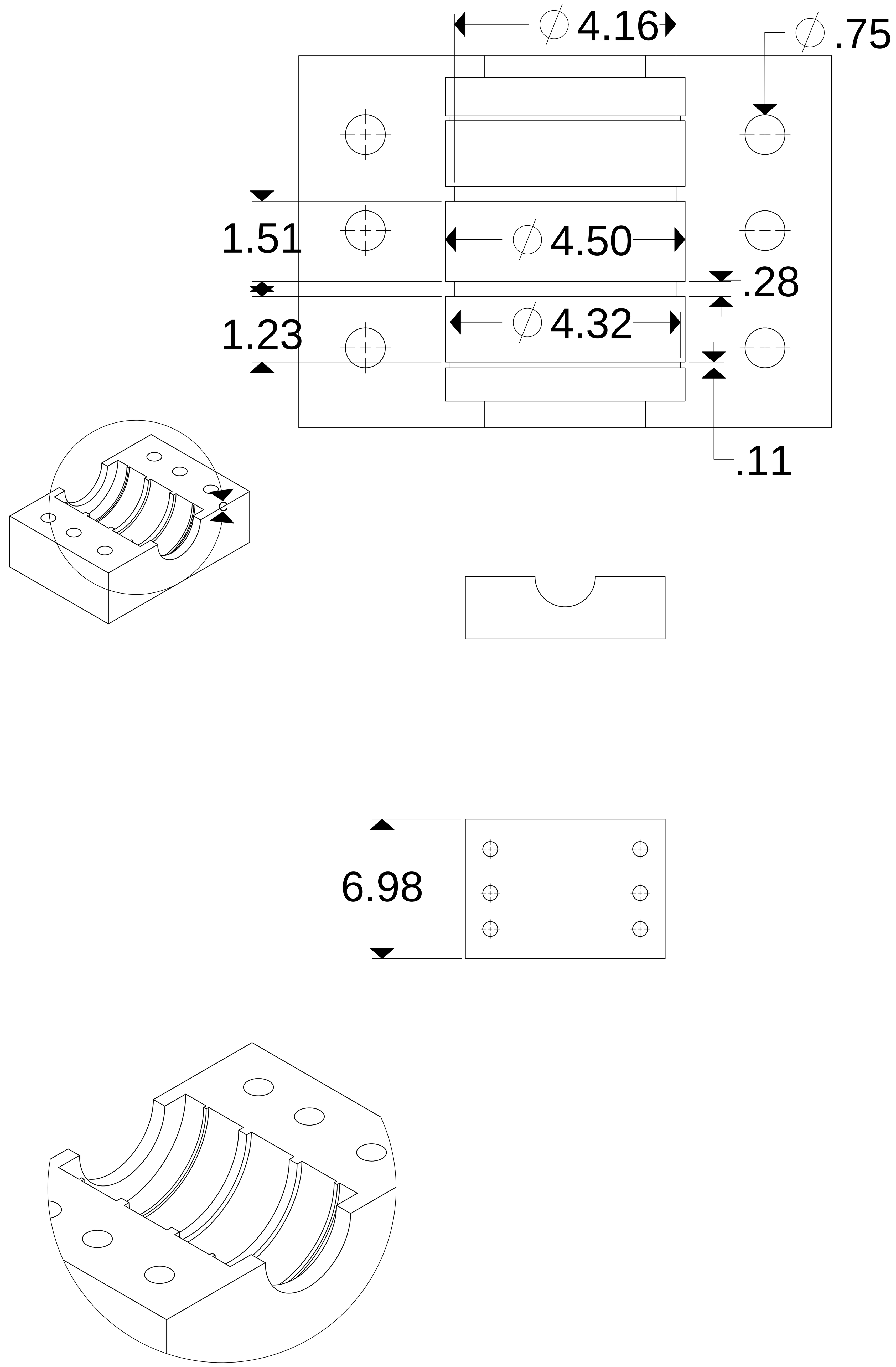
Seawolf Engineering

TITLE:

Slide Bearing System

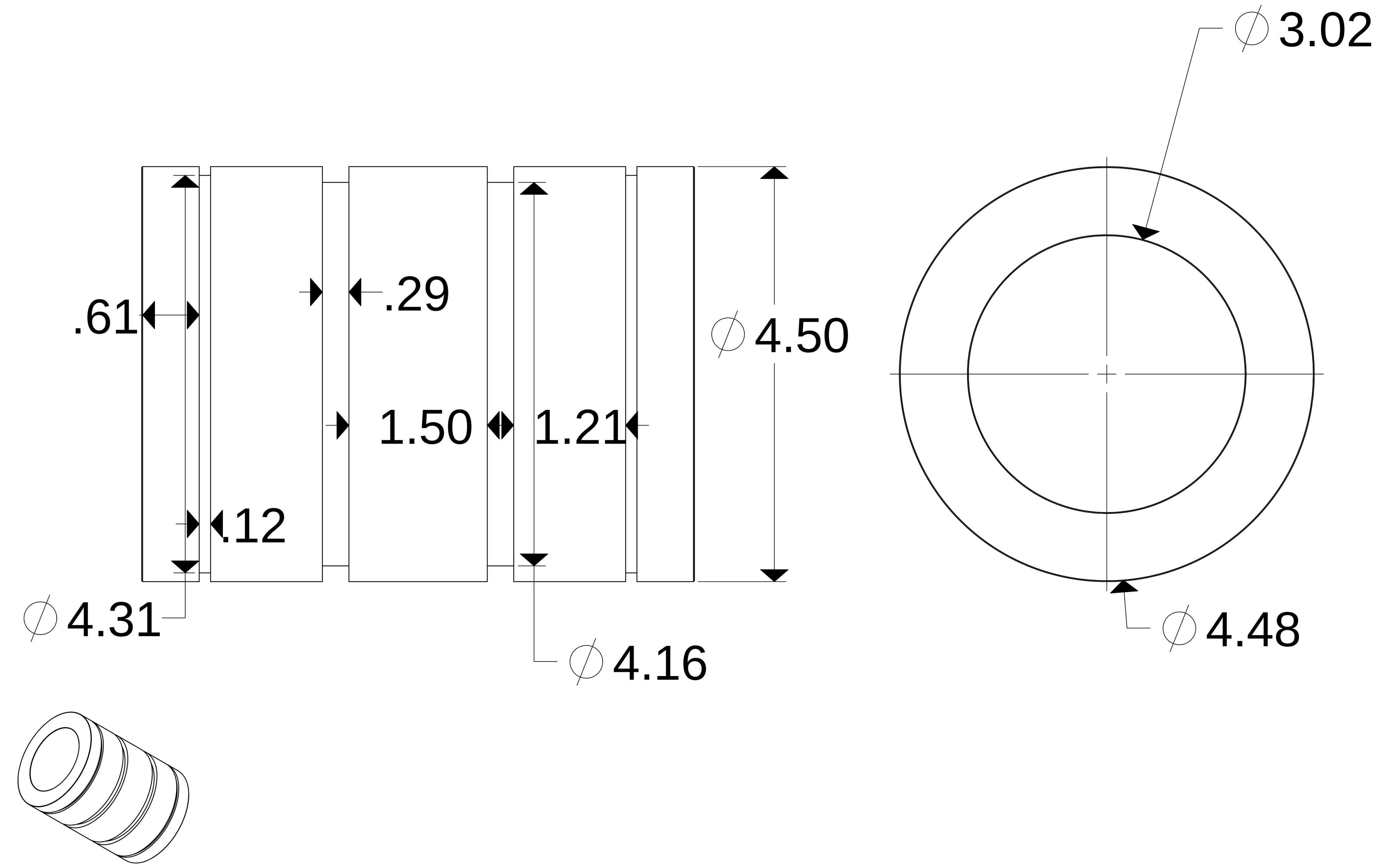
SIZE D | DWG. NO. Sheet_4 of 7 | REV

SCALE: 1:4 | WEIGHT: | SHEET 5 OF 7



Bearing Mount

DETAIL C
SCALE 1 : 2



Sleeve Bearing

Homer Tidal Power and Marine Instrumentation

Seawolf Engineering

TITLE:

Details A

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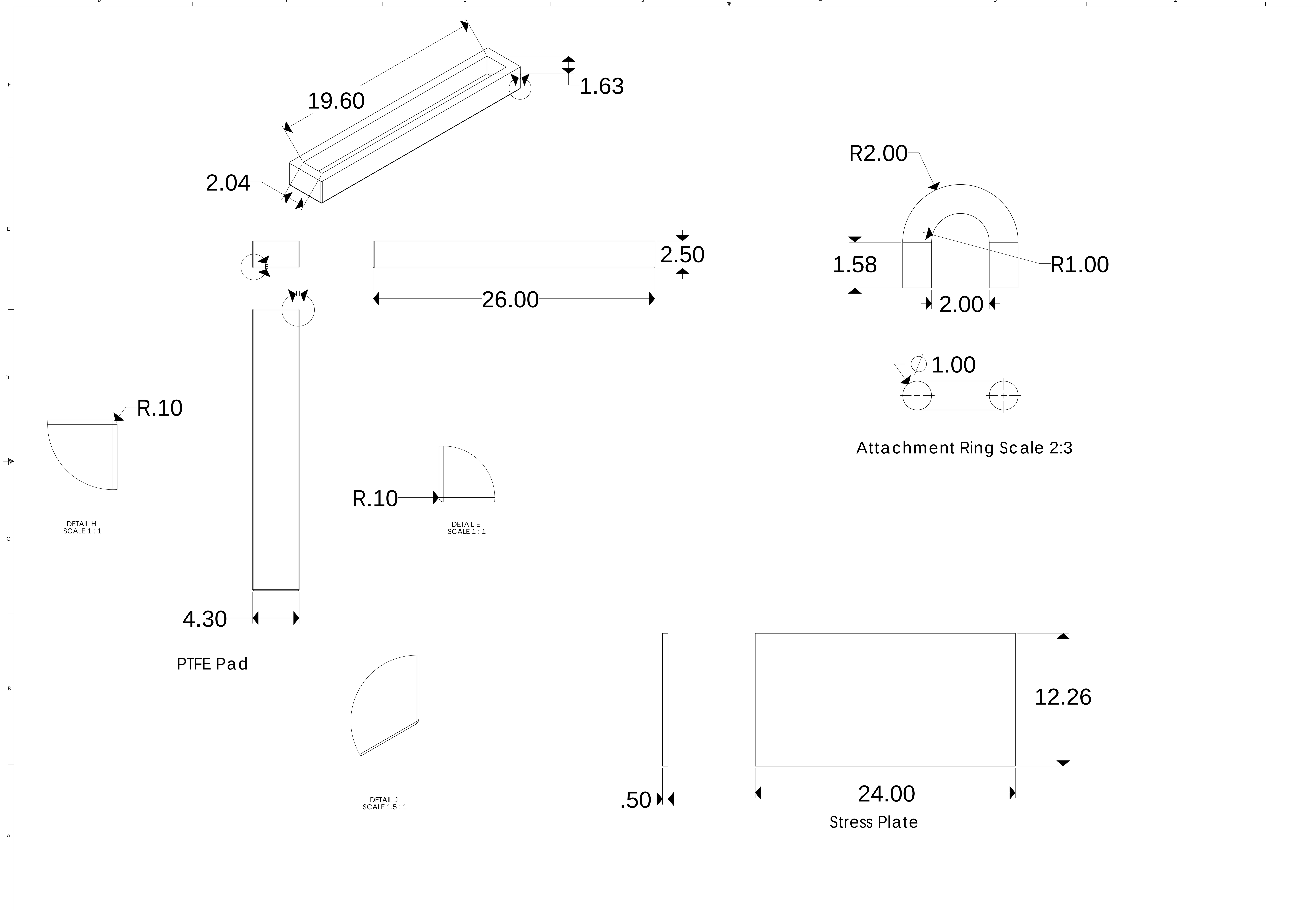

Homer Tidal Power and Marine Instrumentation

Seawolf Engineering

TITLE:

Details B

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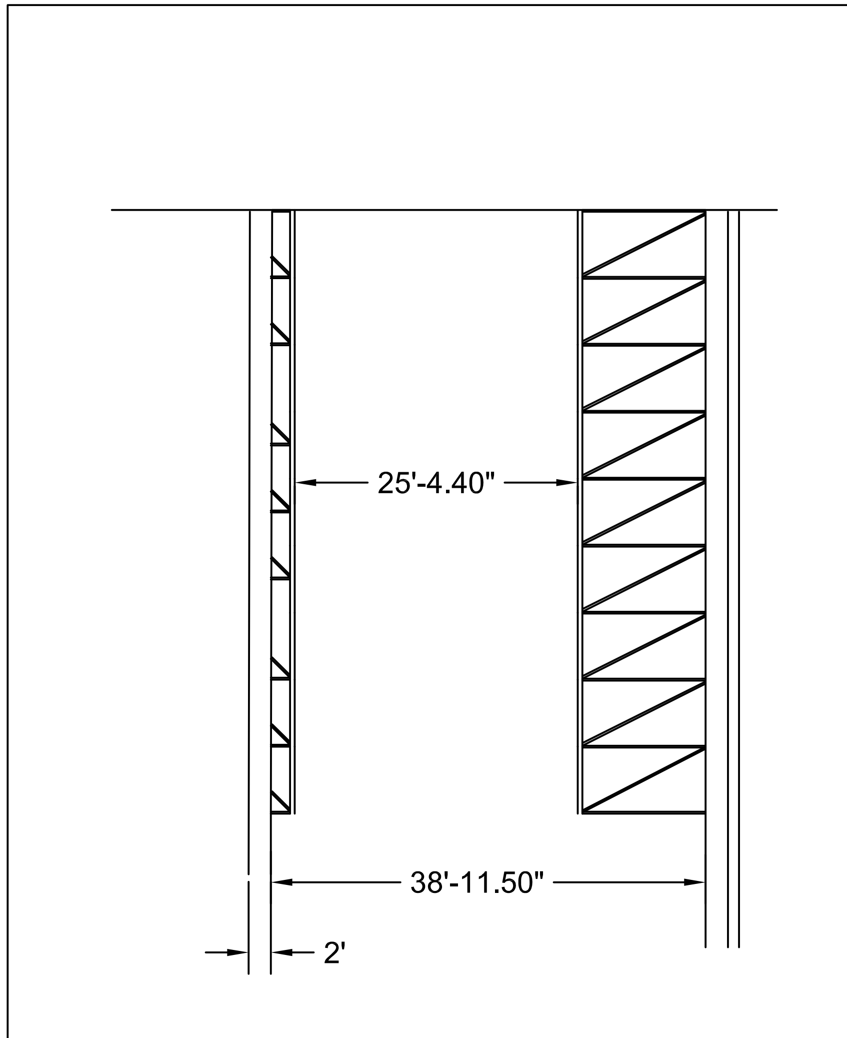
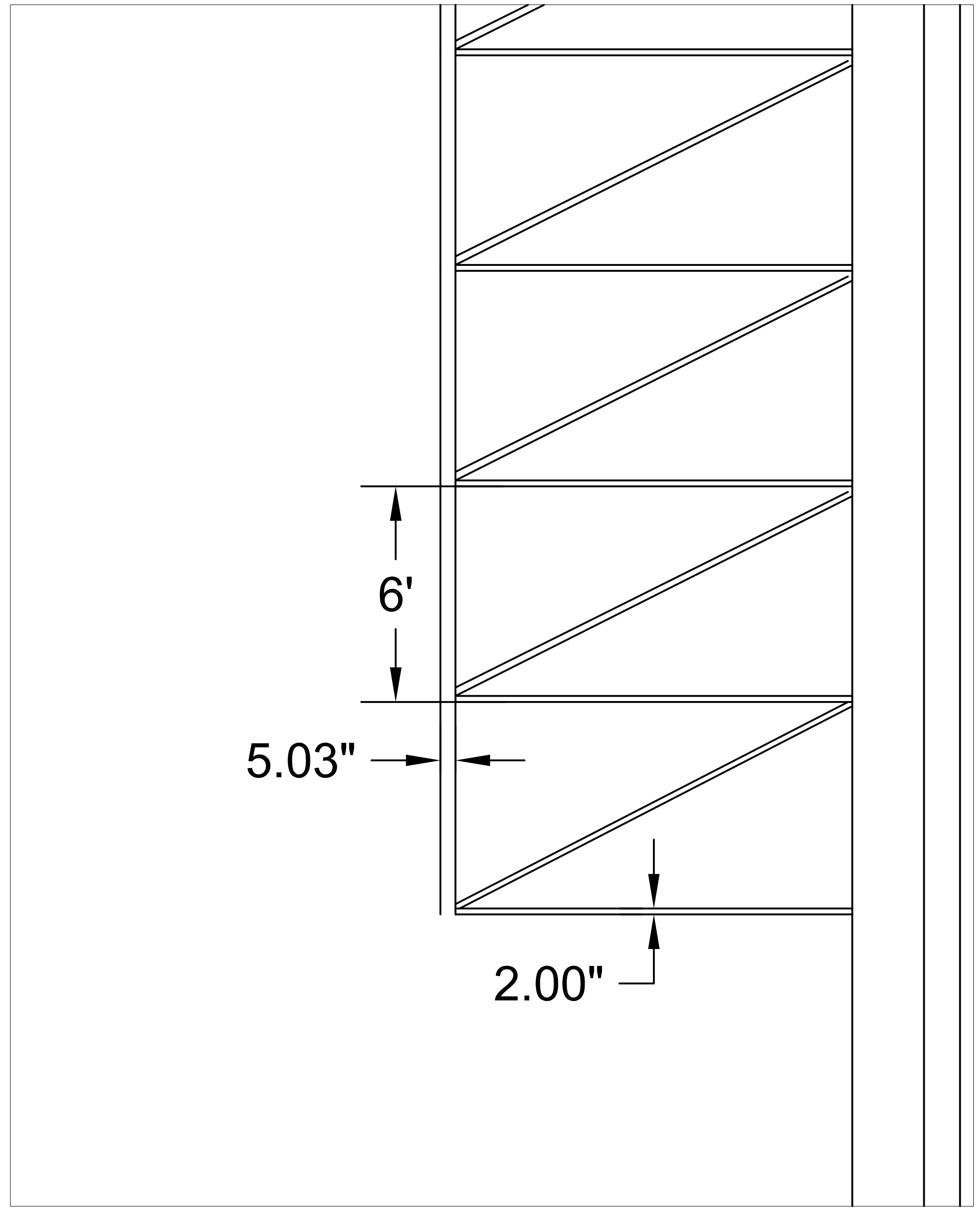
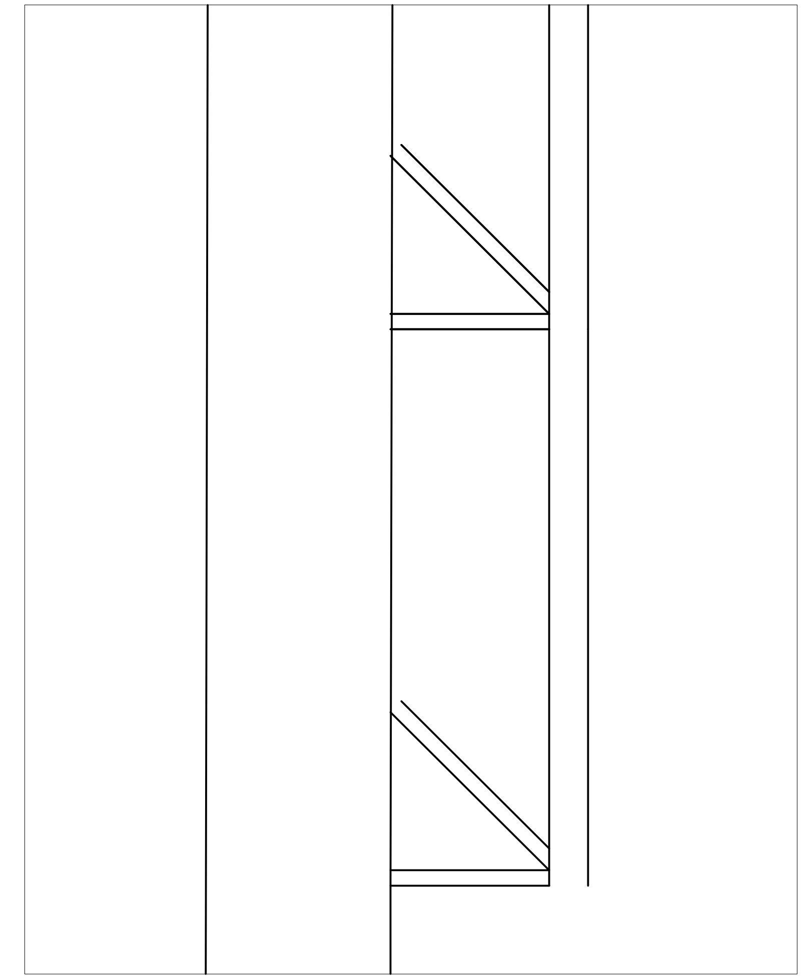


Cradle Rail Sketch
Scale: 7/128" = 1'-0"



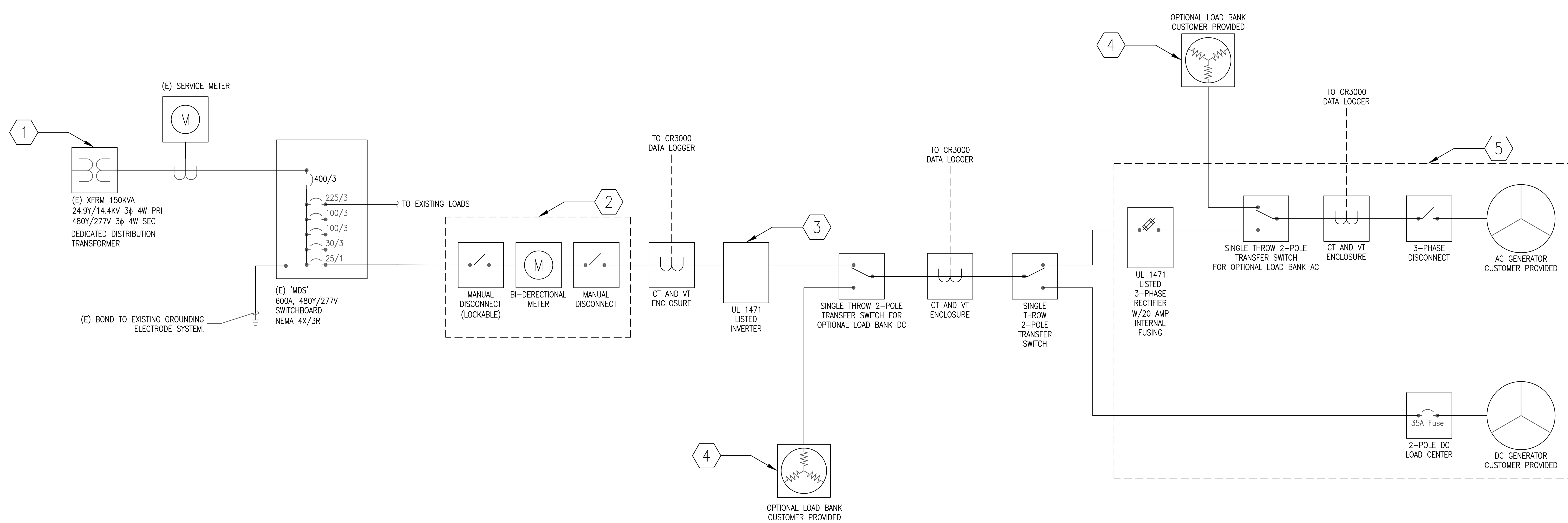


Use 2" gal. tubing for webbing. Non-dimensioned dimensions to dimension after structural and velocity studies have been conducted. Rails to be placed normal to tidal flow.

Submit webbing design upon completion of above studies. See cradle drawings for specifications.

Conform rail position with structural drawings.

UAA SCHOOL OF ENGINEERING				
Drawn By		Checked By		
Date Issued	SCALE	Date Revised	Dwg No	Rev



1
E001

ELECTRICAL ONE LINE

NTS

Appendix D – As-Builts

XREF's USED FOR THIS DWG.
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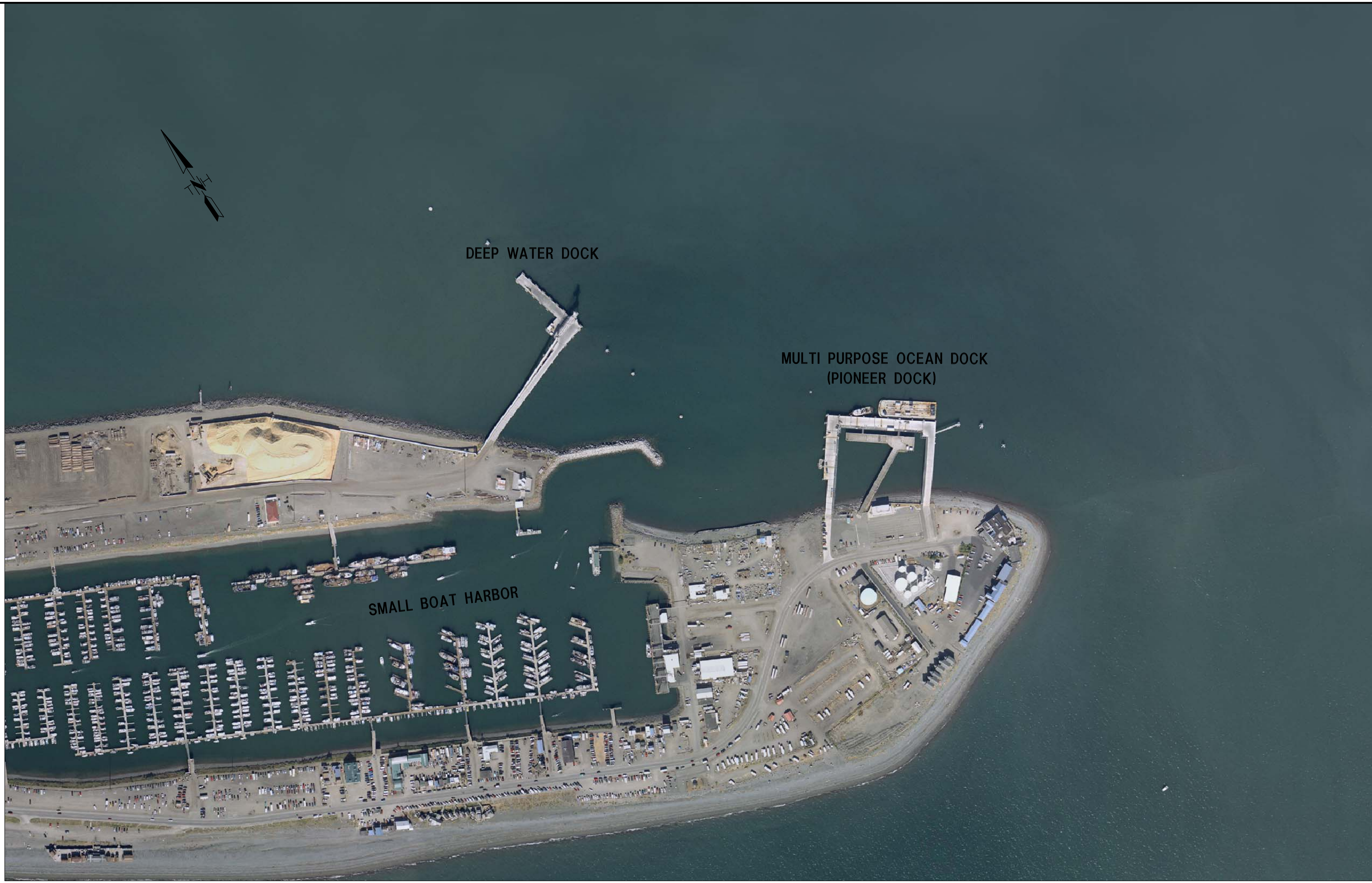
PROJECT No. & LCTN: M:\04085.000\Drawings\Plan Set



C1

GRAPHIC SCALE
200' 0 100' 200' 400'
(IN FEET)
SCALE: 1" = 200'

REV.	DATE	BY	REVISION

FIELD BOOKS			
DESIGN		DESIGNED	JCD
STAKING		DRAWN	SJ
AS-BUILT		CHECKED	JCD
SCALE HOR. AS SHOWN VER.		DATE	08/31/04
		GRID	
		JOB NO.	04085.0000

ENGINEERING/SURVEYING & LANDSCAPE ARCHITECTURE
Tryck Nyman Hayes, Inc.
911 W. 8TH AVENUE, SUITE 300
ANCHORAGE, AK 99501-3497

HOMER DEEP WATER DOCK EXPANSION

EXISTING SITE

HOMER, ALASKA

SHEET 2 OF 11

FILE NO. 4085_C1.dwg

114447

INDEX OF DRAWINGS

GENERAL NOTES

1. GENERAL

A. DESIGN LOADS

UNIFORM LIVE LOAD - 250 PSF

DESIGN VEHICLE - 30 TON FORKLIFT W/ 70 TON FRONT AXLE (DOCK)
15 TON FORKLIFT W/ 30 TON FRONT AXLE (TRESTLE)
AASHTD HS20 - 44 TRUCK (DOCK AND TRESTLE)

DESIGN EARTHQUAKE - UBC SEISMIC ZONE 4 IMPORTANCE OF OCCUPANCY 1

ICE LOADING - 10" THICK 200 PSI ICE FROM NORTH OR EAST.

FENDERING ENERGY - 120 FT-K/FENDER

ALLOWABLE CONSTRUCTION LOAD PRIOR TO GROUTING TENDONS - 200 PSF.

B. THE CONTRACTOR SHALL BE RESPONSIBLE FOR THE SAFETY TO THE STRUCTURAL DURING CONSTRUCTION. ADEQUATE SHORING, TIES, BRACING AND SUPPORTS SHALL BE USED TO INSURE PROPER TEMPORARY STRUCTURAL INTEGRITY DURING ALL PHASES OF CONSTRUCTION.

C. ALL MATERIALS AND WORKMANSHIP SHALL CONFORM WITH THE REQUIREMENTS OF THE UNIFORM BUILDING CODE, 1985 EDITION, UNLESS OTHERWISE NOTED.

D. ALL WORK SHALL CONFORM TO THE PLANS AND SPECIFICATIONS.

2. CAST-IN-PLACE CONCRETE

A. ALL REINFORCEMENT SHALL BE NEW DEFORMED BARS CONFORMING TO ASTM A-615. GRADE 60 TYPICAL UNLESS NOTED OTHERWISE.

B. ALL REINFORCING STEEL SHALL BE FABRICATED, DETAILED AND PLACED IN ACCORDANCE WITH THE MANUAL OF STANDARD PRACTICE FOR DETAILING REINFORCED CONCRETE STRUCTURES - ACI 315, LATEST EDITION.

C. REINFORCING BARS SHOWN OR NOTED TO BE CONTINUOUS SHALL BE IN AS LONG LENGTHS AS PRACTICABLE. UNLESS OTHERWISE SHOWN OR NOTED, ALL SPLICES SHALL BE IN ACCORDANCE WITH BUILDING CODE REQUIREMENTS FOR REINFORCED CONCRETE ACI 318-83.

D. MIXING AND PLACING OF CONCRETE AND SELECTION OF MATERIALS SHALL BE IN ACCORDANCE WITH THE AMERICAN CONCRETE INSTITUTE 318-83.

E. CONCRETE SHALL HAVE A MINIMUM 28-DAY COMPRESSIVE STRENGTH OF 4000 PSI. MAXIMUM AGGREGATE SIZE SHALL BE 1-INCH. MAXIMUM SLUMP SHALL BE 3-INCHES.

3. PRECAST PRESTRESSED CONCRETE

A. ALL REINFORCEMENT SHALL BE NEW DEFORMED BARS CONFORMING TO ASTM-615. GRADE 60.

B. WELDED WIRE FABRIC SHALL CONFORM TO ASTM A-185.

C. ALL REINFORCING STEEL SHALL BE FABRICATED, DETAILED AND PLACED IN ACCORDANCE WITH THE MANUAL OF STANDARD PRACTICE FOR DETAILING REINFORCED CONCRETE STRUCTURES - ACI 315, LATEST EDITION.

D. REINFORCING BARS SHOWN OR NOTED TO BE CONTINUOUS SHALL BE IN AS LONG LENGTHS AS PRACTICABLE. UNLESS OTHERWISE SHOWN OR NOTED, ALL SPLICES SHALL BE IN ACCORDANCE WITH BUILDING CODE REQUIREMENTS FOR REINFORCED CONCRETE - ACI 318-83.

E. MIXING AND PLACING OF CONCRETE AND SELECTION OF MATERIALS SHALL BE IN ACCORDANCE WITH THE AMERICAN CONCRETE INSTITUTE 318-83.

F. CONCRETE SHALL HAVE THE FOLLOWING MINIMUM PROPERTIES:

TRESTLE PANELS	DOCK PANEL
F'ci = 4500 PSI	F'ci = 4000 PSI
F'c = 7000 PSI	F'c = 6000 PSI
MAXIMUM AGGREGATE SIZE = 3/8-INCH	MAX AGGREGATE SIZE = 1/2 INCH
MAXIMUM SLUMP = 2-INCHES	MAX SLUMP = 2-1 INCHES

G. PRESTRESSING STRANDS SHALL BE 1/2-INCH DIAMETER - 270 KSI.
FORCE PER STRAND = 0.153 X 154 = 23.6 K
FORCE PER PANEL = 12 X 23.56 = 282.7 K
ALL PRESTRESSING STRANDS SHALL BE SEVEN WIRE WITH A CROSS-SECTIONAL AREA OF 0.153-SQUARE INCHES.

H. DOCK POST-TENSIONING TENDON SHALL BE 8 STRAND TENDONS JACKED FROM BOTH ENDS. STRANDS SHALL BE 1/2 INCH DIAMETER - 270 KSI.

JACKING STRESS 0.94(0.95) fpy = 205 KSI (5% ASSUMED ANCHOR FRICTION)
DUCK LOSSES = 26.05 KSI
LONG TERM LOSSES = 28.00 KSI
FINAL PRESTRESS = 150.95 KSI

FORCE PER STRAND 150.95 X 0.153 = 23.09 K

FORCE PER TENDON 23.09 X 8 = 184.76 K

PRESTRESS 184.76 / 2 = 92.38 K/FT OF DECK

4. STRUCTURAL STEEL

A. ALL STRUCTURAL STEEL WORK SHALL BE IN ACCORDANCE WITH AISC SPECIFICATIONS FOR "DESIGN, FABRICATION, AND ERECTION OF STRUCTURAL STEEL FOR BUILDINGS", 8TH EDITION.

B. ALL WELDING SHALL BE IN ACCORDANCE WITH THE AMERICAN WELDING SOCIETY STANDARDS FOR ARC AND GAS WELDING. UNLESS OTHERWISE NOTED, ALL FILLET WELDS SHALL BE EQUAL LEG WELDS OF THE MINIMUM SIZE REQUIRED BY AISC, TABLE 1.17.2.A. ALL WELDING SHALL BE DONE BY CERTIFIED WELDERS. MANUAL WELDING ELECTRODES SHALL BE E70XX.

C. ALL STRUCTURAL STEEL, EXCEPT STRUCTURAL TUBING, SHALL BE A-36, UNLESS OTHERWISE NOTED. STRUCTURAL TUBING SHALL BE A-500, GRADE B.

D. ALL WELDING SHALL BE IN ACCORDANCE WITH THE AWS-STRUCTURAL WELDING CODE, D1.1, LATEST EDITION.

E. ALL CONNECTING BOLTS SHALL BE ASTM A-325 WITH THREADS EXCLUDED FROM THE SHEAR PLANE. ALL OTHER BOLTS SHALL BE A-307 UNLESS OTHERWISE NOTED. ALL BOLTS SHALL BE HOT DIP GALVANIZED.

F. ALL EXPOSED STEEL SHALL BE HOT DIP GALVANIZED.

G. STEEL PIPE PILES SHALL CONFORM TO ASTM A 252 GRADE 3.

LEGEND SHEETS C-1 THRU C-4

GRID PILE

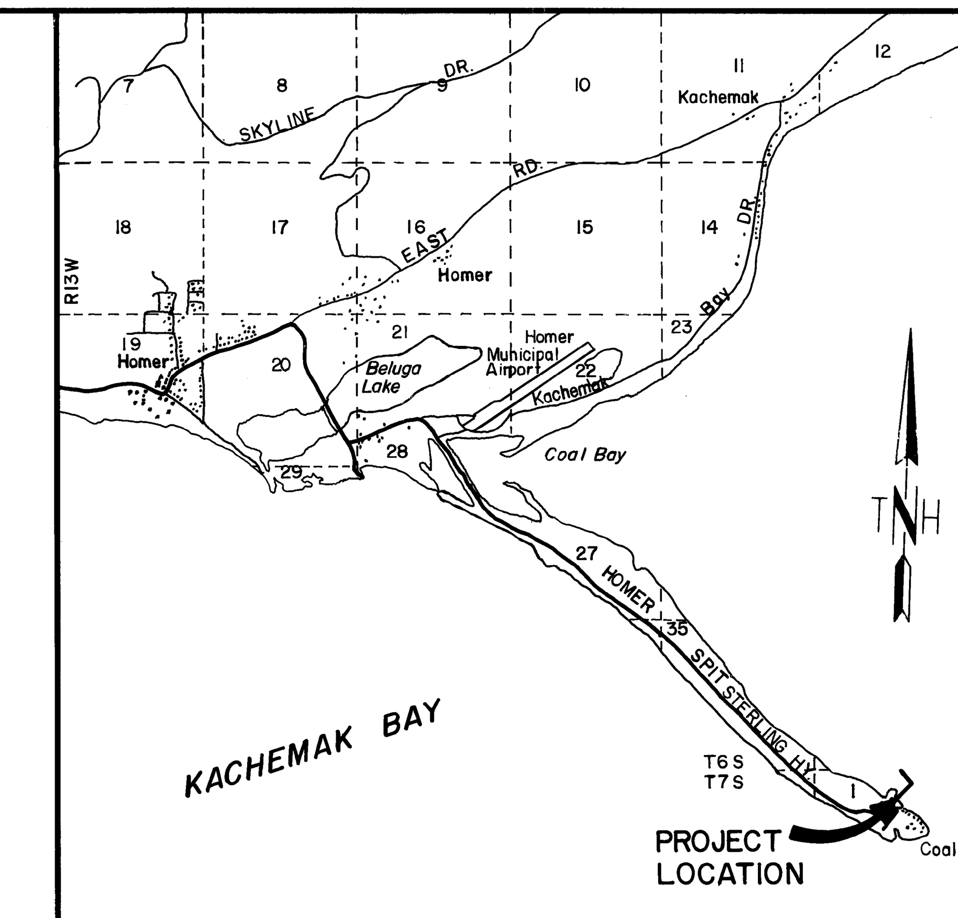
EXIST. CONTOUR -20

CONTROL POINTS

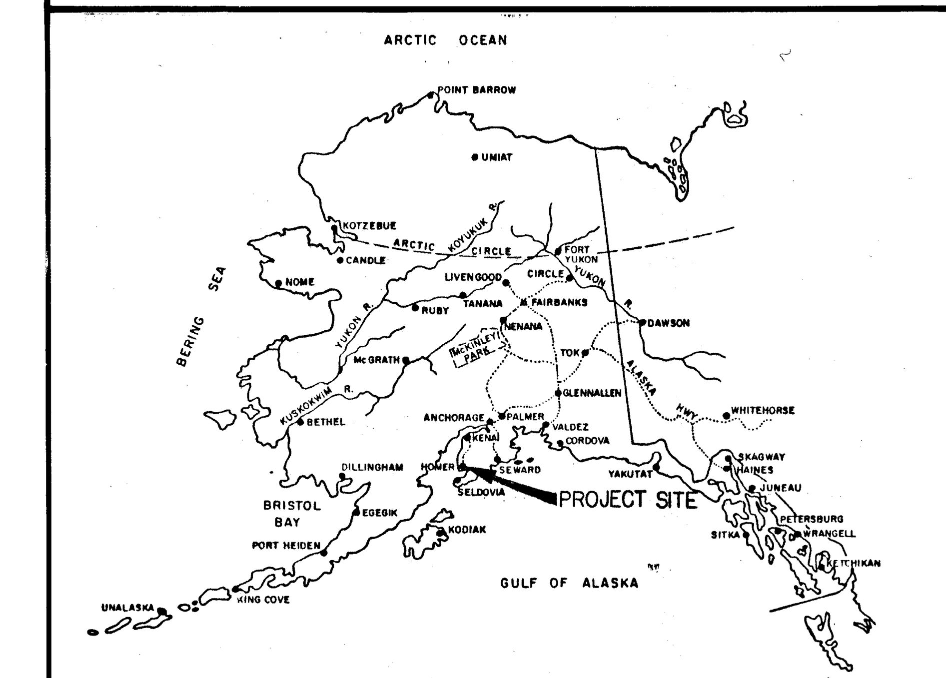
SHEETS S-1 THRU S-15

FENDER PILE

SECTION DESIGNATION: SECTION LETTER (A); DETAIL NUMBER; SHT. SHOWN ON (S2); SHT. CUT ON (S1)



VICINITY MAP



LOCATION MAP

ABBREVIATIONS

ALT.	ALTERNATE
A.B.	ANCHOR BOLT
APPROX.	APPROXIMATE
@	AT
BM.	BEAM
BOT.	BOTTOM
C.I.P.	CAST IN PLACE
CTR.	CENTER
℄	CENTERLINE
CLR.	CLEAR
CONC.	CONCRETE
CONT.	CONTINUOUS
DET	DETAIL
∅	DIAMETER
EA.	EACH
EL.	ELEVATION
EQ.	EQUAL
EXP.	EXPANSION
GA.	GAGE
GALV.	GALVANIZED
HDG.	HEADED
JT.	JOINT
MAX	MAXIMUM
MIN.	MINIMUM
O.C.	ON CENTER
PLS.	PLACES
℔	PLATE
R	RADIUS
REQD.	REQUIRED
TYP	TYPICAL
SHT.	SHEET
SPA.	SPACES
STD.	STANDARD
U.O.N.	UNLESS OTHERWISE NOTED
W/	WITH
W/O	WITHOUT
W.P.	WORK POINT

PORTIONS OF THIS PROJECT WERE FUNDED BY:
EDA PROJECT NO. 07-01-03099
STATE OF ALASKA
DEPT. OF COMMERCE & ECONOMIC DEVELOPMENT
CONTROL NO. 89-001

STATE OF ALASKA 49th — SAMUEL J. SHOEMAKER CE-6478 REGISTERED PROFESSIONAL ENGINEER

STATE OF ALASKA 49th — FRANK E. NYMAN 410-E REGISTERED PROFESSIONAL ENGINEER

REV.	DATE	BY	REVISION	FIELD BOOKS	DESIGNED MJS
				DESIGN	DRAWN HJF
				STAKING	CHECKED MJS
				AS-BUILT	DATE OCT. 86
				SCALE HOR.	GRID
				VER.	JOB NO. 4784.0

TRYCK NYMAN & HAYES
ENGINEERS / PLANNERS / SURVEYORS
ANCHORAGE, ALASKA

CITY OF HOMER
DEEP WATER DOCK
EDA PROJECT NO. 07-01-03[illegible]
TITLE SHEET

SHEET T-1 OF 22

FILE NO. 00400

REV.	DATE	BY	REVISION
1	8-15-90	WH	AS BUILT

FIELD BOOKS — DESIGNED MJS — DRAWN LD — CHECKED MJS — DATE OCT. 88 — JOB NO. 4784.0

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CITY OF HOMER
DEEP WATER DOCK
EDA PROJECT NO. 07-01-03099

DOCK PLAN

SHEET S-1 OF 22
FILE NO. 00405

PORTIONS OF THIS PROJECT WERE FUNDED BY:
EDA PROJECT NO. 07-01-03099
STATE OF ALASKA
DEPT. OF COMMERCE & ECONOMIC DEVELOPMENT
CONTROL NO. 89-001

STATE OF ALASKA 49th — MICHAEL J. SHOEMAKER CE-6478 — REGISTERED PROFESSIONAL ENGINEER
STATE OF ALASKA 49th — FRANK E. NYMAN 440-E — REGISTERED PROFESSIONAL ENGINEER

PORTIONS OF THIS PROJECT WERE FUNDED BY:
EDA PROJECT NO. 07-01-03099
STATE OF ALASKA
DEPT. OF COMMERCE & ECONOMIC DEVELOPMENT
CONTROL NO. 89-001

REV.	DATE	BY	REVISION
1	8-15-90		AS BUILT

FIELD BOOKS — DESIGN / STAKING / AS-BUILT / HOR. / VER. — SCALE

DESIGNED MJS
DRAWN HJF
CHECKED MJS
DATE OCT. 88
GRID
JOB NO. 4784.0

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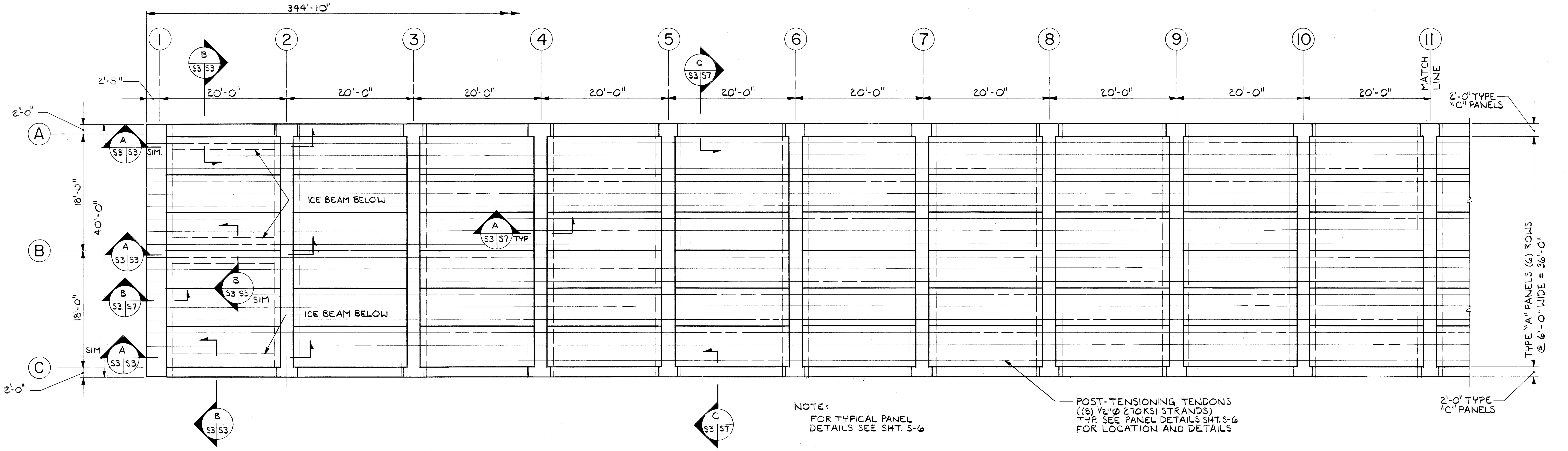
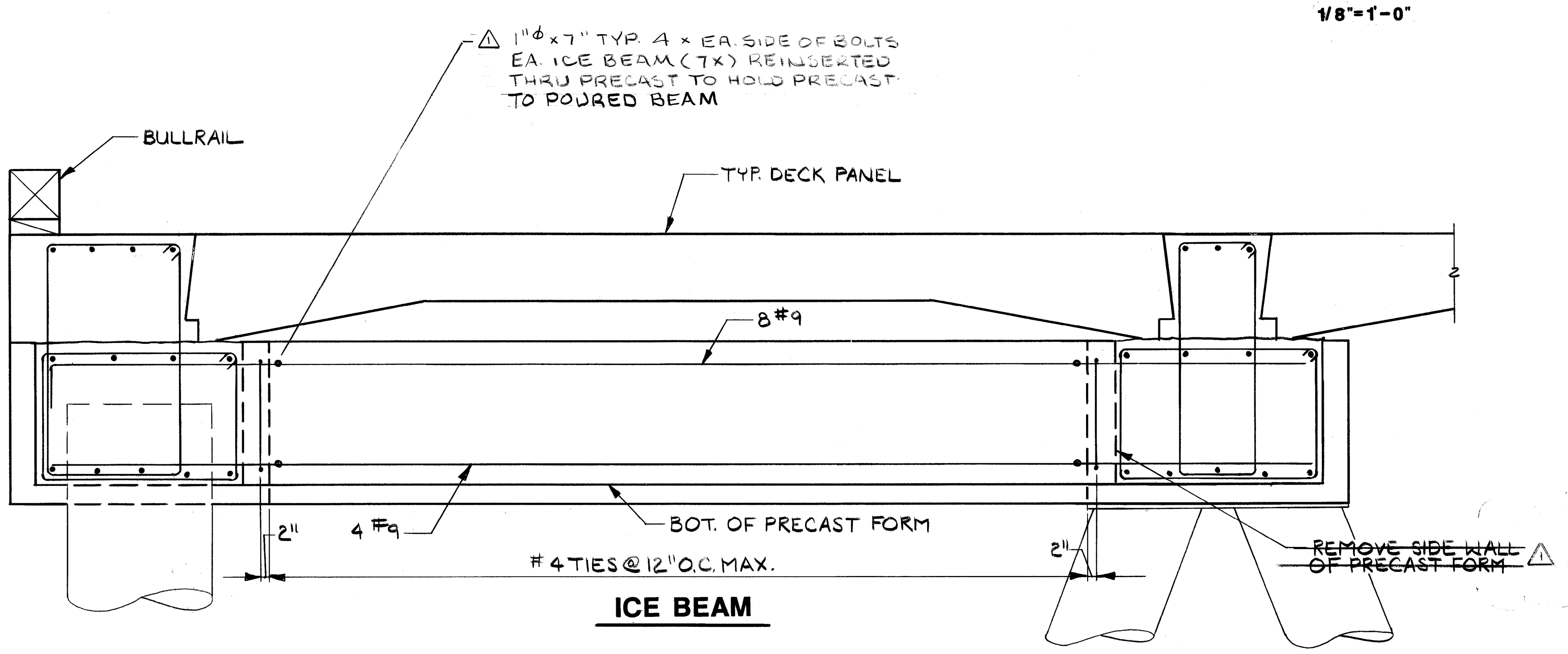
CITY OF HOMER
DEEP WATER DOCK
EDA PROJECT NO. 07-01-03099
DOCK AND TRESTLE PILE PLAN

SHEET S-2 of 22
FILE NO. 00406

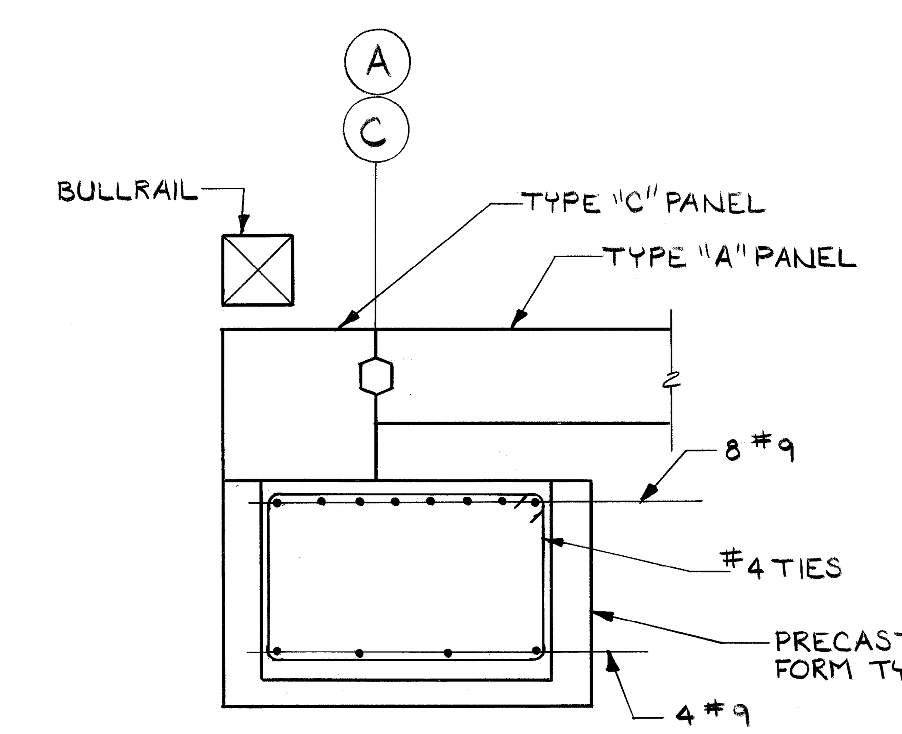


DOCK DECK PANEL PLAN

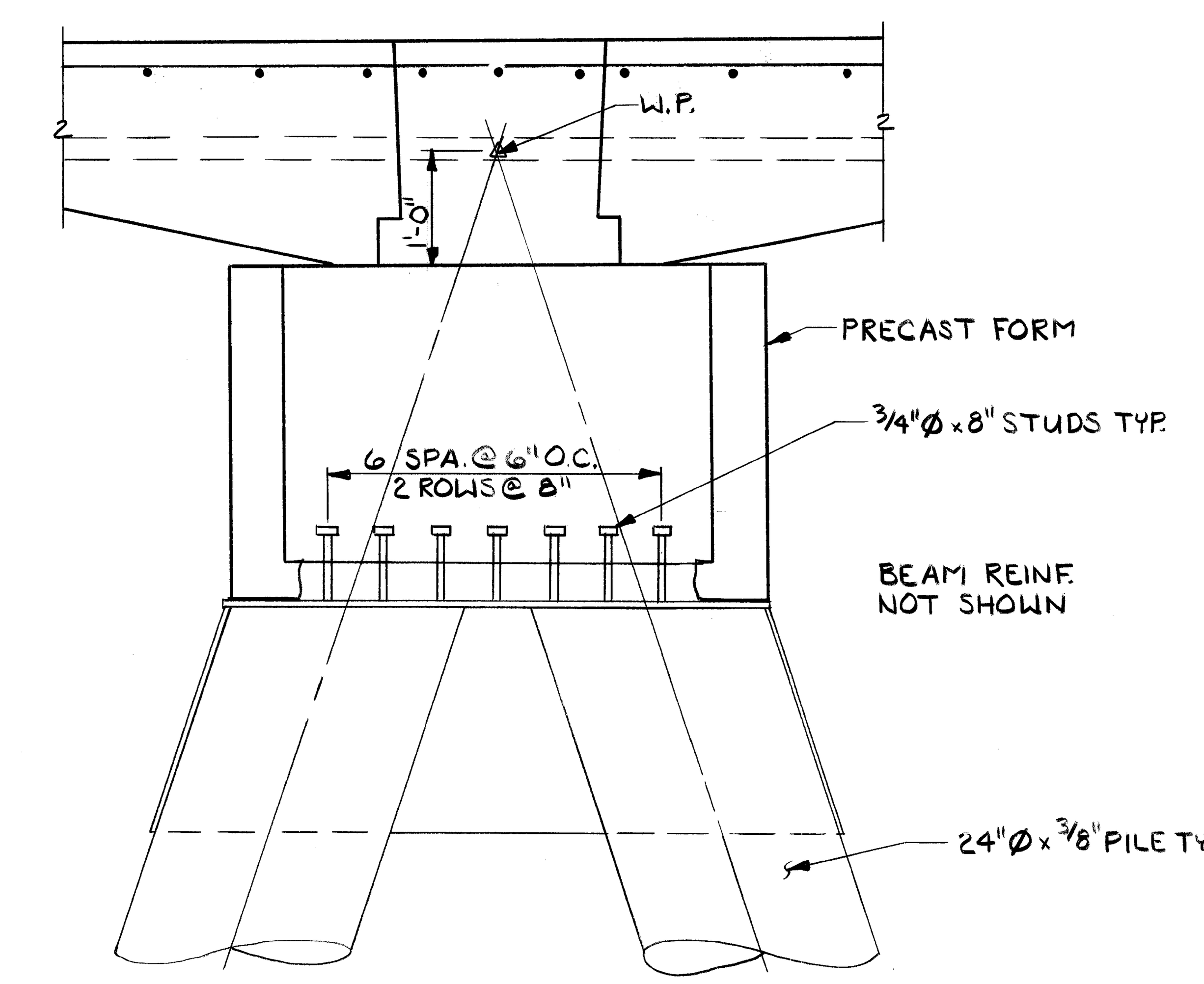
1/8"=1'-0"



SECTION A
1/2"=1'-0" S3 S4 S3



SECTION B
1/2"=1'-0" S3 S4 S3



DETAIL 1
3/4"=1'-0" S3 S7

PORTIONS OF THIS PROJECT WERE FUNDED BY:
EDA PROJECT NO. 07-01-03099
STATE OF ALASKA
DEPT. OF COMMERCE & ECONOMIC DEVELOPMENT
CONTROL NO. 89-001

REV.	DATE	BY	REVISION
1	8-15-90		AS BUILT

FIELD BOOKS		DESIGNED	MJS
DESIGN		DRAWN	HJF
STAKING		CHECKED	MJS
AS-BUILT		DATE	OCT. 88
SCALE HOR.		GRID	
VER.		JOB NO.	4784.0

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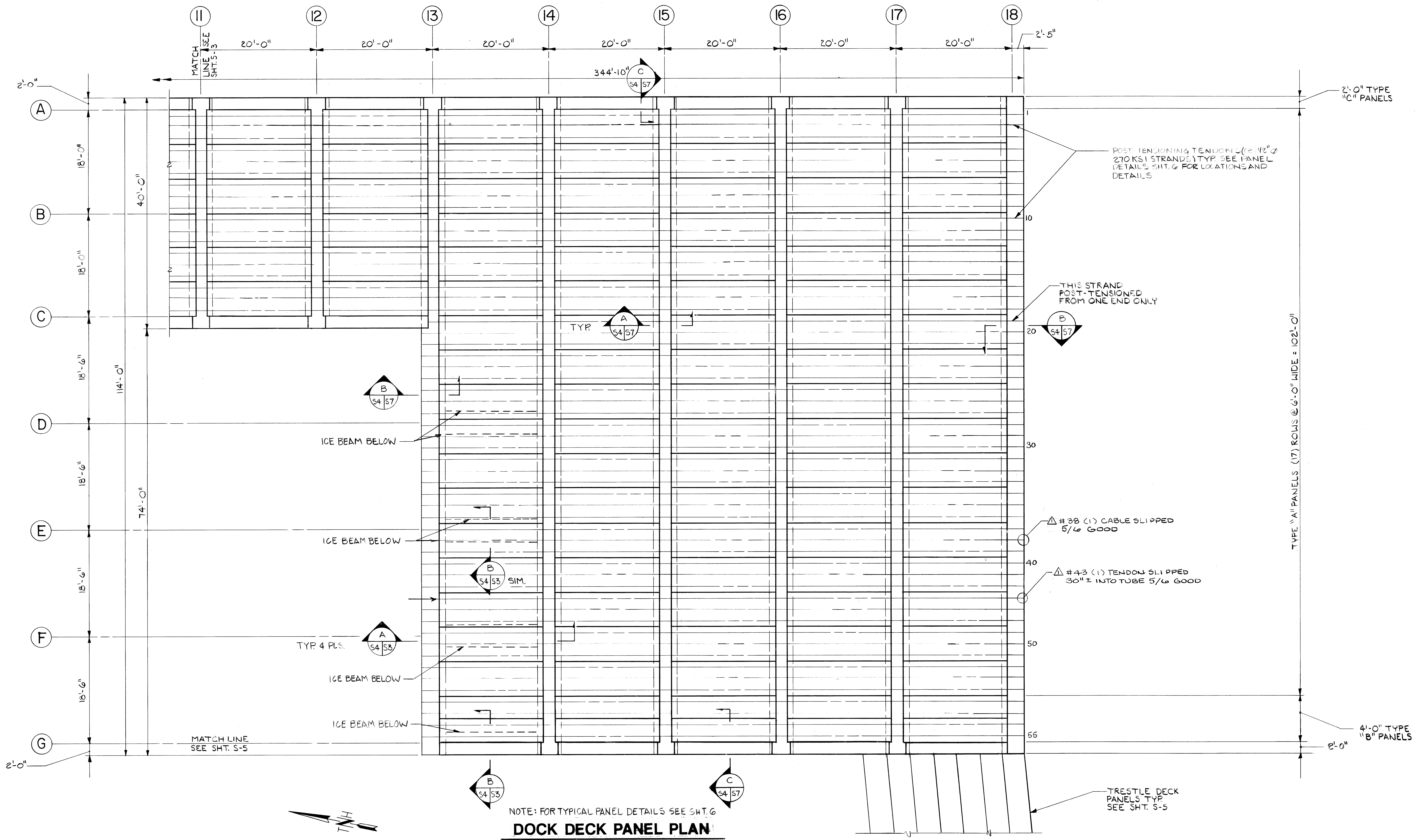
CITY OF HOMER
DEEP WATER DOCK
EDA PROJECT NO. 07-01-03099
DOCK DECK PANEL PLAN

SHEET S-3 of 22
FILE NO. 00407



NOTE: FOR TYPICAL PANEL DETAILS SEE SHT. 6

DOCK DECK PANEL PLAN

1/8"=1'-0"

PORTIONS OF THIS PROJECT WERE FUNDED BY:
EDA PROJECT NO. 07-01-03099
STATE OF ALASKA
DEPT. OF COMMERCE & ECONOMIC DEVELOPMENT
CONTROL NO. 89-001

REV.	DATE	BY	REVISION
1	8-15-90	WH	AS BUILT

FIELD BOOKS
DESIGN
STAKING
AS-BUILT
SCALE HOR. VER.

DESIGNED MJS
DRAWN HJF
CHECKED MJS
DATE OCT. 88
GRID
JOB NO. 4784.0

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CITY OF HOMER
DEEP WATER DOCK
EDA PROJECT NO. 07-01-03099
DOCK DECK PANEL PLAN

SHEET S-4 OF 22
FILE NO. 00408

PORTIONS OF THIS PROJECT WERE FUNDED BY:
EDA PROJECT NO. 07-01-03099
STATE OF ALASKA
DEPT. OF COMMERCE & ECONOMIC DEVELOPMENT
CONTROL NO. 89-001

REV.	DATE	BY	REVISION
1	8-15-90	WH	AS BUILT

FIELD BOOKS: DESIGN / STAKING / AS-BUILT
SCALE: HOR. / VER.
DESIGNED MJS
DRAWN HJF
CHECKED MJS
DATE OCT. 88
GRID
JOB NO. 4784.0

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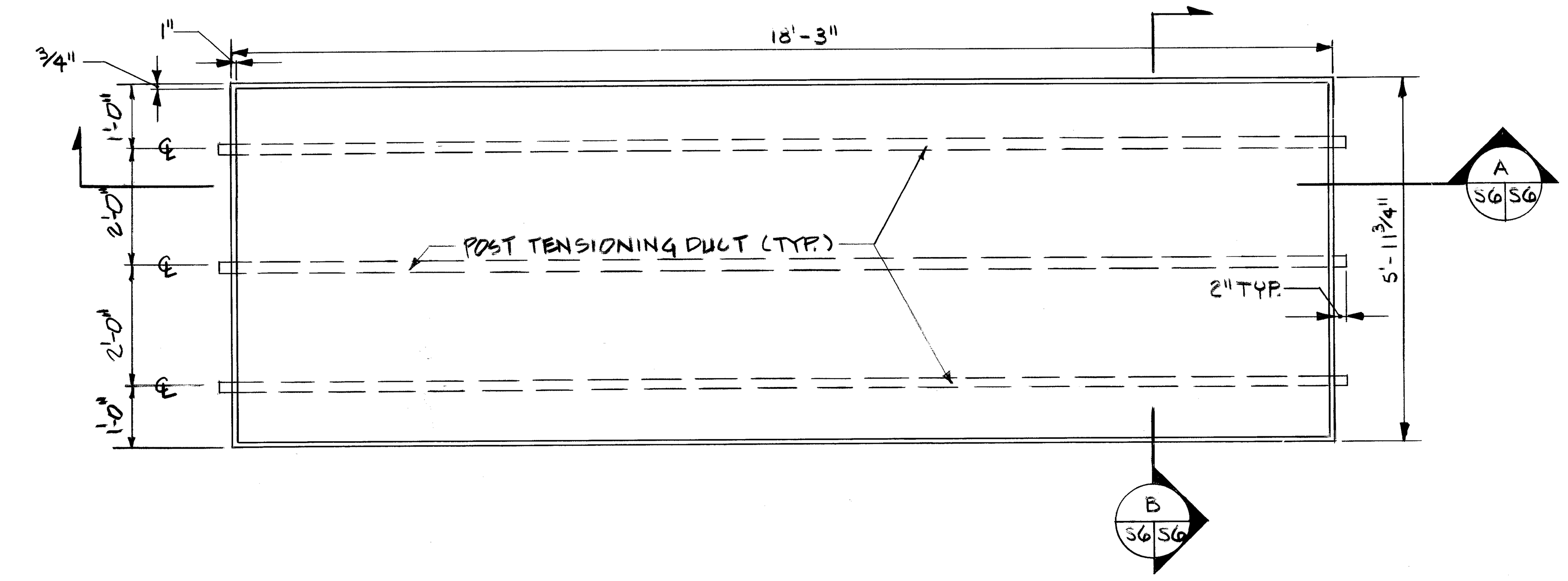
ANCHORAGE, ALASKA

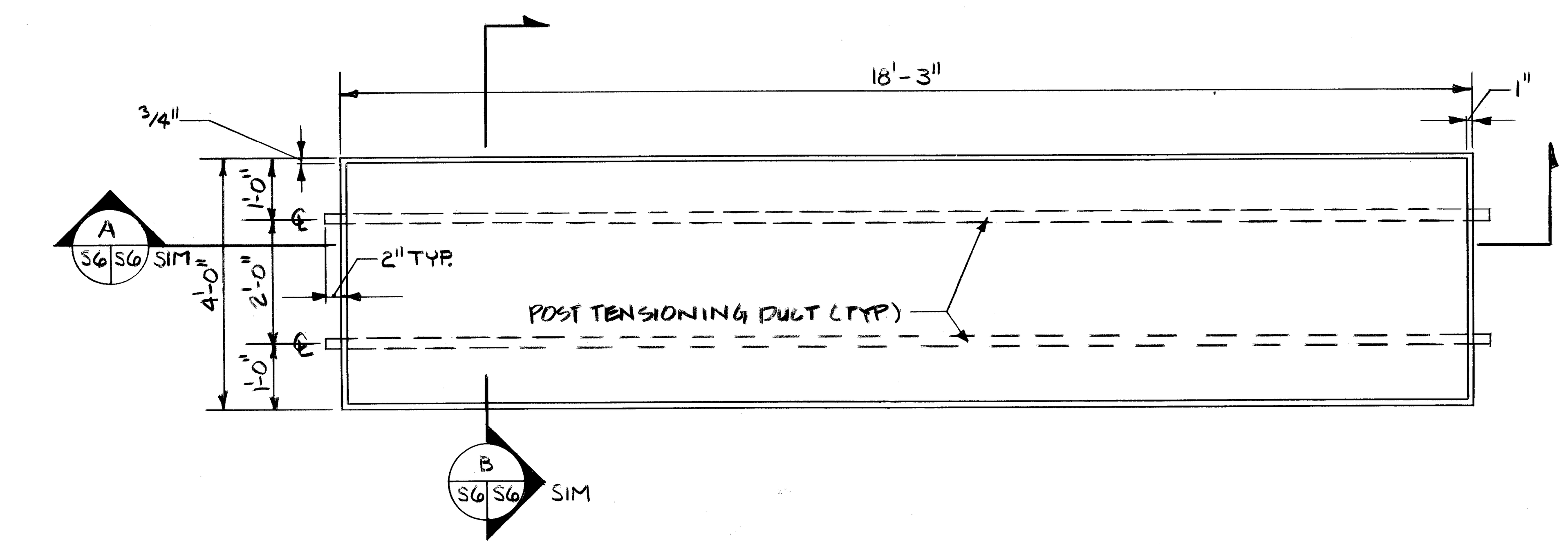
CITY OF HOMER
DEEP WATER DOCK
EDA PROJECT NO. 07-01-03099
TRESTLE PANEL PLAN

SHEET S-5 OF 22
FILE NO. 00409



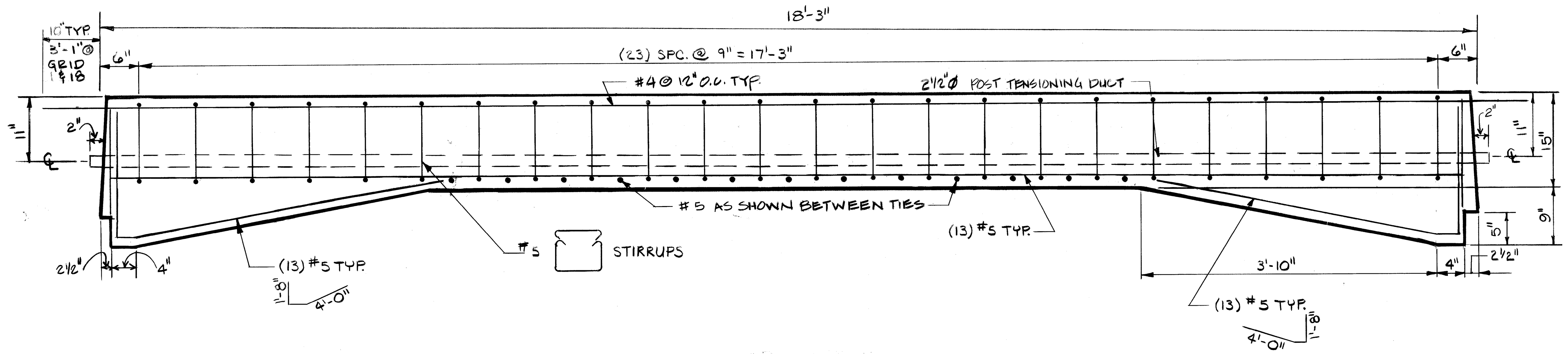
PLAN-6FT. PANEL TYPE A

1/2"=1'-0"



PLAN-4FT. PANEL TYPE B

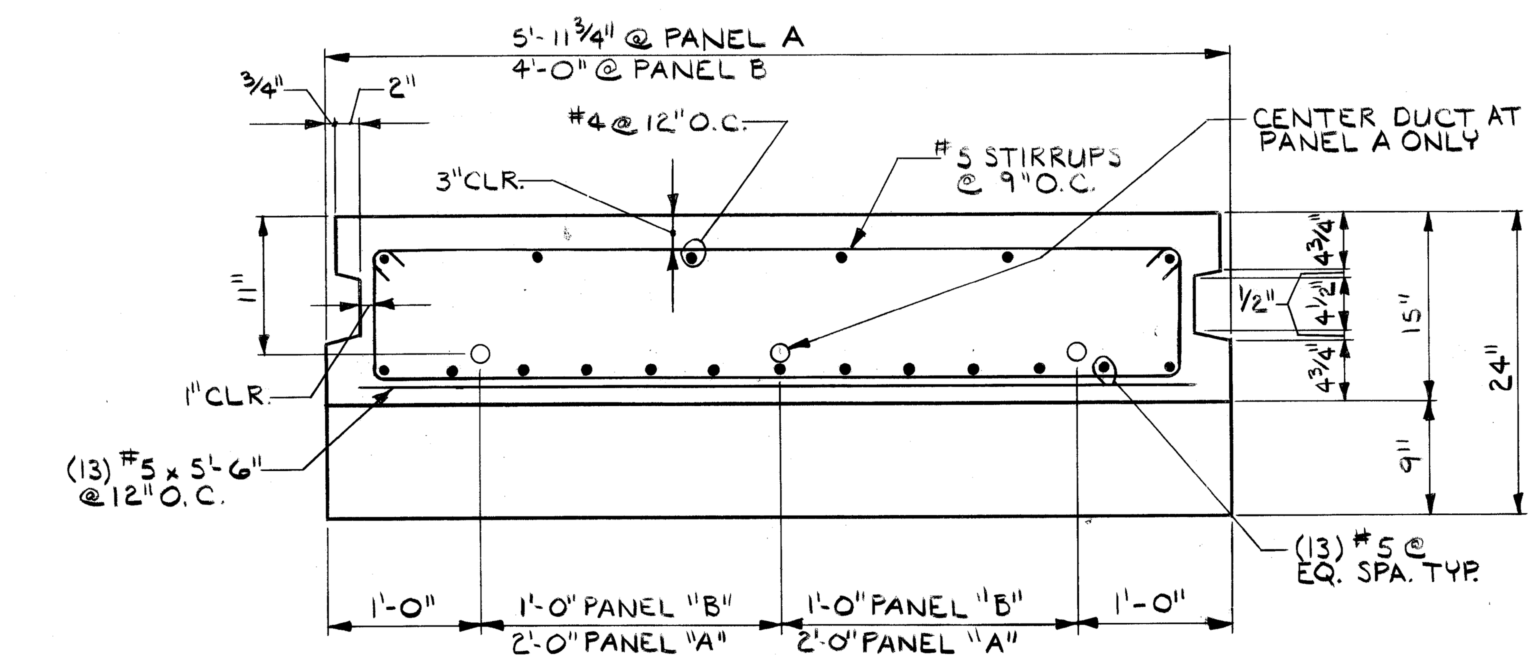
1/2"=1'-0"



SECTION A

1"=1'-0"

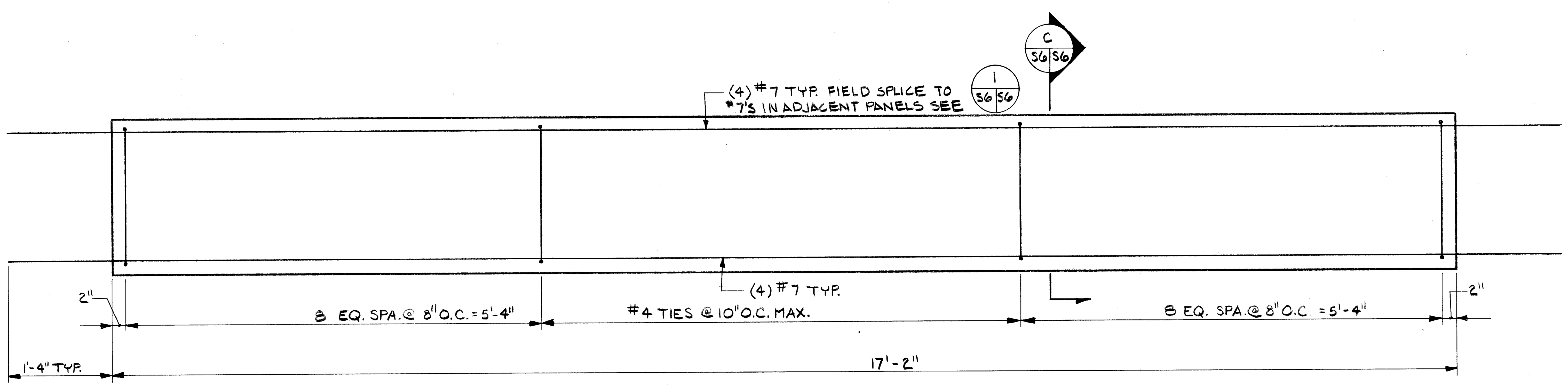
S6 | S6



SECTION B

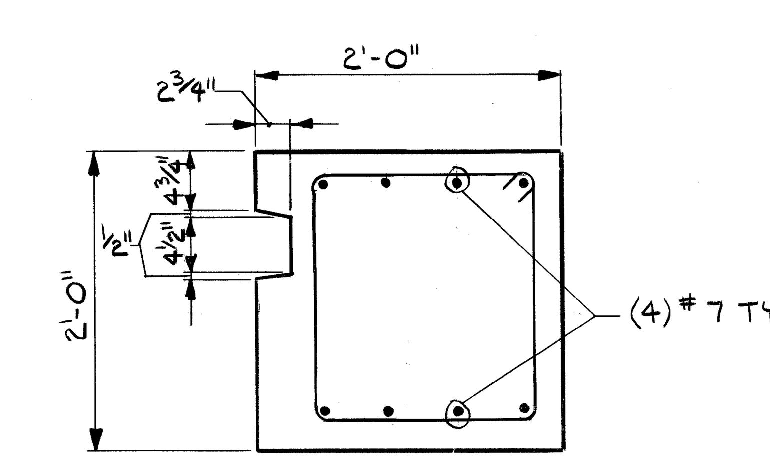
1"=1'-0"

S6 | S6



PANEL TYPE C

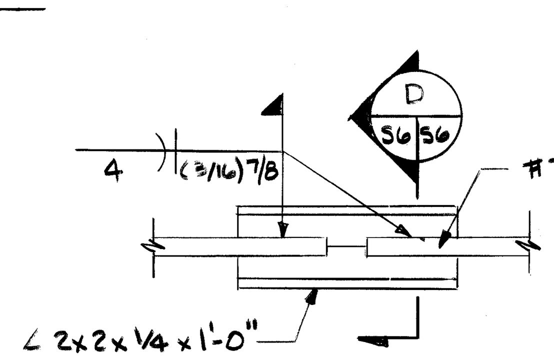
1"=1'-0"



SECTION C

1"=1'-0"

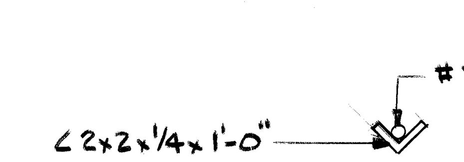
S6 | S6



DETAIL 1

1 1/2"=1'-0"

S6 | S7 | S6



SECTION D

3"=1'-0"

S6 | S6

PORTIONS OF THIS PROJECT WERE FUNDED BY:
EDA PROJECT NO. 07-01-03099
STATE OF ALASKA
DEPT. OF COMMERCE & ECONOMIC DEVELOPMENT
CONTROL NO. 89-001

STATE OF ALASKA — 49th — MICHAEL J. SHOEMAKER — CE-6478 — REGISTERED PROFESSIONAL ENGINEER

STATE OF ALASKA — 49th — FRANK E. NYMAN — 410-E — REGISTERED PROFESSIONAL ENGINEER

REV.	DATE	BY	REVISION

FIELD BOOKS		DESIGNED	MJS
DESIGN		DRAWN	HJF
STAKING		CHECKED	MJS
AS-BUILT		DATE	OCT. 88
HOR.	SCALE	GRID	
VER.		JOB NO.	4784.0

TRYCK NYMAN & HAYES
ENGINEERS / PLANNERS / SURVEYORS
ANCHORAGE, ALASKA

CITY OF HOMER
DEEP WATER DOCK
EDA PROJECT NO. 07-01-03099
DECK PANELS AND SECTIONS

SHEET S-6 OF 22

FILE NO. 00410

PORTIONS OF THIS PROJECT WERE FUNDED BY:
EDA PROJECT NO. 07-01-03099
STATE OF ALASKA
DEPT. OF COMMERCE & ECONOMIC DEVELOPMENT
CONTROL NO. 89-001

STATE OF ALASKA 49th — MICHAEL J. SHOEMAKER CE-6478 REGISTERED PROFESSIONAL ENGINEER
STATE OF ALASKA 49th — FRANK E. NYMAN 410-E REGISTERED PROFESSIONAL ENGINEER

REV.	DATE	BY	REVISION
1	8-15-90	WJ	AS BUILT

FIELD BOOKS / DESIGN / STAKING / AS-BUILT / SCALE HOR. VER.
DESIGNED MJS — DRAWN HJF — CHECKED MJS — DATE OCT. 88 — GRID — JOB NO. 4784.0

TRYCK NYMAN & HAYES — ENGINEERS / PLANNERS / SURVEYORS — ANCHORAGE, ALASKA

CITY OF HOMER
DEEP WATER DOCK
EDA PROJECT NO. 07-01-03099
PILE CAP DETAILS

SHEET S-7 of 22
FILE NO. 00411

PORTIONS OF THIS PROJECT WERE FUNDED BY:
EDA PROJECT NO. 07-01-03099
STATE OF ALASKA
DEPT. OF COMMERCE & ECONOMIC DEVELOPMENT
CONTROL NO. 89-001

STATE OF ALASKA 49th — MICHAEL J. SHOEMAKER CE-6478 REGISTERED PROFESSIONAL ENGINEER

STATE OF ALASKA 49th — FRANK E. NYMAN 490-E REGISTERED PROFESSIONAL ENGINEER

REV.	DATE	BY	REVISION
1	8-15-90		AS BUILT

FIELD BOOKS	
DESIGN	
STAKING	
AS-BUILT	
SCALE HOR.	
VER.	
DESIGNED	MJS
DRAWN	LD
CHECKED	MJS
DATE	OCT. 88
GRID	
JOB NO.	4784.0

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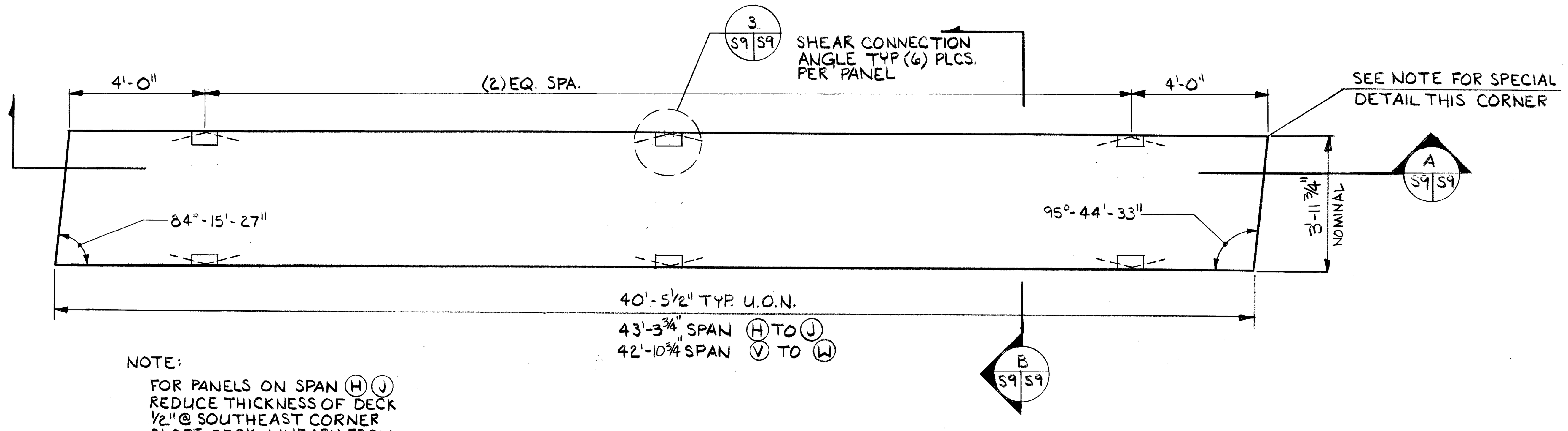
ANCHORAGE, ALASKA

CITY OF HOMER
DEEP WATER DOCK
EDA PROJECT NO. 07-01-03099
PILE CAP DETAILS

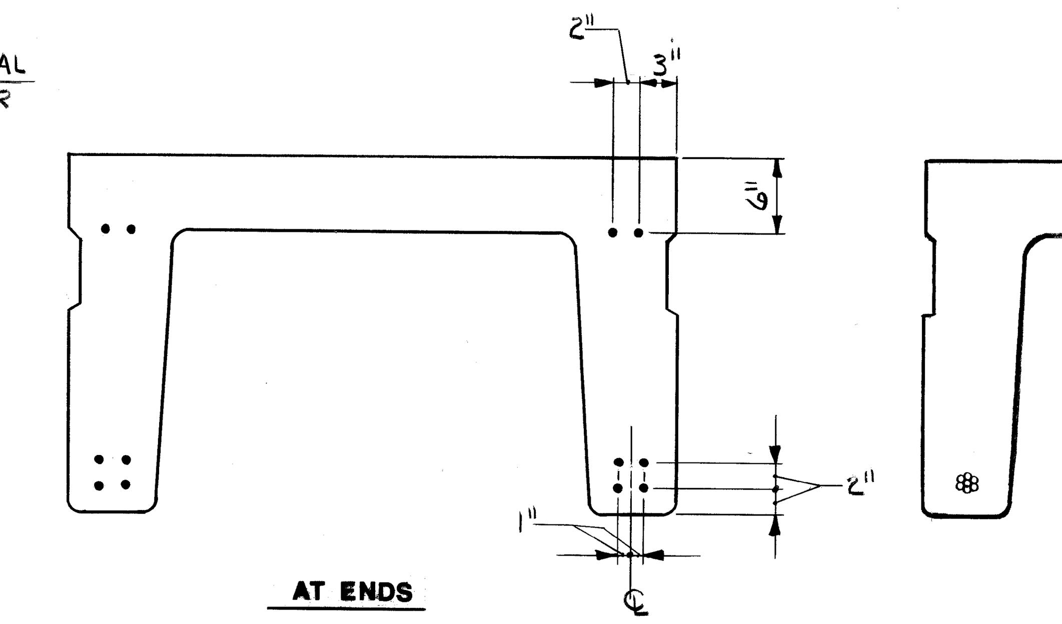
SHEET S-8 of 22
FILE NO. 00412



NOTE:
FOR PANELS ON SPAN (H)(J)
REDUCE THICKNESS OF DECK
1/2" @ SOUTHEAST CORNER
SLOPE DECK LINEARY FROM
ADJACENT CORNERS

TYPICAL PANEL PLAN VIEW

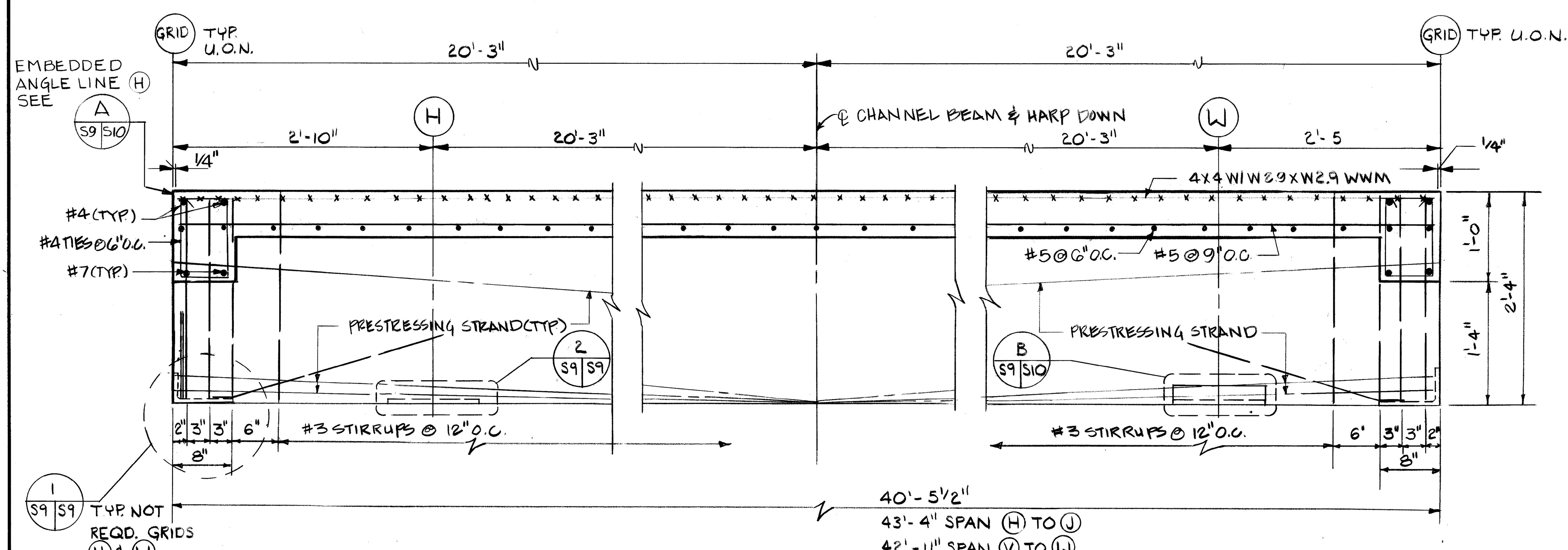
N.T.S.



CHANNEL SLAB PRESTRESS REINFORCING DETAIL

1"=1'-0"

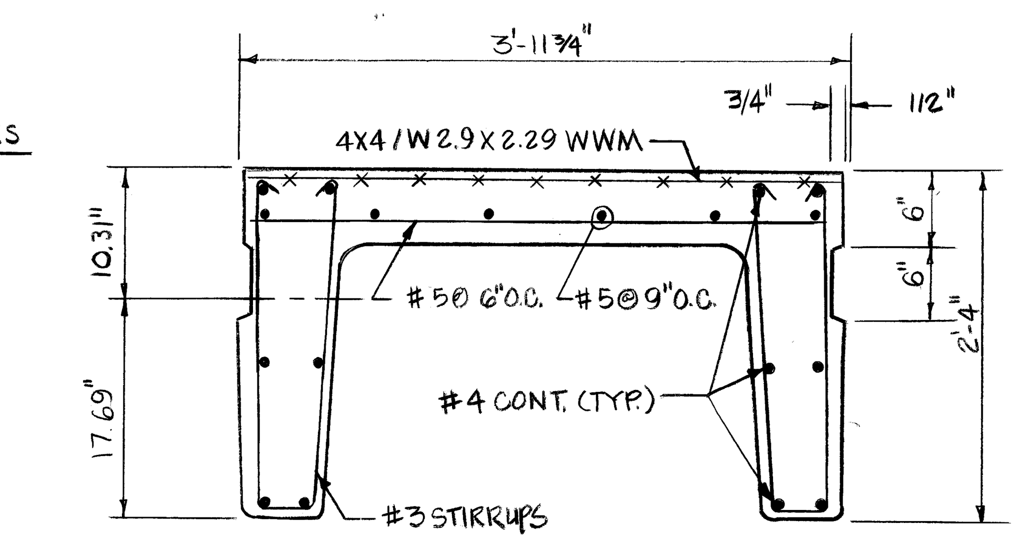
NOTE:
MILD REINFORCING NOT
SHOWN SEE DETAIL (B S9 S9)



SECTION A (S9 S9)

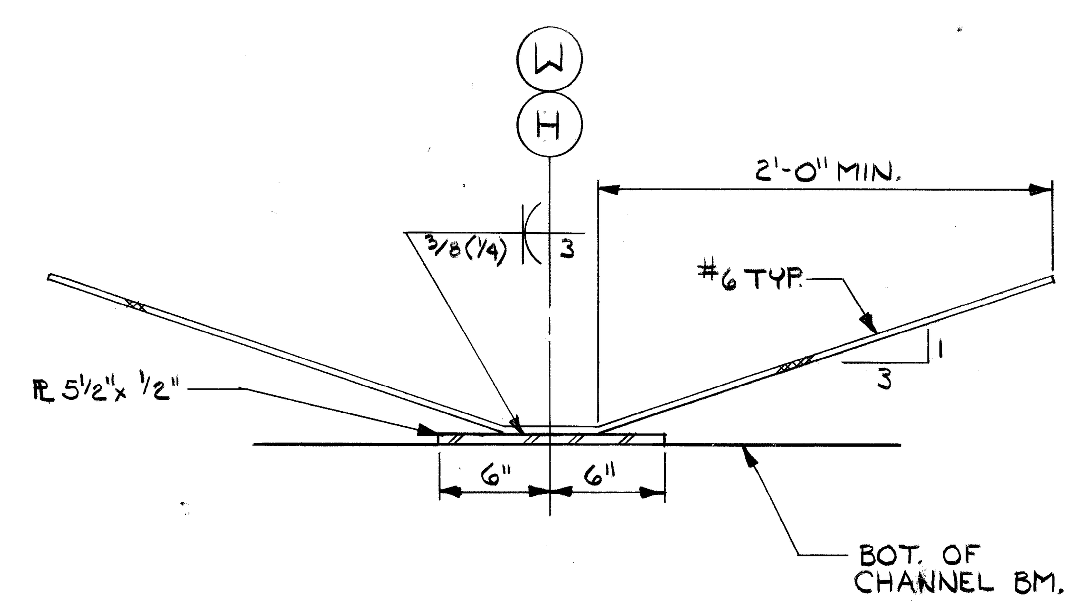
1"=1'-0"

MINIMUM PANEL SECTION PROPERTIES
A = 623. IN² Z_T = 4163 IN³ Z_b 2425 IN³
I = 42912 IN⁴ Y_T = 10.31 IN Y_b = 17.69 IN



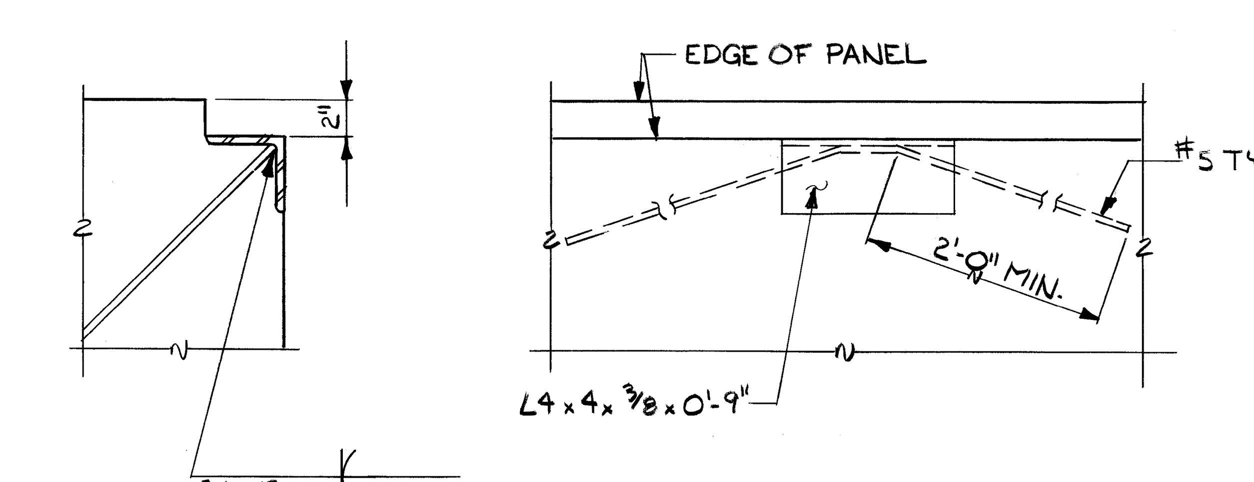
CHANNEL SLAB DIMENSIONS AND TYPICAL REINFORCEMENT DETAIL (B S9 S9)

1"=1'-0"



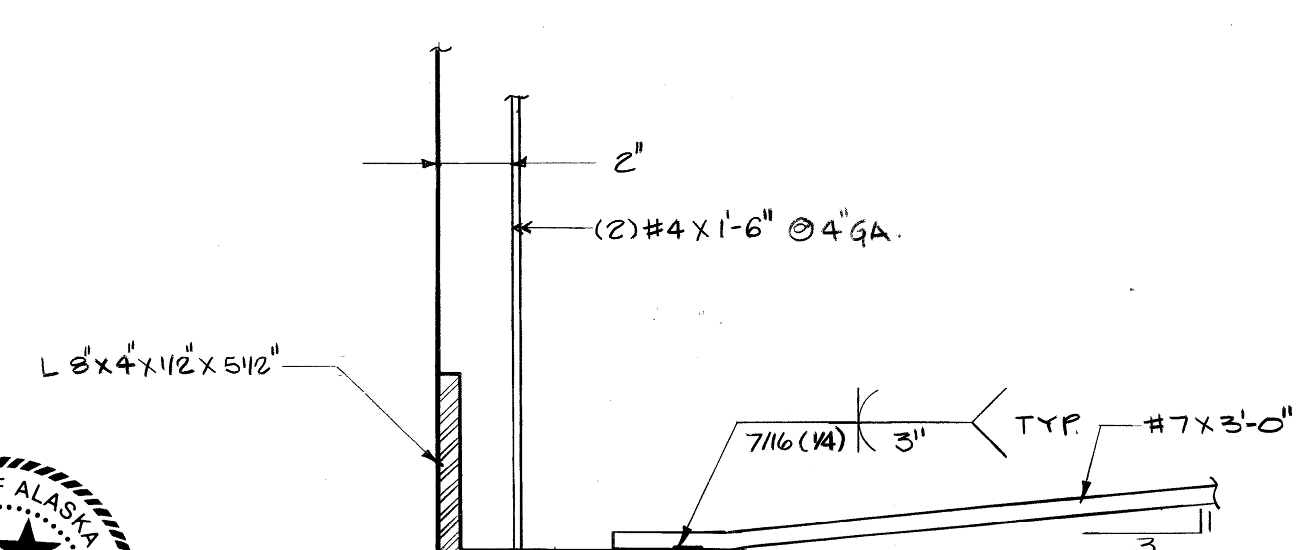
DETAIL 2 (S9 S9)

1-1/2"=1'-0"



DETAIL 3 (S9 S9)

1-1/2"=1'-0"



DETAIL 1 (S9 S9)

3"=1'-0"

PORTIONS OF THIS PROJECT WERE FUNDED BY:
EDA PROJECT NO. 07-01-03099
STATE OF ALASKA
DEPT. OF COMMERCE & ECONOMIC DEVELOPMENT
CONTROL NO. 89-004

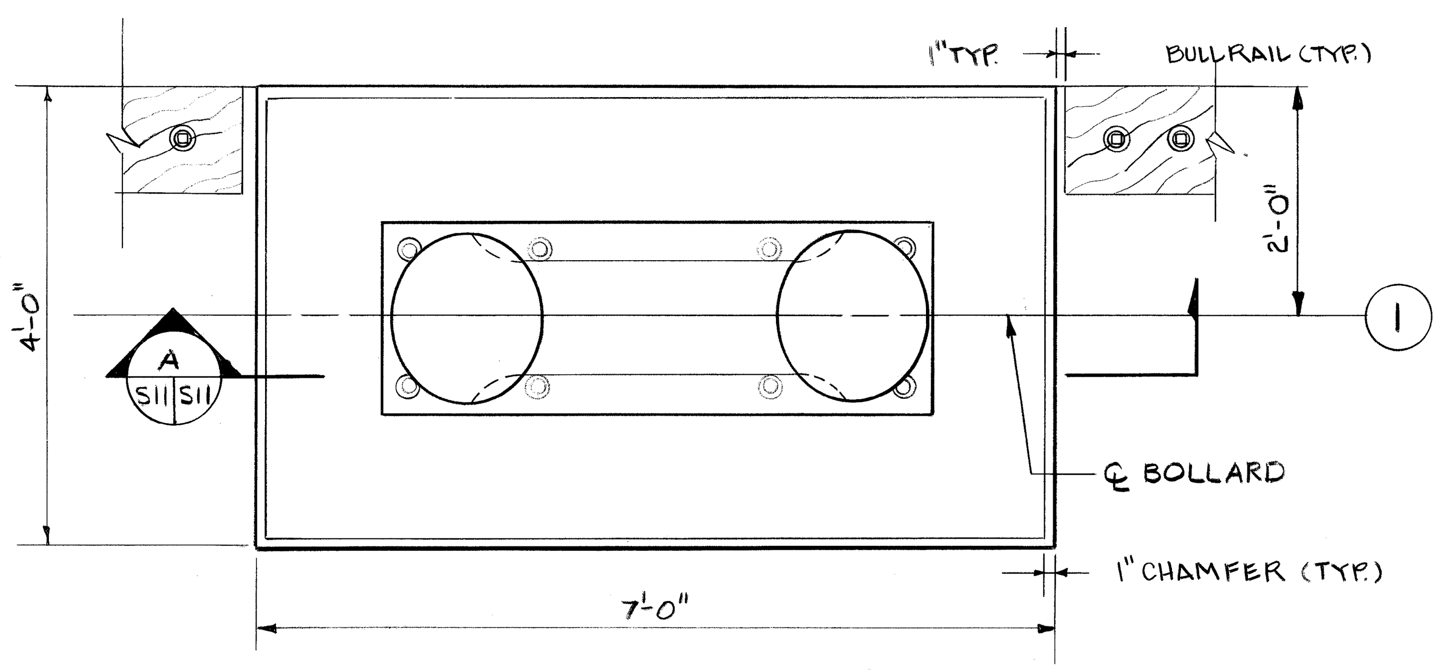
REV.	DATE	BY	REVISION	FIELD BOOKS		
				DESIGN	DESIGNED	
				STAKING	DRAWN	LD
				AS-BUILT	CHECKED	MJS
				SCALE HOR.	DATE	OCT. 88
				VER.	GRID	
					JOB NO.	4784.0

TRYCK NYMAN & HAYES
ENGINEERS / PLANNERS / SURVEYORS
ANCHORAGE, ALASKA

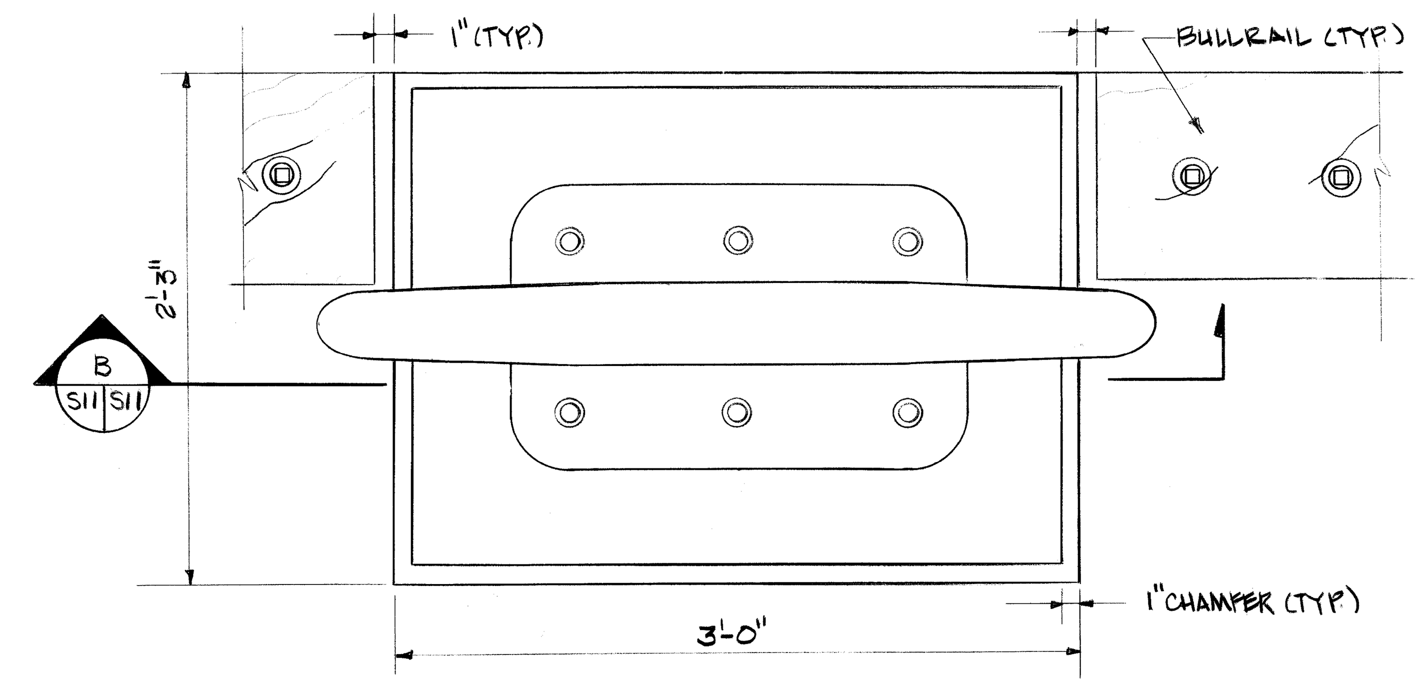
CITY OF HOMER
DEEP WATER DOCK
EDA PROJECT NO. 07-01-03099
CHANNEL BEAM DETAILS

SHEET S-9 OF 22
FILE NO. 00413

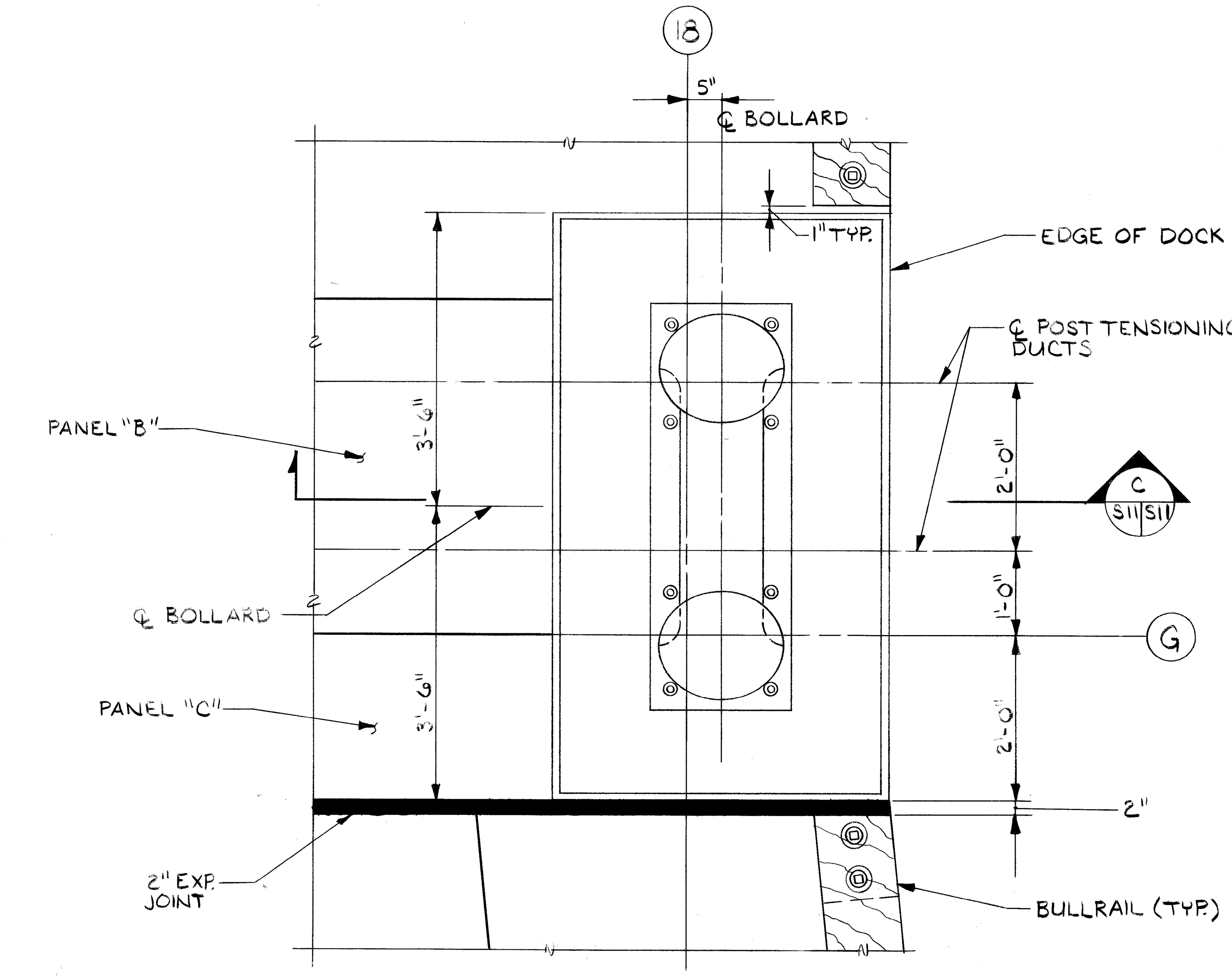
SECTION A
1"=1'-0"
S7 S10
DECK PANEL TYP. "B"
SEE B S6 S10
2'-0"
2"
2'-10"
#4@6"O.C. TOP TO EXTEND 30'-0" BEYOND GRID
1 S10 S10
1'-0"x1'-3"x1/2" 50 DURO PAD (TYP)
1'-0"x 0'-7" x 1/2"@ OUTSIDE LEGS
PANEL TYPE "C"
2"
6" 6"
CHANNEL SLAB SEE SHEET S-9 FOR DETAILS & TYPICAL REINFORCEMENT
PIER CAP TYPICAL SEE DETAIL A S10 S7 FOR REINF.
SECTION B
1"=1'-0"
S7 S9 S10
#4 @ 6" O.C. TOP EXTEND 30'-0" BEYOND GRID
FINISH GRADE
#4 (TYP)
#4 @ 9" O.C.
WELD BOTH SIDES ON OUTSIDE BEAMS
3/4(3/8) 6"
PL 1/2"x6" BEND TO MATCH BM.
#8 EXTEND 3'-0" BEYOND BEARING BEND W/ HOOK @ BEAM END
#5 W/ 90° HOOK EA. END
SEALANT W/ BACKING ROD
PL 1"x6"x 1'-4" EMBED IN CAP 3/4"
PL 1"x6" x 8" @ OUTSIDE BEAMS
CHANNEL SLAB SEE SHEET FOR DETAILS & TYPICAL REINF.
3/4" Ø x 6" HEADED STUDS
4 ROWS @ 3" GA. (8 TOTAL) TYP.
2 ROWS @ 3" GA. (4 TOTAL) @ OUTSIDE BEAM
8"
1 1/2"
1 1/2"
PIER CAP TYPICAL SEE DETAIL A S7 S10
DETAIL 1
S10 S10
ANGLE 3/8" THICK COORDINATE LEG SIZE W/ COMPRESSION SEAL MANUFACTURER
NEOPRENE COMPRESSION SEAL
1/2"Ø x 4" STUD @ 12" O.C.
PER JOINT MANUFACT. RECOMMENDATION
2"@40°F
SECTION D
1/2"=1'-0"
S10 S10
8"
2'-4"
#4 AS SHOWN
#4 @ 8" O.C.
TOP OF PIER CAP
PRECAST PIER FORM BEAM + FORM REINF. NOT SHOWN
ABUTMENT GRADING PLAN
3/16"=1'-0"
NOTE: REMOVE AND REPLACE RIPRAP BELOW ELEVATION 30.0
NORTH WINGWALL SEE 2 S10 S10
26°15'27"
1/2" EXP. JT. MATERIAL
4" Ø HOLE
EDGE OF DECK
TNH CONTROL PT. #110
CONTROL LINE
32°-00'
PILE CAP SEE SHT. S-8
1/2" EXP. JT. MATERIAL
26°15'27"
DELETED BY C.M. #04
SOUTH WINGWALL SEE 3 S10 S10
TNH CONTROL PT. #100
30 29 28 27 26 25
DETAIL 2
1/2"=1'-0"
S1 S10 S10
11'-3"
EL. 30.24'
C S10 S10
TOP OF WALL
1/2" EXP. JOINT
APPROX. FINISH GRADE
EL. 25.5'
PIER CAP TYP.
EL. 22.5'
SECTION C
1/2"=1'-0"
S10 S10
REMOVE & REPLACE RIP RAP BELOW EL. 30.0'
VARIES
#4 @ 8" O.C.
#4 @ 12" O.C. CONT.
REMOVE & REPLACE RIP RAP
#4 @ 8" O.C.
1'-0"
EL. 22.50'
3'-6"
8" 6"
DETAIL 3
1/2"=1'-0"
S1 S10 S10
DELETED
E S10 S10
EL. 30.0'
1/2" EXP. JOINT
EL. 24.5'
8'-6"
PIER CAP TYP.
SECTION E
1/2"=1'-0"
S10 S10
DELETED
EL. 30.0'
REMOVE & REPLACE RIP RAP
#4 @ 8" O.C.
#4 @ 12" O.C. CONT.
#4 @ 8" O.C.
EL. 24.5'
3'-0"
8" 6"
PORTIONS OF THIS PROJECT WERE FUNDED BY:
EDA PROJECT NO. 07-01-03099
STATE OF ALASKA
DEPT. OF COMMERCE & ECONOMIC DEVELOPMENT
CONTROL NO. 89-001
STATE OF ALASKA
49th
MICHAEL J. SHOEMAKER
CE-6478
REGISTERED PROFESSIONAL ENGINEER
STATE OF ALASKA
49th
FRANK E. NYMAN
410-E
REGISTERED PROFESSIONAL ENGINEER
1 8-15-90 AS-BUILT
REV. DATE BY REVISION
FIELD BOOKS
DESIGN
STAKING
AS-BUILT
SCALE
HOR.
VER.
DESIGNED MJS
DRAWN HJF
CHECKED MJS
DATE OCT. 88
GRID
JOB NO. 4784.0
TRYCK NYMAN & HAYES
ENGINEERS / PLANNERS / SURVEYORS
ANCHORAGE, ALASKA
CITY OF HOMER
DEEP WATER DOCK
EDA PROJECT NO. 07-01-03099
ABUTMENT PLAN AND SECTIONS
SHEET
S-10 of 22
FILE NO.
00414



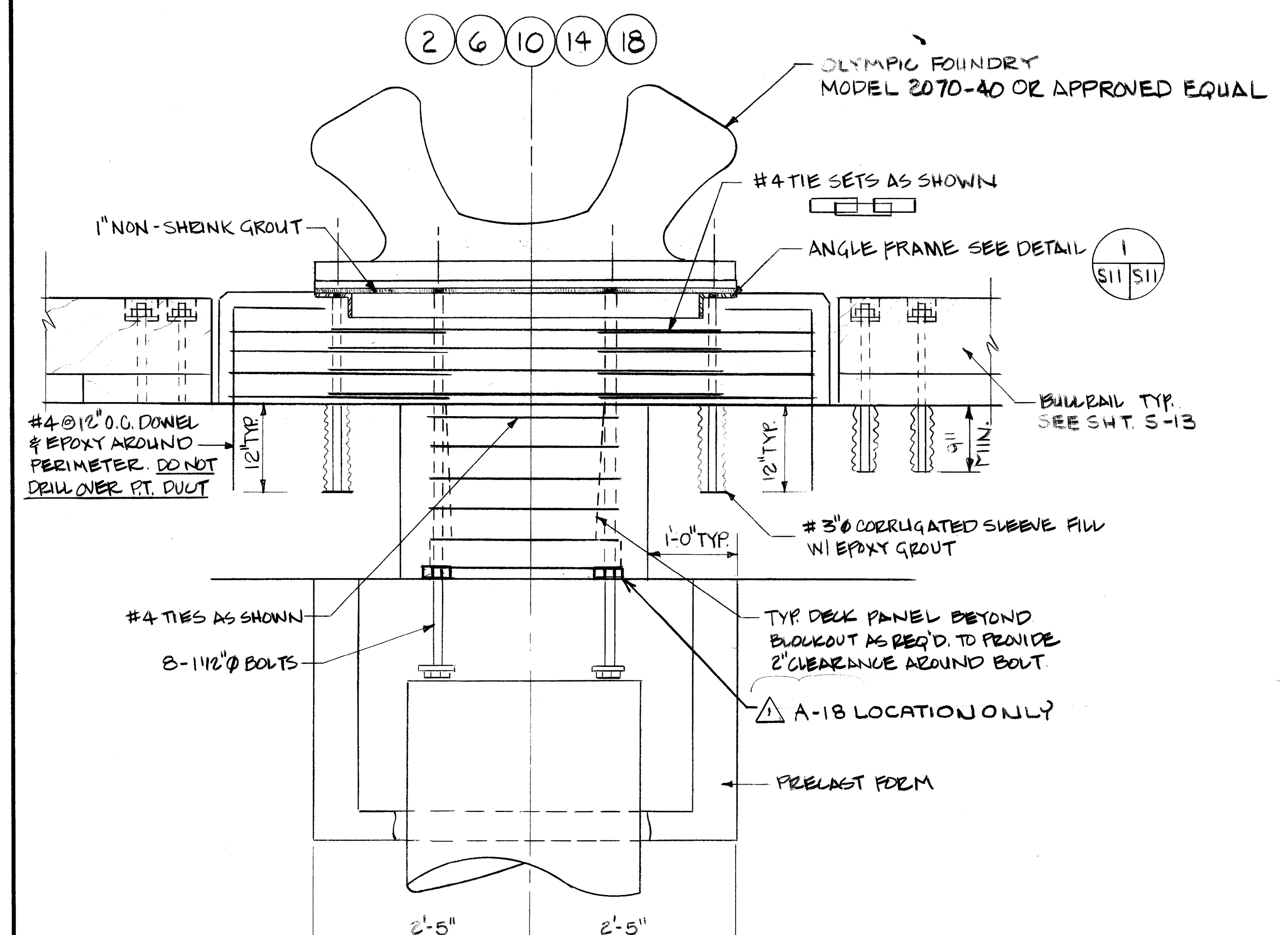
DOUBLE BITT BOLLARD PLAN
5 S1 S11
3/4"=1'-0"



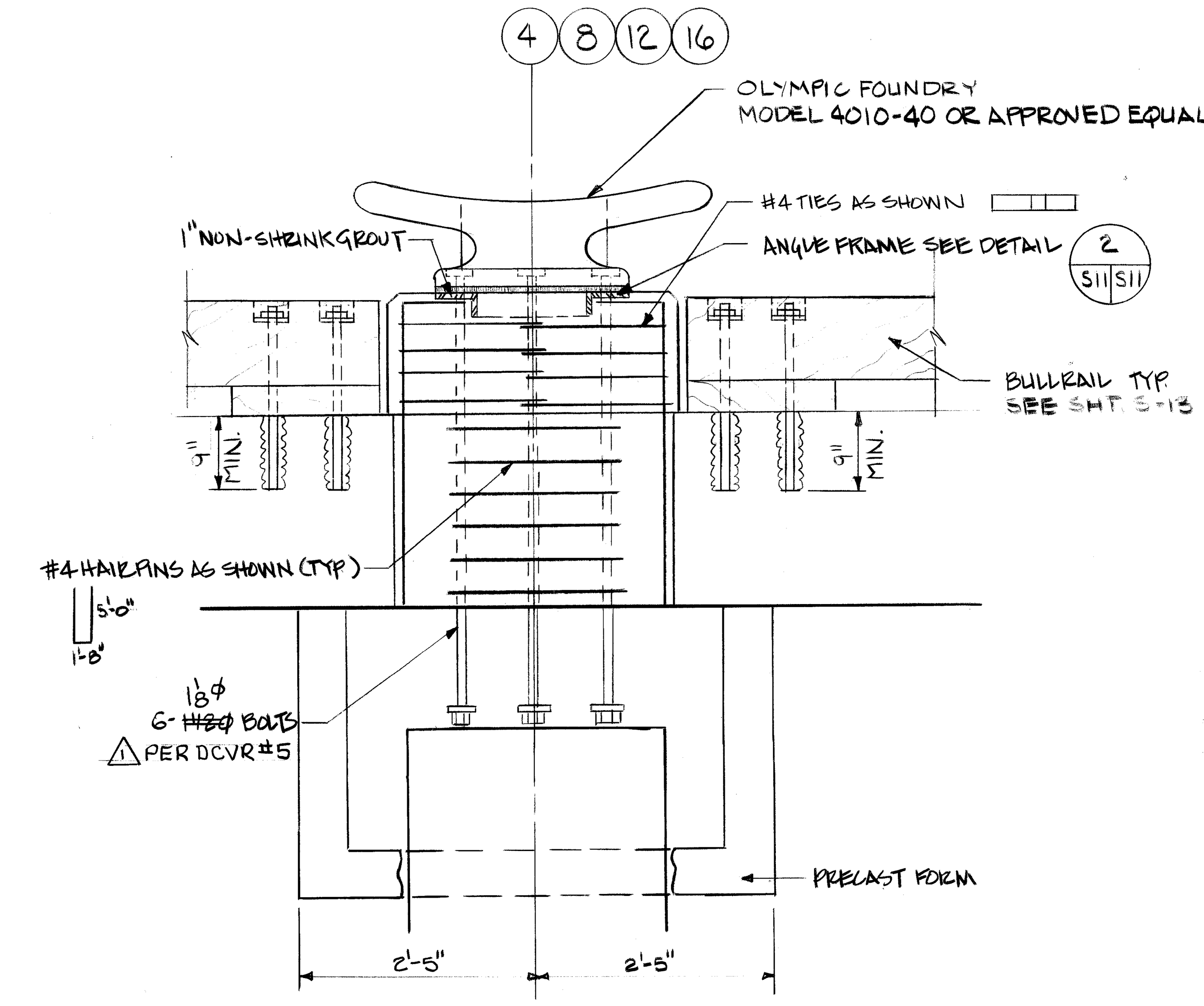
CLEAT PLAN VIEW
4 S1 S11
1 1/2"=1'-0"



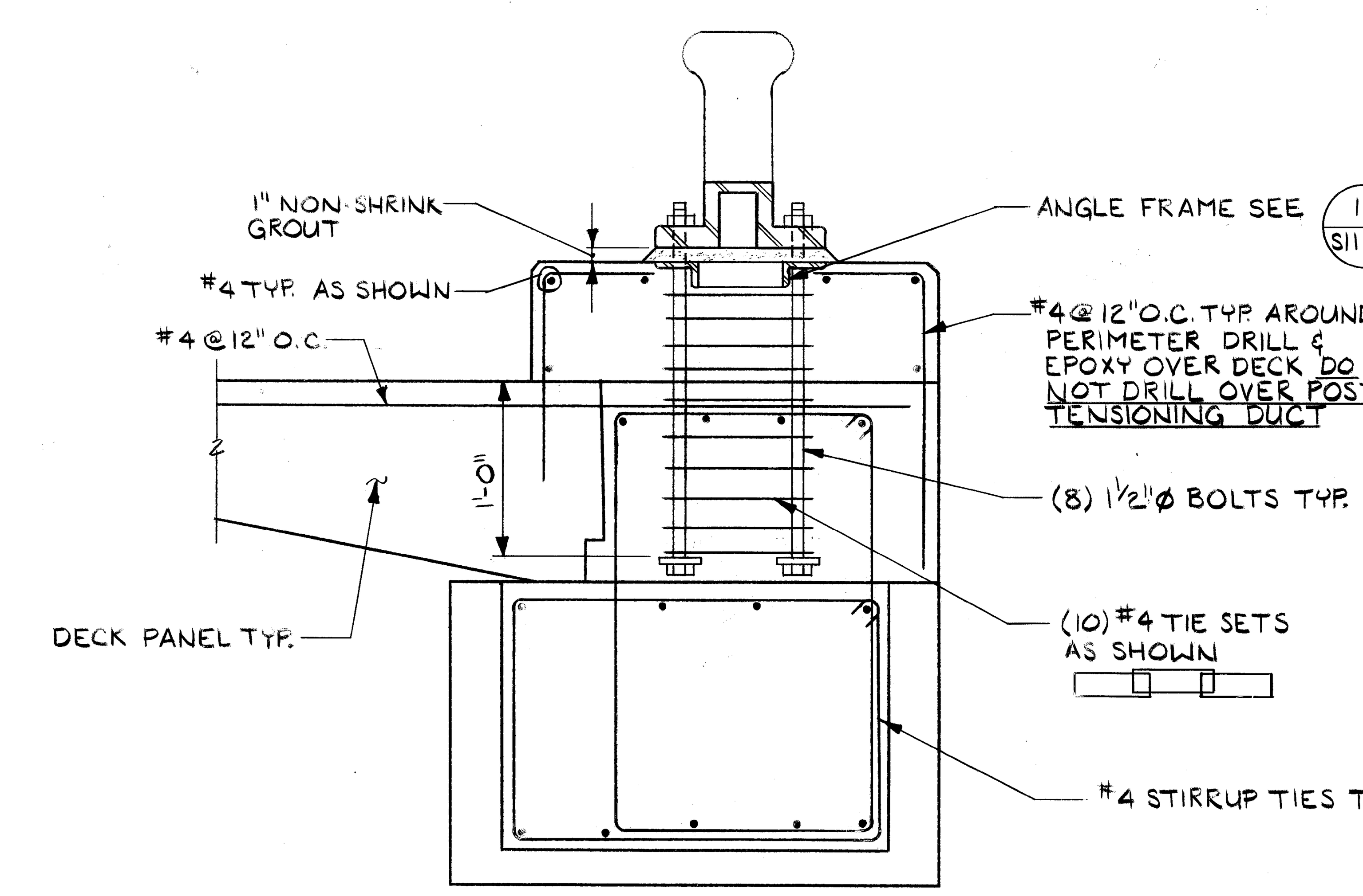
DETAIL
3 S1 S11
3/4"=1'-0"



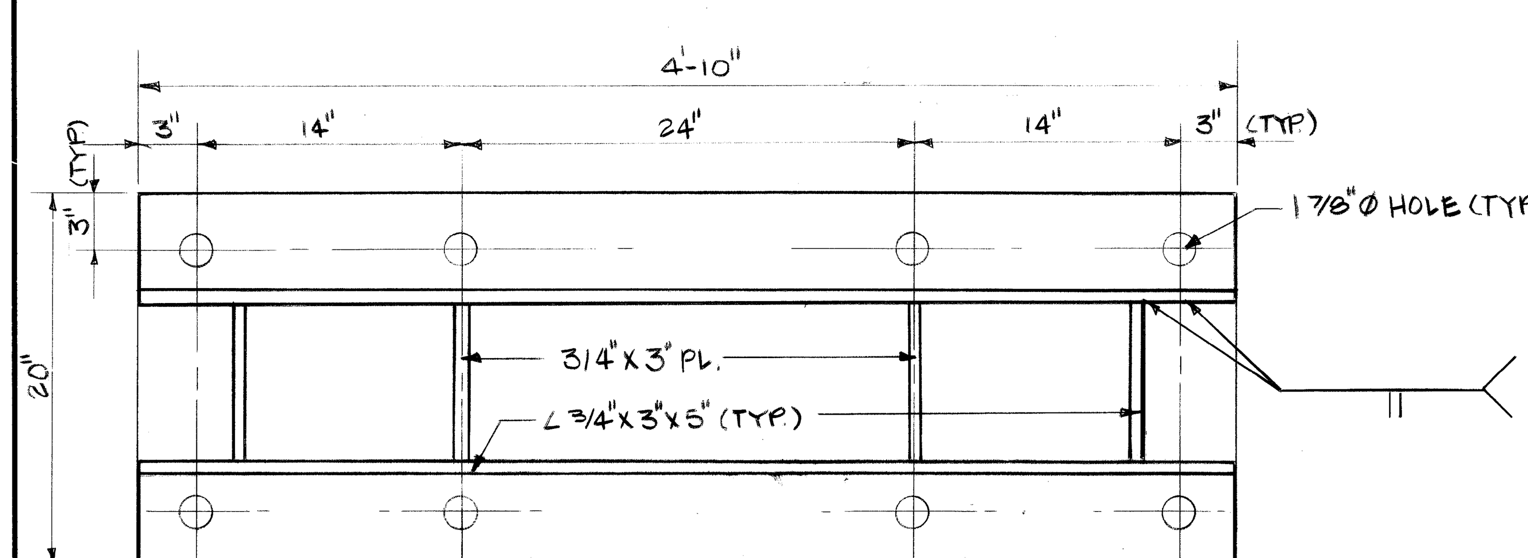
SECTION
A S11 S11
3/4"=1'-0".



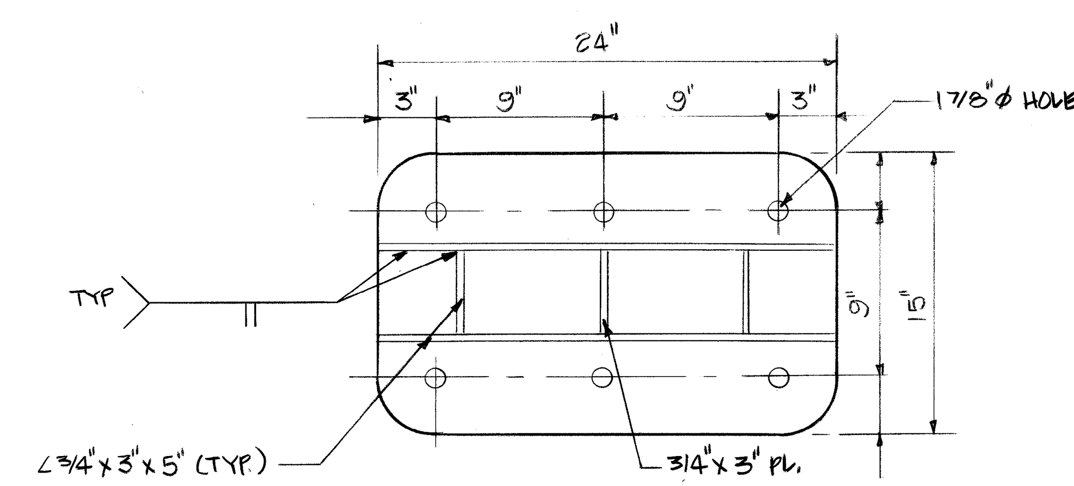
SECTION
B S11 S11
3/4"=1'-0"



SECTION
C S11 S11
3/4"=1'-0"



DETAIL
1 S11 S11
1 1/2"=1'-0"



DETAIL
2 S11 S11
1 1/2"=1'-0"

PORTIONS OF THIS PROJECT WERE FUNDED BY:
EDA PROJECT NO. 07-01-03099
STATE OF ALASKA
DEPT. OF COMMERCE & ECONOMIC DEVELOPMENT
CONTROL NO. 89-001

REV.	DATE	BY	REVISION
1	8-15-90	WJ	AS BUILT

FIELD BOOKS: DESIGN / STAKING / AS-BUILT — SCALE: HOR. / VER.

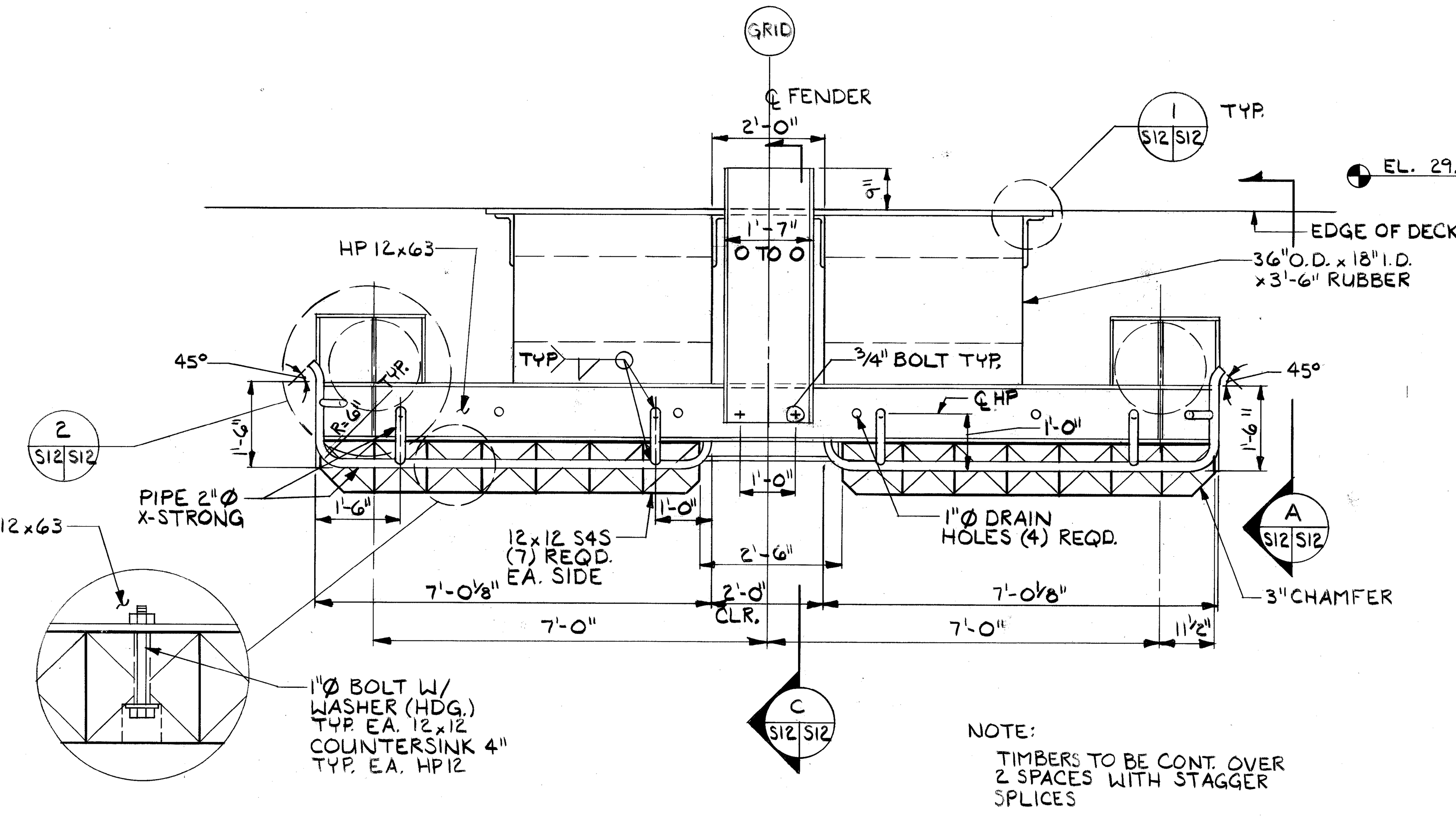
DESIGNED MJS · DRAWN LD · CHECKED MJS · DATE OCT. 88 · GRID · JOB NO. 4784.0

TRYCK NYMAN & HAYES
ENGINEERS / PLANNERS / SURVEYORS
ANCHORAGE, ALASKA

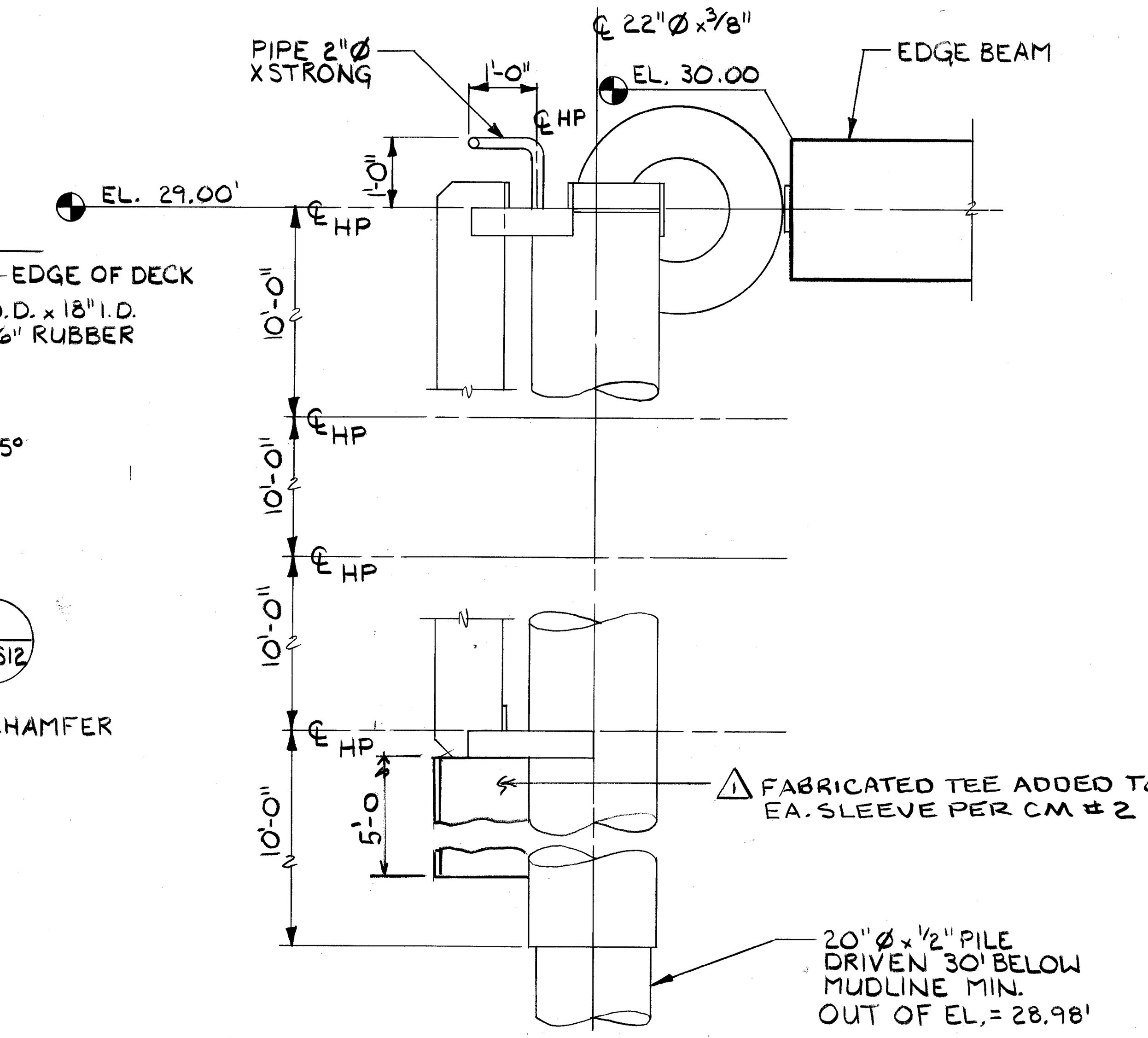
CITY OF HOMER
DEEP WATER DOCK
EDA PROJECT NO. 07-01-03099
BOLLARD AND CLEAT DETAILS

SHEET S-11 of 22
FILE NO. 00415

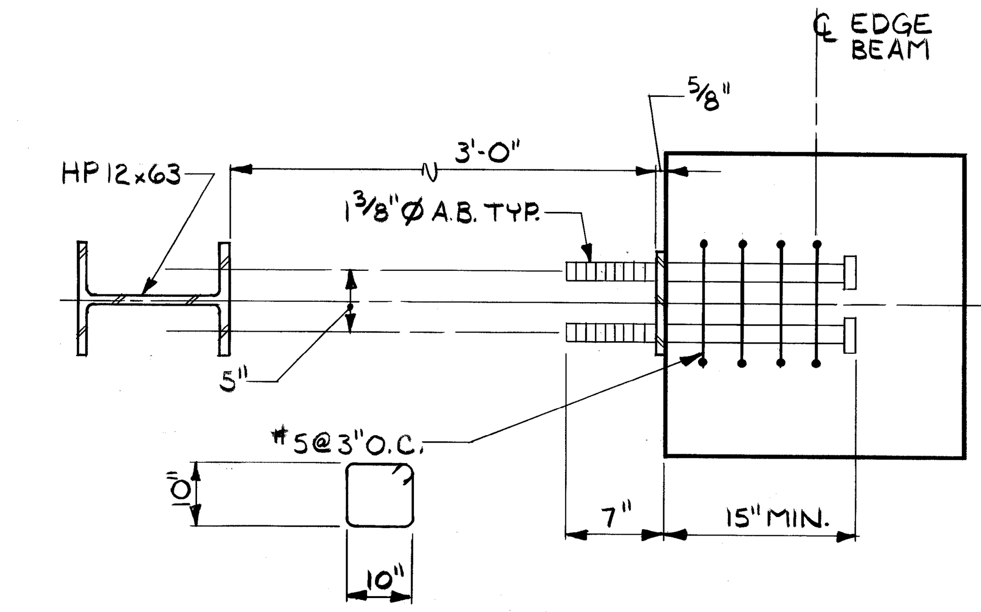
114447



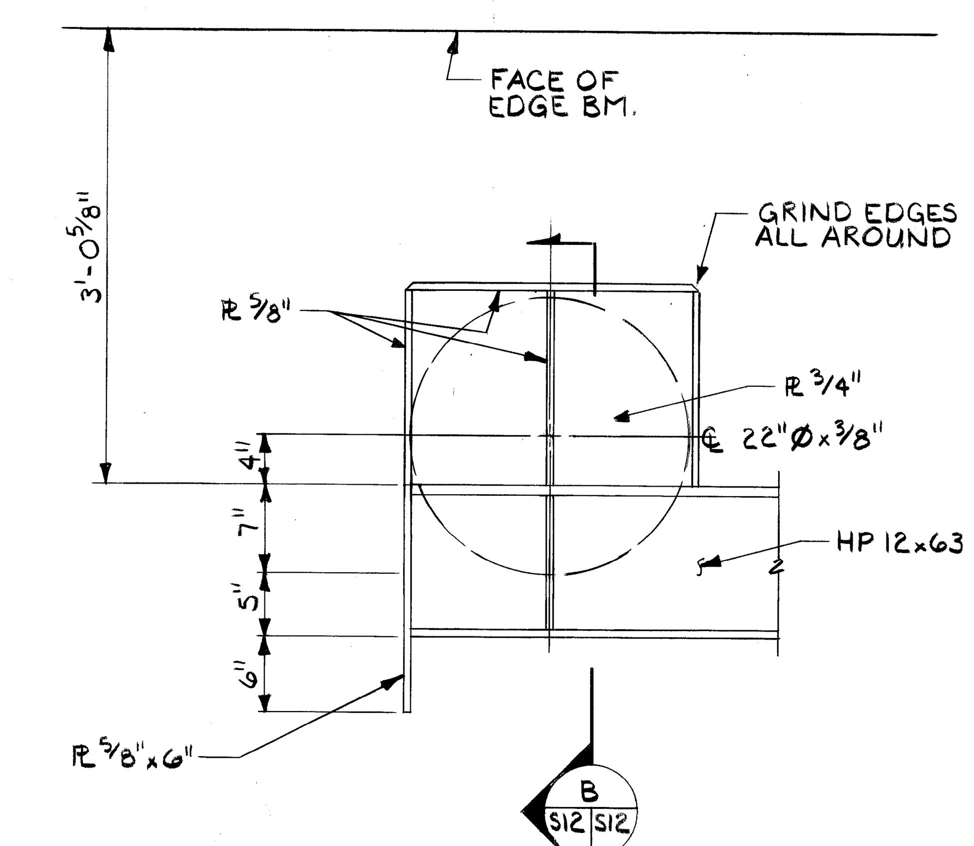
FENDER PLAN
1/2"=1'-0"



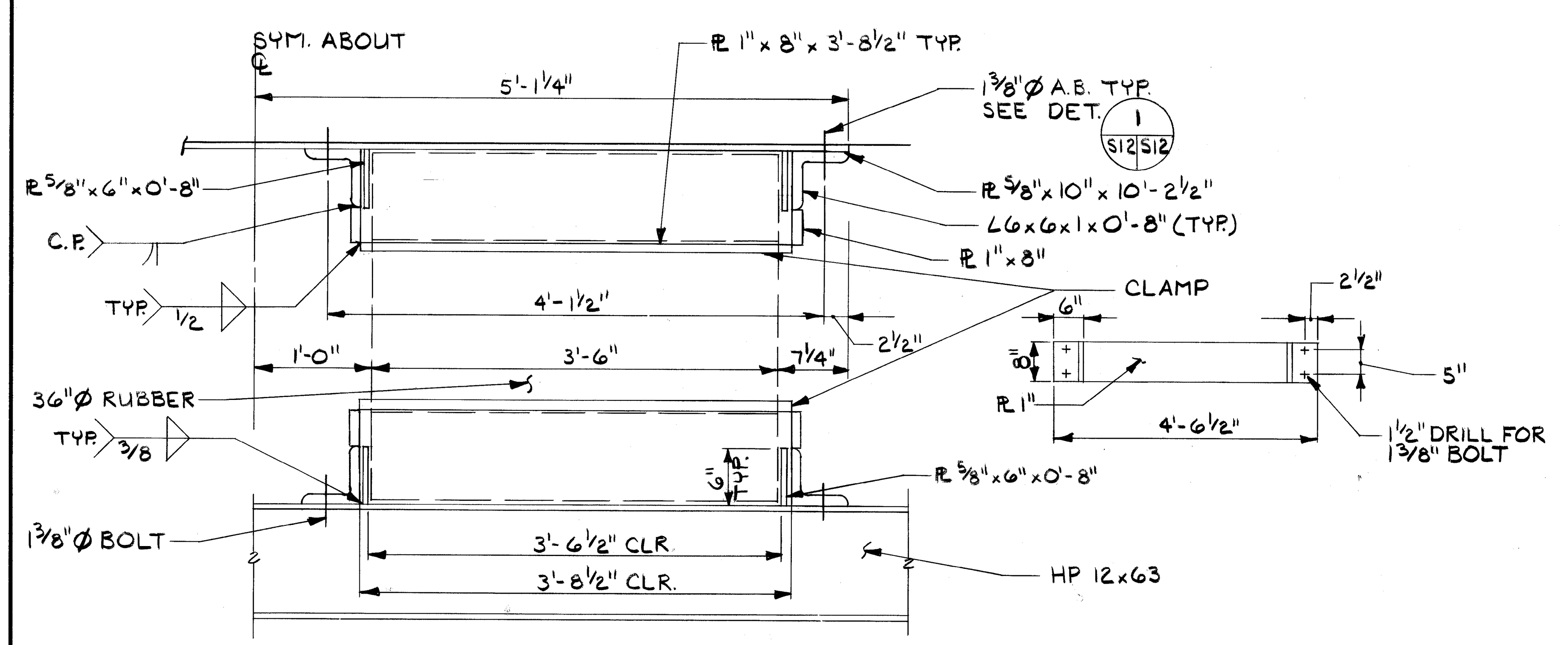
SECTION A S12 S12
1/2"=1'-0"



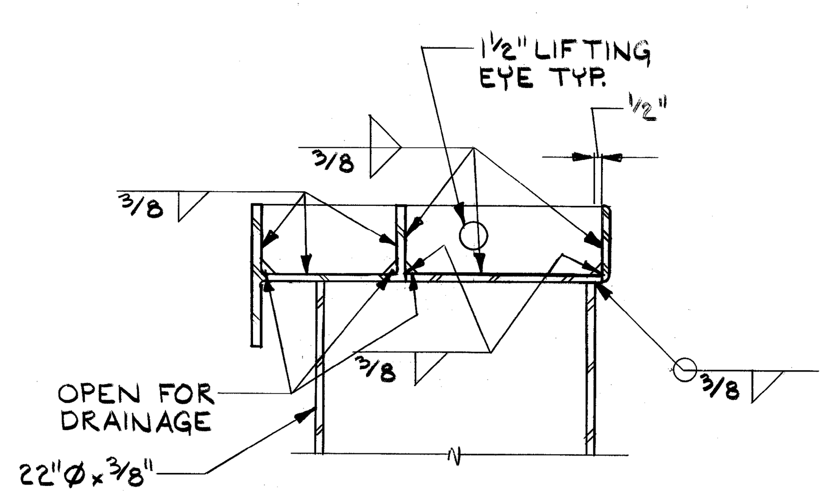
DETAIL 1 S12 S12
1"=1'-0"



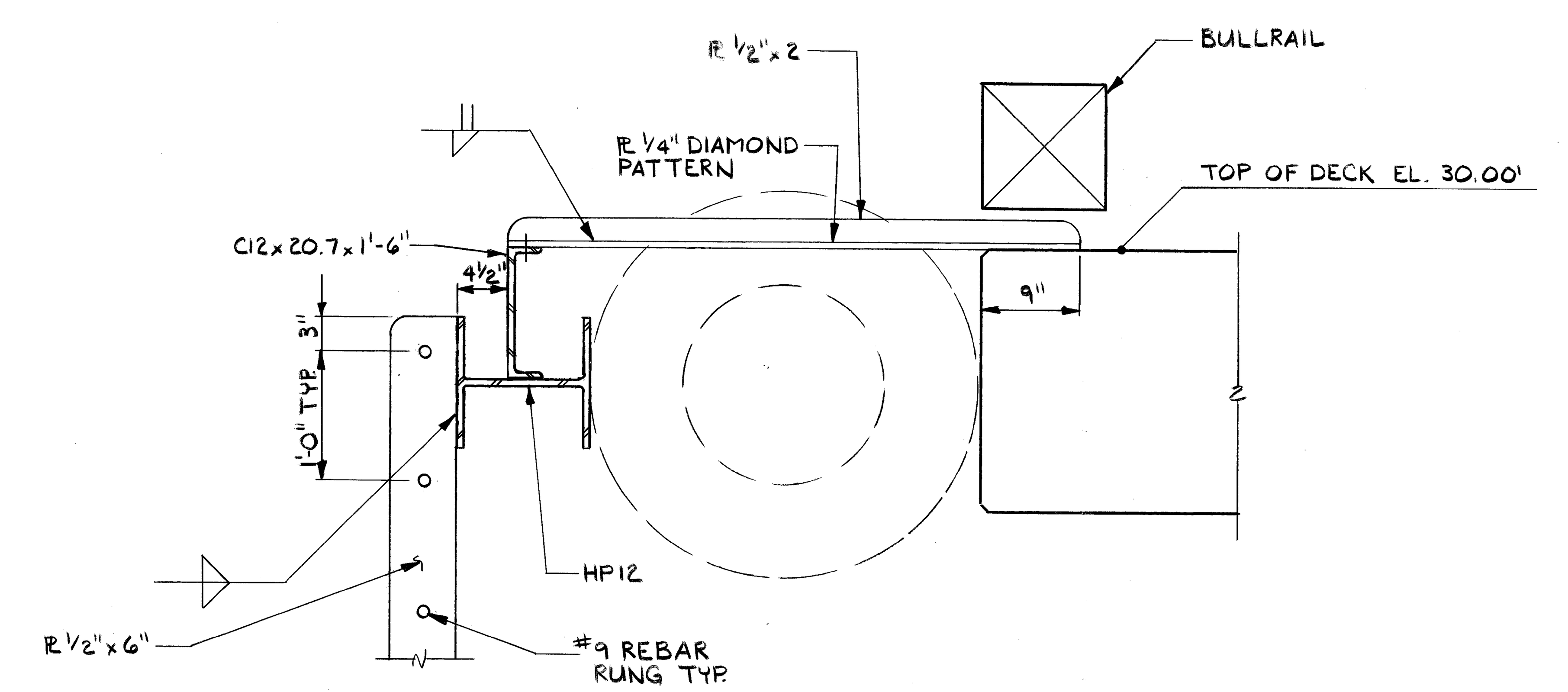
DETAIL 2 S12 S12
1"=1'-0"



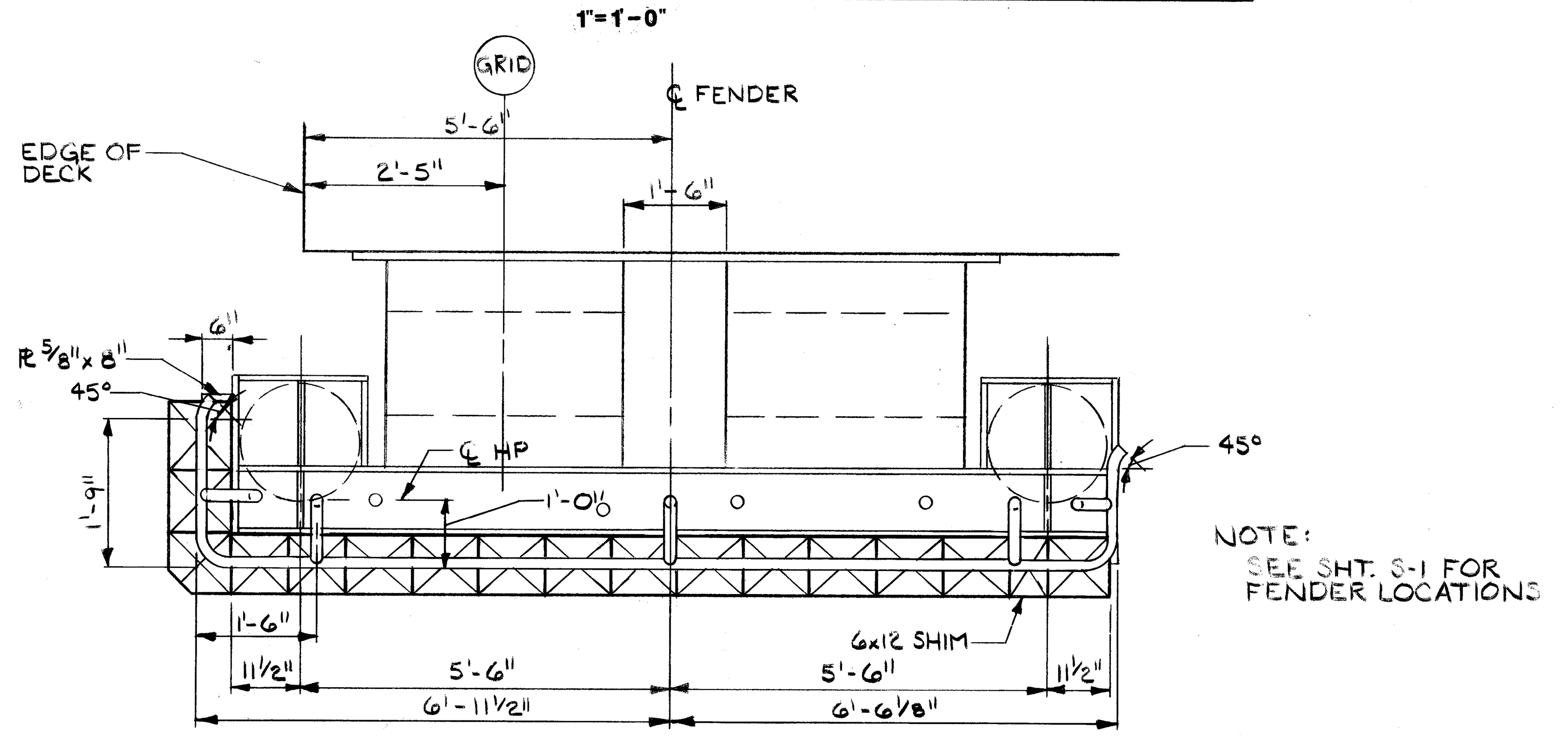
FENDER ATTACHMENT PLAN
1"=1'-0"



SECTION B S12 S12
1"=1'-0"



SECTION C S12 S12
1"=1'-0"



NOTE:
SEE TYP. FENDER PLAN AND ELEVATION FOR DETAILS NOT SHOWN

CORNER FENDER PLAN
1/2"=1'-0"

PORTIONS OF THIS PROJECT WERE FUNDED BY:
EDA PROJECT NO. 07-01-03099
STATE OF ALASKA
DEPT. OF COMMERCE & ECONOMIC DEVELOPMENT
CONTROL NO. 89-001

REV.	DATE	BY	REVISION
1	8-15-90	WH	AS BUILT

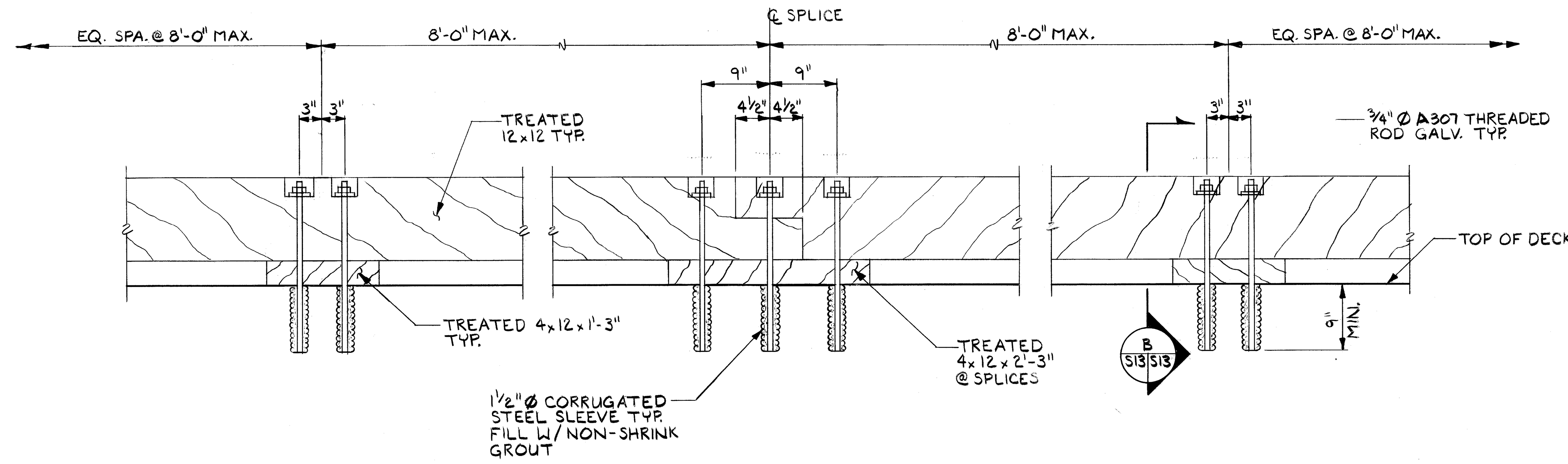
FIELD BOOKS / DESIGN / STAKING / AS-BUILT / SCALE HOR. / VER.

DESIGNED MJS
DRAWN HJF
CHECKED MJS
DATE OCT. 88
GRID
JOB NO. 4784.0

TRYCK NYMAN & HAYES
ENGINEERS / PLANNERS / SURVEYORS
ANCHORAGE, ALASKA

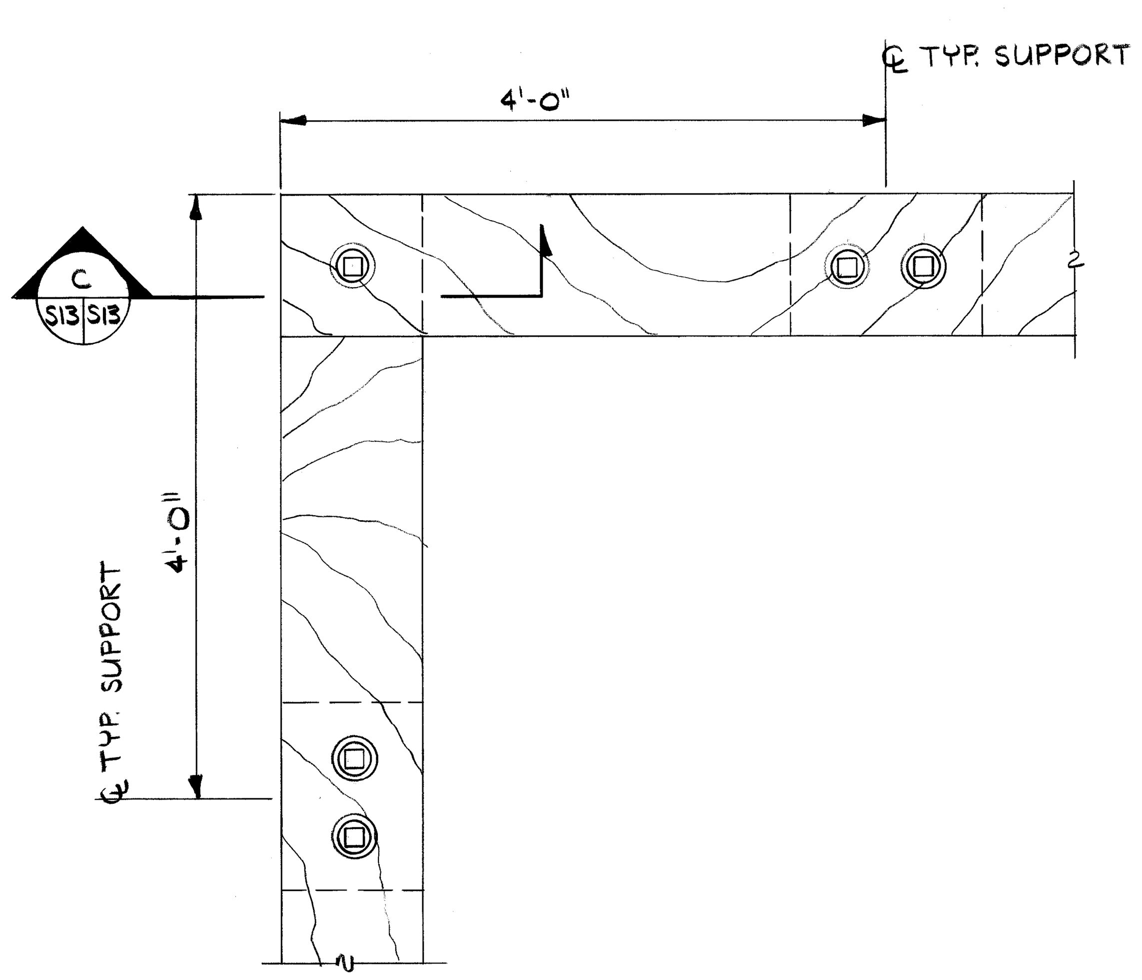
CITY OF HOMER
DEEP WATER DOCK
EDA PROJECT NO. 07-01-03099
FENDER PLANS AND DETAILS

SHEET S-12 of 22
FILE NO. 00416



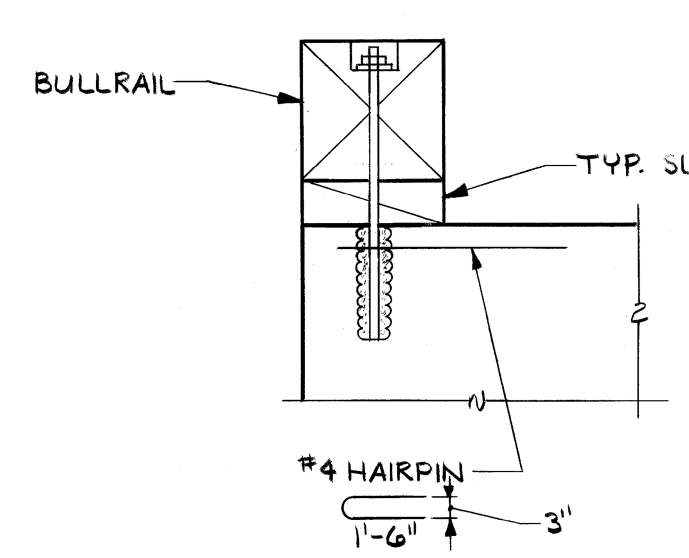
TYPICAL BULLRAIL DETAIL

1"=1'-0"



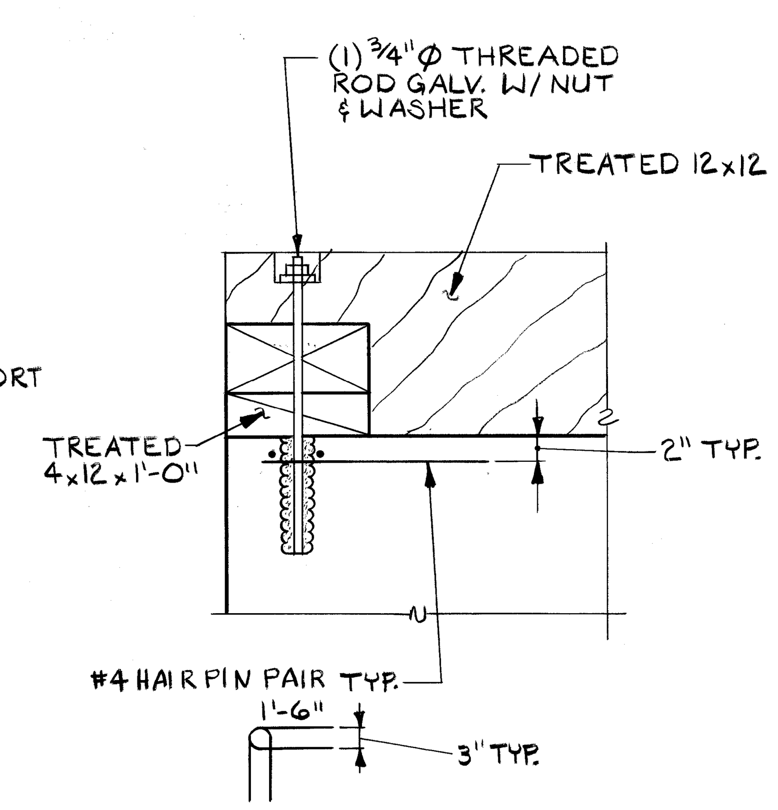
BULLRAIL @ CORNERS

1"=1'-0"



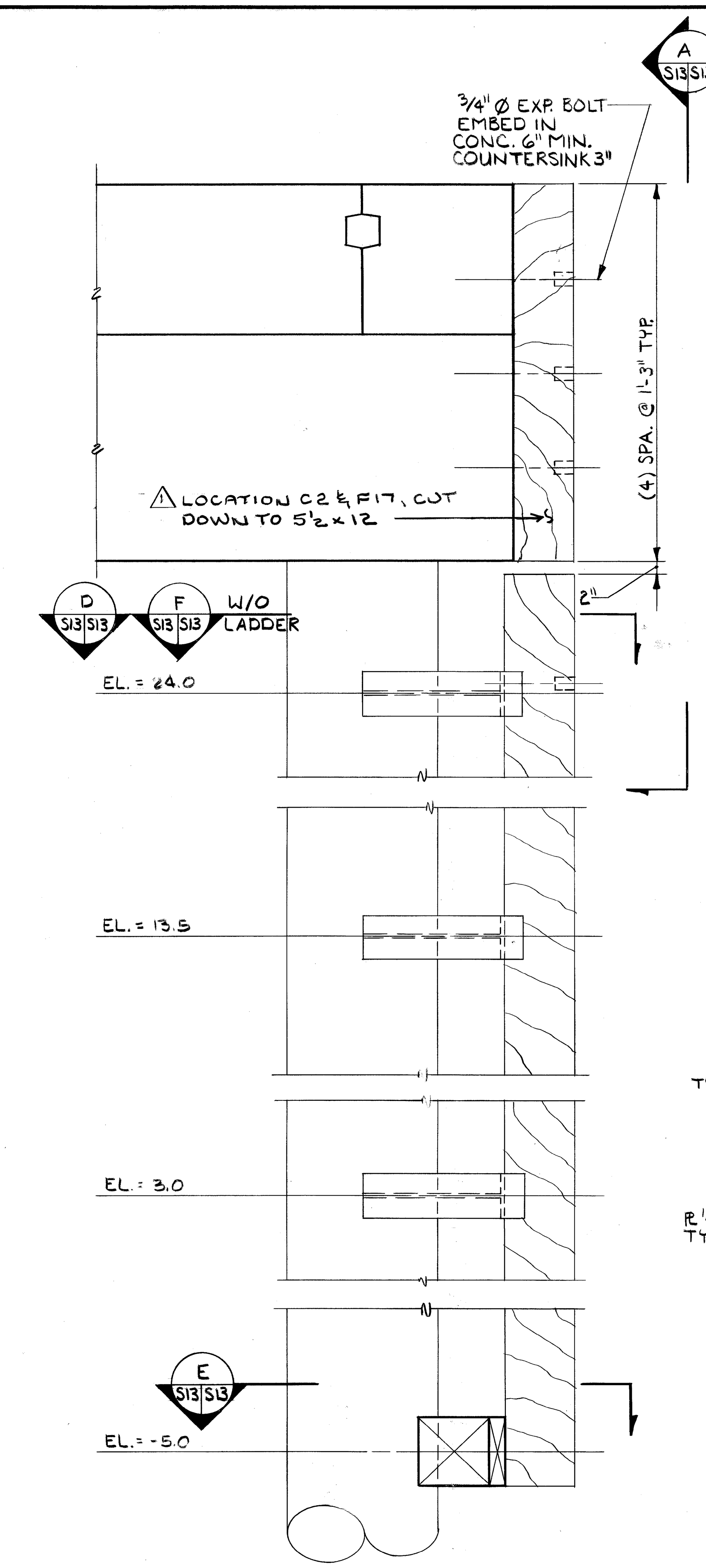
SECTION B S13 S13

1"=1'-0"



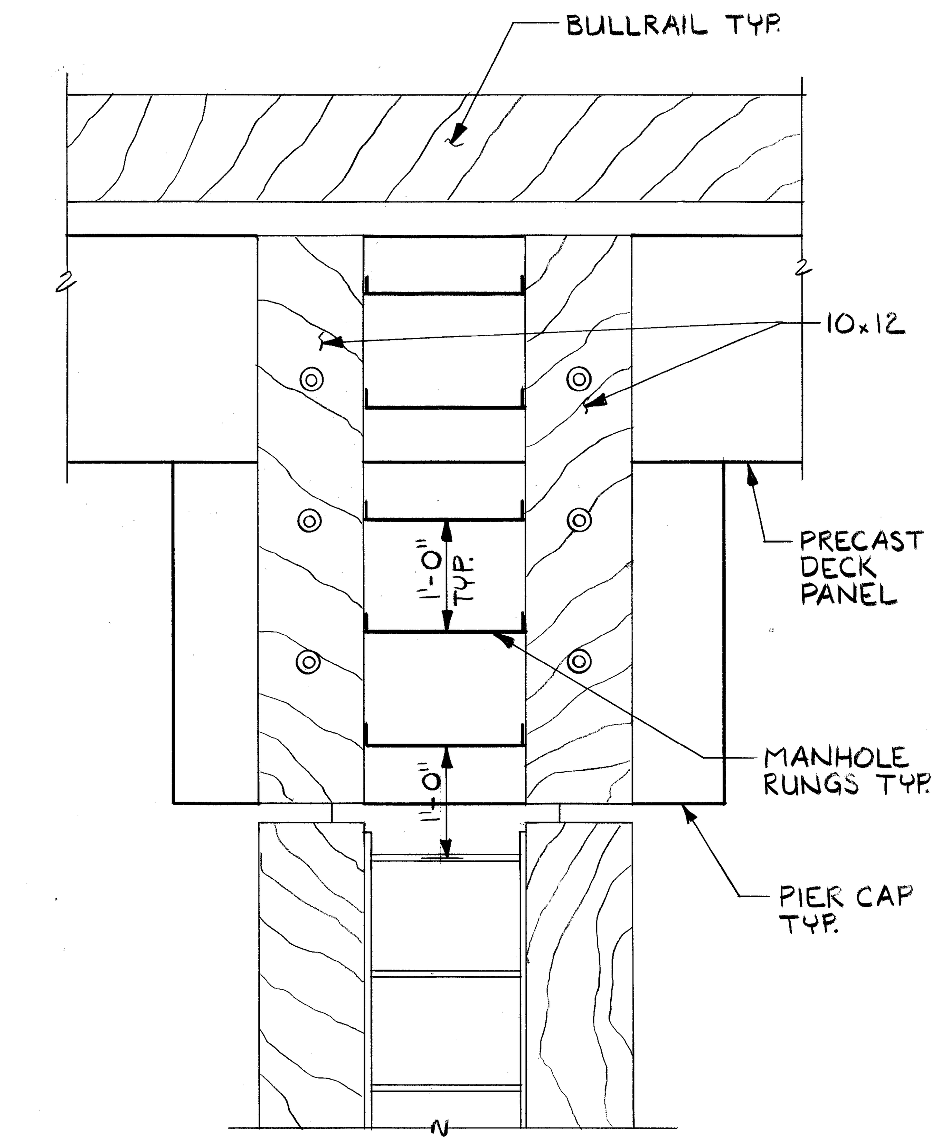
SECTION C S13 S13

1"=1'-0"



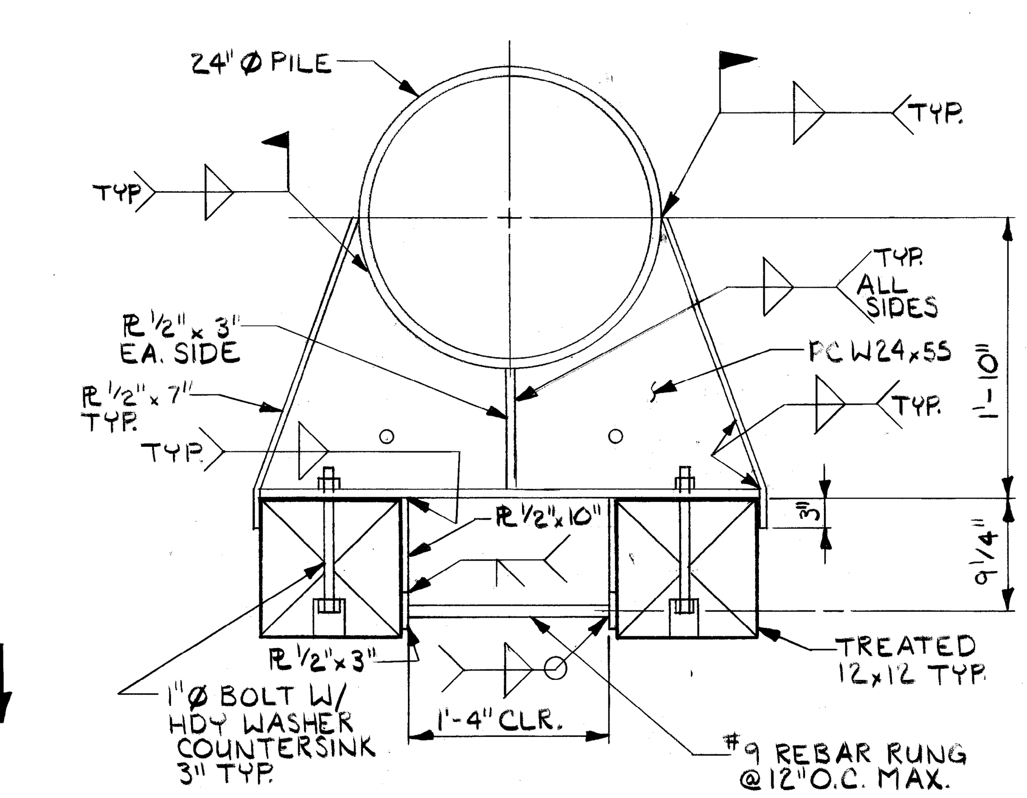
TYPICAL RUB STRIP AND LADDER ELEVATION

3/4"=1'-0"



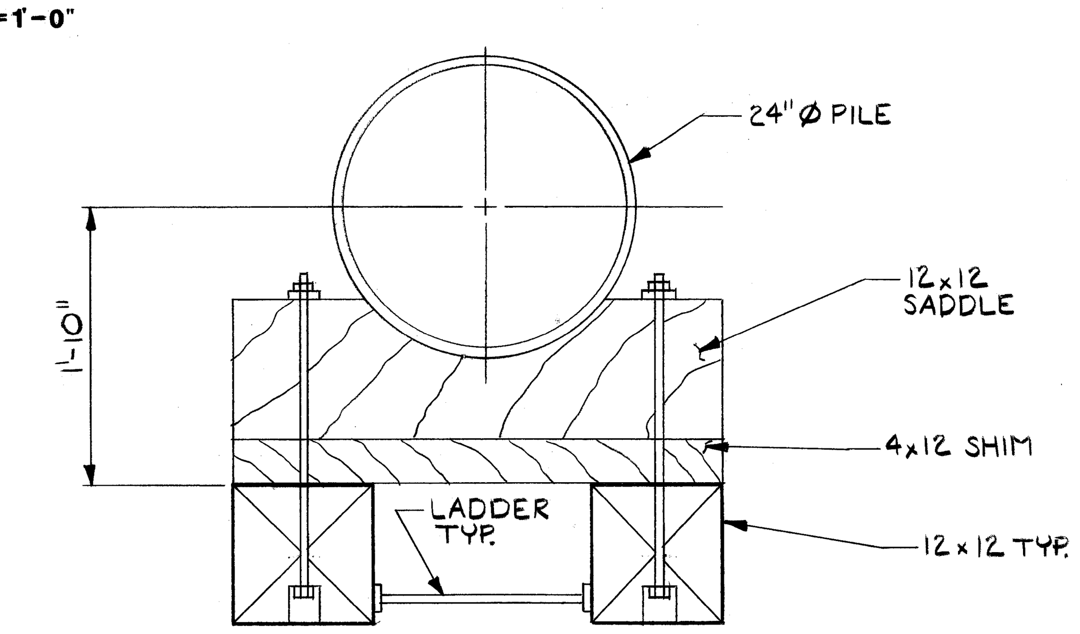
SECTION A S13 S13

3/4"=1'-0"



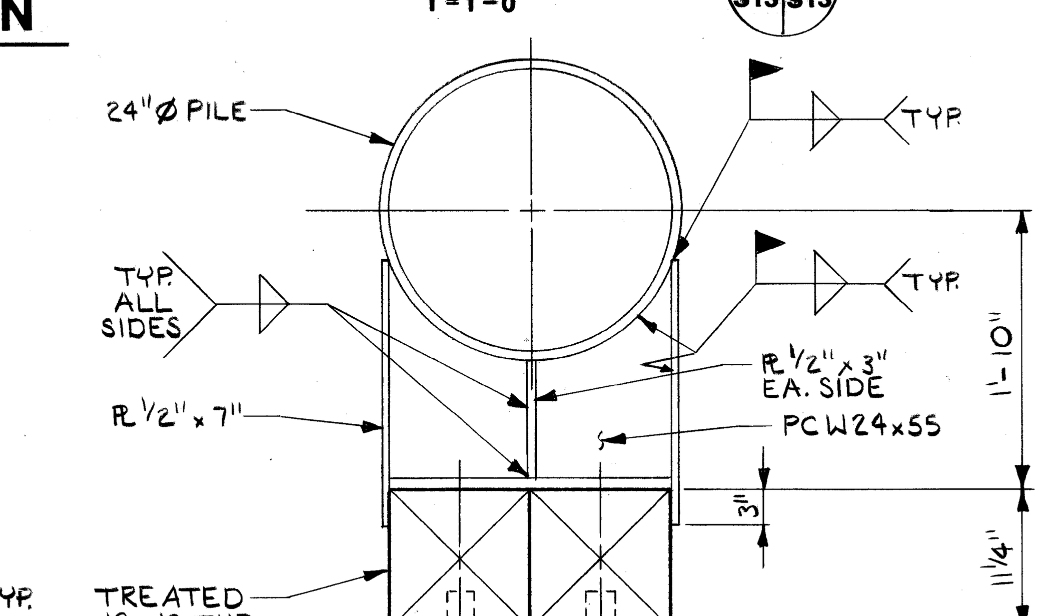
SECTION D S13 S13

1"=1'-0"



SECTION E S13 S13

1"=1'-0"



SECTION F S13 S13

1"=1'-0"

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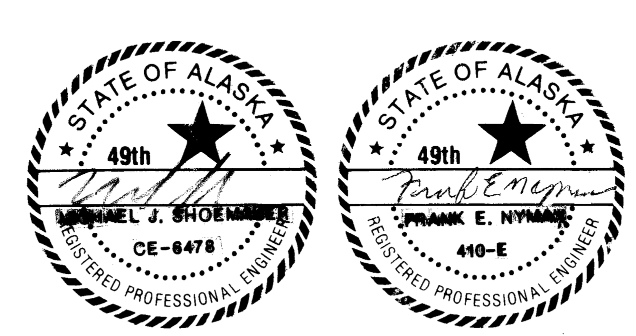
EDA PROJECT NO. 07-01-03099
STATE OF ALASKA
DEPT. OF COMMERCE & ECONOMIC DEVELOPMENT
CONTROL NO. 89-001



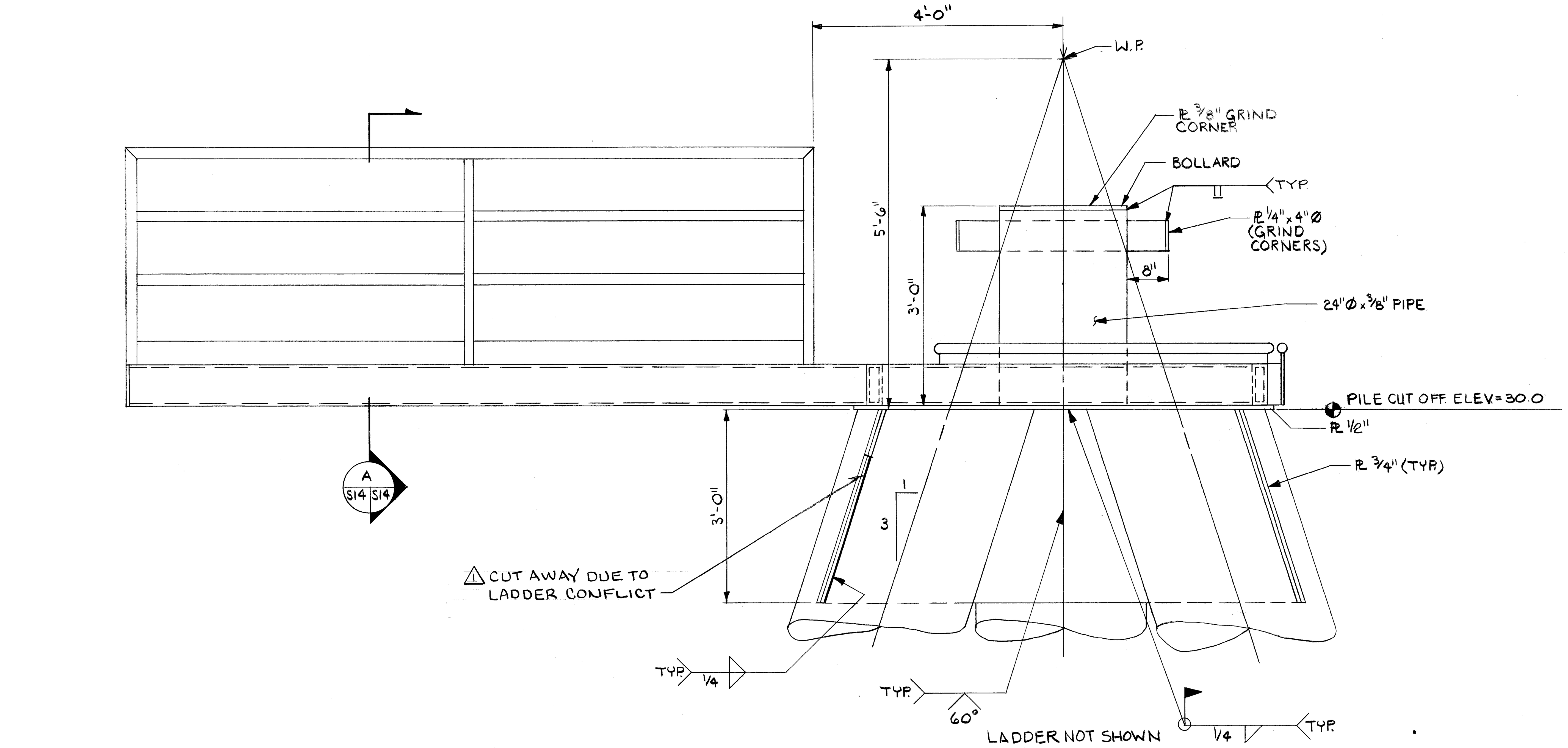
REV.	DATE	BY	REVISION
1	8-15-90	WJ	AS BUILT

FIELD BOOKS	
DESIGN	
STAKING	
AS-BUILT	
SCALE HOR.	
VER.	
DESIGNED	MJS
DRAWN	HJF
CHECKED	MJS
DATE	OCT. 88
GRID	
JOB NO.	4784.0

TRYCK NYMAN & HAYES
ENGINEERS / PLANNERS / SURVEYORS
ANCHORAGE, ALASKA

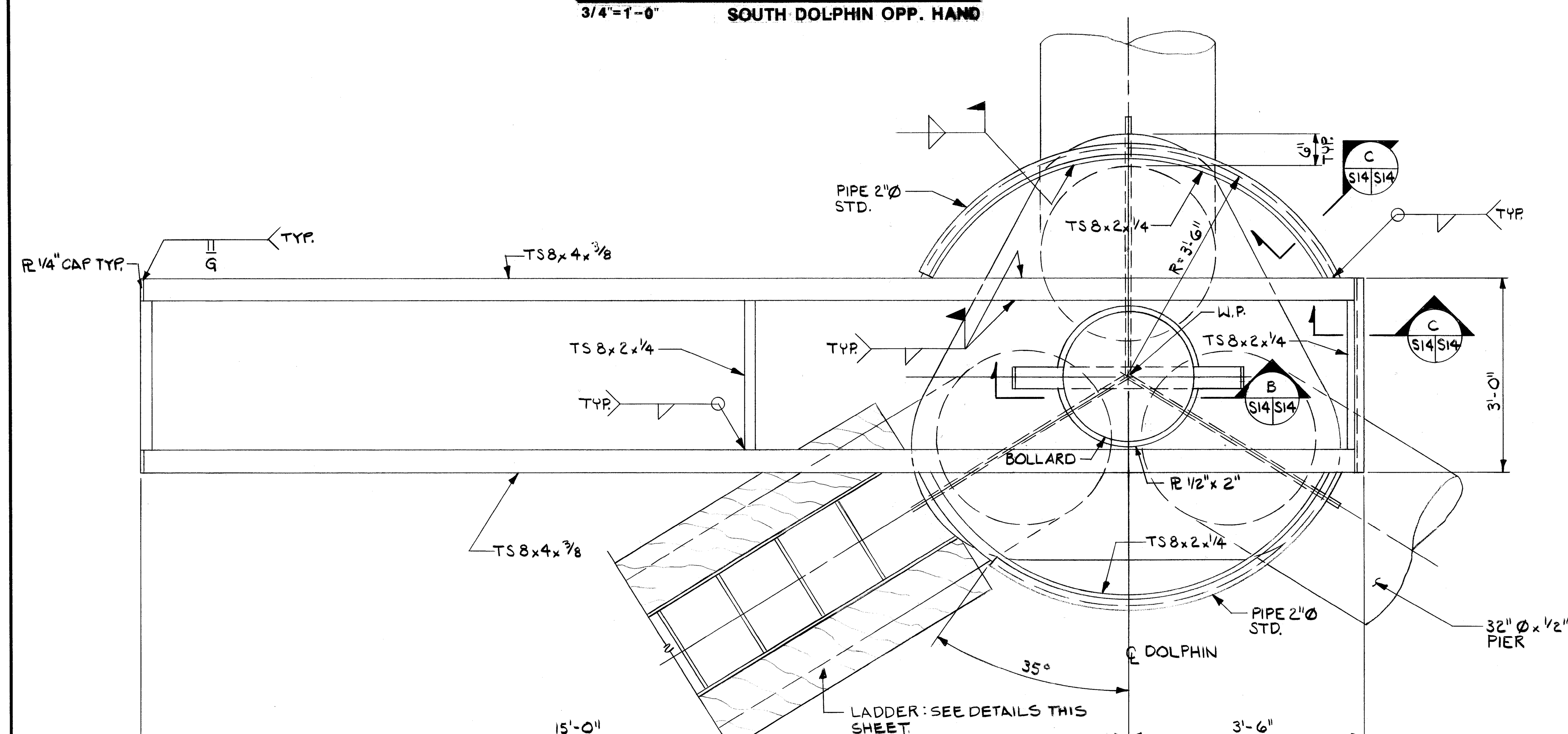
CITY OF HOMER
DEEP WATER DOCK
EDA PROJECT NO. 07-01-03099
BULLRAIL AND RUB STRIP DETAILS

SHEET S-13 OF 22
FILE NO. 00417



NORTH DOLPHIN ELEVATION

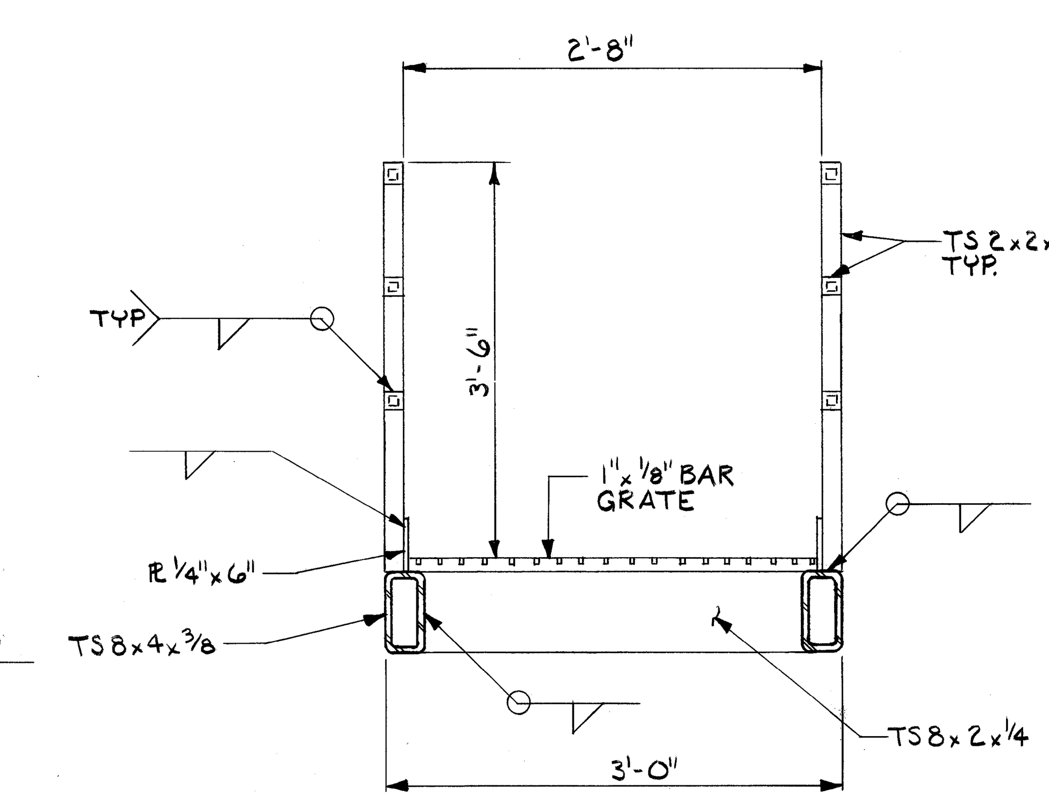
3/4"=1'-0" SOUTH DOLPHIN OPP. HAND



NOTE: GRATING AND HANDRAILS NOT SHOWN FOR CLARITY.

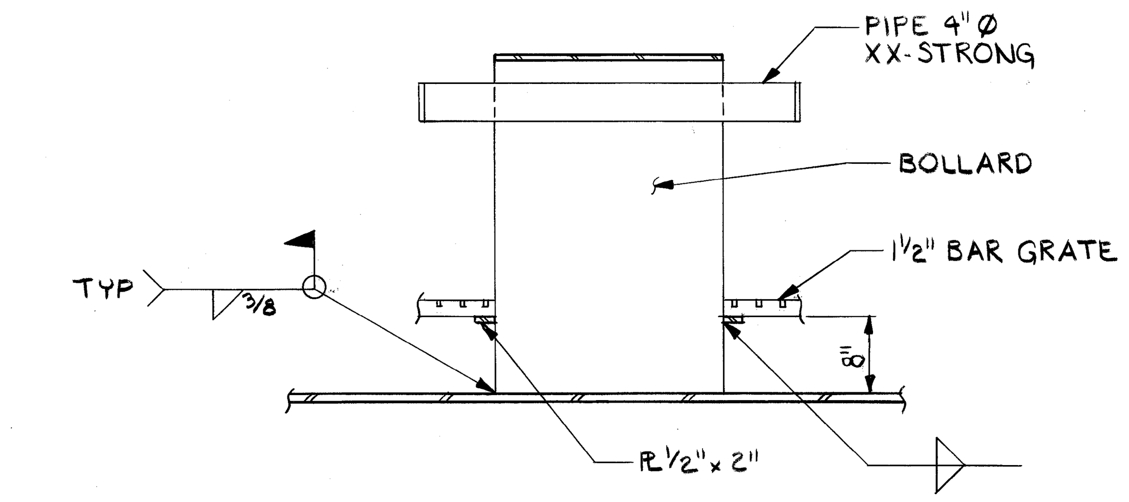
NORTH DOLPHIN PLAN

3/4"=1'-0" SOUTH DOLPHIN OPP. HAND



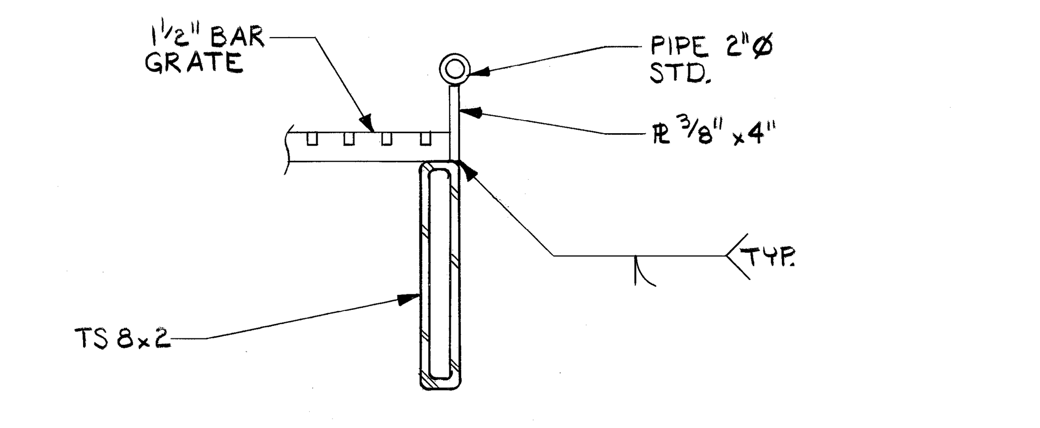
SECTION A

1"=1'-0"



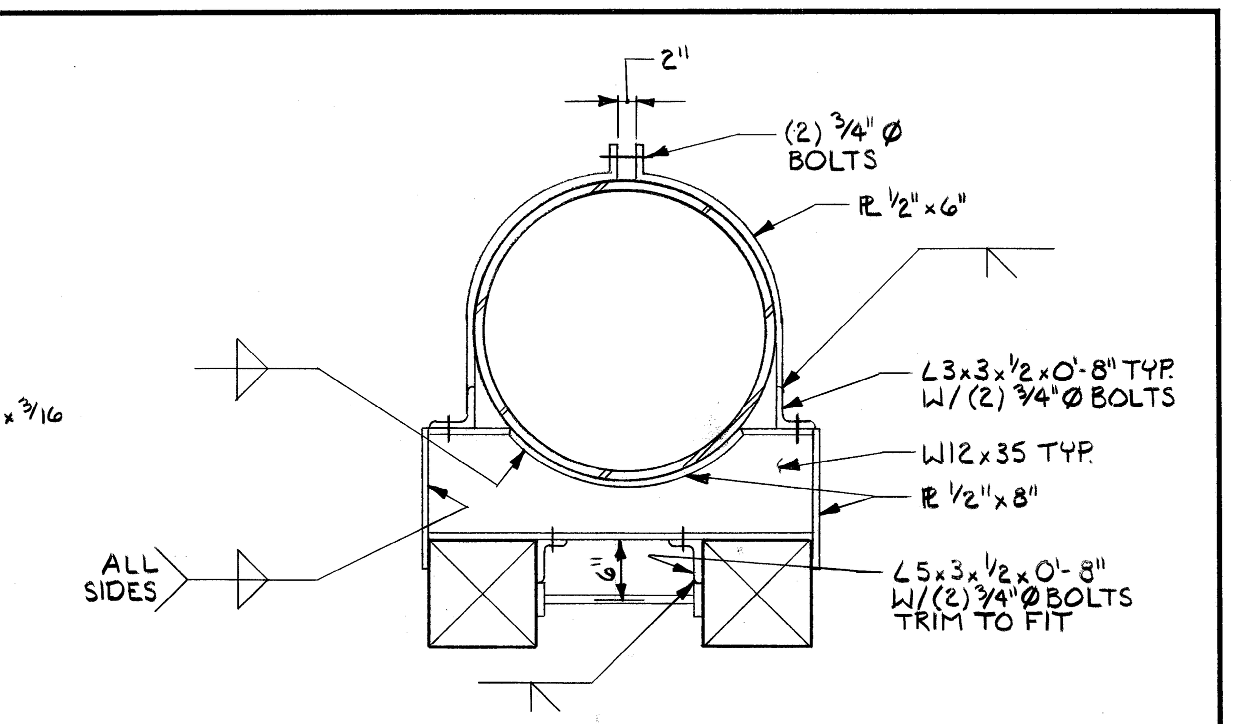
SECTION B

3/4"=1'-0"

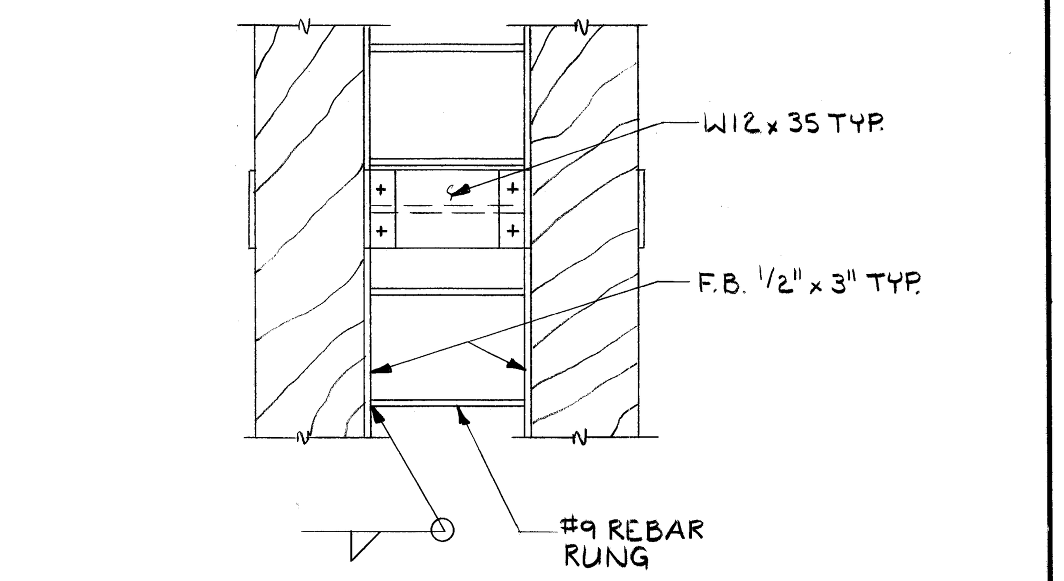


SECTION C

1 1/2"=1'-0"



PLAN



ELEVATION

PROVIDE LADDER FROM EL. 29.67' TO -5.00'
PROVIDE W12x35 PILE CLAMPS AT EL. 29.00', 21.00', 13.00', 5.00' & -3.00'.

TYPICAL DOLPHIN LADDER DETAILS

3/4"=1'-0"

NOTE: SOUTH DOLPHIN NOT AWARDED

PORTIONS OF THIS PROJECT WERE FUNDED BY:
EDA PROJECT NO. 07-01-03099
STATE OF ALASKA
DEPT. OF COMMERCE & ECONOMIC DEVELOPMENT
CONTROL NO. 89-001

STATE OF ALASKA 19th SAMUEL J. SHOEMAKER CE-6478 REGISTERED PROFESSIONAL ENGINEER
STATE OF ALASKA 49th FRANK E. NYMAN 440-E REGISTERED PROFESSIONAL ENGINEER

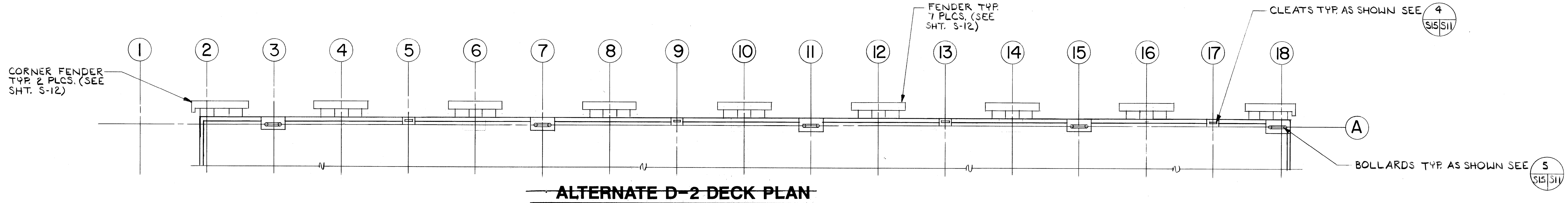
REV.	DATE	BY	REVISION
1	8-15-90	WJ	AS-BUILT

FIELD BOOKS / DESIGN / STAKING / AS-BUILT / SCALE HOR. VER.
DESIGNED MJS · DRAWN HJF · CHECKED MJS · DATE OCT. 88 · GRID · JOB NO. 4784.0

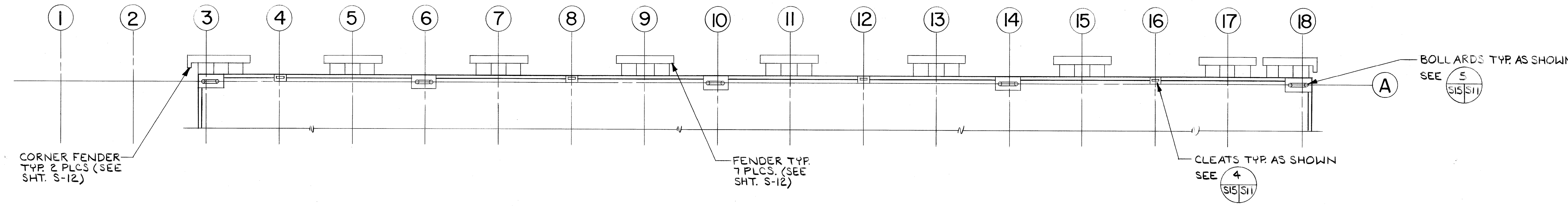
TRYCK NYMAN & HAYES
ENGINEERS / PLANNERS / SURVEYORS
ANCHORAGE, ALASKA

CITY OF HOMER
DEEP WATER DOCK
EDA PROJECT NO. 07-01-03099
MOORING DOLPHIN PLAN AND DETAILS

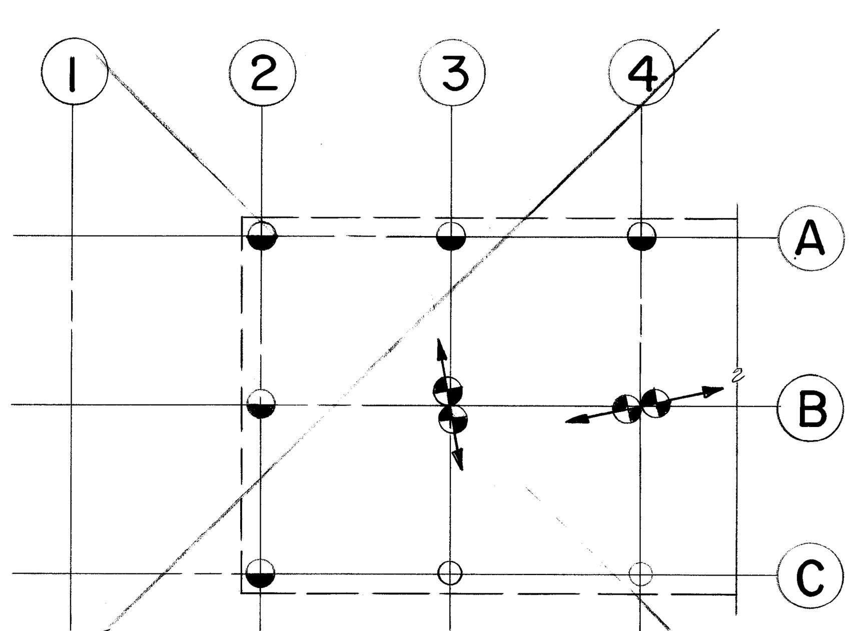
SHEET S-14 OF 22
FILE NO. 00418



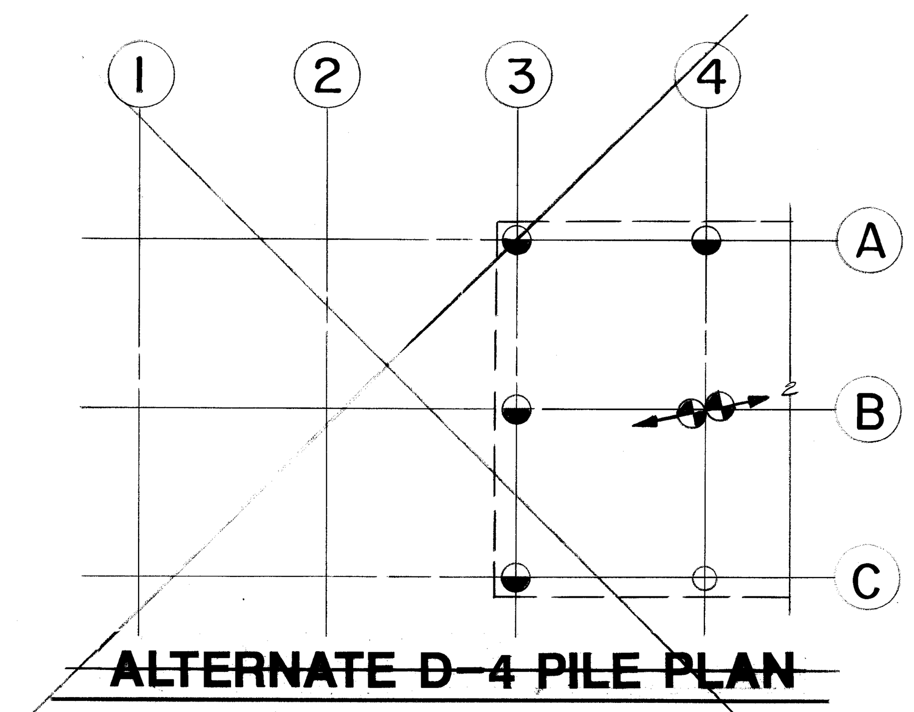
~~ALTERNATE D-2 DECK PLAN~~
1/16"=1'-0"



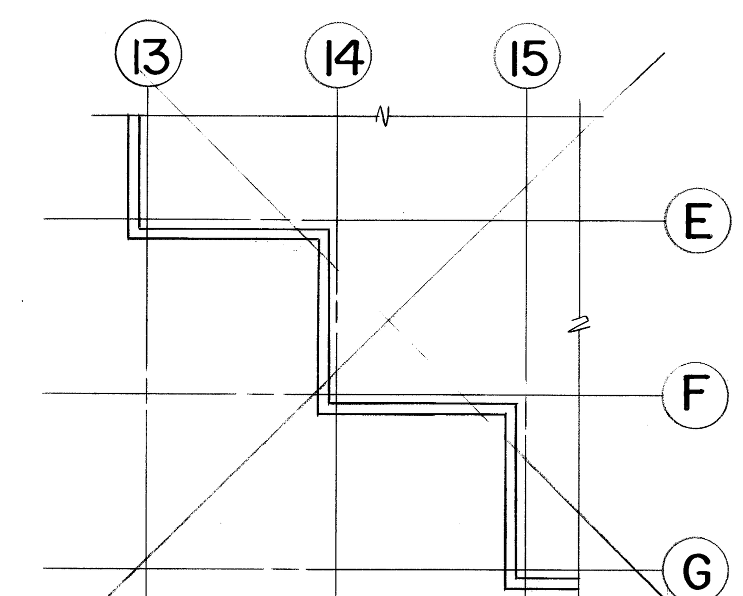
~~ALTERNATE D-4 DECK PLAN~~
1/16"=1'-0"



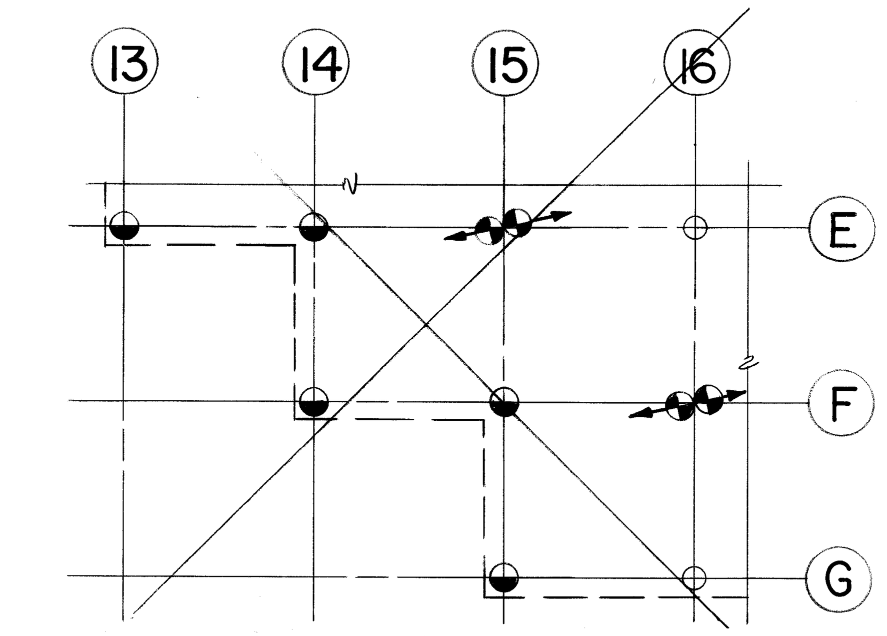
~~ALTERNATE D-2 PILE PLAN~~
1/16"=1'-0"



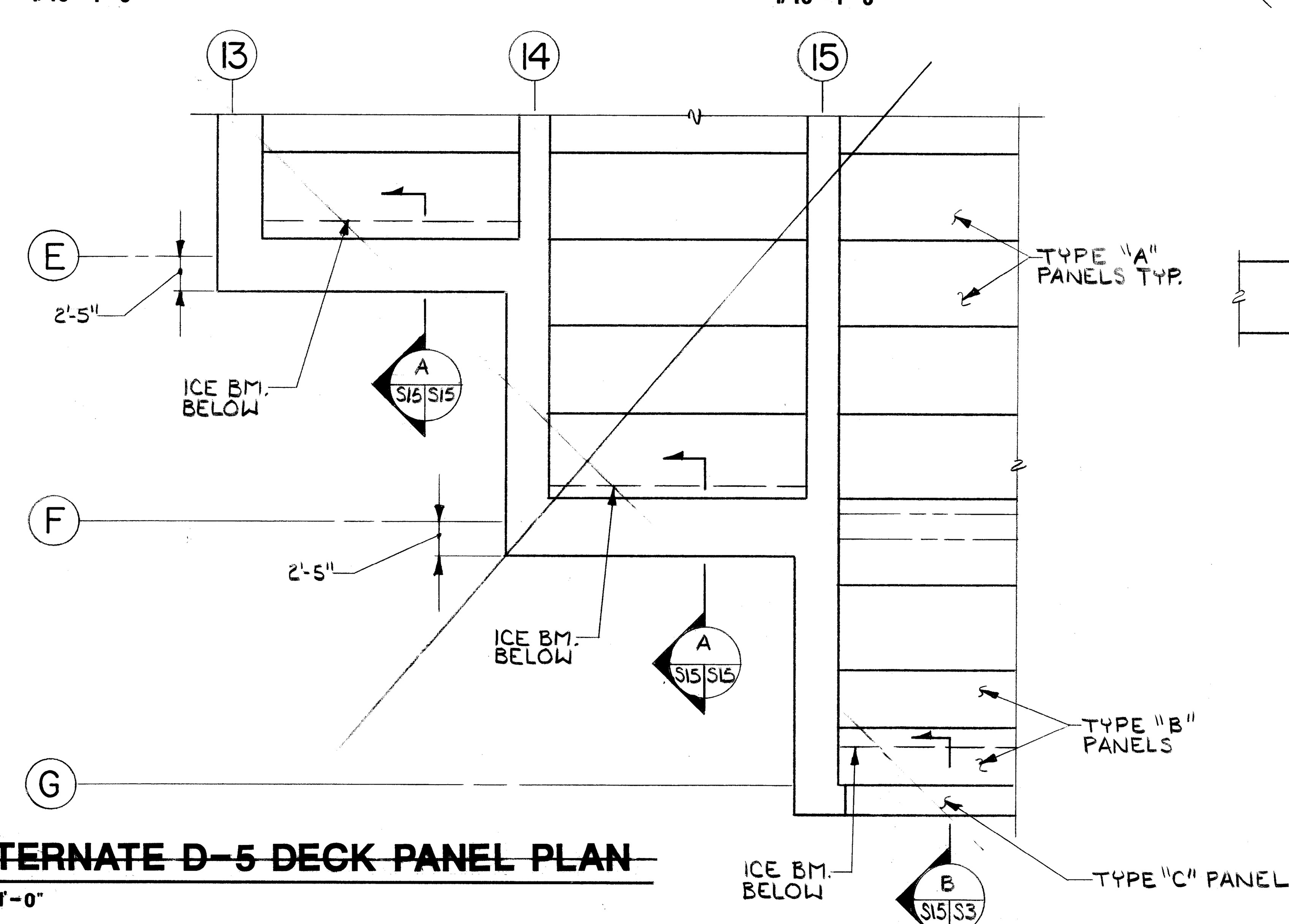
~~ALTERNATE D-4 PILE PLAN~~
1/16"=1'-0"



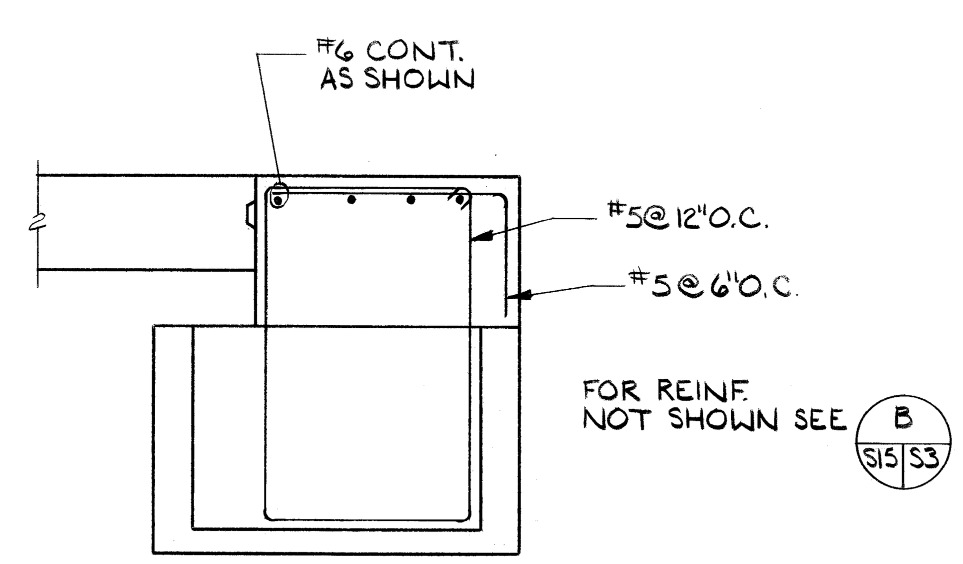
~~ALTERNATE D-5 DECK PLAN~~
1/16"=1'-0"



~~ALTERNATE D-5 PILE PLAN~~
1/16"=1'-0"



~~ALTERNATE D-5 DECK PANEL PLAN~~
1/8"=1'-0"

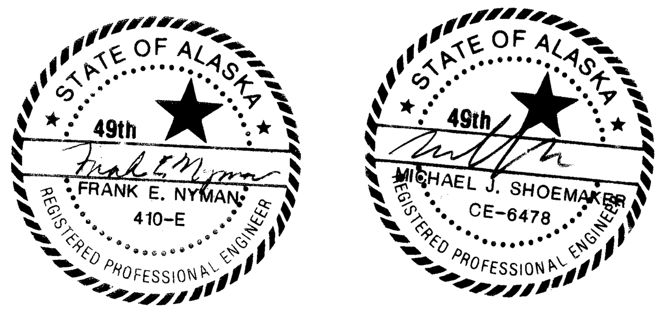


SECTION A S15 S15
1/2"=1'-0"

NOTES:

1. SEE SHEET S2 FOR PILE LEGEND.
2. FOR DIMENSIONS AND DETAILS NOT SHOWN SEE BASIC BID DRAWING.
3. COORDINATE NEW FENDER PILE LOCATIONS WITH APPLICABLE DECK PLAN

⚠ NOTE: NO ALTERNATES SHOWN ON THIS SHEET TAKEN



PORTIONS OF THIS PROJECT WERE FUNDED BY:
EDA PROJECT NO. 07-01-03099
STATE OF ALASKA
DEPT. OF COMMERCE & ECONOMIC DEVELOPMENT
CONTROL NO. 89-001

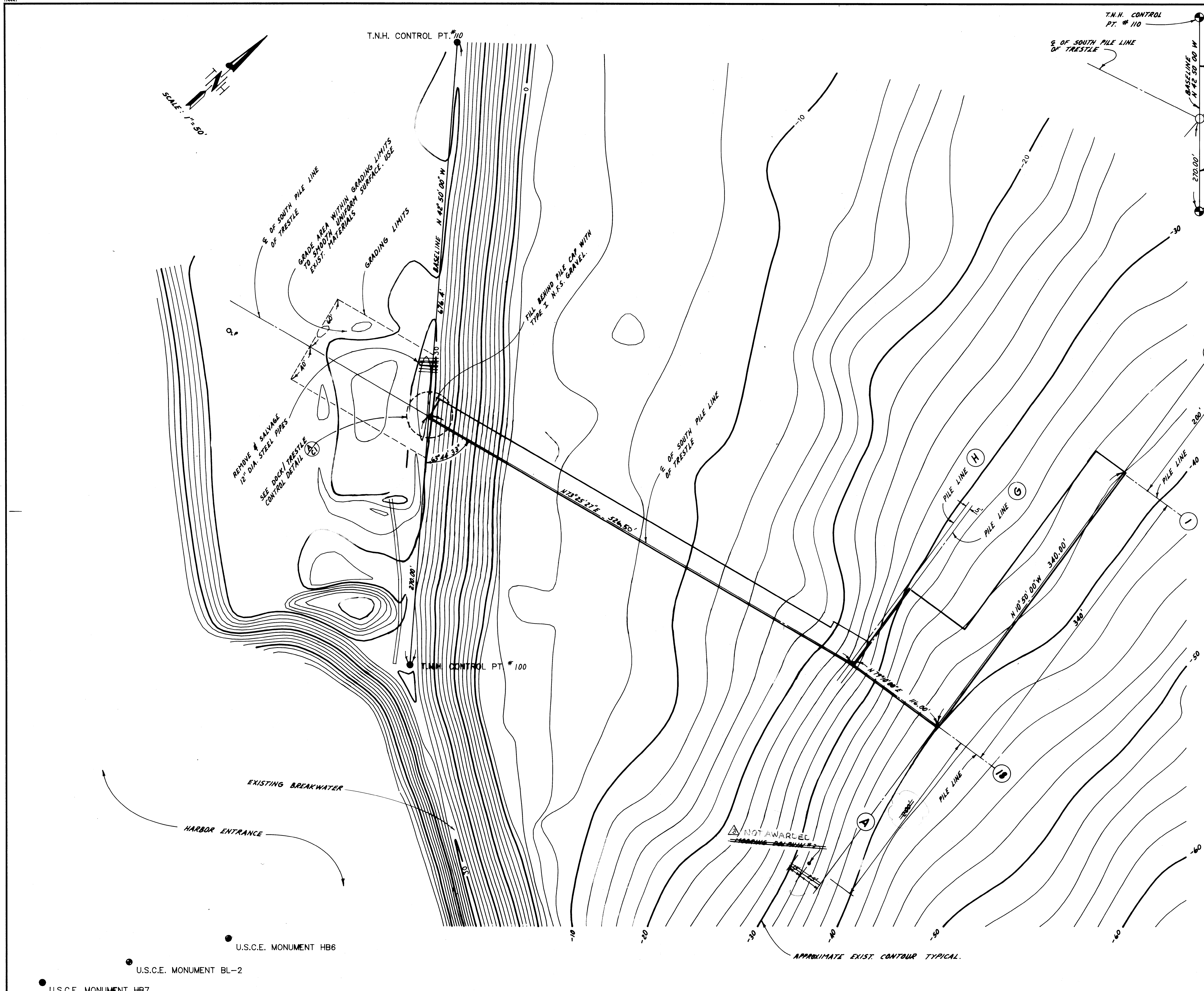
REV.	DATE	BY	REVISION
1	8-15-90	JH	AS BUILT

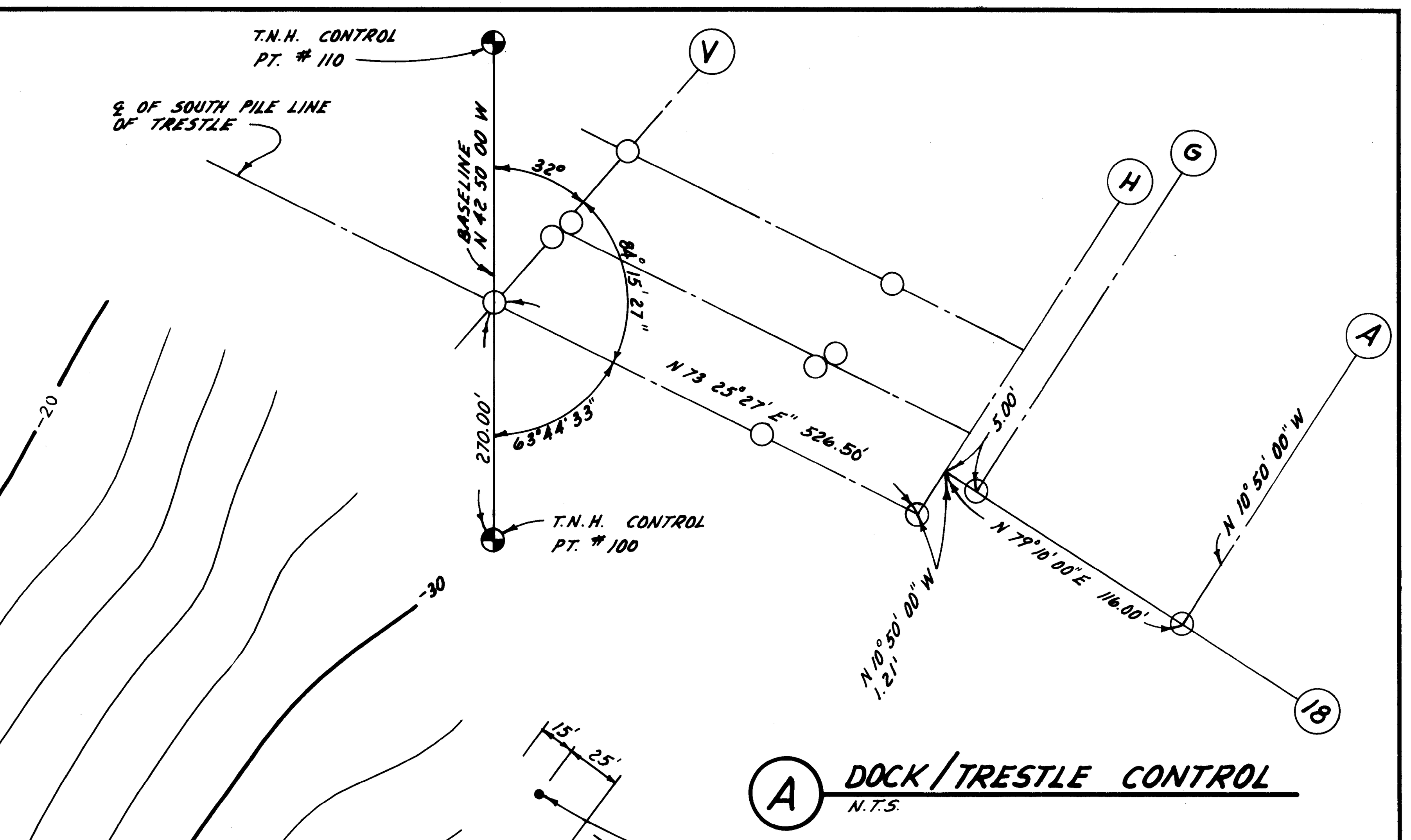
FIELD BOOKS	
DESIGN	
STAKING	
AS-BUILT	
SCALE HOR.	
VER.	
DESIGNED	MJS
DRAWN	HJF
CHECKED	MJS
DATE	OCT. 88
GRID	
JOB NO.	4784.0

TRYCK NYMAN & HAYES
ENGINEERS / PLANNERS / SURVEYORS
ANCHORAGE, ALASKA

CITY OF HOMER
DEEP WATER DOCK
EDA PROJECT NO. 07-01-03099
DEDUCTIVE ALTERNATE DETAILS

SHEET S-15 OF 22
FILE NO. 00419





NOTES

1. EXISTING BREAKWATER AND SLOPES FROM APPROXIMATELY +30' M.L.L.W. AND -2 M.L.L.W. ARE COVERED WITH LARGE RIP RAP.
2. BASIS OF BEARING FROM USCE MON HB-7 TO USCE MON HB-6, N26°28'07"E, FROM COORDINATES ON TAMS ENGINEERING DRAWING OF HOMER FISH DOCK.
3. BASIS OF ELEVATION FROM USCE MON HB-7, EL 30.42'.

COORDINATE LIST*

PT	NORTHING	EASTING	ELEVATION
100	680,808.798	933,982.522	30.376
110	681,304.830	933,522.682	30.377
120	680,283.508	933,964.639	30.420

*VERIFY ALL COORDINATE LOCATIONS AND ELEVATIONS WITH BASIS OF BEARING AND ELEVATION PRIOR TO CONSTRUCTION.

PORTIONS OF THIS PROJECT WERE FUNDED BY:
EDA PROJECT NO. 07-01-03099
STATE OF ALASKA
DEPT. OF COMMERCE & ECONOMIC DEVELOPMENT
CONTROL NO. 89-001

AS-BUILT
CITY OF HOMER

WILLIAM J. NELSON & ASSOCIATES

REV.	DATE	BY	REVISION
1	11-9-88	WJN	NOTES 2&3 + COORDINATE LIST PER TNH
2	11-9-88	WJN	TRESTLE LENGTH PER TNH
3	8-15-90	WL	AS BUILT

FIELD BOOKS | DESIGN | STAKING | AS-BUILT | SCALE HOR. VER.

DESIGNED | DRAWN | CHECKED | DATE OCT. 5, 1988 | GRID | JOB NO. 4784.0

TRYCK NYMAN & HAYES
ENGINEERS/PLANNERS/SURVEYORS
ANCHORAGE, ALASKA

CITY OF HOMER
DEEP WATER DOCK
EDA PROJECT NO. 07-01-03099
LOCATION PLAN

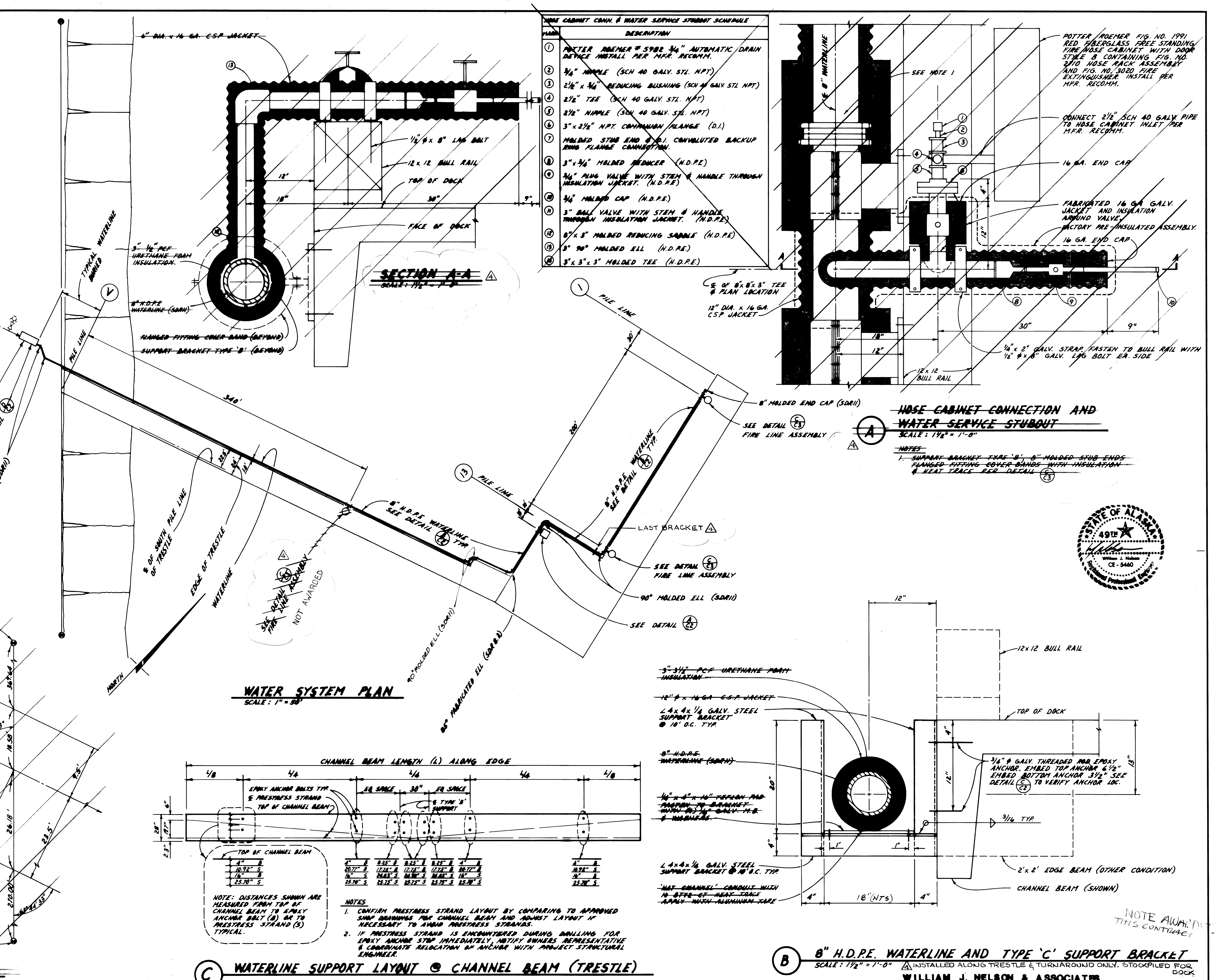
SHEET C-1 OF 22
FILE NO. 00401

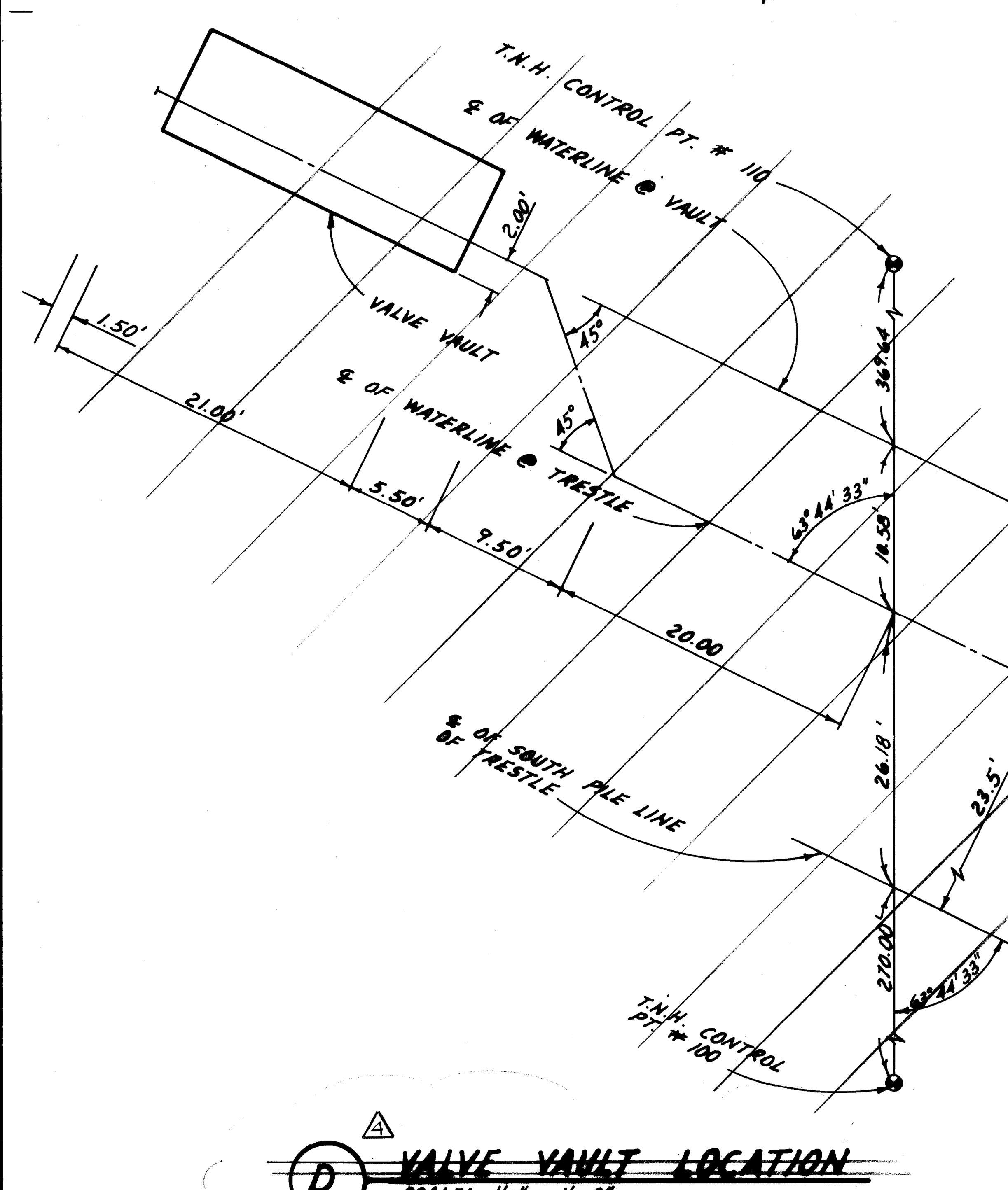
PN. 8811

WATERLINE GENERAL NOTES

1. ~~WATERLINE SHALL BE HIGH DENSITY POLYETHYLENE SDR11 WITH DESIGN PRESSURE RATING OF 160 PSI MINIMUM AND SHALL HAVE THERMALLY FUSED JOINTS AND MOLDED FITTINGS PER SPEC. EXCEPT WHERE NOTED OTHERWISE.~~
2. WATERLINE SHALL BE SUPPORTED PER DETAIL (A/C2) WITH A MAXIMUM SUPPORT SPACING OF 10'-0" O.C. ADJUST LOCATION OF SUPPORTS AS REQUIRED TO MISS PRESTRESS STRANDS. PROVIDE ADDITIONAL SUPPORTS AT SPLICES WHERE THE CSP JACKET DOES NOT OTHERWISE RUN CONTINUOUS OVER TWO OR MORE SUPPORTS.
3. ~~ALL TEES SHALL BE SUPPORTED AT EACH SIDE OF TEE WITH A TYPE 'B' SUPPORT BRACKET PER DETAIL (B/C2)~~
4. ~~8" WATERLINE SHALL BE FURNISHED IN 40' LENGTHS TO THE MAXIMUM EXTENT POSSIBLE.~~

△ WATERLINE NOT AWARDED
TYPE 'C' BRACKETS FURNISHED AND INSTALLED UNDER CONTR. MOD. #1





STATE OF ALASKA 49TH William J. Nelson CE-5460 Registered Professional Engineer

WILLIAM J. NELSON & ASSOCIATES

PORTIONS OF THIS PROJECT WERE FUNDED BY:
EDA PROJECT NO. 07-01-03099
STATE OF ALASKA
DEPT. OF COMMERCE & ECONOMIC DEVELOPMENT
CONTROL NO. 89-001

REV.	DATE	BY	REVISION
1	11-9-88	WJN	SUPPORT BRACKET WIDTH
2	11-9-88	WJN	EXTRA 8' TRESTLE WIDTH @ WEST END (2) 90° ELLS
3	11-9-88	WJN	NOT IN CONTRACT
4	8-15-90	WK	AS BUILT

FIELD BOOKS / DESIGN / STAKING / AS-BUILT / SCALE HOR. VER. / DESIGNED / DRAWN / CHECKED / DATE OCT. 5, 1988 / GRID / JOB NO. 4784.0

TRYCK NYMAN & HAYES
ENGINEERS / PLANNERS / SURVEYORS
ANCHORAGE, ALASKA

CITY OF HOMER
DEEP WATER DOCK
EDA PROJECT NO. 07-01-03099
WATER SYSTEM

SHEET C-2 OF 22
FILE NO. 00402

PN. 8811

WILLIAM J. NELSON & ASSOCIATES

REV.	DATE	BY	REVISION
1	11-9-88	WN	NOT IN CONTRACT
2	8-15-90	WH	AS BUILT

FIELD BOOKS — DESIGN — STAKING — AS-BUILT — SCALE HOR. VER.

DESIGNED — DRAWN — CHECKED — DATE OCT. 5, 1988 — GRID — JOB NO. 4784.0

TRYCK NYMAN & HAYES
ENGINEERS / PLANNERS / SURVEYORS
ANCHORAGE, ALASKA

CITY OF HOMER
DEEP WATER DOCK
EDA PROJECT NO. 07-01-03099
FIRE LINE ASSEMBLY

SHEET C-3 of 22
FILE NO. 00403

PN. 8811

8" ϕ SCH 40 STEEL PIPE BOLLARD. (4 TOTAL) 7' LONG, EMBED 42" IN GROUND. PAINT WITH 2 COATS ALKYD ENAMEL "CATERPILLAR YELLOW". FILL WITH GROUT.
NOT IN CONTRACT
PORTIONS OF THIS PROJECT WERE FUNDED BY:
EDA PROJECT NO. 07-01-03099
STATE OF ALASKA
DEPT. OF COMMERCE & ECONOMIC DEVELOPMENT
CONTROL NO. 89-001
VALVE VAULT LID (PLAN)
SCALE: 1/2" = 1'-0"
VALVE VAULT LID (SECTION C-C)
SCALE: 1/2" = 1'-0"
ACCESS LADDER BY OTHERS N.I.C.
BEND HORIZ. BARS & EXTEND 24" INTO WALLS TYP.
#6 BARS @ 10" O.C. VERT.
PT. 2x4 FIRING WITH 1/2" PT. PLYWOOD BACKING @ 24" O.C. (MAX.) FASTEN TO WALL WITH .177" ϕ x 3 1/2" POWER ACTUATED FASTENER @ 12" O.C. TYP.
NOTE: SLOPE FLOOR SURFACE 1/8"/FT. MIN. TO DRAIN TOWARDS SUMP.
16"x16"x 11 5/8" HIGH CONC. PIPE SUPPORT WITH (4) #4 VERT. & #3 TIES @ 6" O.C. & 2 #3 TIES @ 2" O.C. @ TOP.
℄ PIPING
21'-0"
VALVE VAULT (PLAN)
SCALE: 1/2" = 1'-0"
NOTE: MAINLINE PIPING OMITTED FOR CLARITY SEE SECTION A-A FOR MAINLINE PIPING.
TWO COATS WATER PROOF SEALANT ON WALLS & ROOF PER SPEC.
FINISH GRADE
CAST IN PLACE CONC. VAULT
ELASTOMERIC GROUT AROUND PIPE PER SPEC.
(4) TESTCOCKS, DRAINS TYP.
BEND VERT. BARS & EXTEND 24" INTO SLAB TYP.
BEND HORIZ. BARS & EXTEND 24" INTO WALLS TYP.
VALVE VAULT (SECTION A-A)
SCALE: 1/2" = 1'-0"
NOTES
1. VERIFY LAYING LENGTH OF ENTIRE ASSEMBLY PRIOR TO CASTING PIPE SUPPORTS, ADJUST PIPE SUPPORTS TO MATCH CENTERLINE OF GATE TEE & BASE ELL.
SUMP DETAIL (SECTION D-D)
SCALE: 1/2" = 1'-0"
GRATING, PROVIDE 1/8" CLEARANCE ALL SIDES.
1 1/2" x 1 1/2" x 1/4" GALV. STEEL ANGLE FRAME AROUND SUMP, CAST INTO CONC.
A KEYED CONSTRUCTION JOINT
B SUMP FRAME DETAIL
NOT AWARDED THIS CONTRACT
1 11-9-88 BOLLARDS
2 11-9-88 "NOT IN CONTRACT"
REVISION
OCT. 5, 1988
TRYCK NYMAN & HAYES
ENGINEERS / PLANNERS / SURVEYORS
ANCHORAGE, ALASKA
CITY OF HOMER
DEEP WATER DOCK
EDA PROJECT NO. 07-01-03099
VALVE VAULT
SHEET C-4 OF 22
FILE NO. 00404
PN. 8811