

East Tawas State Harbor Final Report

For mooring Great Lakes cruise ships at the East Tawas State Harbor

Prepared for:
City of East Tawas, Michigan

March 22, 2010



Prepared by:

 ROWE PROFESSIONAL
SERVICES COMPANY
Job No. 09C0064

UNITED DESIGN ASSOCIATES, INC.
Cheboygan, Michigan
Job No. 2009-14

GENERAL INFORMATION

Introduction

This report presents the Cruise Ship Feasibility Study commissioned by Develop Iosco Incorporated for the City of East Tawas, Michigan.

The City of East Tawas, its Tax Increment Finance Authority (TIFA), Develop Iosco Incorporated, other local and regional business interests, and the State of Michigan have long looked at the possibility of drawing cruise ships that travel the Great Lakes to stop in East Tawas State Harbor.



Entrance to East Tawas Streetscape at the beginning of the pier system

The area provides for diverse tourist attractions ranging from unique shops, golf courses, to site-seeing excursions, within 50 miles of the harbor.

The current companies that provide for cruises on the Great Lakes do not have a port-of-call on Lake Huron. Many of the ships have a stop in Detroit or Windsor and travel to Mackinac Island or beyond without stopping.

East Tawas, Michigan would provide for an ideal location as an additional port-of-call for any number of these cruises.

Existing Infrastructure and Condition

The East Tawas State Harbor provides for an excellent sheltered location for ships to harbor. Depths in the harbor range from approximately 20-25 feet at the entrance to the harbor to 10-12 feet adjacent to the pier and docks.



Cruise ship passenger unloading area

The existing pier in the harbor is constructed of steel sheet pile walls tied together creating a 24 feet wide pier with a concrete cap constructed by the United States Army Corps of Engineers in 1966. The pier is armored with limestone riprap along both sides to help stabilize the structure and dissipate wave action. The pier is approximately 2,100 linear feet long. The inner portion of the pier (approximately 500 feet) consists of a wood pier deck on timber cribs. These cribs are filled with stone to provide for stability and ballast.

The overall condition of the pier is good. The steel sheet pile portion is in very good condition with little or no deterioration. The wood crib portion is in adequate condition. The cribs show some signs of dry rot at the water surface. The wood plank surface is warping in some places with the edges of the boards turning up, causing a potential tripping hazard along its length.



Entrance to the Federal Pier mooring area and beginning of the timber plank

In 2003, improvements were made to the shoreline and the park area to help facilitate the public use of the marina and harbor. These improvements included a new entrance from Bay Street (US-23), a revised parking lot layout to provide additional parking, a new boat ramp and new bath house facilities. **Figure 1** depicts the existing conditions in and around the East Tawas State Harbor.

The pier and harbor is currently used by a variety of pleasure craft, commercial fishing operations, and for recreational fishing along the piers and docks. It is not anticipated that the mooring of cruise ships will impact these activities to a great extent. Locations of the mooring site and the duration that the ships will be moored will be limited.

The Michigan Department of Natural Resources (MDNR) has provided a conceptual plan to upgrade the existing marina and mooring facilities within the harbor for pleasure craft. This study is currently being reviewed for potential funding at the state level.

This feasibility study has taken into consideration these conceptual ideas so future mooring for cruise ships will enhance the MDNR's proposed improvements.

The proposed, conceptual, MDNR improvements to the harbor are depicted in **Figure 2**.

From discussions with the Supervisor, the MDNR, and the Department of Management and Budget (MDMB) the proposed improvements may include the following.

- Replacement of all the floating docks
- Removal of the fixed dock
- Relocation of the fueling station
- Steel sheet piling retaining wall along the shoreline
- Dredging of harbor inside existing pier
- Improved electrical and other utilities along the pier

Coordination with the proposed MDNR and MDMB improvements is an important part of this study because it shows the overall master plan for the harbor and adjoining area. The two projects need to complement each other.

ALTERNATIVE INVESTIGATION

Three alternatives were investigated as part of this study. There are as follows:

- **Alternative 1** – Moor cruise ships at outer pier head.
- **Alternative 2** – Moor cruise ships at fixed pier (current fueling station location).
- **Alternative 3** – Moor cruise ships adjacent to shore line (near pavilion/bathroom location).

Figure 3 depicts these three alternatives on the existing East Tawas State Harbor map.

The proposed mooring system (**Figure 3 and Appendix A**) shall consist of a series of steel H-piles (clusters). The existing pier will be protected with timber bumpers. The number of these clusters depends on the size of vessel mooring at the pier. The larger ships (Clelia II, Pearl Seas, Pearl Mist), which range in length from 290 to 335 feet would require three of these clusters (these ships are no longer in service). The smaller ships (Grande Caribe, Grand Mariner, Niagara Prince), which reach up to 183 feet in length would require two of these clusters.

Based on initial investigation, the cruise ships do not require any special facilities other than moorings at ports-of-call. Many of the existing ports-of-call harbors do not provide utility support such as electrical, Wi-Fi, or sewage disposal. It is understood that the cruise ships are self-dependent and do not rely on the harbors for these services. This has been confirmed in initial preliminary discussions with cruise corporations.

The alternatives analyzed as part of this study center around where on the existing infrastructure they can moor with the minimal amount of impact to the pier, to the harbor (dredging), and the current use (boating, fishing, etc.)

Existing Water Depths (Dredging)

There are two types of ships utilized by the cruise lines that travel the Great Lakes, see **Appendix B**.

The largest of the ships (no longer in service) carries up to 300 passengers and has an operating draft (depth below water surface) of approximately 12 feet.

The more common ships carry up to 100 passengers and have an operating draft of approximately 6.5 feet.

Information on existing water depths was gathered from the United States Army Corps of Engineers – Detroit District (USACE-Detroit) and navigational charts for the East Tawas State Harbor. Water depth adjacent to the outer pier, range from 10 feet to 12 feet. Water depth adjacent to the fixed pier (fueling station), range from 8 feet to 10 feet. Water depth adjacent to the shoreline, range in depth from 0 feet to 6 feet. Water depth gradually increases beyond 18 feet as you move 1000 to 2500 feet out into the harbor.

Therefore, except for adjacent to the shoreline, dredging should not be required to navigate and moor the smaller cruise ships within the East Tawas State Harbor.

Alternative I: Small Cruise Ships Mooring at Outer Pier Head

Alternative I consists of mooring small cruise ships at the outer pier head. The mooring location could be along the outside or inside of the pier.

Either outside or inside of the pier the small cruise ships, operating on the Great Lakes, the following improvements would be required.

- Construction of a mooring system, which includes two pile clusters and bumpers.
- No improvements to the outer pier head would be required.
- No dredging adjacent to and around the proposed mooring locations would be required.

Table I provides the estimated costs for mooring the small cruise ships at the outer pier head (either inside or outside).

Table I Mooring at Outer Pier Head

| Description | Quantity | Unit | Unit Price | Amount |
|---|----------|------|-------------|---------------------|
| Mooring Piling | 550 | LFT | \$125.00 | \$68,750.00 |
| Fenders | 1 | LS | \$20,000.00 | \$20,000.00 |
| Material Disposal | 5,000 | CYD | \$5.00 | \$25,000.00 |
| SUBTOTAL | | | | \$113,750.00 |
| CONSTRUCTION CONTINGENCY (15%) | | | | \$17,062.50 |
| SURVEYING, DESIGN, & CONSTRUCTION ENGINEERING (10%) | | | | \$11,375.00 |
| TOTAL | | | | \$142,187.50 |

- Mooring the small cruise ships inside the outer pier head would impact the current pleasure craft operations more than mooring outside the outer pier head.
- Mooring the small cruise ships inside the outer pier head would provide protection from wind and waves to the ships more than mooring outside the outer pier head.
- Neither location would adversely impact the existing outer pier head structure.

Alternative II: Small Cruise Ships Mooring at Fixed Pier (current fueling station location)

Alternative II consists of mooring small cruise ships along the fixed pier. The mooring location could be along the outside of the pier.

Mooring the small cruise ships, operating on the Great Lakes, along the fixed pier would require the following improvements.

- Construction of a mooring system, which includes two pile clusters and bumpers.
- Structural and pedestrian walking surface improvements to the fix pier would be required.
- Relocation of the current fueling station would be required (part of the conceptual MDNR harbor improvement plan).
- Minimal dredging adjacent to and around the proposed mooring locations would be required.

Table II provides the estimated costs for mooring the small cruise ships at the fixed pier.

Table II Mooring at Fixed Pier (Fueling Station)

| Description | Quantity | Unit | Unit Price | Amount |
|---|----------|------|--------------|---------------------|
| Mooring Piling | 550 | LFT | \$125.00 | \$68,750.00 |
| Fenders | 1 | LS | \$20,000.00 | \$20,000.00 |
| Fixed Pier Structural Improvements | 1 | LS | \$100,000.00 | \$100,000.00 |
| Fueling Station Relocation | 1 | LS | \$200,000.00 | \$200,000.00 |
| Material Disposal | 5,000 | CYD | \$5.00 | \$25,000.00 |
| SUBTOTAL | | | | \$413,750.00 |
| CONSTRUCTION CONTINGENCY (15%) | | | | \$62,062.50 |
| SURVEYING, DESIGN, & CONSTRUCTION ENGINEERING (10%) | | | | \$41,375.00 |
| TOTAL | | | | \$517,187.50 |

- Mooring the small cruise ships outside the fixed pier head would significantly impact the current pleasure craft and the current fueling station operations.
- The fueling station would need to be relocated prior to the proposed MDNR East Tawas State Harbor improvements.
- Structure improvements would be required to replace dry rot members on the pier and the pier surface would need to be removed and replaced to improve walking surface.

Alternative III: Small Cruise Ships Mooring at Shoreline (near pavilion/bathrooms)

Alternative III consists of mooring the small cruise ships, operating on the Great Lakes, along the shoreline would require the following improvements.

- Construction of steel sheet pile retaining wall along shoreline.
- Construction of a mooring system, which includes two pile clusters and bumpers.
- Considerable dredging of the inner harbor to a depth of approximately 8 feet to 10 feet.
- Construction of shoreline pedestrian access from shoreline to existing facilities.

Table III illustrates the estimated costs for mooring the smaller ships along the shoreline.

Table III Shoreline Mooring

| Description | Quantity | Unit | Unit Price | Amount |
|---|----------|------|--------------|-----------------------|
| Mooring Piling | 550 | LFT | \$125.00 | \$68,750.00 |
| Fenders | 1 | LS | \$20,000.00 | \$20,000.00 |
| Shoreline Steel Sheet Pile | 8,000 | SFT | \$60.00 | \$480,000.00 |
| Dredging Operations | 1 | LS | \$250,000.00 | \$250,000.00 |
| Material Disposal | 50,000 | CYD | \$1.50 | \$75,000.00 |
| SUBTOTAL | | | | \$893,750.00 |
| CONSTRUCTION CONTINGENCY (15%) | | | | \$134,062.50 |
| SURVEYING, DESIGN, & CONSTRUCTION ENGINEERING (10%) | | | | \$89,375.00 |
| TOTAL | | | | \$1,117,187.50 |

- Mooring the small cruise ships along the shoreline would significantly impact the current pleasure craft and shoreline.
- Significant construction would be required along the shoreline to allow for the cruise ships to moor.
- Significant dredging would be required in the inner harbor to allow for ship maneuverability.

Improvements to Existing Piers

As was stated previously in this report, the wood plank surface area is deteriorating and should be replaced. The estimated cost of this improvement is approximately **\$275,000**.

Recommended Alternative (Potential Phasing)

Based on the alternative investigation completed above, the following recommendation is being made based on a cost/benefit evaluation and the overall master planning for East Tawas State Harbor.

It is recommended that the smaller sized cruise ships moor along the outside of the outer pier head. The moorings should be placed as near the bend in the pier as possible so that additional pile clusters can be added toward the pier head in the future for larger ships (if they resume operations).

This alternative will require the least amount of funds to construct the facilities, have minimal impact to current harbor operations (pleasure craft, fishing, etc.), and will not impede any future development within the harbor. The following phases can be added as funds become available.

- If and when harbor and marina improvements are made, mooring facilities for the smaller ships could be added to the shoreline sheet pile wall.
- If and when funds became available, the pier head area and harbor could be dredged to accommodate large ships. One additional pile cluster and bumpers can be added out to pier head along the inside.

Construction and Permitting

The alternatives utilize standard marine construction activities. Contractors providing these types of services are readily available in the Great Lakes region. Permits and coordination will be required with the United States Army Corps of Engineers – Detroit District, MDNR, MDNRE, State Historic Preservation Office (SHPO), and local officials.

There have been numerous environmental investigations on the potential dredged material located in East Tawas State Harbor. These reports identify the potential contamination and the remediation requirements in disposing of this material during a dredging project. These issues have been incorporated into the preliminary cost estimates for each alternative. If sampling at the time of construction shows that there is no contamination, sediment could be used as beach nourishment if agreed upon by the local communities. The cost estimates assume that sediment is not contaminated. More specific testing will be required prior to issuing construction permits for these types of projects.

There is no requirement for providing for customs facilities for this type of cruise ship port-of-call.

Permitting guidelines and application forms are provided for in **Appendix C**.

Funding

The uniqueness of this proposed project lends itself to any number of funding sources. These range from traditional enhancement and economic development funding sources to special legislation funding, American Reinvestment and Recovery Act (ARRA) funding to private investment (cruise ships, etc.) **Appendix D** provides a list of potential sources.

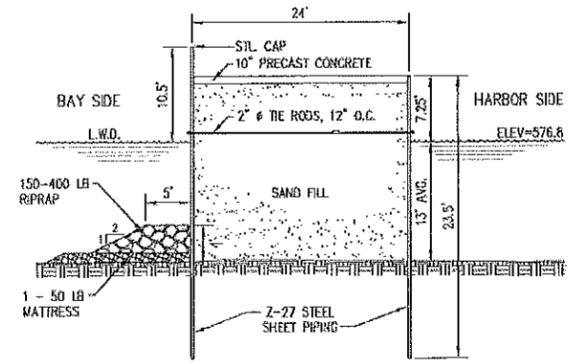
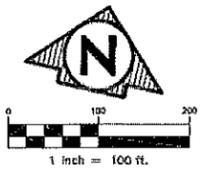
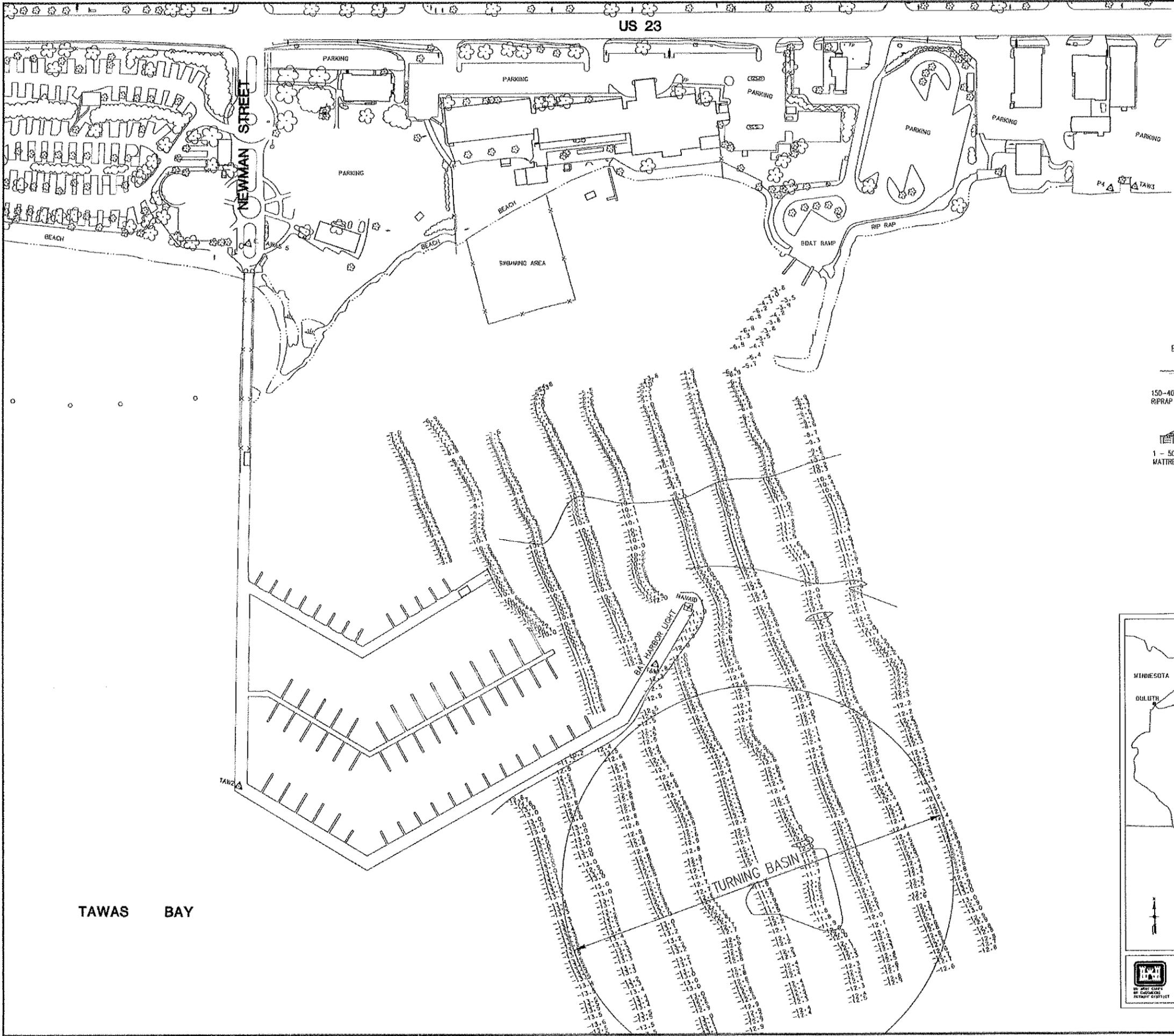
The approach to funding this type of project will be to meet and present this project to as many representatives of these sources as possible. A key will be the fact that a comprehensive study and approach has been developed by East Tawas (Develop losco Inc., TIFA) in pursuing this project.

The Next Steps

In summary, it is feasible for cruise ships to dock in the East Tawas State Harbor, with minimal expenditure from the local agencies. Several issues still need to be resolved before this becomes a reality. The following steps need to be accomplished before construction can be started on mooring facilities within the East Tawas State Harbor.

1. Discussions need to be initiated and completed with a cruise ship line that is interested and willing to make East Tawas a port-of-call.
2. Funding sources and amounts need to be identified so that the project can be completed.
3. With an interested cruise ship and funding identified, final coordination with the stakeholders needs to be completed (MDNR, MDNRE, USACE, SHPO, etc.).
4. Final design, construction documents, permitting needs to be completed.
5. Project advertising, bidding, and construction contract awarded.
6. Construction project completed.

These steps are very generally laid out at this time. Once more detail from each step is identified, more steps maybe added for a successful completion of the project.



**TYPICAL SECTION
DOUBLE WALL BREAKWATER**

SCALE: 1" = 10'



LOCATION MAP

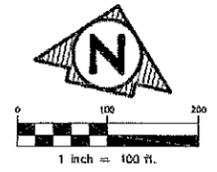
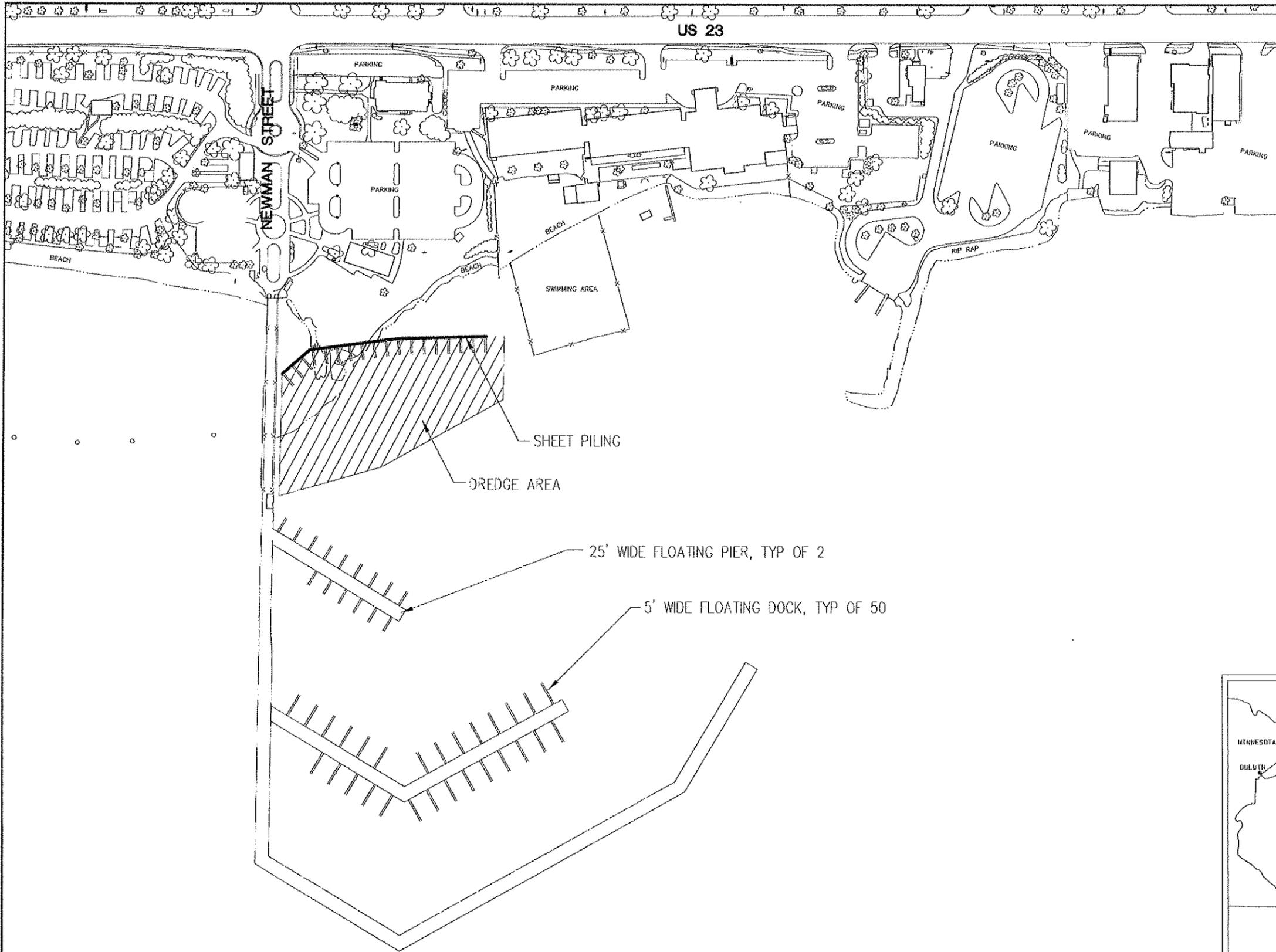
PLAN DATE: JUNE, 2009
 PROJECT MGR: R.A.F.
 REVIEWER: D.A.S.
 SCALE: 1" = 100'

**ROWE PROFESSIONAL
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CITY OF EAST TAWAS
CRUISE SHIP FEASIBILITY
 TAWAS BAY HARBOR
 EXISTING CONDITIONS

FIGURE 1
 REV:
 SHT# OF
 JOB No: 09C0064

DATE: 3/29/2010 9:06 AM
 RE: Tawas Bay Harbor Feasibility Study - Existing Conditions



TAWAS BAY



LOCATION MAP

PLAN DATE: JUNE, 2009
 PROJECT MGR: R.A.F.
 REVIEWER: D.A.S.
 SCALE: 1" = 100'

ROWE PROFESSIONAL SERVICES COMPANY



The ROWE Building
 540 S. Saginaw St., Ste. 200, P. O. Box 3748
 Flint, MI 48902

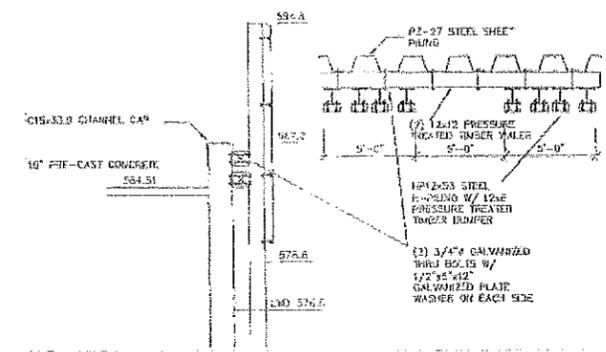
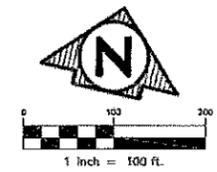
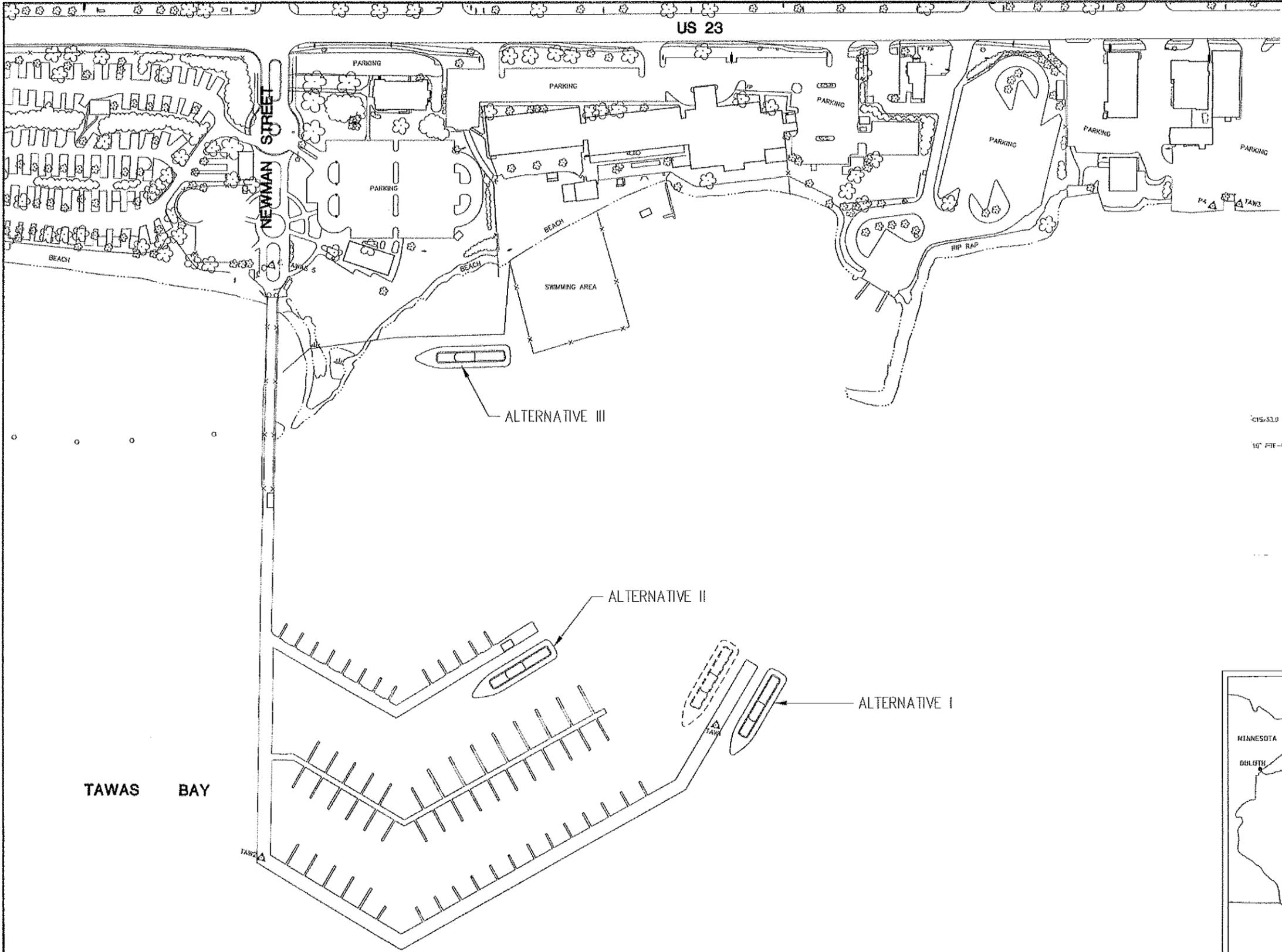
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CITY OF EAST TAWAS
CRUISE SHIP FEASIBILITY
 TAWAS BAY HARBOR
 DNR PROPOSED LAYOUT

FIGURE 2

REV: _____
 SHT# _____ OF _____
 JOB No: 09C0064

PLotted 2/6/2010 8:53 AM



MOORING DETAIL
SCALE: 1" = 5'



LOCATION MAP

PLAN DATE: JUNE, 2009
 PROJECT MGR: R.A.F.
 REVIEWER: D.A.S.
 SCALE: 1" = 100'

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 TAWAS BAY HARBOR
 ALTERNATIVE MOORING LOCATIONS

FIGURE 3

REV: _____
 SHT# _____ OF _____
 JOB No: 09C0064

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APPENDIX A

STRUCTURAL ANALYSIS OF MOORING SYSTEM

SYLLABUS:

As part of the preparation for the analysis of the Federal Sheet Piled Breakwater, United Design Associates (UDA) contacted Mr. Ken Drum of the construction division of the Corps of Engineers and requested the As-Builts of the Breakwater. We were advised that during their process of transcribing their construction drawing records that they were unable, at present, to locate only one sheet showing a general plan of the Bay area that had a Typical Section of the Double Wall Breakwater. This drawing does not show the interior wales and corresponding pertinent structural data.

UDA checked their company records from previous years and found that they did have partial working drawings and borings of the inner pier structures constructed in 1981. This information provided two soil borings in the immediate vicinity of the proposed cruise ship mooring area. These borings are shown on the accompanying drawings and the soil boring information gave the blow counts so that we were able to calculate reasonably well the soil strength characteristics for the mooring piles or fenders. In addition to the soil borings, there is an existing soil profile that indicates the same types of soils down to a depth elevation of 545 for a penetration depth of ± 20 feet. Although this does not have a blow count value it does indicated the feasibility for driving fender piles the required depth.

GREAT LAKES CRUISING CRAFT:

The typical Great Lakes Cruising craft that will Cruise the Great Lakes now or in the future, will probably fit the following general category:

| | CLELIA II | PEARL SEAS | PEARL MIST |
|-----------------|-----------|------------|------------|
| Gross Tonnage: | 4,077 | NA | NA |
| Overall Length: | 290 Feet | 335 Feet | 335 Feet |
| Draft: | 12 Feet | 12 Feet | 12 Feet |
| Beam: | 50 Feet | 56 Feet | 56 Feet |

EXECUTIVE SUMMARY:

The preliminary analysis of the Federal Double walled steel sheet piled breakwater is based on a single U.S. Army Corps of Engineers published drawing of Tawas Bay Harbor, Michigan. As previously stated. The Corps of Engineers As-Built Drawings were misplaced or lost and are now unavailable. United Design Associates did also have some additional information on file regarding previous design work done in 1981 in conjunction with the original piers, and soil borings that was helpful in making an analysis for structural capability for mooring Cruise ships. The available information used for this report was based on 1955 Great Lakes Low Water Datum of 576.8 as the plane of reference as shown on the Corps of Engineers drawing that was available. We have included some pictures of the pedestrian walkway that the Cruise Ship passengers would be using, and the fact that the distance for passengers to walk along the pier system during the disembarking period is approximately 2100 lineal feet. It may be important to consider some type of shuttle transportation as well during the Cruise ship stops to also provide access to the points of interest in the community. The walkway consists of 3 inch concrete plank on the Federal pier and timber planking on the remaining parts of the pier.

The present water depth, based on 1955 LWD and the available soundings is 12 feet. This depth agrees with the penetration depth of the Steel Sheet Piled Breakwater based on its present design stability. The draft depth of the Cruise ships CLELIA II, PEARL SEAS, and PEARL MIST based on their submitted data is also designated as 12 feet. However, it is important to have additional depth over and above the craft draft depth as a safety allowance. In other words the existing water depth for the aforementioned Cruise Ships that were to be using this Mooring Pier is too shallow and should have craft with depth requirements of 6 to 8 feet.

CONCLUSIONS:

United Design Associates Consulted the American Association of Port Authorities Manual for Seaports and did an inordinate amount of structural investigation of several different types of alternative mooring concepts consisting of the following:

- Various Types of Dolphin Systems
- Timber Piling with Timber Fenders
- Timber Rubbing Strips on the Sheet Piling
- Timber Piling with Rubbing Strips
- Steel Fender Piles with Timber Rub Rails (The most suitable)

Until reaching the conclusion for the proposed design as herein presented consisting of a series of HP 12x53 lb Cluster Piles with timber wales that would sustain that part of the transmitted kinetic energy of the proposed type Cruise Ships with the aforementioned recommended draft requirements. This proposed design strengthens the existing steel sheet piled breakwater without unduly stressing or damaging the sheet piled structure.

In spite of our efforts to make a successful venture on behalf of providing a mooring facility for the initially proposed Cruise Ships, we believe that the major problem is actually the water depth and the fact that we believe that there should be a greater allowance for such craft to avoid running aground and the fact that we cannot recommend dredging under the present conditions because of the required penetration depths of the steel sheet piling. You will also note on the enclosed copy of the Tawas Harbor Lake Survey Chart that the natural water depth doesn't deepen a foot for approximately 2,000 feet out further into the Bay. Cruise ships with less draft could utilize the proposed system. In reality it is their decision as to the safe depth that they want and need. We e-mailed specific requests for technical data pertaining to their specific mooring needs, and we did receive the 12 foot draft depths and marketing information for their stateroom and cruise facilities and amenities. The technical information should come from the Captains or their personnel of the Cruise Ships. As a matter of fact it would be advisable, as a practical matter, to have the interested Cruise Ship Captains review the mooring design as a potential mooring site prior to the permitting, bidding, and construction.

CONCLUSIONS CONTINUED:

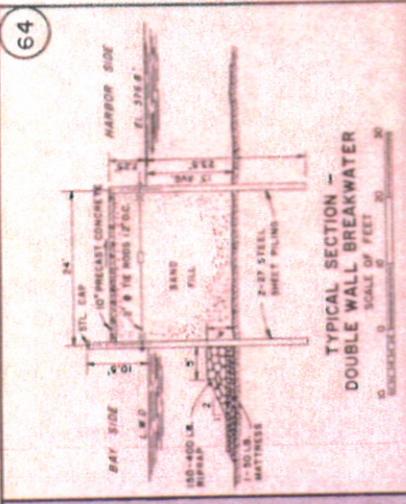
When the preliminary study has been reviewed, approved, and completed to your satisfaction with quantities made with respect to the structural modifications and requirements for the mooring facility and the Captains or Owners review and recommendations, if any, the next step is to apply for permits, prior to requests for bidding. No construction work should begin prior to filing and receiving Joint Permits from the following:

Department of Environmental Quality (MDEQ)
U.S. Army Corps of Engineers (USAC)

Copies of the Joint Permit Application are appended to this Report.

U.S. ARMY

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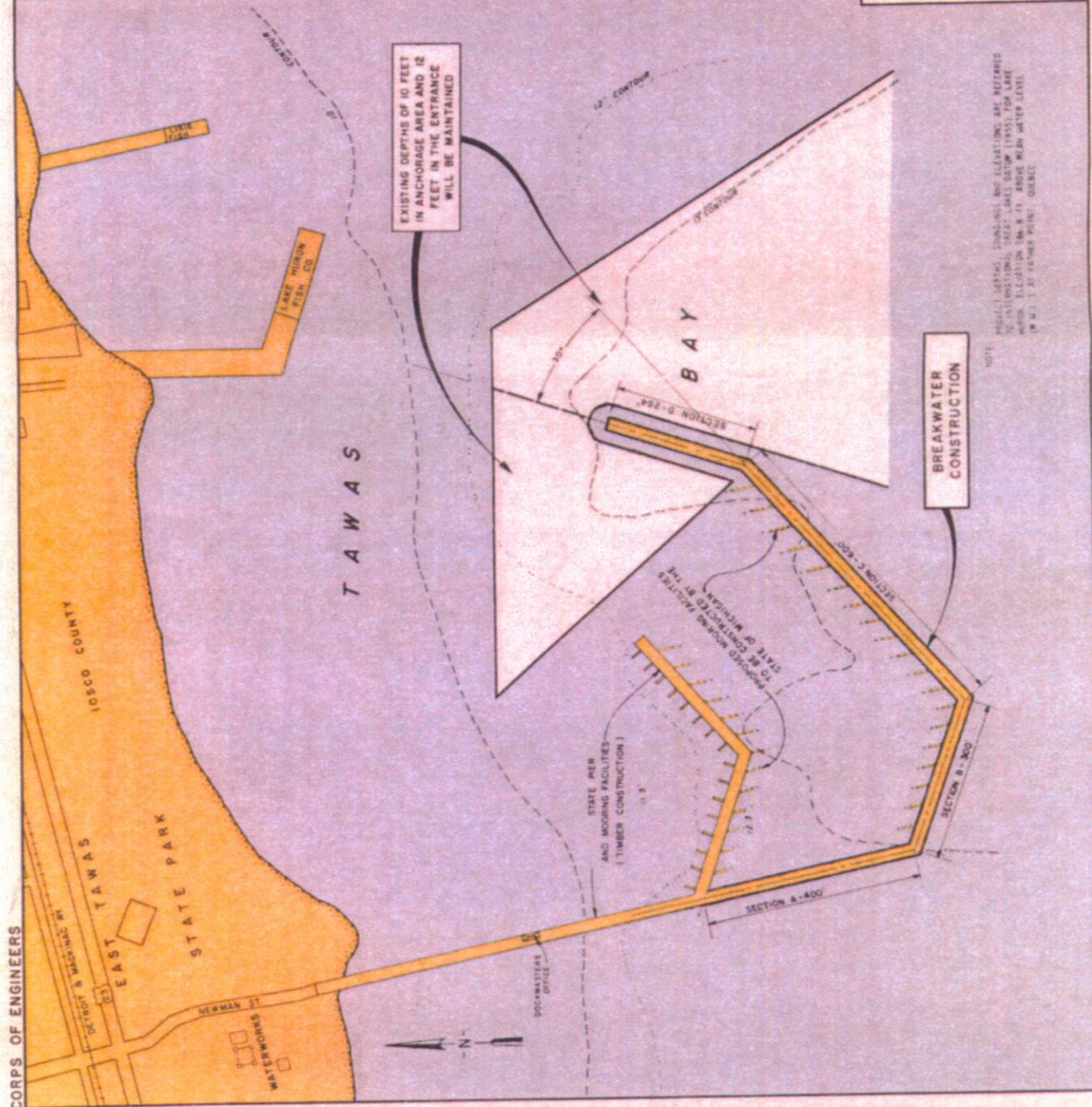
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TAWAS BAY HARBOR, MICHIGAN

U.S. ARMY ENGINEER DISTRICT, DETROIT



SEPTEMBER 30, 1986



CORPS OF ENGINEERS

10500 COUNTY

EAST TAWAS

STATE PARK

WATERWORKS

NEWMAN ST

DOCKMASTER'S OFFICE

STATE PIER AND MOORING FACILITIES (TIMBER CONSTRUCTION)

PROPOSED MOORING FACILITIES TO BE CONSTRUCTED BY THE STATE OF MICHIGAN

SECTION A-400

SECTION B-300

SECTION C-400

SECTION D-264

EXISTING DEPTHS OF 10 FEET IN ANCHORAGE AREA AND 12 FEET IN THE ENTRANCE WILL BE MAINTAINED

BREAKWATER CONSTRUCTION

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SECTION C-400

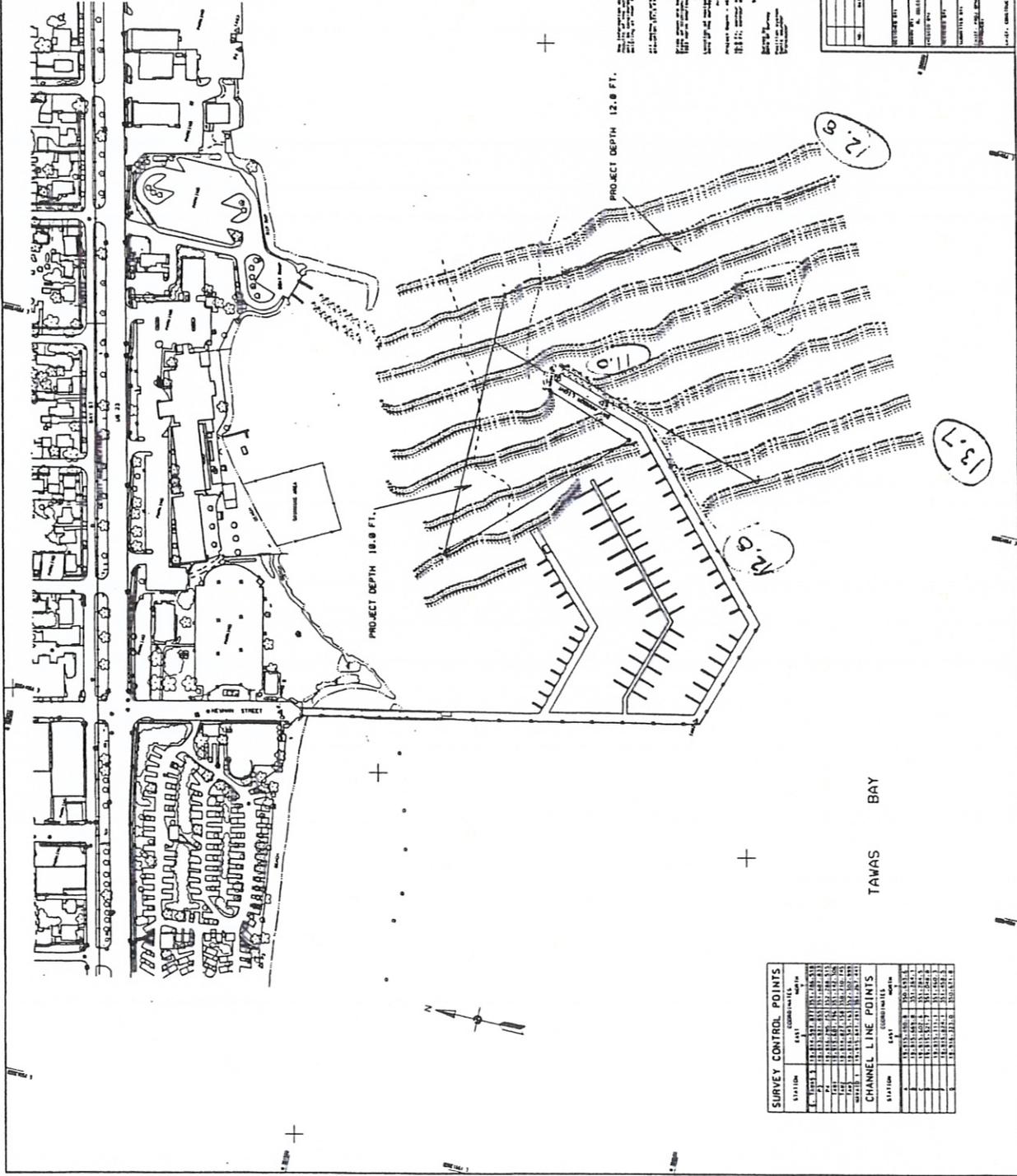
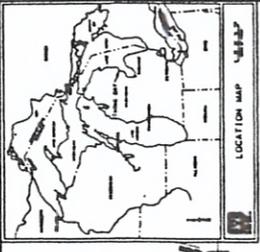
SECTION D-264

EXISTING DEPTHS OF 10 FEET IN ANCHORAGE AREA AND 12 FEET IN THE ENTRANCE WILL BE MAINTAINED

BREAKWATER CONSTRUCTION

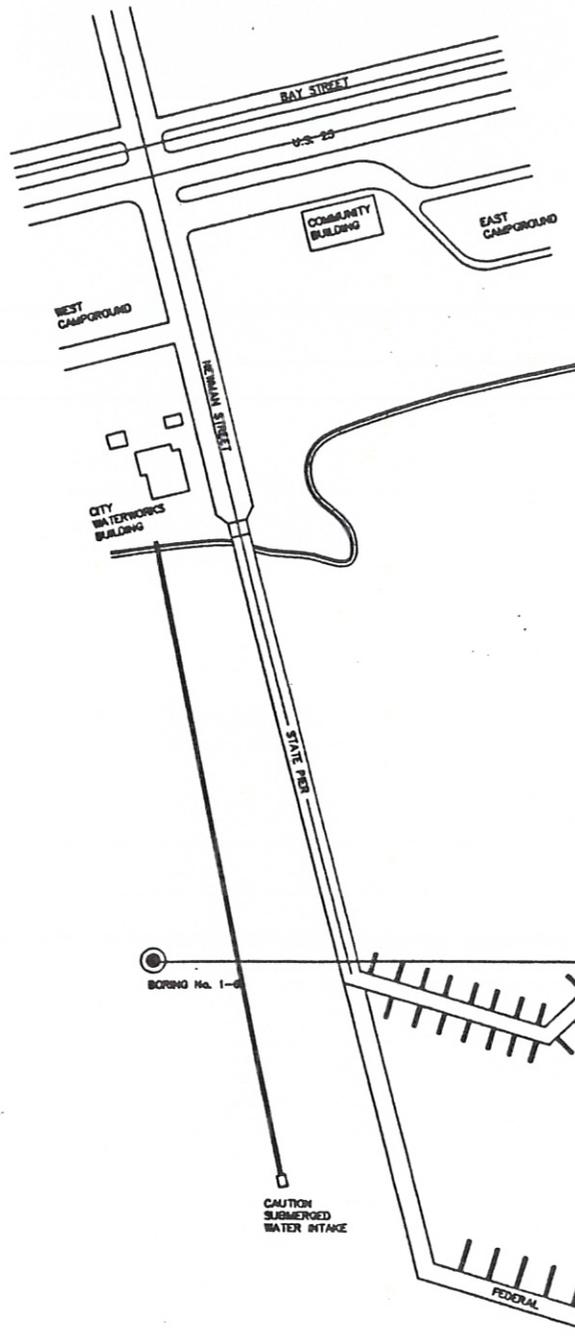
DOCKMASTER'S OFFICE

STATE PIER AND MOORING FACILITIES (TIMBER CONSTRUCTION)



| | |
|---|-------------------------|
| U.S. ARMY ENGINEER DISTRICT - DETROIT CORPS OF ENGINEERS | |
| TAWAS BAY HARBOR, MICHIGAN | |
| PROJECT NO. | CONDITION |
| PROJECT DATE | JULY 2007 |
| PROJECT OFFICE | SAGINAW FIELD OFFICE |
| PROJECT ENGINEER | PROJECT MANAGER |
| PROJECT CHECKER | PROJECT SUPERVISOR |
| PROJECT DESIGNER | PROJECT ASSISTANT |
| PROJECT DRAFTER | PROJECT OPERATOR |
| PROJECT REVISIONS | PROJECT SCALE |
| | SCALE: 1 INCH = 100 FT. |
| | DATE: 07/20/07 |
| | PROJECT NO. |
| | PROJECT NAME |
| | PROJECT LOCATION |
| | PROJECT STATUS |
| | PROJECT DRAWING NO. |

| SURVEY CONTROL POINTS | |
|-----------------------|-------------------|
| STATION | COORDINATES |
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BORING NOTES:

DEPTH ON BORING LOGS ARE BELOW LOW WATER DATUM (L.W.D.) ELEVATION 576.8

BORING LOCATIONS ARE SHOWN THUS 

ALL SOIL CLASSIFICATION MADE FROM VISUAL INSPECTION

CIRCLED FIGURES IN COLUMNS INDICATE NUMBER OF BLOWS REQUIRED TO DRIVE A 2 - INCH O.D. SAMPLING SPOON 12 - INCHES USING A 140 LB. WEIGHT FALLING 30 - INCHES.

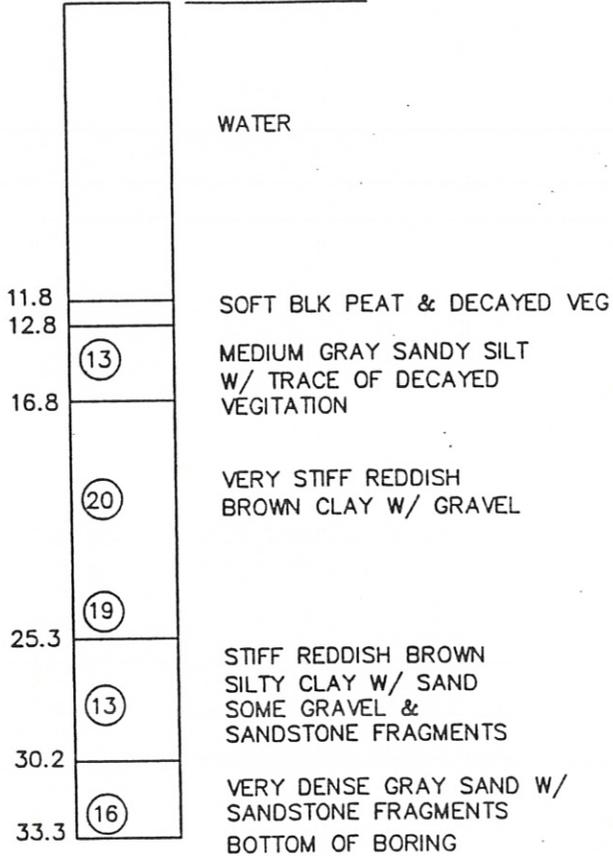
PLEASE NOTE THAT BECAUSE ALL OF THE EXISTING INFORMATION REFERS TO LWD 576.8 THE PRESENT INFORMATION IS ALSO BASED UPON THE SAME DATUM

GENERAL NOTES:

1. ALL DEPTHS AND ELEVATIONS ARE REFERRED TO LOW WATER DATUM (LWD) FOR LAKE HURON ELEVATION 576.8 ABOVE MEAN WATER LEVEL AT FATHER POINT QUEBEC (I.G.L.D. 1955)
2. THE CONTRACTOR IS STRICTLY PROHIBITED FROM OPERATING EQUIPMENT OR VEHICLES ON ANY PORTION OF THE STATE PIER OR FEDERAL BREAKWATER
3. THE CONTRACTOR SHALL CONFINE LAND STORAGE OF ALL EQUIPMENT, SUPPLIES AND MATERIAL TO THAT AREA DESIGNATED ON THE PROJECT PLAN

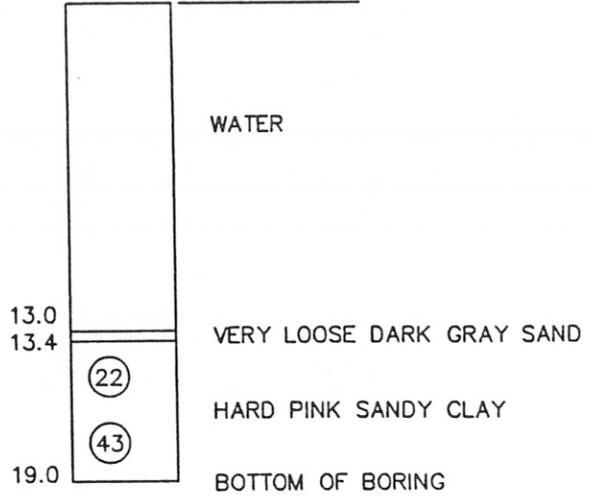
BORING No. 7

L.W.D. 576.8



BORING No. 8

L.W.D. 576.8

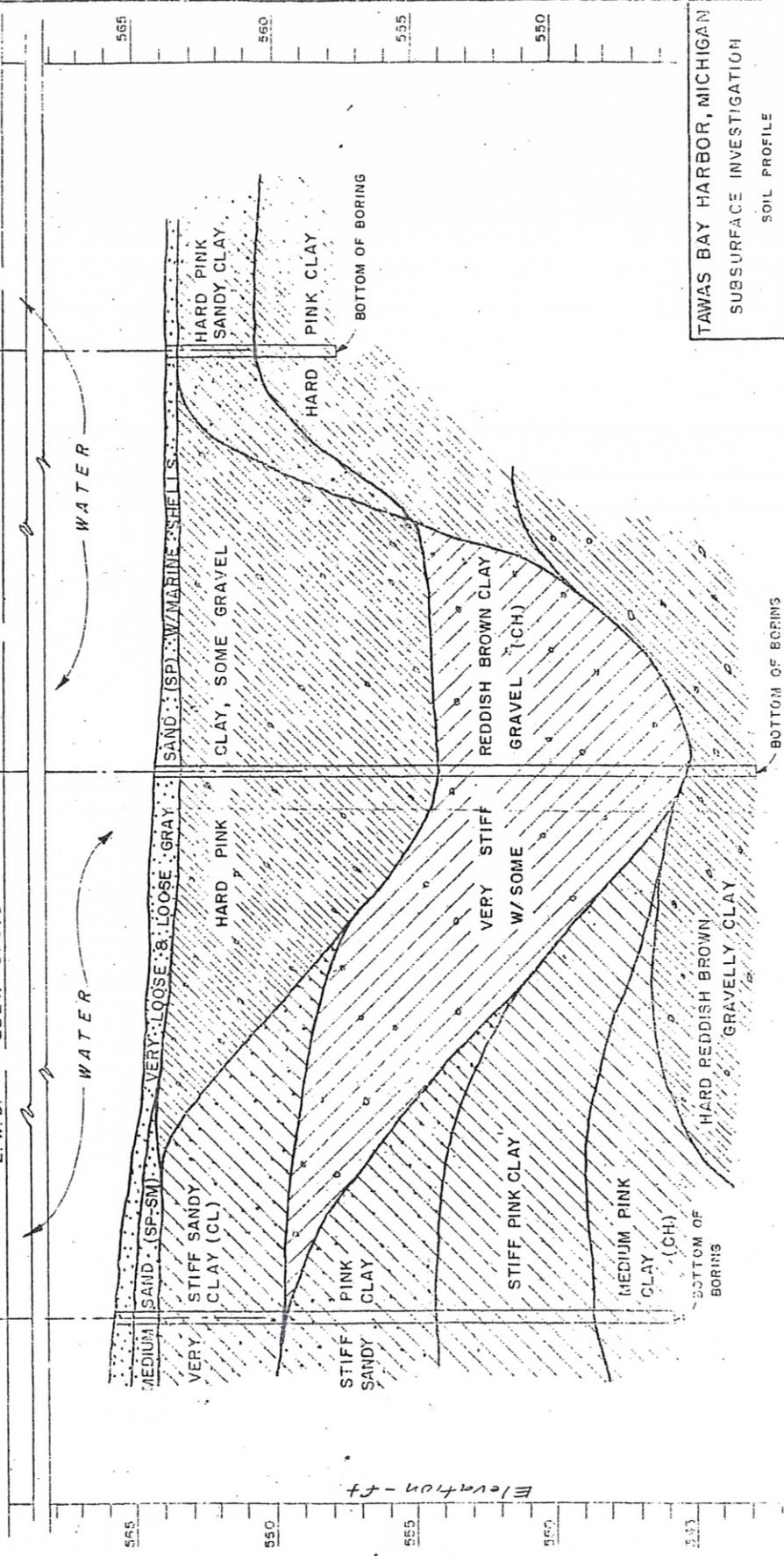


BORING NO. 1-61
C.S. 3+00 W. & 700' S. OF B/L
2 OCTOBER 1961

BORING NO. 2-53
C.S. 7+00 E. & 1000' S. OF B/L
11 JULY 1963

BORING NO. 3-61
C.S. 8+00 E. & 1300' S. OF B/L
4 OCTOBER 1961

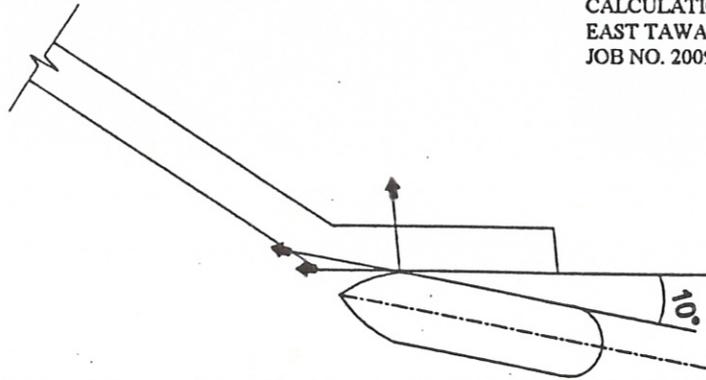
L. W. D. ELEV. 576.8'



SOIL PROFILE B-B

TAWAS BAY HARBOR, MICHIGAN
SUBSURFACE INVESTIGATION

SOIL PROFILE
SECTION B-B



IMPACT LOADING:

The rational analysis for cruise ship impact loading is to assume an impact velocity of 1.5 feet per second, (3 feet per second for recreational craft) at a 10° angle with the pier while under the control of the wheels-man during mooring operations in a protected area. The kinetic energy of impact is equal to the sine of 10° x 1.5 feet per second equal to 0.26 feet per second impact velocity perpendicular to the Fender Pile.

$$E = \frac{MV^2}{2} = \frac{WV^2}{2g}$$

E = Kinetic Energy, ft-tons using long tons (2240lbs).

W = Displaced weight of cruise ship, in long tons.

W = Weight of Impacting Cruise Ship (Tons)

E = Modulus of Elasticity of Southern Pine (12"x12" wales)

E = 1,700,000 psi

I = Moment of Inertia of 12"HP 53 lb. Steel Piles

I = 393 in⁴ S = 66.8 in³

I = 1,458 in⁴ S = 253.5 in³ (12" x12" Wale)

The above equation establishes the kinetic energy of a docking vessel; however, the dock can be expected to receive only a fraction of the total energy. The energy which the dock receives can be derived from the following equation:

$$KE \text{ Fender} = KE \text{ ship} \cdot C_m \cdot C_e \cdot C_s = \frac{MV^2}{2} = \frac{WV^2}{2g} \cdot C_m \cdot C_e \cdot C_s$$

IMPACT LOADING CONTINUED:

$$\text{Where KE Fender} = \frac{MV^2}{2} = \frac{WV^2}{2g} \cdot C_m \cdot C_e \cdot C_s$$

Additional mass of the vessel caused by the compression of the water against the side of the ship, when the ship is stopped by the fenders. The additional mass is the approximate volume of the water displaced by the ship equal to $\frac{\pi D^2}{4} (L)(P)_w$ (D = Draft) · (L = Length of ship in ft) · (P = weight of water = 62.4 lbs/cubic ft).

$$\text{Additional mass} \cong \frac{2,046,609 \text{ lbs}}{2240 \text{ lbs/ton}} \cong 914 \text{ tons}$$

$$C_m \cong \frac{4077 \text{ tons} + 914 \text{ tons}}{4077 \text{ tons}} = 1.22$$

$$C_e = \text{Eccentricity factor} = \frac{K^2}{A^2 + K^2} =$$

Where K: Radius of Rotation of the ship = 0.2 · L = 0.2 · 290 = 58

A = Distance between ship's center of gravity and the point of contact of the ship's side with the fendering system projected onto the ship's axis. A = 0.25L = 0.25(290) = 72.5

$$C_e = \frac{K^2}{A^2 + K^2} = \frac{58^2}{72.5^2 + 58^2} = 0.39$$

C_s = Softness factor : This factor is based upon the rigidity of the fender system compared with the rigidity of the shell structure of the vessel and indicates that portion of the energy to be absorbed by the fender system. An empirical value of 0.9 is normally used for C_s.

$$\text{KE Fender} = \frac{WV^2}{2g} \cdot C_m \cdot C_e \cdot C_s = \frac{4077 \times 2240 \times (0.26 \text{ ft})^2}{64.4} \times 1.22 \times .39 \times 0.9$$

$$\text{KE Fender} = 4,105 \text{ Ft-lbs}$$

The KE Fender energy must be absorbed by the pile fender system and the dock in bringing the ship to rest. The work done by the dock is F x d. Therefore, KE = Fxd. The distance through which the force moves, in feet as the elastic compression of the fender or the deflection of the fender and structure. The general assumed d for the timber compression is ± 1". Considering the Clelia II:

$$\text{KE Fender} = Fd = 4,105 \text{ Ft-lbs} = 49,260 \text{ in-lbs}$$

$$F \times d = 49,260 \text{ in-lbs}$$

$$F \times 1" = 49,260 \text{ in lbs}$$

IMPACT LOADING CONTINUED:

or $F = 49,300 \text{ lb}$

NOTE: This load is to be distributed to a series of 4 parallel cluster pile sections spaced so that the individual load per fender pile will be equivalent to 12,325 lbs to avoid overstressing the cantilevered PZ 27 sheet piling that will support the proposed two 12"x12" wales that will be compressed by the HP 12x53 pound steel Fenders. (See Drawings)

With the proposed spacing of the fender piles the maximum fender load F of 49,300 lbs will be on $\cong 1\text{-}1/2$ fenders. Then estimated compression of a (12"x12") wale, then the force on the wale with the 23.38" clearspan of the PZ 27 is 32,867 lbs.

Therefore the max. Δ deflection at mid-span of the wale::

$$\Delta = \frac{PL^3}{48EI} = \frac{32,867 \text{ lbs} (23.38\text{in})^3}{48(1,700,000)\text{psi}(1,458)\text{in}^4}$$

$$\Delta = 0.004'' \text{ negligible deflection.}$$

Calculating the bending stress of the timber wale:

$$M_{\text{max}} = \frac{PL}{4} = \frac{32,867 \text{ lb} (23.38\text{in})}{4} = 192,108 \text{ in lbs}$$

$$f = \frac{M}{S} = \frac{192,108}{254 \text{ in}^3} = 756 \text{ psi perpendicular to the grain/ 2wales}$$

$$\text{or } f = 378 \text{ psi/wale}$$

NOTE:

The recommended design is to use a series of 4 parallel cluster pile sections spaced so that the individual load per fender pile will be equivalent to 12,325 lbs to avoid overstressing the cantilevered PZ 27 sheet piling that will support the proposed two 12"x12" wales that will be compressed by the HP 12x53 pound steel fenders. As indicated on the accompanying drawings. The segments are as shown on the drawings with the central area free for positioning the passenger exit ramps.

IMPACT LOADING CONTINUED:

The 43,500 impact load is distributed over the 4 cluster piles spaced at variable intervals giving a maximum load of 10,875 lbs on the PZ 27 sheet piling with a cantilever distance of 1.4 ft.

$$M = 10,875 \text{ lbs} \times 1.4' = 15,225 \text{ ft-lbs} \times 12''/\text{ft} = 182,700 \text{ in-lbs}$$

$$S = M/f = 182,700/22,000 = 8.30 \text{ in}^3 \text{ well within the limits of the PZ27.}$$

SEE DRAWING:

ΣM About Point A = 0

$$\begin{aligned} -12,325(31') + 22.1'F_x - 17,000(5.25') + 27,000(17.25') &= 0 \\ -382,075 + 22.1'F_x - 89,250 + 465,750 &= 0 \\ 22.1' F_x - 382,075 - 89,250 + 465,750 &= 0 \\ 22.1' F_x - 471,325 + 465,750 &= 0 \\ 22.1 F_x &= 471,325 - 465,750 = 5575 \\ F_x &= 252 \text{ LBS} \end{aligned}$$

The Cantilevered Bending Moment of the PZ 27 Sheet Piling resisting the Fender wales is as Follows:

$$M = 252 \text{ Lb} \times (585.9 - 584.51) = 252 \text{ LBs} \times 1.39' = 350 \text{ Lb-Ft.} \times 12''/\text{ft} = 4200 \text{ in lbs.}$$

$S = \text{Required Section Modulus for the Sheet Piling} = M/f = 4200 \text{ inlbs}/22,000 = 0.19 \text{ in}^3$
A negligible affect on the sheet piling.

NOTE: The confined sand material within the sheet piled structure does not have an affect on the bending moments of the HP 12x53 lb fender piles, but it does affect the stability of the total structure. According to the Soil Profile submitted, the soil below the bottom of the fill has an estimated compressive value of $\cong 2,000 \text{ psf/ft}$ and an adhesion frictional surface value of $\cong 750 \text{ psf/ft}$ against withdrawal. The cohesive soil below the natural bottom is compressed between the fender piles and the sheet piling on one side and the sheet piling is stressed against the natural bottom material below the confined fill sand by the fender piles.

The cantilevered Moment of the HP 12x53 lb fender piles is as follows:

$$M_{\text{max}} = 12,325 \text{ lbs} \times (594.80 - 585.91) = 12,325 \text{ lbs} \times 8.89' \times 12''/\text{ft} = 1,314,831 \text{ in lbs}$$

$S = \text{Required Section Modulus for the HP 12x53 lb Steel Fender Piles} = M_{\text{max}}/f = 1,314,831 \text{ in lbs}/22,000 \text{ psi} = 59.76 \text{ in}^3$. The HP 12x53 lb Fender Pile has a Section Modulus of 66.8 in^3 thereby exceeding the requirements.

STABILITY:

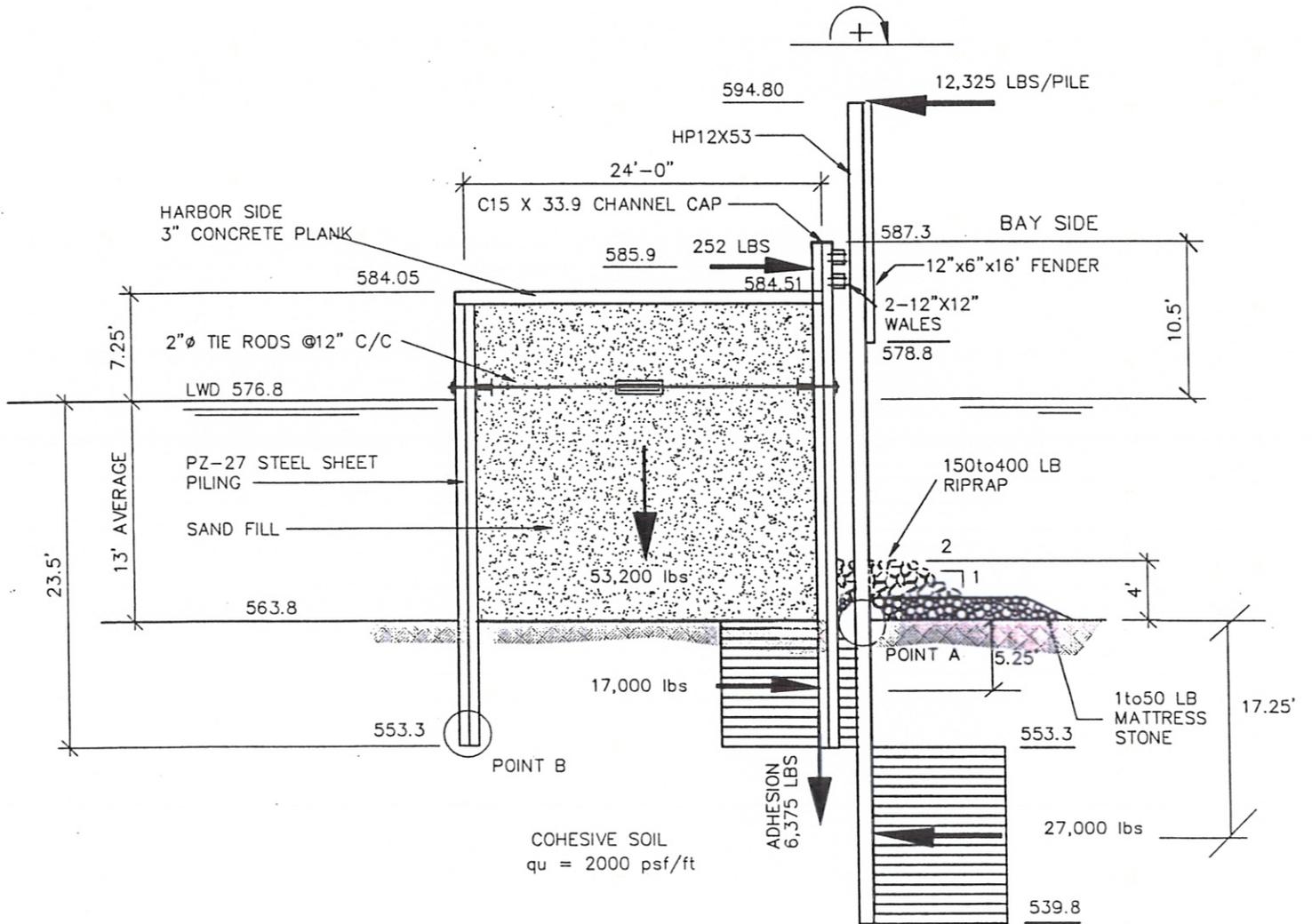
Resisting Moments About Point B:

$$252 \text{ lbs} \times 32.6' + 53,200 \text{ lbs} \times 12' + 17,000 \text{ lbs} \times 5.25' + 6,375 \text{ lbs} \times 24' + 27,000 \text{ lbs} \times 6.75' = 1,071,115 \text{ ft-lbs}$$

Overturing Moments About Point B:

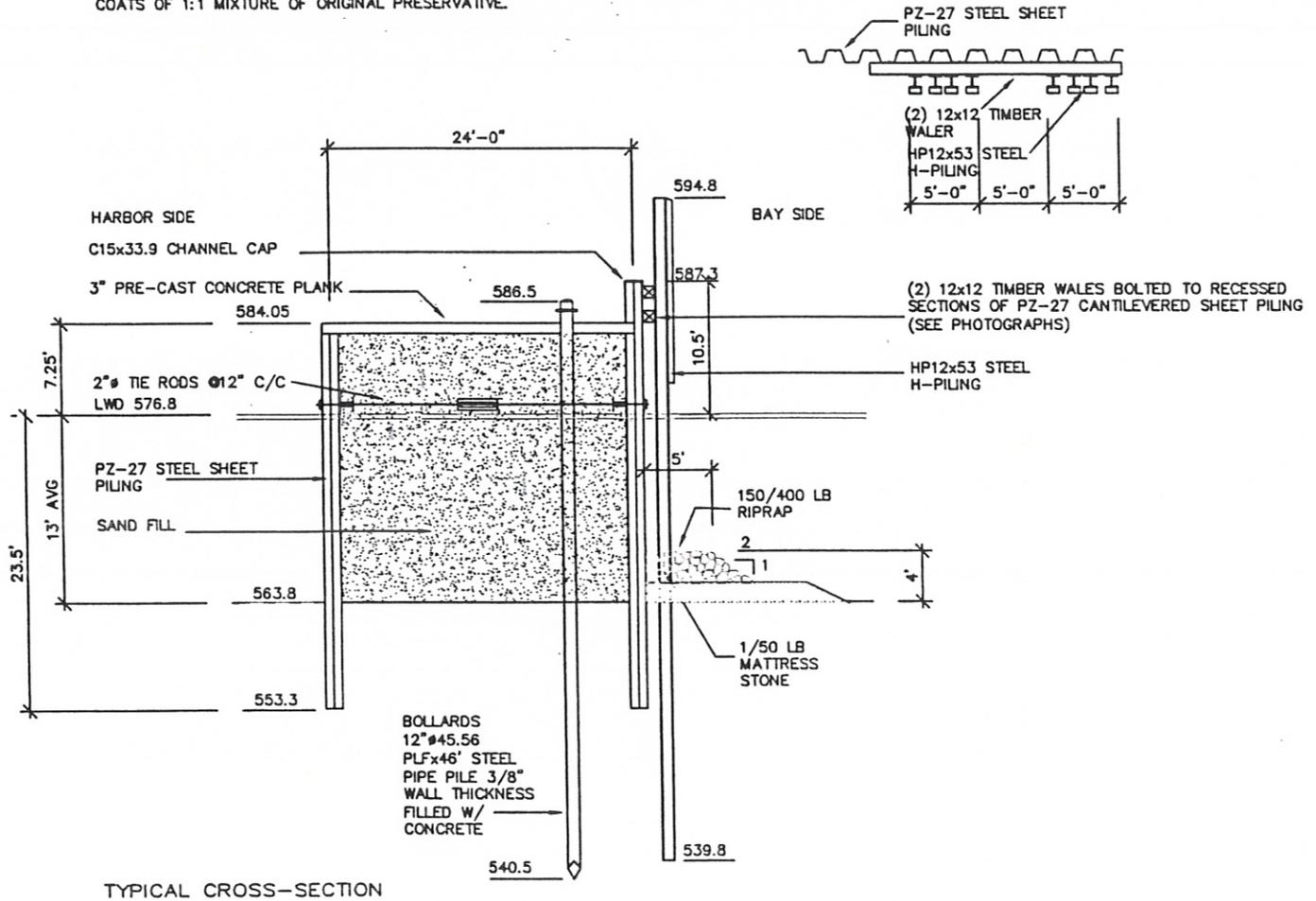
$$12,325 \text{ lbs} \times 41.5 \text{ ft} = 511,488 \text{ ft-lbs}$$

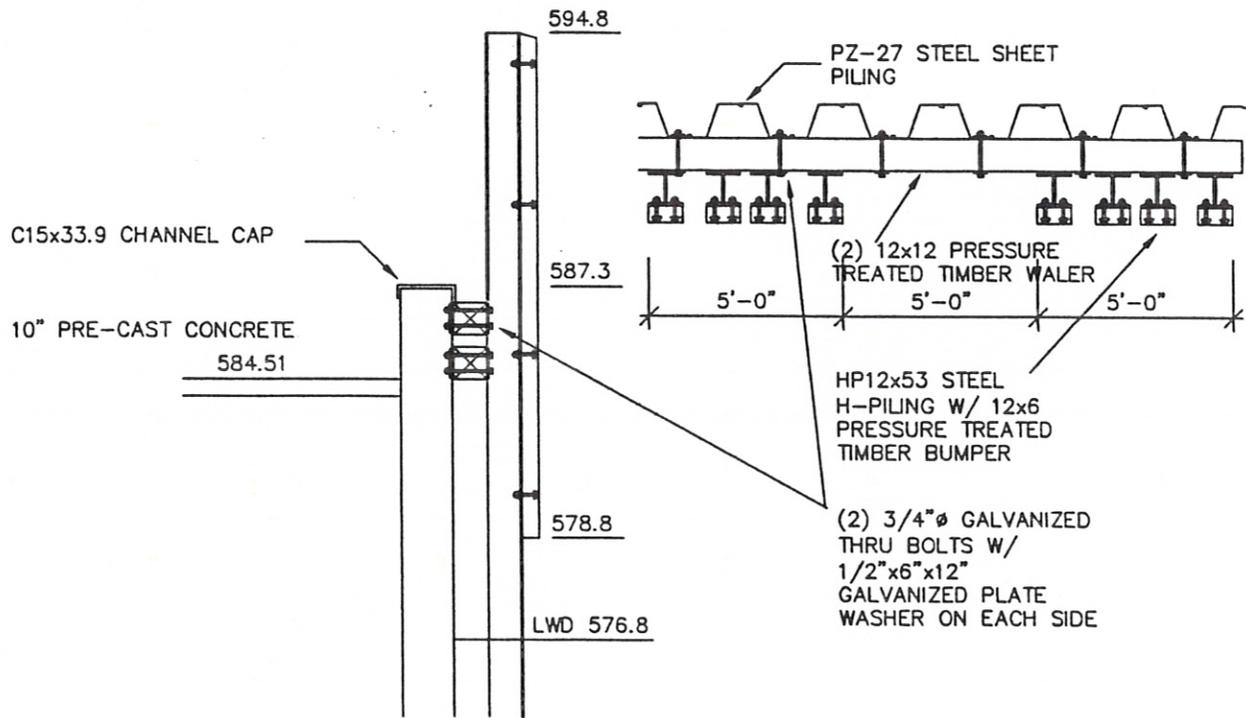
$$\text{Factor Against Overturing: } \frac{1,071,115}{511,487} = 2.09$$



TYPICAL CROSS-SECTION

ALL TIMBER WALES SHALL BE SOUTHERN PINE PRESSURE TREATED IN ACCORDANCE WITH AWPA RETENTION STANDARDS FOR NATURAL SELECT WOOD AND SHALL BEAR AWPA QUALITY MARK. THE AMERICAN WOOD PRESURE ASSOCIATION RETENTION STANDARD FOR NATURAL SELECT WOOD TREATMENT SHALL CONSIST OF PRESSURE TREATMENT WITH COPPER AZOLE CA - B FOR SOUTHERN PINE WITH 0.31 LBS PER CUBIC FOOT AVERAGE RETENTION. FIELD TREATMENT OF WALE END CUTS SHALL CONSIST OF 2 HEAVY COATS OF 1:1 MIXTURE OF ORIGINAL PRESERVATIVE.

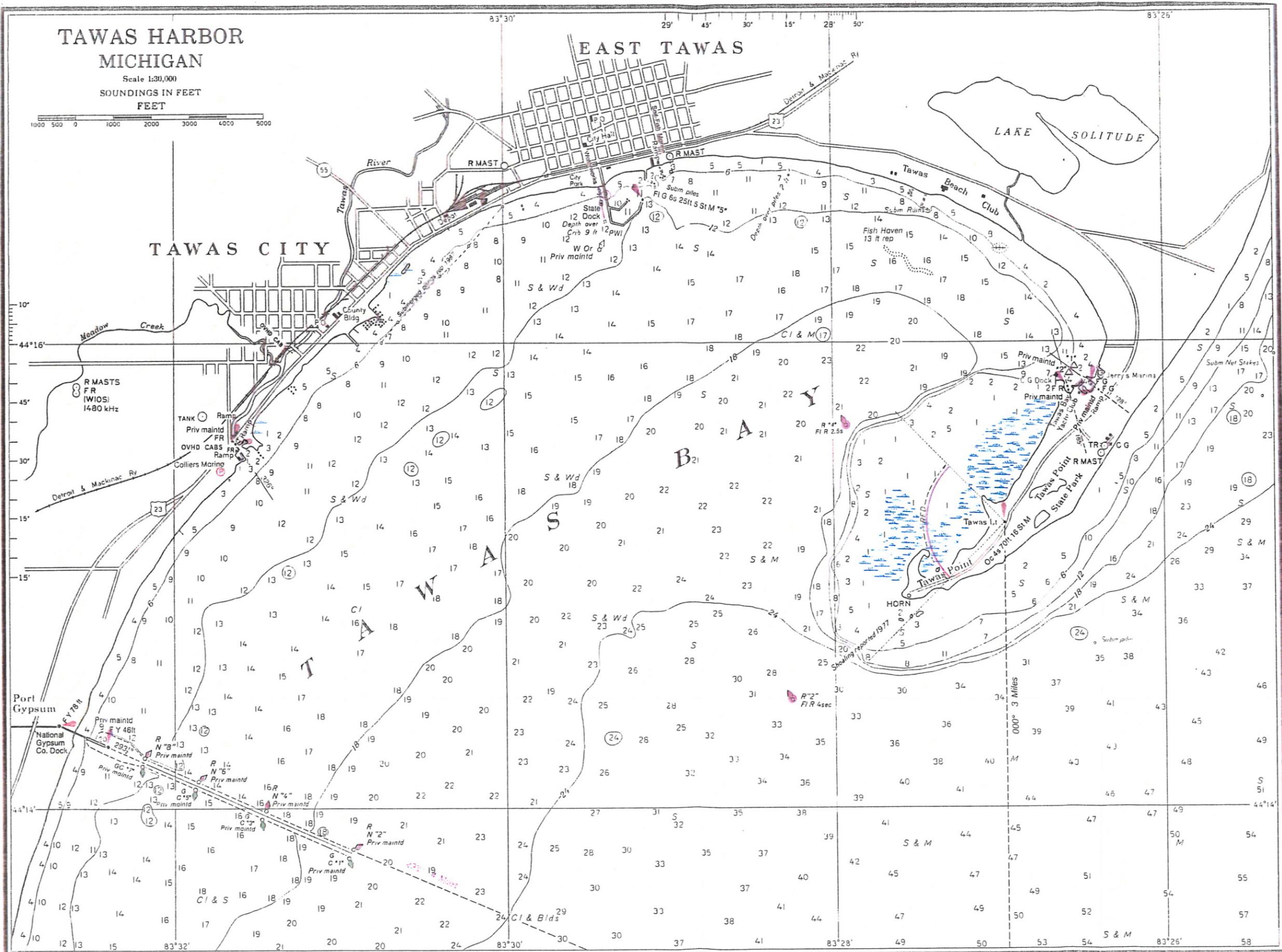
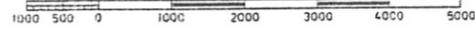




ENLARGED CROSS-SECTION

TAWAS HARBOR MICHIGAN

Scale 1:30,000
SOUNDINGS IN FEET
FEET



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REVISIONS:

PRELIMINARY
CONSTRUCTION
FINAL RECORD

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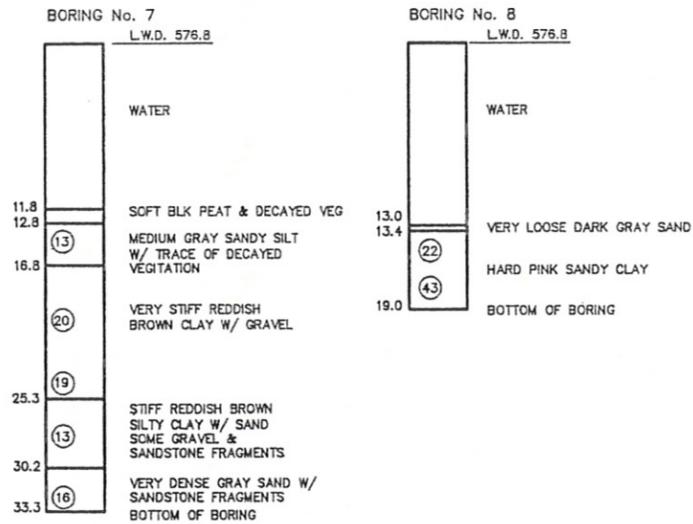
ROWE PROFESSIONAL SERVICES

111 NORTH MAIN STREET
CHEBOYGAN
MICHIGAN 49721
231-627-2299
231-627-3451
FAX 231-627-8577

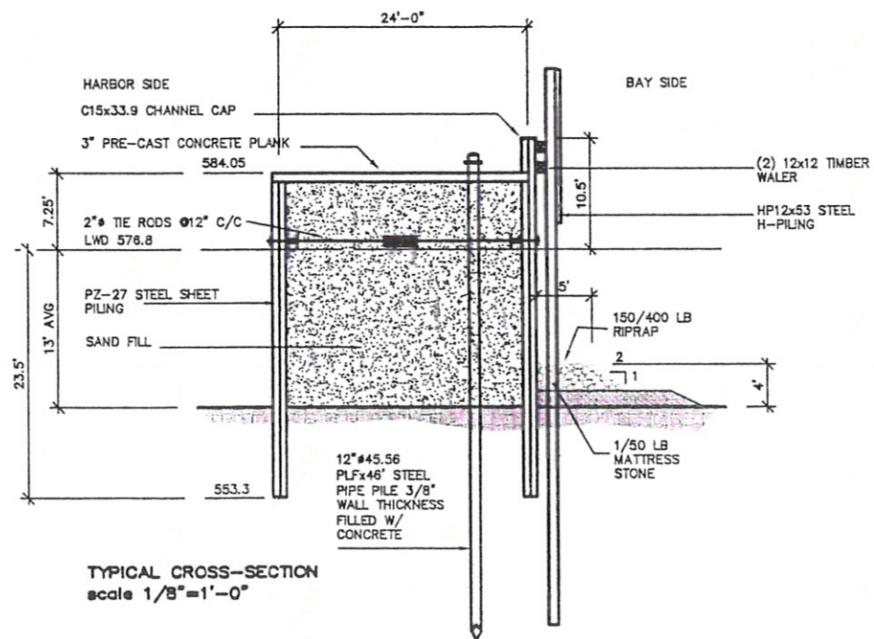
UDA
united design associates

JOB NO: 2009-14

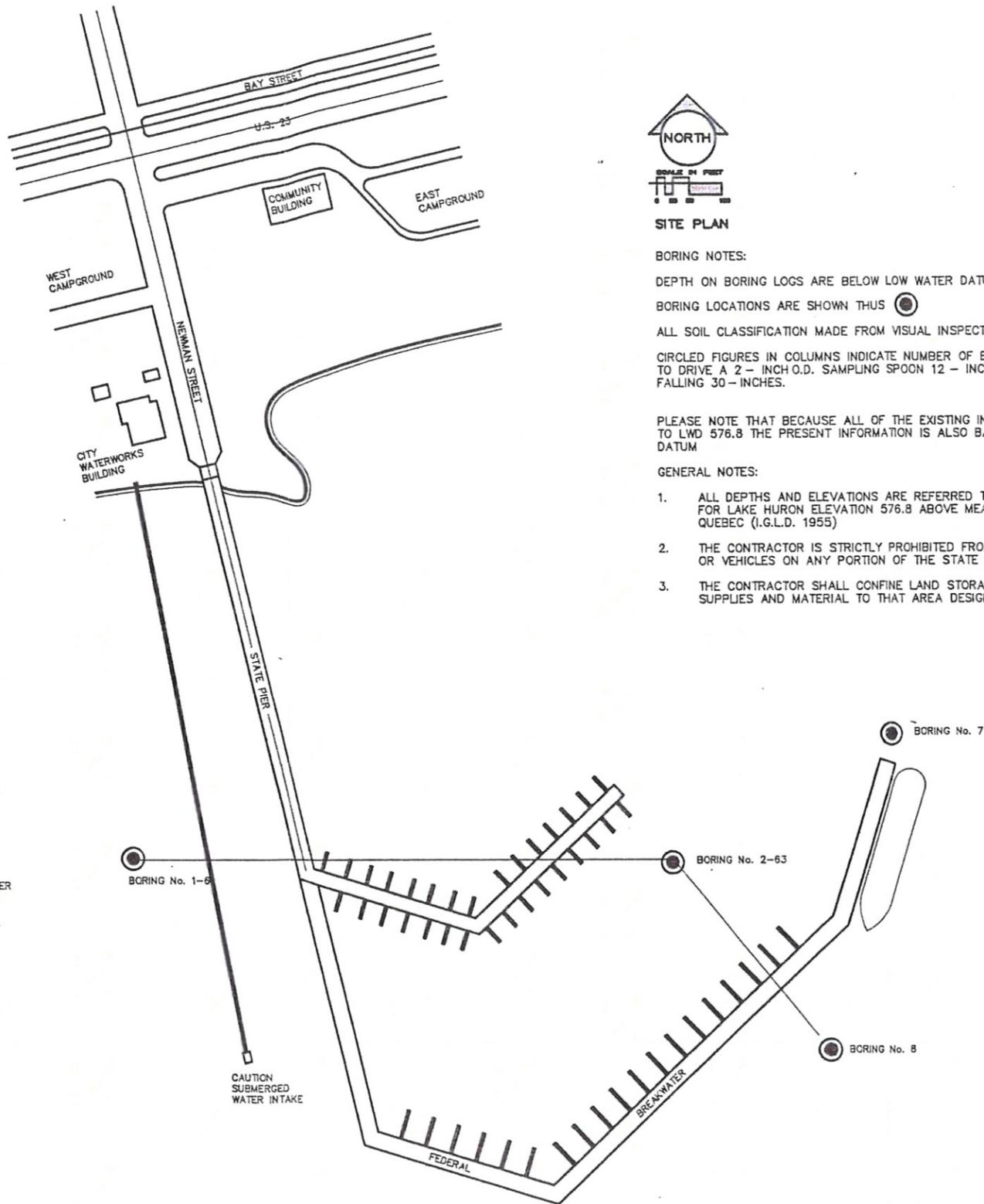
PAGE 23



ALL TIMBER WALES SHALL BE SOUTHERN PINE PRESSURE TREATED IN ACCORDANCE WITH AWPA RETENTION STANDARDS FOR NATURAL SELECT WOOD AND SHALL BEAR AWPA QUALITY MARK. THE AMERICAN WOOD PRESURE ASSOCIATION RETENTION STANDARD FOR NATURAL SELECT WOOD TREATMENT SHALL CONSIST OF PRESSURE TREATMENT WITH COPPER AZOLE CA - B FOR SOUTHERN PINE WITH 0.31 LBS PER CUBIC FOOT AVERAGE RETENTION. FIELD TREATMENT OF WALE END CUTS SHALL CONSIST OF 2 HEAVY COATS OF 1:1 MIXTURE OF ORIGINAL PRESERVATIVE.



TYPICAL CROSS-SECTION
scale 1/8" = 1'-0"



SITE PLAN

BORING NOTES:

DEPTH ON BORING LOGS ARE BELOW LOW WATER DATUM (L.W.D.) ELEVATION 576.8
BORING LOCATIONS ARE SHOWN THUS
ALL SOIL CLASSIFICATION MADE FROM VISUAL INSPECTION

CIRCLED FIGURES IN COLUMNS INDICATE NUMBER OF BLOWS REQUIRED TO DRIVE A 2 - INCH O.D. SAMPLING SPOON 12 - INCHES USING A 140 LB. WEIGHT FALLING 30 - INCHES.

PLEASE NOTE THAT BECAUSE ALL OF THE EXISTING INFORMATION REFERS TO LWD 576.8 THE PRESENT INFORMATION IS ALSO BASED UPON THE SAME DATUM

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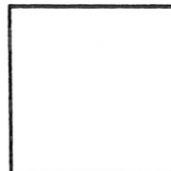
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| CONSTRUCTION | <input checked="" type="checkbox"/> |
| FINAL RECORD | <input type="checkbox"/> |

EAST TAWAS
CRUISE SHIP MOORING FACILITY

SHEET TITLE
SITE PLAN &
DETAILS

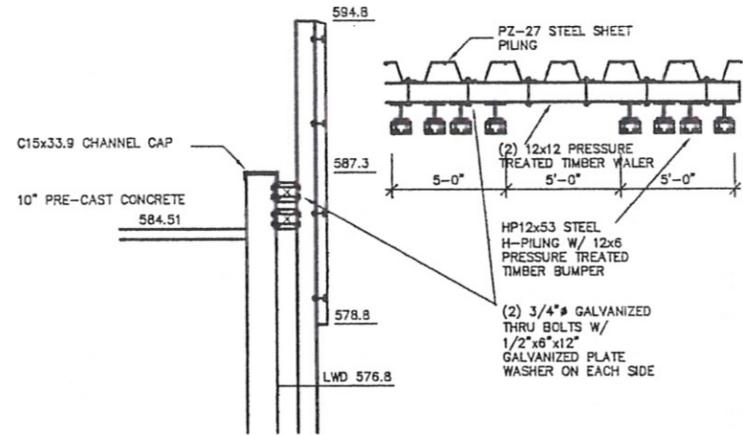
SCALE:



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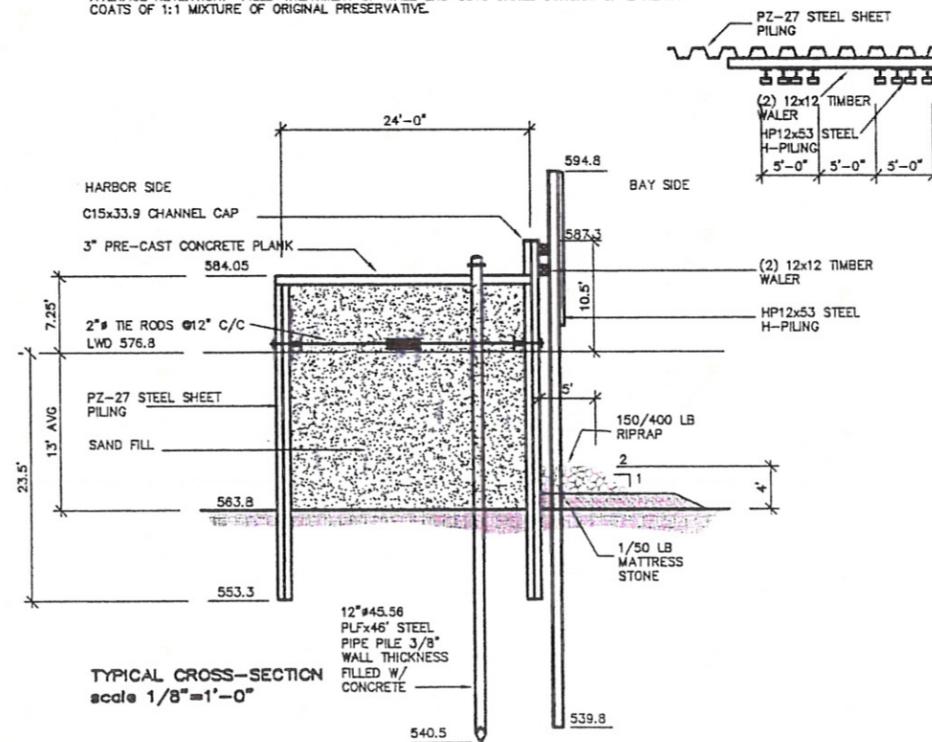
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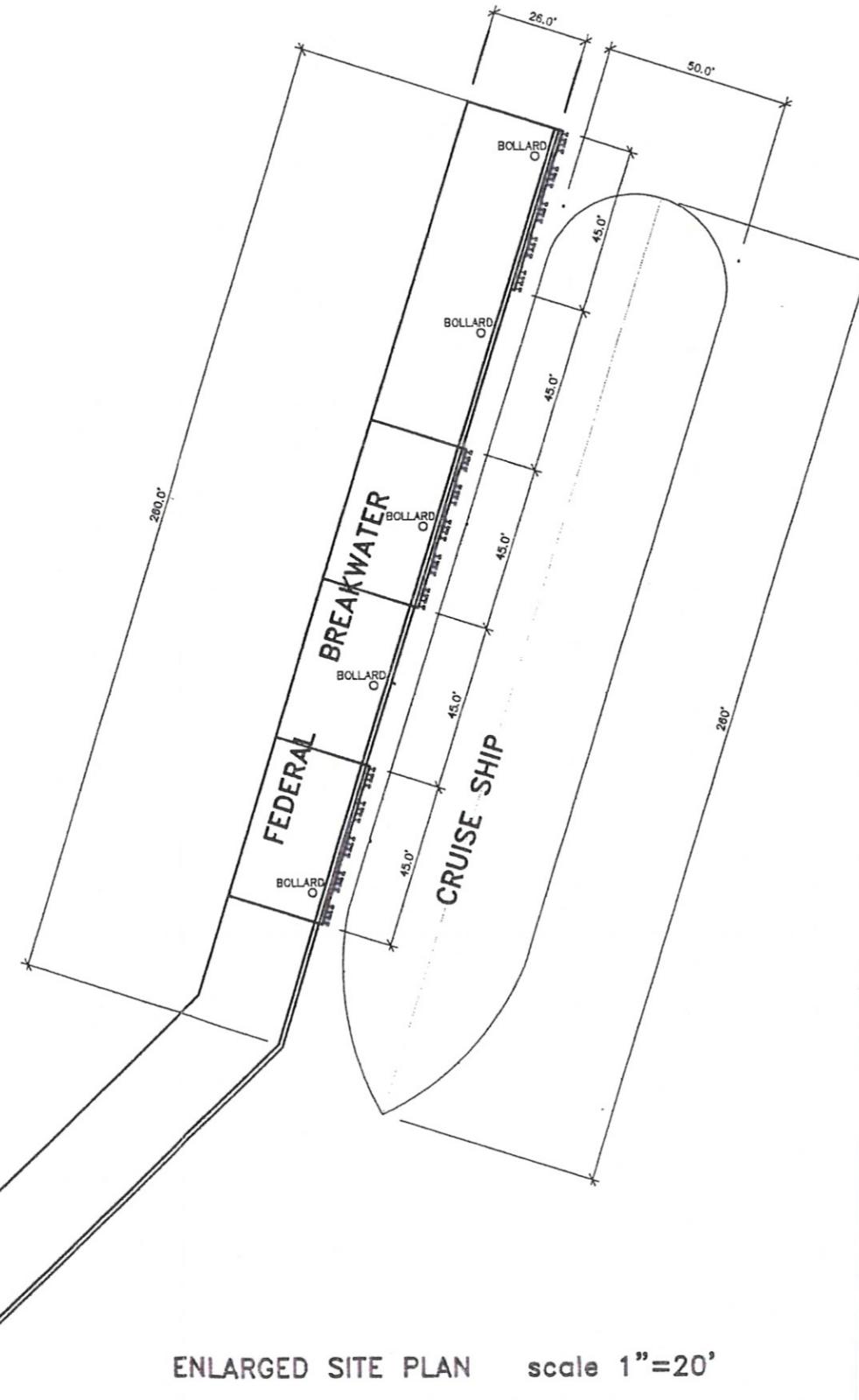


ENLARGED CROSS-SECTION
scale 1/4"=1'-0"

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TYPICAL CROSS-SECTION
scale 1/8"=1'-0"



ENLARGED SITE PLAN scale 1"=20'

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| ISSUED: | |
| REVISIONS: | |

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| CONSTRUCTION | <input checked="" type="checkbox"/> |
| FINAL RECORD | <input type="checkbox"/> |

| | |
|---|--------|
| EAST TAWAS CRUISE SHIP MOORING FACILITY | |
| SHEET TITLE: SITE PLAN & DETAILS | SCALE: |

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