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PRELIMINARY DRAFT

DEC 1986

SUTTONS BAY MARINA MASTER PLAN

GFA #860094

DECEMBER, 1986

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Recommendations & Conclusions

Based on the criteria covered in the report, it is recommended that the development be completed as shown on the exhibit with the proposed utilities as indicated. The project should be divided into phases and completed on a schedule that is acceptable to Village depending on the finances available.

The preliminary design indicates a combination of sheeting and rip-rap for shore stabilization and breakwall construction, deep-pile steel pile construction with wood decking for the main piers and finger piers, asphalt parking areas with related lighting, lighted boardwalk throughout the development and water and electric service to the mooring slips.

The proposed phasing of the project consists of the following:

Phase One:	Upgrade the old coal dock with new shore stabilization and a fishing pier.
Phase Two:	Upgrade the existing breakwall, install new breakwall to the south and install new slips along the north side of the basin.
Phase Three:	Stabilize shoreline, install slips along the south side of the main basin and install a portion of the new parking areas.
Phase Four:	Install remaining slips along the north side of the main basin.
Phase Five:	Stabilize shoreline and install new docks along the south side of the old coal dock.

The phasing that is proposed can be revised as the project continues and money becomes available because the separate phases are not dependent on one another. It is also obvious that the order of the phases could be revised if desired.

INTRODUCTION AND PURPOSE

The Village of Suttons Bay has undertaken the task of preparing a Master Plan to upgrade and expand the existing marina facilities that the Village currently has. Suttons Bay presently owns and operates a 124 slip marina, which is near the southwest end of beautiful Suttons Bay. The marina has many natural qualities and man-made structures that enhance the facility and make it an extremely desirable marina facility. Suttons Bay, which is part of Grand Traverse Bay and in turn a part of Lake Michigan, allows for a variety of water activities, which can meet the needs of water skiers, fishermen, sailors or boaters that might be local people or boaters touring the Great Lakes. The land area surrounding the marina is a fairly large public park owned by the Village on the north end, a private condominium development to the west and existing commercial establishments to the southwest. The majority of the surrounding property that is not owned by the Village is fully developed at this time. The marina is located nearly adjacent to the downtown district which has restaurant facilities, shops and many other commercial businesses that might be required to meet the boaters needs.

This study will analyze the existing marina facilities including the breakwall, water system, electrical system, parking facilities, docking facilities, restroom facilities and the need for additional mooring slips. The recommendations made will be based on the most practical and economical means of accomplishing the objectives and needs as determined by the study.

BACKGROUND

The Suttons Bay area is located on the Leelanau Peninsula in northwestern lower Michigan. The growth that the Village of Suttons Bay has experienced over the years has placed new demands on the area to extend its accommodations for all activities to meet the needs of its permanent residents and visiting vacationers. The Village has indicated that there has been unfulfilled requests for docking space in the existing marina.

Some of the existing facilities date back to around 1960 and have fulfilled their expected service life. The existing breakwall along the north end of the marina has been damaged recently due to the high water levels of the Great Lakes and is in jeopardy of being destroyed completely if something is not done. The mooring docks for the marina are temporary docks that are installed every spring and removed in the fall. The Village has expressed the intent to replace these docks with either permanent fixed docks or floating docks, and to replace and expand the breakwall revetment to add further protection to the facility.

The Village has also applied for a government grant to increase the amenities of the marina facility and install a fishing pier on the old coal dock which is at the south end of the marina.

SITE STUDY

The following will outline and describe the condition of the existing factors in the marina area.

1. Ownership: The area, as previously described, is owned by the Village of Suttons Bay and has sufficient space for both the water and land installation that are required for a modern harbor. To be fully functional, the interdependence of both parts must be recognized. The Village has expressed concern that the existing park area remain a park as much as possible. There are also deed restrictions placed on the property to the south end of the marina including the old coal dock and the marsh area.

2. Present Condition of Facilities: The present marina is providing service for approximately 124 boats with docks in the 25'-30' range. The marina is protected by a breakwall along the north side of the marina that consists of sand fill protected with wood piling, wood sheeting and wales and tie backs to provide stability. This breakwall extends approximately 600 feet off shore and is rapidly deteriorating due to the wave action with the extremely high waters of the Great Lakes. The south side of the main marina basin consists of a peninsula that has the interior of the marina to the north and a swampy marsh area to the south of this peninsula. This peninsula is not exposed to the heavy wave action of the open bay because it is protected, for the most part, by the breakwater to the north. This peninsula has experienced some erosion recently due to high water levels. The southern end of the marina consists of another

peninsula that was used in the past as a loading dock for both potatoes and coal. This peninsula is surrounded by the swampy marsh area to the north and the southern end of Suttons Bay to the south. The Village currently uses the south side of this southern peninsula for docking boats. This peninsula also has been deteriorated somewhat by high water levels and at times has been completely under water. The east end of this peninsula was protected by wood piling at one time and the lake bottom was dredged in front of the pilings to facilitate the docking of large boats. This wood piling wall is very old and quite deteriorated. The Village has requested that this wood piling wall be investigated to determine if it could be upgraded and used in the rehabilitation of the marina. There is also a mooring area provided to the south of the coal dock for patrons to anchor boats in this protected area.

The present facilities provide water and electricity to the main harbor basin. The docks on the south side of the coal dock do not have utilities provided. The water is provided through small lines with risers provided between the slips for joint usage. The electrical service is also provided along the shore with riser pedestals placed between slips for joint use. The water and electrical lines are buried quite shallow and were actually exposed by the erosion of the banks in the past. The Village has requested that these utilities be investigated to determine if they can be used for the expansion or will need to be replaced. They have also requested that the electrical system be upgraded to provide 30 amp service to the slips instead of the 20 amp that is provided now. There is no sewage service provided to the docking slips. There is gasoline available at a service dock location.

The existing water system and electrical systems were exposed earlier this spring due to the high water levels and repairs were required for many of the pedestal risers. The water system consists of small mains that are not adequate to provide the necessary flow for a good water system. Contact with Village Personnel has indicated that a number of problems have occurred with the electrical system in the past. By increasing the number of slips and upgrading the marina facility it is certain that the demand on the electrical system and the water system will increase. It is recommended that the electrical and water system be replaced and increased in size and capacity to adequately serve the needs of a modern marina.

3. <u>Water Depth and Behavior</u>: Some grade elevations of the bottom of the marina basin from 1970 have been provided by the Village. It is obvious that these soundings are not going to be exact but should be adequate for estimating the amount of dredging that will be required. The lake level, which is known to fluctuate, has a low-water datum of 576.8 (IGLD). The preliminary data indicates that dredging will be required in some areas as part of the new construction.

4. <u>Soil Borings and Analysis</u>: Since soil information is necessary prior to design, four (4) soil borings were drilled to depths of 35-40 feet in the harbor area. This information was used along with existing soils information provided by the Village. Continuous logs of borings were recorded, standard penetration tests were performed, undisturbed samples were taken and the depth to groundwater recorded as drilling progressed. The soil borings encountered sand for the majority of the drilling. The

sand ranged from very loose to medium dense through the different layers of depth. The three (3) borings on the middle peninsula and the coal dock encountered an apparent sand fill layer up to seven (7) feet thick. Below the sand fill layer a layer of peat was encountered that ranged from 1.3 to 4.3 feet. Numerous wood fragments were encountered in this strata.

In general, the soil borings indicate that the soils will be suitable to handle a piling system for docks or breakwaters. An analysis will be done to determine the approximate depth required to use a deep-pile system without ice protection or a shallow-pile system with ice protection.

The soil boring report and boring logs are included in the Appendix of this report.

5. <u>Land Services and Relationship to the Community</u>: The existing public park adjacent to the marina is of great importance for it provides additional beauty with green land space for off-the-boat attraction. The park also provides a beautiful beach area for local residents and vacationing tourists. The area surrounding the marina requires little change aside from the addition of parking areas near the west end of the middle peninsula and the marsh area. The present controlled parking is on the north side of the harbor basin. The parking for the south side of the basin and the coal dock area is uncontrolled and the patrons park wherever space is available. The marina has a boat ramp near the center of the main basin. The parking facilities do not provide adequate

parking for trailers but this will be difficult to obtain without expanding the parking area to the north into the park area. The Village has indicated that the vehicles with trailers have a tendency to park on Front Street at the exit of the marina facility. Apparently this has worked in the past and the Village is content to stay in this mode.

PRELIMINARY DESIGN

Since the boating public will be the primary benefactors of the marina development, the design was undertaken with the intention of satisfying their needs in a facility that will be conveniently located, aesthetically pleasing and economical. The major design factors which are an expression of these needs and desires are: harbor size, protection, choice of structural materials, type of structure, docking area, type of mooring, parking and availability of utilities.

WATER DEVELOPMENT

1. Harbor Size: The present marina has a water area of approximately seven (7) acres in the main basin. The area to the south of the coal dock is actually very large but only the small area adjacent to the south shore of the coal dock is used for docks. The mooring area south of the coal dock will be discussed further in this report. The Village has estimated that approximately 150 slips would be desirable for the present time. The existing main basin and area south of the coal dock will provide the area required to handle 146 slips with some excavation and dredging along the south side of the marina basin. The proposed layout is shown on Exhibit A in the Appendix. There is potential for future expansion to the south should the Village deem this necessary in the future.

2. <u>Protection</u>: The Suttons Bay Marina is well protected from winds from the south and west simply by its geographic location near the southwest end of Suttons Bay. The main basin and the remainder of the marina are protected from the north by the existing breakwater along the north side of the main basin. As previously stated, the breakwater is in a state of disrepair and will need to be upgraded. The marina is not protected at this time from an east wind. Our preliminary design indicates an extension of the breakwater to the south from the east end of the existing breakwater. This will virtually protect the marina basin from all directions except the southeast and the marina is the least vulnerable from the southeast due to the fact that the maximum fetch from the southeast is approximately 1/2 of a mile.

A. <u>Foundation Conditions</u>: It has been determined that the lake bottom in the marina basin consists mainly of sand from very loose to medium dense material. The material should be suitable for piling installation of either deep or shallow-pile systems.

B. <u>Water Depth</u>: This is an important factor in choosing the type of boats that can use the marina and in determining the type and size of structural members best to be used. The depth of water is proposed to be brought to a minimum of six (6) feet below low water datum of 576.8 (IGLD). This depth would provide safe navigation for power or sailboats up to 45 feet in length. The Village has indicated that the slips should be kept to a maximum size of 45 feet.

C. <u>Dredging</u>: This is the removal of soil underwater. Dredging will be required for this project to obtain the necessary depths of water for safe navigation through the main channels of the marina basins. The majority of the dredging will be required to move the main entrance channel to the south around the proposed extension of the breakwall. Dredging and excavation will also be required along the north side of the interior peninsula to expand the width of the marina basin. The dredged material will be used to raise the ground elevation of the main breakwall and both peninsulas to offset the high water levels that are currently being experienced. A portion of the dredged material will also be used to fill a small portion of the west end of the marsh area for additional parking spaces.

D. <u>Maintenance</u>: Maintenance is a continuous factor, therefore, it is considered one of the most important items in determining the type of structures to be used. This design will consider the type of material and size of equipment selected to minimize the amount of maintenance required.

E. <u>Economy</u>: After safety, this is the most important factor in any engineering design. The economy must be looked at on a cost per benefit basis for the life of the project. There obviously can be other factors that may govern the outcome of the economics, such as initial capital. If there is only so much money to work with, then the project must be designed accordingly. The Village has indicated that the Marina has been profitable for some time and the sale of revenue bonds might be possible to finance the construction.

F. Availability of Material: Marina structures could be built from several types of material including, wood, steel, concrete, rip-rap or any combination of the above. Since all of the materials are readily available in this area, this should not have a substantial bearing on the design.

3. Choosing Structural Material for Revetments and Breakwater: The following is a discussion of each of the materials that can be used in the construction of revetment and breakwater walls.

A. Wood: Most structures that utilize timber material are built as timber-pile protective structures and are often used in areas of little wave action and in areas of fresh water. Today the availability of timber has decreased and the cost increased, which makes its use less economical than in the past. In sandy and gravel areas, considerable damage may occur from bedload material (lake bottom material moving with the currents), thus increasing maintenance cost.

The existing breakwall, which was built around 1960, is basically constructed as described above, utilizing wood piling with wales for protection, and the wall is tied back to a set of piles that act as anchorage for the revetment.

B. Concrete: In most cases, concrete is used as a cap on a revetment, except in areas of less protection where it is used in the form of reinforced concrete shells floated into location, then filled with sand to give stability and act as a gravity structure. This type of construction is utilized where heavy wave action is involved. The foundation should be built prior to the installation of such structures by either placing a bed of rubble stone or piles to support the structure. The soil conditions must be capable of supporting a gravity wall for use of this type of structure.

C. Steel Revetment: Steel sheet piling has become a desirable method of construction for a revetment or breakwall. This can be accomplished in several ways, such as a single row of cantilever structures for low water height, or anchored wall of sheet piling held together with tie rods with the space between the wall filled with stone or sand. When sand is used, protection should be used to minimize the possible loss of fill through the interlock by the use of a filter cloth. One of the major considerations in using steel pile is its corrosion characteristics, but this is not so great a problem in fresh water. The life expectancy of steel sheet piling structures is expected to be 35 years or longer. Sand can increase corrosion by eroding through the interlock which increases maintenance costs. Use of a filter fabric on the interior of the wall will decrease the movement of sand and increase the service life of the breakwall.

D. Rubble-Mound Shore Protection: Stone rubble-mound is probably the most adaptable to any depth of water and may be placed practically on any type of foundation. It is the most commonly used in the United States especially on the coasts. The prime advantages of the rubble-mound structure is its lack of maintenance costs, its stability and its high effect on the reduction of wave action. The disadvantage is the large quantity of material needed since it has to be built on a slope determined by the wave action. This creates a higher initial cost, especially if satisfactory material is not available within a reasonable hauling distance.

E. Bin Wall: Bin walls are steel type retaining walls that are composed of a series of adjoining close-faced bins, each ten (10) feet long. These bins consist of lightweight steel members bolted together at the job site, backfilled to form a permanent gravity-type retaining wall. Its introduction to marinas and usage as water structure is rather recent. For many years, it was used as a highway or a railroad retaining wall.

The proposed preliminary design for the Suttons Bay Marina uses a combination of steel sheet piling and rubble-mound rip-rap for the protection of the proposed harbor. The areas with deeper water and limited space will be protected with the steel sheet piling. The shallower areas can utilize the stone rip-rap.

4. Type of Structures: Having determined that steel sheet piling is the desirable method, there are two (2) types of design that could be used. These types are a cantilevered wall or anchored wall. The cantilevered wall has a sheet-pile section driven deep enough to support the land mass behind it without anchoring the wall back near the top of the sheet pile. This requires deeper penetration and a stronger sheet pile than

the anchored wall. The anchored wall requires less penetration and a lighter sheet pile but it requires additional sheet piles to be driven behind the wall and tie backs connected from the anchoring piles and the breakwall at set intervals. Since both methods are equally effective, the determining factor will come down to the cost of installation.

5. Docking Facilities: Walkways and docking facilities should be of the type, shape and size that is necessary to meet the need determined by the harbor study. In this section, we will describe various types of piers and their uses and recommend the one which is best suited for the need and function of Suttons Bay Marina. There are two (2) basic functions in designing a docking system; to dock the craft safely while not in use and to provide convenient access to and from shore.

A. Types of Mooring:

1. Anchoring: Anchoring is widely used as a system of holding a boat in a mooring area. It consists of providing a buoy to tie a boat to and a weight to prevent the boat from moving. The only anchoring that should be involved with the Suttons Bay Marina is in the area south of the coal dock where the Village currently allows mooring.

2. Fixed and Floating Piers: Multiple slip piers are in most cases desired for the economy of space that they provide. These piers can be of the floating or the fixed type.

The floating piers are more commonly used for smaller boats. Their purpose and function is more applicable when associated with boats smaller than 30 feet in length, because with larger boats, the needed total stability of a fixed pier is desirable. Floating piers have an advantage in providing possible extension or reduction of the size of the finger piers and the ability to maintain a constant free board for the pier to fluctuate with the fluctuation of the water level. This eases boarding access to and from the boats. The disadvantage to floating piers is that when they are connected to a fixed pier or revetment, they require a ramp that can accommodate the fluctuation in elevation between the floating and fixed piers. This ramp becomes quite long in an area where the water level fluctuates considerably. Another disadvantage to the floating piers is the annual installation and removal costs.

Fixed piers have the advantages that they remain in place year round. There is no annual cost for installation and removal. There is not a ramp from the revetment or breakwater to the dock because they are set at the same elevation. There is potential for making the finger piers adjustable so that if the water level drops the finger pier can be lowered to maintain a somewhat constant freeboard. Fixed piers can be either shallow-pile or deep-pile structures. A deep-pile structure is set with enough penetration into the ground to offset the uplift force of the ice in the basin. This method has a rather high initial cost but lower annual costs. The shallow-pile system is installed at a shallow depth which requires that the pilings be protected from ice up-lift. This protection is most commonly done with a bubbler system. The energy required to operate the bubbler system is obviously an annual cost that must be associated with the shallow-pile system. The shallow-pile system has a lower initial cost but higher annual costs.

Since either system would serve the purpose desired, the economics of the two (2) systems will be compared and the decision made as to which would best serve the Suttons Bay Marina.

Each opening, floating or fixed, except those adjacent to the revetment will accommodate two (2) boats. It is proposed that in between each two (2) spaces, there will be a wooden pile driven to the necessary penetration depth to act as the spring piles. The boat, while not in use, would be fastened to the cleats on the dock and to the spring piles.

6. Decking: There are several types of materials normally used in decking, wood plank, plywood, concrete, fiberglass and metal.

   A. Wood Decking is the most widely used. This usually is 2"x6" wolmanized lumber, spaced 1/4 inch apart. These planks are fastened by galvanized nails or bolts. The Village has expressed a preference for wood decking due to the aesthetics and since it is most commonly used, it will be the decking proposed for this facility.

7. Utilities: A good modern marina should have the necessary public utilities available such as water, sewer and electricity.

A. Water: Adequate water supply must be provided to each slip. It is proposed that a six (6) inch water main be extended from the existing 6-inch water main at the intersection of Front & Jefferson Street. The main would be extended along the north side of the main basin and branch off with 2-inch lines to feed the main piers with a 3/4-inch water tap centered between two (2) slips. This line would only serve the north side of the main basin. It is proposed that a second 6-inch watermain would be installed to serve the south side of the main basin and the old coal dock. It is proposed that this main be extended from the existing line on Front Street along the west side of the Barkentine Condominiums property, to Ames Street (Dock Road) then east to the marina property. The line would be teed at that point with one line serving the south side of the main basin and the other line would service the slips along the coal dock in the same manner as stated above. For estimating purposes it will be assumed that all of the watermain will be 6-inch. Final design may determine that the size could be decreased towards the end of the line. A contact with the Village personnel has indicated that the water system in this area does not have adequate capacity to provide fire protection and the Village Fire Department is equipped to pump directly from the marina for fire fighting. Due to these facts, it is not proposed to provide fire hydrants on the water system. The Proposed Utility Plan, included in the Appendix, indicates the watermain layout.

B. Sewer: The existing Restroom Facilities are served with sanitary sewer. The proposed plan calls for a sewer pump-out facility on the service pier and the addition of a restroom facility on the old coal dock. It is proposed that the existing old weigh station be converted to a restroom facility. Final design would have to determine if this is more economical than building a new restroom facility. In either case, both the sewer pump-out facility and the new restrooms on the coal dock will require a small pump station to pump the sewage up to the existing gravity sewer line on Front Street. The preliminary design would propose two (2) Duplex Grinder Pump Station with 2-inch forcemains to the gravity sewer. The proposed Utility Plan in the Appendix indicates the sewer system layout.

C. Electrical: The Village has requested that the electrical system be sized to provide 30-amp service to all slips. The proposed electrical plan would consist of a connection near the intersection of Front Street and Jefferson Street. The main service would follow the existing entrance drive to the marina along the north side of the main basin. A main branch would serve along the north side of the main basin to the end of the proposed breakwall. A branch line would be proposed to split off and follow the existing easement along the west side of the main basin between the main basin and the Barkentine Condominiums. This branch would then split and serve the south side of the main basin and also continue to the south and serve the coal dock area. The final design of the electrical system would be sized to provide the necessary power for the boat slips, dock lighting, street or parking area lighting, harbor shack, service pier facilities and new restroom facilities. The slips and service dock will be supplied with weatherproof outlets of 125 volts, 30 amp. Navigational lights will be placed at the entrance as required. All of the walkways and main piers are proposed to be provided with low-level dock lights in a staggering sequence along the edge of the walkways. It is anticipated that the water, electricity and lighting for the main piers would be set in one pedestal staggered between slips for joint usage. The Proposed Utility Plan in the Appendix indicates the electrical system layout.

D. Telephone and Natural Gas: Telephone and Natural Gas service will not be provided to the docks of the marina. At least two (2) public telephones should be provided in pertinent locations. Natural gas could be provided to the proposed restroom facilities for heating these areas or providing hot water if it were deemed necessary in the final design.

8. Service Dock: The proposed service dock would be approximately 15 feet wide by 70 feet long. The facilities on the service dock would consist of a gasoline pump, diesel fuel pump, sewage pump-out station and potable water supply. Underground tanks and fuel dispensing units will be

required for gasoline and fuel. For preliminary estimating purposes we will assume a 3,000 gallon gasoline tank and a 2,000 gallon diesel fuel tank.

LAND DEVELOPMENT

1. Parking: A total of 142 parking spaces are proposed for the development of the marina site. The parking areas will be adequately luminated with boardwalks that will function as a boundary for the area. The parking areas will be leveled sand sub base, with six (6) inches of 22A gravel base and two (2) inches of asphalt surface. All parking spaces will be marked. The area around the parking lot will be landscaped with different kinds of plant materials that will be covered in the final design.

   The phasing of the parking areas will coincide with the progress of the marina development.

   As previously discussed, parking spaces will not be provided for cars with trailers. The Village is satisfied to remain in the mode of parking trailers along Front Street.

2. Storm Drainage: Storm drainage will be handled by sloping the parking lot area to a controlled retention basin and piped to the basin with a slow release pipe, or run into a landscaped area and percolate away. Boardwalk surfaces will be pitched to run into the harbor area.

3. Roads: Roadways leading into the site and the parking lot will be built in accordance with Village specifications. All roads will have 6-inch 22A gravel base and 2" asphalt surface.

4. Federal, State & Local Regulations: All design, installation and construction of the marina shall be in accordance with all regulations of the State of Michigan, the Corps of Engineers, the Department of Natural Resources Waterways Commission and local regulations.

APPENDIX A

ESTIMATED CONSTRUCTION COSTS

PHASE ONE: Conversion of Coal Dock to Fishing Pier (Not including docks on south side of coal dock).

			Item Cost	Total Estimated Cost
1.	Steel Sheet Pile Bulkhead			
	a. Steel Anchored Walls		$ 275.00	
	b. Double Channel Wales		30.00	
	c. Tie Rods & Accessories		15.00	
	d. Concrete Anchors		30.00	
	e. Excavation & Backfill		10.00	
	f. Toe Stone Fill		20.00	
		600 LF @	$ 380.00	$228,000
2.	6' Wide Boardwalk	1,500 LF @	20.00	30,000
3.	Footbridge	Lump Sum @	9,000.00	9,000
4.	Shore Stablization			
	a. Quarry Stone Rip-rap	150 LF @	60.00	9,000
5.	Renovate Existing Building into a Restroom Facility	Lump Sum @	10,000.00	10,000
6.	Utilities			
	a. Watermain to Restroom Facility	1,200 LF @	15.00	18,000
	b. Electric Line	1,500 LF @	10.00	15,000
	c. Sewage Pump Station	Lump Sum @	12,000.00	12,000
	d. Sewage Forcemain	800 LF @	10.00	8,000
	e. Restoration	2,000 LF @	3.00	6,000
	f. Exterior Lighting	Lump Sum @	10,000.00	10,000
7.	Landscaping	Lump Sum @	8,000.00	8,000
8.	Fill Site with Dredged Material to Raise Elev. Approximately two feet.	5,300 CuYd @	6.00	31,800
			Estimated Construction Costs	$ 394,800
			10% Construction Contingencies	39,500
			Engineering	30,500
			PHASE ONE Estimated Total Cost	$ 464,800

PHASE TWO: Renovate existing breakwall on north side of main basin, install new breakwall to the south from east end of existing breakwall and install two (2) new piers.

			Item Cost	Total Estimated Cost
1.	Renovate Existing Breakwall			
	a. Steel Anchored Walls		$ 240.00	
	b. Double Channel Wales		30.00	
	c. Tie Rods & Accessories		15.00	
	d. Concrete or Piling Anchors		30.00	
	e. Excavation & Backfill		10.00	
	f. Toe Stone Fill		20.00	
	g. Raise Elevation Approximately 2 feet		15.00	
	h. Concrete Cap Both Sides		20.00	
	i. Filter Cloth		5.00	
		600 LF @	385.00	$231,000
2.	New Breakwall to South			
	a. Steel Piling Breakwall (2 sides, Barge Driven)		600.00	
	b. Quarry Stone Fill		280.00	
	c. Sand Fill		50.00	
	d. Concrete Cap Both Sides		20.00	
	e. Sod		20.00	
		150 LF @	970.00	145,500
3.	Stabilization of Exterior of Existing Breakwall with Rip-Rap (utilize exiting)			
	b. Cover Stone		40.00	
	c. Toe Stone		70.00	
		800 LF @	110.00	88,000
4.	Fixed Main Piers			
	a. 10' Wide Walkway Pier		150.00	
	b. Steel Pipe Pier Piles $30/VFt @ 15' spacing, 75' Pile Length		300.00	
	c. Potable Water for Slips		15.00	
	d. Electrical Service Lines		20.00	
	e. Electrical Pedestal Risers w/lights		35.00	
		275 LF @	520.00	143,000
5.	Fixed Finger Piers Attached to Main Piers			
	a. 3' Wide Finger Pier		70.00	
	b. Steel Pipe Piles (single piles spaced at 15')		125.00	
	c. Miscellaneous Pier Equipment		25.00	
		600 LF @	220.00	132,000

			Item Cost	Total Estimated Cost
6.	Spring Piles	24 EA @	2,250.00	54,000
7.	Utilities to Serve Piers & Lighting			
	a. Potable Watermain	1,200 LF @	15.00	18,000
	b. Electrical	1,500 LF @	10.00	15,000
	c. Restoration	1,500 LF @	6.00	9,000
	d. Lighting	Lump Sum @	6,000.00	6,000
			Estimated Construction Costs	$ 841,500
			10% Construciton Contingencies	84,200
			Engineering	65,000
			PHASE TWO Estimated Total Cost	$ 990,700

PHASE THREE: New piers along south side of main basin and parking areas.

			Item Cost	Total Estimated Cost
1.	Fixed Main Piers	520 LF @	$ 520.00	$270,400
2.	Fixed Finger Piers	1,200 LF @	220.00	264,000
3.	Spring Piles	40 EA @	2,250.00	90,000
4.	Stabilization of Shoreline	800 LF @	60.00	48,000
5.	6' Wide Boardwalk	1,200 LF @	20.00	24,000
6.	Utilities			
	a. Potable Watermain	600 LF @	15.00	9,000
	b. Electrical Service	760 LF @	10.00	7,600
	c. Restoration	500 LF @	6.00	3,000
	d. Lighting	Lump Sum @	6,000.00	6,000
7.	Parking Areas			
	a. Place Compacted Fill	2,400 CuYd @	6.00	14,400
	b. Gravel Base	3,000 SqYd @	3.00	9,000
	c. Asphalt Surface	3,000 SqYd @	10.00	30,000
	d. Entrance Drives	300 LF @	25.00	7,500
	e. Asphalt Striping	Lump Sum @	1,500.00	1,500
	f. Parking Lot Lighting	Lump Sum @	10,000.00	10,000
8.	Landscaping	Lump Sum @	8,000.00	8,000
			Estimated Construction Costs	$802,400
			10% Construction Contingencies	80,200
			Engineering	61,800
			PHASE THREE Estimated Total Cost	$944,400

PHASE FOUR: Piers along north side of basin and service dock.

			Item Cost	Total Estimated Cost
1.	Fixed Finger Piers (Approx. 40'length w/3 piles)	600 LF @	$ 250.00	150,000
2.	Spring Piles	17 EA @	2,250.00	38,250
3.	Service Pier	120 LF @	650.00	78,000
4.	Sewage Pump-out Station	Lump Sum @	8,000.00	8,000
5.	Sewage Forcemain	600 LF @	10.00	6,000
6.	Fueling System			
	a. Underground Gas Tank (3,000 gal)	Lump Sum @	7,000.00	7,000
	b. Underground Diesel Tank (2,000 gal)	Lump Sum @	6,000.00	6,000
	c. Fuel Lines	1,200 LF @	12.00	14,400
	d. Fuel Dispensers	2 EA @	2,000.00	4,000
	e. Pumps & Controls	Lump Sum @	5,000.00	5,000
	f. Restoration of Park Area	Lump Sum @	8,000.00	8,000
	g. Removal of Existing Equip.	Lump Sum @	2,000.00	2,000
7.	Electrical System			
	a. Electric System for Service Pier	Lump Sum @	2,500.00	2,500
	b. Electrical Pedestal	15 EA @	600.00	9,000
8.	Potable Water Risers	15 EA @	200.00	3,000
9.	Parking Lot Revisions			
	a. Lighting	Lump Sum	10,000.00	10,000
	b. Pavement Striping	Lump Sum	1,500.00	1,500
	c. Minor Asphalt Work	Lump Sum	2,000.00	2,000
10.	Minor Shore Stabilization	Lump Sum	12,000.00	12,000
			Estimated Construction Costs	$366,650
			10% Construction Contingencies	36,650
			Engineering	28,200
			PHASE FOUR Estimated Total Cost	$431,500

PHASE FIVE: Piers along south side of coal dock.

			Item Cost	Total Estimated Cost
1.	Fixed Finger Piers (Approx. 40' length w/3 piles)	480 LF @	$ 250.00	$120,000
2.	Spring Piles	13 EA @	2,250.00	29,250
3.	Electrical Pedestals	11 EA @	600.00	6,600
4.	Potable Water Risers	11 EA @	200.00	2,200
5.	Shore Stabilization	450 LF	60.00	27,000
6.	Landscaping	Lump Sum	5,000.00	5,000
			Estimated Construction Costs	190,050
			10% Construction Contingencies	19,000
			Engineering	14,650
			PHASE FIVE Estimated Total Cost	$223,700

SUMMARY OF COST ESTIMATES

PHASE ONE:	Conversion of Coal Dock to Fishing Pier	$ 464,800.00
PHASE TWO:	Renovate Existing Breakwall, Install New Breakwall to South and Install two (2) Pew Piers	990,700.00
PHASE THREE:	New Piers along South Side of Main Basin and Parking Areas	944,400.00
PHASE FOUR:	Piers along North Side of Basin and Service Dock	431,500.00
PHASE FIVE:	Piers along South Side and Coal Dock	223,700.00
	ESTIMATED TOTAL COST	$3,055,100.00

APPENDIX B

PRELIMINARY PILE PENETRATION DESIGN FOR A DEEP PILE SYSTEM

1. Determine approximate pile penetration depths based on soil parameters from the soil borings performed as part of this study.

2. Design Criteria and Assumptions

   A. Maximum design ice thickness = 30 inches.

   B. Maximum design ice uplift pressure on the pile perimeter = 60 psi. (This is a generally used value and provides for a factor of safety of 1.5).

   C. Ice uplift forces are considered to be the controlling design factor in determining pile penetration depths.

   D. 8-inch and 14-inch pipe piles will be looked at in combination; i.e., a composite pile with 14-inch pile section at soil interface and 8-inch pile section at ice interface.

   E. All four borings will be looked at individually with the estimated pile penetration determined by averaging the values obtained from each boring.

3. Calculate ice uplift force for each type of pile.

A. For 8" Pipe Pile

Sample Calculation

Perimeter = π x diameter = 3.14 x 8" = 25.1 inches

Ice uplift = 30" x 25.1" x 60 psi x 1 kip/1000 lbs = 45.2 kips

Use a factor of safety of 2, therefore, ice uplift = 90 kips

B. For 14" Pipe Pile

Perimeter = 44 inches

Ice uplift = 158 kips

4. Calculate required pile penetration depth for each 14 inch pipe pile for each boring based on design criteria of the existing soils. The pile penetration must produce enough frictional resistance to overcome the uplift force of the ice on the 8 inch pile. These calculations were made using the different types of soil and taking into consideration the weight of the pile and concrete fill. The resulting penetrations required are shown in TABLE ONE below:

TABLE ONE

Summary of Penetration Depths
Based on Soil Borings

	Boring #1	Boring #2	Boring #3	Boring #4	Average
8" Pipe Pile at Ice & 14" Pipe Pile at Soil	60'	60'	66.5'	55'	60.4'

Past experience indicates that H-piles would produce very similar results to the pipe piles. Therefore, for estimating purposes, we will assume the use of pipe piles.

Summary of Pile Penetration Design

1. 8" Diameter, concrete filled pipe pile extending through ice.
2. 14" diameter, concrete filled pipe pile from lake bottom downward.
3. 30" ice thickness.
4. Factor of safety of 2 against uplift.
5. Average of 60 psi ice to pile adhesion.
6. Assumes large displacement piles can be driven through the existing site soils.

APPENDIX C

PRESENT WORTH ECONOMIC EVALUATION OF BUBBLER SYSTEM OPERATION AND MAINTENANCE AND REPLACEMENT COSTS

1. Assumptions and Basis of Analysis

   A. Assume 20 year service life for the bubbler system.

   B. Assume one bubbler system will be installed to serve the entire marina. The blower system will be installed with the first phase and sized to serve the entire development. The extension of aeration tubing will be expanded as the permanent slips are installed.

   C. Assume entire bubbler system will be replaced after 20 years of operation and will have no salvage value.

   D. Assume 8 percent interest rate.

   E. Assume operation and maintenance costs go up 8 percent per year.

   F. Assume operation and maintenance costs are paid at the beginning of each year.

2. Cost Analysis

A. Operating Costs

Operating cost for one 30 HP blower running continually for a 120 day season at 80 percent efficiency and at $0.08/KWH is calculated as follows:

30 HP x 0.746 KWH/HP - 0.80% eff. = 28 KWH x 24 hrs/day x 120 days x $0.08/KWH = $6,445.00

Therefore, the estimated seasonal cost at today's rates to operate a bubbler system would be approximately $6,450.00.

B. Maintenance Costs

Maintenance cost to check blowers daily, change their oil and filters and lubricate periodically, to hire a diver to check aeration tubing once a season, to purge and clean lines periodically and to perform other necessary maintenance on the bubbler system is estimated at today's cost to be: $2,000/season.

C. Replacement Costs

The cost to replace the entire bubbler system at the end of its service is estimated at today's costs to be: $80,000.00.

D. Determine Present Work of Annual Operation & Maintenance and Replacement Costs Over 20 Year Project Life for Entire Installation

(1) If operation and maintenance costs go up 8 percent per year and the required capital to pay these operation and maintenance costs for 20 years is invested at an 8 percent interest rate, then the present worth of the annual operation and maintenance costs over the twenty year project life is calculated as followed:

$$P = 20 \times \$8{,}450 \approx \$169{,}000.00$$

(2) The present worth replacement cost of the bubbler system is: $80,000.00.

(3) Therefore, the total present worth of operation and maintenance and replacement costs over the 20 year project life is:

$$\$169{,}000.00 + \$80{,}000.00 = \$249{,}000.00$$

Therefore, the total present worth value of a bubbler system would be:

Present value of O & M costs =	$169,000.00
Present value of replacement costs =	$ 80,000.00
Present installation costs =	$ 80,000.00
	$329,000.00

From this analysis we can determine the cost comparison between deep-pile and shallow-pile systems.

Deep piles at 75 feet deep at $30.00/vertical foot

Shallow piles at 45 feet deep at $30.00/vertical foot

The cost of the piles would be the only cost difference between the two (2) systems. Therefore, the savings in initial cost for the shallow-pile system must be compared to the present value of the O & M and replacement of the bubbler system at $329,000.00.

The difference in cost for the piles is 30 vft. x $30.00/vft. = $900.00

The preliminary design indicates that there are approximately 400 piles in the main piers, finger piers and spring piles. At $900.00/pile this equates to a net difference of approximately $360,000.00. This compared to the $329,000.00 calculated above indicates that the deep-pile system has a higher overall cost of approximately $31,000.00.

Since the projected O & M costs for the Bubbler System are estimates at best and the actual future costs could vary considerably, it is recommended that the initial installation be installed with the deep-pile system and avoid the annual operation and maintenance of a bubbler system.

It should also be noted that it is questionable whether a bubbler system would work adequately in the Suttons Bay Marina since the system requires adequate physical parameters to be effective. Depth of water is a major factor and Suttons Bay Marina is fairly shallow. This system would be investigated further in the final design but preliminary design and costs will be considered with a deep-pile system.