www.baird.com

Baird

oceans

engineering

lakes

design

rivers

science

watersheds

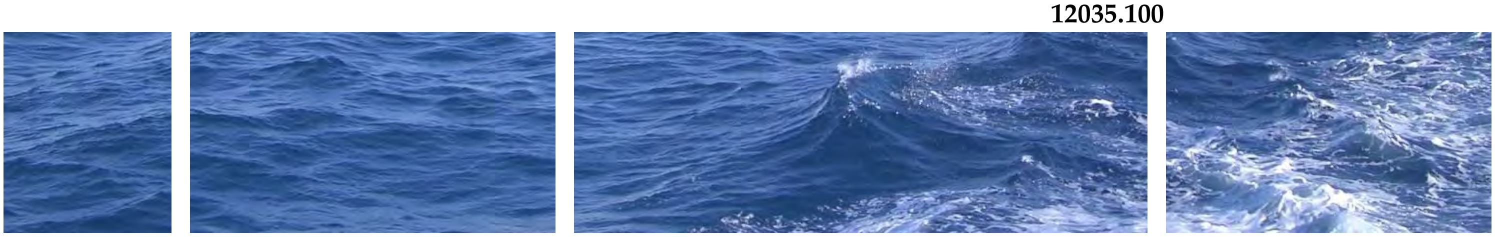
construction

Final Report

Lakeshore Boulevard Redesign and Shoreline Restoration Project – Phase I

Marquette, Michigan

July 3, 2013
12035.100



Innovation, Excellence & Service

Lakeshore Boulevard Redesign and Shoreline Restoration Project – Phase I
Marquette, Michigan

Prepared for

Superior Watershed Partnership and Land Trust
Marquette, MI

Prepared by

Baird

W.F. Baird & Associates Ltd.

For further information please contact
Dan Veriotti at (312) 893-5442

12035.100

Financial assistance for this project was provided, in part, by the Michigan Coastal Management Program, Department of Environmental Quality (DEQ), through a grant from the National Oceanic and Atmospheric Administration (NOAA), U.S. Department of Commerce. The statements, findings, conclusions, and recommendations in this report are those of the Superior Watershed Partnership (Grantee) and do not necessarily reflect the views of the DEQ and the NOAA.

TABLE OF CONTENTS

EXECUTIVE SUMMARY

The Lake Superior Watershed Partnership (LSWP), in cooperation with the City of Marquette, Michigan initiated a preliminary engineering study, Lakeshore Boulevard Redesign and Lake Superior Shoreline Restoration Project-Phase I.

The scope of the preliminary engineering study was to formulate alternatives for shoreline improvements along the Lakeshore Boulevard stone revetment section, currently subject to road flooding and ice build-up in the winter.

Five conceptual alternatives have been formulated. Alternatives 1, 3, 4 and 5 show that the Lakeshore Boulevard realignment will be further inland compared to existing location. This additional separation from the lake, plus the proposed coastal/shoreline improvements have been conceptually designed to reduce wave overtopping, flooding and overspray on the roadway during both winter and summer months. Alternative 2 maintains the current road alignment.

The preliminarily estimated construction costs range between $1.8M (Alternative 1) and $12.1M (Alternative 5).

The local community, along with the City and the LSWP, will select one alternative that provides the best combination of advantages, performance and cost. The selected preferred alternative will be the starting point for permitting, preliminary design, detailed design development, and final design.

Following the selection of a preferred alternative, future studies should be undertaken to fully understand the complex coastal processes in the project area, and to determine the ultimate feasibility of the proposed shoreline enhancements.

It is anticipated that land-based improvements will be included in future project phases (parking, plantings, landscaping, bicycle and pedestrian paths, designated public access points and signage), following the selection of a preferred alternative by LSWP and the City.

1.0 INTRODUCTION

The need for the Lakeshore Boulevard project was first identified in the City of Marquette adopted Community Master Plan (2004). Utilizing this plan as a starting point, the main goal of the project is to analyze alternatives and initiate preliminary engineering that will assist in identifying a preferred option for the shoreline and road redesign. The project includes a phased approach as summarized below:

- Phase I: preliminary technical investigation, development and screening of shoreline alternatives, and identification of the preferred alternative by LSWP and the City.
- Subsequent phases: more detailed coastal analysis and revisions to the preferred alternative as required.

Baird was commissioned to address Phase I of the project, which includes the following tasks:

- Overview of project conditions from available documents;
- Summary of coastal conditions in support of the conceptual design alternatives;
- Development of conceptual design alternatives with construction cost estimates; and
- Recommendations for detailed analysis (future project phases).

1.1 Project Background

The project's general limits of interest are described as the Lake Superior shoreline from the Dead River mouth (north) to Shiras Park (south), or approximately 1.7 miles of shoreline in Marquette, MI.

The project's main focus area is along the approximately 3,500-ft long stone revetment, between Hawley Street and a point midway between Wright Street and Pine Street. The stone revetment is located within the downdrift influence of the Presque Isle Harbor (also known as the "Upper Harbor"), that has an impact on the natural sediment movement, distribution of incoming wave energy, and induced nearshore circulation. To the south of the project area there is the Marquette Harbor ("Lower Harbor"), as shown in Figure 1.1.

Significant overtopping of Lakeshore Boulevard occurs during storm events, especially at high water levels. Various sections of existing land along Lakeshore Boulevard have limited flood storage capacity and are subject to flooding. Ice build-up is also recorded during the winter months, see Figure 1.2.

1.2 Existing Conditions

Baird has performed a preliminary review of several sources of readily available information to achieve a general understanding of the existing conditions at the Lakeshore Boulevard location.

The northern section of the stone revetment was constructed before 1939, while the southern section was constructed between 1939 and 1972. Based on a review of aerial photographs and images supplied by the Lake Superior Watershed Partnership (LSWP), it appears that the revetment shows signs of aging, was not well engineered, and the material was dumped in place by trucks. The material ranges in size from cobble to armor stone, see Figure 1.3.

Physical changes to the shoreline south of the upper harbor have been recorded since the completion of the multi-phase harbor of refuge in 1939, which included the construction of a 2,600 foot federal breakwater. The shoreline erosion processes south of the harbor determined the need to provide a stone revetment along Lakeshore Boulevard.

Figure 1.1 Project Location Map

Figure 1.2 Lakeshore Boulevard in Winter (view looking south)

Figure 1.3 Lakeshore Boulevard Stone Revetment

The National Oceanic and Atmospheric Administration (NOAA) has published LiDAR (Joint Airborne Lidar Bathymetry) surveys of the Great Lakes from several sources including the U.S. Army Corps of Engineers (USACE) through the Joint Airborne Lidar Bathymetry Technical Center of Expertise. Data compiled by NOAA in 2011 was utilized in the basemap of the study, see Figure 1.4. All elevations are referenced in Lake Superior Low Water Datum (LWD). 0.00 LWD=601.1 International Great Lakes Datum 1985 (IGLD85). For example, the Ordinary High Water Mark (OHWM) for Lake Superior is 2.0 feet LWD or603.1 feet IGLD85.

Based on the 2011 Lidar data, the following elevations are noted:

- Elevations along the centerline of Lakeshore Boulevard vary between 606.5 ft (Hawley Street) to 606.8 ft IGLD 85 (Wright Street).
- Elevations along the crest of the stone revetment vary between 608.0 and 612.0 (higher elevations at Wright Street).
- The average water depth along the toe of the revetment is 577.0 (or approximately 4 feet at LWD).

A detailed survey (both bathymetric and topographic) is recommended in the project future phases. A detailed stone survey to document the sizes and stone condition is also recommended.

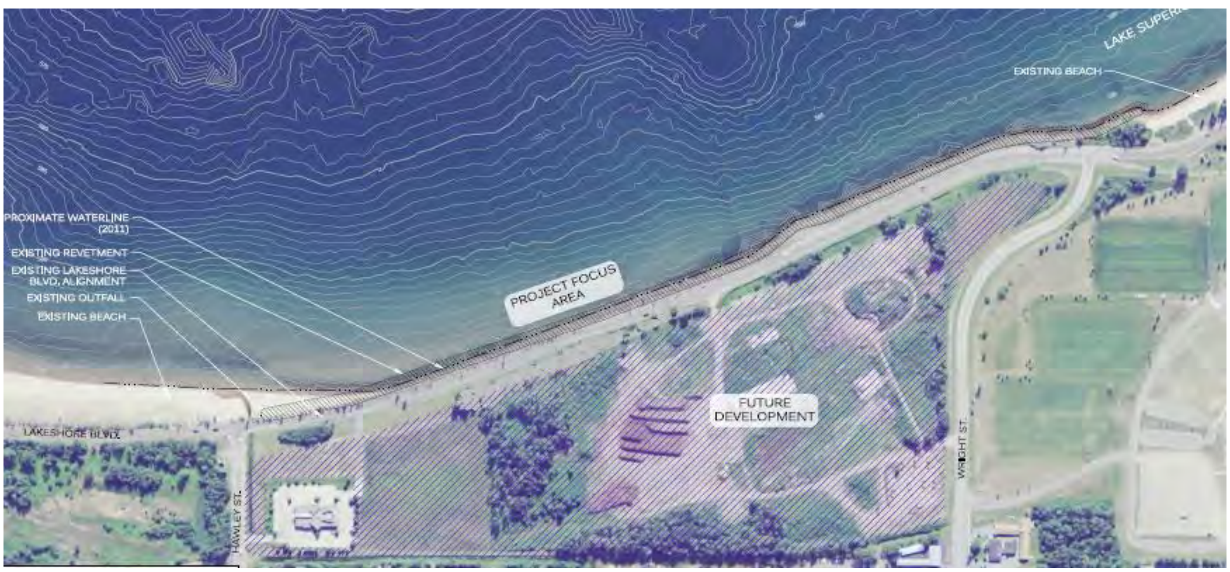


Figure 1.4 Existing Conditions

1.3 Coastal Conditions Overview

A preliminary understanding of the natural coastal processes in the project area is key to formulating and evaluating possible feasible shoreline alternatives in the project area.

The condition of the underwater slopes, and their response to extreme storm waves, is a critical consideration in design development for a shoreline protection system. The key site-specific design parameters for a shoreline protection system are the design wave height, design high and low water levels and the nearshore bathymetry. Design criteria (as noted above), constructability (e.g. available materials, equipment and access) and cost are also important considerations.

In shallow water, the design wave height is limited by the water depth, as defined by the elevation difference between the design high water level and the lakebed elevation at the location of interest; the nearshore (underwater) slope is also an important parameter. Assuming severe storm conditions, the offshore wave height and wave period have a secondary effect on the depth-limited (breaking) wave height at the shoreline.

Finally, it is noted that the design/construction of the repair/rehabilitation/upgrade of an existing structure is more complicated than the design/construction of a new structure.

1.3.1 Sediment Characteristics

No data is available regarding the properties of the nearshore and open shorelines, along with sediment depths (thicknesses) in the project area. For the purpose of this preliminary study, it is assumed that the nearshore area in front of the revetment consist of primarily sand materials. A detailed soil sampling and analysis, along with jet probes (for documenting the sand thicknesses) are recommended in the project future phases.

1.3.2 Water Levels

Water levels on Lake Superior vary on several different time scales in response to climatic fluctuations. Lake Superior levels tend to be highest during July and lowest during March, with the typical annual variation in lake levels being approximately one foot.

In addition, local water levels may vary significantly on a short-term basis (i.e. over a period of hours to days) due to storm surge resulting from meteorological forcing such as wind stress and barometric pressure. Storm surges on Lake Superior may reach several feet (positive/setup or negative/setdown), depending on site location, and occur independent of the long-term and seasonal lake level fluctuations. However, there is a tendency for the most severe surges to occur during the stormy winter period when lake levels tend to be lower.

A water level analysis was performed by the USACE and documented in a 1993 report (Design Water Level Determination on The Great Lakes). Design water levels are published with respect to various return periods. The design water level is defined as still water level and rise (storm surge) combined. Table 1.1 provides a summary of the analysis for the Marquette, Michigan gauge.

Table 1.1 Design Water Levels from USACE 1993 Report

Return Period (Years)	Design Water Level (ft, LWD)
10	3.1
20	3.2
30	3.4
50	3.6
100	3.8

The 20-year water level is a reference level adopted for this conceptual study: 3.2 feet LWD (604.3 feet IGLD85).

1.3.3 Waves

Waves are one of the controlling factors in the design of coastal protection structures. Severe wave events on Lake Superior result from the passage of storms, with the magnitude of the wave conditions controlled by wind speed, fetch (distance on the lake over which the wind propagates) and water depth. In general, wave measurements are insufficient to define design conditions for coastal engineering projects, so "hindcast" methods are utilized, where wave conditions are estimated based on historical wind records.

The parametric hindcast model determines the wave climate at a specific location from input such as fetch length (distance over the lake to the hindcast location), depth of water along the fetch, and wind climate at the project location.

Baird performed an analysis in 2011 of the Pictured Rocks location for the Natural Park Service. While the parametric hindcast performed to determine the wave climate at Pictured Rocks is specific for that particular site, an overview of the methodology is presented for reference.

The model utilized the recorded wind data and was calibrated based on the recorded offshore waves at Buoy 45004, see Figure 1.5. A location in the proximity of Pictured Rocks was selected and the wave statistics (direction, percentage of occurrence, magnitude) are summarized in Figure 1.6, also known as a wind rose.

The largest and most common offshore waves at Pictured Rocks approach from the north-west and south-east directions. The large northwest waves are generated by the long fetch lengths in the north quadrant and the large winds from the same direction.

We recommend including a Marquette site hindcast analysis to quantity the offshore wave climate in future project phases. This analysis will provide the wave climate at a location close to the site, to be determined. The waves from the northeast direction will be of particular interest.

Figure 1.5 Location of Buoy 45004 and Stannard Rock

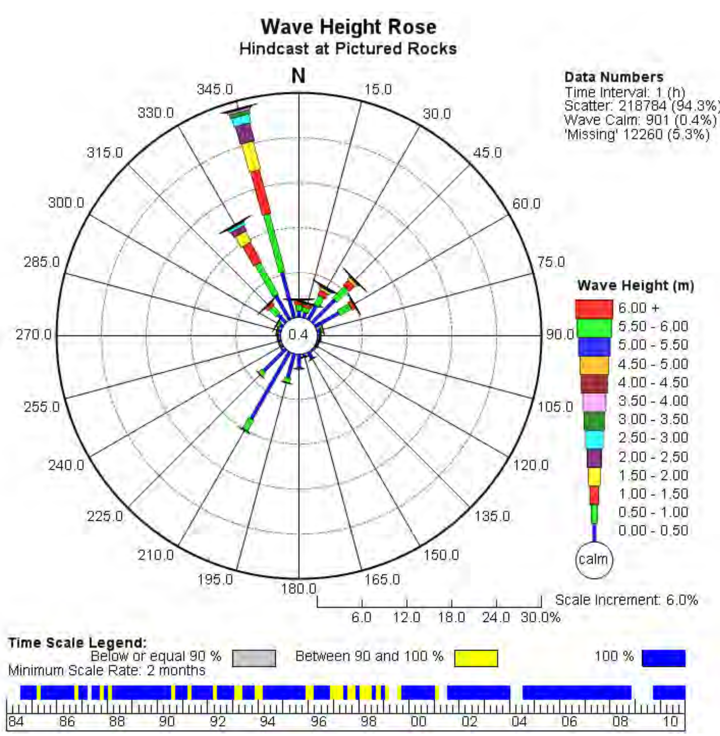


Figure 1.6 Wave Rose at Pictured Rocks

These deep water wave conditions are subject to various shallow water transformations as they propagate towards the shoreline. In particular, the wave heights at the project site will be controlled by breaking, with the wave height limited to approximately 70% of the water depth. For example, assuming a lakebed elevation of -4 ft LWD and a design high water level of +3.2 ft LWD, the wave height would be approximately five feet. More detailed analyses of offshore and nearshore wave conditions will be required to support future detailed project phases.

1.3.4 Sediment Transport Processes

In a completely natural system, which the Lake Superior near Marquette is not, sand is transported in both a longshore and cross-shore direction in response to waves and currents generated during storms. Over long temporal periods, the magnitude and directionality of the storms influences the rate at which sand is transported along the coast and ultimately the resulting morphology of the shoreline.

Longshore sediment transport (LST) refers to the transport of sediment in the littoral zone along the shoreline as a result of obliquely approaching waves. Over time, waves can move significant volumes of sediment along the shoreline. Harbors and coastal structures such as groynes and jetties can significantly impact this process by trapping the sediment that is being transported along the shoreline.

The natural net sediment transport along the shoreline (longshore) in the project area is from the north to the south. Based on the Presque Isle existing stone outcropping and significant nearshore water depths, there is limited sediment supply north of the harbor. Therefore, the impact of the Upper Harbor on sedimentation north of the breakwater might be negligible; however, the construction of the harbor may have contributed to the shoreline erosion approximately one mile south of the federal breakwater.

The Upper Harbor was identified by USACE (1976) to be the main cause for the different shoreline evolution trends (discussed in the next section); the breakwater shelters the area north of Hawley Street and creates a sediment “trap” for sediment moving north due to south and southeast induced storm circulation.

The Upper Harbor is being maintained at 28 feet (approach channel) and 30 feet (inner harbor) of water depth, reported at Low Water Datum (601.1 ft IGLD 85). Based on a review of the Upper Harbor dredging between 1971 and 1984 (last dredging event), approximately 57,600 cubic yards (cy) of sediment have been dredged, 49,300 cy of which have been placed as open water disposal, while approximately 8,300 cy have been placed as beach nourishment south of the Lakeshore Boulevard stone revetment.

A detailed sediment transport analysis is recommended in future project phases.

1.3.5 Shoreline Evolution

According to USACE, there were three main areas with different historic evolution trends between the Upper and Lower Harbors at the time of their study (1976):

1. Accreting shoreline north of Hawley Street towards the Dead River mouth.

Oblique of Shoreline Accreting Area: http://superiorwatersheds.org/shorelineviewer2011/

2. Stable shoreline (stone armored) between Hawley Street and a midpoint between Center Street and Summit Street, or approximately 1,000 feet south of the Lakeshore Boulevard stone revetment.

Oblique of Stone Armored Area: http://superiorwatersheds.org/shorelineviewer2011/

3. Eroding shoreline between 1000 feet south of the stone revetment and Shiras Park.

Oblique of Shoreline Eroding Area: http://superiorwatersheds.org/shorelineviewer2011/

Two aerials (see table 1.2) were obtained and geo-referenced with GIS software and analyzed in order to refine the previous USACE findings and to estimate the long-term average shoreline evolution rates. The position of the shoreline was adjusted based on the water level at the time of the aerial.

Table 1.2 Project Aerials

Date	Source	Water Level (ft, IGLD 85)	Resolution (ft)
1951-11-01	USGS/USDA	603.0	3
2008-08-25	USGS/USDA	601.8	1

The analysis confirms that there are three different shoreline evolution trends, as shown in Figure 1.7:

- Zone 1: accretion from Dead River to approximately 200 feet south of Hawley Street;
- Zone 2: stable at the location of the stone revetment; and
- Zone 3: erosion from Wright Street to Picnic Rocks.

The long-term (1951 to 2008) shoreline change rates were calculated along 100-foot established transects as shown in Figure 1.8. It was found that the rates vary along these transects. The calculated long-term (1951 to 2008) shoreline change rates are 2.7 feet/year in Zone 1 (accretion) and 1.5 feet/year in Zone 3 (erosion). Based on the results of this analysis, it is very likely that if the stone revetment in Zone 2 is removed, the shoreline will erode; this preliminary study considered an average erosion rate of 1.5 feet/year, as calculated for Zone 3. To note this rate is likely conservative, as Zone 2 is located between an accretion and erosion zone.

There is no survey data available for the 1951 aerial. The 2008 Lidar survey data shows an average beach slope of 1 (Vertical): 10 (Horizontal). Assuming the same beach slope existed in 1951, preliminary calculations show that Zone 3 eroded at a long-term average rate of 2,200 to 3,200 cubic yards per year. This is provided as a range based on two different calculation methods utilized.

Figure 1.7 Shoreline Evolution Analysis

Figure 1.8 Shoreline Change Rates

2.0 CONCEPTUAL ALTERNATIVES

Baird has prepared five conceptual shoreline alternatives. The intent is to provide a range of preliminary options and estimated costs for long-term project planning.

2.1 Alternative 1: Remove Existing Revetment

Under this alternative, the armor stone is removed along approximately 3,500 feet of shoreline. Based on the preliminary shoreline evolution analysis performed, the shoreline will likely become a sediment source and will experience an erosional trend. Using the calculated long-term erosion rate (from Zone 3), approximately 150′ of shoreline will be lost in the next 100 years.

This alternative is shown in Figure 2.1. A summary of Alternative 1 is presented below:

- Provides unobstructed views of Lake Superior.
- Increases the amount of available sediment supply for nearshore transport processes.
- Preliminary estimated average annual rate of shoreline erosion 1.5 ft/year.
- Requires future relocation of Lakeshore Boulevard.
- Limited site restoration/habitat improvement opportunities.

Figure 2.1 Alternative 1

2.2 Alternative 2: Restore Revetment

Under this alternative, the armor stone is removed along approximately 3,500 feet of shoreline. Alternative 2 focuses on restoring the existing stone revetment as a shoreline protection structure. A new stone revetment with a crest elevation of +9.5 LWD (610.6 ft IGLD85) is proposed, which is comparable to the existing revetment crest elevation. A brief summary of Alternative 2 is provided below.

- Lake views are obstructed.
- Significant developable land area.
- No opportunities for recreational beach development.
- Potential for existing stone material re-use.
- Limited site restoration/habitat improvement.

Figure 2.2 Alternative 2

2.3 Alternative 3: Landward Beach Development

Under this alternative, a new shoreline protection system will be provided: stone revetments and beach cells. The cells will be provided in selected areas by land excavation and placement of beach fill material.

A brief summary of Alternative 3 is provided below:

- Improved lake views.
- Beach recreational opportunities.
- Improved shoreline access points.
- Might be designed with different beach materials (pending future studies results).
- New Lakeshore Boulevard alignment.
- Potential for existing stone material re-use.
- Reduced developable land area.
- Site restoration/habitat improvement opportunities.

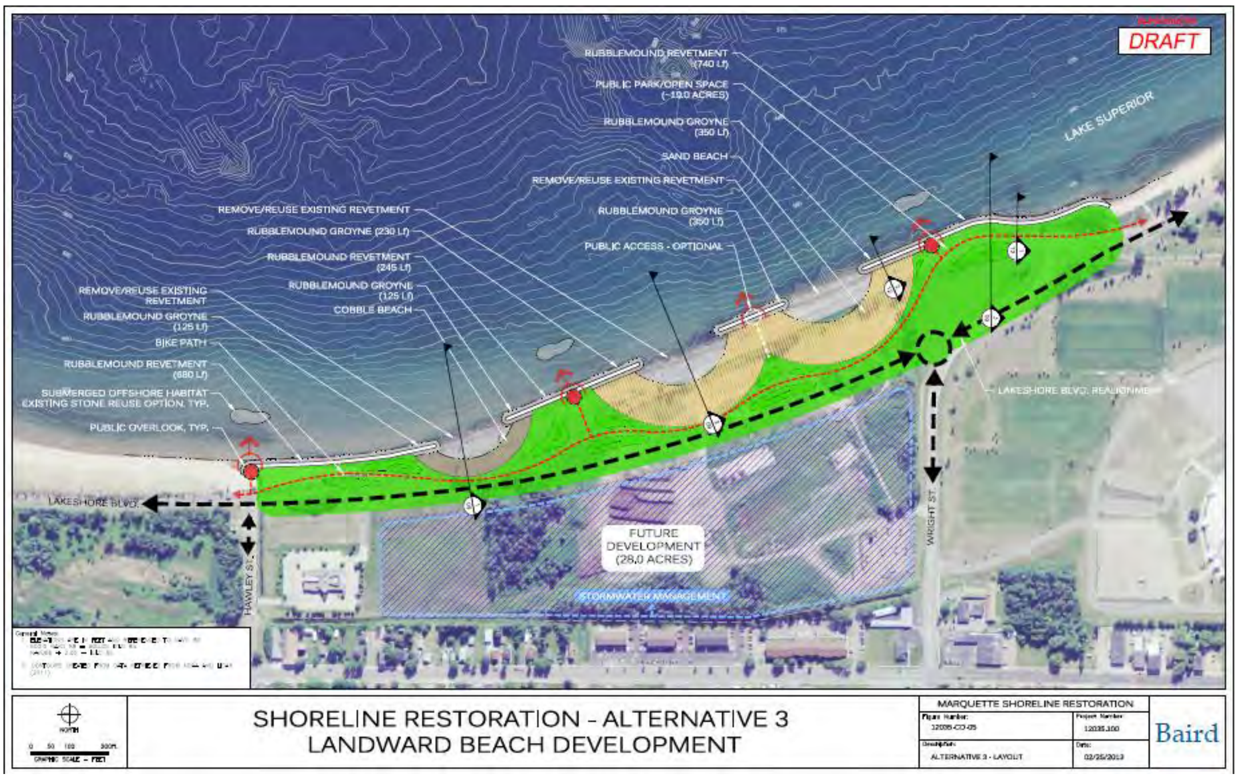


Figure 2.3 Alternative 3

2.4 Alternative 4: Nearshore Breakwaters Beach Development

Under this alternative, a series of nearshore breakwaters will be provided, along with a series of nearshore parallel breakwaters to stabilize the beach fill material.

A brief summary of Alternative 4 is provided below.

- Continuous beach area with linear connection.
- Partial lake view obstructions.
- Multiple beach recreational opportunities.
- Improved shoreline access points.
- New Lakeshore Boulevard alignment.
- May be designed with different beach materials (pending future studies results).
- Potential for existing stone material re-use.
- Site restoration/habitat improvement opportunities.

Figure 2.4 Alternative 4

2.5 Alternative 5: Stone Groins Beach Development

Under this alternative, a series of shoreline perpendicular stone groin structures are used to create a series of beach cells that run the entire length of the project area. A brief summary of Alternative 5 is provided below.

- Continuous beach area with linear connection.
- Improved lake views.

- Beach recreational opportunities.
- Improved shoreline access points
- New Lakeshore Boulevard alignment.
- Might be designed with different beach materials (pending future studies results).
- Potential for existing stone material re-use.
- Site restoration/habitat improvement opportunities.

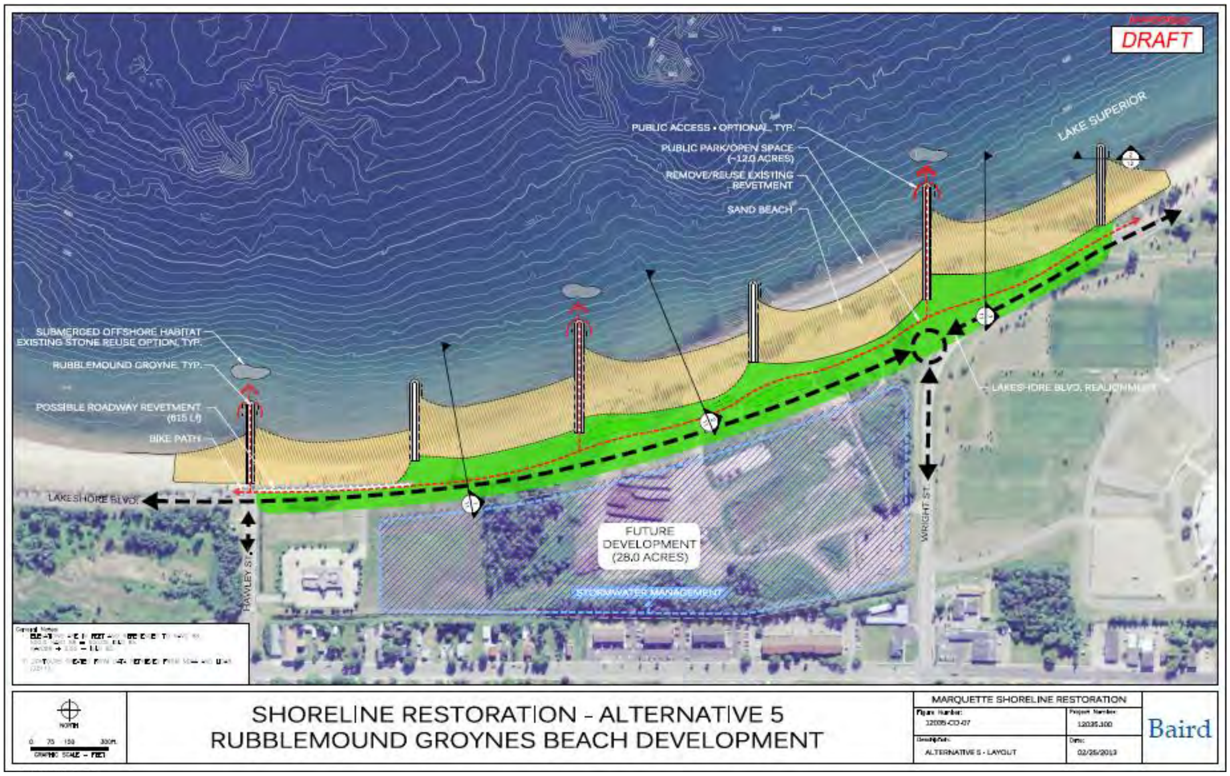


Figure 2.5 Alternative 5

The alternative plan views and details are included in Appendix A.

2.6 Preliminary Quantities and Costs

Preliminary construction cost estimates have been developed for the proposed coastal structures and beach fill for each alternative presented. The material quantities were estimated based on the conceptual design cross-sections developed. Anticipated unit prices for construction have been estimated based on a review of unit prices from contractor bids for various projects in the Upper Peninsula, as well as Baird's in-house cost database and the City of Marquette supplied information.

Table 2.1 summarizes the preliminary cost estimates for the alternatives. Estimates of probable construction cost are included in Appendix B.

Table 2.1 Estimated Construction Costs

Alternative	Estimated Cost ($M)
1	1.8
2	5.4
3	9.8
4	11.3
5	12.1

2.7 Project Meetings

Project meetings were conducted on February 5; March 26 and June 4, 2013. Baird attended the February and March meetings, where the developed alternatives were presented and discussed. There was no consensus reached on the locally preferred alternative. It is expected that this will be selected during future project phases.

3.0 CONCLUSIONS AND RECOMMENDATIONS

Five conceptual alternatives have been formulated for the Lakeshore Boulevard Redesign and Lake Superior Shoreline Restoration Project-Phase I. Alternatives 1, 3, 4 and 5 show that the Lakeshore Boulevard realignment will be further inland compared to existing location. This additional separation from the lake, plus the proposed coastal/shoreline improvements have been conceptually designed to reduce wave overtopping, flooding and overspray on the roadway during both winter and summer months. Alternative 2 maintains the current road alignment.

The preliminary estimated construction costs range between $1.8M (Alternative 1) and $12.1M (Alternative 5). The estimated costs vary based on the amount of in-water fill and the offshore extents of the coastal structures.

The local community, along with the City and the LSWP, will select one alternative that provides the best combination of advantages, performance and cost. The selected preferred alternative will be the starting point for future studies including permitting, preliminary design, detailed design development, and final design.

It is important to note that this conceptual study for shoreline alternatives is preliminary in nature. Following the selection of a preferred alternative, future studies should be undertaken to fully understand the complex coastal processes in the project area, and to determine the ultimate feasibility of the proposed shoreline enhancements. Potentially, the following tasks might be included in the next project phase:

- Data collection (topographic and bathymetric surveys, soil sampling, jet probes, stone survey);
- Detailed coastal analysis (wind waves, water levels, sediment transport, analysis of potential project impacts);
- Application of empirical and numerical models to assess the performance of the preferred alternative for a range of wave conditions and water levels;
- Pre-permit regulatory coordination meeting to define the permitting requirements.

It is also recommended that the following land-based improvements be included in future project phases, after the preferred alternative has been identified:

- Parking for park and beach users;
- Plantings and landscaping;
- Bicycle and pedestrian paths; and
- Designated public access points and signage.

4.0 REFERENCES

Baird (September 2011). Pictured Rocks, MI. Conceptual Solutions for the Sand Point Revetment and Beach Restoration.

USACE St. Paul District (June 1976). Section 111 Detailed Project Report on Shore Damage for Presque Isle Harbor, MI.

R.J. Dean and R.A. Dalrymple (2002). Coastal processes with engineering applications. Cambridge University Press.

Beckett & Raedar (2004). Community Master Plan, City of Marquette.

APPENDIX A

CONCEPTUAL DRAWINGS AND DETAILS

General Notes:
1. ELEVATIONS ARE IN FEET AND REFERENCED TO NAVD 88.
600.0 NAVD 88 = 600.05 IGLD 85.
NAVD88 + 0.05 = IGLD 85
2. CONTOURS CREATED FROM DATA RETRIEVED FROM NOAA AND LIDAR (2011).

NORTH

0 75 150 300ft.
GRAPHIC SCALE – FEET

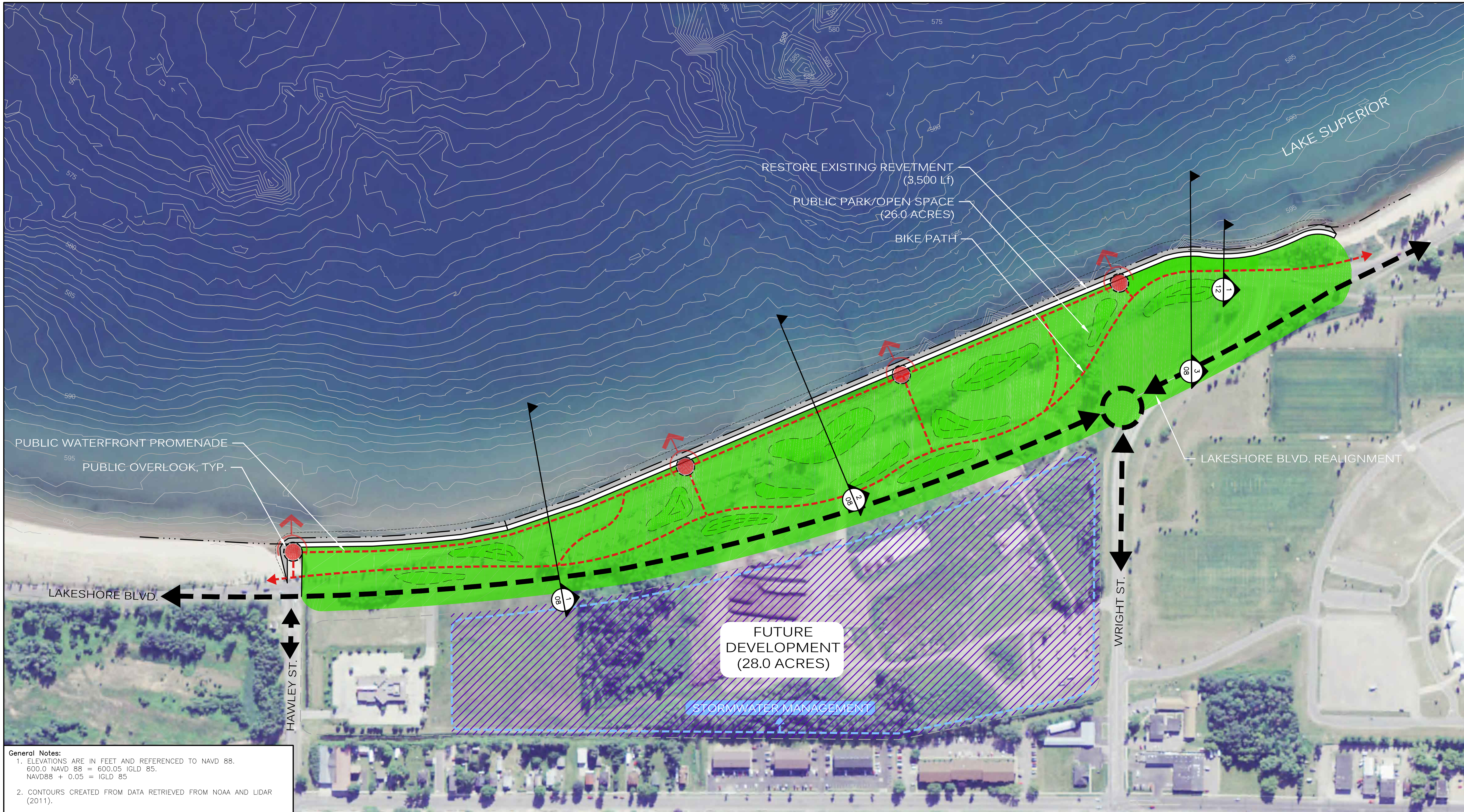
SHORELINE RESTORATION - ALTERNATIVE 1
REMOVE EXISTING REVETMENT

MARQUETTE SHORELINE RESTORATION	
Figure Number: 12035-CD-03	Project Number: 12035.100
Description: ALTERNATIVE 1 - LAYOUT	Date: 02/25/2013

Baird

P:\12035.100 LAKE SUPERIOR SHORELINE RESTORATION MARQUETTE MI\H-CADD\WORKING\DWG\2013-01-25 (PLAN - ALT 1).DWG

Date Plotted: 6/28/2013 1:41:00 PM



General Notes:

1. ELEVATIONS ARE IN FEET AND REFERENCED TO NAVD 88.
   600.0 NAVD 88 = 600.05 IGLD 85.
   NAVD88 + 0.05 = IGLD 85
2. CONTOURS CREATED FROM DATA RETRIEVED FROM NOAA AND LIDAR (2011).

NORTH

0 75 150 300ft.

GRAPHIC SCALE – FEET

SHORELINE RESTORATION - ALTERNATIVE 2
RESTORE EXISTING REVETMENT

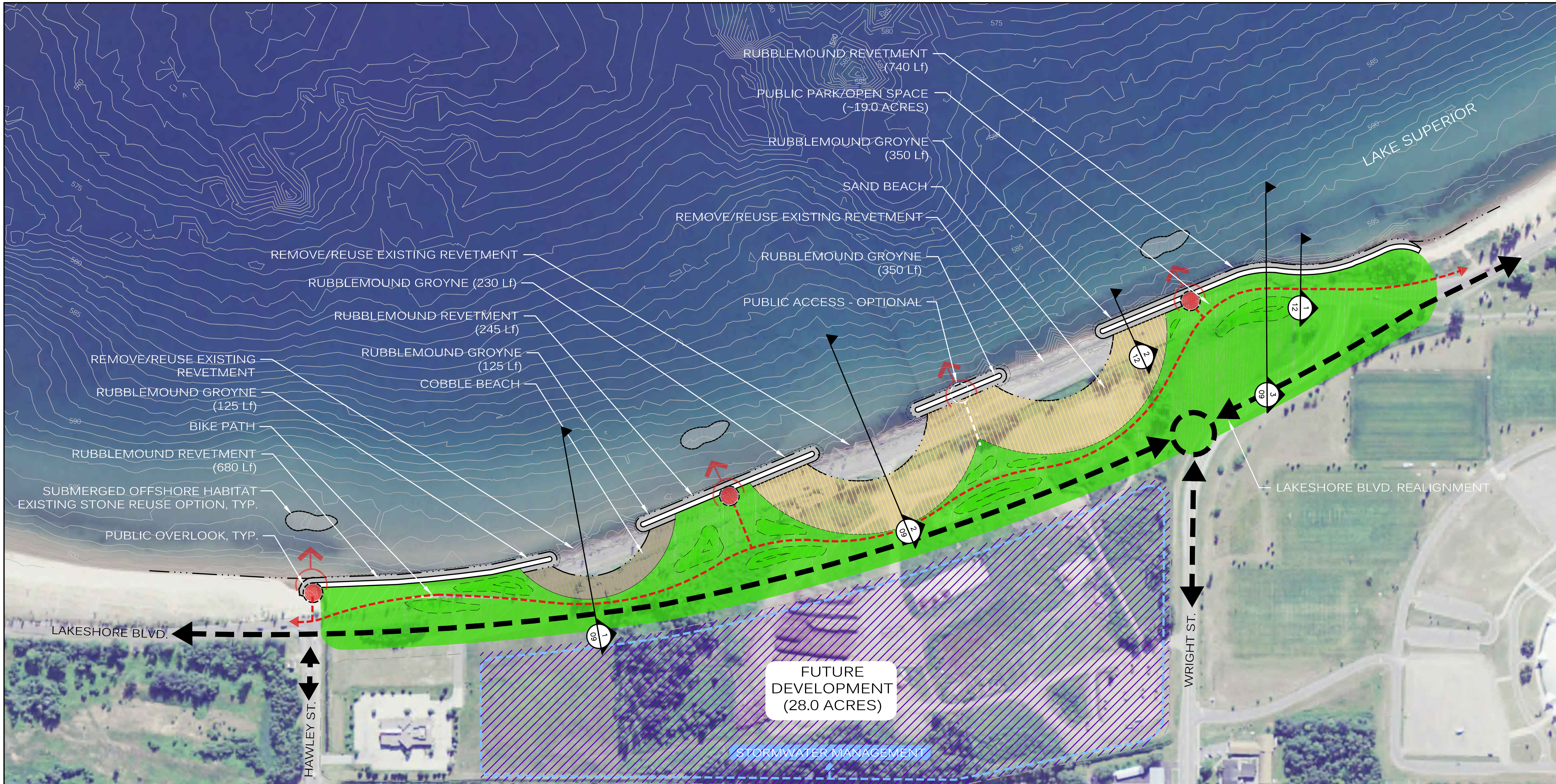
MARQUETTE SHORELINE RESTORATION

Figure Number:	Project Number:
12035-CD-04	12035.100
Description:	Date:
ALTERNATIVE 2 - LAYOUT	02/25/2013

Baird

P:\12035.100 LAKE SUPERIOR SHORELINE RESTORATION MARQUETTE MI\H-CADD\WORKING\DWG\2013-01-25 (PLAN - ALT 2).DWG

Date Plotted: 6/28/2013 1:41:55 PM



General Notes:

1. ELEVATIONS ARE IN FEET AND REFERENCED TO NAVD 88.
   600.0 NAVD 88 = 600.05 IGLD 85.
   NAVD88 + 0.05 = IGLD 85
2. CONTOURS CREATED FROM DATA RETRIEVED FROM NOAA AND LIDAR (2011).

NORTH

0 50 100 200ft.

GRAPHIC SCALE – FEET

SHORELINE RESTORATION - ALTERNATIVE 3
LANDWARD BEACH DEVELOPMENT

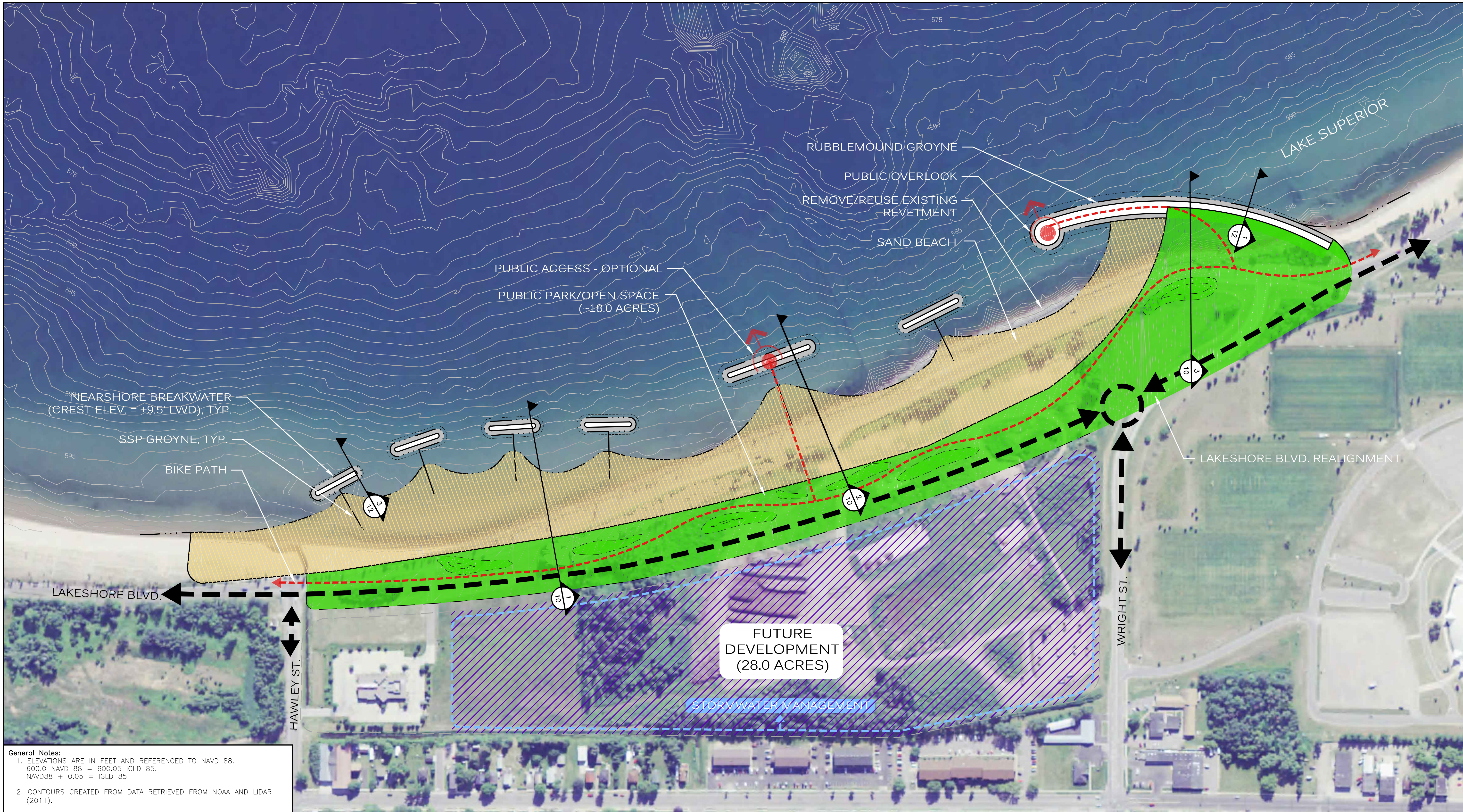
MARQUETTE SHORELINE RESTORATION

Figure Number:	Project Number:
12035-CD-05	12035.100
Description:	Date:
ALTERNATIVE 3 - LAYOUT	02/25/2013

Baird

P:\12035.100 LAKE SUPERIOR SHORELINE RESTORATION MARQUETTE MI\H-CADD\WORKING\DWG\2013-01-25 (PLAN - ALT 3).DWG

Date Plotted: 6/28/2013 1:42:53 PM



General Notes:

1. ELEVATIONS ARE IN FEET AND REFERENCED TO NAVD 88.
   600.0 NAVD 88 = 600.05 IGLD 85.
   NAVD88 + 0.05 = IGLD 85
2. CONTOURS CREATED FROM DATA RETRIEVED FROM NOAA AND LIDAR (2011).

NORTH

0 75 150 300ft.

GRAPHIC SCALE – FEET

SHORELINE RESTORATION - ALTERNATIVE 4
NEARSHORE BREAKWATER BEACH DEVELOPMENT

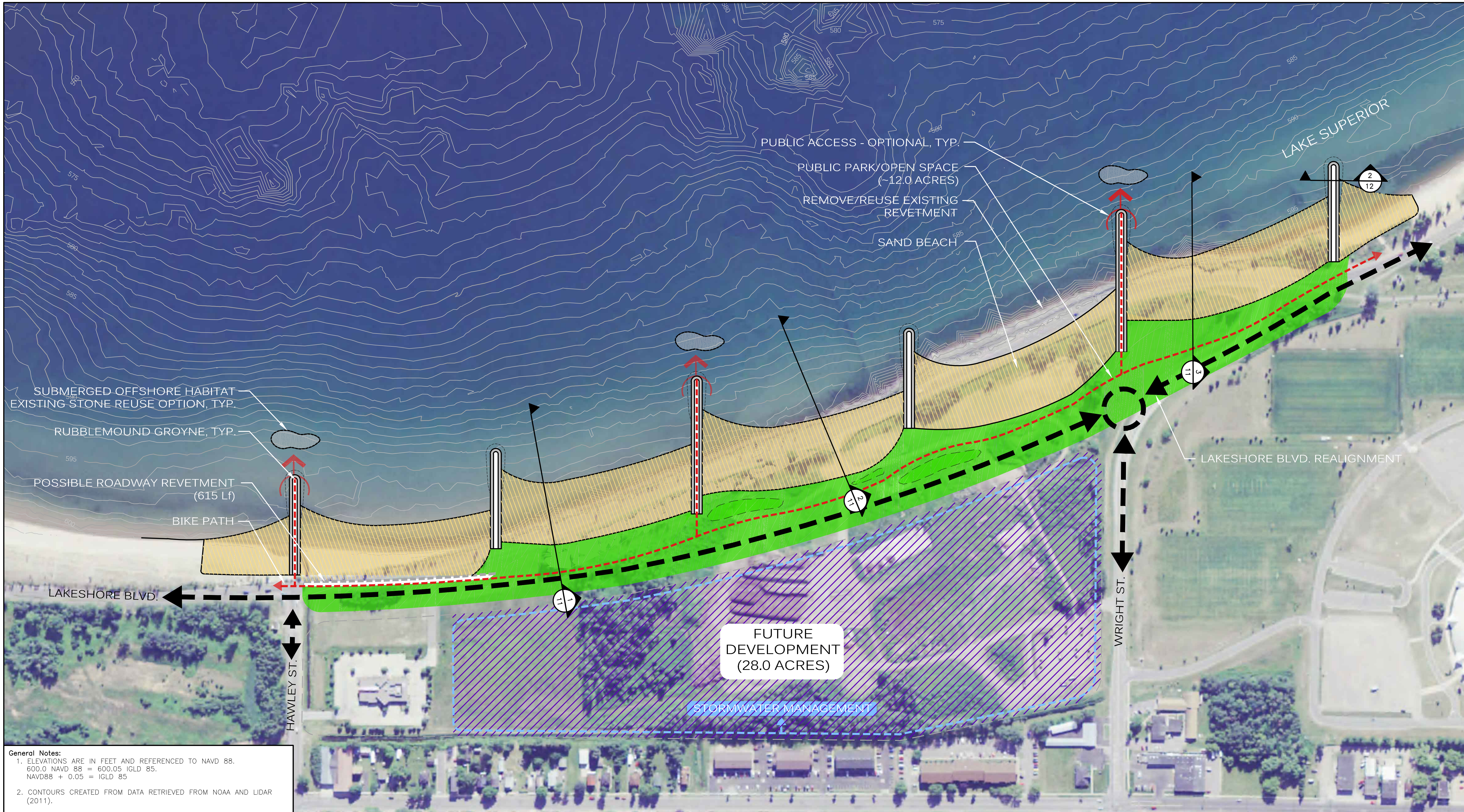
MARQUETTE SHORELINE RESTORATION

Figure Number: 12035-CD-06	Project Number: 12035.100
Description: ALTERNATIVE 4 - LAYOUT	Date: 02/25/2013

Baird

P:\12035.100 LAKE SUPERIOR SHORELINE RESTORATION MARQUETTE MI\H-CADD\WORKING\DWG\2013-01-25 (PLAN - ALT 4).DWG

Date Plotted: 6/28/2013 1:43:35 PM



General Notes:
1. ELEVATIONS ARE IN FEET AND REFERENCED TO NAVD 88.
600.0 NAVD 88 = 600.05 IGLD 85.
NAVD88 + 0.05 = IGLD 85
2. CONTOURS CREATED FROM DATA RETRIEVED FROM NOAA AND LIDAR (2011).

NORTH

0 75 150 300ft.
GRAPHIC SCALE – FEET

SHORELINE RESTORATION - ALTERNATIVE 5
RUBBLEMOUND GROYNES BEACH DEVELOPMENT

MARQUETTE SHORELINE RESTORATION

Figure Number:	Project Number:
12035-CD-07	12035.100
Description:	Date:
ALTERNATIVE 5 - LAYOUT	02/25/2013

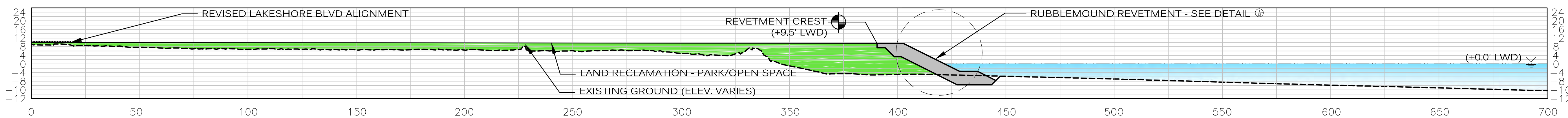
Baird

P:\12035.100 LAKE SUPERIOR SHORELINE RESTORATION MARQUETTE MI\H-CADD\WORKING\DWG\2013-01-25 (PLAN – ALT 5).DWG

Date Plotted: 6/28/2013 1:45:21 PM

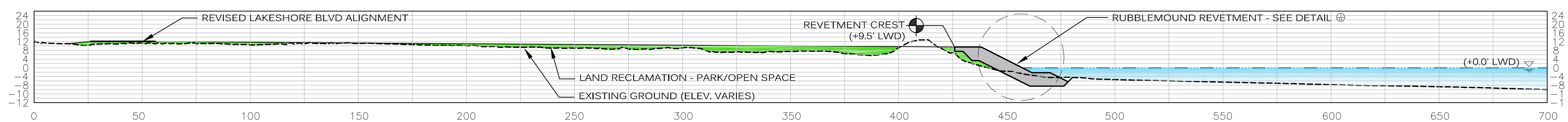
1/08 CONCEPTUAL CROSS SECTION - ALTERNATIVE 2 PROFILE (1)

0 12.5 25 50ft.
GRAPHIC SCALE – FEET



2/08 CONCEPTUAL CROSS SECTION - ALTERNATIVE 2 PROFILE (2)

0 12.5 25 50ft.
GRAPHIC SCALE – FEET



3/08 CONCEPTUAL CROSS SECTION - ALTERNATIVE 2 PROFILE (3)

0 12.5 25 50ft.
GRAPHIC SCALE – FEET

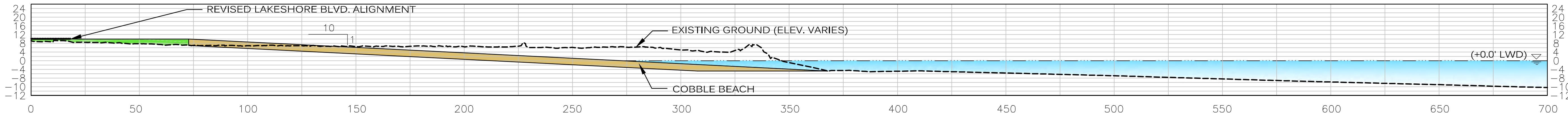
General Notes:
1. ELEVATIONS ARE IN FEET AND REFERENCED TO (LWD)IGLD 85. 0.0 (LWD)IGLD 85 = 601.1 IGLD 85.
2. CONTOURS CREATED FROM DATA RETRIEVED FROM NOAA AND LIDAR (2011).
3. STRUCTURAL DETAILS TO BE REFINED IN FUTURE DESIGN PHASES.
4. ALL DIMENSIONS ARE IN FEET.

SHORELINE RESTORATION - CROSS SECTIONS
MARQUETTE, MICHIGAN

MARQUETTE SHORELINE RESTORATION

Figure Number: 12035-CD-08	Project Number: 12035.100
Description: ALTERNATIVE 2 - SECTIONS	Date: 02/25/2013

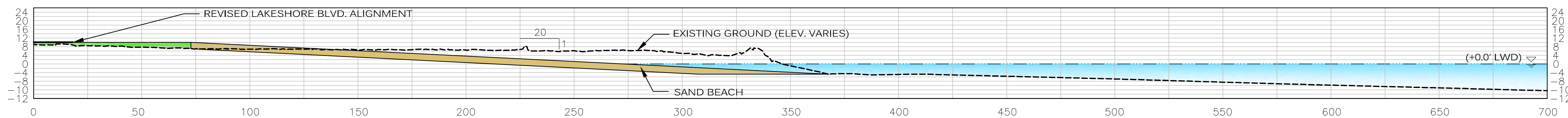
Baird



CONCEPTUAL CROSS SECTION - ALTERNATIVE 3 PROFILE (1)

1 / 09

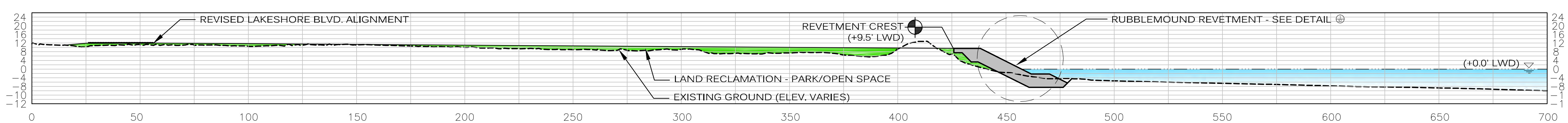
0 12.5 25 50ft.
GRAPHIC SCALE – FEET



CONCEPTUAL CROSS SECTION - ALTERNATIVE 3 PROFILE (2)

2 / 09

0 12.5 25 50ft.
GRAPHIC SCALE – FEET



CONCEPTUAL CROSS SECTION - ALTERNATIVE 3 PROFILE (3)

3 / 09

0 12.5 25 50ft.
GRAPHIC SCALE – FEET

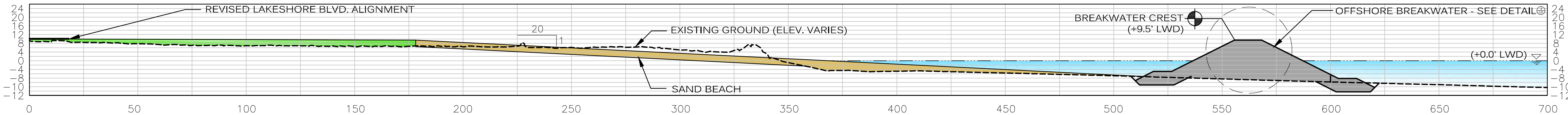
General Notes:

1. ELEVATIONS ARE IN FEET AND REFERENCED TO (LWD)IGLD 85. 0.0 (LWD)IGLD 85 = 601.1 IGLD 85.
2. CONTOURS CREATED FROM DATA RETRIEVED FROM NOAA AND LIDAR (2011).
3. STRUCTURAL DETAILS TO BE REFINED IN FUTURE DESIGN PHASES.
4. ALL DIMENSIONS ARE IN FEET.

SHORELINE RESTORATION - CROSS SECTIONS
MARQUETTE, MICHIGAN

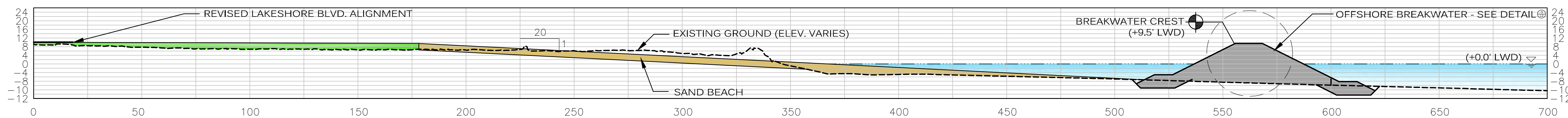
MARQUETTE SHORELINE RESTORATION	
Figure Number: 12035-CD-09	Project Number: 12035.100
Description: ALTERNATIVE 3 - SECTIONS	Date: 02/25/2013

Baird



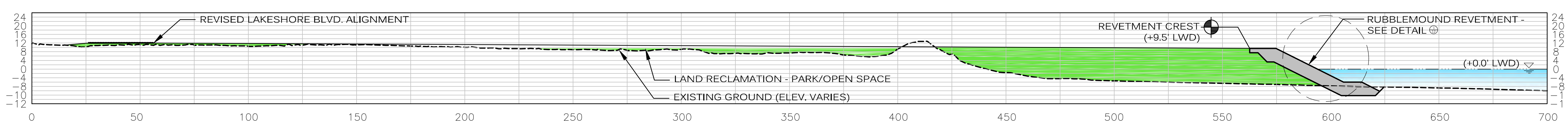
1/10 CONCEPTUAL CROSS SECTION - ALTERNATIVE 4 PROFILE (1)

0 12.5 25 50ft.
GRAPHIC SCALE – FEET



2/10 CONCEPTUAL CROSS SECTION - ALTERNATIVE 4 PROFILE (2)

0 12.5 25 50ft.
GRAPHIC SCALE – FEET



3/10 CONCEPTUAL CROSS SECTION - ALTERNATIVE 4 PROFILE (3)

0 12.5 25 50ft.
GRAPHIC SCALE – FEET

General Notes:

1. ELEVATIONS ARE IN FEET AND REFERENCED TO (LWD)IGLD 85. 0.0 (LWD)IGLD 85 = 601.1 IGLD 85.
2. CONTOURS CREATED FROM DATA RETRIEVED FROM NOAA AND LIDAR (2011).
3. STRUCTURAL DETAILS TO BE REFINED IN FUTURE DESIGN PHASES.
4. ALL DIMENSIONS ARE IN FEET.

SHORELINE RESTORATION - CROSS SECTIONS
MARQUETTE, MICHIGAN

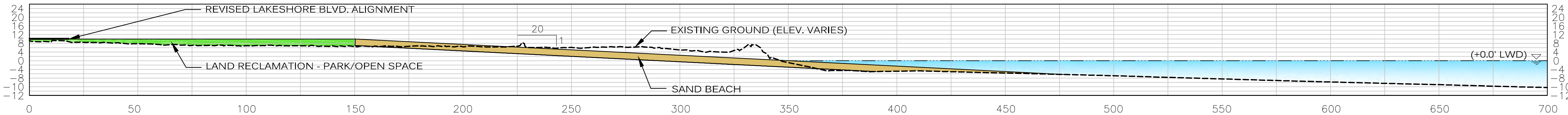
MARQUETTE SHORELINE RESTORATION

Figure Number: 12035-CD-10	Project Number: 12035.100
Description: ALTERNATIVE 4 - SECTIONS	Date: 02/25/2013

Baird

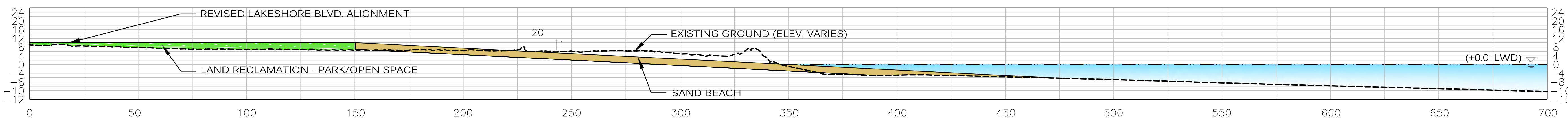
P:\12035.100 LAKE SUPERIOR SHORELINE RESTORATION MARQUETTE MI\H-CADD\WORKING\DWG\2013-01-24 (SECTIONS -ALT 4).DWG

Date Plotted: 6/28/2013 1:46:42 PM



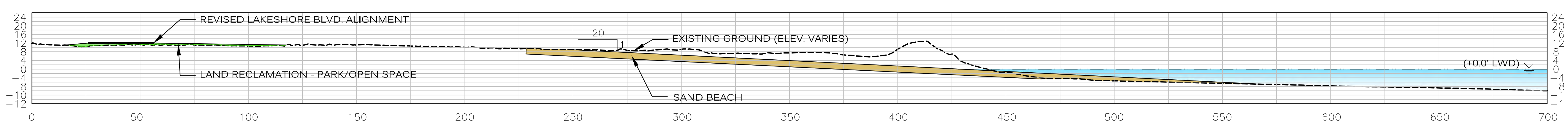
1/11 CONCEPTUAL CROSS SECTION - ALTERNATIVE 5 PROFILE (1)

0 12.5 25 50ft.
GRAPHIC SCALE – FEET



2/11 CONCEPTUAL CROSS SECTION - ALTERNATIVE 5 PROFILE (2)

0 12.5 25 50ft.
GRAPHIC SCALE – FEET



3/11 CONCEPTUAL CROSS SECTION - ALTERNATIVE 5 PROFILE (3)

0 12.5 25 50ft.
GRAPHIC SCALE – FEET

General Notes:
1. ELEVATIONS ARE IN FEET AND REFERENCED TO (LWD)IGLD 85. 0.0 (LWD)IGLD 85 = 601.1 IGLD 85.
2. CONTOURS CREATED FROM DATA RETRIEVED FROM NOAA AND LIDAR (2011).
3. STRUCTURAL DETAILS TO BE REFINED IN FUTURE DESIGN PHASES.
4. ALL DIMENSIONS ARE IN FEET.

SHORELINE RESTORATION - CROSS SECTIONS
MARQUETTE, MICHIGAN

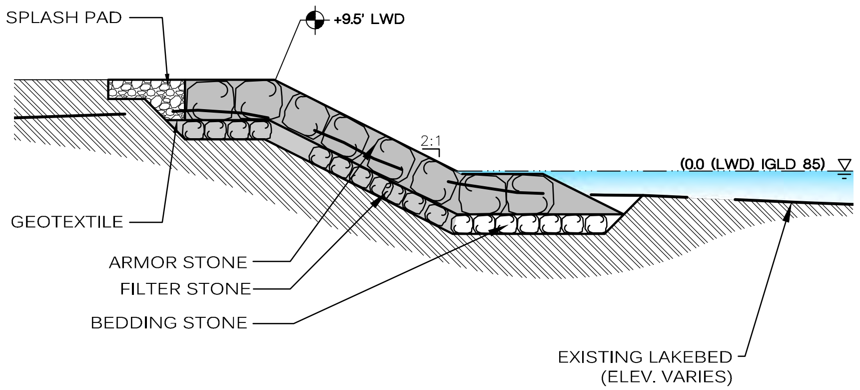
MARQUETTE SHORELINE RESTORATION

Figure Number: 12035-CD-11	Project Number: 12035.100
Description: ALTERNATIVE 5 - SECTIONS	Date: 02/25/2013

Baird

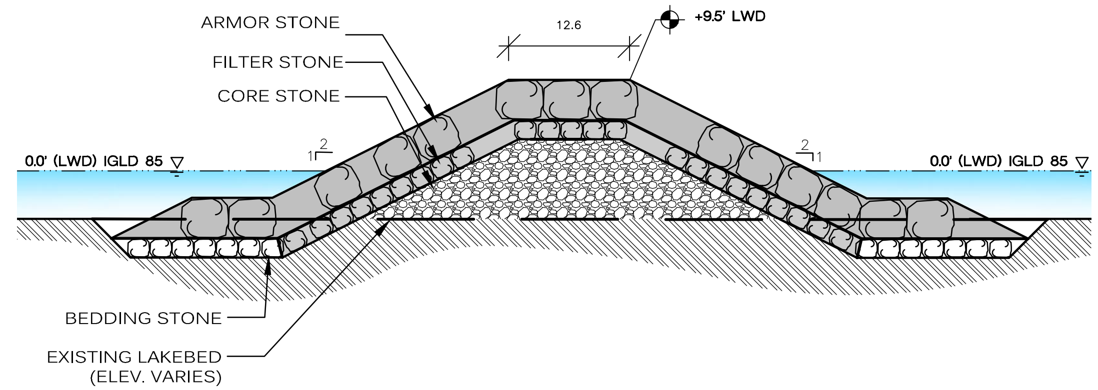
P:\12035.100 LAKE SUPERIOR SHORELINE RESTORATION MARQUETTE MI\H-CADD\WORKING\DWG\2013-01-24 (SECTIONS -ALT 5).DWG

Date Plotted: 6/28/2013 1:47:07 PM



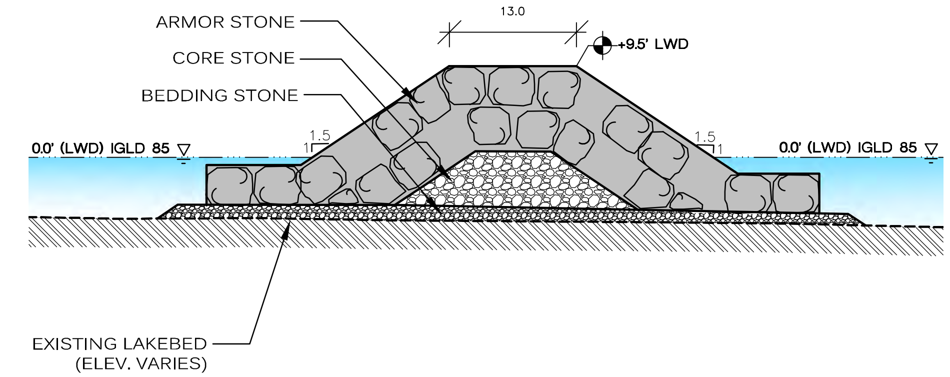
1/12 CONCEPTUAL CROSS SECTION
RUBBLEMOUND REVETMENT

0 5 10 20ft.
GRAPHIC SCALE - FEET



2/12 CONCEPTUAL CROSS SECTION
RUBBLEMOUND GROYNE

0 5 10 20ft.
GRAPHIC SCALE - FEET



3/12 CONCEPTUAL CROSS SECTION
RUBBLEMOUND BREAKWATER

0 5 10 20ft.
GRAPHIC SCALE - FEET


LANDWARD BEACH DEVELOPMENT

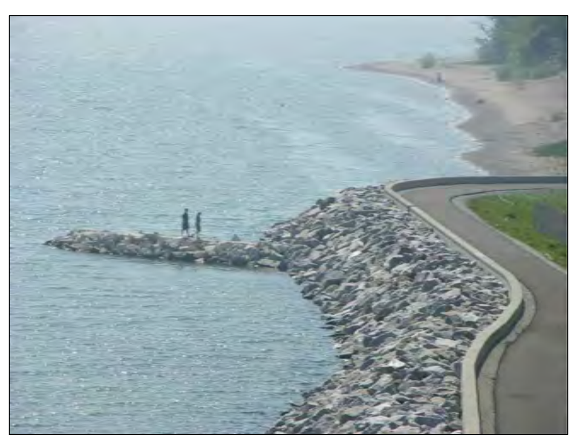

RUBBLEMOUND GROYNES


NEARSHORE BREAKWATERS (LOW CRESTED)

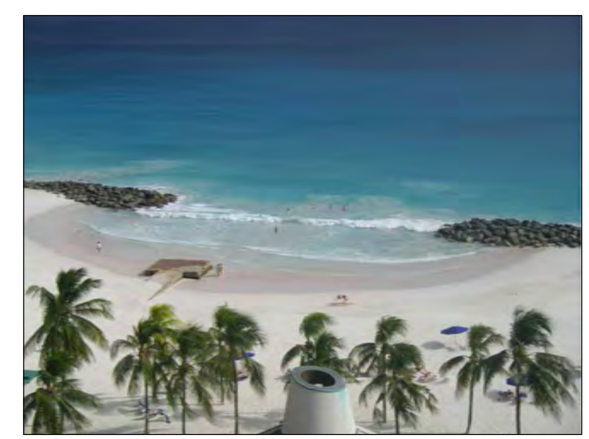

NEARSHORE BREAKWATERS (EMERGENT) WITH SSP GROYNE


OFFSHORE BREAKWATERS (EMERGENT)


RUBBLEMOUND REVETMENT


RUBBLEMOUND REVETMENT WITH LAKE SHORE PATH


NEARSHORE BREAKWATERS (EMERGENT) WITH SSP GROYNE


LANDWARD BEACH DEVELOPMENT


COBBLE BEACH MATERIAL

General Notes:
1. ELEVATIONS ARE IN FEET AND REFERENCED TO (LWD)IGLD 85. 0.0 (LWD)IGLD 85 = 601.1 IGLD 85.
2. CONTOURS CREATED FROM DATA RETRIEVED FROM NOAA AND LIDAR (2011).
3. STRUCTURAL DETAILS TO BE REFINED IN FUTURE DESIGN PHASES.
4. ALL DIMENSIONS ARE IN FEET.

SHORELINE RESTORATION - CROSS SECTIONS
MARQUETTE, MICHIGAN

MARQUETTE SHORELINE RESTORATION	
Figure Number: 12035-CD-12	Project Number: 12035.100
Description: DESIGN DETAILS/IMAGES	Date: 02/25/2013

Baird

P:\12035.100 LAKE SUPERIOR SHORELINE RESTORATION MARQUETTE MI\H-CADD\WORKING\DWG\2013-01-24 (DETAILS & IMAGES).DWG

Date Plotted: 6/28/2013 1:48:29 PM

APPENDIX B

PRELIMINARY CONSTRUCTION COST ESTIMATES

Marquette Shoreline Restoration Study

Baird

ALTERNATIVE 1

Project No 12035.100
Date: 02/27/2013
DRAFT

Itemized Statement of Comparative Construction Costs
Conceptual Design Phase

Item	Unit	Quantity	Unit Cost	Extension	Sub Total
Mobilization	Allow	1	$50,000	$50,000	$50,000
Site Preparation					
Excavation Revetment	CY	39,000	$15	$585,000	
Load and Haul Excavated Material-Stone Mix *(~4 Mile Round Trip)*	CY	39,000	$15	$585,000	
Grading	CY	3,200	$12	$38,400	
Seeding/Erosion Control	MSF	175	$42	$7,350	$1,215,750

Sub Total	$1,265,750
Contingency 25%	$316,438
Total	$1,582,188
Professional Services 15%	$237,328
Alternative 1 Total	$1,819,516

Marquette Shoreline Restoration Study

Baird

ALTERNATIVE 2

Project No 12035.100
Date: 02/27/2013

Itemized Statement of Comparative Construction Costs
Conceptual Design Phase

Item	Unit	Quantity	Unit Cost	Extension	Sub Total
Mobilization	Allow	1	$100,000	$100,000	$100,000
Site Preparation					
Excavation Revetment and Sort Stone	CY	39,000	$15	$585,000	
Grading	CY	3,200	$12	$38,400	$623,400
(1) Rubblemound Revetment (3500 Lf)					
Armor Stone	TON	35,000	$65	$2,275,000	
Filter Stone	TON	12,600	$55	$693,000	
Bedding Stone	TON	6,800	$50	$340,000	
Splash Pad Stone	TON	4,900	$50	$245,000	
Geotextile Fabric	SY	13,600	$7	$95,200	
Total Revetment Cost-25% (Reuse of Existing Revetment Stone)				$3,648,200	$2,736,150
Public Park/Open Space Fill					
General Fill	CY	25,000	$7	$175,000	
Top Soil (6")	CY	18,000	$6	$108,000	
Seeding/Erosion Control	MSF	1,000	$42	$42,000	$325,000

Sub Total	$3,784,550
Contingency 25%	$946,138
Total	$4,730,688
Professional Services 15%	$709,603
Alternative 2 Total	$5,440,291

Marquette Shoreline Restoration Study

Baird

ALTERNATIVE 3

Project No 12035.100
Date: 02/27/2013

Itemized Statement of Comparative Construction Costs
Conceptual Design Phase

Item	Unit	Quantity	Unit Cost	Extension	Sub Total
Mobilization	Allow	1	$150,000	$150,000	$150,000
Site Preparation					
Excavation Revetment and Sort Stone	CY	39,000	$15	$585,000	
Grading for Beach Fill	CY	76,000	$12	$912,000	
Load and Haul Excavated Material-Soil Mix *(~4 Mile Round Trip)*	CY	61,400	$5	$307,000	$1,804,000
Beach Fill					
Initial Beach Fill Placement *(Cobble)*	CY	7,000	$35	$245,000	
Initial Beach Fill Placement *(Sand)*	CY	39,000	$15	$585,000	$830,000
Public Park/Open Space Fill					
General Fill *(Sort Grading Material and Reuse)*	CY	4,100	$7	$28,700	
Top Soil (6") *(Sort Grading Material and Reuse)*	CY	10,500	$5	$52,500	
Seeding/Erosion Control	MSF	600	$42	$25,200	$106,400
(2) Rubblemound Revetments (1665 Lf)					
Armor Stone	TON	16,500	$65	$1,072,500	
Filter Stone	TON	6,000	$55	$330,000	
Bedding Stone	TON	3,200	$50	$160,000	
Splash Pad Stone	TON	2,300	$50	$115,000	
Geotextile Fabric	SY	6,474	$7	$45,318	
Total Revetment Cost-25% (Reuse of Existing Revetment Stone)				$1,722,818	$1,292,114
(5) Rubblemound Groynes (1,180 Lf)					
Armor Stone	TON	25,000	$75	$1,875,000	
Filter Stone	TON	8,500	$65	$552,500	
Core Stone	TON	14,600	$55	$803,000	
Bedding Stone	TON	4,300	$55	$236,500	
Total Revetment Cost-25% (Reuse of Existing Revetment Stone)				$3,467,000	$2,600,250
				Sub Total	$6,782,764
				Contingency 25%	$1,695,691
				Total	$8,478,454
				Professional Services 15%	$1,271,768
				Alternative 3 Total	$9,750,223

Marquette Shoreline Restoration Study

Baird

ALTERNATIVE 4

Project No 12035.100

Date: 02/27/2013

Itemized Statement of Comparative Construction Costs
Conceptual Design Phase

Item	Unit	Quantity	Unit Cost	Extension	Sub Total
Mobilization	Allow	1	$200,000	$200,000	$200,000
Site Preparation					
Excavation Revetment and Sort Stone	CY	39,000	$15	$585,000	
Grading for Beach Fill	CY	3,000	$12	$36,000	$621,000
Beach Fill					
Initial Beach Fill Placement *(Sand)*	CY	133,000	$15	$1,995,000	$1,995,000
Public Park/Open Space Fill					
General Fill	CY	17,000	$7	$119,000	
Top Soil (6")	CY	12,000	$6	$72,000	
Seeding/Erosion Control	MSF	700	$42	$29,400	$220,400
(1) Rubblemound Revetment (550 Lf)					
Armor Stone	TON	5,500	$65	$357,500	
Filter Stone	TON	2,000	$55	$110,000	
Bedding Stone	TON	1,000	$50	$50,000	
Splash Pad Stone	TON	800	$50	$40,000	
Geotextile Fabric	SY	2,100	$7	$14,700	
Total Revetment Cost-25% (Reuse of Existing Revetment Stone)				$572,200	$429,150
(1) Rubblemound Groyne (450 Lf)					
Armor Stone	TON	9,500	$75	$712,500	
Filter Stone	TON	3,200	$65	$208,000	
Core Stone	TON	5,600	$55	$308,000	
Bedding Stone	TON	1,600	$55	$88,000	
Total Revetment Cost-25% (Reuse of Existing Revetment Stone)				$1,316,500	$987,375
(6) Nearshore Rubblemound Breakwaters (1,250 Lf)					
Armor Stone	TON	33,000	$75	$2,475,000	
Core Stone	TON	6,600	$55	$363,000	
Bedding Stone	TON	6,500	$55	$357,500	
Steel Sheet Pile (SSP) Groyne	LF	900	$1,500	$1,350,000	
Total Revetment Cost-25% (Reuse of Existing Revetment Stone)				$4,545,500	$3,409,125
				Sub Total	$7,862,050
				Contingency 25%	$1,965,513
				Total	$9,827,563
				Professional Services 15%	$1,474,134
				Alternative 4 Total	$11,301,697

Marquette Shoreline Restoration Study

Baird

ALTERNATIVE 5

Project No 12035.100

Date: 02/27/2013

Itemized Statement of Comparative Construction Costs
Conceptual Design Phase

Item	Unit	Quantity	Unit Cost	Extension	Sub Total
Mobilization	Allow	1	$250,000	$250,000	$250,000
Site Preparation					
Excavation Revetment and Sort Stone	CY	39,000	$15	$585,000	
Grading for Beach Fill	CY	18,000	$12	$216,000	$801,000
Beach Fill					
Initial Beach Fill Placement *(Sand)*	CY	146,000	$15	$2,190,000	$2,190,000
Public Park/Open Space Fill					
General Fill	CY	17,000	$7	$119,000	
Top Soil (6")	CY	7,000	$6	$42,000	
Seeding/Erosion Control	MSF	400	$42	$16,800	$177,800
(6) Rubbelmound Groyne (2200 Lf)					
Armor Stone	TON	46,000	$75	$3,450,000	
Filter Stone	TON	16,000	$65	$1,040,000	
Core Stone	TON	27,000	$55	$1,485,000	
Bedding Stone	TON	8,000	$55	$440,000	
Total Revetment Cost-25% (Reuse of Existing Revetment Stone)				$6,415,000	$4,811,250
Roadway Revetment (615 Lf)					
Armor Stone	TON	3,000	$65	$195,000	
Filter Stone	TON	1,100	$55	$60,500	
Bedding Stone	TON	600	$50	$30,000	
Splash Pad Stone	TON	850	$50	$42,500	
Geotextile Fabric	SY	1,200	$7	$8,400	
Total Revetment Cost-25% (Reuse of Existing Revetment Stone)				$336,400	$252,300

Sub Total	$8,482,350
Contingency 25%	$2,120,588
Total	$10,602,938
Professional Services 15%	$1,590,441
Alternative 5 Total	$12,193,378