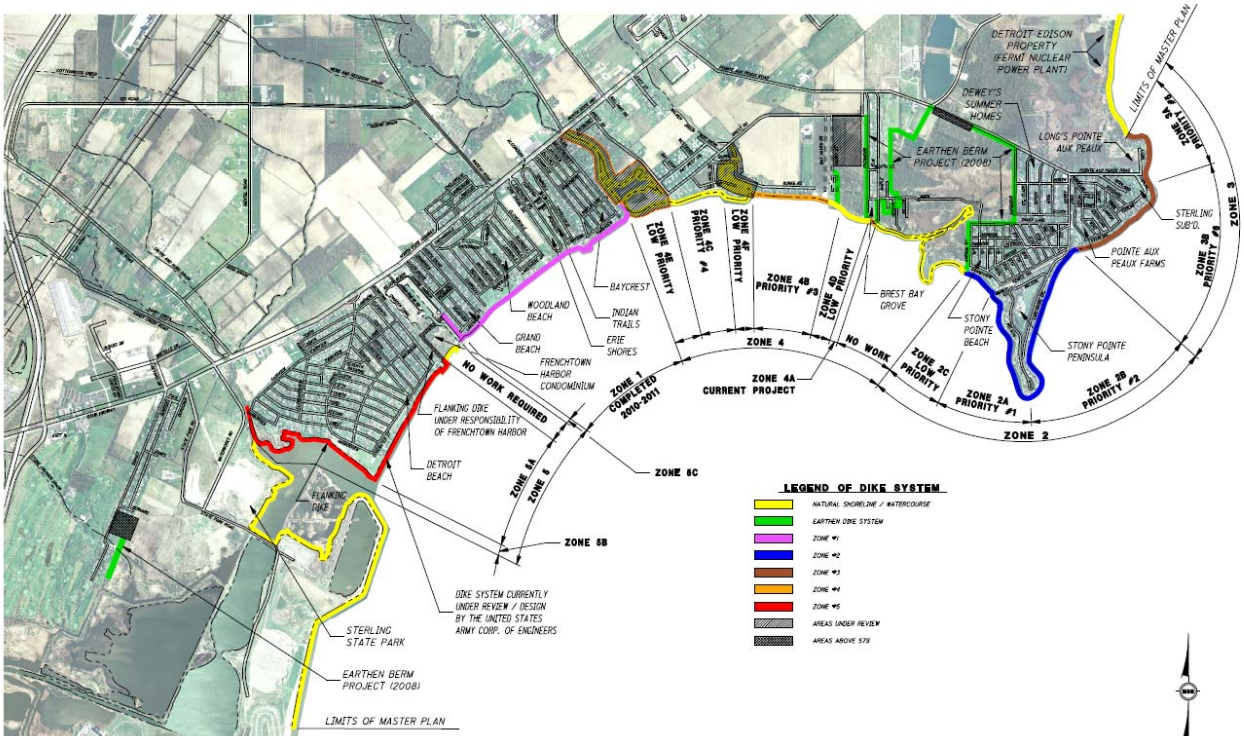
RDA
Frenchtown Charter Township
Resort District Authority

Mannik Smith GROUP

AN INNOVATIVE APPROACH TO COMMUNITY FLOODPLAIN MANAGEMENT & SEAWALL CONSTRUCTION



DIKE REHABILITATION MASTER PLAN

NATIONAL ASSOCIATION OF FLOODPLAIN MANAGERS CONFERENCE PAPER
GRAND RAPIDS, MICHIGAN

JUNE 19-24, 2016

ABSTRACT

Frenchtown Charter Township of Monroe County, Michigan created a special tax assessment district, unique in the State of Michigan, for the express purpose of correcting and preventing further deterioration in a defined area along the shorelines of Lake Erie and the properties adjacent thereto. The district, titled “Resort District Authority” (RDA) has the primary goal to protect property from damage due to lake flooding, since the majority of properties lie within the 100 year flood plain area.

This paper will discuss the authority established to manage the district and the actions that have been and are being taken to mitigate damage from flooding with special emphasis on rehabilitation of the seawall.

ACKNOWLEDGEMENTS

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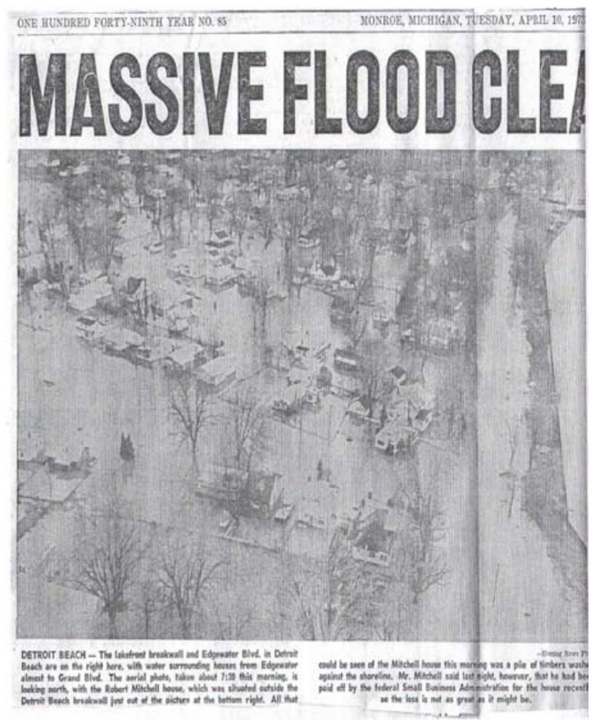
RDA Jurisdiction

The RDA, being on the Lake Erie shoreline, has historically been subject to significant flooding and erosion caused by a combination of high water levels and wind generated wave action. Flooding that occurred in 1972 and 1973 was devastating to the area leaving homes and streets flooded for weeks.

The homeowners associations did not have sufficient funding to maintain the common property nor had access to government funding for any immediate improvement projects. With little or no storm water drainage, subsequent flooding in the 1980's continued to do damage and further deteriorate the roads.

Historical Flooding

Before the RDA was established, the major flooding that devastated the community in the 1970's and 80's began to receive assistance in risk reduction. The United States Army Corp of Engineer's (USACE) placed a combination of tied-back sheet pile walls and temporary gabion basket walls to prevent further damage to these communities and homes. The work was done under Operation Foresight and Advanced Measures which can further be researched in the article "Draft Detailed Project Report and Environmental Assessment (USACE, 2010).



ONE HUNDRED FORTY-NINTH YEAR NO. 85 MONROE, MICHIGAN, TUESDAY, APRIL 10, 197

MASSIVE FLOOD CLE

DETROIT BEACH — The lakefront breakwall and Edgewater Blvd. in Detroit Beach are on the right here, with water surrounding houses from Edgewater almost to Grand Blvd. The aerial photo, taken about 7:30 this morning, is looking north, with the Robert Mitchell house, which was situated outside the Detroit Beach breakwall just out of the picture at the bottom right. All that could be seen of the Mitchell house this morning was a pile of timbers washe against the shoreline. Mr. Mitchell said last night, however, that he had be paid off by the federal Small Business Administration for the house recentl so the loss is not as great as it might be.

(Monroe Evening News, 1973)

Establishment of the Authority

The Frenchtown Charter Township Resort District Authority (RDA) is located in southeast Michigan on the western shores of Lake Erie. The name "Resort District" reflects the historical use of the lakeshore communities as summer and weekend residences. Over the years, the RDA has become predominately year round bedroom communities and has transitioned away from the summer homes that predominantly made up the area from a bygone era.

The RDA is a unique tax assessment district in the State of Michigan. It was created by Frenchtown Charter Township in 1986 by Ordinance No. 143; in accordance with Michigan Public Act 59 of 1986. Through the vision of local leaders, and championed by the district representative in the state legislature, this act permits establishment of a defined tax assessment district in order to rehabilitate the portion of the township covered by the district.

Demographics

The district boundaries encompass a contiguous area within Frenchtown Township, Michigan. It is comprised of thirteen independent residential associations as well as other commercial and industrial property. The district has 7.5 miles of Lake Erie shoreline and contains approximately 2,450 homes and approximately 5,600 residents; comprising 40% of the township population. The RDA is a unique entity in the State of Michigan and has been overwhelmingly accepted and supported by the subdivision associations and residents; reversing a rapidly deteriorating trend and creating a desirable place to live and raise a family.

Accomplishments to Date

After the RDA was created, a 3 mill levy on all property in the district, as allowed by the act, was overwhelmingly approved by popular vote. Three separate issues of bonds in the amount of 23 million dollars were sold to finance initial construction of improvements which included 42 miles of roadway paving and drainage. Over 80 miles of storm drains and 6 large storm water pump stations were also constructed. The pump stations are capable of pumping 346,900 gallons of water per minute and all have back-up diesel powered generators in the likely event of electric power interruption during a severe storm event. Clay berm flanking dikes were also built to supplement the then existing flood risk reduction devices.

Figure 1: Pump Station

Seawall Projects

After completion of the internal roads and storm drainage systems, the RDA launched a major project to upgrade the flood risk reduction seawalls along the Lake Erie shoreline. The new seawall was designed by the district's engineers, the Mannik & Smith Group (MSG), and received recognition by their peers; winning the "Award of Merit for Engineering" from the American Civil Engineering Council of Michigan. The wall design consists of soldier piles and precast concrete panels with a wave deflection flare at the top of the wall. The master plan is broken down into 15 projects to manage size, cost, and then prioritized based on need and flood risk reduction. The $32M project is being funded with approximately $1M annually being set aside for construction on a pay as we go basis. The first zone was completed in 2010 at a cost of $5M and included seawall replacement for 5 subdivisions within the RDA jurisdiction. A major challenge to the projects is the fact that the seawalls are located on private property or in private parks, requiring easements from every landowner or association. All have been obtained for no cost to the projects.

The higher lake levels of 2015 and 2016 have caused increased shoreline distress; i.e. coastline erosion and failures along the old, deteriorated seawalls. The RDA and their engineer, the Mannik & Smith Group, Inc. (MSG), continue to work to rehabilitate the rest of the seawalls before the destressed older wall gives way to Mother Nature. Comprehensive engineering services for the rehabilitation and reconstruction of the first zones of the Master Plan have been completed and more are underway. The project plans provide details of the existing wall, the proposed design for the replacement and/or rehabilitation of the seawalls, utilities, cofferdam construction, erosion and sediment control measures, temporary dewatering requirements, and temporary construction access provisions.

Seawall Master Plan

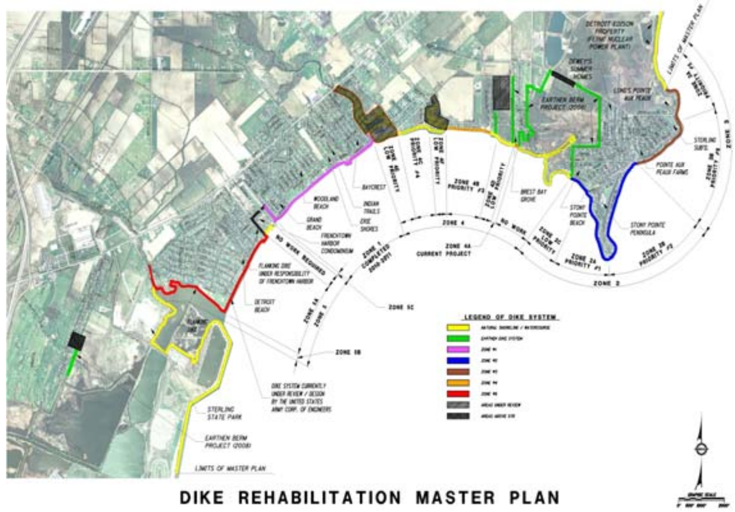


Figure 2: Master Plan

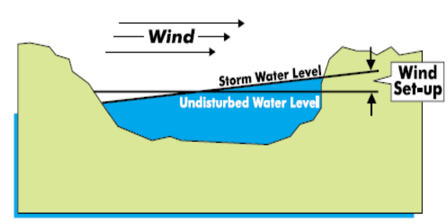
It has now been nearly 40 years since the USACE constructed the rock-filled gabion type flood control structures along the shores of Lake Erie. The goal in placing the gabion walls was to reduce the risk of flooding for the thousands of residents and their homes from severe and repeated flooding until a more permanent solution was installed. The majority of the dike systems have since fallen into disrepair and many have become structurally deficient. Significant segments of property have had high lake levels breach the deteriorated structures; threatening more damage from flood events.

Survey Study and Structural Assessment

MSG has been the engineer for the RDA for over a decade. The original efforts by MSG date back to 2001 when the RDA requested that MSG perform a complete structural assessment and elevation analysis of the existing flood control dike system along the Lake Erie shoreline. MSG, in conjunction with the RDA, developed a Master Plan for rehabilitation and/or replacement of the 7+ miles of existing Lake Erie Seawall. The overall Master Plan project has been divided into zones based on location along the shoreline. The zones are subdivided into projects and have been prioritized based on condition of the existing wall to be rehabilitated and risk of flooding. Currently, there are 5 Zones and 15 Sub-Zones identified as part of the Master Plan.

Establishing the Wall Elevation

The survey study and structural assessment revealed that the existing walls were in various condition and state of disrepair and the majority were in need of replacement or rehabilitation. The study also revealed that the existing top of wall was not consistent and there were areas where the wall was much lower than other walls. The question was what the wall elevation should be in order to provide the level of protection needed in the various area.



Lake profile showing wind set-up

(Unknown, Great-Lakes.net, 2016)

MSG performed research which used FEMA flood plain maps, NOAA Hindcast Data, USACE Wave Information Station (WIS) Data, and existing elevations in order to evaluate what the wall should be set at to provide a safe level of protection. It was decided that higher storm surge risk area would be set at elevation 581.00 IGLD 85 as they are subject to a higher risk of wave overtopping. Lower risk storm surge areas would be set at 579.00 IGLD 85.

Ordinance Updates

The RDA wanted to address not only the elevation, but the materials used to construct future walls. Existing walls made of timber, gabion baskets, concrete masonry units (CMU) and other materials were proven not to be robust under wave action and ice impact loading. It was determined that the construction materials needed to be Steel, Concrete and/or Heavy Riprap to prolong the life of the flood risk reduction system. The Township ordinances were updated to reflect these requirements and others as pertaining to the seawall protection and other Flooding concerns.

Design Parameters

The fundamental purpose of the seawall construction along the Lake Erie shoreline includes flood risk reduction, shoreline protection and soil retention. All three of these characteristics were considered as the study, analysis and design unfolded for this project, as follows:

Risk Reduction

- The height of the wall was a key consideration in development of the design.
- The FEMA flood elevation currently published for this area along the Lake Erie Shoreline is 578.15 referenced to the International Great Lake Datum of 1985 (IGLD 85).
- In order to accommodate a flood and surge that would produce water elevations of this height the proposed minimum wall height was set to 579.00 IGLD 85.
- In some cases, due to the height of the surrounding finished grade, the top of wall elevation was set at a higher elevation of 581.00 IGLD 85.

Shoreline Protection

- In addition to controlling the height of the wall, the seawall had to be constructed with materials that would withstand the brutal forces of nature including both cold winter ice conditions and strong summer storms.
- Several engineering materials were considered including concrete, steel, polyethylene, and large riprap.
- It was determined that in order to minimize disruption to the shoreline following completion of construction and to maximize protection of the shoreline a concrete wall system would be utilized.
- Wave action created from storm surge and wave run-up was also considered.
- MSG investigated and utilized a wave energy dissipater constructed at the crest of the wall.
- The energy dissipaters, or flares, were designed with a radius and an exit angle from the vertical face of the wall that would redirect crashing waves onto the waves approaching the shoreline.
- The flares were a key element in the design of the panels to reduce the amount of energy that causes wave overtopping and erosion along an unprotected shoreline.

Soil Retaining

- In addition to the seawall providing protection from flooding and erosion it also serves a major function as a soil retaining wall.
- Cohesive soil passive pressures and embedment into rock were used for the design based on information obtained from the geotechnical investigations that were performed by MSG.

- Net water pressures were included assuming saturated soil conditions for a portion of the soil strata and low water conditions as a worse case loading.
- This combination generated maximum wall pressures and forces used for sizing the structural wall elements.

Permitting

A large effort in the design phase was also attributed to the USACE/MDEQ Joint Permit Application.

The applications were developed and submitted for review and approval for each phase prior to finalizing plans. Through extensive coordination, review and revisions, and a cooperative effort with regulatory agencies, approved Joint Permits were obtained for Zone 1 & 5. During preliminary stages of the permitting process MSG was required to minimize all impacts to the Lake Erie shoreline. Many meetings were conducted by MSG with agencies such as the MDEQ, USACE, MDNR, Fisheries, Congressman Dingell's Office, and local residences. As part of the project, a study of the littoral drift was also performed by Anchor QEA and is discussed later in this paper.

To date, two seawall projects are complete and a third is currently in design and planning to being launched this year. The process has taken nearly a decade from the initial study, cataloging the township shoreline dike system, development of a comprehensive solution, development of engineering plans, easement acquisition, bidding award, and finally construction.

Reducing Impacts

In talking with the USACE and MDEQ their primary concerns were that the project would need to show an effort to reduce impacts to the shoreline with the proposed wall. This statement had a drastic impact to the types of wall construction to consider and construction methods used. A thin profile wall would need to be used as to not protrude into the lake more than necessary. Cofferdams, turbidity curtains, time constraints for tree removals, and work restrictions during certain times of year, due to the varying lake levels, would all need to be considered for the design.

Design Considerations

As noted, numerous structural wall systems were investigated to accommodate the design parameters listed above. Some of these systems included reinforced concrete cantilever walls, driven steel sheet pile, tied-back steel or concrete walls, riprap revetments, vinyl and composite sheet pile, break walls, and many more. However, more information was needed to finalize the design concepts and move into a final design.

Geotechnical Investigation

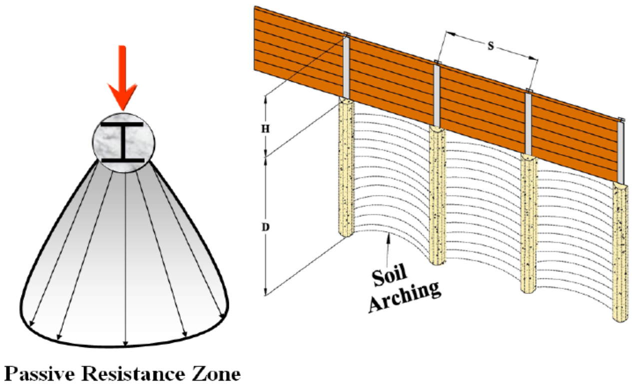
MSG performed a preliminary geotechnical investigation along the entire length of the master plan limits. This method allowed an estimated depth of rock to be established along the project limits.

In general, the rock increases in elevation from Detroit Beach (approximately 20 ft rock depth) to Stoney Point Peninsula where there is rock outcropping. More detailed investigation was then performed for each zone during final design phase.

Zone 1 of the seawall project found good to fair quality rock based on its Rock Quality Designation (RQD). Design recommendation in AASHTO that were used are based on an assumption that good quality rock is found. In Zone

5A, however, the rock quality found was poor. Due to this, alternative methods needed to be considered in design if the rock were to be utilized to stabilize the wall.

Structural Design Decisions and Methodology



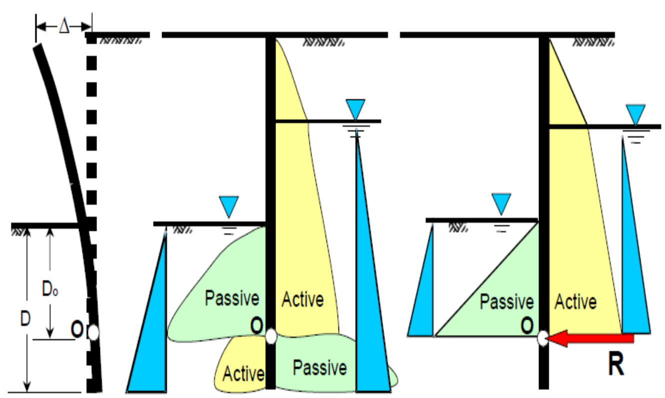
(CALTRANS, 2011)

It was determined that a soldier pile wall system would be utilized in order to minimize impacts to the shoreline. The wall type would provide the necessary flood and shoreline protection, provide the soil retaining strength, and would be a cost effective wall with substantial longevity, The wall "footprint" required limited disruption to the existing shoreline and numerous residential obstacles that had to be worked around in order to complete the project; minimizing impacts. Since the wall is essentially vertical construction excessive excavations required by other wall systems were eliminated that reduced the overall impact to the natural habitat of shoreline and aquatic species.

Due to the shallow bedrock conditions along the shoreline MSG engineers utilized a cantilever wall design embedding steel pile into a rock socket. Rock auguring machines cored holes into the rock to the required depths based on design. The holes then had the steel piles placed and were backfilled with concrete. The concrete and steel were used for structural capacity and deflection resistance.

The precast panels were designed as simple spans between the steel piles and reinforced accordingly. Precast concrete panels were then installed between the piles. As indicated above, flares were cast integral at the top of the panels in controlled conditions off site and shipped to the site for installation. The soldier pile type wall uses soils arching action to economize the demand on the wall. The wall was backfilled with low strength control density fill (CDF) in order to eliminate voids or non-compacted soils between the existing structures (portions left in place) or the shoreline and the new concrete wall.

The soldier pile and panel system develops overturning resistance from the depth of rock embedment. The rock depth to install the piles was determined by computing forces acting on the wall from soil, water, ice, and other loads that would be resisted by the rock. Some cohesion was also considered as the soil strata predominately consisted of clay soils. Rock shear strengths were computed from rock core data and correlation with similar published rock types. Overall wall stability including overturning, sliding, and bearing were checked against appropriate factors of safety. Bending and shear stresses were computed for the steel piles to be within tolerable stress limits provided by AASHTO. Weak rock encountered in Zone



(a)- Wall Deformed (b)- Load Distributions (c)- Load Simplification

(CALTRANS, 2011)

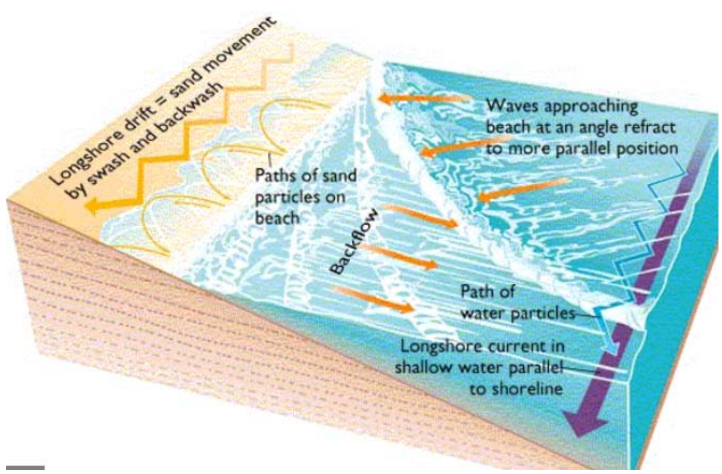
5A required the use of the Hoek-Brown failure criterion and *RocLab* software to model the weak rock as an equivalent soil.

Following the initial design and sizing of the soldier pile and panel wall, MSG consulted with well-known engineers affiliated with the University of Toledo to provide quality assurance of the design methodology; including Dr. Gerald R. Frederick, Ph.D, P.E., and Dr. Andrew G. Heydinger, Ph.D, P.E. Both provided input for the design concepts, the detailed structural analysis, and structural elements of the wall. The use of soil arching and the passive resistance zone are major design advantages of using the soldier pile wall system.

While a precast concrete wall was predominately used for seawall construction, there were several areas, due to site restrictions or deflections in the wall, which required use of reinforced concrete cast-in-place walls. This eliminated the need to fabricate expensive specialized panel sizes and configurations and allowed the contractor to make necessary adjustments on site.

Aesthetics was a major concern for this project. MSG worked diligently with the RDA, landowners, homeowner associations and other stakeholders to provide an aesthetically pleasing finished product. Form liners to provide graphics on the exposed face were considered, but determined to be costly and would also create possible "catch points" for debris. A smooth faced wall with a rubbed finish and treated with a penetrating sealer for protection against the elements was determined to be the most cost effective solution.

Effects on Shoreline



(Unknown, 2016)

Along the Zone 5 project area, small sandy beach areas that exist outside the seawall are part of the lakebed and are exposed during periods of low lake levels. In contrast, during high water levels on Lake Erie, Detroit Beach experiences wave overtopping on the existing seawall and water levels on the wall itself. The amount of visible beach area is highly impacted by the water level of Lake Erie. These beach areas are not engineered or nourished beaches intended to provide prolong recreational use, more typically associated with ocean coast environments. Therefore, the purpose of the seawall rehabilitation project is to improve flood risk reduction for the community while minimizing impacts on the environment.

MSG's subconsultant, Anchor QEA, performed an evaluation of the potential effects the seawall rehabilitation may have on the shoreline and the net littoral drift in the project area. A desktop analysis was performed to review available wave, water level, and bathymetry in the vicinity of the project area, as well as evaluate the coastal setting and littoral drift characteristics of the area. In addition to the desktop analysis, a numerical shoreline model (i.e., Genesis Software) was used to evaluate the longshore transport characteristics and shoreline change in the vicinity of the project area. The GENESIS-calculated littoral drift alternated directions throughout the simulation period. The calculated net littoral drift rates to the north ranged from approximately 1,000 to 2,000 cubic yards, whereas net littoral drift rates to the north ranged from approximately 1,500 to 5,000 cubic yards. These findings are consistent with previous evaluations for the area, as described above.

In summary, the Genesis-calculated shorelines for both the existing and proposed conditions showed nearly identical results, indicating that the placement of the new seawall several feet lakeside of the existing wall would not have significant impact on the system littoral drift characteristics of the shoreline shape and position.

Construction Methods

For Project #1, the contractor elected to install a continuous concrete roadway type barrier wall lakeside of the temporary access roadway for the first zone of the project. This helped to confine the stone from eroding into the lake and protected the work area from wave action. A turbidity curtain was also installed in Lake Erie in close proximity to the shoreline in areas where earth excavation was required. Silt fence was installed landward of the construction limits.

The temporary access roadway was constructed on concrete slabs and 4-6 inch crib rock from the old USACE gabions. Geotextile fabric was installed under the concrete and rock for protection of the shoreline. The temporary roadway was removed upon completion of work.

For Project #2, the cofferdam type was changed from the plan for Project #1. A steel sheet pile cofferdam was installed along the entire route in front of the old seawall due to depth of water and level of wave action. The sand and boulders in front of the old wall were graded and crane mats were used. By not introducing new stone, the clean-up effort after construction was drastically reduced and need for turbidity curtain was eliminated.

In certain areas of Project #1, 18 inch wide concrete backwalls were constructed due to the configuration of the existing dike systems. The subgrade portion of the concrete backwalls was poured against the earth trench with full reinforcing steel cages. The top section was formed and poured in place. No wave deflectors were required on the backwalls.

The precast concrete panels were fabricated off site and shipped to the job site. The panels were lifted into place between the galvanized soldier piles, which were placed on 8 ft. centers. Lifting lugs were used for Project #1, and lifting scissors were fabricated and used for Project #2. The lifting scissors eliminated the need to fill lifting holes when lugs were removed after setting. The piling was installed into augured excavation approximately 3-4 feet into strong bedrock or 6 feet minimum into weak bedrock and filled with concrete.

The new concrete walls had cast in place concrete steps at several locations as well as concrete cast in place closure pours. Openings for steps were protected by aluminum stop planks set into framed drop-in panels. Swing gates were installed on Project #2. Drainage behind the walls used specially designed yard drains with weep (holes) set in the walls with check valves to prevent back flow.

Seawall Progress to Date

Zone 1

The first contract for this project (Phase 1) was let for construction in May of 2010 and involved the Master Plan area identified as Zone 1, which included approximately 1 mile of seawall rehabilitation. Zone 1 is located from Grand Beach to Baycrest subdivision and included several beach association subdivisions and private parks.

Rehabilitation for this zone included removal of existing gabion baskets and other make-shift walls from stacked concrete barrier to welded beams, restoration of a portion of the existing concrete walls and complete replacement of the majority of existing walls with soldier pile cast-in-place concrete or precast concrete panel walls including installation of wave deflectors.

Major construction activities were completed by May of 2011 with minor restoration and miscellaneous project close-out items in the fall of 2011.

Zone 5a

The second contract for this project (Phase 2) was let for construction in May of 2014 and involved the Master Plan area identified as Zone 5A, which included approximately 3/4 mile of seawall rehabilitation.

Zone 5a is located in Detroit Beach subdivision and included private residences and several private parks.

Rehabilitation for this zone included removal of portions of the existing steel sheet pile wall and placement of the soldier pile and precast concrete panel walls including installation of wave deflectors on heavier portions of sheet pile wall to remain.

Major construction activities were completed by May of 2016 with minor restoration and miscellaneous project close-out items in the Spring of 2016.

Zone 2a

The third contract for this project (Phase 3) will be let for construction this year and involves the Master Plan area identified as a slightly modified Zone 2A, which included approximately 1/2 mile of seawall rehabilitation. Zone 2a is located in Stoney Point Peninsula subdivision and includes private residences, private parks and the Dewey Lagoon inlet. The walls in Zone 2A vary from lot to lot and the slot of coordination was required to come up with a unifying plan for the zone. Rehabilitation for this zone will include removal of portions of the existing walls and placement of the soldier pile and precast concrete panel walls.

Project Value Added

It is important to describe value added proposition that the RDA and MSG believe is critical to this shoreline area.

Original or Innovative Application of New or Existing Technology

- The project considered a multitude of existing and innovative application of technologies throughout the study of the existing walls and options for the construction of the new walls, as noted under "Structural Design Decisions and Methodology" above.
- The project involved unique and diverse engineering design and construction challenges, much of which had to be studied and developed by MSG, since there was surprisingly little available data for this type of construction.

Future Value to the Engineering Profession

- There is significant value to the engineering profession, as the design work for this project was unique to this particular application and will provide guidance for future engineering application on the remainder of the phases for this project as well as other potential projects along the Great Lakes shoreline or other similar applications.
- In fact, the USACE had requested a copy of our design plans and information to review and consider as part of a similar project being designed by the USACE along the shores of Lake Erie in the Detroit Beach area (not a part of the RDA projects) as part of the reconstruction of the USACE Advanced Measures dike system.

Social, Economic & Sustainable Design Considerations

- There were significant considerations with all three of these design considerations, as noted above in the project write-up.
- Social considerations involved the intense work required to meet with citizens, shoreline residents and associations to involve them in the decision making process to protect and enhance the aesthetics and value of their shoreline properties.
- Economic decisions and value engineering was employed throughout the design process in order to determine the most cost effective solution to this challenging project.
- Numerous design decisions throughout project included a cost evaluation and consideration of alternate design methods.
- Sustainable considerations were likewise considered an essential part and priority to this project.
- The project was designed to provide long term protection with minimal future disruption or maintenance requirements that could impact the wetlands or bottom lands of Lake Erie.
- In addition, significant coordination with the USACE and Michigan Department of Environmental Quality (MDEQ) was performed to limit work within the sensitive lake environment.
- Greenbelt and yard areas were enhanced.
- The design was performed to eliminate the need for shoreline riprap, which would have reduced or eliminated the environmentally and aesthetically important beach areas along Lake Erie.
- Strict SESC measures were included in the design to prevent degradation of the lake and shoreline.

Complexity

- This was a highly complex construction project from initial concept through the design and construction stages.
- As described above, many complex structural and hydraulic considerations were involved throughout the design of the project.
- Design of the soldier pile and methods to construct, given the fluctuating ground and lake levels, provided greater engineering challenges.
- Access to work along the shoreline, protection of the environment and providing cost effective and reasonable work areas for the contractor were difficult and challenging engineering decisions.
- Consideration of littoral drift along the proposed seawall.
- Finally, designing closure pours and other unique elements on the meandering shoreline provided the structural engineers with many complex design decisions.

Exceeding Owner/Client Needs

- The RDA Boards and Director have expressed their great satisfaction with this project.
- The projects came in under budget which further added to the owner's satisfaction.
- In addition, the shoreline residents and beach associations have all voiced their strong approval of the design and aesthetics of the project.
- MSG and the RDA have worked diligently with all shoreline residents to address concerns related to the individual property owners, which was a unique and challenging part of the overall project.

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