COASTAL INFRASTRUCTURE RESILIENCE RESEARCH AND DEVELOPMENT

SHORELINE MITIGATION FEASIBILITY STUDY PARK POINT RECREATIONAL AREA

DULUTH, MINNESOTA

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City of Duluth

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ENVIRONMENT & HEALTH

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1. INTRODUCTION

Portions of the Duluth shoreline and associated infrastructure have been damaged as a result of major storm events and ongoing natural erosional processes. In response to these changes, the Coastal Infrastructure and Resilience Research and Development project objectives are to identify economically feasible methods for reducing shoreline erosion and to provide recommendations for preserving existing assets along the lakeshore. These recommendations are intended for use on this project and may serve as a template for asset repair and protection in similar situations and locations. Accordingly, this document serves as a Feasibility Study to identify and evaluate potential mitigation measures for the vulnerable shoreline areas of Park Point (also known as Minnesota Point) and provide the City of Duluth, Minnesota, with practical solutions to address shoreline erosion, bank failures, and corresponding infrastructure risks associated with this area.

2. SITE CHARACTERIZATION

2.1 Site Location and History

The City is located on the westernmost shoreline of Lake Superior in St. Louis County in northeastern Minnesota. Duluth is known for its port and associated shipping traffic into and out of Duluth Harbor. Lake Superior, the largest of the North American Great Lakes, experiences fluctuating water levels over time and is well known for its intense storms throughout the year, which can lead to erosion along exposed stretches of shoreline. Over the past decade, Duluth experienced record high and low water levels and several storm events leading to erosion along tributary banks and its shoreline. This feasibility study focuses harbor-facing shoreline area of Park Point Recreation Area (PPRA) within Duluth. PPRA is known for its recreation area, beaches, shorelines, and green space.

PPRA is approximately 46 acres in size that consists of a recreational area with green space, parking lots, a dock/harbor, and a beach facing the lake (Figure 1). The area is frequented by residents of the area and tourists. High water levels at the PPRA have rendered the athletic fields periodically unusable and threatened the road through the PPRA. The harbor-side of the area is experiencing erosion, subsidence, and flooding into the green space. These forces have also resulted in infrastructure damage to the harbor and parking lots.

2.2 Site Characterization

2.2.1 Geology

The PPRA is located within a sand spit system southeast of downtown Duluth, which serves as a boundary between Lake Superior and Superior Bay. The Lake Superior basin was created by 2 million years of erosion of continental glaciers that advanced and retreated on Minnesota. Approximately 1,109 million years ago, the Midcontinent Rift fractured the crust of Minnesota causing basaltic magma to erupt from the crust and create a wide rift valley. The glaciers subsequently moved southward, eroding the cemented sandstone formed by the eruption which currently fills the bottom of the lake. However, the ice could not erode the igneous rocks that formed the flanks of the rift during the magma eruption thereby forming the shoreline of the lake today.

2.2.2 Topography

Duluth is positioned on the western-most shore of Lake Superior. Lake Superior is 600 feet above mean sea level (AMSL), and Duluth is situated on a steep hillside, resulting in approximately a 200 foot elevation change over roughly 10 miles. The PPRA is relatively flat with a peak elevation of

10 feet on the beach dune that slopes down on both sides toward the lake and the harbor shorelines (Google Earth, 2022).

2.2.3 Soil Types

Based on the United States Department of Agriculture (USDA) Natural Resources Conservation Service (NRCS) Web Soil Survey (WSS) (NRSC, 2021), there are two soil types on the PPRA: Udifluvents, which is a loamy soil, and Udipsamment, which is an urban land complex (Figure 2). NRCS did not classify the beach sand as soil. Beach sand has very little to no organic matter, therefore does not meet the NRCS definition of soil.

2.2.4 Shoreline Vegetation

The primary arboreal vegetation around the PPRA is sparse and, in some places, subsiding into the harbor. The vegetation at the PPRA consists primarily of cultivated ornamental non-native grasses. There are a number of species of mature trees, including red pine (*Pinus resinosa*), jack pine (*Pinus banksiana*), eastern white pine (*Pinus strobus*), black spruce (*Picea mariana*), white spruce (*Picea glauca*), quaking aspen (*Populus tremuloides*), paper birch (*Betula papyrifera*), red maple (*Acer rubrum*), sugar maple (*Acer saccharinum*), American elm (*Ulmus americanus*), green ash (*Fraxinus pennsylvanica*), bur oak (*Quercus macrocarpa*), American basswood (*Tilia americana*), and other species. These trees are primarily along the harbor shoreline and scattered around the recreation area. There are also clusters of shrub species along the harbor shoreline primarily consisting of willow species (e.g., *Salix bebbiana*, and *Salix petiolaris*), smooth shadbush (*Amelanchier laevis*), redosier dogwood (*Cornus sericea*), pin cherry (*Prunus pensylvanica*), and smooth rose (*Rosa blanda*). The shoreline also features forbs such as dogbane (*Apocynum androsaemifolium*), harebell (*Campanula rotundifolia*), large-leaved aster (*Eurybia macrophylla*), anise root (*Osmorhiza longistylis*), giant goldenrod (*Solidago gigantea*), long-leaved starwort (*Stellaria longifolia*), Lindley's aster (*Symphyotrichum ciliolatum*), blue verbane (*Verbena hastata*), Labrador violet (*Viola labradorica*), smooth white violet (*Viola macloskeyi* var. *pallens*), and other species.

In addition, there is a remnant old-growth forest at the eastern terminus of Park Point that features white pine and red pine, which appear to range in age from 120 to 200 years old, and with maximum heights approaching 100 feet. This old-growth forest serves as a reference area for PPRA to help understand the enhancement potential and overall trajectory of the area, versus its current baseline vegetative conditions.

2.2.5 Hydrodynamics

Duluth Harbor is predominantly shallow, with depths ranging from less than 1 foot to 7 feet near the PPRA. Across the harbor, adjacent to the City of Superior, Wisconsin, the navigation channel is dredged to a depth of 27 feet. Because Duluth Harbor is protected from the higher wave energies of Lake Superior by Park Point, the harbor does not experience the large waves observed on the lake side of the spit. Additionally, the relatively small area of the harbor does not allow for wind to create substantial wave action. Most of the wave action observed in the harbor can be attributed to the wake resulting from ships and boats. Flanking either end of Park Point are the Duluth and Superior entries to the harbor, allowing for water exchange between Lake Superior and Duluth Harbor. Other sources of water entering the harbor are the St. Louis and Nemadji Rivers.

3. PARK POINT RECREATIONAL AREA PRIORITY SHORELINE AREAS

As consequence of the differences in location, geology, geomorphology, erosive forces, shoreline stabilization concerns, and local concerns, the harbor shoreline of the PPRA is evaluated separately from Duluth's North Shore area. The priority areas for PPRA are presented below and shown in Figure 3.

3.1 Area A - Marina and Shoreline

The Marina is located at the western extent of the PPRA and features a parking, drop-off location, docks, and boat launch area. The Marina and surrounding shoreline are settling and eroding into the harbor. Additionally, the parking in the area exhibits cracking and subsidence due to harbor settling.

3.2 Area B - South Point Shoreline

South Point Shoreline is located on the southern extent of the harbor-side shoreline of PPRA. The area includes a parking lot, small boat launch, and beachfront. The beachfront is particularly susceptible to erosion and is likely impaired by the presence of *E. coli* in the water.

3.3 Area C - Minnesota Avenue Shoreline

Minnesota Avenue Shoreline follows the southwestern extent of PPRA, parallel to Minnesota Avenue, along PPRA. This area is becoming exceedingly close to the harbor shoreline and is subsiding due to flood events. Erosive features are common along this stretch.

3.4 Area D - Minnesota Avenue Road

Minnesota Avenue Road is parallel to the harbor shoreline along the southwestern extent of Park Point. The roadway is subsiding and degrading in response to flood events and may become unusable in the future without maintenance and long-term preventative restoration.

4. PPRA MITIGATION ALTERNATIVES

Ramboll recommends using a combination of natural and nature-based solutions to mitigate the current issues at PPRA. Appendix A (Shoreline Management Alternative Matrix) illustrates the possible alternative, applicability, constraints, shoreline classification, and includes a visual example. Below is a focused list of recommended alternatives for each Priority Area.

4.1 Area A - Marina and Adjacent Shoreline

To address the erosion along the marina and adjacent shoreline, the following alternatives are proposed for consideration.

<u>Alternative 1</u>: ***Establish living shorelines to reduce erosion by planting containerized plants, live stakes, fascines, and seed.*** Revegetate eroding shorelines (Figure 4) by planting with containerized plants, live stakes, fascines, and seed. This alternative can be implemented with armoring to protect the toe of the slope while also using vegetation to stabilize the area behind the toe and improve biodiversity. Stone is commonly used for the toe structure to protect the bank from erosion until vegetation is established and even after vegetation is established. Toe armoring can be implemented on all shorelines but needs to be paired with other stabilization features to prevent bank

erosion. This alternative can be used in conjunction with hardened engineering measures to add tensile strength to the banks.

Alternative 2: ***Stone revetments with integrated vegetation.*** This technique improves shoreline resiliency using a combination of boulder cobble toe constructed from angular rock, stone revetment, and plantings integrated into the revetnment structure. The plantings add habitat to the stone structure and can be designed to help deflect overbank high flows when planted close together.

Alterative 3: ***Incorporate rock revetments to reduce erosion without bioengineering/ nature-based features to improve protection from erosion and scour.*** This technique increases the physical resiliency of the shoreline through dissipating energy, but does not result in ecological uplift or increased biodiversity.

Alternative 4: ***No action.*** The marina, boat launch, and adjacent shoreline are likely to continue subsiding, as erosion and scour result in further degradation.

4.2 Area B - South Point Shoreline

To address the erosion and exposure of South Point Shoreline, the following alternatives are proposed for consideration. For Alternatives 1 through 3, consider using sediment nourishment through the addition of clean beach sand to the beach area. Sand could be potentially obtained from harbor dredging.

Alternative 1: ***Establish living shorelines to reduce erosion by combining planted container, live stakes, fascines, and seed.*** Revegetate eroding shorelines (Figure 4) by planting with containerized plants, live stakes, fascines, and seed. This alternative can be implemented with traditional (gray) engineering to protect the toe of the slope while also using vegetation to stabilize the area behind the toe. The toe structure protects the bank from erosion until vegetation is established. It can be implemented on all shorelines but needs to be paired with other stabilization features (e.g., angular riprap) on highly erosive areas. This alternative can be used in conjunction with hardened engineering measures to add tensile strength to the banks.

Alternative 2: ***Incorporate joint planted rock revetments, live stakes, and fascines.*** This technique dissipates flow energy and traps sediment. A combination of angular cobble toe with joint plantings provides added tensile strength and toe protection. Joint plantings and fascines deflect overbank high flows when planted close together.

Alternative 3: ***Incorporate rock revetments without bioengineering/nature-based features to improve protection from erosion and scour.*** This technique increases the physical resiliency of the shoreline by dissipating energy, but does not result in ecological uplift or increased biodiversity.

Alternative 4: ***No action.*** The South Point shoreline and its adjacent area are likely to continue subsiding, as erosion and scour result in further degradation.

4.3 Area C – Shoreline Adjacent to Minnesota Avenue

To address the shoreline adjacent to Minnesota Avenue, the following alternatives are proposed for consideration.

Alternative 1: ***Establishment of living shoreline adjacent to road, revegetated with containerized plants, live stakes, fascines, and seed.*** Establish living shoreline adjacent to road establishing living shoreline adjacent to harbor with native trees, shrubs, and forbs to promote biodiversity, habitat enhancement, increased shoreline resiliency, and reduced goose influx. Revegetate adjacent eroding shorelines (Figure 4) with containerized plants, live stakes, and fascines. This alternative can be implemented on all shorelines but needs to be paired with other stabilization (e.g., angular riprap) features on highly erosive shorelines. This alternative can be used in conjunction with hardened measures to add tensile strength to the banks.

Alternative 2: ***Establish living shoreline adjacent to road, revegetate live stake incorporated into rock reventments.*** Incorporate joint planted revetment to improve shoreline resiliency using large angular rock and live stakes. This technique dissipates flow energy and traps sediment. A combination of angular cobble toe with joint plantings provides added tensile strength and toe protection. Joint plantings and fascines deflect overbank high flows when planted close together.

Alternative 3: ***Protect road with unrevgetated rock revetments.*** Incorporate angular riprap rock revetments without bioengineering/nature-based features to improve protection from erosion and scour but does not result in ecological uplift or increased biodiversity.

Alternative 4: ***No action.*** With no action, the adjacent area to Minnesota Avenue is likely to continue to subside and degrade, further eroding and exhibiting a loss of ecological functionality over time.

4.4 Area D - Minnesota Avenue Adjacent to the Shoreline

To address the portion of Minnesota Avenue adjacent to the shoreline, the following alternatives are proposed for consideration.

Alternative 1: ***Convert road to multiuse path for walking and bicycling.*** Convert road into a walking/bike path with porous pavers to promote improved drainage.

Alternative 2: ***Raise the road level to serve to provide additional access.*** Raise the road elevation to provide additional access and to minimize flooding of the road and park areas. This can be with or without converting the road into a walking/bike path with porous pavers to promote improved drainage. A hydrologic evaluation is recommended to determine the overall effect of changing the road elevation.

Alternative 3: ***Add beneficial sediment to the green space inland from the road to reduce water influx and flooding.*** This approach can be implemented with or without: (a) converting the road into a walking/bike path with porous pavers to promote improved drainage, or (b) raising the road elevation to provide additional access and help reduce flooding. A hydrologic evaluation is recommended to determine the overall effect of changing the road elevation.

Alternative 4: ***No action.*** With no action, the road and its adjacent area are likely to continue to subside and degrade, potentially becoming unusable over time.

5. EVALUATION OF MITIGATION ALTERNATIVES

An evaluation for each of the four PPRA priority areas was made to identify an effective, implementable, and cost-effective approach for stabilization and ecological uplift. These alternatives consider nature-based approaches that are robust and resilient enough to stabilize the shoreline and adapt to future changing conditions. The focus of this evaluation was an integrated approach that combines green and grey-solutions and associated best practices to protect critical infrastructure, restore habitat, and provide long-term resiliency. This integrated approach recognizes the need for some hardened infrastructure, while also recognizing the limitations of such infrastructure to provide habitat, improved biodiversity, and aesthetic value.

For each alternative, an assessment was performed to include the following:

- *Long-term effectiveness and resilience* - This criterion evaluates the alternative for long-term effectiveness and resilience with respect to the ability to maintain shoreline stabilization. Factors considered under this criterion include the potential for additional erosion or slope failure after implementation.
- *Implementabilty* - This criterion evaluates the implementability of the alternative by considering technical feasibility, administrative feasibility, and availability of services and materials required for implementation.
- *Operation and maintenance (O&M) requirements* – This criterion evaluates the need and extent of maintenance required for the mitigation alternative to remain effective over time. The costs associated with O&M are captured within the costs criterion.
- *Cost* - The cost criterion evaluates the cost of the alternative by considering the scope of work to be completed under the alternative including capital costs, installation, and monitoring costs.

Table 2 summarizes the evaluation of each of the four alternatives. Each mitigation alternative was assigned a score between 1 and 5 for each evaluation criterion, with 1 representing an option that is less effective and implementable and/or with more O&M and higher cost, and a score of 5 representing an option that is more effective and implementable and/or with less O&M and lower cost. The values were then summed across each alternative, such that a lower score represents a less preferred alternative and higher score represents a more preferred alternative. Resulting scores were found to be largely similar with a two to three point difference for each alternative. Because of this, Ramboll recommends that each alternative should be evaluated independently to inform the selection of best option.

Table 3 provides cost estimates for each alternative used in the evaluation of alternatives. The costs identified in Table 3 were derived from a combination of RS Means, prior construction projects by Ramboll, and prior bid prices from City of Duluth shoreline repairs. Additional cost assumptions included the following:

- Several priority locations will likely be a combination of nature-based solutions such as living shorelines combined with traditional engineering such as riprap.
- Costs include design, permitting, construction and oversight.
- Costs are preliminary for budgetary purposes only (-10% + 30%).
- Costs for additional vegetation other than seeding will be on a site-specific basis.

In addition to Table 2 and Table 3, the subsections below provide a summary of the alternatives evaluations for the four PPRA priority areas.

5.1 Area A - Marina and Adjacent Shoreline

Alternative 1: ***Revegetate eroding shorelines by planting containerized plants, live stakes, fascines, and seeds.*** This alternative can be implemented on all shorelines within the priority areas but should be paired with other stabilization features (e.g., bank toe reinforcement) on highly erosive areas. Revegetation also can be used with hardened engineering measures to integrate rock revetments with plants and habitat. Once established, vegetation has the benefit of promoting habitat uplift and biodiversity improvement for avian, terrestrial, and aquatic species. Vegetation using containerized materials results in higher survival rates, faster establishment times, and facilitates implementability. Additionally, restoration with containerized plants tends to include the application of a broader diversity of species compared to live stakes and fascines (dormant plant materials), thereby having a greater ability to further increase species richness and habitat diversity.

Conversely, revegetation with dormant plant materials tends to be less expensive and can be collected from local populations of dogwood, buttonbush, willows, and cottonwoods. In comparison to containerized plants, revegetation with dormant plant materials can occur only while those materials are dormant, and therefore is limited to early spring prior to leaf emergence or late fall after leaf abscission (leaf drop). In comparison to containerized plants, dormant plant materials tend to be less expensive per planting.

The relative percentage of containerized plants in comparison to dormant plant materials can be optimized to align with budget, plant materials availability, regulatory and/or success criteria, and site-specific requirements such as erosion potential. All newly transplanted revegetation require protection from predation and trampling.

Once the local native vegetation has been established, there is little maintenance required other than weeding and/or irrigation during extended drought, unless there is subsequent site disturbance, erosion, slippage, or subsidence.

Alternatives that incorporate plant-based solutions have an increased ability to sequester carbon in comparison to those techniques that do not include vegetation. Similarly, areas that feature increased wetland hydrology, have an increased ability to sequester carbon.

Alternative 2: ***Stone revetments with integrated vegetation.*** This alternative uses rock (i.e., riprap) reinforcement coupled with dormant vegetation to stabilize the area behind the toe. The stone material helps protect the bank from erosion until vegetation is established in comparison to measures that solely use revegetation. Joint plantings with live stakes and fascines deflect overbank high flows when planted close together. Once established, the resulting revegetation has the benefit of promoting habitat enhancement and biodiversity improvement for avian, terrestrial, and aquatic species. However, revegetation through dormant plant materials can have lower survival rates, increased establishment times, and can only be implemented while dormant, therefore is limited to early spring before leaf emergence or late fall after leaf abscission. Additionally, dormant plant materials tend to have a reduced diversity of species in comparison to container plant materials as consequence of their need to be established from plant species with adventitious bud production. As consequence, dormant plant materials have a reduced ability to increase species richness and habitat diversity.

Revegetation with dormant plant materials tends to be less expensive in comparison to containerized plants and can be collected from local populations of dogwood, buttonbush, willows, and cottonwoods.

Due to the lower cost per planting unit, there is potential for an increased number of stakes and/or fascines to be planted within a given budget.

All newly transplanted revegetation requires protection from predation and trampling. Once local native vegetation has been successfully established, other than weeding and/or irrigation during extended drought, there is little maintenance required unless there is subsequent site disturbance, erosion, slippage, or subsidence.

Alternatives that incorporate nature-based solutions, such as containerized and/or dormant plant materials have an increased ability to sequester carbon in comparison to those techniques that do not include revegetation. Similarly, areas that feature increased wetland hydrology, have an increased ability to sequester carbon.

Alterative 3: ***Incorporate rock revetments without bioengineering/nature-based features to improve protection from erosion and scour.*** Rock revetments can be used to harden shoreline areas to help protect them from erosion and scour. While this technique is appropriate for high-energy areas, it lacks the benefit of ecological uplift, habitat enhancement, and improvement of biodiversity in comparison to container planting and/or the use of dormant materials. This alternative has a reduced capability of sequestration carbon in comparison to nature-based solutions.

Alternative 4: ***No action.*** The marina, boat launch, and adjacent shoreline are likely to continue to subside, as erosion and scour result in further degradation. This alternative also has a reduced capability of sequestration carbon in comparison to nature-based solutions. Lastly, the “no action” alternative would not respond to the City’s land use strategy for Park Point.

5.2 Area B - South Point Shoreline

Alternative 1: ***Establish living shorelines to reduce erosion by combining planted containerized plants, live stakes, fascines, and seed.*** Please see the narrative for Alternative 1 for Priority Area A.

Alternative 2: ***Incorporate joint planted revetment using angular large rock, live stakes, and fascines.*** Please see the narrative for Alternative 2 for Priority Area A.

Alternative 3: ***Incorporate angular riprap rock revetments without bioengineering/nature-based features to improve protection from erosion and scour.*** Please see the narrative for Alternative 3 for Priority Area A.

Alternative 4: ***No action.*** The South Point shoreline and its adjacent area are likely to continue to subside, as erosion and scour result in further degradation. This alternative also has a reduced capability of sequestration carbon in comparison to nature-based solutions. The “no action” alternative would not respond to the City’s land use strategy for Park Point.

5.3 Area C – Shoreline Adjacent to Minnesota Avenue

Alternative 1: ***Establishment of living shoreline adjacent to road, revegetated with containerized plants, live stakes, and fascines.*** Please see the narrative for Alternative 1 for Priority Area A.

Alternative 2: ***Establishment of living shoreline adjacent to road, revegetated with angular large rock, live stakes, and fascines.*** Please see the narrative for Alternative 2 for Priority Area A.

Alternative 3: ***Protect road with unrevgetated angular riprap rock revetments.*** Please see the narrative for Alternative 3 for Priority A.

Alternative 4: ***No action.*** With no action the adjacent area to Minnesota Avenue is likely to continue to subside and degrade, further eroding into the harbor and exhibiting a continued loss of ecological functionality over time.

5.4 Area D - Minnesota Avenue Adjacent to Shoreline

Alternative 1: ***Convert road to walking/bike path.*** Convert the existing road into a walking/bike path with porous pavers to promote improved drainage and reduced water retention. Such conversion would align with a number of United Nations Sustainabie Development Goals (UNSDGs), including:

- SDG 3 - Ensure healthy lives and promote well-being for all ages.
- SDG 6 – Ensure availability and sustainable management of water and sanitation.
- SDG 9 – Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation.
- SDG 11 – Make cities and human settlements inclusive, safe, resilient, and sustainable.
- SDG 15 – Protect restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss.

Potential negatives for road conversion include, but are potentially not limited to, the additional costs for road removal and realignment, the need to dispose of removed road materials, and potential concentration of vehicular traffic to a more confined area.

Alternative 2: ***Raise the road level to provide additional accessibility.*** Raising the road may serve to provide additional accessibility and potentially reduce flooding, thereby providing additional usability of this area throughout the year. This could be combined with Alternative 1 (converting the road into a walking/bike path) to improve local use of the trail. A hydrologic evaluation is recommended to determine the overall effect of changing the road elevation.

The potential downside of raising the road is the cost for raising the road, including long-term maintenance requirements and costs to maintain the converted road. Changes in hydraulogy and natural habitat conditions should be considered to ensure that building up the road does not adversely impact local habitat.

Alternative 3: ***Sediment beneficial use, adding sediment to raise the elevation of the the green space inland from the road.*** Clean dredged sediment can be used to raise the ground elevation to reduce flooding potential and improve usability of the area throughout the year. This alternative could be combined with Alternative 1 or Alternative 2. A hydrological evaluation is recommended to determine the overall effect of adding beneficial sediment.

The potential downsides of adding sediment to raise the field elevation include:

- identifying a source of clean sediment and depositing it onto the green space inland from the road in a manner that does not cause further degradation to the area; and
- the cost of transporting and adding sediment.

Alternative 4: ***No action***. With no action the road and its adjacent area are likely to continue to subside and degrade, potentially becoming unusable over time.

5.5 Summary of Alternatives Evaluation

The shoreline stabilization alternative with the highest score is typically the living shoreline option using native containerized plants, dormant woody materials, and seed combined with traditional engineering, such as a stone toe and stone revetment (Table 2). Additionally, the road stabilization alternatives for the portion of Minnesota Avenue adjacent to the shoreline can be combined with one another, depending on available budget and City of Duluth priorities. The combination can include porous pavers to improve drainage, raising the road level to help ensure the road is accessible during high water and potentially reduce flooding, and using the addition of beneficial sediment to assist with maintaining the usage of the adjacent greenspace throughout more of the year.

Following additional discussions with the City and St. Louis County, a preferred mitigation option for each priority area will be selected. Once mitigation measures have been identified, Ramboll will work with the City and County to identify grant opportunities and to prepare grants to financially support the implementation of the selected shoreline mitigation measures.

6. REFERENCES

Miller, J. An introduction to the Geology of the North Shore. https://www.lakesuperiorstreams.org/understanding/geology.html. Accessed September 2022.

TABLES

Park Point Priorities				
Element	**Location**	**Description**	**Notation**	**Recommendation**
Marina and Shoreline	A	Western extent of PPRA including parking area, dock and boat launch	Rehabilitate boat facilities. Address resiliency issues adjacent to shoreline. Provide hardened armoring and living shoreline to improve long-term reliency and functionality.	Establish living shoreline adjacent to harbor with native trees, shrubs, and forbs to promote biodiversity, habitat enhancement, and increased resiliency. Use a mixture of container plants, vegetative plantings, and seeding. Reinforce bulkheads/seawall as appropriate using a combination of nature-based and traditional engineering measures such as riprap, including erosion control measures.
South Point Shoreline	B	Southern extent of PPRA including parking area and boat launch.	Beach and shoreline are not sustainable on exposed point. Beach is susceptable to E. coli. Address resiliency issues adjacent to shoreline. Provide hardened armoring and living shoreline to improve long-term resiliency and functionality, while discouraging bird ingress.	Establish living shoreline adjacent to harbor with native trees, shrubs, and forbs to promote biodiversity, habitat enhancement, and increased resiliency. Use a mixture of nature-based and traditional engineering measures such as riprap, including erosion control measures. Consider using sediment nourishment through the addition of clean beach sand to beach area. Sand could be potentially obtained from harbor dredging. Use living shoreline to discourage bird ingress, helping to reduce E. coli.
Minnesota Ave Shoreline	C	Southwestern extent of PPRA; shoreline parallel to Minnesota Avenue.	Habor-facing shoreline along Minnesota Avenue is eroding and potentially subject to scour and lake-level rise. Address resiliency issues adjacent to shoreline. Provide hardened armoring and living shoreline to improve long-term resiliency and functionality, while discouraging bird ingress.	Establish a living shoreline adjacent to harbor with native trees, shrubs, and forbs to promote biodiversity, habitat enhancement, and increased resiliency. Use a mixture of container plants, vegetative plantings, and seeding. Use a combination of nature-based and traditional engineering measures such as riprap, including erosion control measures. Use living shoreline to discourage bird ingress, helping to reduce E. coli.
Minnesota Ave Road	D	PPRA access road	Road is subsiding and subject to degredation. Without realignmet and potential modification, road is likely to further subside and degrade, potentially becoming unusable over time.	Assignment only focuses on harbor shoreline portion of the road, however per request of the City, the greenspace just inland from the road has also been considered. Consider potential road realignment and raise level to discourage water ingress. Consider turning road into a nature path trail walking - bike path with porous pavers to promote improved drainage and increased resiliency. Consider using sediment nourishment for the adjacent greenspace in order to raise it in elevation. Sand can be potentially obtained from harbor dredging.

Evaluation of Stabilization/Uplift Alternatives by Priority Area

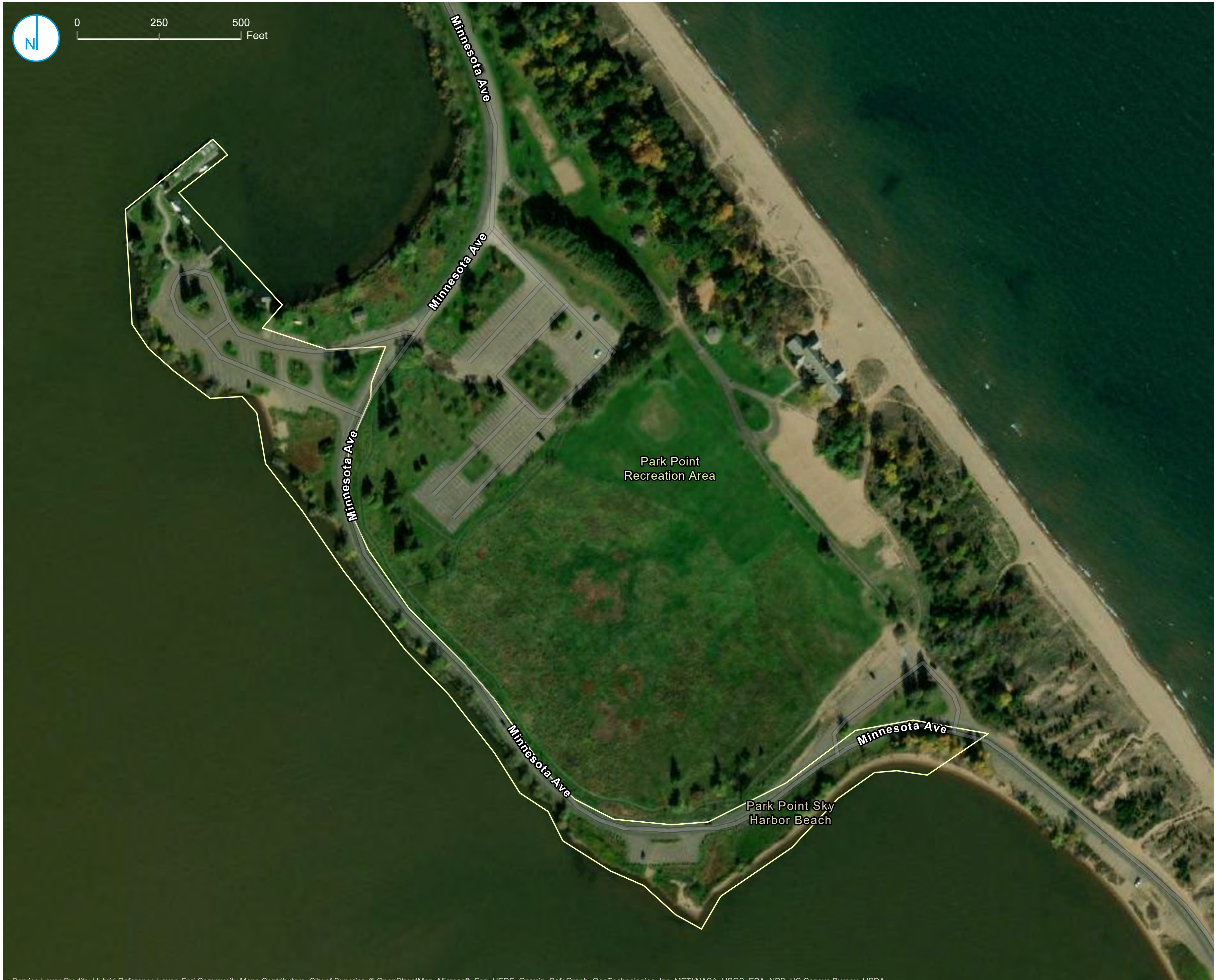
Priority Area	Option	Long Term Effectiveness	Implementability	Operations and Maintenance Requirement	Cost	Total	Comment
		1 = least effective 5 = most effective	1 = least implementable 5 = most implementable	1 = most O&M required 5 = least O&M required	1 = highest cost 5 = least cost		
Area A - Marina and Shoreline	Alternative 1: Establish living shorelines to reduce erosion by planting containerized plants, live stakes, wattles/fascines, and seed.	5	3	4	4	16	Revegetation with plants, biostabilization, and seed will result in the greatest amount of ecological uplift. May need to be combined with traditional engineering such as riprap to achieve maximum effectiveness. Stabilization will increase over time.
	Alternative 2: Revegetate eroding shorelines by incorporating joint planted revetment using large rocks, live stakes, and fascines.	4	2	4	2	12	Reduced habitat enhancement in comparison to revegeation with containerized plants, but potentially reduced costs. Revegetation with cuttings must be installed while dormant.
	Alterative 3: Incorporate riprap rock revetments to reduce erosion without bioengineering/nature-based features to improve protection from erosion and scour.	2	3	5	3	13	No habitat enhacement, increased scour at edges of installed riprap
	Alternative 4: No action	1	5	1	5	12	
Area B - South Point Shoreline	Alternative 1: Establish living shorelines to reduce erosion by planting containerized plants, live stakes, wattles/fascines, and seed.	5	3	4	4	16	Revegetation with plants, biostabilization, and seed will result in the greatest amount of ecological uplift. May need to be combined with traditional engineering such as riprap to achieve maximum effectiveness. Stabilization will increase over time.
	Alternative 2: Revegetate eroding shorelines by incorporating joint planted revetment using large rocks, live stakes, and fascines.	4	2	4	2	12	Reduced habitat enhancement in comparison to revegeation with containerized plants, but potentially reduced costs. Revegetation with cuttings must be installed while dormant.
	Alterative 3: Incorporate riprap rock revetments to reduce erosion without bioengineering/nature-based features to improve protection from erosion and scour.	2	3	5	3	13	No habitat enhacement, increased scour at edges of installed riprap
	Alternative 4: No action	1	5	1	5	12	
Area C – Shoreline Adjacent to Minnesota Avenue	Alternative 1: Establish living shorelines to reduce erosion by planting containerized plants, live stakes, wattles/fascines, and seed.	5	3	4	4	16	Revegetation with plants, biostabilization, and seed will result in the greatest amount of ecological uplift. May need to be combined with traditional engineering such as riprap to achieve maximum effectiveness. Stabilization will increase over time.
	Alternative 2: Revegetate eroding shorelines by incorporating joint planted revetment using large rocks, live stakes, and fascines.	4	2	4	2	12	Reduced habitat enhancement in comparison to revegeation with containerized plants, but potentially reduced costs. Revegetation with cuttings must be installed while dormant.
	Alterative 3: Incorporate riprap rock revetments to reduce erosion without bioengineering/nature-based features to improve protection from erosion and scour.	2	3	5	3	13	No habitat enhacement, increased scour at edges of installed riprap
	Alternative 4: No action	1	5	1	5	12	
Area D - Minnesota Avenue Adjacent to Shoreline	Alternative 1: Convert road to nature trail/walking – bike path.	5	3	4	5	17	Porous pavers can be combined with other measures including raising the road level and/or beneficial sediment application.
	Alternative 2: Raise the road level to provide additional access and potentially serve as an additional impediment to water influx.	4	2	3	4	13	Raising the road level can be combined with other measures including porous pavers and beneicial sediment applixation
	Alternative 3: Add beneficial sediment to the area just inland from the road to reduce water influx/nuisance flooding.	4	2	2	4	12	Beneficial sediment must be characterized as "cliean" prior to application. It can be combined with porous pavers and raising the road level.
	Alternative 4: No action.	1	5	1	5	12	

Park Point - Costing for Various Alternatives by Priority Area		
Priority Area	**Option**	**Approximate Total Cost**
Area A - Marina and Shoreline	Alternative 1: Establish living shorelines to reduce erosion by planting containerized plants, live stakes, wattles/fascines, and seed.	$9,750 per 1,000 linear ft.
	Alternative 2: Revegetate eroding shorelines by incorporating joint planted revetment using large rocks, live stakes, and fascines. **Recommended option**	$170,000 per 1,000 linear ft plus $12,500 for dormant plants, therefore $182,500 total.
	Alternative 3: Incorporate riprap rock revetments to reduce erosion without incorporating bioengineering /nature-based features to improve protection from erosion and scour.	$170,000 per 1,000 linear ft
	Alternative 4: No action	NA
Area B - South Point Shoreline	Alternative 1: Establish living shorelines to reduce erosion by planting containerized plants, live stakes, wattles/fascines, and seed.	$9,750 per 1,000 linear ft.
	Alternative 2: Revegetate eroding shorelines by incorporating joint planted revetment using large rocks, live stakes, and fascines. **Recommended option**	$170,000 per 1,000 linear ft plus $12,500 for dormant plants, therefore $182,500 total.
	Alternative 3: Incorporate riprap rock revetments to reduce erosion without incorporating bioengineering /nature-based features to improve protection from erosion and scour.	$170,000 per 1,000 linear ft
	Alternative 4: No action	NA
Area C - Shoreline Adjacent to Minnesota Avenue	Alternative 1: Establish living shorelines to reduce erosion by planting containerized plants, live stakes, wattles/fascines, and seed.	$9,750 per 1,000 linear ft.
	Alternative 2: Revegetate eroding shorelines b incorporating joint planted revetment using large rocks, live stakes, and fascines. **Recommended option**	$170,000 per 1,000 linear ft plus $12,500 for dormant plants, therefore $182,500 total.
	Alternative 3: Incorporate riprap rock revetments to reduce erosion without incorporating bioengineering /nature-based features to improve protection from erosion and scour.	$170,000 per 1,000 linear ft
	Alternative 4: No action	NA
Area D - Minnesota Avenue Adjacent to Shoreline	Alternative 1: Retreat road. **Recommended option**	$3,611.00 per 1,000 linear ft.
	Alternative 2: Raise the road level to serve as an additional impediment to water influx.	TBD
	Alternative 3: Add beneficial sediment to the area just inland from the road to reduce water influx/nuisance flooding.	TBD
	Alternative 4: No action.	NA

PHOTOS AND FIGURES

Photo 1: Park Point Habor showing subsidence of parking lot.

Photo 2: Park Point Habor showing undercutting of bulkhead and shoreline erosion.



Site Boundary

Notes
All locations are approximate

SITE BOUNDARY

Park Point
Duluth, Minnesota

FIGURE 1

RAMBOLL US CONSULTING, INC.
A RAMBOLL COMPANY

RAMBOLL

C:\Users\almiller\OneDrive - Ramboll\Documents\ArcGIS\Projects\Duluth\DuluthPro\Duluth_MM.aprx\Site boundary

PROJECT: 169000XXXX | DATED: 7/21/2022 | DESIGNER: ALMILLER

Site Boundary
1026A - Udifluvents, loamy 0-2 % slopes, occasionally flooded
F157C - Udipsamments - Urban land complex, 1-20 % slopes
W - Water

C:\Users\almiller\OneDrive - Ramboll\Documents\ArcGIS\Projects\Duluth\DuluthPro\Duluth_MM.aprx\Soils_20211015

PROJECT: 169000XXXX | DATED: 7/21/2022 | DESIGNER: ALMILLER

SOILS
NATURAL RESOURCES CONSERVATION SERVICE (NRCS)

Park Point
Duluth, Minnesota

FIGURE 2

RAMBOLL US CONSULTING, INC.
A RAMBOLL COMPANY

Site Boundary

Priority

- A: Marina and Shoreline
- B: South Point Shoreline
- C: Minnesota Avenue Shoreline
- D: Minnesota Avenue Road

Notes

All locations are approximate

PARK POINT PRIORITIES

Park Point
Duluth, Minnesota

FIGURE 3

RAMBOLL US CONSULTING, INC.
A RAMBOLL COMPANY

Previous Shoreline
- 1992
- 1997
- 2005
- 2015
- 2020

SHORELINE EROSION

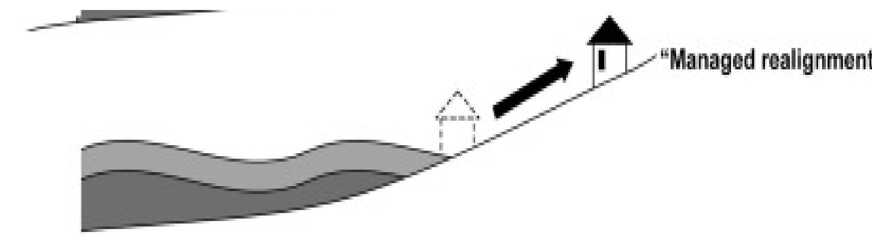
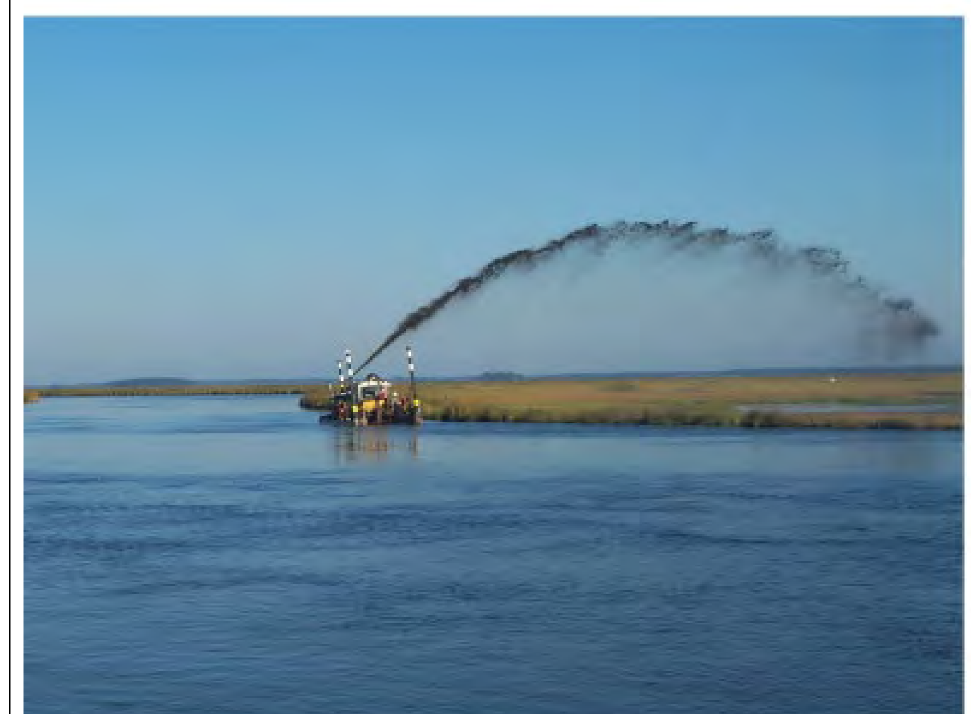
Park Point
Duluth, Minnesota

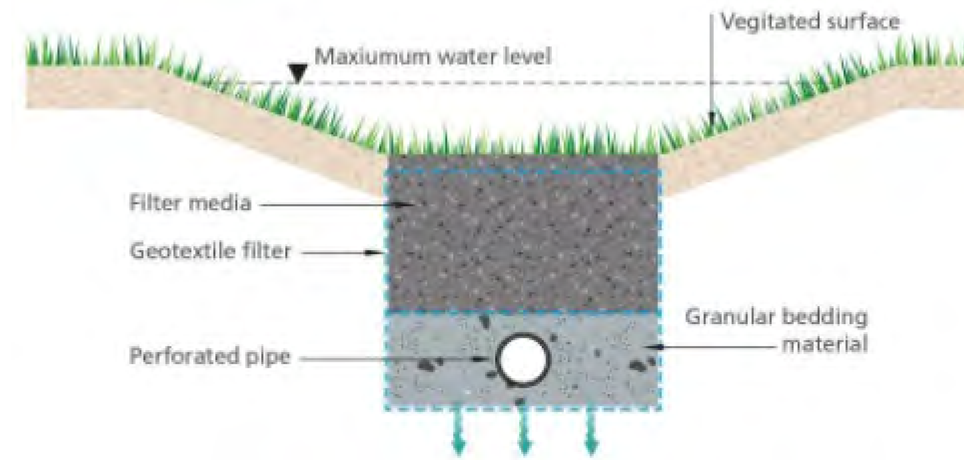
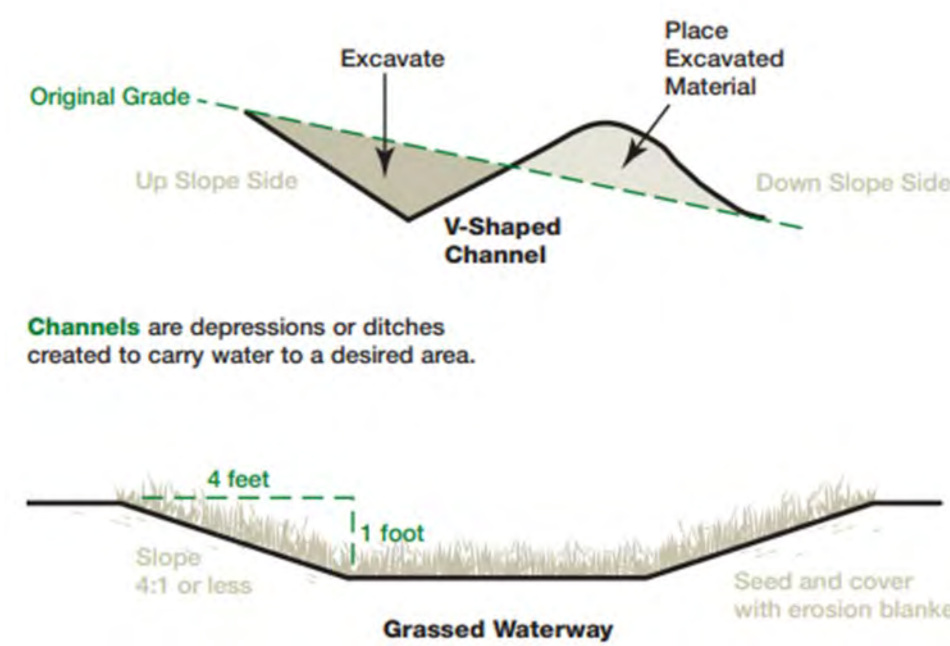
FIGURE 4

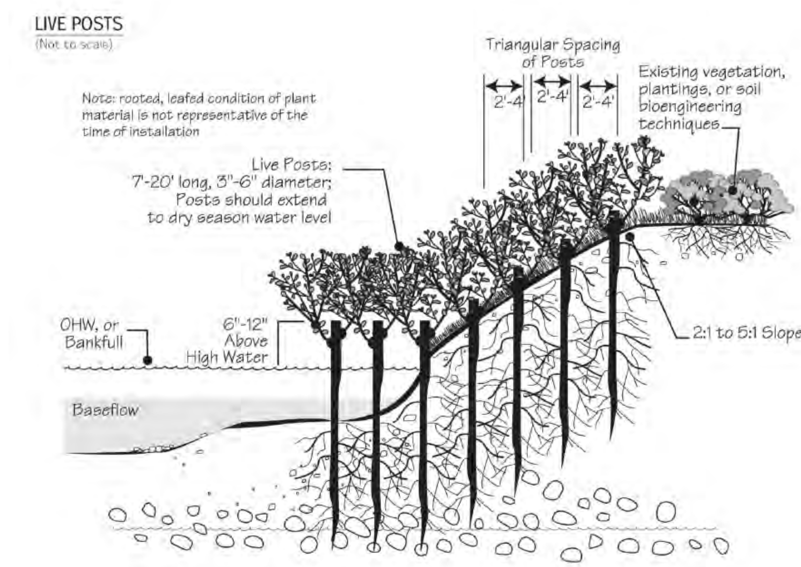
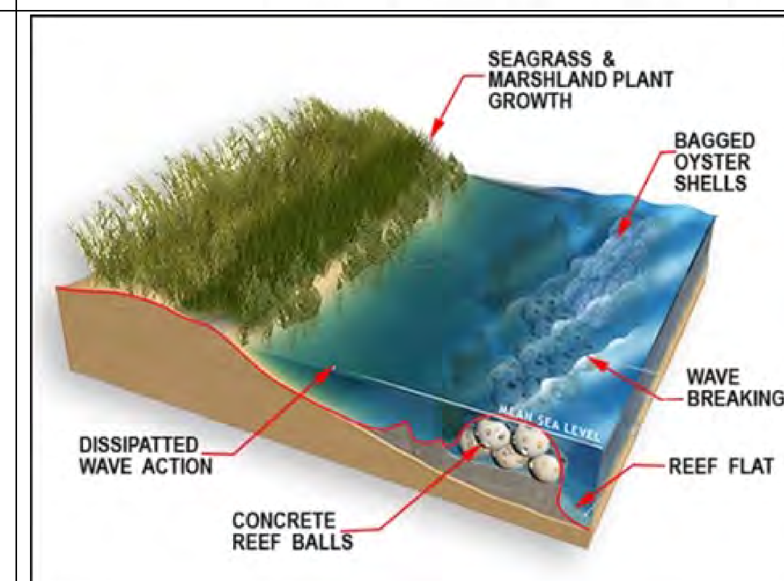
RAMBOLL US CONSULTING, INC.
A RAMBOLL COMPANY

APPENDIX A

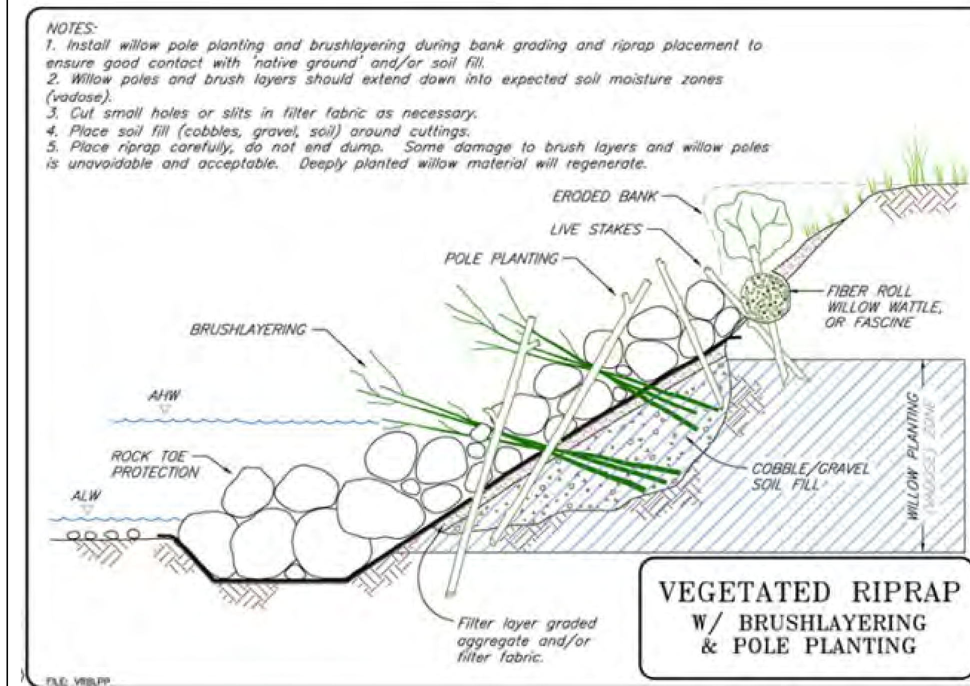
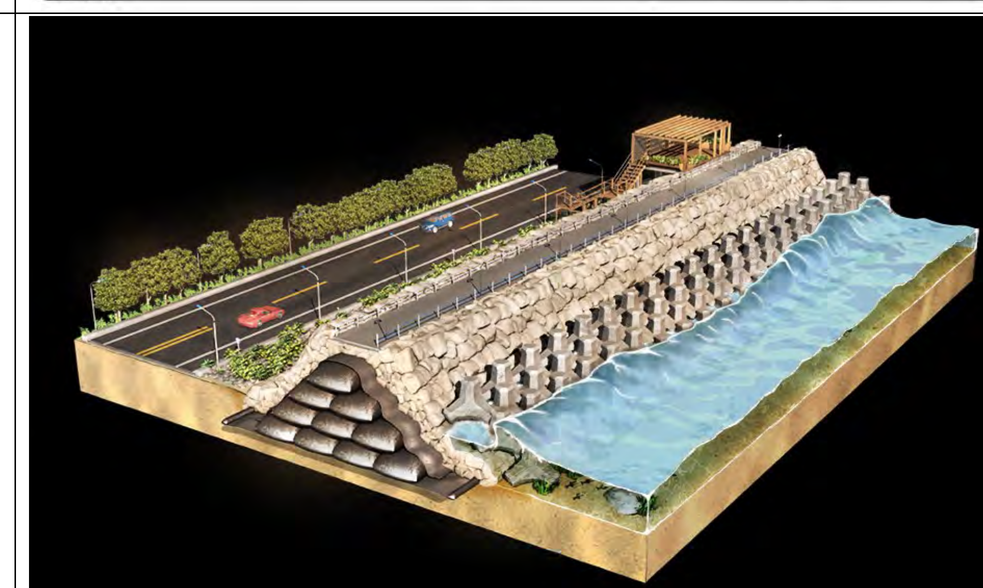
SHORLINE MANAGEMENT ALTERNATIVE MATRIX

Duluth Park Point				
Shoreline Management Alternative Matrix				
Alternative	**Applicability**	**Constraints**	**Shoreline Classification**	**Example**
NON-STRUCTURAL				
Managed retreat/ realignment - Move infrastructure (roads, buildings, parking lots, etc.) away from shoreline	Use non-structural measures whenever possible.	Size of property, type and size of structure, cost.	All shoreline types.	 Roca E, Villares M. 2012. Public perceptions of managed realignment strategies: The case study of the Ebro Delta in the Mediterranean basin. Ocean & Coastal Management. 60:38–47.
Thin-layer placement	Used to increase elevation to protect against high level flood events and help establish vegetation. Used in locations that are being impacted by rise in water level and cannot transition to wetland due to land use constraints. Beneficial use of dredged material.	Requires uncontaminated dredged sediment, permitting constraints.	Existing upland and wetland areas with little elevation change.	 Ray, LG. USAGE. Thin Layer Placement of Dedged Material. 2007.

Duluth Park Point				
Shoreline Management Alternative Matrix				
Alternative	**Applicability**	**Constraints**	**Shoreline Classification**	**Example**
SURFACE WATER MANAGEMENT				
Surface water management- diversion swale with pipe/ French drain	Assist with collecting and diverting surface water runoff from bluff and/or slope face that often leads to bluff erosion.	Size of property, drainage needs to connect to culverts and surface drainage infrastructure. Benefits from comprehensive infrastructure planning for local drainage systems. Expensive.	Inland of all shoreline types. Could assist with surface water runoff that leads to bluff erosion.	
Surface water management- reduce runoff rate toward bluff, diverting surface runoff away from bluffs and shorelines by creating a grasses waterway between road and top of bluff	Assist with collecting and diverting water runoff from the pavement/ roads away from bluffs.	Size and width of property. End location of the grassed waterway/ drainage. Proximity of road to top of bluff. Benefits from comprehensive infrastructure planning for local drainage systems.	Inland of all shoreline types. Could assist with surface water runoff that leads to bluff erosion.	

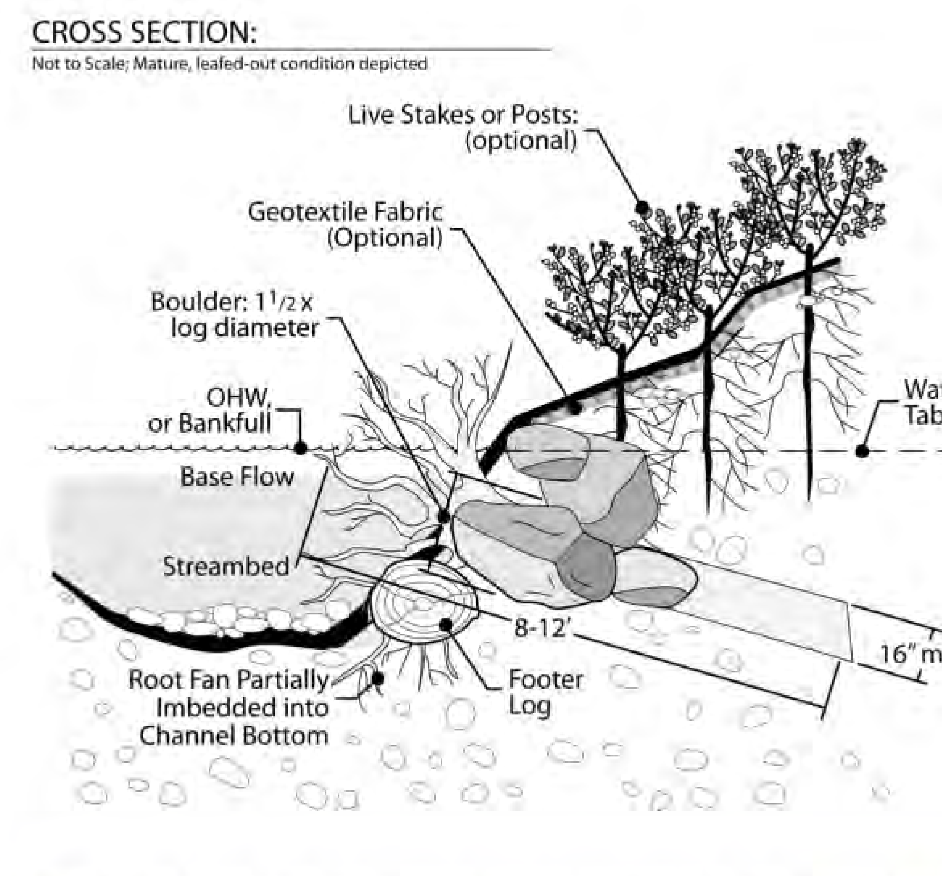
Duluth Park Point				
Shoreline Management Alternative Matrix				
Alternative	**Applicability**	**Constraints**	**Shoreline Classification**	**Example**
NATURE AND NATURE-BASED MEASURES				
Vegetation management-revegetating with containerized plants and live stakes	Pre-existing vegetative areas, all areas where vegetation is disturbed, all areas with adequate sediment and hydrological connectivity to support a vegetative community. Can be paired with other natural and nature-based features (NNBF) and structural measures to add tensile strength to banks.	Needs to be paired with other stabilization features.	All shoreline types with adequate hydrology and soils.	
Wave break structures (oyster shells, rock)	Large waves, long fetch length, open coast sites. Wave break structures are intended to break waves, reduce the force of wave action, and encourage sediment accretion. Could be floating, fixed to ocean floor, continuous, or segmented.	Shoreline width, expensive, permitting constraints, can reduce water circulation, can create a navigational hazard.	All shorelines with high wave energy, often in conjunction with marinas.	

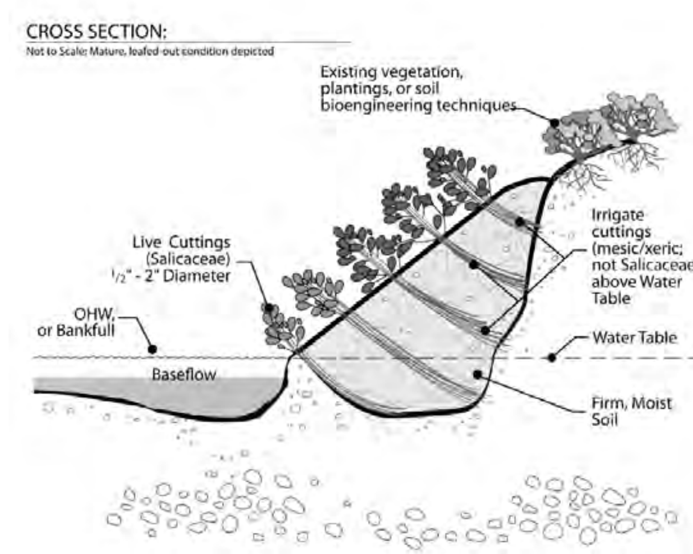
Duluth Park Point				
Shoreline Management Alternative Matrix				
Alternative	**Applicability**	**Constraints**	**Shoreline Classification**	**Example**
Living shorelines-freshwater wetland restoration	Areas that would benefit from habitat enhancement.	For many areas, would need to be combined with hard structural measures.	All shorelines with adequate substrate and low energy environments.	
HARD STRUCTURAL MEASURES				
Articulated concrete block (ACB)	Large waves, long fetch length, open coast sites.	Shoreline width, slope. Requires smooth, uniform surfaces to avoid erosion and differential settling.	All shorelines.	

Duluth Park Point				
Shoreline Management Alternative Matrix				
Alternative	**Applicability**	**Constraints**	**Shoreline Classification**	**Example**
Joint planted revetment	Aids in natural regeneration colonization. Minimal site disturbance. Protects banks from shallow slides and stabilizes banks. Dissipates flow energy and traps sediment. Branches add tensile strength to bank. Combination of boulder cobble toe with joint plantings provides added tensile strength and toe protection. Boulder cobble toe stabilizes the toe of the bank providing protection while vegetation stabilizes mid and upper. Joint plantings deflect overbank high flows when planted close together.	Size of property, width of property, proximity of development to shoreline.	Areas highly vulnerable to storm surge and wave forces. Areas adjacent to critical infrastructure. High wave energy settings.	
Bulkheads/seawalls	Seawalls and bulkheads are parallel to the shoreline and are vertical or slopes walls intended to hold soil in place and allow for a stable shoreline. Harbors, marinas, other working waterfronts, areas without room for a rock revetment.	Large waves, erosion of seaward, seabed, disrupt sediment transport, high up-front cost, loss of intertidal zone, prevents upland from being a source of sediment to the system, can be damaged from overtopping oceanfront storm waves.	Bluffs, areas highly vulnerable to storm surge and wave forces. Areas adjacent to critical infrastructure. High wave energy settings.	

Duluth Park Point				
Shoreline Management Alternative Matrix				
Alternative	**Applicability**	**Constraints**	**Shoreline Classification**	**Example**
Retaining walls	Retaining walls are also parallel to the shoreline and are vertical walls intended to hold soil in place and allow for a stable shoreline. Harbors, marinas, other working waterfronts, areas without room for a rock revetment.	Disrupt sediment transport, high up-front cost, prevents upland from being a source of sediment to the system, can be damaged from overtopping oceanfront storm waves. Expanding ice sheets can damage vertical walls.	Bluffs, areas highly vulnerable to storm surge and wave forces. Areas adjacent to critical infrastructure. High wave energy settings.	
Riprap rock revetment	Revetments are hardened areas that lay over a slope of a shoreline to project from erosion and waves. Large waves, long fetch length, open coast sites. Benefits include mitigates wave energy, little maintenance, and indefinite life span	Loss of intertidal and coastal habitat, requires more land area, potential erosion of adjacent unreinforced sites, prevents upland from being a sediment source to the system.	All shorelines, including bluffs, are experiencing toe erosion. Sites with pre-existing hardened shoreline structures.	

Duluth Park Point				
Shoreline Management Alternative Matrix				
Alternative	**Applicability**	**Constraints**	**Shoreline Classification**	**Example**
OTHER REVIEWED OPTIONS				
Biodiversity Enhancement: Native open space revegetation and Pollinator habitat	Increases biodiversity, habitat provision, beauty, and soil stability. Flowering plants attract pollinators (insects, birds etc.), which are responsible for fertilizing over 70% of flowering plants. They also increase biodiversity across trophic levels and contribute to many ecosystem services (clean air, water, and soil). Other non-flowering species can provide habitat for pollinators and other wildlife as well.	Property size, soil condition, labor costs. Flowering plants can take longer to establish and are more expensive to plant than grasses.	All shorelines and upland habitats with adequate soil.	  University of Minnesota

Duluth Park Point				
Shoreline Management Alternative Matrix				
Alternative	**Applicability**	**Constraints**	**Shoreline Classification**	**Example**
Biostabilization - Rootwad revetment with riprap toe and willow cuttings	Provides habitat and stabilization, can be paired with riprap and willow cuttings.	Requires bank excavation then regrading, expensive, rootwads will decay over time unless wood is continuously submerged	Areas that require toe protection such as banks.	 Figure 19. Log Anchor / Root Wad Revetment (Adapted with permission from Eubanks & Meado 2002).

Duluth Park Point				
Shoreline Management Alternative Matrix				
Alternative	**Applicability**	**Constraints**	**Shoreline Classification**	**Example**
Biostabilization- brush layering	Unvegetated bluffs, steep slopes, areas undercut by wave action, slump areas that require erosion protection. Benefits include reinforcing bank through the placement sequential layers of cuttings and soil, providing sub subsurface bank stability, riparian vegetation and streamside habitat restoration and revegetation.	Size of property, width of property, proximity of development to shoreline.	Bluffs and banks.	 https://extensionpublications.unl.edu/assets/html/g1307/build/g1307.htm

Definitions:

Natural and Nature-Based Measures: Measures that use the landscape to provide engineering functions relevant to flood risk management while production additional economic, environmental, and/or social benefits. Examples include beaches, dunes, salt marshes, etc.

Living Shorelines: Living shorelines use plants and other natural elements such as sand and rocks to protect and stabilize a shoreline. Living shorelines can be used alone or in combination with other harder features to stabilize a shoreline.

Bioengineering or Biostabilization: Practice of using natural vegetative materials to provide long-term bank stability and strength by using root systems to bind soil particles and impart cohesion to the soil and resistance to erosional loss.

Non-Structural Measures: Includes modification in public policy, management practices, regulatory policy, and pricing policy. Examples include flood preparedness planning, emergency response plans, flood proofing, or acquisitions and relocations.

Hard or Grey Structural Measures: Structural measures that use non-natural materials such as concrete, piping, etc. to reduce coastal risks by decreasing shoreline erosion, wave damage, and flooding. Examples include sea walls, groins, and riprap.

Subsurface Drainage Management: The process of managing water discharges from subsurface systems (natural groundwater seepage or manmade drainage systems) with water-control structures.

Park Point - Priorities as Shared by the City		
Element	**Notation**	**Recommendation**
New road alignment	Remove horseshoe portion of the road, preserving primary road.	For road removal, excavate road, replace sediment, regrade, put in rip rap then revegetate (re-seed, hydromulch, and planting of living shoreline with shrubs and forbs for pollinators). For new road alignment.
Parking facilities	Reconstruct at a higher elevation, increase capacity. Improve ADA access. Provide Ample Parking. Add parking facilities closer to the beach house. Add adequate parking for all users including beachgoers.	Increase elevation using dredged sediment placement.
Drop-off parking	Needed for emergency access, ADA access, drop-off and pick-up, food truck access.	N/A
Improve connection	Create safe connections from parking and green space to beach house and beach.	Revegetate greenspace with native vegetation, add lighting for safety.
Improve road alignment	Improve road alignment closer to beach house and away from beach shoreline.	Revegetate as need to stabilize new road alignment.
Multi-use greenspace	Multi-use greenspace. Needs to be elevated to reduce the impact from flooding from either waves or rising water levels.	Consider thin-layer placement to increase the elevation of greenspace, reduce fields and increase native communities (pollinator and water-tolerant species) that provide protection.
Reconstruct parking lot closest to point	Provide increased capacity for parking lot closest to point.	Expand parking lot closet to point to include additional boat parking and revegetate as needed to stabilize the new parking area design.
Beach sustainability closest to point	Beach is not sustainable on exposed point. Also susceptible to E. coli.	Add geese fencing, green and gray infrastructure combination and living shorelines.
Road and parking lot by harbor	Remove road and parking lot closest to harbor area (horseshoe road). Improve armoring and resiliency. Provide natural vegetation/living shoreline with habitat enhancements.	For road and parking lot removal excavation, sediment placement, regrade. Add living shorelines, vegetation enhancement, revegetation, and strategic joint planting. Consider adding elevation to protect further inland.
Boat parking area	Improve boat parking area for boat trailer combos and ADA access.	Expand parking lot closest to point to include additional boat parking and revegetate as needed.
Boat facilities	Rehabilitate boat facilities. Address resiliency issues adjacent to shoreline. Provide hard and green armoring to improve long-term resiliency and functionality.	Use strategic placement of bulkhead/ seawall, joint planting, and living shoreline (edging).