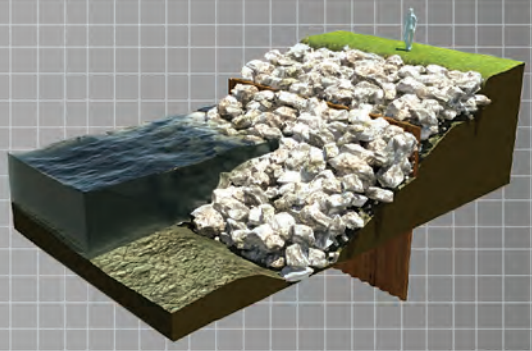
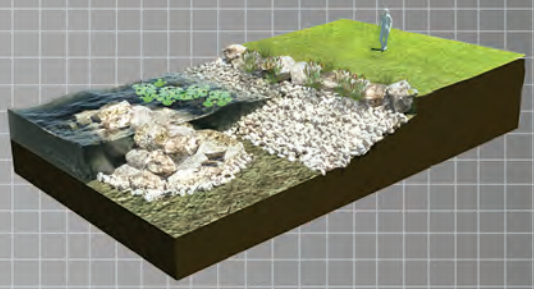
Detroit River Canadian Shoreline

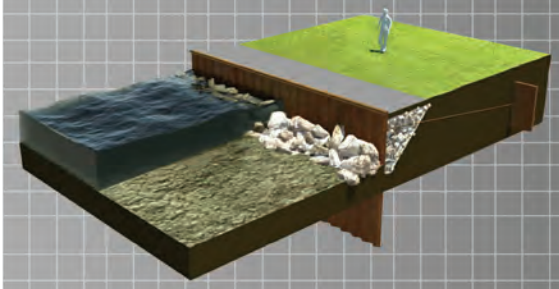
Restoration Alternatives Selection Manual



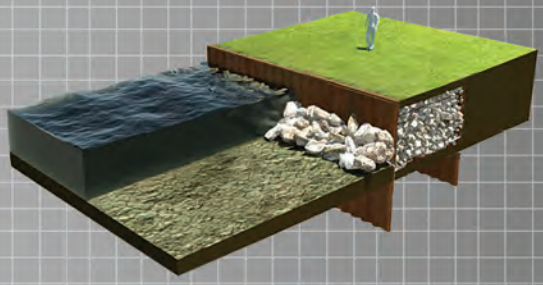
DOUBLE ARMOUR LAYER REVETMENT FOR SEVERE WAVE EXPOSURE AND DEEP WATER



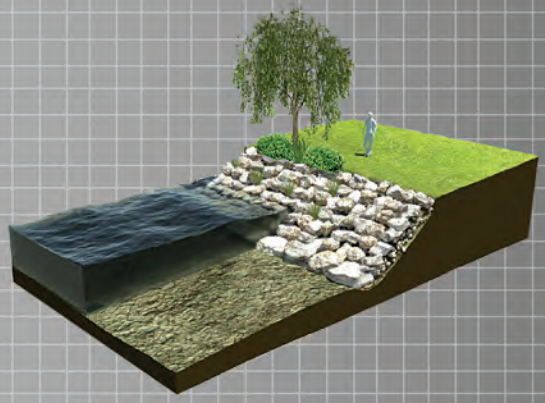
LIGHT REVETMENT/EDGE TREATMENT



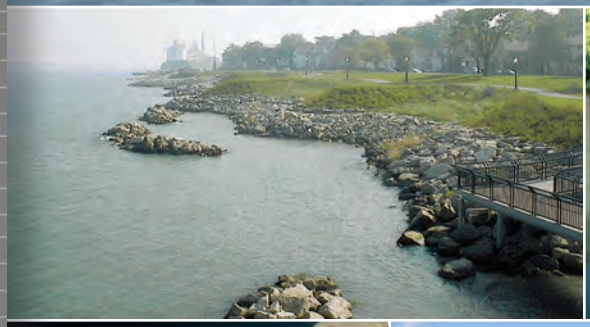
NEW ANCHORED BREAKWALL WITH CONTINUOUS ROCK TOE PROTECTION



NEW BIN-TYPE BREAKWALL WITH CONTINUOUS ROCK TOE PROTECTION



SINGLE ARMOUR LAYER REVETMENT FOR MODERATE SHORELINE EXPOSURE



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Contents

1.1 Introduction

In 2011, the Essex Region Conservation Authority and its partners (including Environment Canada) completed a shoreline assessment of Canadian mainland properties within the Detroit River Area of Concern (AOC) to inventory and assess shoreline structures and conditions. This study (i.e., the *Detroit River Shoreline Assessment Report*) determined that more than 80% of the shoreline length has been developed as a result of urbanization, and that the shorelines fronting the large majority of the developed properties have been artificially hardened. This shoreline hardening has resulted in the direct loss and fragmentation of natural habitat along the Detroit River shoreline – replacing it with reclaimed parkland, industrial land, housing, and other artificial structures such as seawalls. The study concluded that the improvements associated with most shoreline development have created habitats that are unsuitable for many desirable species.

In addition to characterizing the type of structures that exist along the shoreline, the above-noted study also considered fish and aquatic habitat restoration or enhancement opportunities and erosion protection opportunities that existed along the shoreline. Restoring and enhancing fish and wildlife habitat has been identified by the Detroit River Canadian Cleanup (DRCC) partnership as a priority for the delisting of the Detroit River AOC.

Building on the findings of the prior study, the Essex Region Conservation Authority, in partnership with Environment Canada, has commissioned a follow-up study to:

- Create a public-friendly, visually appealing manual that describes the various options for shoreline restoration that are possible along the Canadian side of the Detroit River; and,

- Create an easy-to-follow decision-making matrix to help guide landowners, contractors, and the technical staff of various approving agencies to choose the best shoreline solution for a given site, based on common site characteristics.

This Manual represents the culmination of the follow-up study.

The expectation is that this Manual will be used (along with the original *Detroit River Shoreline Assessment Report*) to guide shoreline restoration efforts for private landowners working within the Detroit River AOC, and also to assist the DRCC partnership in determining the suitability of various sites for implementing fish habitat enhancement works.

1.2 Manual Outline

This Shoreline Protection Manual addresses several principal questions, namely:

1. What are the traditional types of shoreline protection that have been used within the Detroit River AOC in the recent past?

2. What are the alternatives to traditional shoreline protection?
    - What types of shoreline protection alternatives achieve significant fish and aquatic habitat enhancement while still achieving the essential function of erosion protection?
    - How do habitat-friendly systems differ from the more traditional shoreline protection systems?

3. What are the advantages and disadvantages of habitat-friendly shoreline protection, and what are the principal design considerations?

4. What are the approval/permitting issues associated with each type of shoreline protection?

5. How does the cost of habitat-friendly shoreline protection compare with the cost of more traditional protection systems?

6. Where are some examples of habitat-friendly, ecologically sustainable shoreline protection systems?

7. How do I decide whether habitat-friendly shoreline protection is suitable for my property?

1.3 The Traditional Approaches to Shoreline Protection

Historically, the development of lands abutting the Detroit River (for human habitation, commercial or industrial uses) has led to the installation of erosion and flood control works that are intended to arrest the natural and persistent processes of erosion. It has been estimated that over 95% of the natural coastal wetlands that once lined the Detroit River have been lost as a result of human use. The fact is that in the absence of development, coastal erosion is neither a problem nor a hazard, but is rather a natural process that does not require human intervention.

Along the Detroit River shoreline, the predominant approach to erosion protection has involved the installation of vertical bulkheads – initially constructed with wood sheeting, and more recently with steel sheet piling. ERCA's 2012 *Detroit River Shoreline Assessment Report* found that approximately 40% of existing shoreline protection installations consist of steel sheet piling breakwalls/bulkheads. This has significant implications for the environmental health of the River, since the construction of such shoreline protection systems has historically

occurred without much regard for the natural environment. This has resulted in the loss of natural coastal habitats that are vital to providing a range of ecosystem functions along the shoreline of the Detroit River.

Other common approaches to shoreline protection have involved the ad-hoc armouring of the shoreline slopes with whatever materials were available and affordable (e.g., concrete rubble, larger field stones, etc.). Such "non-engineered" types of erosion mitigation tend to have limited, short-term effectiveness, and often require periodic supplementation of the armouring material in order for them to remain functional. Although they can provide slightly improved habitat value over vertical bulkheads, they are commonly associated with significant infilling of the foreshore - and have probably resulted in significant loss of more productive native nearshore wetlands and other aquatic habitats.

1.4 Options to Traditional Shoreline Protection

Engineered shoreline structures such as steel sheet pile and concrete bulkheads are certainly a viable means of erosion protection. In specific applications, they may even be the preferred approach - particularly in deep water applications or in cases where the landowner wishes to maximize nearshore navigability and the vessel mooring potential along the shoreline. Nevertheless, bulkheads typically provide a hard and homogeneous substrate of concrete or steel, and often exist in areas where natural hard substrate was originally absent or sparse. This differs significantly from natural habitats such as marshes, forest swamps, sand or cobble beaches, and eroding bluffs – habitats that originally would have dominated the Detroit River shoreline. In comparison, vertical-faced concrete and steel structures have limited potential to provide habitat and other environmental functions and therefore are poor surrogates. Therefore, there has been a growing effort among approving agencies to address the issue of shoreline erosion in a manner that restores sustainability and ensures habitat diversity, while still achieving the primary erosion protection function.

Most of the development that we see today occurred during a period when the general knowledge with respect to the cumulative impacts of aquatic habitat loss was limited. The introduction of shoreline regulations in the 1970s and 1980s attempted to limit further habitat degradation.

The Great Lakes Water Quality Agreement (GLWQA), signed by the governments of Canada and the United States in 1972 (and most recently amended by Protocol in 2012), commits both countries to prepare Remedial Action Plans for the restoration of 43 designated Areas of Concern around the Great Lakes. There are presently 38 AOCs remaining. The Detroit River Canadian Cleanup (DRCC) is a partnership of all levels of government, business and industry, educational institutions, and community groups, whose role is to restore, enhance, and clean up the Detroit River and its source watersheds. One of the DRCC's restoration priorities is to improve fish and aquatic habitat.

Over the past 20 years, there has been an emergence of more ecologically sensitive approaches to shoreline protection. These include beach nourishment, "dynamic" revetments,

living gabions and other (often proprietary) systems that aim to preserve the dynamic and diverse characteristics of the shoreline and nearshore area. Many such designs focus on the preservation or supplementation of desirable substrates and the maintenance or establishment of desirable nearshore and riparian vegetation.

1.5 Characteristics and Advantages of Soft, Habitat Sensitive Shoreline Protection

"Soft" shoreline treatment techniques have become more prevalent in recent years, and involve the use of rock (and other natural materials) in combination with plants to resist erosion. They endeavour to reverse the past trends that have transformed shorelines from near-horizontal or gradually-sloping landscapes to near-vertical landscapes, and they often combine various design elements, including: shoreline crenulation, diversity of substrate type and sizes, and sheltering structures (shore-connected or offshore). In the end, "soft" shoreline treatments more closely mimic the naturally-occurring foreshores on the Great Lakes, and in doing so, provide greater environmental value.

The general advantages to this type of erosion mitigation approach include:

- an increase in the effective shoreline length;
- a decrease in the foreshore slope (and corresponding increase in the foreshore length);
- an increase in the diversity of the interstitial (void) space - making it more suitable for spawning habitat for some species, and providing shelter from predation for smaller fish;
- the use of more natural materials that are readily available, such as rock, cobbles, sand, and plant materials;
- better absorption of wave energy and reduction in nearshore current – making the foreshore more habitable to aquatic plants and animals;
- improved ability of the shoreline to filter overland runoff;
- achievement of a more natural-appearing shoreline; and,
- improved mimicking of natural coastal zone processes to increase the quantity and quality of aquatic and fish habitat.

The primary goal of this Design Manual is to identify the advantages, disadvantages and typical construction costs associated with the various types of shoreline protection systems available to waterfront landowners - acknowledging that substantial variations in the bathymetry, geologic conditions, wave climate, hydraulic and biologic environments must be properly considered when selecting and designing shoreline protection. Accordingly, the characteristics of each system are illustrated with typical design drawings and photographs. In addition, a decision-making matrix has been developed to assist in guiding landowners and approval agencies through the process of selecting a shoreline protection system that suits the specific site environment where the improvements are to be undertaken.

2.0 SUMMARY OF SHORELINE PROTECTION TYPES

There are three primary types of shoreline protection that have typically been employed along the Canadian shore of the Detroit River, namely: Seawalls or Bulkheads; Revetments; and, Beach Foreshores. Although there are some variations to these systems, and measures can be added to further enhance their environmental and habitat value (e.g., providing a native riparian vegetation buffer landward of the shoreline protection), they constitute the core systems that should be considered for new shoreline rehabilitation projects in the study area.

This section includes a brief description of each system and its major components as well as a summary of the fundamental advantages and disadvantages that are associated with each type of protection system.

2.1 Seawalls/Bulkheads/Breakwalls

Description:

In this region, the terms breakwall, seawall and bulkhead are often used interchangeably when referring to a vertical faced shoreline protection system.

Technically, a seawall is any structure that prevents inland flooding from major storm events accompanied by large, powerful waves. The key functional element in design is the crest elevation, which is set high enough to minimize the overtopping from wave run-up. They typically consist of a massive, concrete structure with its weight providing stability against sliding and overturning. There are very few structures along the Detroit River shoreline that would be properly categorized as seawalls.

By comparison, a bulkhead is a vertical retaining wall used along a waterfront to hold or prevent soil from sliding seaward. Their main purpose is not to mitigate coastal flooding and wave damage, but to reduce land erosion. In this region, most vertical faced shoreline protection systems that are referred to as breakwalls are actually bulkheads. They can be either cantilevered or anchored sheet piles (steel, wood or concrete) or gravity structures (concrete, rock-filled timber cribs, gabions). In a shoreline application, bulkheads typically perform a dual purpose; to hold land or fill in place (prevent shore side losses) and to protect the land from wave attack.

Cantilever bulkheads derive their support from ground penetration. Anchored bulkheads are similar to cantilevered bulkheads except they gain additional support from anchors embedded on the landward side. Gravity structures eliminate the expense of pile driving and can often be used where subsurface soil conditions are suitable to support their weight.

A bulkhead derives its strength to resist wave forces primarily from the backfill/fill material. It follows then that if the backfill/fill material is lost, the bulkhead has no practical mechanism to adequately protect against waves. Hence, two critical elements of a good bulkhead design that prevent or limit loss of backfill/fill material are:

- return walls at the alongshore ends or ”flanks” of the structure to prevent high water from washing material away from behind the structure; and,
- geotextiles to allow water (but not finer backfill material) to flow through the structure.

Drainage of water through the structure is crucial to relieve hydrostatic pressure from rainfall or wave overtopping. This is normally achieved by using weep holes in the structure face to allow water to seep out.

For the purpose of this document, the term “breakwall” will be used to describe any vertical faced shoreline protection system. Along the Detroit River, the most common type of breakwall is the anchored steel sheet pile (SSP) wall.

Examples

Given that approximately 40% of existing shoreline protection installations within the study area consist of steel sheet piling breakwalls/bulkhead, there is no shortage of examples where this type of shore protection can be observed. Some of the better examples are depicted below.

Steel Sheet Pile Wall East of St. Paul Pump Station (between Eastlawn Avenue and Lauzon Road)

Steel Sheet Pile Breakwall at St. Rose Beach (at St, Rose Avenue)

Summary of Impacts

Physical Impacts:

- Shoreline Erosion:
  - Effectively protects upland properties from wave attack and erosion
  - Provides long-term shoreline stability

- Hydrodynamics:
  - Has negligible effects on local river current/flow patterns
  - Final alignment must adhere to the provisions of the Bi-National Encroachment Analysis
  - Reflects wave energy which amplifies nearshore wave dynamics

- Water Quality:
  - Some temporary disturbance of bottom sediments and increased turbidity occurs during construction
  - Clearing of driving line causes disturbance of river bottom and temporary increased turbidity
  - Breakwalls effectively halt the erosion of fill materials into the river

Biological Impacts:

- Aquatic Habitat:
  - Impermeable vertical wall provides poor aquatic habitat
  - Often requires on-site or off-site fish habitat compensatory works to satisfy the Fisheries Act
  - A non-linear, curvilinear alignment provides the opportunity for compensatory habitat to be created on-site
  - Construction creates temporary stress on aquatic communities

- Terrestrial Habitat:
  - Usually little to no impact on terrestrial habitat

Socio-Economic Impacts:

- Construction, Maintenance and Costs:
  - Placement and construction is more complicated than other protection systems
  - High construction costs (most expensive of all options)
  - Requires more intense drainage measures to prevent hydrostatic pressure
  - Requires proper tie-in at terminations to adjacent properties
  - May require substantial disturbance of upland area to install anchors (if needed)

- Requires minimal regular maintenance
- Service life expectancy of steel sheet piling is limited by steel gauge and corrosion processes

- Shoreline Uses:
  - Maximizes usable table land area
  - Creates vertical barrier to shoreline and limits direct access to the river
  - Minimal potential for flotsam and jetsam (river debris) retention

- Navigation:
  - Accommodates mooring of vessels better than other shoreline protection systems
  - Minimizes encroachment into navigable waters

- Safety:
  - Creates barrier between land and water minimizing direct access to river
  - Impedes egress from river

2.2 Revetments

Description:

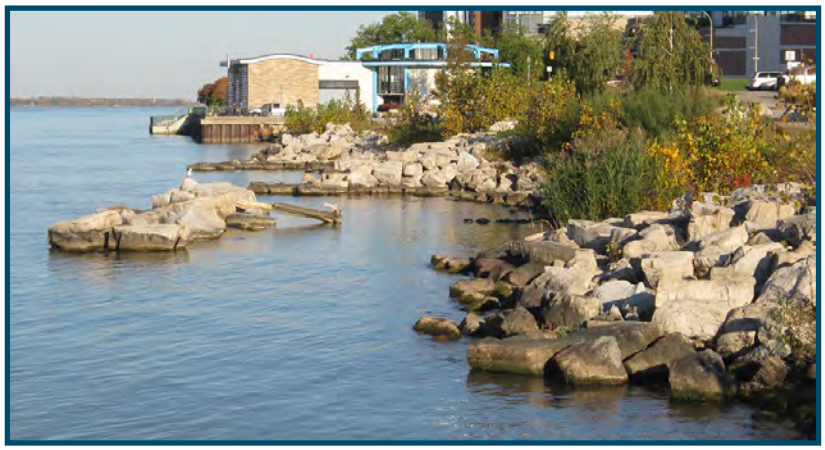
In coastal applications, revetments consist of a covering or facing of erosion resistant material placed on a slope or embankment to protect the area from waves and/or currents. To be effective in the long-term, a revetment requires four key features: a stable armour layer, a filter (geotextile cloth or filter stone), an under-layer (bedding stone), and toe protection. The filter and underlayer support the armour, yet allow for passage of water through the structure. Toe protection prevents undercutting and provides support for all the layer materials previously mentioned.

Armour layers consisting of rock (riprap and larger quarrystone) are good examples of flexible designs that can tolerate some movement of the armour units or settlement of their underlying foundation while remaining functional. The most critical factors that limit the effectiveness of a rock revetment are the size of the armour units in relation to the wave and ice exposure, and the durability of the individual armour units.

Examples

There are many good examples of where revetments have been utilized within the study area to mitigate shoreline erosion. Some of the more recently constructed rock revetments can be observed at the locations indicated below.

Hatch Gardens Armour Rock Revetment (between Langlois Avenue and Moy Avenue)



Legacy Park Revetment (between Crawford Avenue and Caren Avenue)

RTB Revetment (between Glengarry Avenue and Louis Avenue)

Summary of Impacts

Physical Impacts:

- Shoreline Erosion:
  - Effectively protects upland properties from wave attack and erosion
  - Provides long-term erosion protection and shoreline stability

- Hydrodynamics:
  - Has negligible effects on local river current/flow patterns
  - Final alignment must adhere to the provisions of the Bi-National Encroachment Analysis
  - Reflects less wave energy which reduces alteration of nearshore wave dynamics

- Water Quality:
  - Construction causes temporary disturbance of bottom sediments and increased turbidity
  - Will effectively halt the erosion of fill materials into the river

Biological Impacts:

- Aquatic Habitat:
  - Sloping rock structure provides long-term improvement to fish and aquatic habitat
  - Curvilinear revetment provides more edge length than linear systems
  - Requirements of Fisheries Act can normally be addressed on-site by integrating habitat enhancements with protective works
  - Construction creates temporary stress on aquatic communities
  - Substantial encroachment of revetment toe into river may introduce permitting issues

- Terrestrial Habitat:
  - Normally no adverse impact on terrestrial habitat
  - Compatible with introduction of terrestrial habitat

Socio-Economic Impacts:

- Construction and Maintenance Costs:
  - Placement and construction is simpler and less expensive than other protection systems
  - Relatively lower initial construction costs and maintenance costs
  - Potential for flotsam and jetsam (river debris) retention

- Service life should exceed that of a typical residential grade steel breakwall
- Service life expectancy of revetment is limited by durability of rock (potential for rock disintegration)
- Durable against full range of wave action and ice loads

- Shoreline Uses:
  - Provides improved access to water's edge compared to breakwalls
  - Resembles a more natural and aesthetic shoreline

- Navigation:
  - Complicates vessel mooring opportunities
  - Encroaches into navigable waters

- Safety:
  - Provides direct public access to the deep water sections of the river

2.3 Artificial Cobble/Gravel/Sand Beach Foreshore

Description:

Beach foreshores (cobble, gravel or sand) can be naturally occuring or artificial. Many beach foreshores exist within the study area and provide an effective, natural form of erosion protection. It should be clarified that in this document, the term beach is intended to describe the shape, profile and composition of the foreshore as opposed to its intended use. The beach features referred to in this document should not be confused with swimming beaches.

Artificial cobble and sand beaches have been constructed at several locations within the study area and have proven to be effective alternatives to static revetments and breakwalls, provided they are appropriately sited and constructed. This approach to erosion protection dates back to the 1970s. The features are sometimes referred to as “cobble berms” and “dynamic revetments.” The term cobble beach foreshore will be used to reference this type of shoreline protection throughout this report. The concept involves placing ample cobble material of sufficient size to mimic the shoreline armouring function of a natural beach.

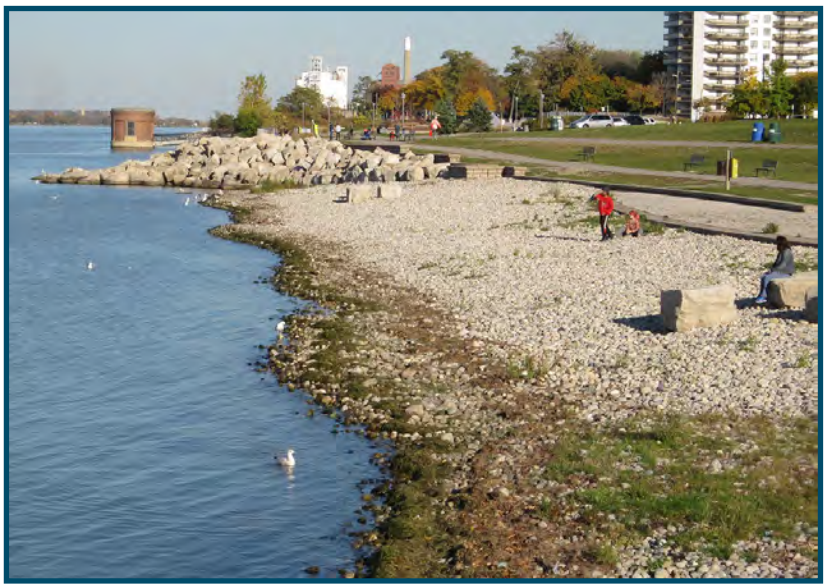
To be effective in the long term, the volume of gravel and cobbles must be ample to produce a beach feature that has a sufficient width and elevation to buffer the shoreline property from the expected combinations of extreme water levels and wave climate. Placement of the cobbles during construction mainly involves the creation of a beach that has the expected equilibrium slope or profile for its particle sizes and the wave climate of the site. The choice of a slope in the design need only be a reasonable approximation, since the cobbles will be sorted and rearranged by the waves into what constitutes the correct “design” for that site.

The stone sizes needed to construct a cobble beach are significantly smaller than that required for the bedding and armour layers of a conventional static revetment. The process of construction is also much simpler than that for a conventional revetment, in which each armour unit must be individually placed. More material can be needed for a cobble beach as compared to a revetment - however, the gravel and cobble-sized material is typically less expensive than the materials used in a conventional revetment.

Often, a more effective approach would be to combine an artificial beach with other shoreline protection systems. An example would be backing a constructed beach with a scaled-down revetment. In fact, this arrangement better mimics natural landforms. Another effective approach entails constructing a "pocket" beach between artificial rock promontories.

Examples

There are several examples of where constructed beach features have been utilized within the study area to mitigate shoreline erosion, either as a stand-alone feature or in combination with other shoreline protection measures. Some of the better examples are depicted below.



RTB Cobble Beach
(between Louis Ave and Marentette Avenue)

Hatch Gardens Cobble Beach
(at Moy Avenue)

McKee Park
Cobble/Sand
Beach
(at Chewett Street)

Summary of Impacts

Physical Impacts:

- Shoreline Erosion:
  - Effectively protects upland properties from wave attack and erosion, especially when combined with other shoreline protection measures
  - Provides long-term erosion protection and shoreline stability

- Hydrodynamics:
  - Has negligible effects on local river current/flow patterns
  - Reflects less wave energy which reduces alteration of nearshore wave dynamics

- Water Quality:
  - Construction causes very minor temporary disturbance of bottom sediments and increased turbidity
  - Will effectively halt the erosion of fill materials into the river

Biological Impacts:

- Aquatic Habitat:
  - Artificial beaches provide long-term improvement to fish and aquatic habitat
  - Curvilinear alignment of pocket beaches provides more edge length than linear systems
  - Requirements of Fisheries Act can normally be addressed on-site by integrating habitat enhancements with protective works
  - Construction creates temporary stress on aquatic communities
  - Encroachment of the beach slope into river may cause permitting issues if the nearshore area supports soft sediments and wetland vegetation habitat

- Terrestrial Habitat:
  - Normally no adverse impact on terrestrial habitat
  - Compatible with introduction of terrestrial habitat

Socio-Economic Impacts:

- Construction and Maintenance Costs:
  - Placement and construction is simpler and less expensive than other protection systems
  - Relatively lower initial construction costs
  - Potential maintenance costs associated with supplementation of beach material (if needed)
  - Potential for flotsam and jetsam (river debris) retention
  - Service life should approach that of a typical residential grade steel breakwall
  - Service life expectancy of beach is limited by quantity of beach material
  - Durable against full range of wave action and ice loads

- Shoreline Uses:
  - Potential reduction in usable table land area, especially where shoreline is pulled back to create pocket
  - Provides improved access to water's edge compared to breakwalls and conventional revetments
  - Resembles a more natural and aesthetic shoreline, and mimics natural shoreline function

- Navigation:
  - Complicates vessel mooring opportunities
  - Facilitates launching and beaching of small personal watercraft (canoes and kayaks)

- Safety:
  - Provides more gradual grade transition which mitigates the potential for accidental entry into the River and provides unimpeded egress from the river

2.4 Other Shoreline Protection Systems and Elements

Other Design Elements and Variations

In addition to the three primary types of shoreline protection presented above, there are many other elements that could be integrated into a shoreline protection design. Some examples include:

- Introducing a native vegetation buffer directly behind the principal shoreline protection
- Establishing native vegetation such as cattails, willow seedlings, and other wetland plants seaward of the protection
- Adding rock in front of vertical bulkheads, either continuously as toe protection, in clusters placed intermittently along the seawall, or as offshore shoals.

There has been considerable research that demonstrates the importance of riparian vegetation in freshwater environments. During the design and implementation of any shoreline protection project, it is beneficial to the natural environment to retain existing shoreline vegetation to the extent practical, and to introduce new plantings where appropriate. Some example of were vegetation has been integrated into the shore protection are depicted below.

Vegetated Backshore along Goose Bay Revetment (between Jos Janisse Ave and Pillette Road)

Vegetated Foreshore along St. Rose Beach Revetment (west of St. Rose Avenue)

Riparian vegetation by itself will not provide the level of erosion mitigation expected by most shoreline property owners. However, the introduction of terrestrial plantings can significantly increase habitat, shelter and food sources for aquatic and terrestrial species along the foreshore. Furthermore, by filtering pollutants out of overland runoff before it enters the River, a contribution can be made to improving Detroit River water quality.

The viability of establishing native wetland vegetation seaward of the primary protection system should also be examined, particularly where the nearshore is shallow and consists of soft sediments. As in the case of riparian vegetation, the establishment or enhancement of vegetation seaward of shoreline alone will not address the issue of shoreline erosion mitigation to the satisfaction of most landowners.

The addition of rock to the front of vertical bulkheads (either continuously or in intermittent clusters) will increase the habitat complexity of the shoreline in the same manner that the submerged portion of a revetment increases the habitat value. The gaps and crevices among the rocks (i.e., interstitial spaces) provide refuge for small fish and other aquatic organisms. In addition, the wave energy and current at the shoreline is decreased, which provides scour protection to the wall as well as increasing habitat area. At some locations, particularly where aquatic or wetland vegetation is already well established, it may not be desirable to replace soft sediment habitat with artificial, hard structure.

In addition to the systems highlighted above, there are numerous proprietary, non-traditional, erosion control products and approaches that have been marketed for shoreline protection. It is beyond the scope of this manual to evaluate all proprietary erosion control systems. Nevertheless, before adopting any such technique, a careful site specific evaluation of the product should be made by a qualified designer in order to ensure its suitability.

Bioengineered Shoreline Protection

Much has been published about the application of bioengineered shoreline protection along river banks. Thus, some discussion regarding the applicability of adapting "bioengineered" techniques to the Detroit River shoreline is warranted.

Bioengineering incorporates plants in combination with natural materials (e.g. logs, live stakes, live brush bundles) to create a natural appearing, and habitat-friendly form of erosion protection. These approaches are well suited to river systems, where a bioengineering design can lead to the long-term stabilization of a stream bank, reducing the need for future works. The approach is particularly effective at controlling stream bank erosion above the normal or dominant discharge of a river or stream. This is primarily due to the infrequency and brief duration of major flow events – the period during which the riparian vegetation of a stream or river experiences complete submergence and high erosion energy.

Unfortunately, pure "bioengineering" erosion protection techniques have limited application along the Detroit River. This is primarily due to the principal distinction between the flow characteristics of a river (or stream) and the flow characteristics of the Detroit River, which is actually not a river, but rather a connecting channel between Lake St. Clair and Lake Erie. In the Detroit River, when water levels are high, they remain high for extended periods, generally following the seasonal and annual fluctuations of the water levels in Lake St. Clair and Lake Erie. The amount that water levels can fluctuate annually is substantial. For example, the difference between the recorded maximum and minimum annual mean water level on the Detroit River is approximately 1.5 metres. It is this natural occurrence alone that renders bioengineering as an ineffective technique of achieving long-term erosion protection along the Detroit River.

Substantially all riparian vegetation that is submerged during extended periods of high lake levels will tend to die back to the high water line, leaving the river bank and foreshore below this level relatively unprotected. As high water levels decline to average or below average levels, re-establishment of the riparian vegetation is unable to keep pace with the falling water levels. As a result, the unprotected soils are exposed to direct wave attack and erosion is accelerated. It is for this reason that some form of shoreline armouring with structures or suitable substrate is needed to protect the shorelines of the Detroit River from the processes of erosion.

3.0 ALTERNATVE SHORELINE PROTECTION DESIGNS, SELECTION CONSIDERATIONS and SELECTION MATRIX

3.1 Shoreline Protection Designs

There are a variety of techniques that can be used to achieve the objective of erosion mitigation along the Detroit River, while achieving significant enhancement to the quantity and quality of aquatic and fish habitat. All of the methods recommended herein are variations of

the three main systems presented in Section 2 of this document, namely: breakwalls, revetments, and cobble beach foreshores.

A total of fifteen (15) design variations have been developed to assist landowners and approval agencies with the process of planning shoreline protection works. These include four revetment options, four breakwall options, and four cobble beach foreshore options. Some of the cobble beach options are actually hybrid designs that combine components from multiple systems (e.g., revetments fronted by a cobble beach foreshore). In addition, there are three shoreline enhancement elements that, when used in combination with other shoreline protection systems, can significantly increase the total habitat area. Some of the designs are suited to a specific combination of site conditions and existing shoreline geometry, and therefore will have limited application. Some, while providing significant enhancement to the natural ecology, would typically be subjected to a higher degree of scrutiny by approval agencies. The specific design types that this document addresses are listed below:

Revetment Options

1.a Light Revetment/Edge Treatment
1.b Single Armour Layer Revetment for Moderate Shoreline Exposure
1.c Double Armour Revetment for Severe Wave Exposure and/or Asset Protection
1.d Double Armour Layer Revetment for Severe Wave Exposure and Deep Water

Breakwall Options

2.a Continuous Rock Toe Protection for Existing Breakwalls
2.b New Anchored Breakwall with Continuous Rock Toe Protection
2.c New Bin-Type Breakwall with Continuous Rock Toe Protection
2.d Intermittent Cobble Reef with Armour Rock Cluster for Existing or New Breakwalls

Cobble Beach Foreshore Options

3.a Standard Cobble Beach Foreshore
3.b Double Layer Cobble Beach Foreshore with Armour Rock Edging
3.c Cobble Beach Foreshore fronting Single Armour Layer Revetment
3.d Cobble Beach Foreshore with Armour Rock Edging and Perched Sand Beach Backshore

Other Coastal Treatments

4.a Intermittent Emerging Rock Island/Breakwater
4.b Shore Perpendicular Cobble and Armour Cluster Shoals
4.c Rock Vane/Spur with Cobble Beach Foreshore and Armour Edging

Illustrations that depict the above shore protection systems are appended hereto. All of the above-noted systems have been successfully employed within the Detroit River. Some of the techniques are suited to a specific combination of site considerations and may have only

limited application. Others have more universal application throughout the River, as well as in other coastal regions.

3.2 Construction Cost Estimates

The construction cost of the various shore protection types is an important selection consideration. The unit material quantity that would be required to construct each system or element has been estimated. Based on the material quantity estimates, a unit construction cost estimate has been assembled for each of the design types listed in Section 3.1 and are summarized in the following table.

It should be noted that the costs that are presented in the table include only the material and labour costs associated with installation of each system. Other costs including mobilization, insurance, overhead and profit are not included in the estimates. Also, it should be noted that the costs reflect 2013 prices.

Shore Protection Type		Shore Protection Element									Total Estimated Cost (rounded)
		Site Preparation, Removals and Excavation	Filter Fabric (sq.m)	Bedding Stone (tonnes)	Armour Rock (tonnes)	Small Rock (tonnes)	Cobble Stone (tonnes)	Granular Backfill (tonnes)	Steel Sheet Piling (sq.m)	Backfill and Final Grading	
Type 1a	quantity **cost**	n/a $30	3 $6	0.6 $30	1.0 $70	0.6 $33	nil	nil	nil	n/a $20	**$200/m**
Type 1b	quantity **cost**	n/a $30	5 $10	2.0 $100	4.0 $280	nil	nil	nil	nil	n/a $20	**$450/m**
Type 1c	quantity **cost**	n/a $30	6 $12	3.0 $150	8.0 $560	nil	nil	nil	nil	n/a $20	**$800/m**
Type 1d	quantity **cost**	n/a $30	10 $20	6.5 $325	20 $1,400	nil	nil	nil	nil	n/a $20	**$1,800/m**
Type 2a	quantity **cost**	n/a $20	nil	nil	nil	2.0 $100	nil	nil	nil	nil	**$120/m**
Type 2b	quantity **cost**	n/a $50	nil	nil	nil	2.0 $100	nil	5.0 $200	5.5 $1,150	n/a $40	**$1,600/m**
Type 2c	quantity **cost**	n/a $120	nil	nil	nil	2.0 $100	nil	15.0 $750	6.0 $1,250	n/a $40	**$2,250/m**
Type 2d	quantity **cost**	nil	nil	nil	1.5 $105	nil	1.2 $50	nil	nil	nil	**$150/m**
Type 3a	quantity **cost**	nil	nil	2.5 $125	nil	nil	3.5 $140	nil	nil	nil	**$300/m**
Type 3b	quantity **cost**	nil	nil	2.5 $125	1.5 $105	nil	3.5 $140	nil	nil	n/a $20	**$400/m**
Type 3c	quantity **cost**	n/a $30	4 $8	1.5 $75	4.0 $280	nil	1.5 $60	nil	nil	n/a $30	**$500/m**
Type 3d	quantity **cost**	n/a $20	2 $4	1.0 $50	1.0 $70	nil	1.5 $60	1.0 $40	nil	n/a $30	**$300/m**
Type 4a	quantity **cost**	nil	nil	7.5 $375	20.0 $1,400	nil	nil	nil	nil	nil	**$1,800 each**
Type 4b	quantity **cost**	nil	nil	5.0 $250	10.0 $700	nil	5.0 $200	nil	nil	nil	**$1,200 each**
Type 4c	quantity **cost**	n/a $30	nil	3.0 $150	9.0 $630	nil	2.0 $80	nil	nil	nil	**$900 each**

3.3 Selection Considerations and Selection Matrix

As noted previously, a principal objective of this Manual is to provide an easy-to-follow decision-making matrix to help guide landowners, contractors, and the technical staff of various approving agencies to choose the best shoreline solution for a given site, based on common site characteristics. Accordingly, a **Selection Matrix** has been developed using of a Microsoft Excel to assist with the selection process.

The Selection Matrix is a compilation of 18 separate criteria and considerations that are common to most sites and shore protection installations on the Detroit River. The following figure presents a summary of these criteria and considerations.

Category A
Owner's Rationale for Shoreline Protection, Needs for Protection of Assets, and Specific Preferences for Site Aesthetics and Other Uses

1) User Needs and Expectations
- Primary Need for Project
- Aesthetic Preferences
- Desire for Vessel Mooring
- Proximity of Buildings/Structures

Category B
Importance that Owner Places on Ecological Restoration, and Differentiators of the Natural Environment

2) Environmental Considerations
- Owner's Value of Ecological Restoration
- Site Suitability/Need for Restoration/Enhancements
- Environmental Sensitivity of Area
- Special Environmental Needs

Category C
Differentiators of the Physical Site Environment

3) Hydrodynamic Processes
- Local Wave Climate Severity
- Amount of River Current Present
- Exposure to Ice Flows

4) Site Topography and Bathymetry
- Nearshore Bathymetry
- Shoreline Condition
- Topography

5) Site Scale, Geometry and Geomorphology
- Overall Project Shoreline Length
- Shoreline Geometry
- Geomorphology
- Recession State

The criteria and considerations can be separated into three principal categories, namely:

A. The owner's rationale for shoreline protection, the need for the protection of assets (an existing or proposed dwelling), and the owner's specific preferences for site aesthetics and other site uses.

B. Importance that owner or other project stakeholders places on ecological restoration, and the various differentiators of the natural environment.

C. The various differentiators of the physical site environment.

For the purpose of the preparation and use of the spreadsheet/selection matrix, the parameters in Category C were further subdivided under the headings of Hydrodynamic Processes, Site Topography and Bathymetry, and Site Scale, Geometry and Geomorphology.

In order to employ the Selection Matrix, the user simply needs to enter one value for each of the 18 selection criteria. The matrix then calculates a score for 9 shoreline protection systems and/or shore protection elements. Based on the calculated score, the matrix identifies three shore protection systems or elements that may be most suited to the site and the particular application.

Each of the 18 criteria has been assigned an importance weighting of 1, 3 or 5, based on the professional judgement of Landmark Engineers Inc. The calculated scores take into consideration the weighted importance values. The following lists the weighted importance that has been assigned to each selection criteria.

	Weighted Importance
User Needs and Expectations	
• Primary Need for Project	**3**
• Aesthetic Preferences	**5**
• Desire for Vessel Mooring	**3**
• Proximity of Buildings/Structures	**5**

Environmental Considerations	
• Owner's Value of Ecological Restoration	**5**
• Site Suitability/Need for Restoration/Enhancements	**3**
• Environmental Sensitivity of Area	**5**
• Special Environmental Needs	**5**

	Weighted Importance
Hydrodynamic Processes	
• Local Wave Climate Severity	**3**
• Amount of River Current Present	**3**
• Exposure to Ice Flows	**1**

Site Topography and Bathymetry	
• Nearshore Bathymetry	**5**
• Shoreline Condition	**3**
• Topography	**3**

Site Scale, Geometry and Geomorphology	
• Overall Project Shoreline Length	**3**
• Shoreline Geometry	**3**
• Geomorphology	**3**
• Recession State	**5**

The matrix is employed simply by entering weighted importance values in the weighted importance column of spreadsheet. It should be noted that there are multiple possible entries for each of the 18 considerations and criteria noted above. The recommended weighted importance value indicated above should be entered next to the description that best describes the project circumstances. Only one value should be entered for each of the 18 criteria.

For example, consideration **1a) Primary Need for Shore Protection** offers three possible entries – owner concern over site aesthetics, protection needed for existing development, or protection needed for new development. An entry should be made in weighted importance next to only **one** of the three choices.

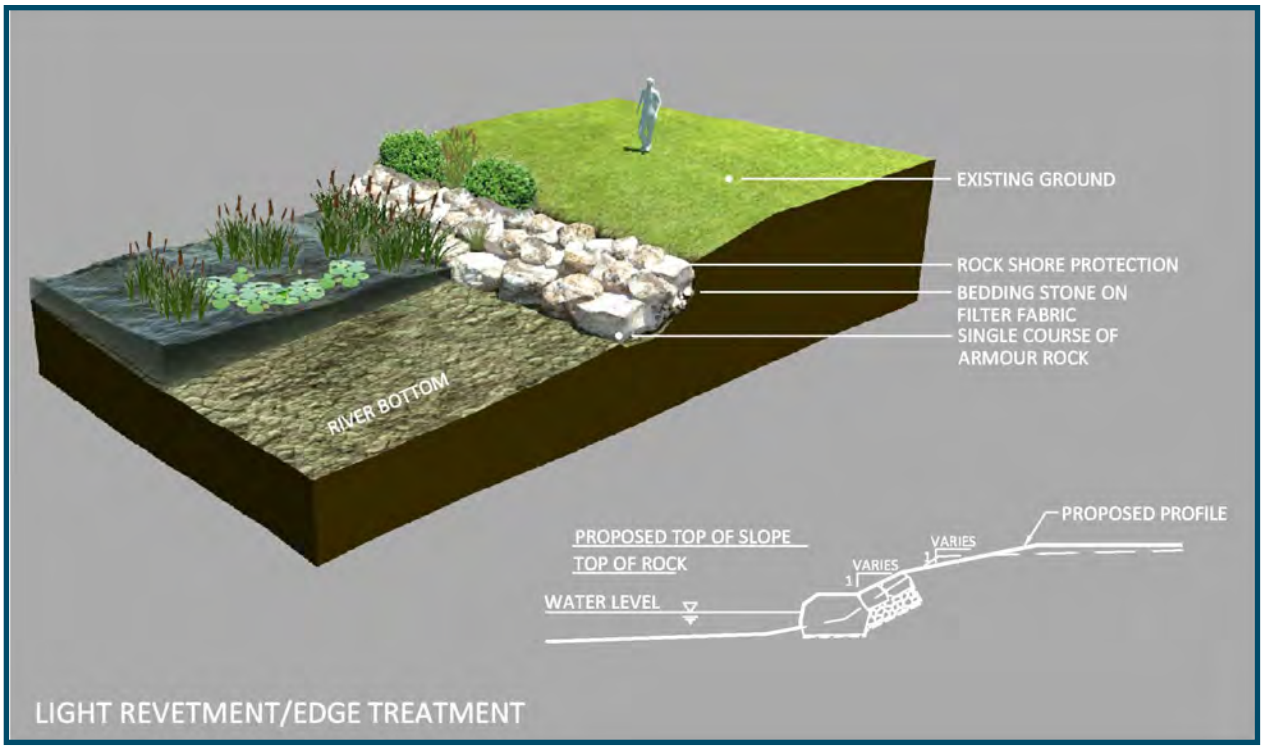
The process is repeated until an entry has been made for each of the 18 considerations. Once all entries are made, the matrix will calculate a Net Score for 9 different shore protection systems, and then rank the systems based on the net scores. The matrix will automatically flag the three highest scoring systems as suitable for further consideration.

It should be noted that employment the Selection Matrix should identify the most suitable shore protection system for most site applications. However, there may be additional selection criteria that are relevant to a specific site or project circumstance that the matrix does not properly evaluate. For this reason, the conclusions of the Selection Matrix should not

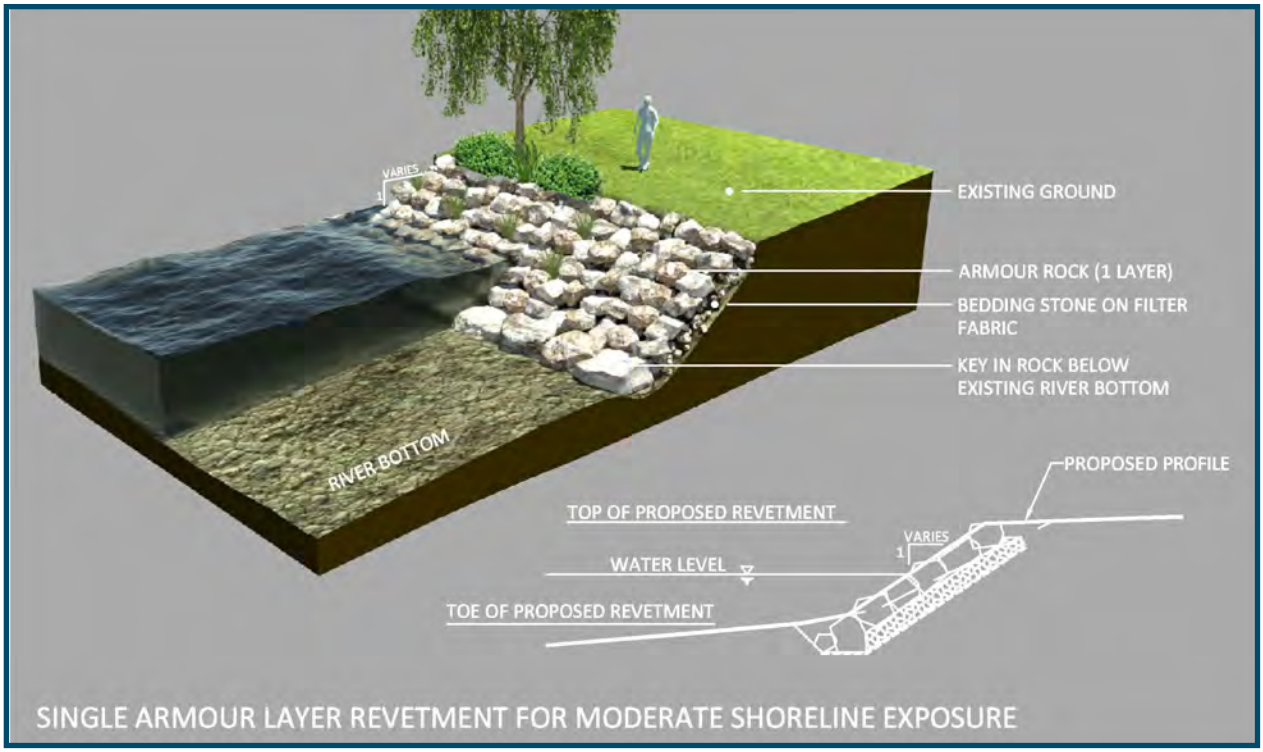
be regarded as absolute. Instead, output from the matrix should be used in combination with other well-established planning and coastal engineering principles for the purpose of identifying the preferred shore protection strategies.

Two sample applications of the Selection Matrix are appended to this manual to demonstrate its application. Example 1 would apply to a site where the installation of a steel sheet pile breakwall would be most appropriate. In contrast, Example 2 applies to a site where the installation of a rock revetment would be most appropriate.

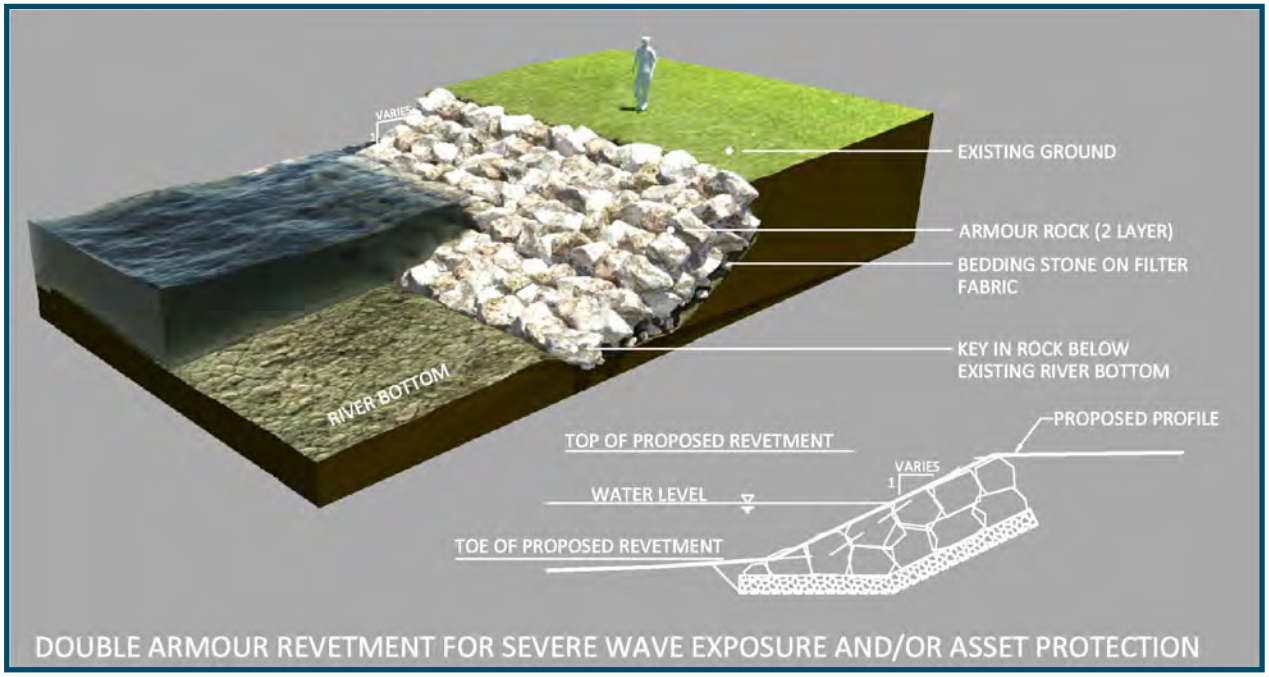
Illustration of Alternative Shore Protection Strategies for the Canadian Detroit River Shoreline



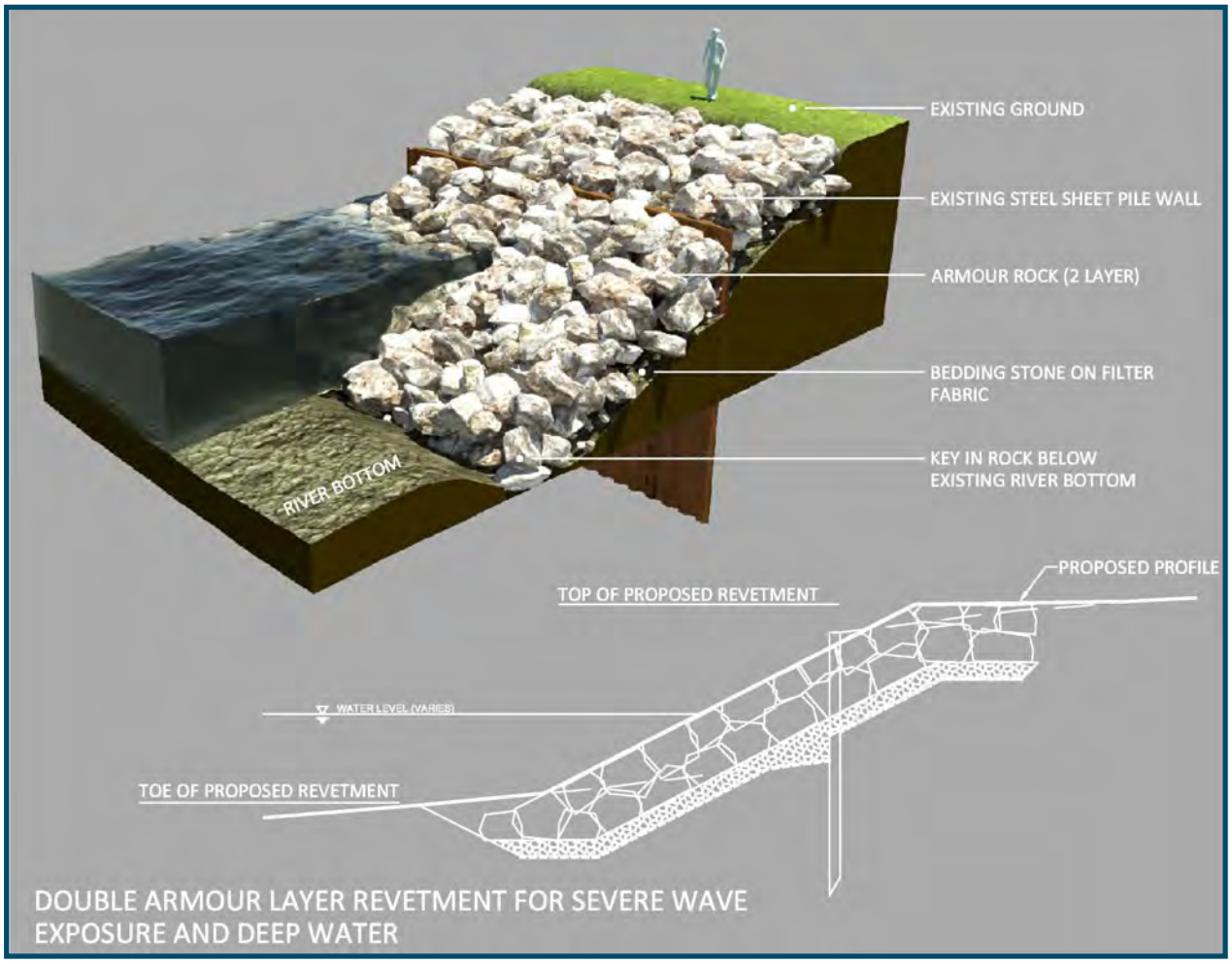
LIGHT REVETMENT/EDGE TREATMENT



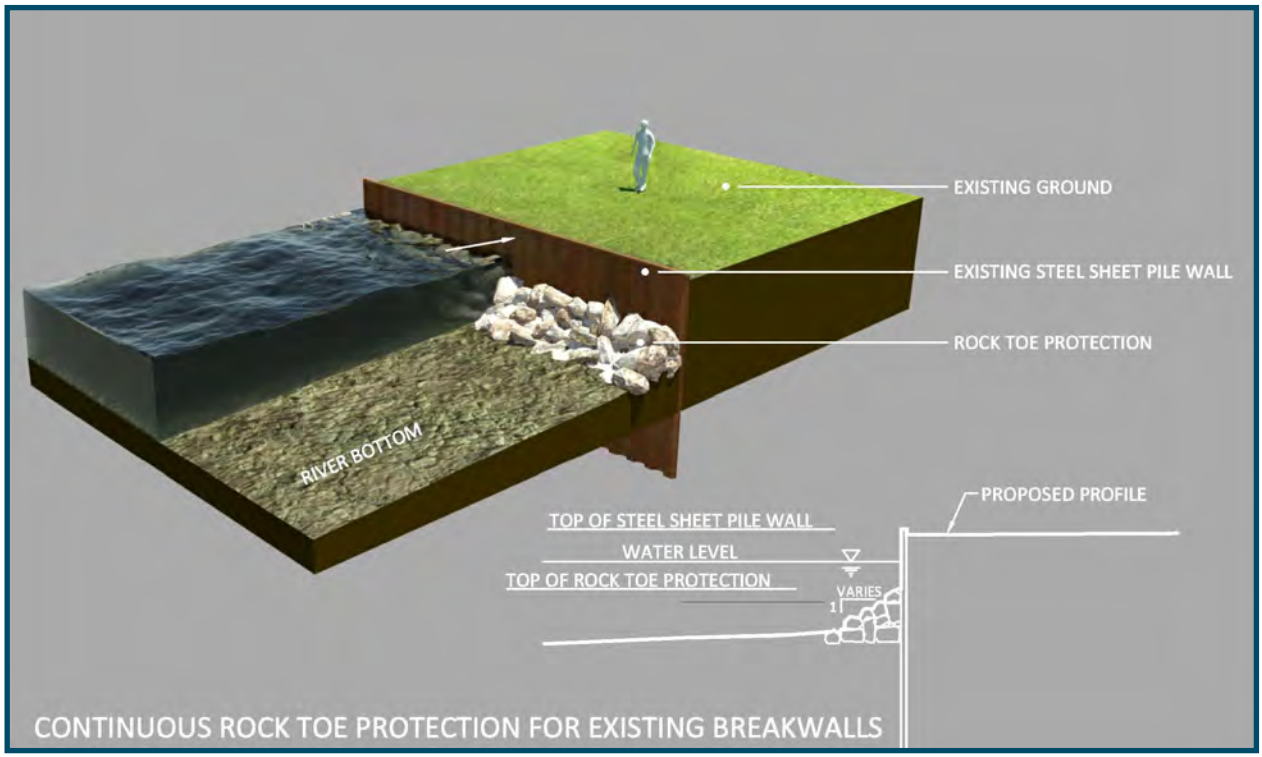
SINGLE ARMOUR LAYER REVETMENT FOR MODERATE SHORELINE EXPOSURE



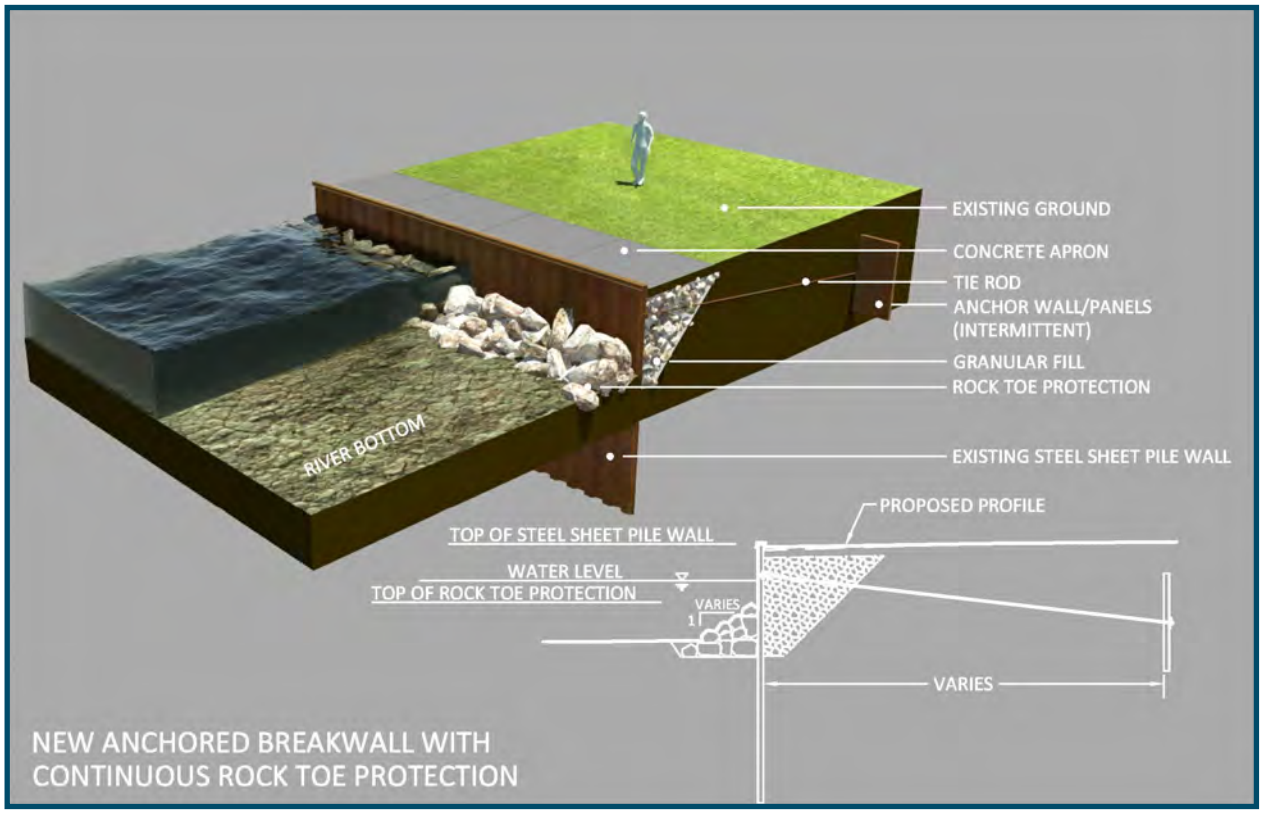
DOUBLE ARMOUR REVETMENT FOR SEVERE WAVE EXPOSURE AND/OR ASSET PROTECTION



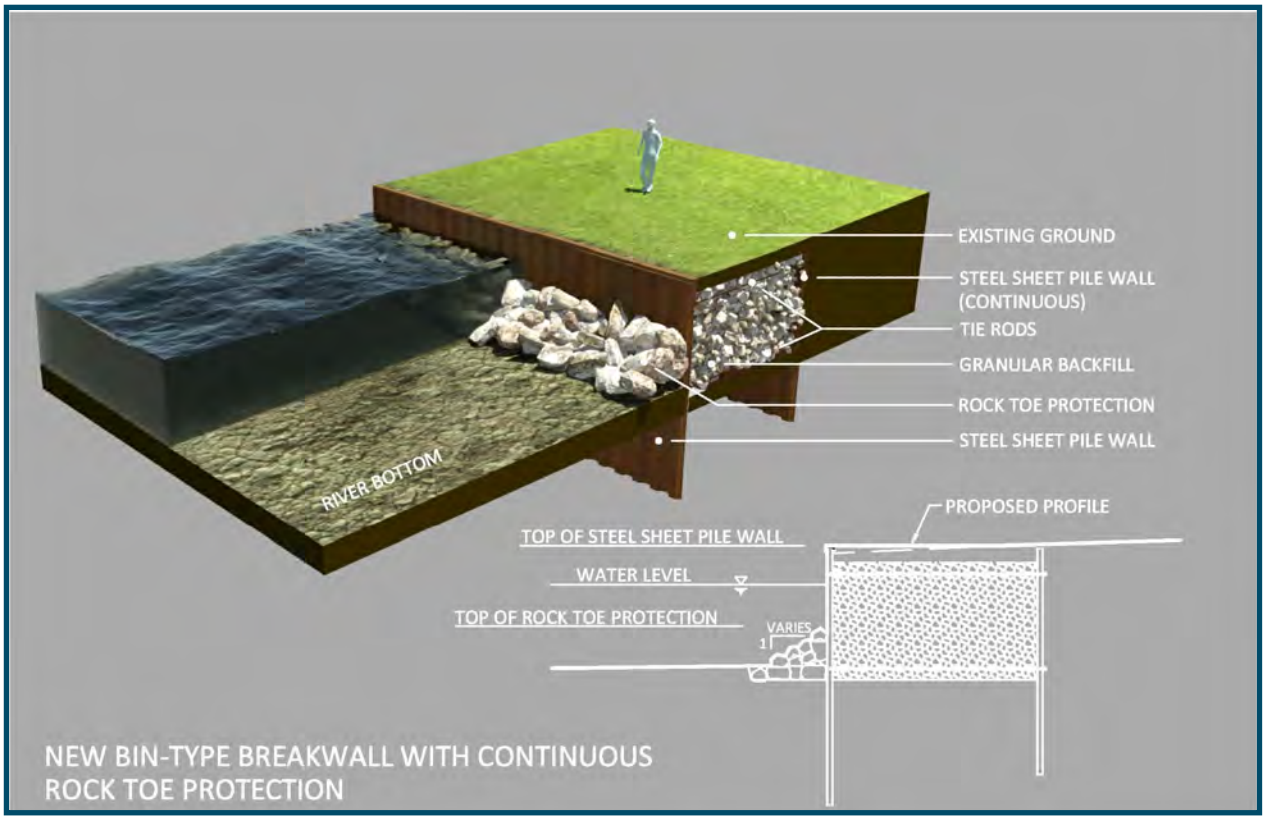
DOUBLE ARMOUR LAYER REVETMENT FOR SEVERE WAVE EXPOSURE AND DEEP WATER



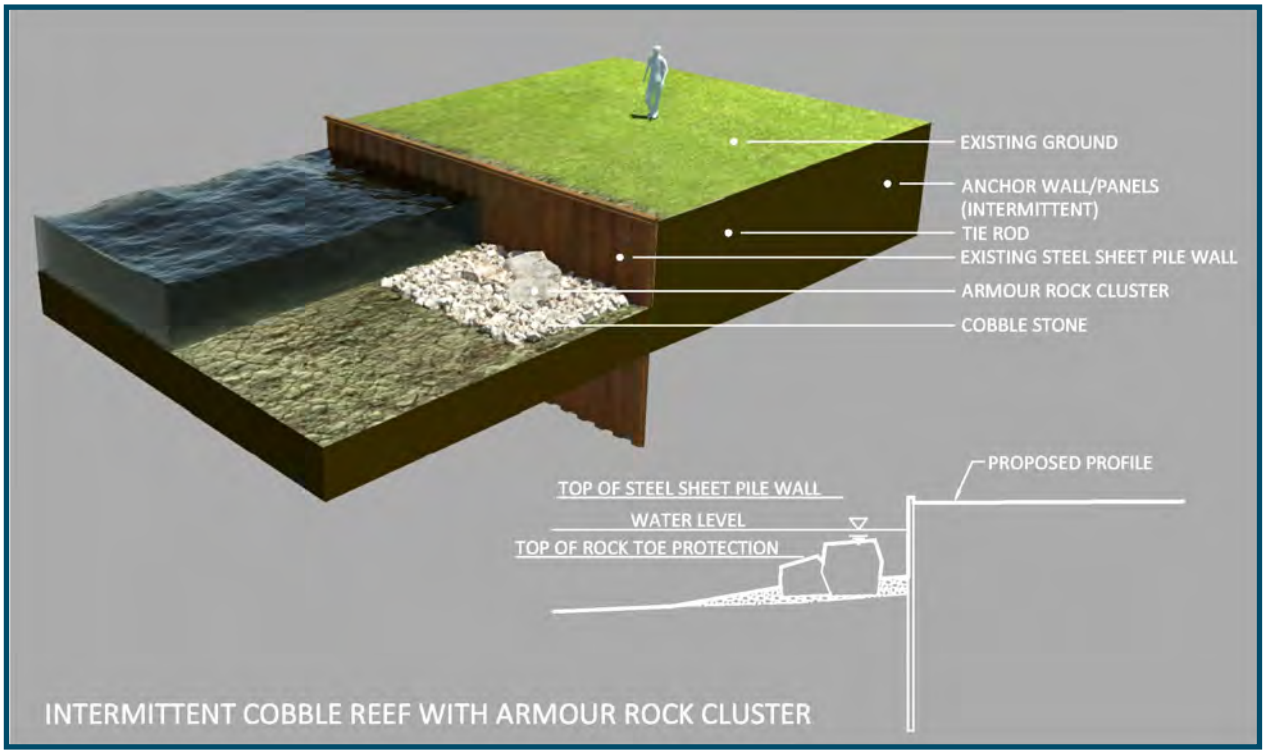
CONTINUOUS ROCK TOE PROTECTION FOR EXISTING BREAKWALLS



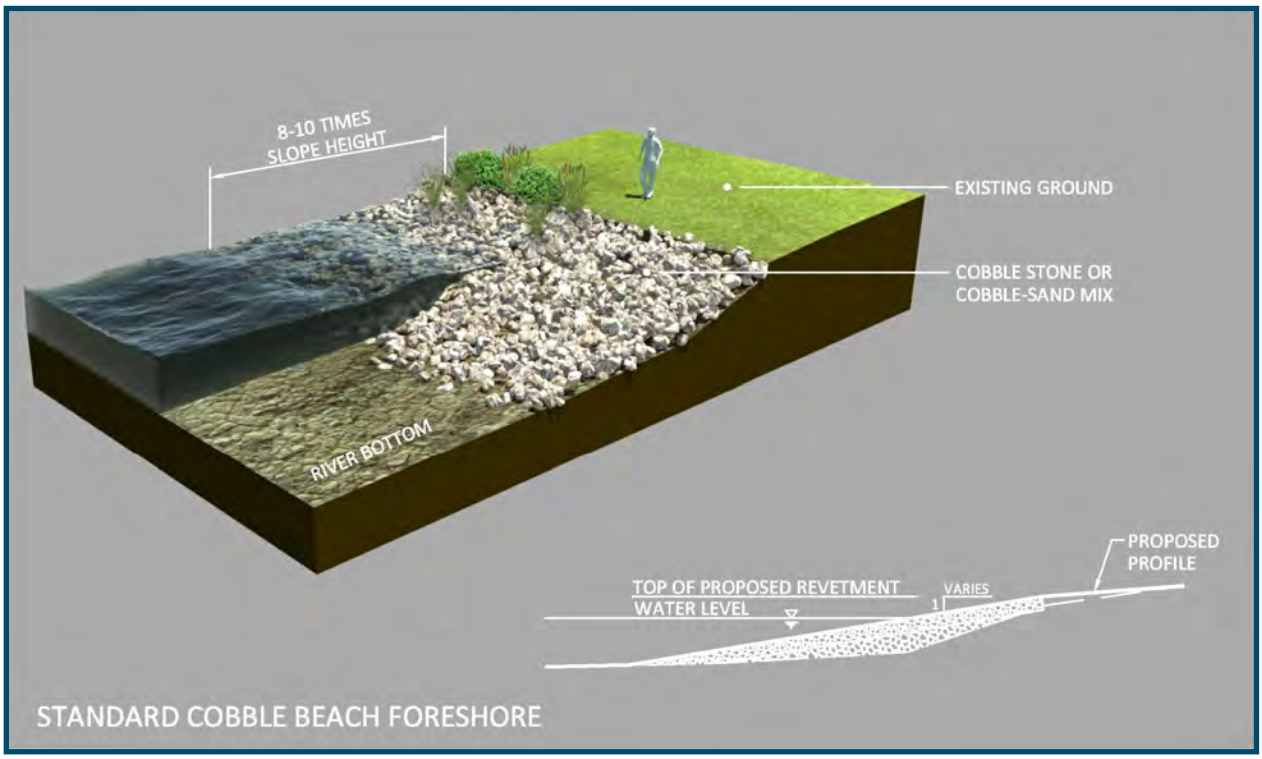
NEW ANCHORED BREAKWALL WITH
CONTINUOUS ROCK TOE PROTECTION



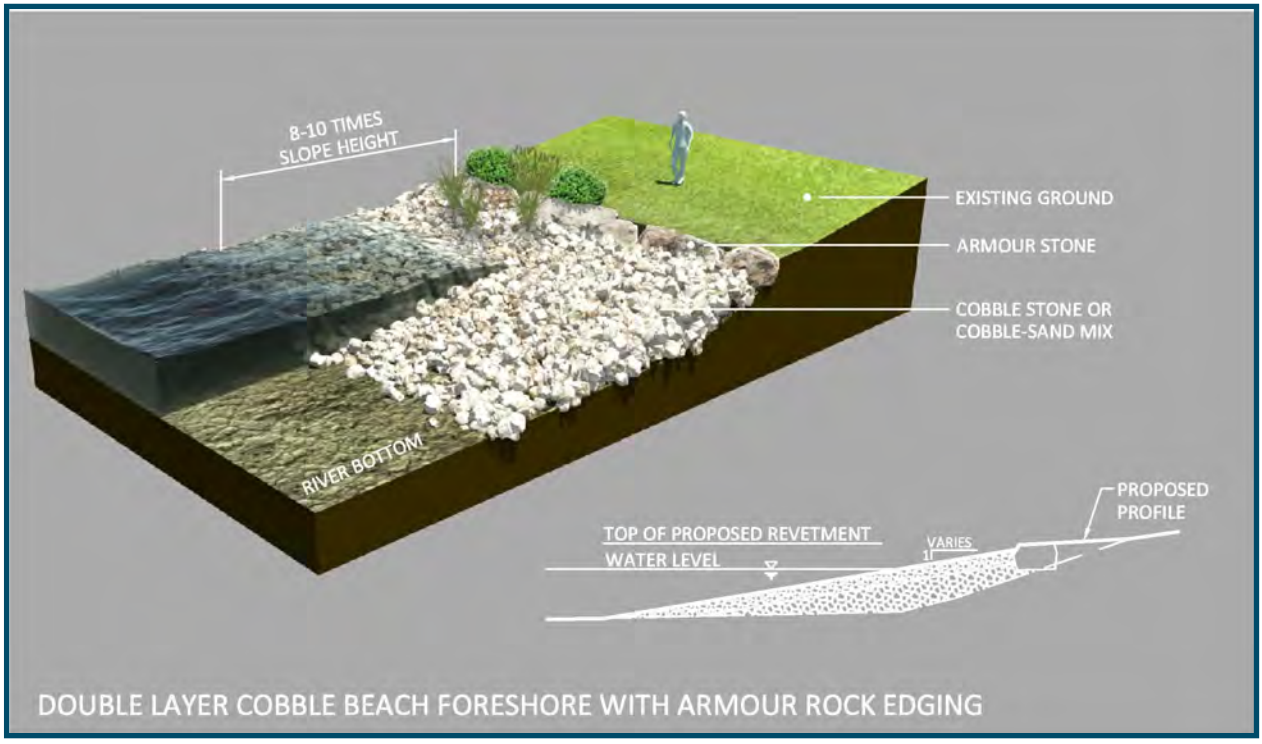
NEW BIN-TYPE BREAKWALL WITH CONTINUOUS ROCK TOE PROTECTION



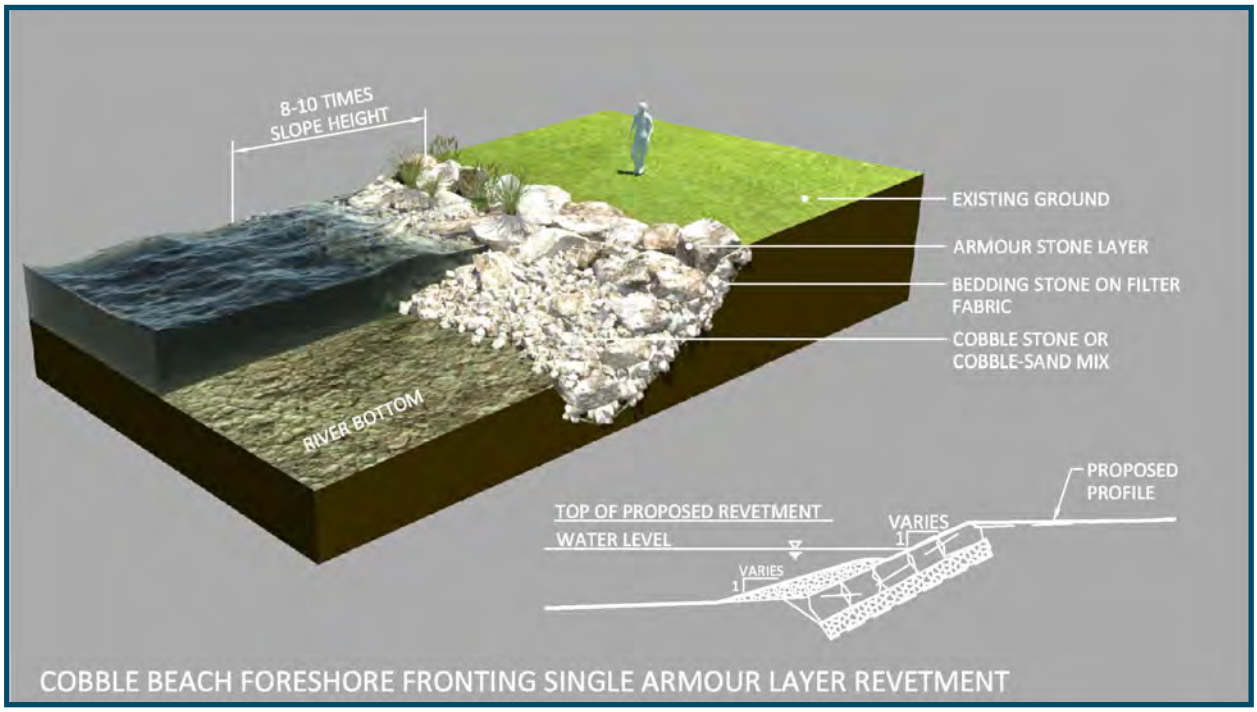
INTERMITTENT COBBLE REEF WITH ARMOUR ROCK CLUSTER



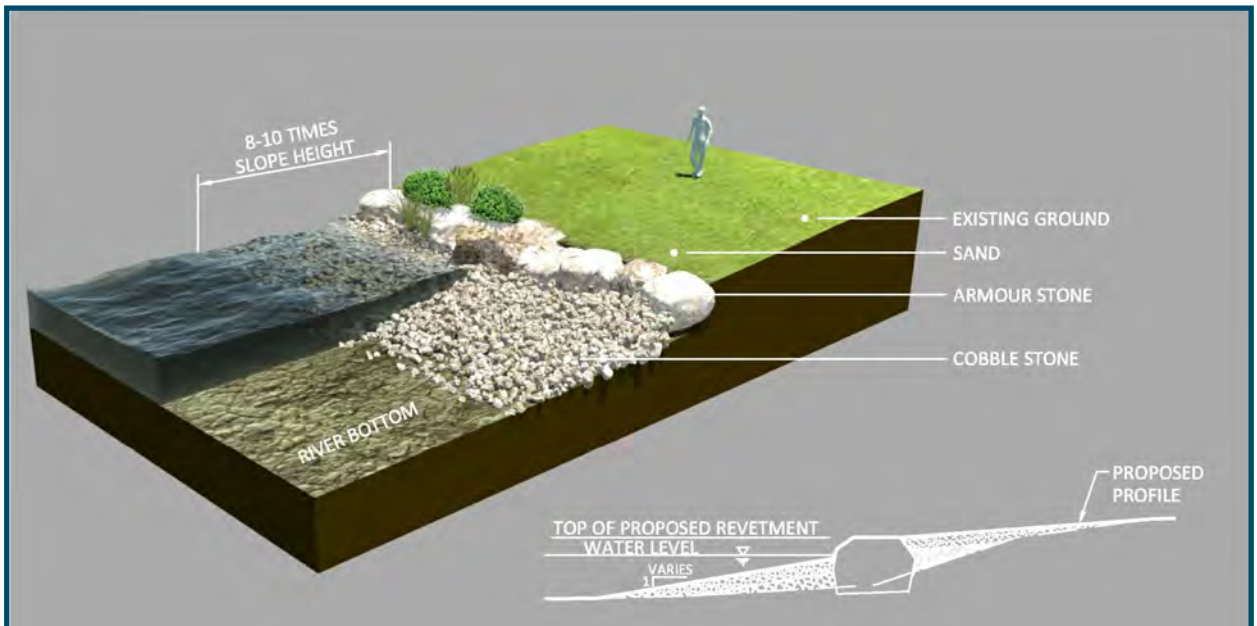
STANDARD COBBLE BEACH FORESHORE



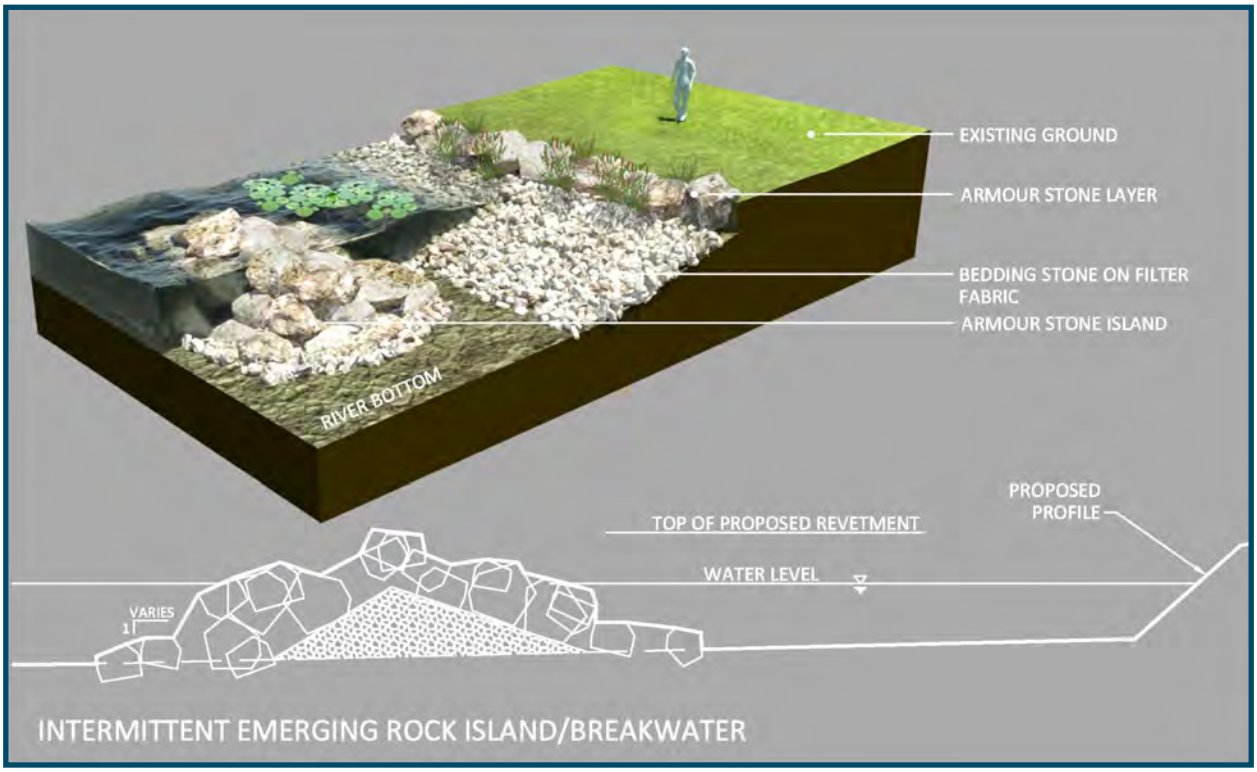
DOUBLE LAYER COBBLE BEACH FORESHORE WITH ARMOUR ROCK EDGING



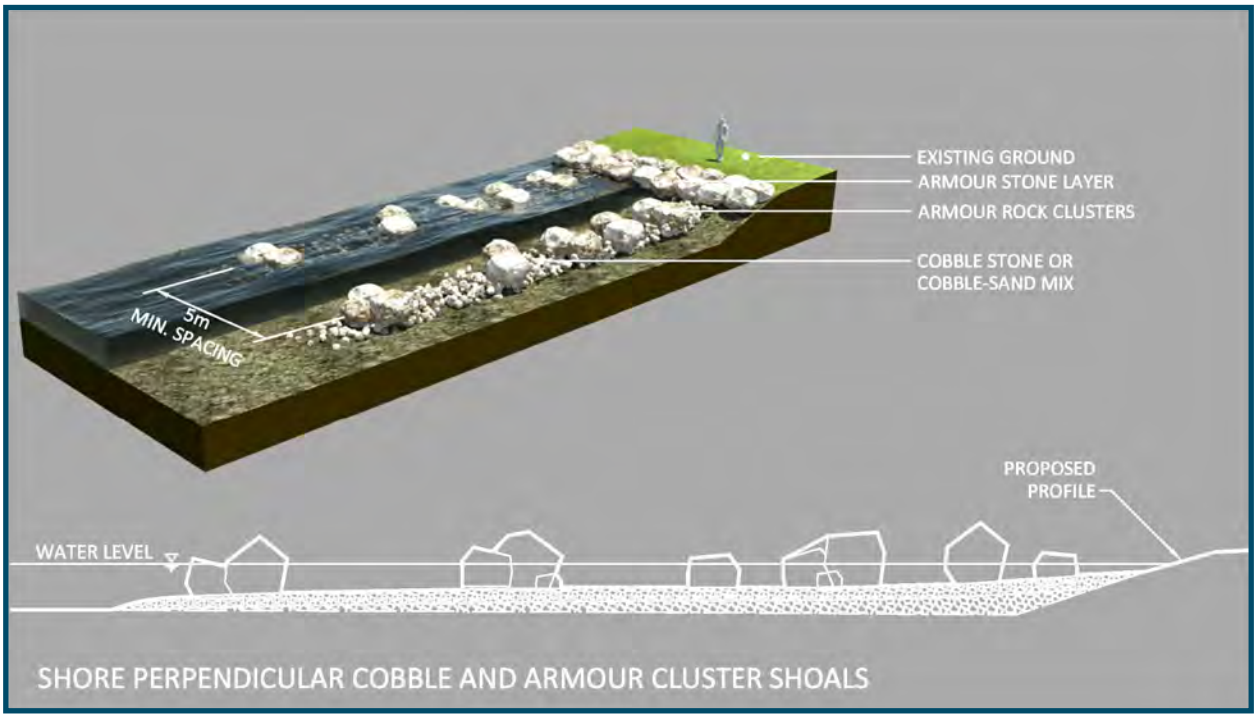
COBBLE BEACH FORESHORE FRONTING SINGLE ARMOUR LAYER REVETMENT



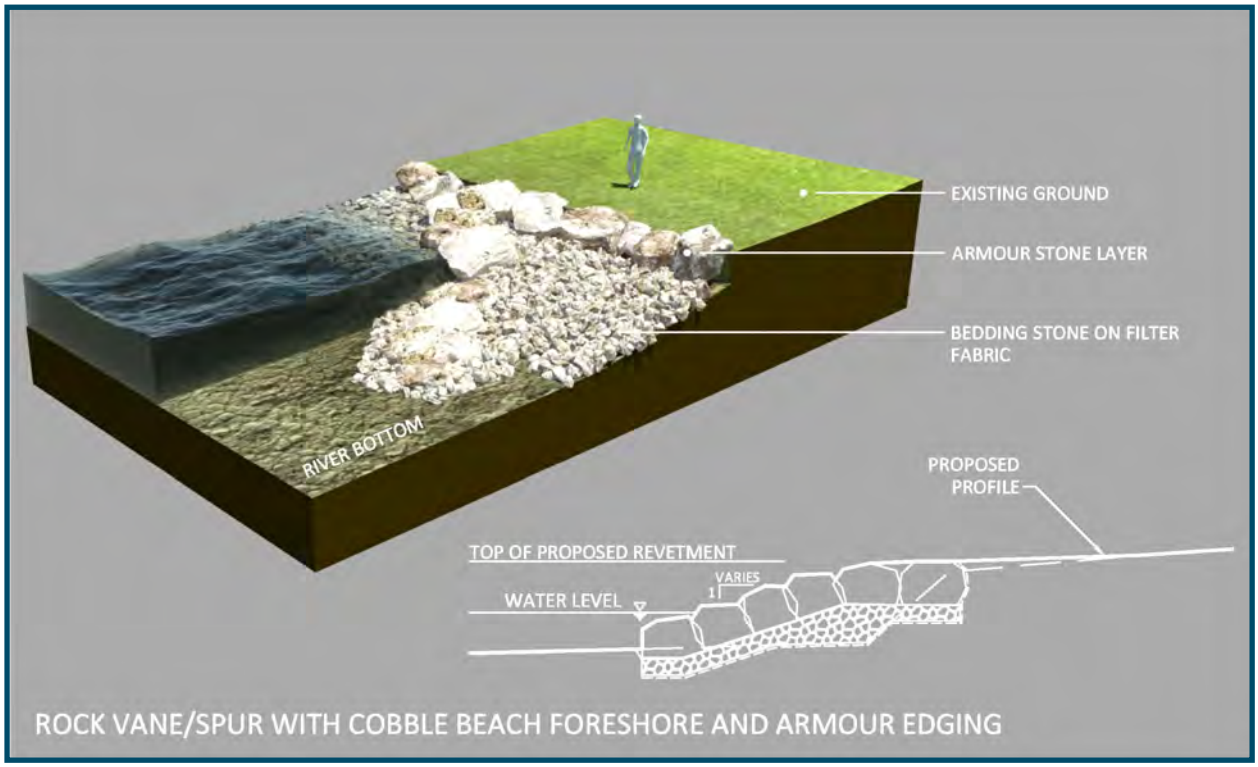
COBBLE BEACH FORESHORE WITH ARMOUR ROCK EDGING AND PERCHED SAND BEACH BACKSHORE



INTERMITTENT EMERGING ROCK ISLAND/BREAKWATER



SHORE PERPENDICULAR COBBLE AND ARMOUR CLUSTER SHOALS



ROCK VANE/SPUR WITH COBBLE BEACH FORESHORE AND ARMOUR EDGING