Rondout Riverport Shoreline Stabilization and Public Access – Phase II

City of
Kingston
New York

NEW YORK STATE OF OPPORTUNITY. Department of State

Project Advisory Committee – Meeting 2
May 01, 2019

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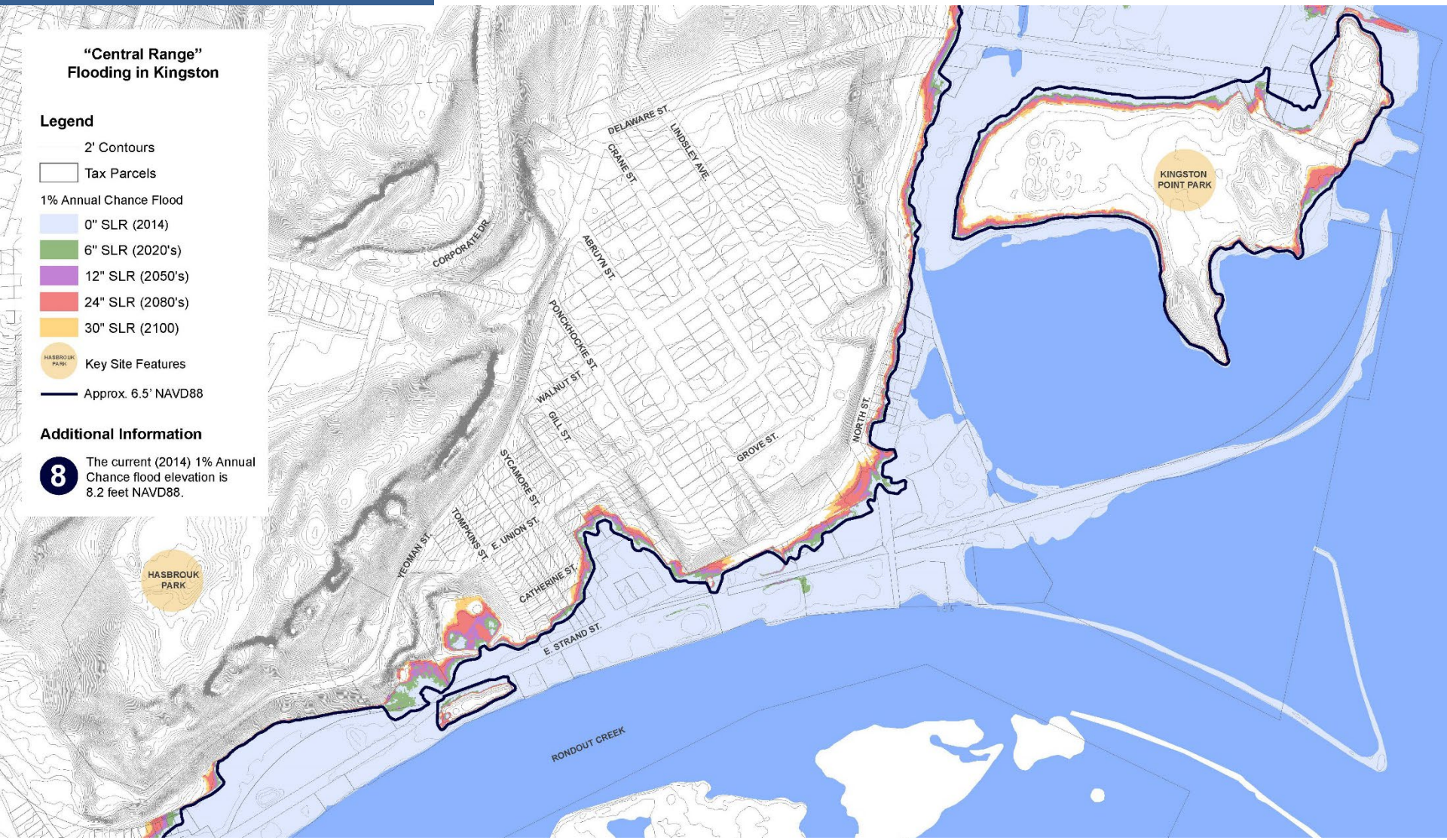
Weston & Sampson SM


project area

site analysis

climate resiliency



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climate resiliency

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shoreline stabilization

Multi-Purpose Flood Storage

Plazas can be designed as active recreation spaces during clement weather and storage during floods.

Image credit: Hans Tavsens Park and Korsgade by SLA.

Living Shoreline

A "soft," green infrastructure approach to managing erosion and flooding, providing habitat, and enhancing public space.

Image credit: Center for Coastal Resources Management, Virginia Institute of Marine Science.

Tiered Walkway

This design creates a tiered, raised area that provides gathering space and boating access to the waterfront.

Image credit: walkway design by Weston & Sampson.

Adaptable Raised Roadway

Elevated roadways act as flood barriers and can provide emergency access and evacuation routes during a flood event.

Image credit: Weston & Sampson.

Adaptable Floodwall

These barriers allow for incremental adaptation while maintaining pedestrian connectivity to the waterfront.

Image credit: Weston & Sampson.

Walking/Biking Connections

Pedestrian and bike pathways provide important shoreline access points for waterfront communities.

Image credit: walkway rendering by Weston & Sampson.

Vegetated Berm

These berms serve as flood barriers while also creating open spaces and additional value along the waterfront.

Image credit: Weston & Sampson.

Live Crib Wall

A built structure that uses vegetated root mass to stabilize slopes and manage erosion.

Image credit: New York State Soil & Water Conservation Committee

Bioretention

This green infrastructure approach can help manage stormwater by increasing infiltration and filtering runoff.

Image credit: bioretention design by Weston & Sampson.

Breakwater

An offshore strategy to attenuate wave action, facilitate sediment accretion, and provide habitat.

Image credit: oyster reef breakwater. Photo by FCIS staff.

Revetments

A transitional, sloped structure constructed with stones or other materials to help manage storm surge.

Image credit: North Carolina Division of Coastal Management.

Steel Bulkhead

A vertical, "hard" infrastructure, coastal retaining structure.

Image credit: Emilie Hauser.

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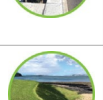
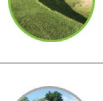
Icon	Type	Where it works	Where it doesn't work	Width of Shoreline Required for Construction	Erosion Protection	Environmental Impact	Aesthetics	Public Access	Maintenance/ Longevity	Cost	Regulatory Requirements
	Vegetated Riprap	embankments with stable soils	densely shaded areas; loose soils/steep banks	6' to 20': width dependent on wave action and fill required at the toe of the slope to stabilize grade	immediate protection, less over-topping and wave run-up than smooth structures	shelters microhabitats; native vegetation provides forage and shelter; may be a barrier to some species of fish and wildlife	vegetation softens the appearance of the riprap	Can be dangerous if/when people climb on the riprap. Elevated walkways may be constructed on top of the riprap	riprap easily maintained, vegetation may need to be pruned to create views; must be weeded to prohibit spread of invasive species	moderate to high	may result in land encroachment to obtain proper slope; permit required to construct; accepted by the NYSDEC AND USACOE
	Vegetated Gabion Wall	moderate slopes	densely shaded areas; steep slopes with unstable/loose soils	2-4' of wall; 6' of stabilized slope with vegetation behind the wall (varies per design criteria and site conditions)	increases stability	vegetation may provide habitat	natural appearance; may impact views when vegetation matures	prohibits access close to the water's edge	high failure rate of vegetation in first two years; heavy monitoring and maintenance	high	moderate
	Vegetated Gabion Mattress	ice; surface erosion; moderate slopes	densely shaded areas; steep slopes with unstable/loose soils	3' to 12', depending on severity of erosion potential and height of mattress	increases stability	vegetation may provide habitat	fairly natural appearance; may impact views when vegetation matures	limits access close to the water's edge	high failure rate of vegetation in first two years; installation is labor intensive	high; installation very complex	moderate; may replace hardened shorelines in some instances
	Vegetated Cribbing	unvegetated slopes; adequate backfill; low wave inputs	densely shaded areas; steep slopes; high wave inputs	4' to 12', depending on severity of erosion potential	not good for wave energy dissipation; holds eroding soils in place	vegetation may provide habitat	timber has natural appearance; may impact views when vegetation matures	prohibits access close to the water's edge	periodic maintenance to ensure success of plantings. Pruning and plant replacement may be necessary; high failure rates of vegetation	moderate to high; requires heavy equipment and pre-cast concrete structures	natural stabilization may be favorably reviewed
	Bulkhead (Timber)	high banks with adequate backfill; sites with low wave inputs	steep slopes; high wave inputs	2' width of bulkhead; potential for 10' promenade behind bulkhead; anchorage widths are site dependent and may affect placement of structures	scour occurs at the base of the river side wall; erosion is controlled behind the wall	hydro acoustic effects may harm fish; no associated habitat value	generally favorable; may impact views when vegetation matures	walkway and boardwalk access can be constructed at the top of the bulkhead; prohibits access close to the water's edge	replacement of timber boards or steel; longer initial design life	pile driving equipment; materials; $265 per linear foot (Hudson River Sustainable Shorelines)	not preferred by regulatory agencies
	Floating Wetland	areas with high urban runoff/pollutants	where open water surface is required; water depths shallower than 3'	3' to 10' width; may be designed to fit existing shoreline conditions and access considerations	reduces undercutting; attenuates wave action	vegetation may provide habitat; filters pollutants; filters suspended solids; must be anchored	enhances visual appearance of hardened shorelines	not appropriate for placement near boat launches	may require annual harvest and weeding	$1 to $24 per square foot; substantially lower costs than constructed wetlands (Biomatrix Solutions)	unknown
	Vegetated Geogrid	slopes less than 70 degrees; sites with limited space; elevations where the invert of the structure will be kept wet during the growing season	densely shaded areas; soils not suited to plant growth; must analyze structural capabilities of soils	can be built into the side of existing slopes	resists shear stress	creates vegetative habitat; provides non-point pollution control	natural looking; may impact views when vegetation matures	mature plantings restrict access	periodic maintenance to ensure success of plantings; Pruning and plant replacement may be necessary	$130 - $300 per linear foot; soil conditioning and excavation necessary (Massachusetts Clean Water Toolkit)	natural stabilization may be favorably reviewed; may replace hardened shorelines in some instances
	Living Shoreline	areas with low wave energy, parks, and areas not immediately adjacent to urban development	areas with high wave energy; areas vulnerable to storm surge; areas vulnerable to high water	6' to 20'; site dependent	slows inland water encroachment; reduces wave energy	creates vegetative habitat and opportunities for fish and wildlife; provides corridor for species to move and breed	natural appearance; may impact views when vegetation matures	mature plantings restrict access; public access may impact wildlife and success of vegetation and stabilized soils	periodic maintenance to ensure success of plantings; pruning and plant replacement may be necessary; removal of invasives required	$1,000 to $5,000 per linear foot (NOAA Fisheries)	guidelines, regulations, and incentives encourage adoption of living shorelines
	Low Impact Development	areas slated for redevelopment; areas with extensive impervious surfaces; existing parks and lawns	historic structures that must maintain original visual elements; areas where maintenance will not be possible	site dependent/green infrastructure design element dictates width of installation	captures stormwater inland, reducing runoff and CSO outfall volumes	vegetation may provide habitat	vegetation adds color, texture, and visual variation to the urban landscape; some communities resist LID installations due to unkept appearance	does not restrict public access in majority of instances; tree pits reduce the width of sidewalks	periodic maintenance to ensure success of plantings; pruning and plant replacement may be necessary	$10 to $40 per square foot (LID Stormwater)	permitting generally favorable due to reductions in stormwater
	Vegetated Berm	undeveloped areas; natural areas with ample inland depth; parks	areas with development close to the shore; structures at risk of damage from flooding	16' - 20' width (varies with existing elevation site)	captures stormwater and reduces runoff volumes, especially when designed with an upland retention basin; vegetated slopes reduce shoreline erosion	vegetation may provide habitat	undulating topography enhances the visual quality of landscapes	limits access close to the water's edge, unless designed with access points at selected locations	periodic maintenance to ensure success of plantings; pruning and plant replacement may be necessary	moderate	unknown
	Steel Bulkhead	high wave energy areas; sites with existing hardened shorelines; sites with active water fronts	sensitive environmental resources; areas with limited development; areas adjacent to sensitive downstream shore conditions	2' width of bulkhead; potential for 10' promenade behind bulkhead; anchorage widths are site dependent and may affect placement of structures	wave action moderated at the site; wave energy deflected downward contributing to foundational and downstream erosion	unreinforced shorelines bear the brunt of erosion; inhibits sediment replenishment; does not provide habitat value; damages intertidal habitats	limited aesthetic potential; urban/industrial visual elements rather than natural	public access easily facilitated with the addition of ramps, stairs, docks, and boat launches	long lifespan; relatively easy to repair (limited components)	$1,200 per linear foot (Hudson River Sustainable Shorelines)	regulatory approval very difficult for new bulkhead construction; restoration in place may be less burdensome
	Gravity Concrete Retaining Wall	high wave energy areas; sites with existing hardened shorelines; sites with active water fronts	sensitive environmental resources; areas with limited development; areas adjacent to sensitive downstream shore conditions	2' width of wall; potential for promenade and or stairs/seating; anchorage widths are site dependent and may affect placement of structures	wave action moderated at the site; wave energy deflected downward contributing to foundational and downstream erosion	unreinforced shorelines bear the brunt of erosion; inhibits sediment replenishment; does not provide habitat value; damages intertidal habitats	limited aesthetic potential; urban/industrial visual elements rather than natural	public access easily facilitated with the addition of ramps, stairs, docks, and boat launches	long lifespan; toppling a concern as foundation is eroded and pressure increases behind the wall	$500 to $1,000 per linear foot (Hudson River Sustainable Shorelines)	regulatory approval very difficult for new bulkhead construction; restoration in place may be less burdensome
	Boardwalk over Jetty	low-lying areas at risk of flooding that require an access route	boardwalks along coastlines should be designed to withstand high wave inputs	5' to 12' width (potential for maintenance vehicle access)	boardwalk design can incorporate erosion management strategies, such as adding riprap and cribbing to edges	no associated habitat value	timber has a natural appearance. The design of an elevated boardwalk can incorporate a canopy with PV panels	elevated boardwalks are typically intended for pedestrian use, but may be used to facilitate maintenance vehicle access. An elevated boardwalk can include improved viewscapes, year-round access, and stairs to kayak launches	replacement of timber boards as required	pile driving equipment and materials: moderate to high cost	unknown

steel bulkhead with floating wetland

Benefits & Opportunities:

- Value creation and public open space opportunities include elevated walkways, kayak tie-up areas, floating wetlands, and floating pathways.
- Protection of existing buildings behind the bulkhead.
- Opportunities to raise elevations over time to adapt to changing conditions.

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Image from Biomatrix Water

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Image from Biomatrix Water

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steel bulkhead with floating wetland

Images from Biomatrix Water

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steel bulkhead

Benefits & Opportunities:

- Sheet pile walls can support a cap for pedestrian walkways and mooring for boat access.
- Protection of existing buildings behind the bulkhead.
- Opportunities to raise elevations over time to adapt to changing conditions.

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tiered concrete plaza

Benefits & Opportunities:

- Provides public open space with joint planting, seating, and access to the waterfront.
- Tiered approach softens the impact of an elevated space and creates safe, visible spaces.
- Can be adapted (raised) over time to increase resilience.

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LID practices: street trees & bioretention

Benefits & Opportunities:

- Improve stormwater management through retention and detention.
- Improve water quality through filtration.
- Address the urban heat island effect through increased vegetation and porosity.

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elevated boardwalk

Benefits & Opportunities:

- Benefits include improved viewscapes, year-round access, and stairs to kayak launches.
- PV panel canopies can provide shade.
- Elevated boardwalks can incorporate suspended conduits for water and sewer.
- Easier to permit than filling and raising existing breakwater.

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promenade/public access

Benefits & Opportunities:

- Provides public open space and access to the waterfront.
- Improves public health through outdoor recreation.
- Can incorporate GI stormwater controls

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vegetated riprap

Benefits & Opportunities:

- Provides immediate erosion protection.
- Native vegetation provides forage and shelter.
- Vegetation softens appearance of riprap.

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living shoreline/restored wetland

Benefits & Opportunities:

- This ecological strategy slows inland water encroachment and reduces wave energy.
- Creates vegetative habitat and opportunities for fish and wildlife.
- Can adapt over time to increasing water levels

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vegetated berm

Benefits & Opportunities:

- Can be designed to any elevation necessary to achieve climate resilience.
- Can provide pedestrian pathways and a venue for outdoor activities.

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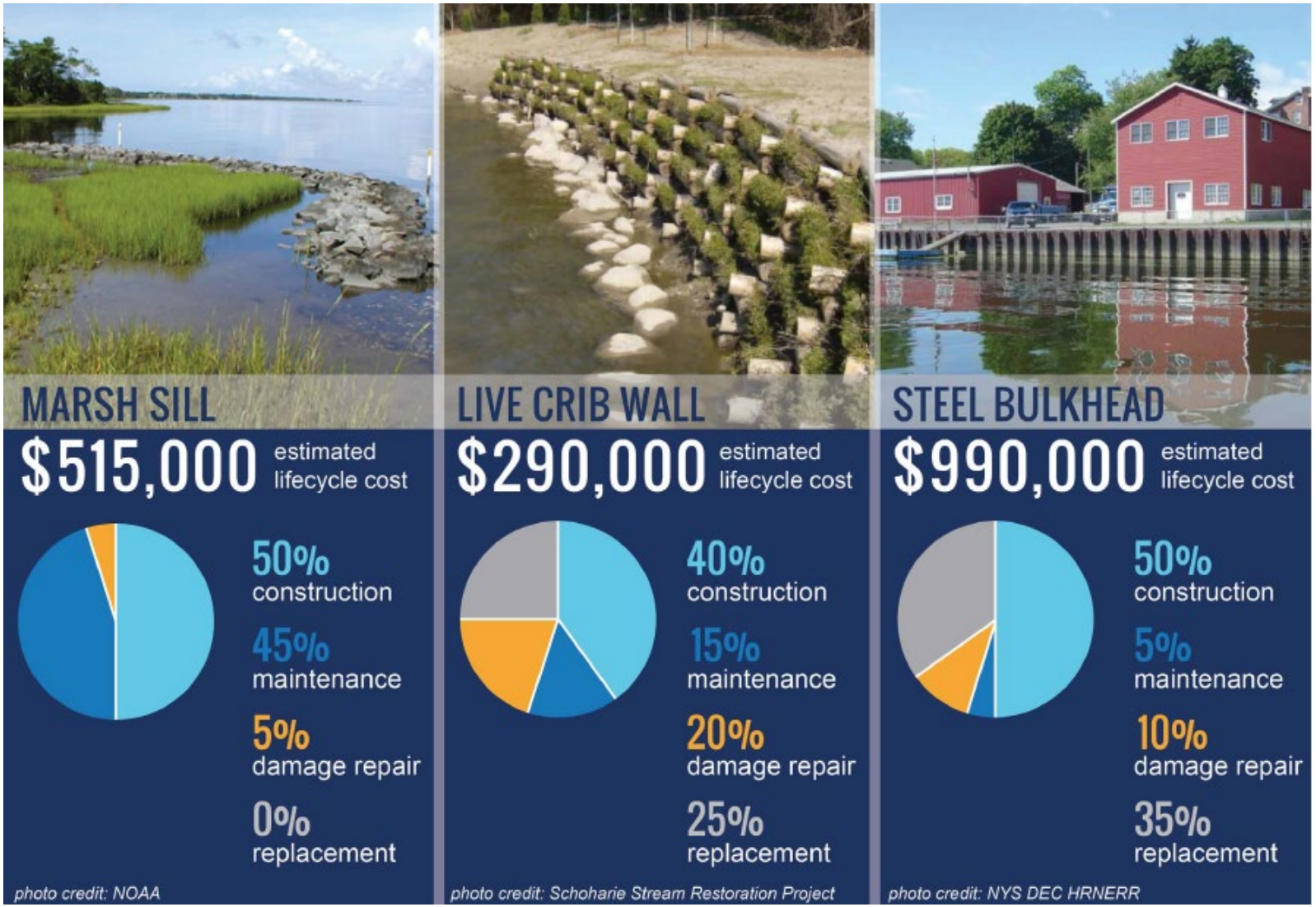
long term costs



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APPROXIMATE COST COMPARISON		
ICON	**STRATEGY**	**UNIT COST**
	Steel Bulkhead with Floating Wetland	Steel sheet pile: $2,000/lf Floating wetland: $1-$24/sf
	Steel Bulkhead	Steel sheet pile: $2,000/lf
	Tiered Concrete Plaza	Concrete cast-in-place: $4,000/lf
	LID Practices	Rain garden: $12/cubic foot of storage; $15-$25/sf
 	Elevated Boardwalk	Elevated boardwalk: $55-$95/sf including reinforced, concrete caisson footings. Flex MSE erosion and breakwater repairs: $40-50/lf
	Promenade	
	Vegetated Riprap	Riprap with live stakes (including materials and labor): $404/lf
	Living Shoreline/Restored Wetland	$1,000-$5,000/lf
	Vegetated Berm	$100 - $500/lf

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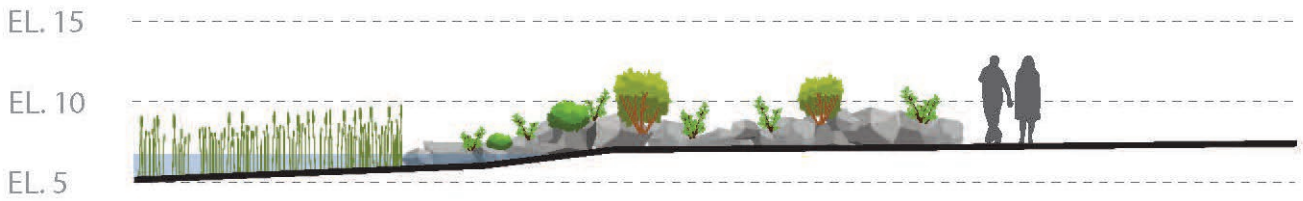
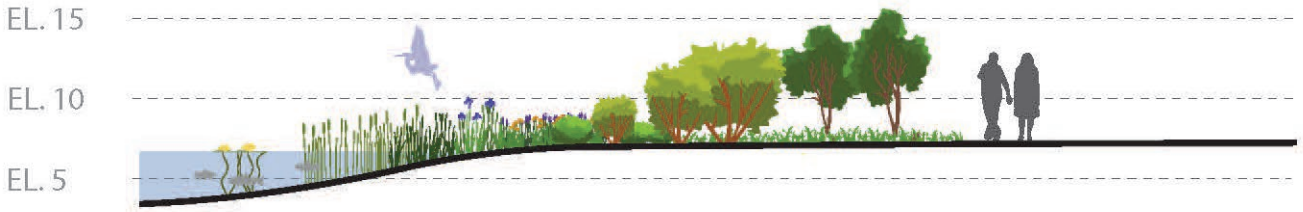
vegetation in riprap



restored wetland



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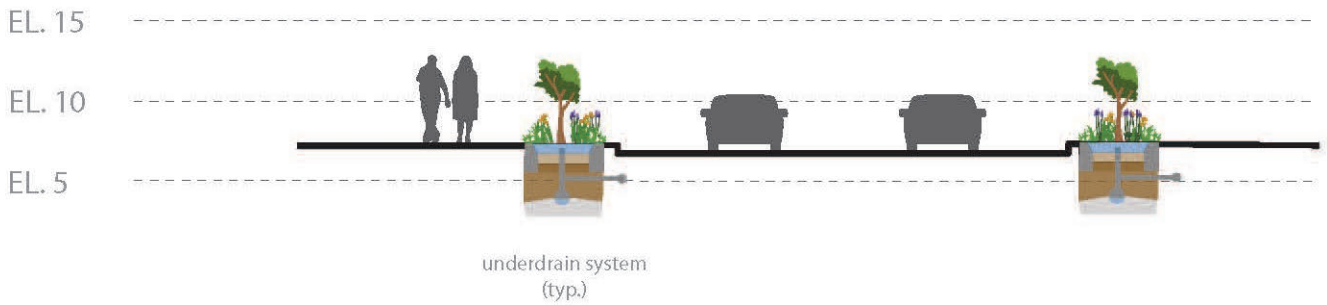
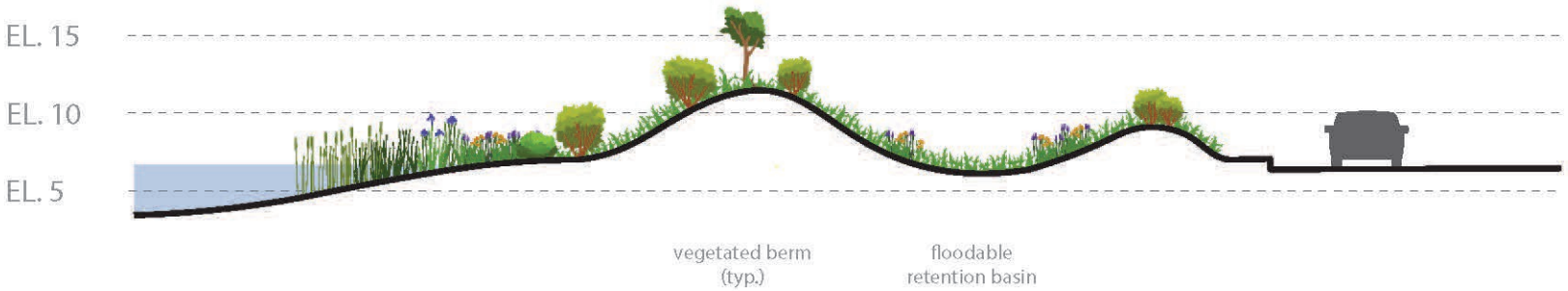
low impact development



vegetated berm/park/flood storage



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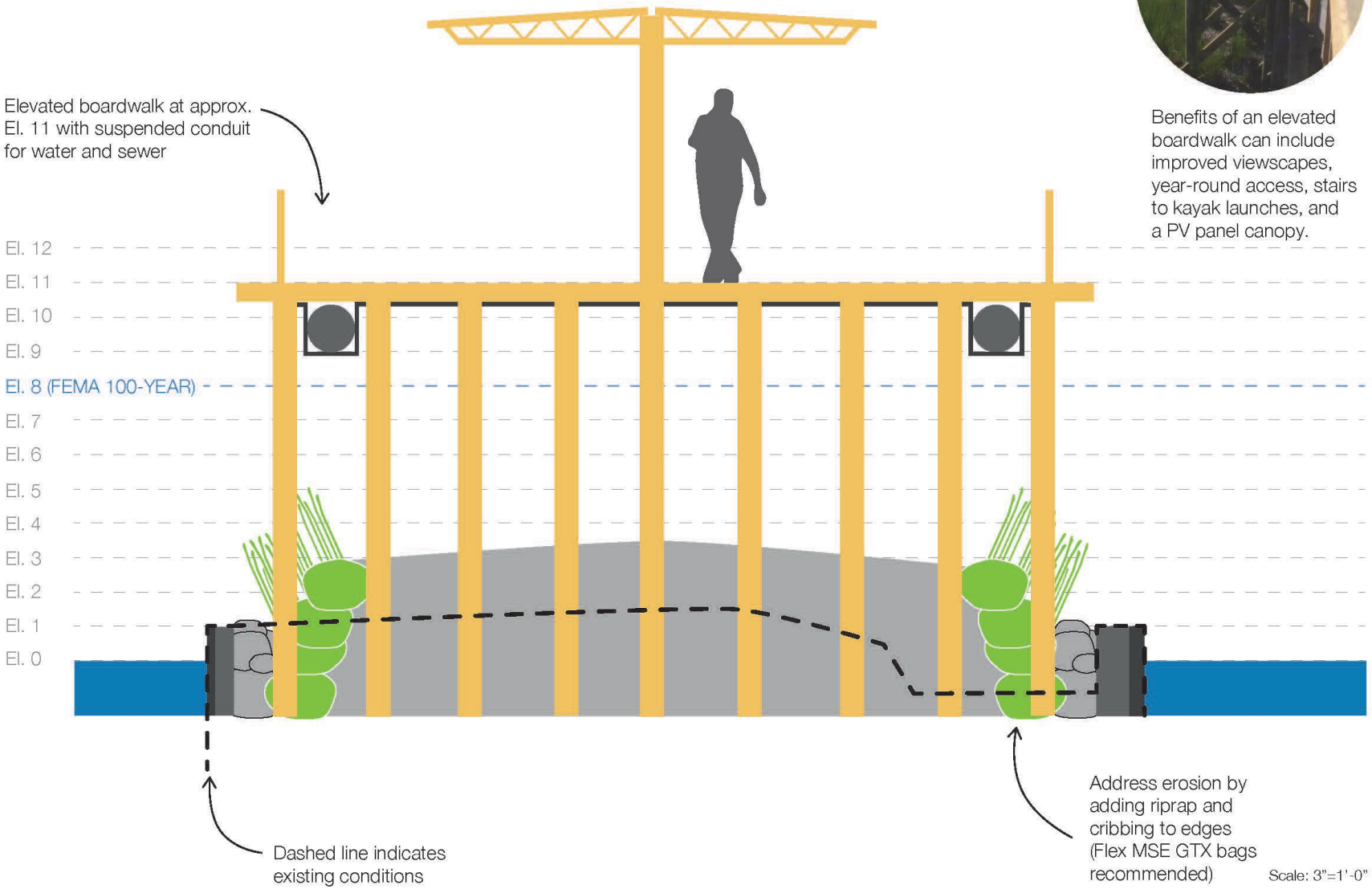
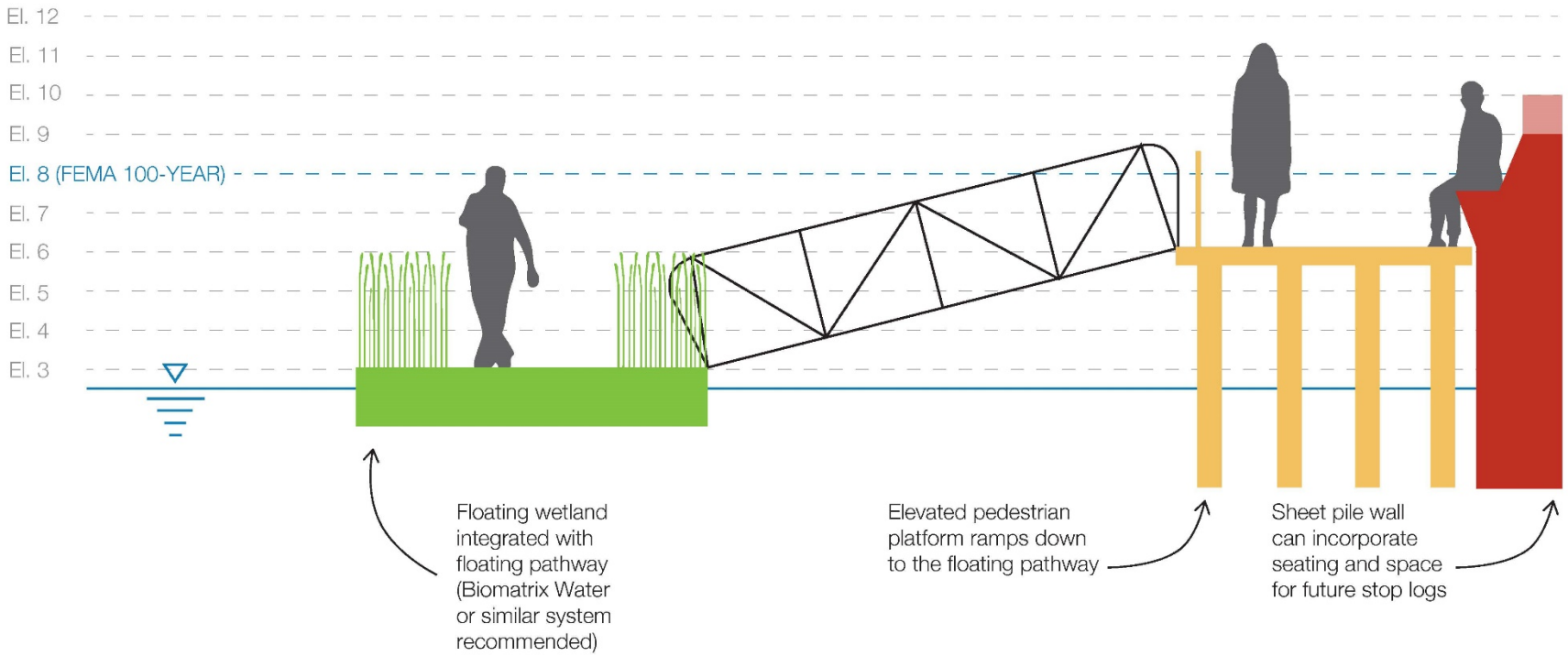
roundout lighthouse breakwater

Benefits of an elevated boardwalk can include improved viewscapes, year-round access, stairs to kayak launches, and a PV panel canopy.



sheet pile wall and floating ecosystem

Sheet piles walls can incorporate elevated walkways, kayak tie-up areas, floating wetlands, and incremental attachment points to accomodate sea level rise.



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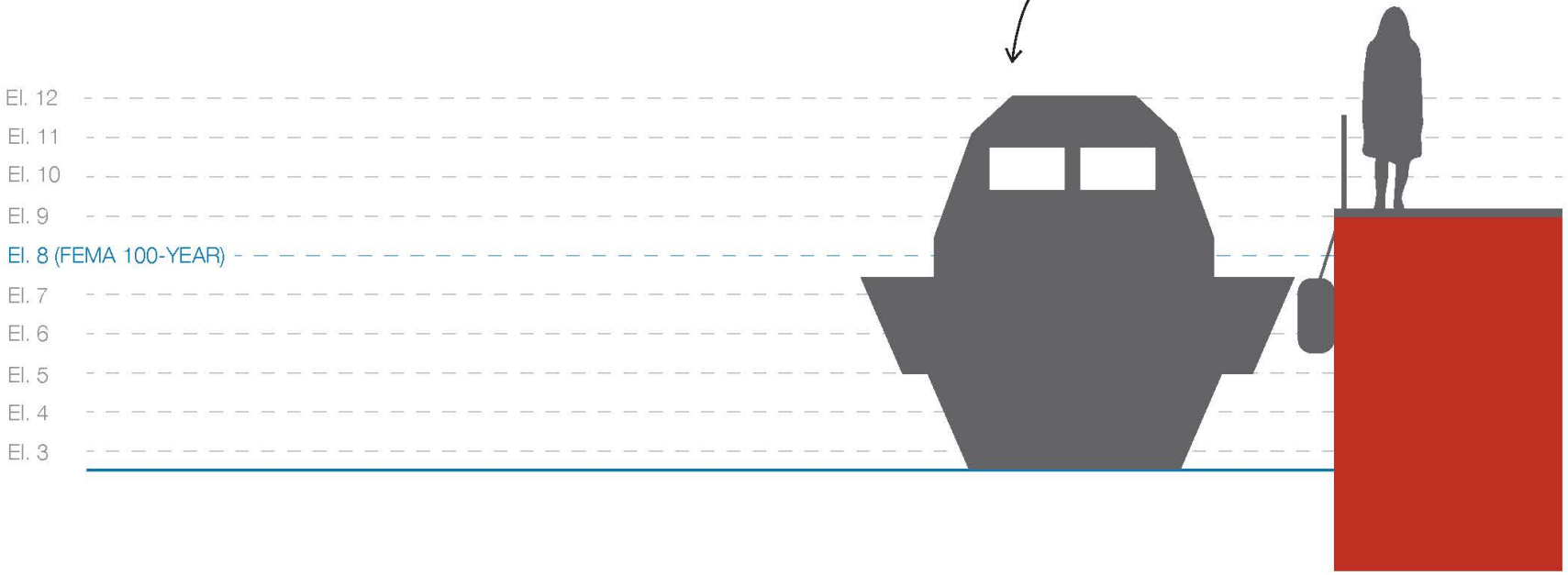
sheet pile wall with boat access

Sheet piles walls can incorporate a cap for a pedestrian walkway and mooring for boat access.



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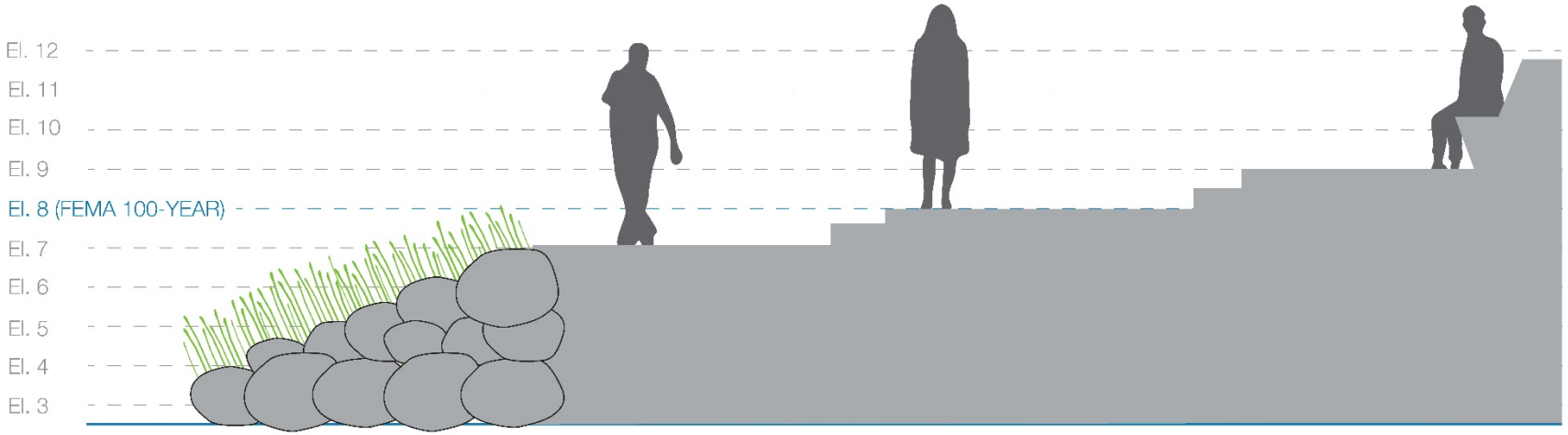
pedestrian plaza/ tiered access

Pedestrian spaces can incorporate tiered plazas, joint planting, seating, and access to the waterfront.



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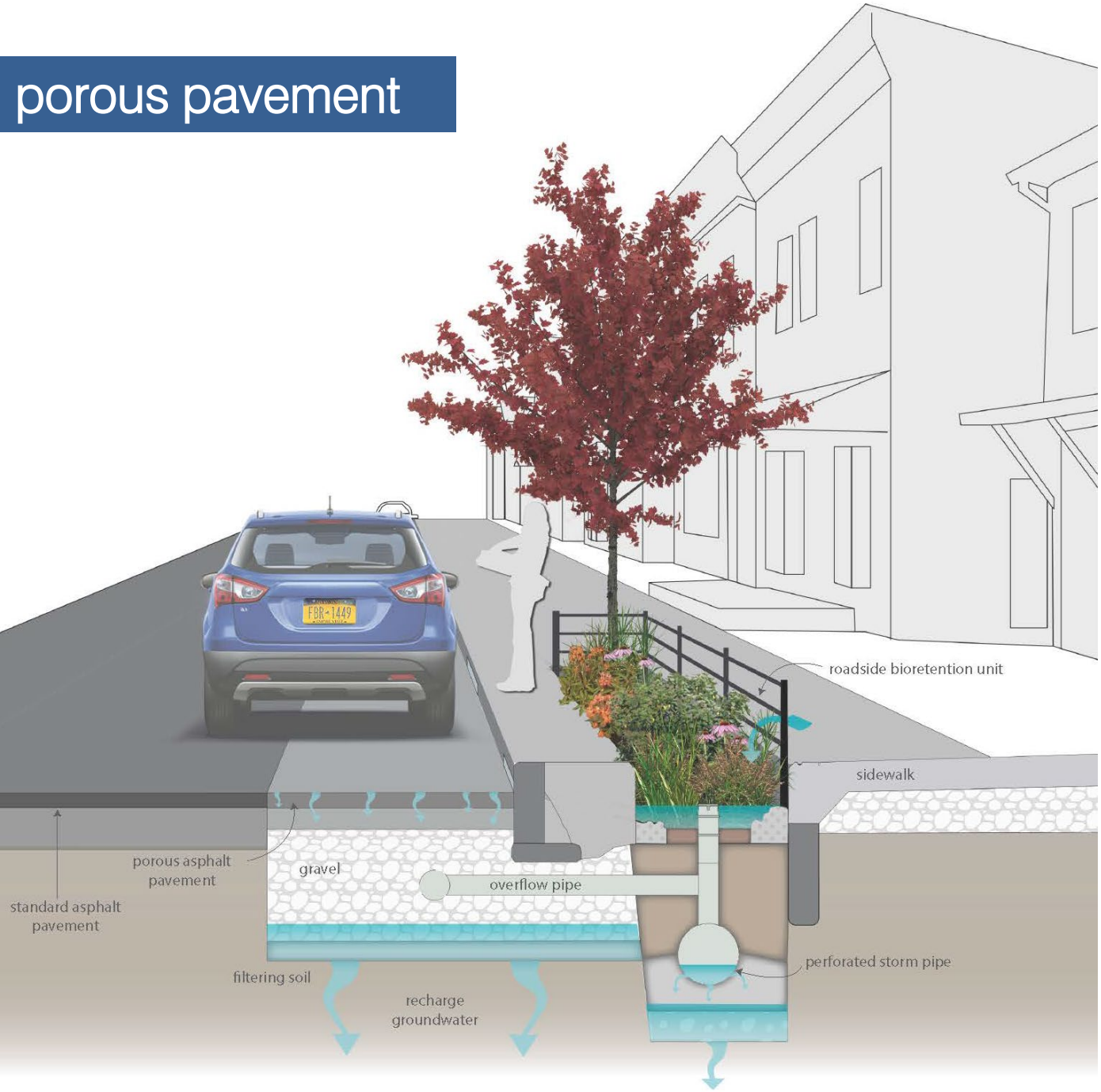
porous pavement



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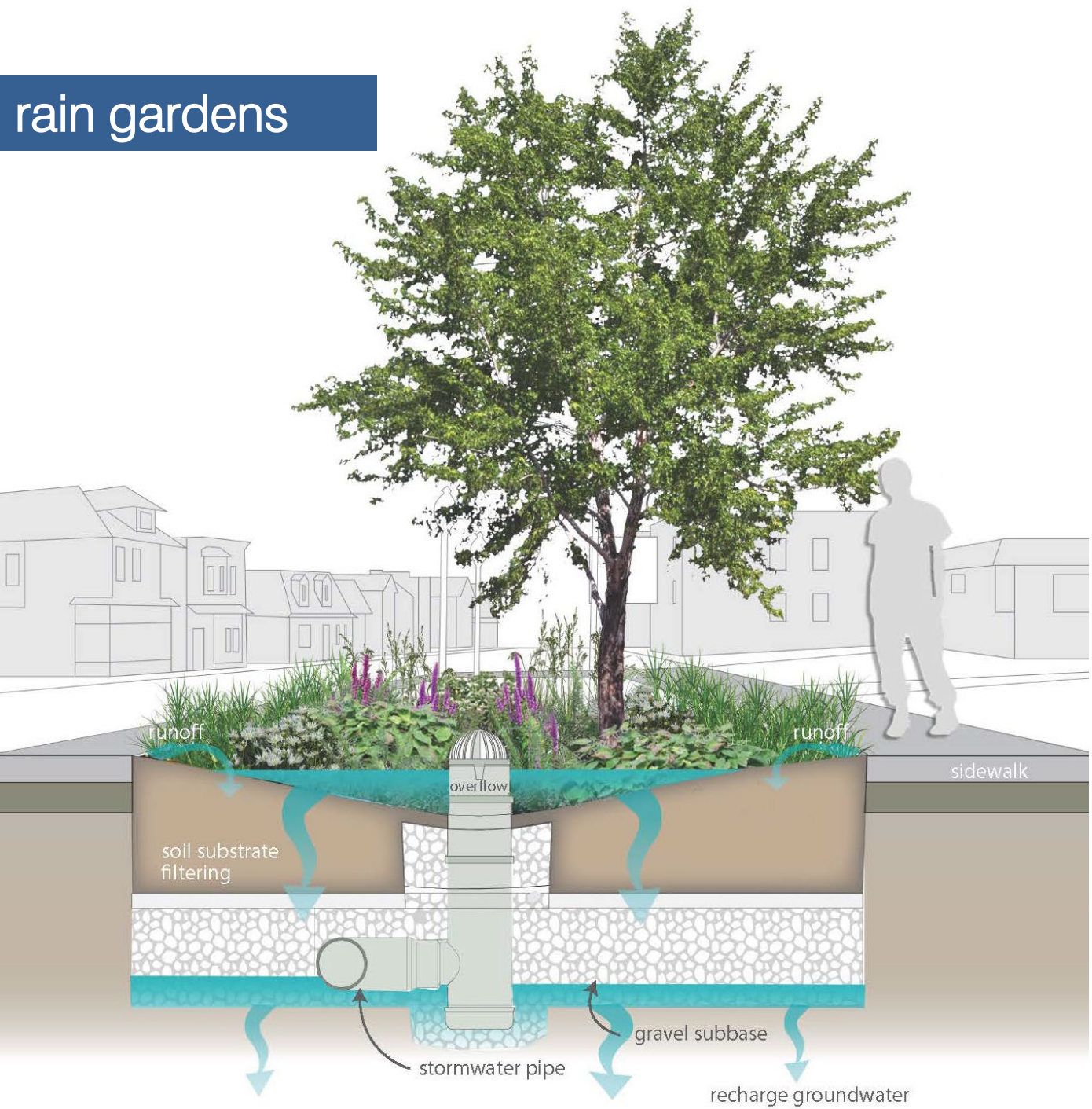
rain gardens



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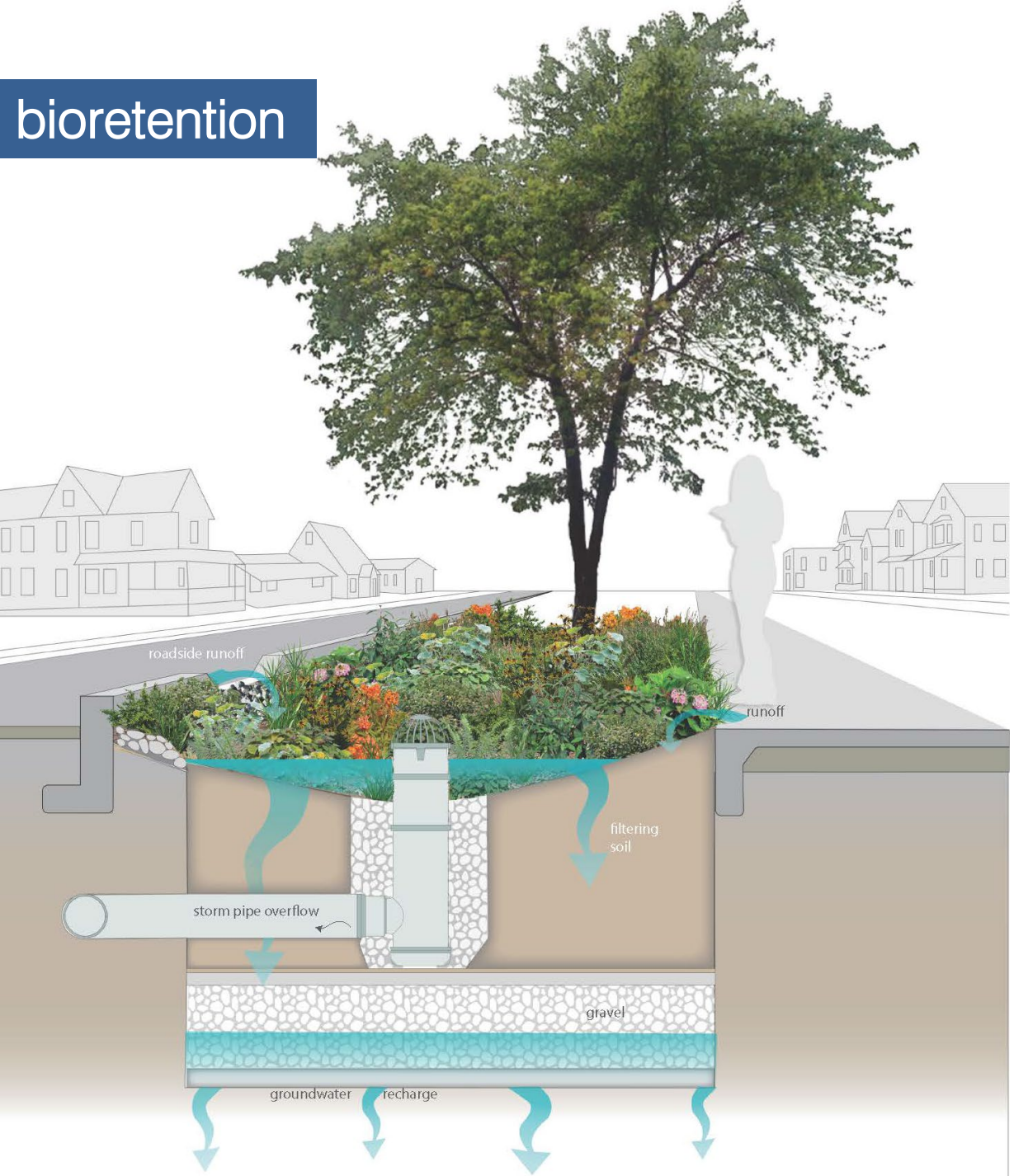
bioretention



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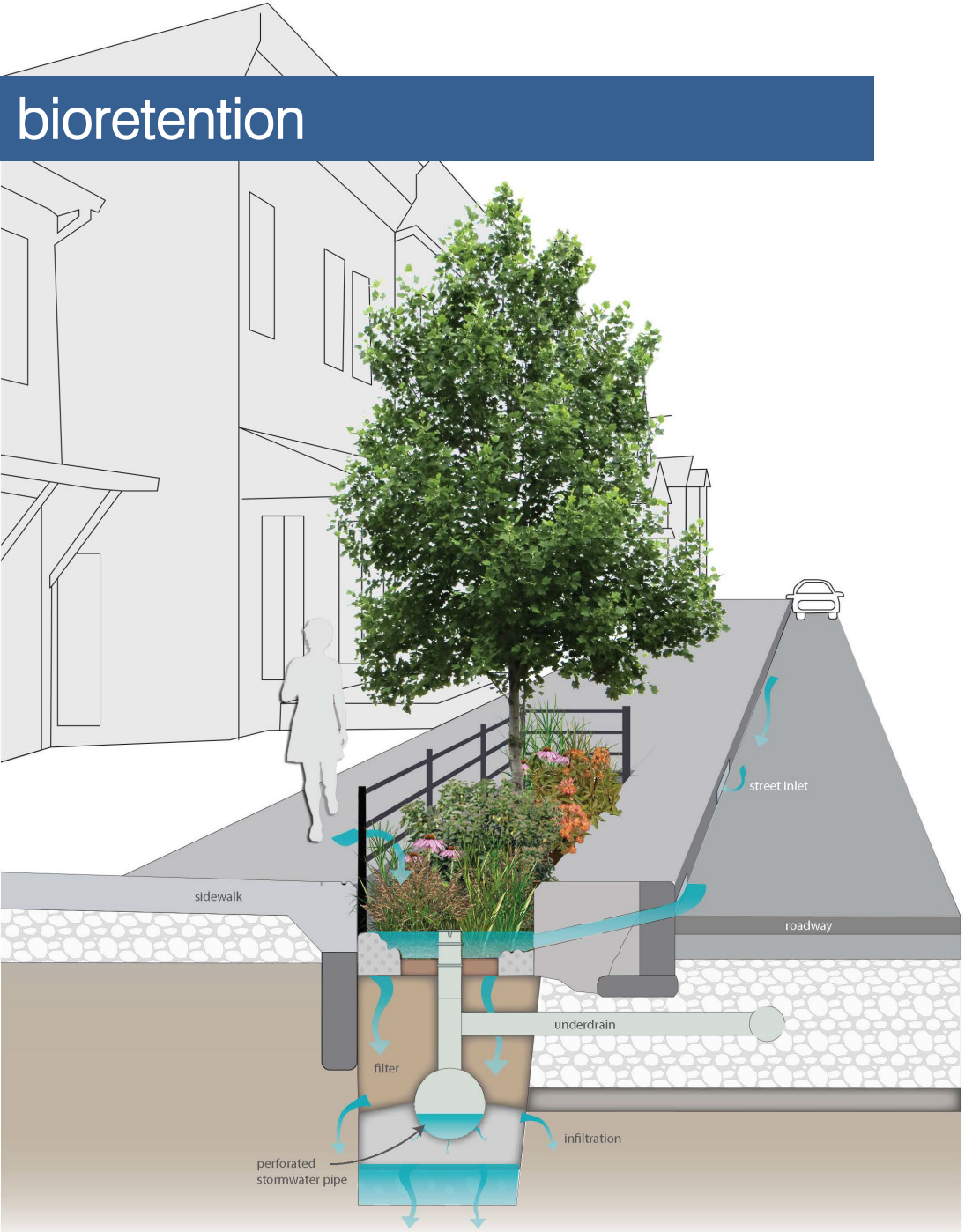

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schematic design

Rondout Riverport Shoreline Stabilization and Public Access – Phase II

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