2012 GREEN INFRASTRUCTURE TECHNICAL ASSISTANCE PROGRAM
City of Portland, Bureau of Environmental Services
Portland, Oregon

District-Scale Green Infrastructure Scenarios for the Zidell Development Site, City of Portland

An Exploration of Holistic, Adaptive, and Flexible Green Infrastructure Strategies within a 33-acre Remediated Brownfield Development

Photo: River East, Portland

AUGUST 2013
EPA 830-R-13-002

About the Green Infrastructure Technical Assistance Program

Stormwater runoff is a major cause of water pollution in urban areas. When rain falls in undeveloped areas, the water is absorbed and filtered by soil and plants. When rain falls on our roofs, streets, and parking lots, however, the water cannot soak into the ground. In most urban areas, stormwater is drained through engineered collection systems and discharged into nearby waterbodies. The stormwater carries trash, bacteria, heavy metals, and other pollutants from the urban landscape, polluting the receiving waters. Higher flows also can cause erosion and flooding in urban streams, damaging habitat, property, and infrastructure.

Green infrastructure uses vegetation, soils, and natural processes to manage water and create healthier urban environments. At the scale of a city or county, green infrastructure refers to the patchwork of natural areas that provides habitat, flood protection, cleaner air, and cleaner water. At the scale of a neighborhood or site, green infrastructure refers to stormwater management systems that mimic nature by soaking up and storing water. These neighborhood or site-scale green infrastructure approaches are often referred to as *low impact development*.

EPA encourages the use of green infrastructure to help manage stormwater runoff. In April 2011, EPA renewed its commitment to green infrastructure with the release of the *Strategic Agenda to Protect Waters and Build More Livable Communities through Green Infrastructure*. The agenda identifies technical assistance as a key activity that EPA will pursue to accelerate the implementation of green infrastructure.

In February 2012, EPA announced the availability of $950,000 in technical assistance to communities working to overcome common barriers to green infrastructure. EPA received letters of interest from over 150 communities across the country, and selected 17 of these communities to receive technical assistance. Selected communities received assistance with a range of projects aimed at addressing common barriers to green infrastructure, including code review, green infrastructure design, and cost-benefit assessments. The City of Portland was selected to receive assistance identifying green infrastructure opportunities for a 33-acre brownfield redevelopment project.

For more information, visit http://water.epa.gov/infrastructure/greeninfrastructure/gi_support.cfm.

Contents

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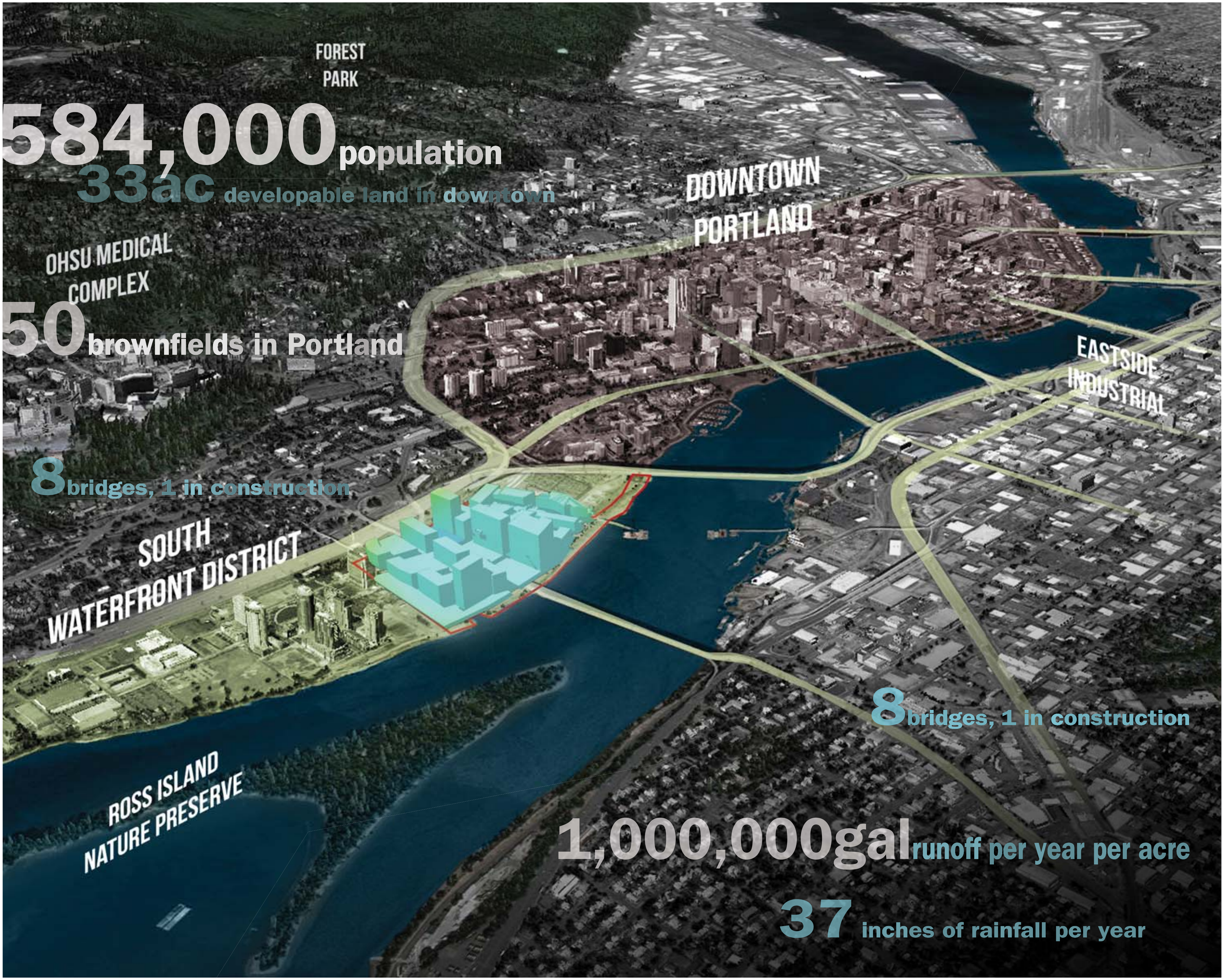
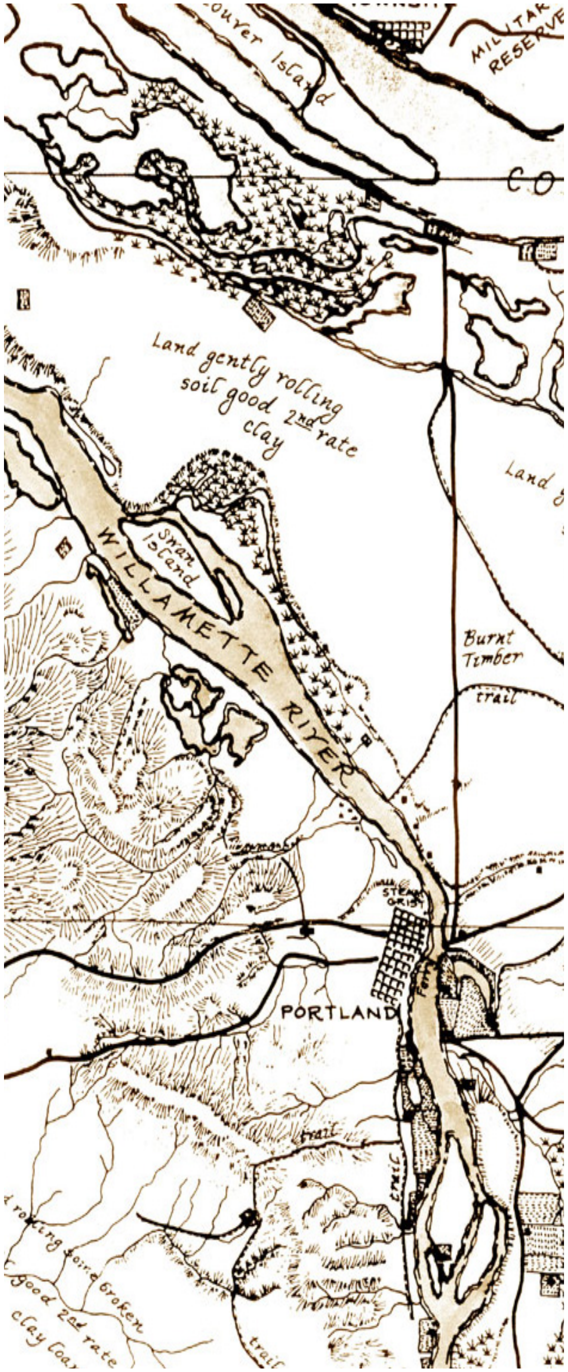

FOREST PARK
584,000 population
33ac developable land in downtown
DOWNTOWN PORTLAND
OHSU MEDICAL COMPLEX
50 brownfields in Portland
EASTSIDE INDUSTRIAL
8 bridges, 1 in construction
SOUTH WATERFRONT DISTRICT
8 bridges, 1 in construction
ROSS ISLAND NATURE PRESERVE
1,000,000gal runoff per year per acre
37 inches of rainfall per year



INTRODUCTION

This Zidell Yards project offers the first holistic, comprehensive opportunity in Portland, Oregon to identify solutions for applying green infrastructure to manage stormwater on one of the largest brownfield remediation and redevelopment sites in Portland—the Zidell site, a 33-acre industrial property adjacent to the Willamette River and downtown Portland. The Zidell site is in the 120-acre South Waterfront District, which encompasses existing and former industrial areas in Portland's Central City. Recently, the South Waterfront District has been a hub of sustainable building and planning and, as a result, was identified as one of five pilot eco-districts in the city. With its commitment to explore new applications of green infrastructure in our urban environments, the City of Portland, supported by ZRZ Realty, applied for U.S. Environmental Protection Agency technical assistance to develop green infrastructure scenarios for the Zidell Yards site.

The goal of this effort is to develop a range of green infrastructure scenarios consistent with the constraints of a recently remediated brownfield that can be implemented within the framework of a 15- to 20-year development master plan. Conversations with local and national experts and stakeholders resulted in much consensus regarding the application of green infrastructure at this site and similar sites, but this effort is just the beginning of a broader conversation that will continue as green infrastructure and brownfield redevelopment are studied and applied. This report was written to collect and describe key findings during our exploration of this topic that can be applied to the Zidell site and other redevelopment projects of similar character.

This is a critical time and opportunity to explore the use of green infrastructure on remediated sites specifically because of the extensive remediation, redevelopment, and retrofit opportunities expected in the next decade in former industrial areas locally and throughout the nation. As our urban areas continue to develop, the discussion of redeveloping brownfields and its associated benefits and constraints has become more pertinent; an estimated 450,000 properties in the United States are brownfields. The study of mobilization of pollutants and the advancement of remediation solutions have allowed many of these brownfield properties to transcend their former uses and become housing, new business incubators, productive greenspaces such as community gardens or urban farms, and hotbeds of new jobs. Redeveloping these properties can bring revenue to local municipalities through increase in property values and taxes.

Property improvements can also benefit natural systems. Many of the brownfields in Portland are next to the Willamette River, which is a significant and highly visible natural resource. The Willamette River is impaired for

ZIDELL SHIPYARD

Brownfields redevelopment can have the following benefits:

- Eliminating health and safety hazards
- Eliminating eyesores
- Bringing new jobs into the community
- Bringing new investment into the community
- Increasing the productivity of the land
- Increasing property values and tax receipts by local and state governments
- Ensuring, by using a soil cap, that the remaining contaminated soil, buried deep underground, does not pose an environmental or health risk

temperature, Escherichia coli, and toxic pollutants including PCBs. Six species of salmon and trout that use this section of the river are listed as threatened under the Endangered Species Act.

The proximity of brownfields to significant natural resources is common as industry historically relied on our nation's waterways for transportation of goods. While remediation solutions for brownfields can remove and encapsulate pollutants from historic uses of the site, these natural resources also need to be protected from the effects of future development. Specifically, green infrastructure is being applied throughout cities worldwide as a sustainable form of stormwater management.

Green infrastructure solutions—such as green streets, ecoroofs, rain gardens, stormwater planters, open space or parks, permeable pavement, street trees, and cisterns—mimic the natural water cycle and integrate the management of stormwater into our urban fabric to help reduce the damaging effects of urbanization. By integrating these natural processes into the built environment, green infrastructure manages stormwater and provides additional benefits such as climate resiliency, air cooling and filtering, community beautification, and multi-modal transportation benefits. Portland has received national and international recognition as a leader in the application of green infrastructure solutions through early adoption, research, and monitoring of these practices at new development and retrofit sites.

The project team collaborated in a workshop-driven process to develop three alternative scenarios for the Zidell Yards. The conceptual design scenarios apply green infrastructure solutions that capitalize on infiltration and innovation for the remediated brownfield site with the goal of exceeding existing regulatory requirements for stormwater management and providing creative solutions with multiple community benefits. This report explores three alternative scenarios to maximize onsite stormwater infiltration across the entire property. Though the stormwater techniques are familiar—green streets, ecoroofs, rain gardens, stormwater planters, open space/parks, permeable pavement, street trees, and cisterns, among others—their application at a brownfield site is truly innovative.

THE SITE

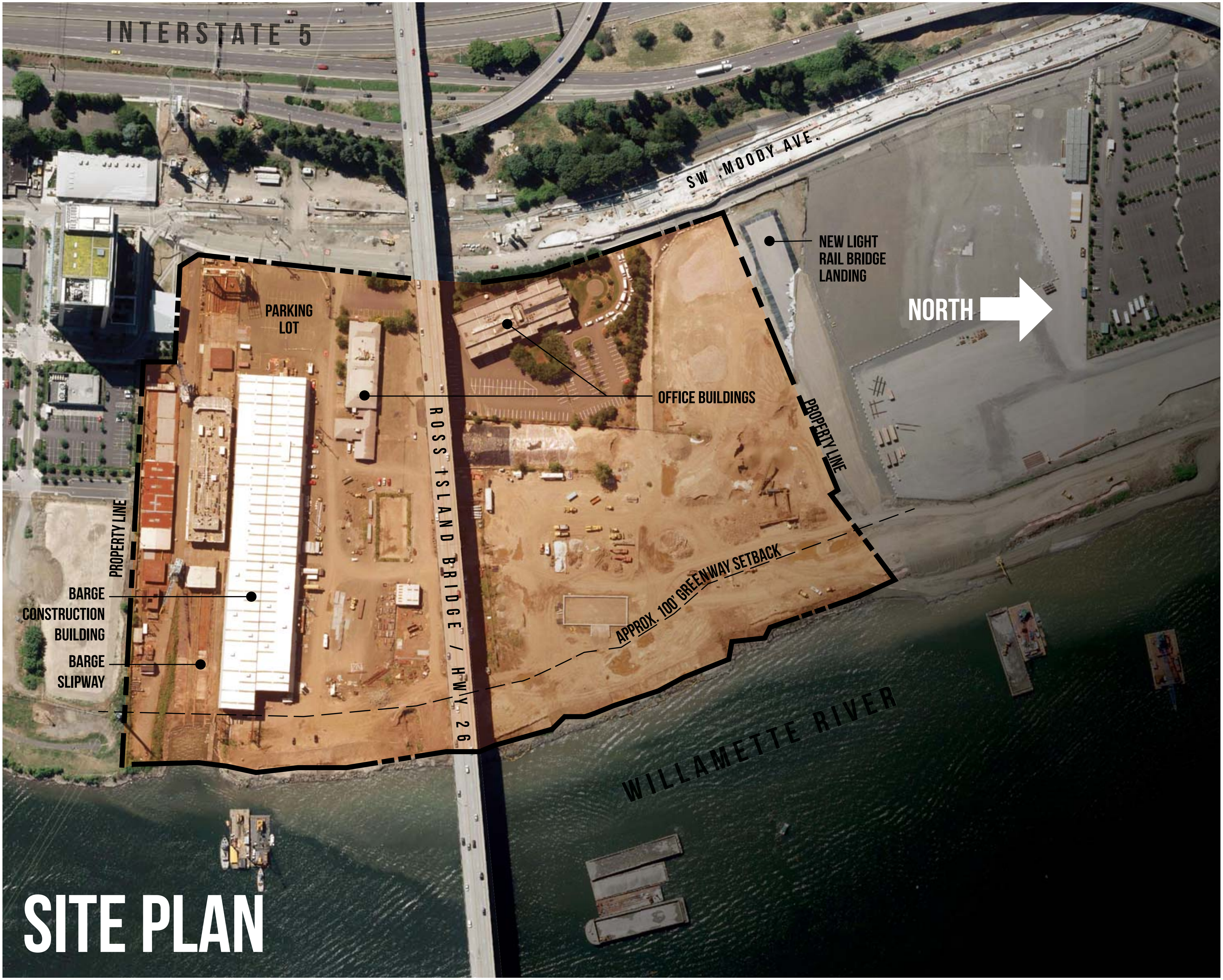
The 33-acre project area is in the northern portion of the South Waterfront District. The site is generally flat, sloping gently from the northeast to southwest. Elevations range from 35 feet along the north side of the site to 28 feet along the south side. The site's riverbank along the Willamette River is approximately 2,700 feet long. An approximately 100-foot-wide greenway setback is along the east edge of the property, and this segment accounts for approximately 40 percent of the total length of the South Waterfront Greenway. The Ross Island Bridge crosses the property from east to west approximately 100 feet overhead, including multiple bridge footings. The bridge carries Highway 26, a major east/west transportation corridor owned by the Oregon Department of Transportation (ODOT). The bridge covers approximately 20,000 square feet of the site. The Zidell Corporation maintains marine operations fabricating barges in the two large buildings in a small portion of the site along its southern edge.

The site has been filled over the years; it is underlain by construction fill material and sediment deposits from periodic flooding by the Willamette River. The sediments consist of fine-grained, sandy silt and are approximately 75 feet thick. Groundwater is present and generally shallow, ranging from 5 to 30 feet deep. The groundwater depth varies seasonally, but it generally flows from southwest to northeast toward the Willamette River. The site is not connected to Portland's stormwater infrastructure system. Stormwater from the site was served by two private outfalls owned by ZRZ Realty Company and one public outfall, a brick pipe built in 1892. The public outfall was decommissioned as part of the recent site remediation. The two private outfalls remain in service; one conveys overflows from an infiltration basin that was constructed when the public outfall was decommissioned. Along the site's north edge, a bridge landing is being constructed for the city's newest light-rail extension to connect Portland to Milwaukie to the south. To accommodate the height of the new light-rail bridge, approximately 14 feet of fill has been placed along the north side of the site. Future roadways and development in that part of the site must be raised to meet the new bridge landing.

Historical maps identify the entire South Waterfront District along the west bank of the Willamette River as primarily floodplain marshes. Small streams conveyed water from the West Hills down to a small pond in the floodplain and eventually flowed to the Willamette River. Typical native tree species that grew in these fertile alluvial soils were Oregon ash, black cottonwood, red alder, and bigleaf maple. Much of the fertile floodplain had been cleared of vegetation for farm cultivation by the 1850s. As with many floodplains next to growing urban areas, the farmland was eventually filled over several decades to meet the ever-growing demand for industrial land beside the river. Many industrial businesses have occupied this site since the 1920s, most of which were related to ship building and dismantling. As a result of historical industrial land uses, the Zidell Yards site and adjacent river sediments were contaminated and were entered into Oregon's Department of Environmental Quality (DEQ) Voluntary Cleanup Program. For the purposes of comparison of this site to other remediated brownfields, the pollutants found during the remedial investigation were asbestos materials, volatile organic compounds (VOCs), total petroleum hydrocarbons (TPH), metals, polycyclic aromatic hydrocarbons (PAHs), polychlorinated biphenyls (PCBs), dioxins, and furans.

Site remediation work began in 2010 with excavation and disposal of upland hotspot soils. Riverbank and river sediment remediation was conducted in the summer of 2011 including constructing a sediment cap and landscaping the riverbank with thousands of native plants. A 2-foot-thick soil cap was placed over the greenway setback in 2012 to isolate residual low-level soil contamination, and a gravel cap was placed on the remaining upland areas under and north of the Ross Island Bridge. The remaining contaminants on the remediation site are considered non-mobile and do not pose a risk to groundwater. Because of this, Oregon DEQ does not prohibit stormwater infiltration on the site. The remediation project enhances water quality in the river and greatly improves fish and wildlife habitat in and beside the water.

VIEW FROM UNDER ROSS ISLAND BRIDGE


INTERSTATE 5
SW MOODY AVE.
NEW LIGHT
RAIL BRIDGE
LANDING
NORTH
PARKING
LOT
OFFICE BUILDINGS
ROSS ISLAND BRIDGE / HWY 26
PROPERTY LINE
PROPERTY LINE
BARGE
CONSTRUCTION
BUILDING
BARGE
SLIPWAY
APPROX. 100' GREENWAY SETBACK
WILLAMETTE RIVER

SITE PLAN

Master Plan Surfaces

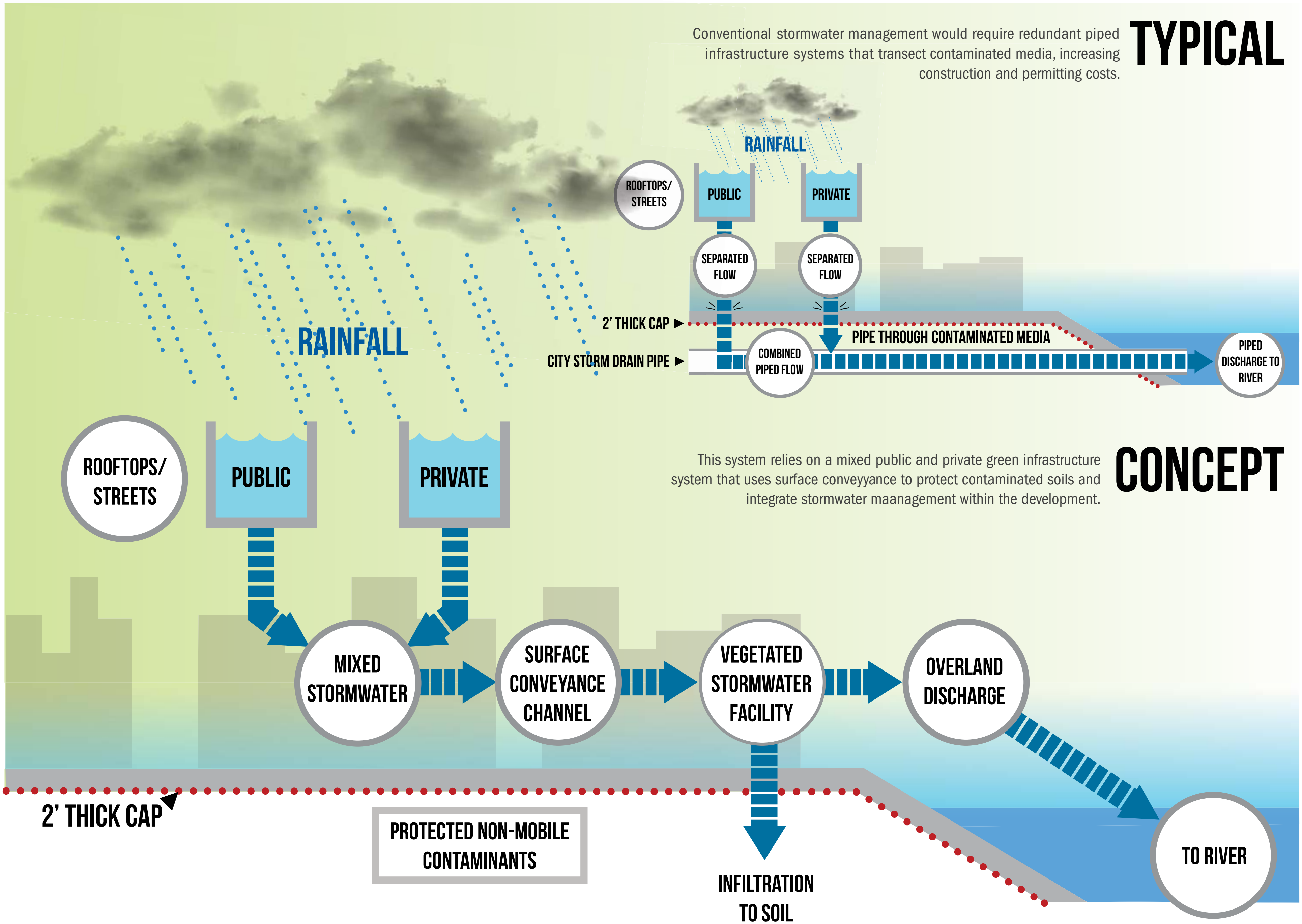
Master Plan Surfaces	Acres	Total % of plan
Building Footprints	11.42	38% (3817 sq' overhang in greenway)
Streets	1.86	6%
Plaza and Curbless Streets	3.79	12%
Remainder	3.43	11%
Greenspace	5.82	19%
Greenway	4.07	13%
Total Calculated Area	30.22	100% (0.2 acre degree of accuracy)

MASTER PLAN

"The Zidell family has deep roots in this land, and they see the Yards as an opportunity to create something distinct, bold, and of lasting value for the City of Portland."

The site is in a dynamic development location catalyzed by recent development of the South Waterfront District, expansion of Oregon Health Sciences University, and the new light-rail bridge terminus on the west side of the Willamette River. This site is one of the largest remaining parcels of developable land that is immediately south of downtown Portland. ZRZ Realty is developing a vision and master plan for their development, named Zidell Yards. Development is planned to occur in several major phases over a 15- to 20-year time frame. The site is envisioned to integrate buildings and open space into a sustainable, mixed-use development that embraces the history and ecology of the Willamette River. ZRZ Realty provided a preliminary master plan to the project team to develop an understanding of total impervious surface and approximate locations of buildings and other site elements. The preliminary master plan is, of course, subject to change. The development is planned to have a mix of office, residential, retail, and hotels with large areas of open space. Portland Parks and Recreation has identified the area under and next to the Ross Island Bridge for park area up to 4 acres that would take advantage of its unique location under the bridge and its proximity to the Willamette River.

The master plan diagram identifies the approximate location of buildings, streets, plazas, and open space in the future development; the absolute and relative acreage of each feature type is indicated in the legend. The land area of the master plan is 30 acres; an additional 3 acres are next to the site north of the light-rail bridge and are outside the project's study area. A future greenway trail will be designed and constructed within the 100-foot greenway setback area. For the purposes of this project, we used a snapshot of the master plan as ZRZ Realty continued to refine its development concept. This project is not intended to finalize the master plan for the development but to use the master plan as a framework in which to work.


TYPICAL
Conventional stormwater management would require redundant piped infrastructure systems that transect contaminated media, increasing construction and permitting costs.
RAINFALL
ROOFTOPS/ STREETS
PUBLIC
PRIVATE
SEPARATED FLOW
SEPARATED FLOW
2' THICK CAP
PIPE THROUGH CONTAMINATED MEDIA
CITY STORM DRAIN PIPE
COMBINED PIPED FLOW
PIPED DISCHARGE TO RIVER
CONCEPT
This system relies on a mixed public and private green infrastructure system that uses surface conveyyance to protect contaminated soils and integrate stormwater maanagement within the development.
RAINFALL
ROOFTOPS/ STREETS
PUBLIC
PRIVATE
MIXED STORMWATER
SURFACE CONVEYANCE CHANNEL
VEGETATED STORMWATER FACILITY
OVERLAND DISCHARGE
TO RIVER
2' THICK CAP
PROTECTED NON-MOBILE CONTAMINANTS
INFILTRATION TO SOIL

THE CHALLENGE

The challenge of the Zidell Yards site project was to collaboratively develop an innovative green infrastructure system to maximize stormwater capture and treatment through an integrated system of public and private facilities across the entire site. The site's unique characteristics as a brownfield adjacent to the Willamette River combined with its location at the nexus of sustainable planning and development in Portland provided the opportunity for an ambitious and innovative conversation related to the future of green infrastructure and sustainable development. Early in the process, the project team developed a list of goals (below) for a successful project.

PROJECT GOALS

- Provide flexible and adaptive solutions for the specific conditions of a remediated brownfield
- Support EPA's Strategic Agenda for Green Infrastructure
- Evolve current sustainable stormwater management techniques
- Provide a range of concepts
- Minimize or eliminate the need for new piped outfalls to the river

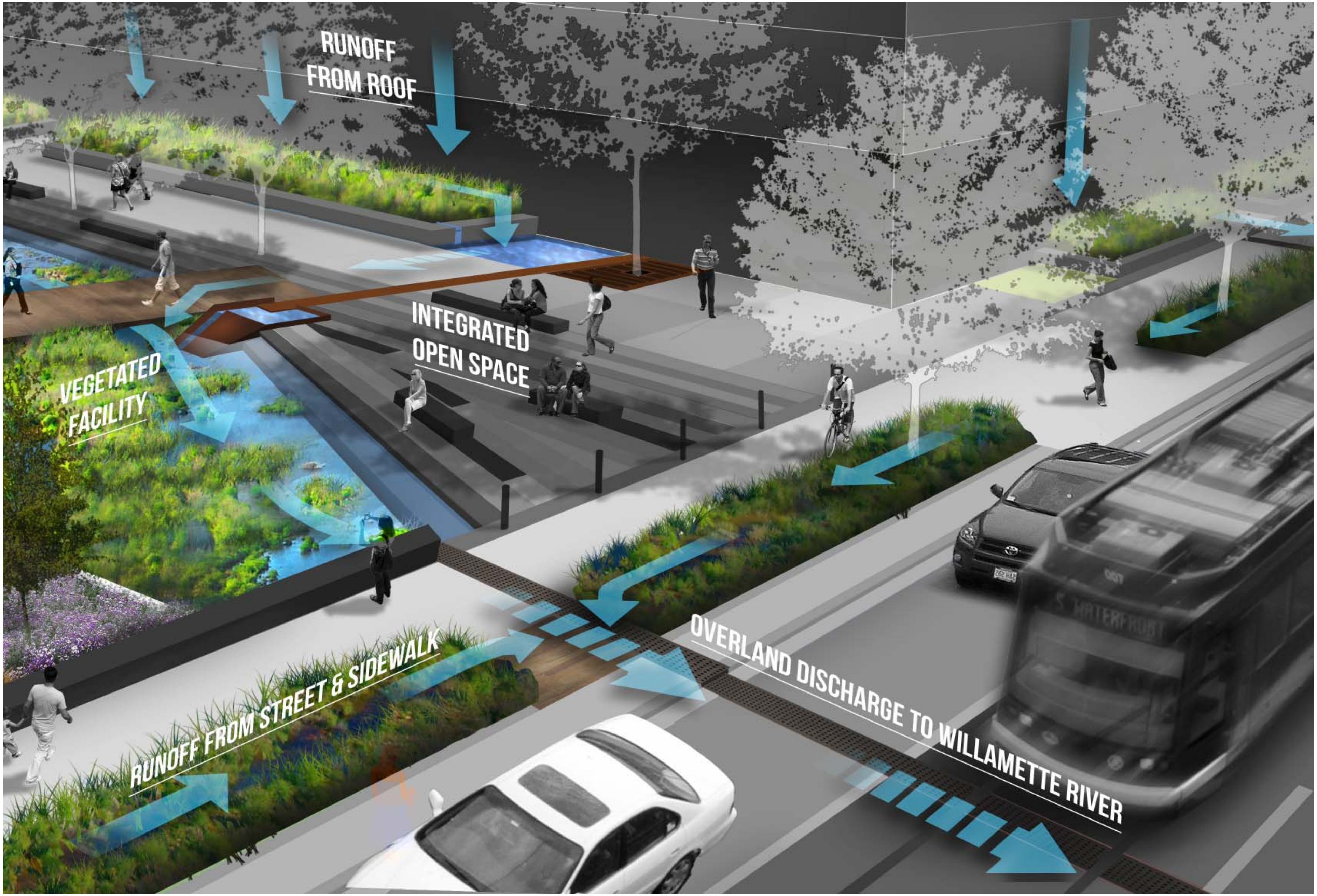
Once the project goals were developed, a list of ground rules or design assumptions for the scenarios was established. Although many design assumptions were developed early in the project, several arose as key assumptions as discussions progressed. Each of the three scenarios meets the following assumptions.

KEY DESIGN ASSUMPTIONS

Mixing of Private and Public Stormwater

This site provides a unique opportunity for a public-private partnership because the entire site has one property owner, and the site will be developed over a 15- to 20-year time frame. To ensure the development of a flexible and innovative stormwater management system, we assumed that stormwater from public areas (streets and rights of way) and private land can be managed holistically in combined facilities and an integrated conveyance system. This concept has been applied at individual sites throughout Portland but never on a district scale. This fundamental design assumption allows us to explore a district-scale stormwater network that provides greater flexibility for placement of buildings, infrastructure, and open space. The scenarios provide three examples as to how this integrated, district-scale concept could be applied.

SURFACE CONVEYANCE DIAGRAM



Managing Stormwater on the Surface

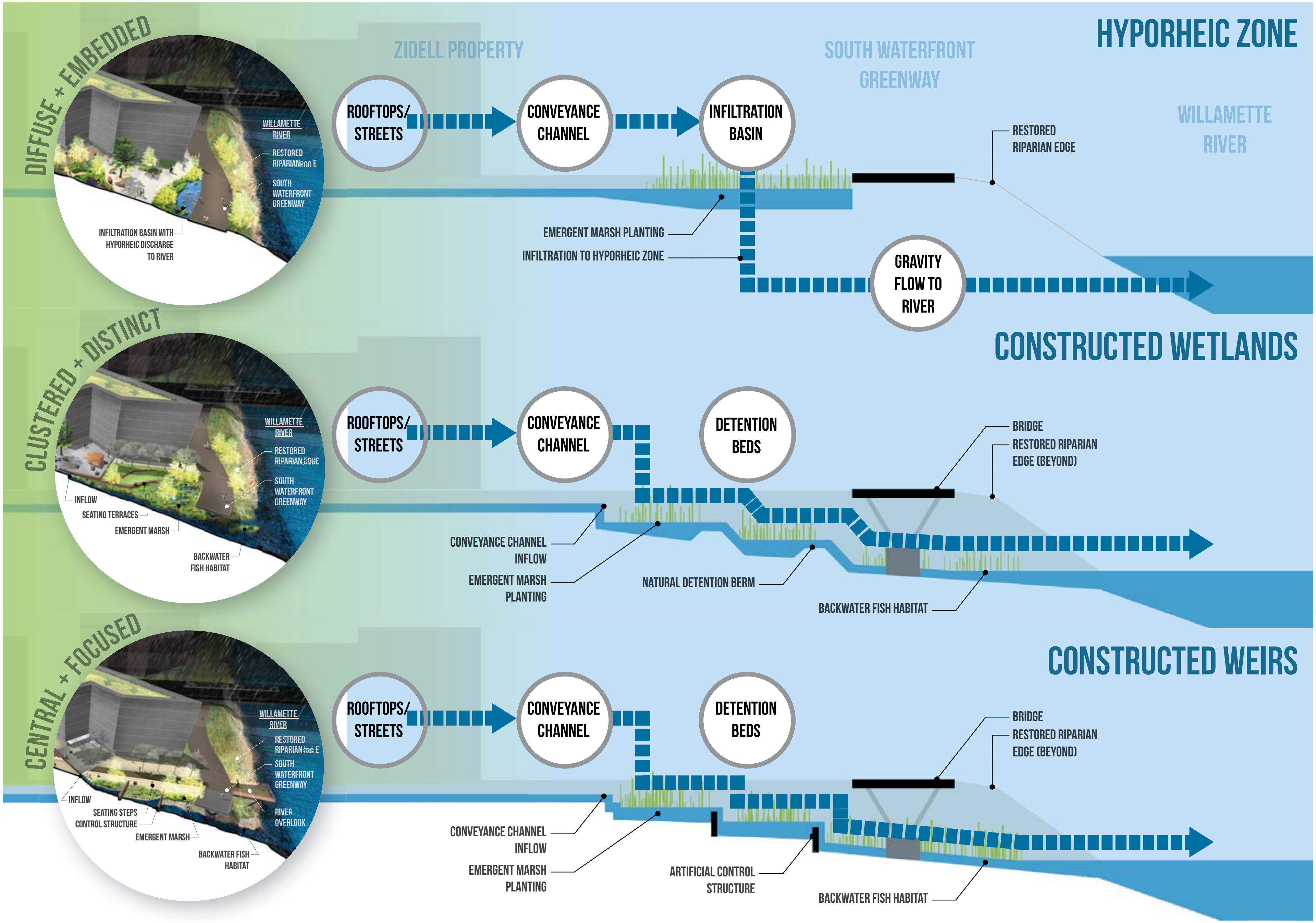
Because this site is a brownfield, it requires special consideration during site design and development. Specifically, a cap was required for remediation to prevent disturbance or erosion of the remaining contaminated soils. As development occurs on the site, contaminated soil disturbance should be minimized to prevent exposure, erosion, or its costly hauling away. This constraint poses challenges for the traditional application of underground, piped gray infrastructure, so the design team sought to focus on managing stormwater on the surface. All three scenarios developed for the site rely on a network of surface conveyance channels and infiltration facilities to manage stormwater and convey larger flows to the Willamette River via an overland discharge system. Infiltration of stormwater on this site is possible because of the nature of the remaining soil contaminants and the extensive remediation that has already occurred.

The primary goal for applying a surface conveyance system is to reduce the potential for disturbing contaminated media. A surface conveyance system would not penetrate the cap, therefore, avoiding the potentially significant costs of excavating and disposing of contaminated soils. Furthermore, a surface conveyance network and green infrastructure facilities will provide other benefits beyond a traditional piped system, including visible water flow, connecting people to water, sustainable site identity, and treatment of stormwater before it flows into the Willamette River.

Integrating Green Infrastructure

The concept of green infrastructure is inherently connected with integration. Whether it is a green roof, green street, or flow-through planter, successful facilities are integrated in the site design to manage stormwater and provide multiple benefits. A district-scale system of green infrastructure can become a fundamental organizing element of the site by influencing development patterns, views, and circulation corridors. If applied and organized as an amenity, the green infrastructure system can begin to influence the marketability and potential value of a development.

The scenarios reveal a variety of ways that green infrastructure can be implemented in a phased, 15- to 20-year development timeline. The owner can look to invest in and develop a full stormwater network, as in the Central and Focused scenario, and require building developers to connect to its system. Or the owner could require a performance-based approach such as the Diffuse and Embedded scenario and require building developers to manage their own stormwater at the source on the basis of a common model. Each of these scenarios can be mixed and matched across the site to accommodate multiple buildings, timing, or site-specific constraints.



OVERLAND DISCHARGE CONCEPTS

Overland Discharges to the River

Because the site is by the Willamette River, the surface conveyance network will convey treated stormwater directly to the river. Typical stormwater infrastructure systems rely on a pipe outfall to discharge treated stormwater to a water body. A piped outfall would require that a large-diameter pipe be installed through the cap, disturbing the contaminated media. The permitting process for outfalls can be costly and a take a long time that could affect future development. Furthermore, regardless of outfall size, there is a need to convey larger storm events such as the 50-year and 100-year events safely across the surface of the site and to the Willamette River. With the overall project goals of integration/flexibility and site constraints of the brownfield, in lieu of piped outfalls we have considered the use of an indirect, overland discharge system to convey treated stormwater under the Willamette River Greenway Trail to the Willamette River. Many potential benefits exist to indirect, overland discharge to the river, including the following:

- Reduced temperature of water because of underground, hyporheic flow
- Additional treatment of water before discharge
- Visible flow connecting people to natural processes
- No penetration of the cap, which reduces disturbance of contaminated soils
- Increased natural area and integration in the development
- Potential ease of permitting compared to a piped outfall

To explore the overland discharge conversation more thoroughly, the team applied a different indirect discharge system to each of the three scenarios. The systems are hyporheic discharge ponds, constructed wetlands, and a constructed weir channel. We included these three concepts to demonstrate the range of alternatives and weigh the advantages and disadvantages of each. Any of the overland discharge concepts could be used for each scenario. A diagram of each overland discharge concept has been provided to the left.

In addition to the Key Design Assumptions, the following design assumptions provided the foundation for each of the three scenarios:

- Stormwater is allowed to infiltrate through the existing engineered cap and through the contaminated media.
- Solutions must be adaptable to a phased 15- to 20-year time frame of development.
- Reduce or eliminate disturbance of the cap and contaminated soil beneath.
- Public street network can be crossed with surface conveyance systems.
- Vegetated facilities will manage up to the Type 1A, 10-year, 24-hour design storm.
- Pervious pavement can be applied only on private or semiprivate roadways and plazas and not in the public right of way.
- Green roofs can be applied on any and all buildings as necessary


RIVEREAST - PORTLAND, OR

RECURRENCE INTERVAL, YEARS	24-HOUR DEPTHS, INCHES
WQ	0.83
2 YR	2.4
5 YR	2.9
10 YR	3.4
25 YR	3.9
100 YR	4.4

NRCS TYPE 1A
24-HOUR STORM DISTRIBUTION

Stormwater Modeling

The Santa Barbara Urban Hydrograph method was used to calculate flows and sizing for stormwater facilities for the three scenarios. This is an accepted approach for stormwater calculations based on Portland's Stormwater Management Manual. Portland's Bureau of Environmental Services uses an NRCS Type 1A 24-hour storm distribution. The depth of rainfall for different storm sizes, from the water quality event to the 100-year storm event, is shown in the table below. A 1-inch infiltration rate was assumed for all vegetated facilities managing stormwater. The greenspace is assumed to be approximately 50 percent pervious, providing for the likely design of pathways and plaza spaces in the greenspace areas. The impervious area of the Ross Island Bridge above the site (approximately 20,000 square feet) drains through an ODOT drainage pipe away from the development and was removed from any stormwater calculations as impervious area. Because of the location of this property in the stormwater system, Portland's Stormwater Management Manual requires the developer to manage the water quality event onsite. Portland does not require flow control when discharging directly to large water bodies such as the Willamette River or Columbia River. Because this project was developed to advance stormwater management techniques and exhibit innovation in public-private partnerships, it was agreed that all three scenarios should meet the following requirements for storm events:

- Manage the water quality storm event
- Detain and infiltrate the 10-year, 24-hour design storm
- Safely convey the 100-year, 24-hour design storm

These stormwater modeling goals established the baseline stormwater management that must be met in all three scenarios. Each of the scenarios meets these goals through applying green infrastructure in different combinations and configurations.

Green Infrastructure Toolbox & Integration

In an effort to focus on solutions that manage stormwater at the source, the design team early in the process developed a toolbox of green infrastructure technologies (e.g., swales, planters, and green roofs) that can be integrated into this site and other, similar sites. The tools represent solutions for sustainable stormwater management by either reducing impervious area (green roofs and pervious pavement) or managing stormwater via collection and infiltration. The toolbox is meant to provide examples of the technologies applied in this project and not to be a comprehensive list of all the variations on green infrastructure solutions. To broaden the conversation about integrating green infrastructure in development, various precedent projects were reviewed from around the world that demonstrate successful green infrastructure integration in the sites. The projects selected were ones most applicable to the Zidell Yards site, relating to its context, master plan, and marine heritage. The following pages highlight the tools and how they are integrated into the precedent projects.

TOOLBOX GREEN INFRASTRUCTURE

green roof

FIRST AND MAIN - PORTLAND, OREGON

Can capture, store, and filter runoff from rooftops. In Portland they can remove up to 50% of the total annual rainfall volume. Many additional benefits such as increasing roof membrane lifespans, insulating buildings, and providing wildlife habitat.

swale

WARNER MILNE ROAD - OREGON CITY, OREGON

Can be located in almost any planting bed within a site, such as adjacent to parking lots, roadways, and sidewalks. They are effective in providing infiltration and conveyance of runoff while also allowing for the integration of plant material and artwork.

planter

BEAUMONT VILLAGE LOFTS - PORTLAND, OREGON

Often located adjacent to roadways or buildings and provide an efficient, focused treatment solution for runoff. Are appropriate where space is tight and where a more urban aesthetic is desired.

basin

RIVEREAST - PORTLAND, OREGON

Can be integrated within site planting beds and can provide treatment and infiltration of stormwater. Often are shallow depressions which can blend in with the surrounding plant material and become integrated into the site.

artwork

VINE STREET - SEATTLE, WASHINGTON

Can provide a unique celebration of stormwater and provide a more “visual” experience for visitors. This project by Buster Simpson provided visitors with a unique experience of stormwater while also conveying and treating water from a rooftop.

pervious pavement

PORT OF PORTLAND TERMINAL 6 - PORTLAND, OREGON

Provide the opportunity to reduce impervious surfaces within a site. This project eliminated the need for a piped outfall to the river through the application of approximately 35 acres of pervious asphalt at an auto storage facility.

GREEN INFRASTRUCTURE INTEGRATION

open space

HINGE PARK - VANCOUVER, BC

Constructed as one of the amenities for the 2010 Winter Olympics athletes village. The project successfully integrated the treatement of flow from a zero-energy treatment plant within an urban park space.

context

TANNER SPRINGS PARK - PORTLAND, OREGON

The park was designed as the “peeling back” of the urban fabric to reveal the wetland that once existed in that location prior to western settlement. The project successfully embeded the context of the site within the park space

heritage

HOUTAN PARK - SHANGHAI, CHINA

Built on a brownfield of a former industrial site, it treats polluted river water and recover the degraded waterfront in an aesthetically pleasing way. It successfully reclaimed industrial structures and materials to acknowledge the heritage of the site.

convevance

SCHARNHAUSER - OSTFILDERN, GERMANY

Stormwater is collected from roof tops and impervious surfaces and directed in open channels to the central spine, which is both a park and stormwater detention feature. This site successfully integrates the conveyance of stormwater at the surface.

housing

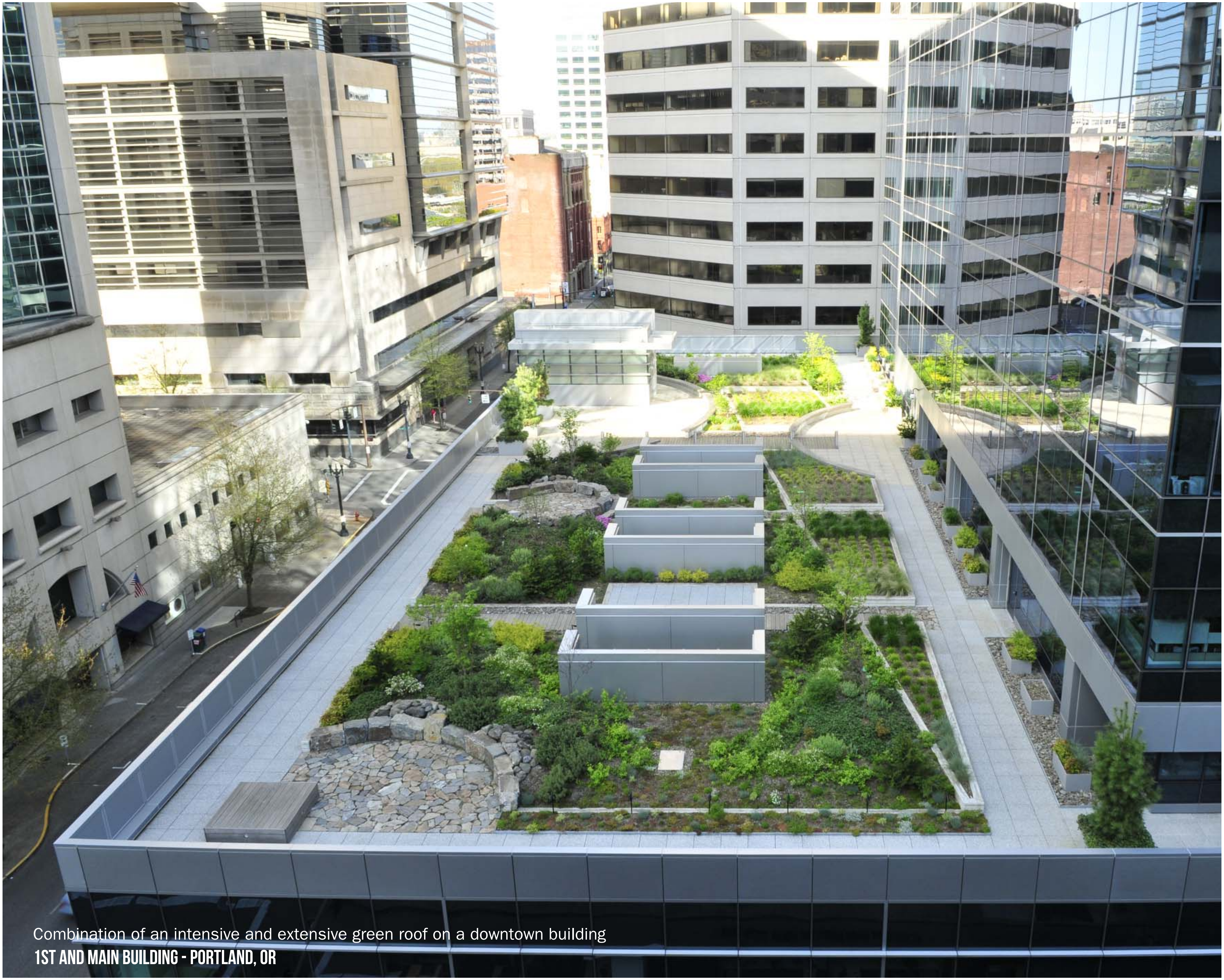
HEADWATERS AT TRYON CREEK - PORTLAND, OREGON

Integrated LEED Silver rated senior housing, town homes and market-rate apartments with the first daylighted creek in the City, running the length of the 2.8 acre property and numerous green street, ecoroof, and planter stormwater facilities.

treatment

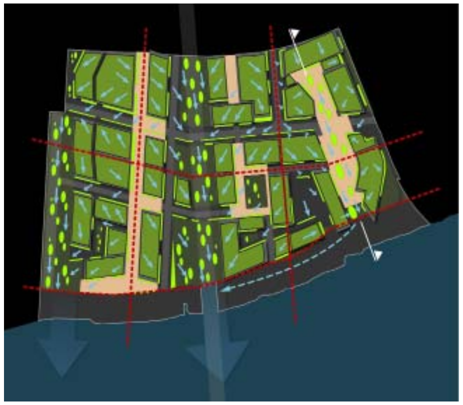
WAITANGI PARK - WELLINGTON, NEW ZEALAND

The wetlands ‘daylight’ the historic Waitangi Stream and channel it through a series of treatment systems designed into the park landscape. Th water passes through both artificial and natural filtration systems before discharge to the harbor.

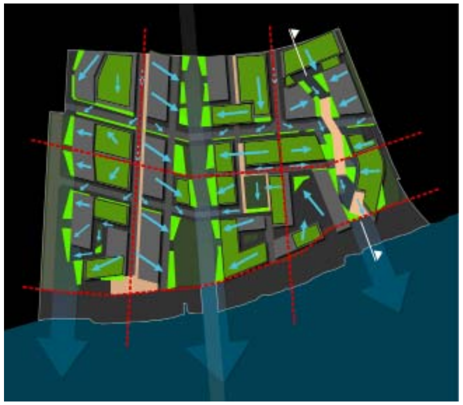


Combination of an intensive and extensive green roof on a downtown building

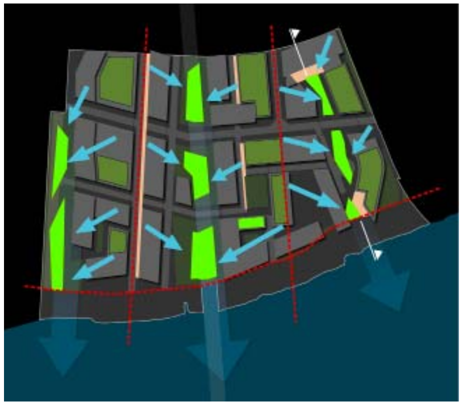
1ST AND MAIN BUILDING - PORTLAND, OR



DIFFUSE + EMBEDDED



CLUSTERED + DISTINCT



CENTRAL + FOCUSED

THE SCENARIOS

To develop the most credible and thorough scenarios, the design team recognized that the scenarios could not be developed on a best-to-worst or high-to-low range. Each scenario had to be developed as a stand-alone solution to meet the goals of the project and design assumptions. Early discussions of the project focused on the comparison of a dispersed network versus a more focused or concentrated network of green infrastructure solutions. From that comparison, three scenarios were developed to investigate the range of methods to embed green infrastructure in a future development on a brownfield. The conceptual master plan provided by ZRZ Realty was used as the basis for sizes and locations of general site elements such as buildings, plaza spaces, and roadway networks. The green infrastructure network of green roofs, pervious pavement, and vegetated stormwater facilities was then applied in the framework of the master plan according to each scenario's theme.

A conceptual plan view and section/perspective were developed for each of the three scenarios to illustrate how the scenarios could be applied in the development. Impervious area reduction techniques (green roofs and pervious pavement) were applied to each of the scenarios in varying amounts to investigate how their application might affect storm facility sizing, visibility of water in the site, and site character. The total square footage of green roofs, pervious pavement, and facility sizing or depth is shown in the three-dimensional graph for each scenario. An example project photo is provided for each scenario that best shows what the green infrastructure facilities might resemble in the development. A description of each scenario follows.

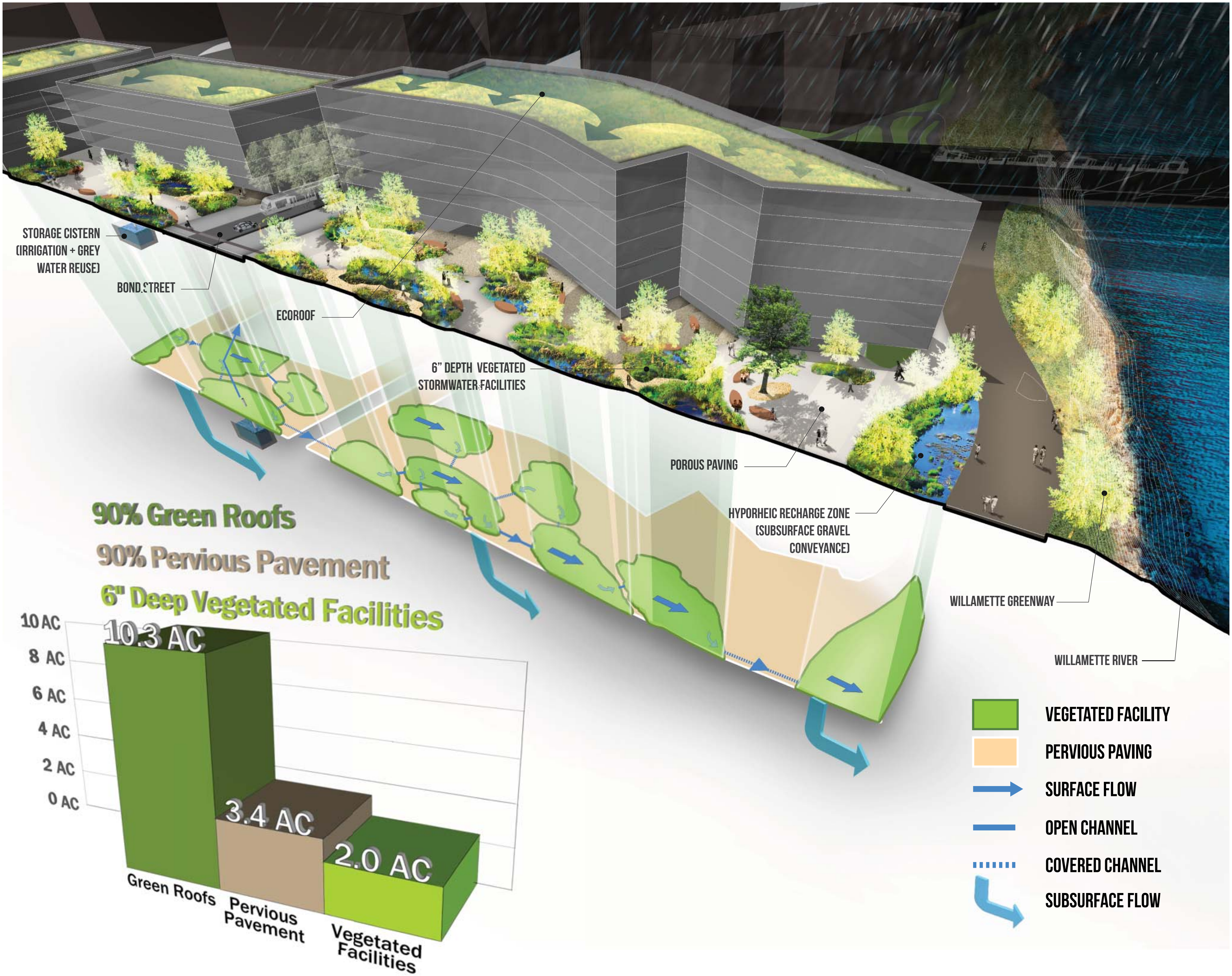
Example of shallow vegetated stormwater facilities integrated within site planting
LANE COMMUNITY COLLEGE HEALTH AND WELLNESS CENTER - EUGENE, OR

DIFFUSE AND EMBEDDED

The Diffuse and Embedded scenario collects, conveys, and treats stormwater adjacent to where it falls on Zidell Yards. As an evenly distributed network, the site's green infrastructure maximizes stormwater infiltration through an integrated network of techniques including ecoroofs, porous paving, and small-scale vegetated facilities. The stormwater collection and infiltration system relies on a network of small-scale vegetated facilities that mimic a native wetland. The basins are linked through an interconnected network of v-channels, swales and trench grates that collect and convey stormwater throughout public and private land. The distributed management approach means that visitors might not see water during small storm events because it will be quickly absorbed by multiple small-scale basins. This concept could be applied as a performance-based approach with a specific, defined plant palette to ensure that each future building can be knitted into the existing pattern of the system. The dispersed network allows for maximum flexibility to work around specific brownfield conditions. The collection capacity of the Diffuse and Embedded system fosters many secondary distributed benefits, such as rich pockets of vegetation and opportunities for storage and water reuse for building functions and irrigation. The distributed application of these green infrastructure techniques provides a unifying identity and sense of place.

Green roofs cover 90 percent of the rooftops (10 acres) and pervious pavements cover 90 percent of the plazas (3.4 acres). Two acres of 6-inch-deep, small-scale vegetated facilities manage runoff from the site and convey the treated stormwater through the surface conveyance network to a series of hyporheic ponds, which will indirectly discharge flows to the Willamette River via subsurface flow. The site was divided into six basins for stormwater modeling purposes, assuming that each basin might be developed at different times throughout the 15- to 20-year development time frame. The western three subwatersheds (1, 3, and 5) would connect to the surface conveyance network in the eastern subwatersheds to convey water safely to the river.

DIFFUSE AND EMBEDDED



STORAGE CISTERN (IRRIGATION + GREY WATER REUSE)
BOND STREET
ECOROOF
6" DEPTH VEGETATED STORMWATER FACILITIES
POROUS PAVING
HYPORHEIC RECHARGE ZONE (SUBSURFACE GRAVEL CONVEYANCE)
WILLAMETTE GREENWAY
WILLAMETTE RIVER
90% Green Roofs
90% Pervious Pavement
6" Deep Vegetated Facilities
10 AC
8 AC
6 AC
4 AC
2 AC
0 AC
10.3 AC
3.4 AC
2.0 AC
Green Roofs
Pervious Pavement
Vegetated Facilities
VEGETATED FACILITY
PERVIOUS PAVING
SURFACE FLOW
OPEN CHANNEL
COVERED CHANNEL
SUBSURFACE FLOW

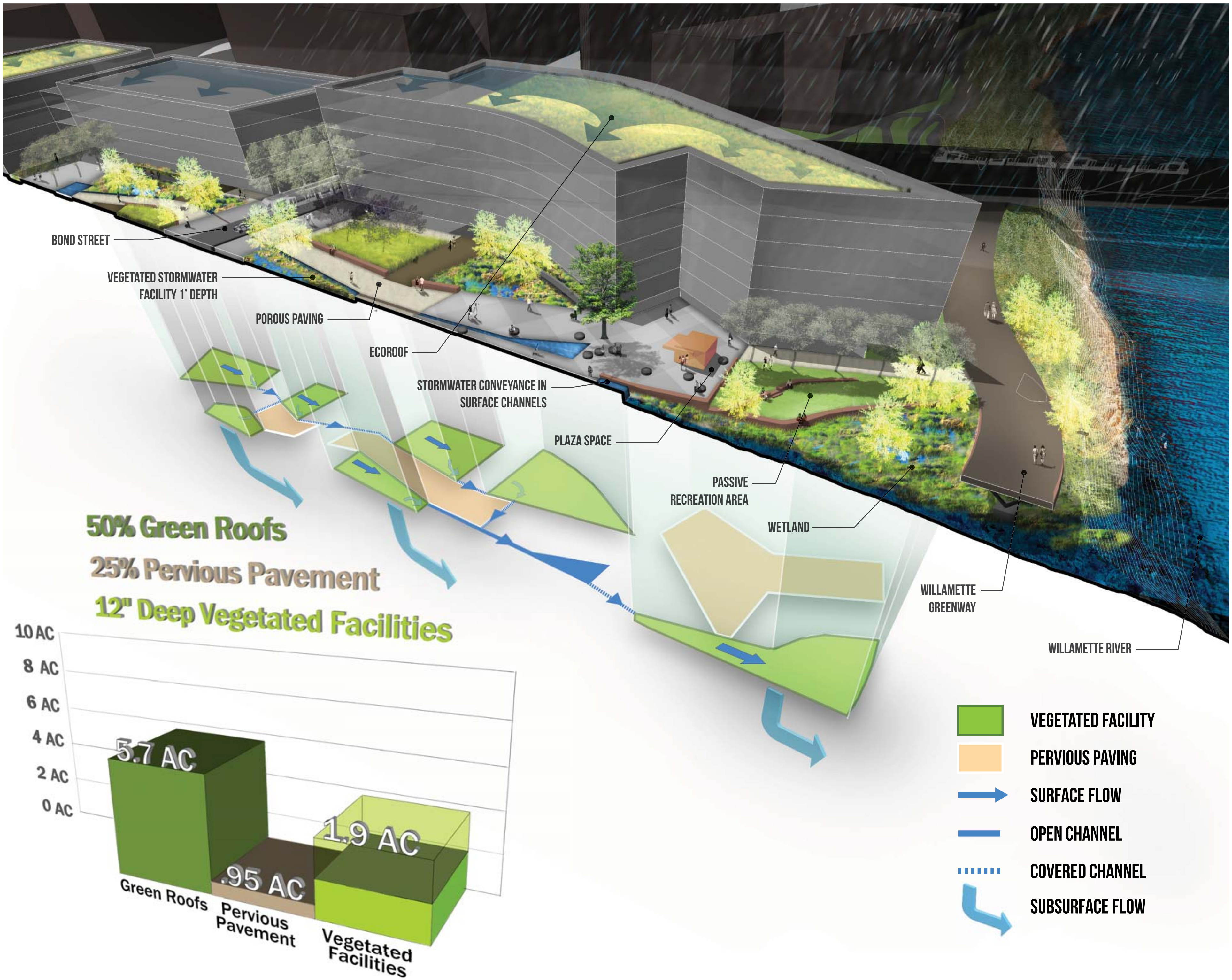
Example of stormwater planter integrated with adjacent building and urban plaza
PULS 5 DEVELOPMENT - ZURICH, SWITZERLAND

CLUSTERED AND DISTINCT

The Clustered and Distinct scenario incorporates components of both centralized and distributed systems by managing stormwater at a subdistrict or neighborhood scale. This management technique is uniquely tailored to groups of buildings to create distinct management areas or neighborhoods. How and where water is stored, treated, collected and infiltrated can vary depending on localized limitations and opportunities encountered in the development footprint. These facilities would manage stormwater from a small subdistrict of buildings. This concept would provide flexibility for developing smaller, subdistrict stormwater networks as development occurs over the next 15 to 20 years. This smaller network would allow for a reduced initial capital investment while maximizing the efficiency of construction of only a handful of larger facilities. The system would rely on 12 inch-deep, urban stormwater planters that, while likely are more expensive to construct than the shallow facilities, provide a more efficient footprint for management of stormwater. The visibility of stormwater in the conveyance network might be higher as smaller storm events would be conveyed from rooftops, across plazas, and to the vegetated planter.

In this scenario, 50 percent of the rooftops (5.7 acres) are covered with green roofs and 25 percent (0.95 acre) of the plazas are covered with pervious pavement. These features reduce the effective impervious area of the site to approximately 20 acres. Cumulatively, 1.9 acres of 12-inch-deep, urban stormwater planters collect, treat, and infiltrate runoff from the remaining impervious areas. A 12-inch-deep planter provides more capacity for each facility than the Diffuse and Embedded scenario basins to accommodate the reduction in green roof and pervious pavement applications. Overflow of the larger storm events is conveyed via a network of surface conveyance channels to a constructed wetland complex that will indirectly discharge treated stormwater to the Willamette River. Flow from the wetlands will pass under the greenway trail at three, overland discharge locations. These locations were identified to provide the maximum flexibility for future phased development and to reduce conveyance distances.


Flow Direction, Roof
Flow Direction, Street/Sidewalk
Drainage Catchment Boundary
Green Roof
Vegetated Facility
Pervious Paving
Impervious Roof / Pavement
WILLAMETTE RIVER



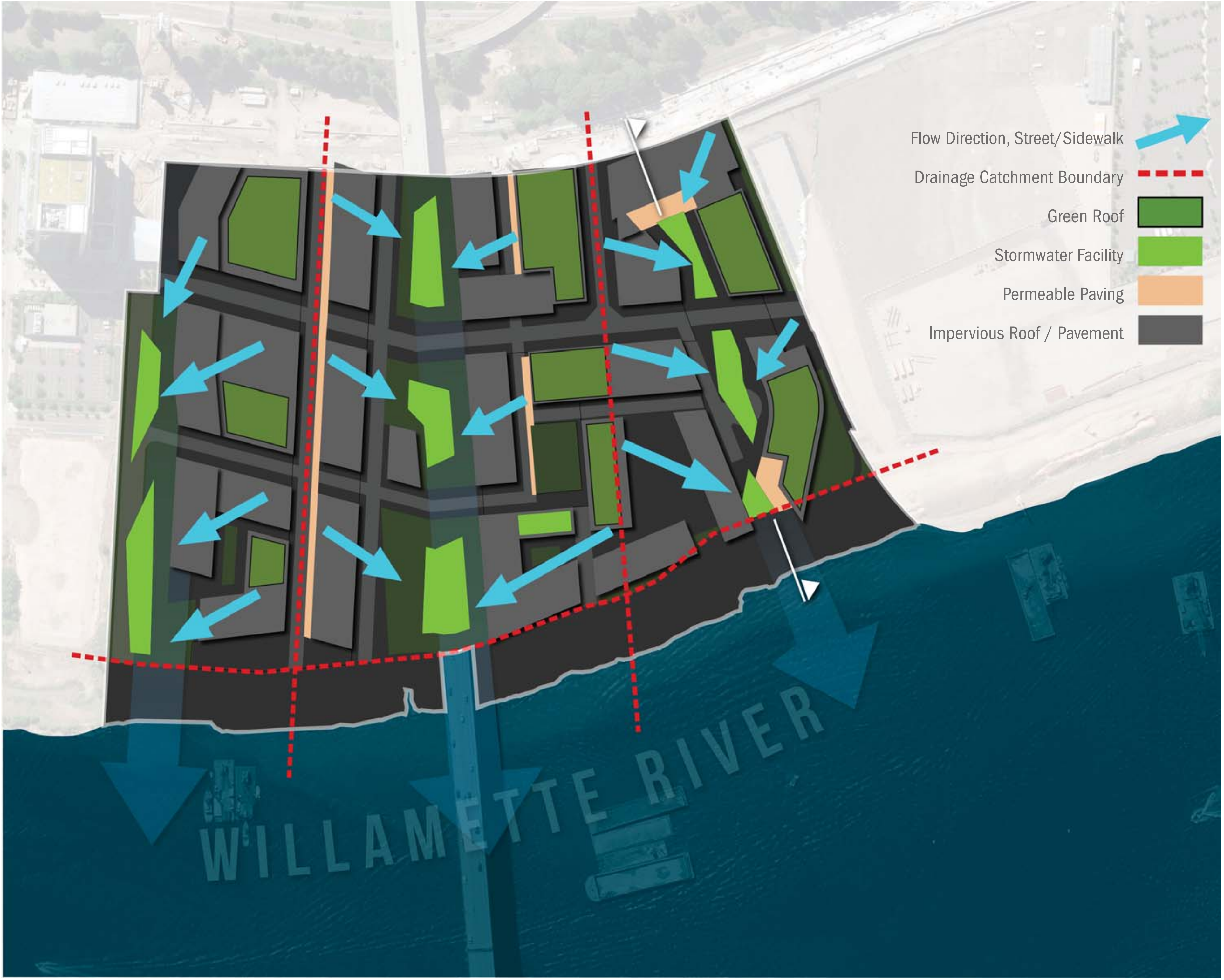
BOND STREET
VEGETATED STORMWATER FACILITY 1' DEPTH
POROUS PAVING
ECOROOF
STORMWATER CONVEYANCE IN SURFACE CHANNELS
PLAZA SPACE
PASSIVE RECREATION AREA
WETLAND
WILLAMETTE GREENWAY
WILLAMETTE RIVER
50% Green Roofs
25% Pervious Pavement
12" Deep Vegetated Facilities
10 AC
8 AC
6 AC
4 AC
2 AC
0 AC
5.7 AC
.95 AC
1.9 AC
Green Roofs
Pervious Pavement
Vegetated Facilities
VEGETATED FACILITY
PERVIOUS PAVING
SURFACE FLOW
OPEN CHANNEL
COVERED CHANNEL
SUBSURFACE FLOW

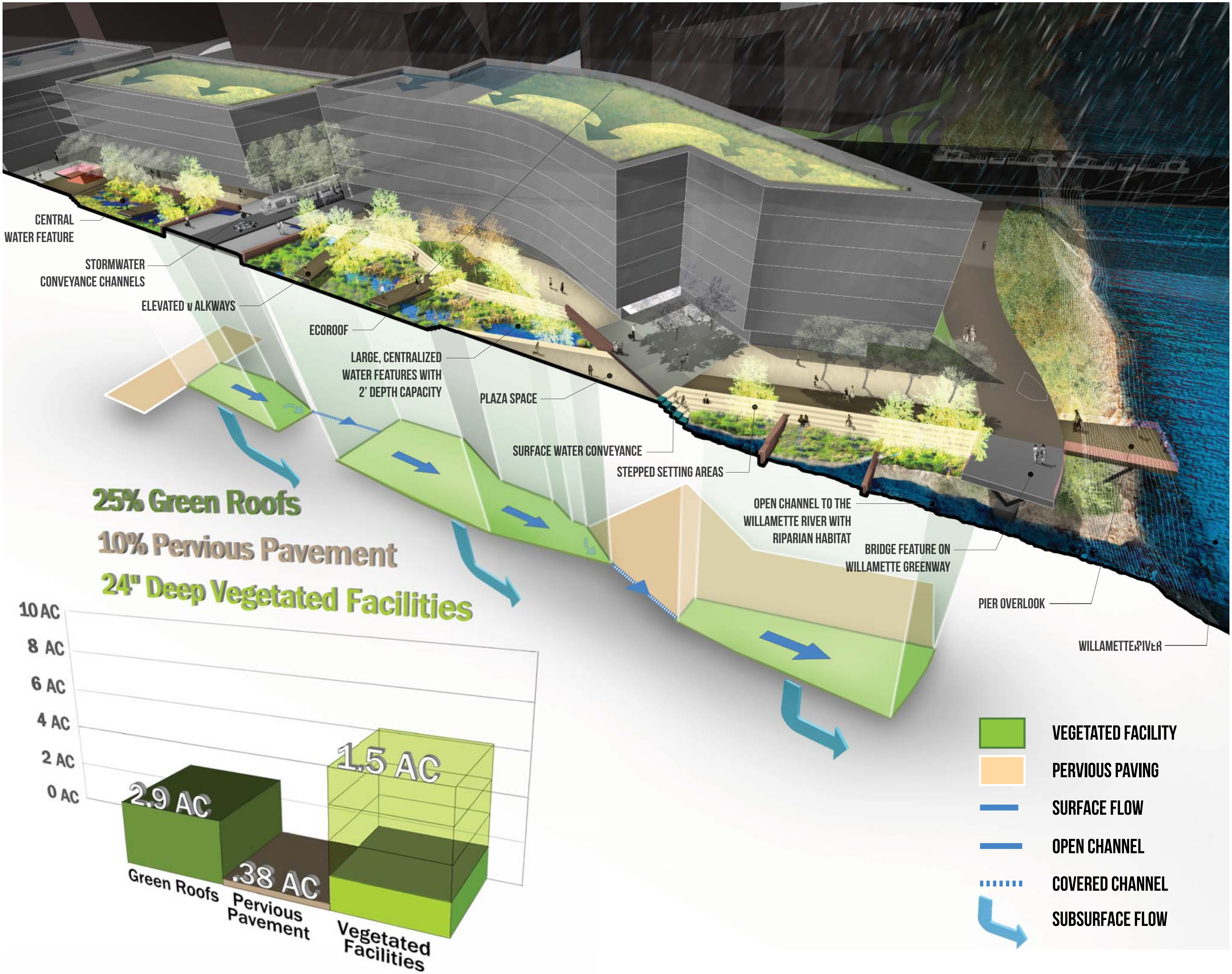
Example of large-scale centralized stormwater facility integrated within surrounding urban context
TANNER SPRINGS PARK - PORTLAND, OR

CENTRAL AND FOCUSED

In the Central and Focused scenario, stormwater is conveyed through a network of open channels to large, centralized, district-scale facilities. Three subwatersheds collect stormwater from buildings and pavement areas before treatment and infiltration in the large and integrated facilities. The stormwater facilities take the form of 24-inch-deep geometric stormwater planters that are integrated with the surrounding plaza spaces. The reduction of green roofs and pervious pavements provides more frequent filling of conveyance channels during smaller storm events, increasing the visibility of water. Overflow from larger storm events is conveyed to a series of weirs to discharge runoff via overland flow to the Willamette River. The larger size of this green infrastructure enhances the visual, recreational, and habitat value of the water being conveyed.

In this scenario, 25 percent of the rooftops (2.9 acres) are covered with green roofs, and 10 percent of the plazas (0.38 acre) have pervious pavements. This reduces the effective impervious area of the site to approximately 21.9 acres. The facilities have been deepened to approximately 24 inches and cover approximately 1.5 acres to accommodate the additional stormwater volume. This district-sized scenario could be implemented through a more substantial, up-front capital investment to fully define the site identity and major green infrastructure design elements. The size of the green infrastructure facilities allows them to become the organizing element of the site, and their multiple benefits can be realized early in the development timeline. The location of these facilities might be determined early in the development process to avoid areas with contamination that could be mobilized by stormwater, or their location could be flexible where contaminated media does not pose a risk, as was the case at our project site.


Flow Direction, Street/Sidewalk
Drainage Catchment Boundary
Green Roof
Stormwater Facility
Permeable Paving
Impervious Roof / Pavement
WILLAMETTE RIVER

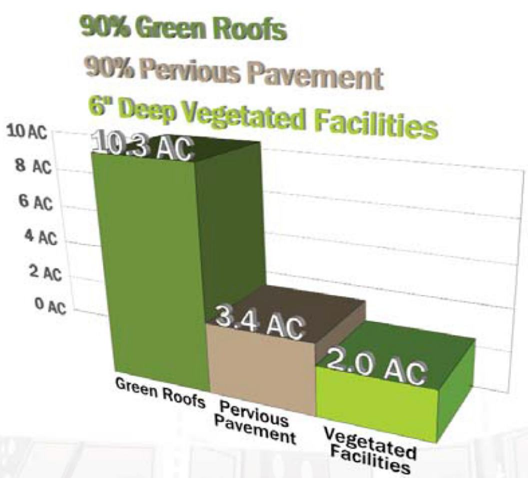


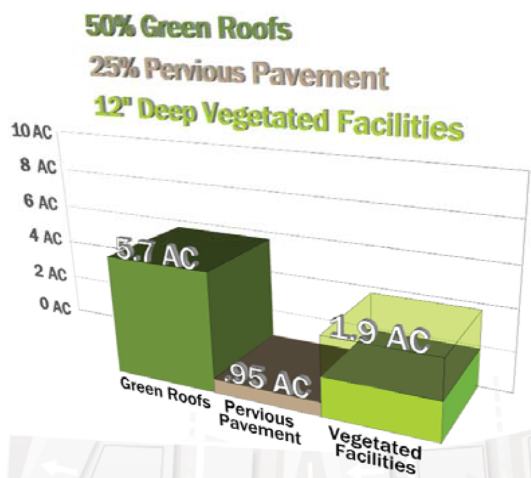
CENTRAL WATER FEATURE
STORMWATER CONVEYANCE CHANNELS
ELEVATED WALKWAYS
ECOROOF
LARGE, CENTRALIZED WATER FEATURES WITH 2' DEPTH CAPACITY
PLAZA SPACE
SURFACE WATER CONVEYANCE
STEPPED SETTING AREAS
OPEN CHANNEL TO THE WILLAMETTE RIVER WITH RIPARIAN HABITAT
BRIDGE FEATURE ON WILLAMETTE GREENWAY
PIER OVERLOOK
WILLAMETTE RIVER
25% Green Roofs
10% Pervious Pavement
24" Deep Vegetated Facilities
10 AC
8 AC
6 AC
4 AC
2 AC
0 AC
2.9 AC
.38 AC
1.5 AC
Green Roofs
Pervious Pavement
Vegetated Facilities
VEGETATED FACILITY
PERVIOUS PAVING
SURFACE FLOW
OPEN CHANNEL
COVERED CHANNEL
SUBSURFACE FLOW

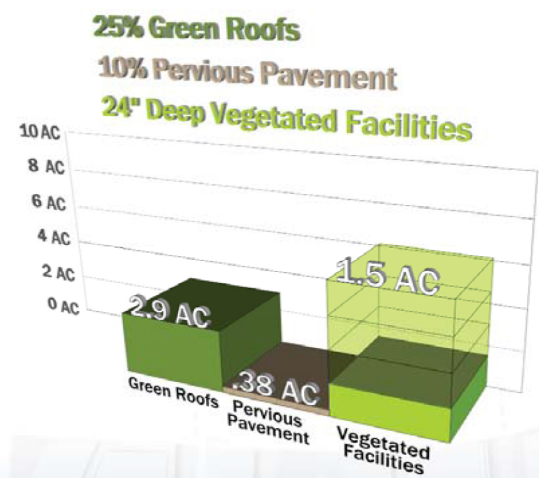
SCENARIO COMPARISON

The three design scenarios developed for this report meet the project goals by providing flexible, sustainable stormwater management within the constraints of a remediated brownfield site using innovative green infrastructure techniques that offer multiple environmental, economic, and community benefits. The green infrastructure design principles presented here are not limited to brownfield sites but can be transferred to new development, redevelopment, and infill settings. Each of the scenarios offers viable alternatives for green infrastructure implementation in public and private spaces, and elements of the scenarios can be mixed and matched throughout the site as development begins, if desired.

GREEN INFRASTRUCTURE DISTRIBUTION GRAPH (10-YR, 24 HR DESIGN STORM):







CONCEPTUAL COSTS:

DIFFUSE + EMBEDDED

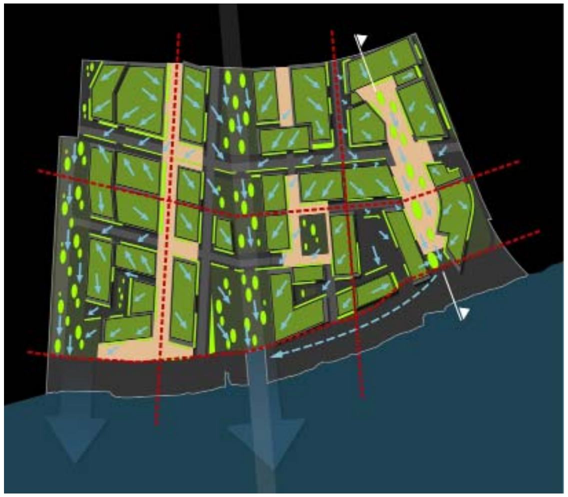
	DIFFUSE + EMBEDDED			
	QTY.	UNIT	COST	TOTAL
GREEN ROOF	448,668	SF	$7	$2,947,749
PERVIOUS PAVEMENT	148,104	SF	$15	$2,221,560
TREES	125	EA	$350	$43,750
RAINGARDEN	87,120	SF	$26	$2,265,120
12" DEEP PLANTERS				
24" DEEP PLANTERS				
CONVEYANCE CHANNELS	8,000	LF	$20	$160,000
OVERLAND DISCHARGE	2	LS	$250,000	$500,000
			SUBTOTAL	$8,138,179
			CONTINGENCY (40%)	$3,255,272
			TOTAL	**$11.393.450**

CLUSTERED + DISTINCT

	CLUSTERED + DISTINCT			
	QTY.	UNIT	COST	TOTAL
GREEN ROOF	248,292	SF	$7	$1,631,278
PERVIOUS PAVEMENT	41,382	SF	$15	$620,730
TREES	125	EA	$350	$43,750
RAINGARDEN				
12" DEEP PLANTERS	82,764	SF	$67	$5,545,188
24" DEEP PLANTERS				
CONVEYANCE CHANNELS	8,000	LF	$20	$160,000
OVERLAND DISCHARGE	3	LS	$250,000	$750,000
			SUBTOTAL	$8,750,946
			CONTINGENCY (40%)	$3,500,379
			TOTAL	**$12,251,325**

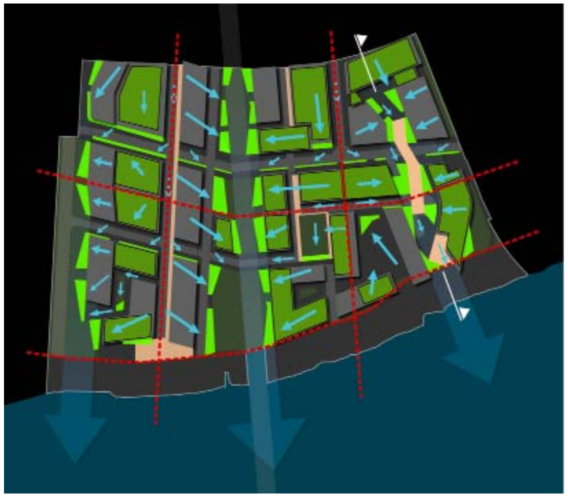
CENTRAL + FOCUSED

	CENTRAL + FOCUSED			
	QTY.	UNIT	COST	TOTAL
GREEN ROOF	126,324	SF	$7	$829,949
PERVIOUS PAVEMENT	16,552	SF	$15	$248,280
TREES	125	EA	$350	$43,750
RAINGARDEN				
12" DEEP PLANTERS				
24" DEEP PLANTERS	65,340	SF	$134	$8,755,560
CONVEYANCE CHANNELS	8,000	LF	$20	$160,000
OVERLAND DISCHARGE	3	LS	$250,000	$750,000
			SUBTOTAL	$10,787,539
			CONTINGENCY (40%)	$4,315,015
			TOTAL	**$15,102,554**



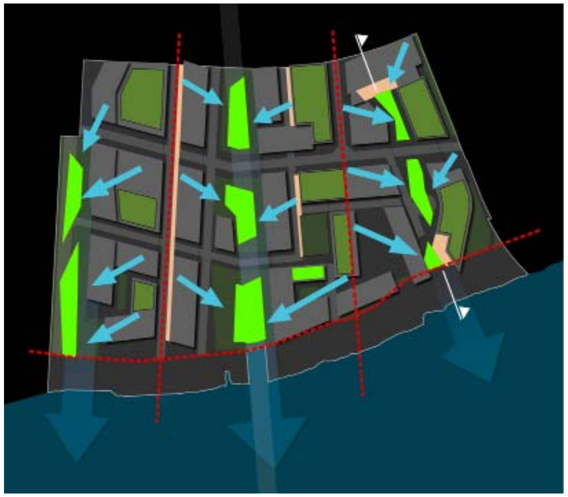
DIFFUSE + EMBEDDED

- Location of facilities can be easily modified to accommodate brownfield constraints.
- Facilities can be implemented through a performance-based approach and required as each new building is constructed.
- Embedded facilities throughout the development would create a consistent palette of plant material and integrated design aesthetic.
- Water might not be visible during smaller storm events because multiple smaller facilities would serve as a sponge for the stormwater before entering major surface conveyance channels.
- Green roofs and pervious pavement are essential tools and must be either required or heavily suggested for each building rooftop or plaza space.
- Relies on the ability to infiltrate stormwater throughout the development.



CLUSTERED + DISTINCT

- Can be implemented as each new subwatershed or cluster of buildings is developed.
- Facility design can be integrated with new buildings to create unique neighborhoods as phased development continues.
- Facilities can be shared among clusters of buildings to provide for more efficient construction.
- Smaller storm events might be more visible because stormwater flows from buildings through surface conveyance channels to the infiltration facility.
- Green roofs and pervious pavement are less emphasized as a tool for reducing overall impervious surfaces, therefore reducing the requirement for green roofs on buildings.



CENTRAL + FOCUSED

- Facilities become an organizing element for urban open space in the development.
- Water would be most visible with this scenario during all types of storm events because stormwater is conveyed from multiple buildings and paved surfaces to larger central stormwater facilities.
- Design and construction of these facilities can be done early in the development process, and building owners would pay into a stormwater fee.
- Centralized facilities can be in areas of brownfields that do not pose a stormwater contamination risk.

Daylighted creek through housing development
HEADWATERS AT TRYON CREEK - PORTLAND, OR

CONCLUSION

The scenarios can serve as a template for remediation and redevelopment of contaminated sites. Throughout the design process, several key principles were identified that mitigate the concerns associated with stormwater management on a remediated brownfield site. These principles can be applied at other brownfield sites to minimize exposure of stormwater to legacy pollutants:

- Proactively conduct brownfield remediation activities to remove or isolate pollutants that stormwater could mobilize, ensuring that onsite stormwater management is feasible
- Recognize that many contaminants (e.g., those that are insoluble or bound to soil particles) are not mobilized by infiltrating stormwater and therefore do not pose a threat to surface or groundwater
- Place stormwater facilities away from contamination hot spots that stormwater could mobilize
- Use surface conveyance rather than underground pipe conveyance to minimize soil disturbance below the cap
- Reduce or eliminate the amount of trenching to minimize soil disturbance

As more former industrial properties are redeveloped, we will understand the opportunities and limitations of various green infrastructure approaches on them and be able to test innovative stormwater solutions in areas previously considered off limits because of contamination.

Portland has identified numerous benefits from green infrastructure, including clean water, clean and cooler air, improved livability and health by encouraging people to walk and spend more active time outside, and most recently, increasing pollinator and wildlife use and green jobs. These benefits could be realized through green infrastructure implementation at this site and would improve conditions in the Willamette River and increase the attractiveness and marketability of the site for economic development.

Because of its high visibility, strong public interest, and the significance of this project to pave the way for stormwater management throughout the city, this project is receiving strong support across all city bureaus and with our elected officials. Not only is Zidell Yards property on the waterfront, but it will also be a hub for mass transit activity, including a new light-rail line and stop, an expansion of the Portland Streetcar, and a new pedestrian bridge across Interstate 5 to residential neighborhoods. The Zidell Yards project is an ideal showcase for highly visible, innovative, multi-benefit stormwater management that residents and visitors can experience and enjoy daily.