

UNIVERSITY DISTRICT LIVING INFRASTRUCTURE ECOLOGICAL DESIGN GUIDELINES

SPOKANE, WASHINGTON
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Prepared for:

Juliet Sinisterra, CEO – University District
120 N Pine St, Ste 252, Spokane, WA 99202

Prepared by:



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UD DIRECTOR’S LETTER

Dear Partners, Stakeholders, and Community Members,

The University District has long envisioned a future where innovation, education, economic opportunity, and environmental stewardship work together to create a thriving place for all. Through the University District Next Generation Conceptual Plan, we established a bold vision for a district that is connected, resilient, and distinctly Spokane. Today, the Living Infrastructure Ecological Design Guidelines represent an important next step in bringing that vision to life.

At the heart of this work is a simple belief: great cities are places where people and nature flourish together. These guidelines recognize that healthy ecosystems contribute directly to human well-being. Tree canopies, pollinator gardens, green streets, restored riverfronts, and welcoming public spaces do more than manage stormwater or improve biodiversity; they create opportunities for connection, discovery, comfort, and belonging.

The University District is uniquely positioned to demonstrate how ecological design can strengthen both community vitality and environmental resilience. By integrating living infrastructure into future development, public spaces, and transportation corridors, we are investing in a district that is cooler, healthier, more walkable, and more beautiful. These investments support biodiversity, improve water quality, mitigate urban heat, and create memorable experiences that connect people to place and to one another.

This document provides a practical framework for transforming our shared vision into action. Together, we can create a district where innovation and ecology coexist, where public spaces inspire joy, and where future generations inherit a community that is both prosperous and resilient.

Thank you to the many partners, community members, designers, scientists, and civic leaders whose contributions continue to shape the future of the University District.

Sincerely,

Juliet Sinisterra
Chief Executive Officer
University District

ACKNOWLEDGMENTS

Land Acknowledgment

We pay respect to and acknowledge the First Peoples of this Land, the Salmon People, the Spokane Tribal peoples. We pay respect to the Tribal leaders, past, and present and yet to come, and to the legacy of the original people and their descendants. We acknowledge we are here on the unceded land of the Spokane people and that these lands were once a major trading center and winter gathering place for the Spokanes. We honor their sacred homeland. This land holds their DNA and the spirit of the Tribe’s ancestors.

We honor with grateful hearts the Spokane River, the native plants and species of this land. We are thankful for the legacy of the Spokane Tribe, their reciprocal relationship with this ecosystem and we pledge to act as continuing stewards of this place as we honor the mission of the University District.

Thank you to everyone who offered their time and input into the framework and guidance development including:

- Kathryn Alexander, Soil Smart
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- Katelyn Scott, Spokane River Keepers
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GLOSSARY

Adaptive Management

A process that integrates design, management, and monitoring to systematically test assumptions, evaluate results, adjust decisions, and generate learning. (Conservation Measures Partnership Open Standards)

Alluvium

Unconsolidated clay, silt, sand, and/or gravel deposits associated with streams or rivers.

Basalt

A very hard, fine-grained, dark-colored, extrusive igneous (volcanic) rock formed by the cooling of molten lava.

Best Management Practices (BMP)

Practices that are effective, practical, and sustainable to achieve environmental or management goals while minimizing negative impacts.

Ecological Function

The roles and processes that occur within and among ecosystems, encompassing physical, biological, and chemical interactions that sustain life and maintain ecosystem health.

Ecosystem Services

Benefits that humans receive from nature. The Millennium Ecosystem Assessment (MEA), which is the most widely used ecosystem services framework, classifies ecosystem services into provisioning (e.g., food and fresh water), regulating (e.g., water purification), cultural (e.g., recreation and aesthetics), and supporting (e.g., soil formation) services. (EPA)

Green stormwater infrastructure (GSI)

“The range of measures that use plant or soil systems, permeable pavement or other permeable surfaces or substrates, stormwater harvest and reuse, or landscaping to store, infiltrate, or evapotranspire stormwater and reduce flows to sewer systems or to surface waters.” – as defined by the Clean Water Act.

Hydrologically functional landscape

A design approach for the built environment that attempts to more closely mimic the natural water flows over land and in the subsurface through infiltration, storage, evapotranspiration, and time of concentration characteristic of the native landscape of the area.

Living Infrastructure

A strategically planned and managed network of multi-functional landscape elements, that work together at multiple scales to conserve ecosystem functions, restore ecosystem processes, and regenerate healthy, robust, and resilient communities.

Natural systems

Complex and interconnected systems that sustain life and encompass living and non-living components of the environment.

Nature-based solutions

Actions to protect, sustainably manage, and restore natural and modified ecosystems that address societal challenges effectively and adaptively, simultaneously benefiting people and nature. (UN Environment Program)

Nature-positive

Generally, refers to design approach that tries to give back to nature. “Delivering the Nature Positive goal requires measurable net-positive biodiversity outcomes through the improvement in the abundance, diversity, integrity and resilience of species, ecosystems and natural processes.” The-Definition-of-Nature-Positive.pdf

Non-functional turf

Lawn areas with limited to non-functional recreation value” where water conservation and habitat benefits could occur if turfgrass were not be planted and irrigated.

Rain garden

A non-engineered, shallow landscape depression with native soil or a soil mix and plants that is designed to capture stormwater from small, adjacent contributing areas or downspouts.

EXECUTIVE SUMMARY

Today, cities all around the world are recognizing that natural systems play a critical role in the healthy culture, economy, and resilience of urban landscapes. The City and University District (UD) of Spokane recognize the importance of sustainability as reflected in recent planning efforts. The 2024 UD Next Generation Plan, for example, highlighted green infrastructure and conservation as major planning objectives. The current challenge is translating high-level visions and strategies into on-the-ground actions that inspire ideas and create momentum for the transformation of the UD. This Living Infrastructure Guidelines supports this effort by providing a holistic, ecological framework and directions for nature-positive planning, design, and implementation.

Following a brief introduction and ecological context summary, the Guidelines centers around ecological landscape typologies. For each landscape typology, individual insets describe the purpose, benefits, design elements, context & site analysis, maintenance considerations, and additional resources. The attached Framework document (Appendix B) offers additional details about how working with water movement pathways and climate-adapted plant communities helps reduce water pollution, heat intensity, and mitigate for drought impacts while also supporting biodiversity. It also recognizes that different opportunities and challenges for stewardship occur on both sides of the river as well as block-by-block variations based on natural history and the layout of the built space.





Source: Biohabitats

10 | 2026 Living Infrastructure Design Guidelines

1. INTRODUCTION

Spokane's 770-acre University District (UD) has laid a strong planning foundation for a Living Infrastructure approach to development. UD-led projects are ready to apply the living landscape principles presented here to be catalysts for change. This section briefly introduces the purpose and goal of living infrastructure. Additional details are provided in the Framework document in Appendix B.

1.1 PURPOSE & GOAL

Each upcoming development and infrastructure improvement project in the UD is an opportunity to create a living network of resilient, nature based solutions, not just by improving key areas but also by connecting them so they belong to a system. The purpose of Living Infrastructure Guidelines is to recommend best practices for designing and creating nature-positive improvements that build on the City's existing resources such as for Low Impact Development (LID). In this way, Spokane and the UD are aligning with cities around the world that realize:

"partnering with nature represents an investment opportunity allowing cities to tackle urban development priorities and conservation goals concurrently."*

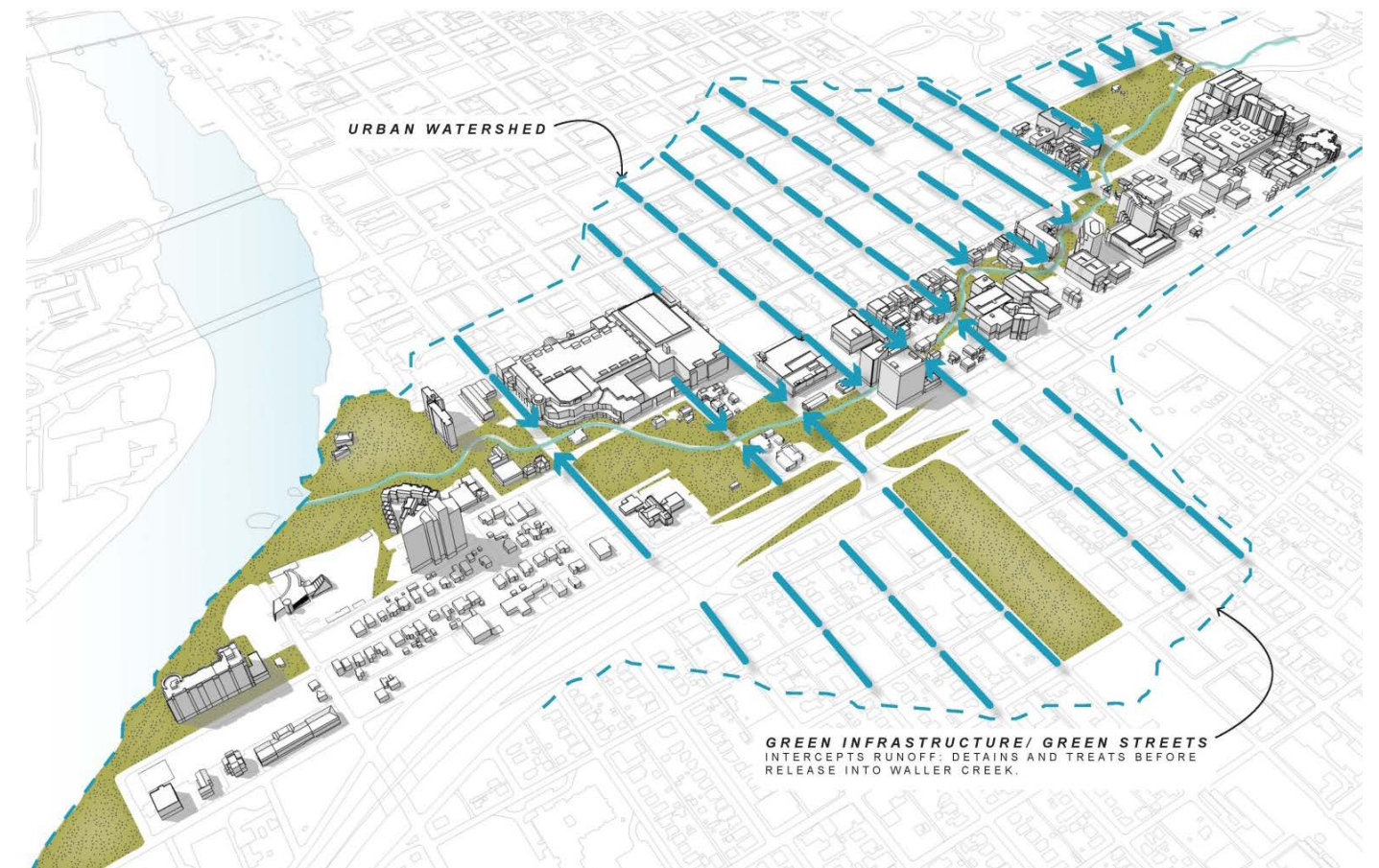
This approach also supports the University District Vision from the *U Vision 2044 Strategic Priority Plan (2023)* as "A thriving and sustainable hub of innovation, environmental health, and community activity."

Living infrastructure refers to a strategically planned and managed network of multi-functional landscape elements, that work together at multiple scales to conserve ecosystem functions, restore ecosystem processes, and regenerate healthy, robust, and resilient communities.

Based on this understanding of the importance of relationships between landscape improvements, the following overarching living infrastructure goal was drafted with input from the UD staff and the planning team, existing guidance (e.g. <https://livinginfrastructure.org/learn>), and prior University District planning documents (See Technical Memorandum).

LIVING INFRASTRUCTURE GOAL

The University District is a network of natural and semi-natural ecological features and processes that improve biodiversity and ecosystem services such as heat regulation, stormwater management, pollutant reduction, and pollination.



Source: CMG

* https://www3.weforum.org/docs/WEF_BiodiverCities_by_2030_2022.pdf

1.2 ECOLOGICAL DESIGN PRINCIPLES

To achieve the living infrastructure goal for the UD, the following core urban ecology principles should be applied:



- **Plant species diversity** improves system-wide biodiversity
- **Restoration and management** of native vegetation and soils support the food web for desirable urban wildlife
- **Connected** ecosystems are more resilient than fragmented systems



- **Protection** of existing natural ecosystems is of primary concern
- **Multiple, redundant treatments** or features, e.g., to manage water, ensure ecosystem resilience
- **Biophilic, nature-based designs** offer opportunities to connect people to nature and support bioregional identity



- **Natural water flows** organize the landscape and yield greater efficiencies for energy and materials
- **Retention of water** in the landscape close to where precipitation falls allows for aquifer recharge and more opportunities to improve water quality



- **Cooling and Multifunctional** design elements can yield multiple benefits, e.g., to improve water quality, provide evaporative cooling, and other ecosystem services

1.3 HOW TO USE THIS GUIDE

This guide is streamlined for practitioners to a) get an overview of UD’s ecological context, b) assess site opportunities and constraints, and c) select design typologies to integrate into resilient site plans. To use the guide:



2. LIVING INFRASTRUCTURE FRAMEWORK



The Living Infrastructure Framework is based on the UD’s ecology, which provides the foundation for priority ecological objectives. For additional details please refer to the Appendix B.

2.1 SUMMARY OF UNIVERSITY DISTRICT ECOLOGY

To understand how ecology informs planning and design, this section briefly summarizes local climate patterns, how water moves through the UD, historic land cover, and wildlife.

CLIMATE

Spokane’s low annual rainfall (average 16.5 inches) is a critical characteristic of the landscape and informs selection of appropriate planting and water management recommendations. Recent episodes of drought, extreme heat, precipitation, and flooding across the region underscore local vulnerabilities and the need to increase regenerative capacity and overall resilience.

Most precipitation occurs between November and April. During the growing season (May–October), monthly rainfall can be less than an inch and temperatures regularly above 80°F. In these conditions, non-native and poorly adapted plants need supplemental water to survive.

WATER FLOW PATHS

How water moves through the UD varies with location, local hydrogeologic patterns, land cover, and existing stormwater infrastructure. Hydrogeology combines an understanding of rock and soil formations with groundwater and surface water movement. Although the intense urbanization of the UD has altered most of the natural flowpaths, there are still opportunities to support a more hydrologically functional landscape with designs that reconnect and reflect natural patterns.

The Spokane Valley–Rathdrum Prairie (SV–RP) Aquifer is beneath the UD in the northern and eastern portion of the University District, coinciding with the Glacial Lake Missoula flood deposits and alluvium. It is generally absent, however, in the southern and western UD areas that are underlain with relatively impermeable basalt (Figure 2.1).

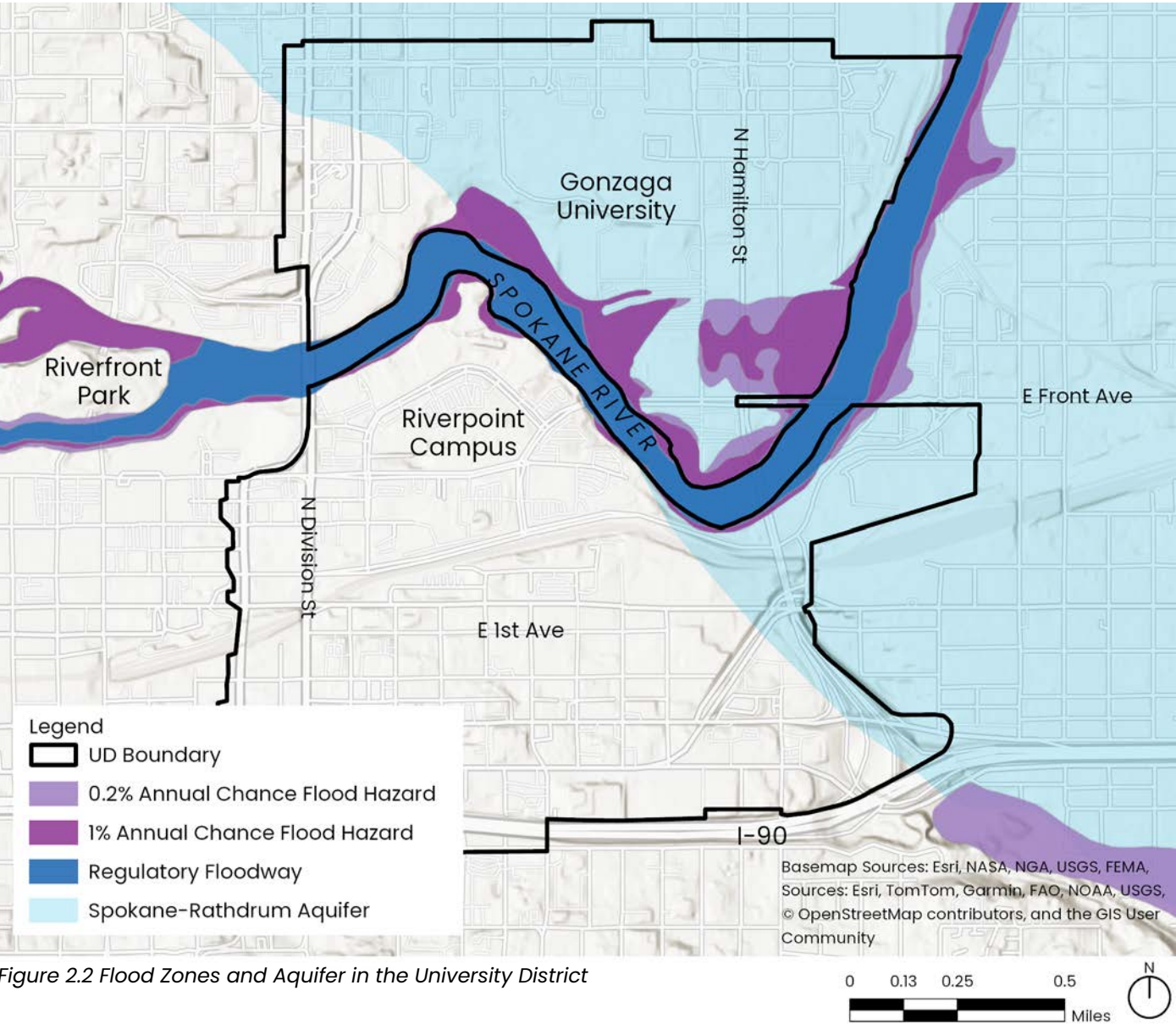
Three main hydrogeologic zones have been identified with distinct hydrogeologic characteristics. These units are briefly described below.



Figure 2.1. View to southwest of major geologic and hydrologic features in the University District. (Notice the direction of the north arrow in the lower right of figure).

Basalt Upland Zone: The basalt uplands in the southwest half of the UD are characterized by thin soils, near-surface bedrock, and very limited water infiltration capacity. The low water retention very likely contributes to higher afternoon temperatures in this area compared to elsewhere in the UD. Priority strategies for this zone should focus on detaining/storing/slowing stormwater runoff.

Spokane Valley–Rathdrum Prairie Aquifer Zone: Glacial outwash and alluvial deposits are in the northeast half of the UD (Figure 2.2), where their permeability allows infiltration of rainwater and aquifer recharge. Because the UD is located on the west edge of the aquifer, this zone is an important area to ensure water quality protection and improvement before the groundwater discharges to the river.

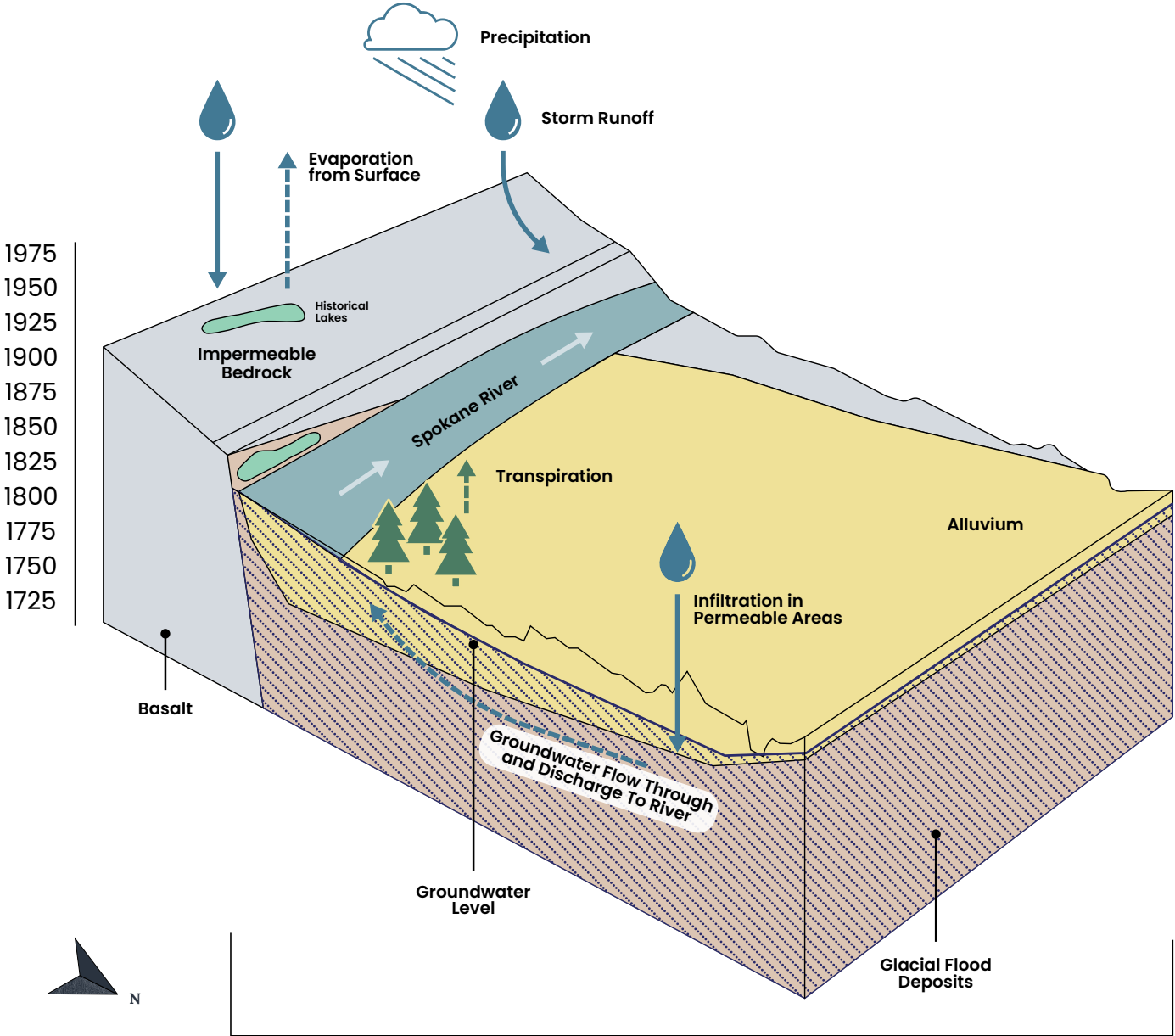


River Corridor: The riverine zone includes the river channel and a relatively narrow riparian buffer on both sides. The river receives groundwater discharge from unconsolidated deposits in the northeast half of the UD. In the southwest half, however, basalt prevents hydrologic connection to groundwater. When precipitation falls on the UD, the ultimate receiving waterbody is the Spokane River. Under natural conditions, depending on the location, the route and timing of that flow vary considerably.

In the basalt landscape of the southwestern UD, there are relatively high runoff volumes into the Spokane River and minor storage. In the northeastern UD (mostly north of the river), the deep SV-RP Aquifer allows much higher infiltration, decreased runoff volumes, and a much slower subsurface pathway to the river. Figure 2.3 illustrates the general flow pathways through the landscape in UD.

Establishment and growth of the City of Spokane resulted in a complex man made drainage network, which interrupts and interacts with the natural conditions described above. Within the southwestern UD, much of the runoff is collected in the sewer and directed to the Riverside Park Water Reclamation Facility.

When the combined runoff and sewage volume exceeds sewer capacity, the excess overtops the system’s combined sewer overflow (CSO) weirs and is routed to the river. In the northeastern portion of the UD where the substrate is more easily modified, runoff enters the municipal separate storm sewer system (MS4), where it is directed to detention areas and dry wells, providing attenuation and infiltration and eventually flowing to the river.



HISTORICAL LAND COVER

Spokane is in the Spokane Valley Outwash Plains Ecoregion, which reflects features of the last continental glaciation. The mixed conditions of geology, topography, and soil types formed several key habitat types in the region as described below (reference Appendix B).

Inter-Mountain Basin Big Sagebrush Shrubland and Steppe (Figure 2.4) historically occurred in the uplands on the north side of the UD and significant areas of the southern side. A native shrubland steppe community has varying amounts of shrub and herbaceous cover and very few trees.



Figure 2.4. Sagebrush reference site in Moses Coulee, eastern Washington. Source: Chase Gunnell, Our Sagelands Heritage Program.

Columbia Plateau Steppe (Figure 2.5) historically occupied a swath through the southern portion of the UD, mostly south of E Martin Luther King Jr. Way. These native systems are very similar to the big sagebrush shrubland and steppe except for the dominance of shrubs and a fire return interval of about 20 years.



Figure 2.5. Columbia Plateau steppe reference site at Yakima Training Center. Source: Jay Kehne, Conservation Northwest.

Ponderosa and Mixed Forests, Woodlands, and Savanna (Figure 2.6) historically occurred near the Spokane River channel as well as on uplands to the north.



Figure 2.6. Ponderosa pine savanna. Source: Aaron Theisen, Washington Native Plant Society.

Montane Riparian Systems (Figure 2.7) surrounding the Spokane River are a type of woody wetland where tree cover can reach 100%. Replacement fires in these native systems occurred every 68-182 years on average, caused by ignition in adjacent systems (USFS 2020c,d).



Figure 2.7. Example montane riparian and wetland system reference, Columbia Plateau Trail State Park. Source: Railtrailingblog, TrailLink.

WILDLIFE

Not including insects, 77 native wildlife species have been reported in the UD (iNaturalist). The Spokane River corridor and connected green spaces provide the most diverse wildlife habitat. Mammals and native fishes depend on the river, migratory birds rely on riparian and canopy structure, and pollinators use flowers.

Reptiles and amphibians also use moist refugia and undisturbed edges that can be found along the river and at Lake Arthur. The UD has remnants of wildlife habitat concentrated in riparian areas with vegetation cover and some connectivity. Wildlife summaries are provided in the Framework memorandum.

Some Wildlife Species Benefiting from UD Open Space Connectivity

Select Species documented in or near the UD with habitat needs potentially supported by proposed ecological landscape typologies.

Guild	Common Name	Scientific Name	Status
Birds	Rufous Hummingbird	<i>Selasphorus rufus</i>	BCC
Birds	Calliope Hummingbird	<i>Selasphorus calliope</i>	BCC
Birds	Lewis’s Woodpecker	<i>Melanerpes lewis</i>	BCC
Birds	Olive-sided Flycatcher	<i>Contopus cooperi</i>	BCC
Birds	Evening Grosbeak	<i>Coccothraustes vespertinus</i>	BCC
Birds	Cassin’s Finch	<i>Haemorhous cassinii</i>	BCC
Birds	Bald Eagle	<i>Haliaeetus leucocephalus</i>	Eagle Act / Non-BCC Vulnerable
Birds	Golden Eagle	<i>Aquila chrysaetos</i>	Eagle Act / Non-BCC Vulnerable
Insects	Monarch Butterfly	<i>Danaus plexippus</i>	Proposed Threatened
Insects	Suckley’s Cuckoo Bumble Bee	<i>Bombus suckleyi</i>	Proposed Endangered
Mammals	Silver-haired Bat	<i>Lasionycteris noctivagans</i>	WDFW SWAP S3
Fishes	Bull Trout	<i>Salvelinus confluentus</i>	Threatened
BCC = Bird of Conservation Concern (USFWS). SWAP S3 = Washington State Wildlife Action Plan Species of Greatest Conservation Need, rank S3 (vulnerable). Proposed Threatened / Proposed Endangered = proposed for listing under the Endangered Species Act as of report date.			
Sources: USFWS. IPaC Resource List, Spokane County, Washington. Generated October 10, 2025. https://ipac.ecosphere.fws.gov Washington Department of Fish and Wildlife. Priority Habitats and Species on the Web (PHS Web). Report Date: September 11, 2025. iNaturalist species observations, University District area.			

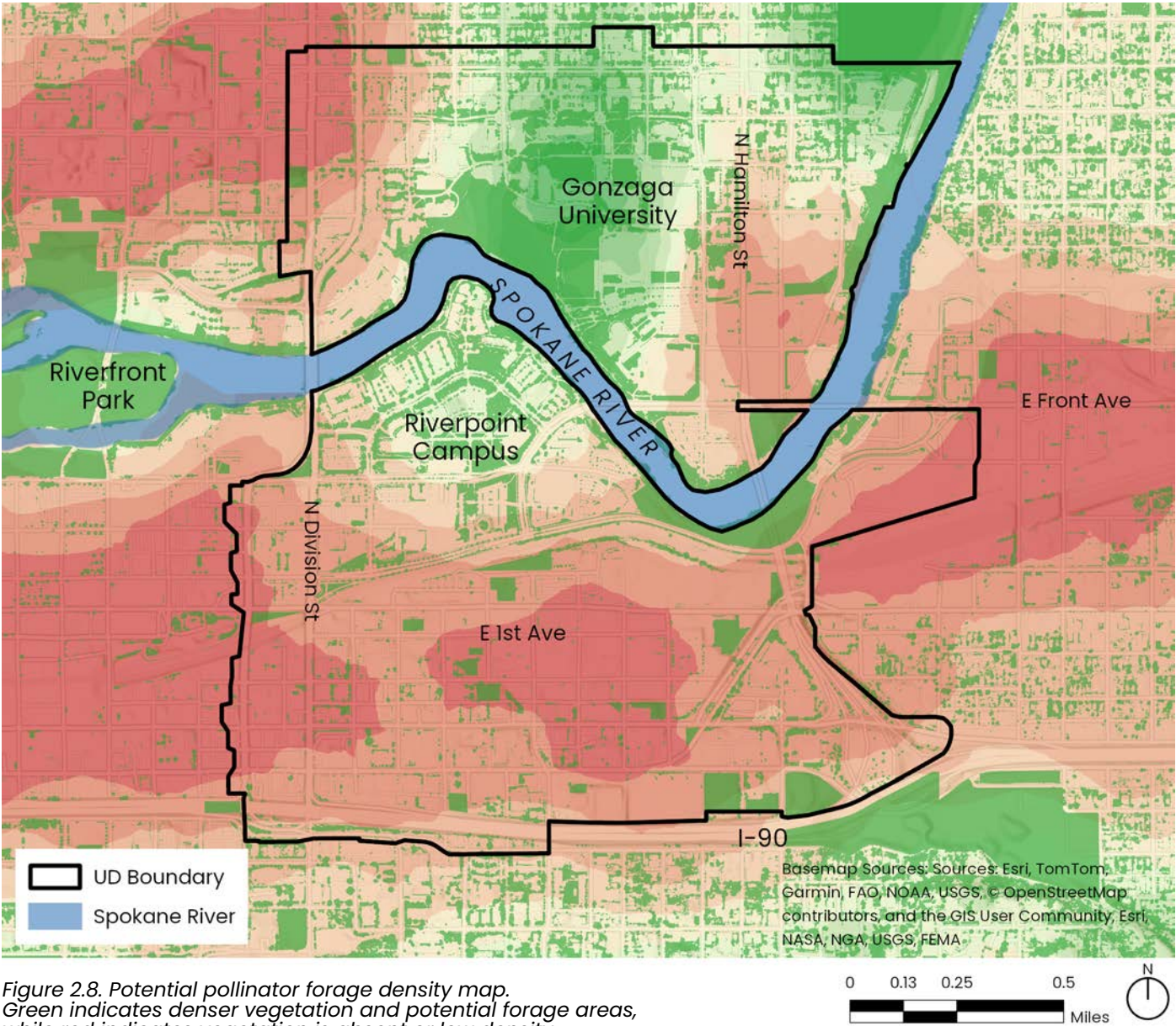


Figure 2.8. Potential pollinator forage density map. Green indicates denser vegetation and potential forage areas, while red indicates vegetation is absent or low density.

CURRENT LAND COVER

Current land cover of the UD is a range of development intensities, including buildings, roads, and infrastructure. Exceptions include the open water of the Spokane River and small, isolated patches of Ponderosa pine woodland and savanna, urban forest, and riparian woodland. The intensity of development in the UD makes it especially important to understand the locations and availability of remaining permeable surfaces for stormwater management.

POTENTIAL POLLINATOR FORAGE

An analysis of habitat needs of select bee species mapped foraging distances based on existing land cover (except athletic fields). Figure 2.8 illustrates where potential forage density is highest (green) and lowest (red) and patterns across the UD and its boundaries. The low forage density on the south side of the UD represents a potential focal area for improvement.

2.2 ECOLOGICAL OBJECTIVES AND CONSIDERATIONS

Based on Ecological Design Principles (in Section 1) and an understanding of the historical and existing conditions (in Section 2.1, Appendix B), priority ecological objectives for the Living Infrastructure Framework are summarized at right. These ecological objectives informed the map of ecological priority opportunity areas in Figure 2.9.

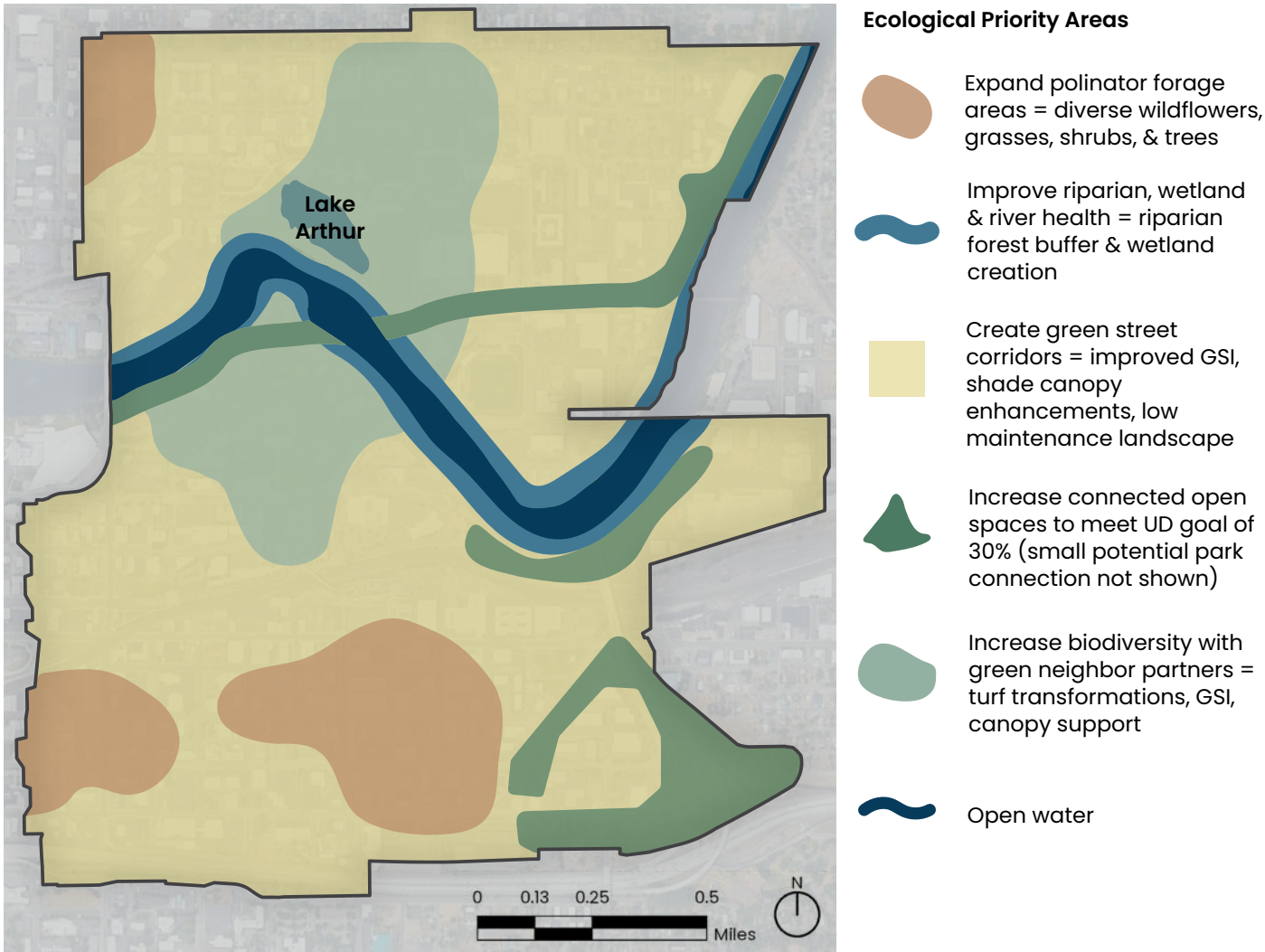


Figure 2.9. General ecological priority areas based on existing conditions.

Ecological Objectives for the UD



Increase biological diversity by expanding the types and extent of native plant communities in opportunity areas including a) expanding pollinator habitat and b) protecting and enhancing riparian and wetland habitat.



Improve landscape connectivity by increasing open spaces and park linkages.



Improve stormwater management and reduce pollutant discharge to the river through integrated green infrastructure practices .



Moderate urban heat through canopy enhancements, water retention, and additional open spaces and green street corridors.

An additional overall objective is to minimize maintenance needs through collaborative planning, application of ecological design guidelines, and adaptive management stewardship as described in the following sections.

Depending on desired ecological objectives and site conditions, a variety of native plant community types may be suited for a project location. Figure 2.10 shows considerations for plant communities along gradients of moisture, trees/shade, other ecosystem services, and maintenance.

Although necessary space is not captured in the figure, larger planting spaces generally have more opportunities for trees, and will therefore provide shade.

Importantly ecosystem services and needs vary within each community type (for example, riparian forest can have a range of canopy densities). Additionally at a site level, soil conditions, topography, and aspect will be additional considerations in plant selection. Further details about planting suitability for different landscape typologies are explored in Section 4.2.

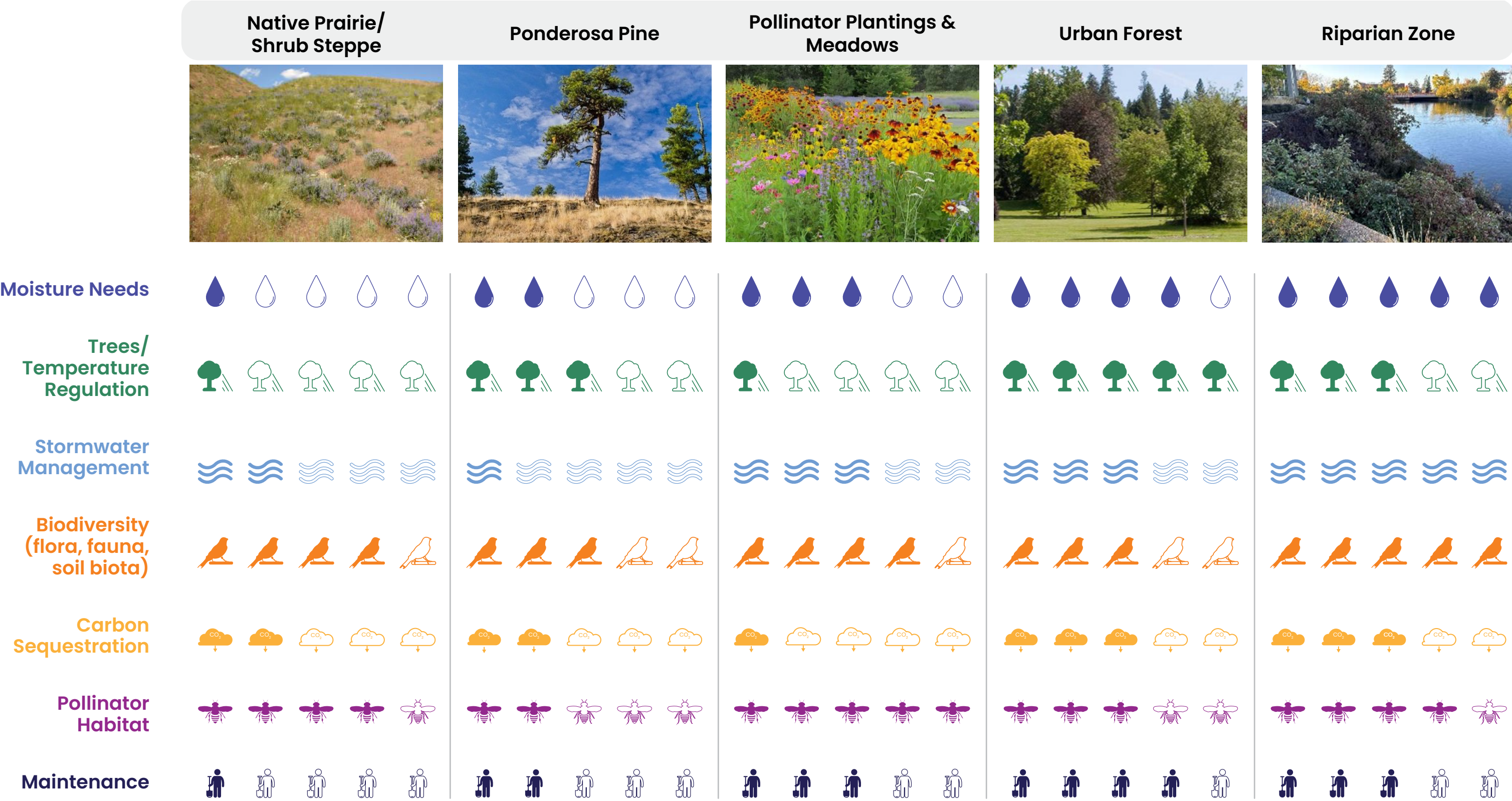


Figure 2.10. Relative ecosystem services by candidate plant community types for the UD.



3. ASSESSMENT APPROACH

3.1 PLANNING PROCESS OVERVIEW

Community developers and landowners make multiple decisions that affect the potential for living infrastructure throughout the project planning and construction processes. At a high level, a nature-positive process includes visioning and assembling a multidisciplinary team, discovering and understanding existing conditions and opportunities, designing a project that addresses and maintains objectives for the long term, and implementing the project, including planning for future management (Figure 3.1).

Members of a multidisciplinary development team will vary depending on size and complexity of a project. In general, living infrastructure projects, ecological outcomes are typically improved when natural systems specialists are integrated into the planning process alongside architects, landscape architects, and engineers.

For the rigorous Sustainable Sites Initiative (SITES), the guide suggests integrated design teams should “include experts in natural systems, design, construction, and maintenance, in addition to representatives of the community, the owners, and the intended site users”.

This section focuses on the discovery phase, providing guidance for site assessment and analysis to integrate nature-positive living infrastructure approaches. Additional details on biodiversity support through an entire project life cycle are provided in the American Society of Landscape Architecture 2040 Climate and Biodiversity Action Plan.

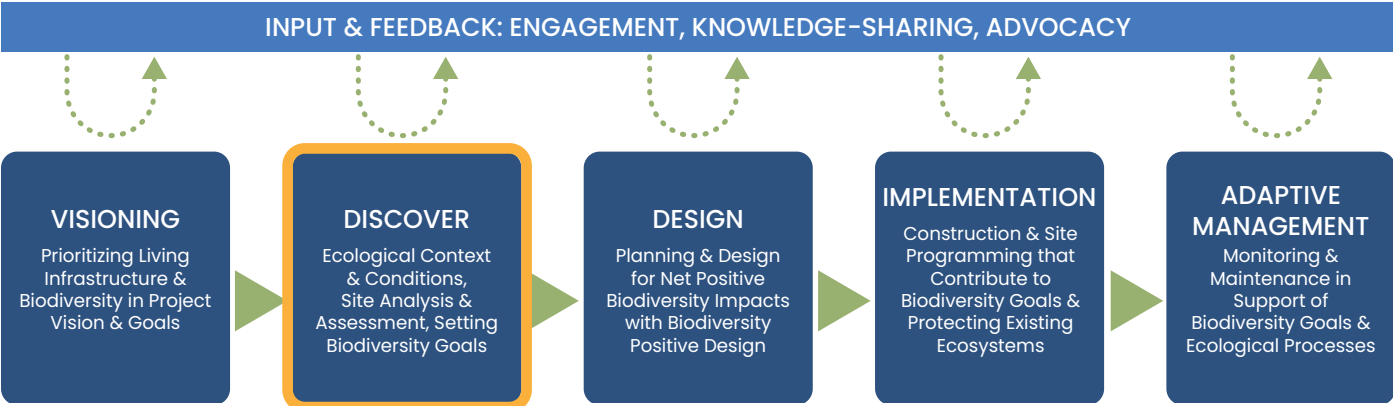


Figure 3.1. A biodiversity-positive planning and design process is iterative and integrative during all phases. This Section of the guideline documents is focused on the Discovery step highlighted in orange. Source: Jennifer Dowdell, Biohabitats, and Meg Calkins; Modified from ASLA guide.

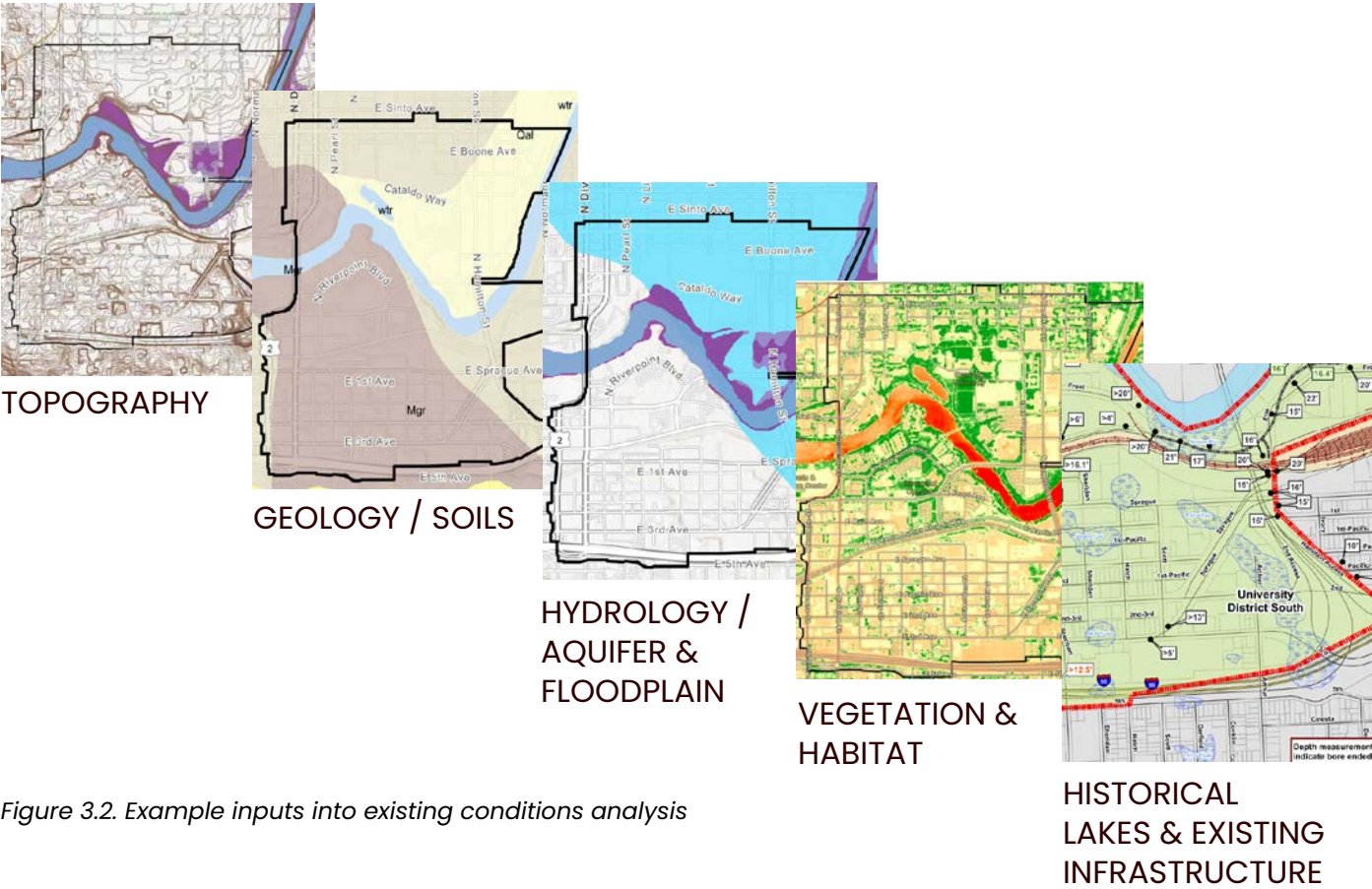


Figure 3.2. Example inputs into existing conditions analysis

3.2 ANALYZING SITE CONDITIONS

A landscape ecology perspective (Figure 3.2) can help refine the vision for a project as well as help prioritize its objectives (see p. 27). Refer to the overall ecological conditions in the UD as described in Section 2 and the more detailed Framework (Appendix). Using these resources for context combined with site-specific observations, summarize its expected ecohydrology conditions, pollinator forage potential, and general ecological opportunities, and use the information to refine the project vision.

The amount of site information needed to analyze existing conditions depends on the project vision, scale, and level of complexity. At a minimum, site assessment and analysis should characterize conditions related to soils, water, and vegetation. Appendix D provides an example of items to include in a typical assessment. Recommendations for these assessments are discussed below. It is also helpful to understand habitat opportunities, sensitivity of land and water resources, and anticipated social needs, all in the context of existing uses (the 2024 UD Next Generation Plan provides a good example).

3.2.1 SOILS

Six urban land soil types characterize the UD with varying substratum and slopes (Figure 3.3). Because available data do not identify site opportunities, onsite observations should identify and map:

- Relatively undisturbed soils and/or desirable vegetation which could be preserved or salvaged,
- Areas that are likely to be impacted by development or construction staging, access, etc.

- Areas of erosion, compaction, and disturbed soils that have potential to be restored.
- Areas of shallow bedrock where soil restoration is limited.

Mapping soil conditions in the Discovery stage (Figure 3.1 on p.32) is important for identifying where soil protection and improvements can help support plants and soil biodiversity which form the base of the food web for insects, birds, and other wildlife.



Source: Biohabitats.

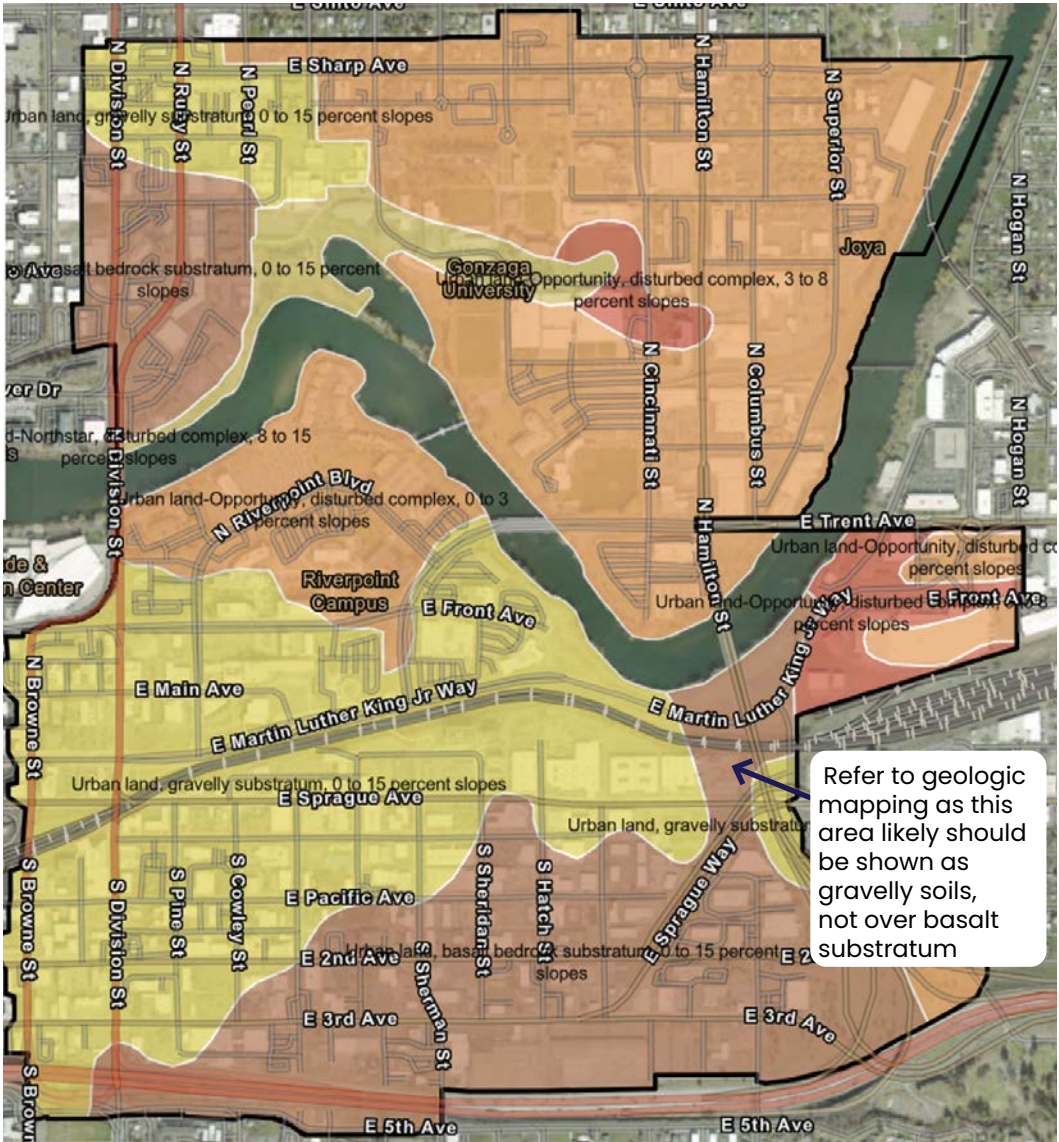


Figure 3.3. Soil types mapped by the Natural Resources Conservation Service.

3.2.2 WATER

Assessing existing water flow patterns and infrastructure helps inform how to design with natural flows and identify opportunities to retain and manage precipitation on site. During the Discovery process (Figure 3.1 on p.32), developers and planners should document:

- Land formations and other topographic factors such as upland, hillslopes, and lowland areas, as changes in grade are potential opportunity areas for treatments.
- Presence of underlying SV-RP Aquifer and depth to groundwater
- Regulatory floodplain extent on Flood Emergency Management Agency (FEMA) Flood Insurance Rate Maps

- Proximity to Spokane River [shoreline jurisdiction zone](#)
- Proximity to riparian buffer or wetlands
- Sewer, stormwater, and irrigation infrastructure
- Contributing drainage area
- Areas of erosion or gullying
- Areas of potential contamination

Depending on site conditions and with input from City stormwater engineers, site planners can confirm applicable stormwater management strategies and opportunities to support living infrastructure typologies (described further in Section 4).



Source: Biohabitats.

Water Budget Estimates

Many strategies used in the built space to convey and treat water require calculation of a water budget to design appropriate sizes and treatment methods. The 2008 [Spokane Regional Stormwater Manual](#) has a simple method using the following equations:

$$V_{STORAGE}(x) = V_{IN}(x) - V_{OUT}(x) + V_{STORAGE}(x-1)$$
$$V_{POND} = \max[V_{STORAGE}(x)]$$

- Where:
- x = any given month;
 - V_{IN} = water volume entering the evaporative pond in a given month. Stormwater runoff volume is calculated using the NRCS runoff Equations 5-1 and 5-2;
 - V_{OUT} = stormwater volume leaving the evaporative pond in a given month (i.e. pan evaporation, surface release);
 - V_{STORAGE} = storage volume necessary for a given month; and,
 - V_{POND} = storage volume necessary to reach equilibrium in a 2-year cycle.

The analysis is repeated until the maximum storage volume in a second year is equal to or less than the maximum storage volume in the first year.

The cycle shall start in October, the month that yields the greatest net storage volume for the year.

The 2024 [Stormwater Management Manual for Eastern Washington](#) provides methods to calculate a water budget including considerations around climate change.

3.2.3 VEGETATION

Most of the vegetation across the UD has been impacted by long-term industrial use and development, with many areas paved over. However, patches of existing vegetation can provide a starting point for reintroducing more vegetation into the UD using a living Infrastructure approach. Vegetation inventory and assessment should describe and/or map:

- Land cover types including trees, shrubs, herbaceous, turf, bare ground, and developed areas
- Tree numbers by species, diameter at breast height, approximate tree height, overall condition, concerns (e.g., hazardous branches, trunk or root damage or decay), and whether risk warrants immediate attention. Methods should be consistent with the [assessment methods](#) of Spokane's Urban Forestry Department.
- Areas of native or adapted vegetation to potentially protect, salvage, or improve
- Areas of non-native vegetation with potential to restore

- Irrigated areas
- Invasive species, where, and how much (e.g., patch size and percent cover)
- Areas of shade or conversely intense heat
- Landscape character of adjacent properties and what stresses or support they may provide to the protected area
- Connectivity potential for pollinator forage (see Figure 2.8)

From the inventory process, assess appropriate strategies caring for plant health. Depending on project priorities, identify potential native plant communities or climate adapted plant palettes which may be suitable when developing the preliminary concepts. Overall, the selection considerations during concept development include available space, available moisture, constraints such as depth of soils, shade, and cultural goals. Plant communities are further described in the Framework and Section 4.



Preliminary concept of Medellín's green corridors.
Source: City of Medellín, Colombia

4. ECOLOGICAL DESIGN TYPOLOGIES



4.1 APPLIED TYPOLOGIES

This section provides design guidelines for a select set of ecological design typologies to aid planners, decision makers and designers in incorporating these approaches into UD projects and initiatives. Completion of a site assessment (Section 3) will help select a typology appropriate for the site.

The typologies are rooted in ecological principles but their implementation will be multidisciplinary and involve engineering and planning input for hardscape features such as inlets, outlets, curb cuts, and sediment traps. Guidance for these other hardscape and engineered components should be consulted in other references such as the [Eastern Washington Stormwater LID Guidance Manual](#) (2013) to ensure appropriate dimensions, edging, materials, and stormwater flow and sediment management.

The typologies are organized in order of their potential to meet living infrastructure objectives for cooling, stormwater and biodiversity. Each of the following insets addresses the following topics:

- PURPOSE
- ECOLOGICAL & WELL BEING BENEFITS
- ECOLOGICAL DESIGN ELEMENTS & CONSIDERATIONS
- CONTEXT & SITE ANALYSIS
- MAINTENANCE CONSIDERATIONS
- ADDITIONAL RESOURCES



Source: Susan Mulvihill <https://www.spokesman.com/stories/2021/jun/19/in-the-garden-pollinator-garden-provides-habitat-f/>

Ecological Design Guide Typologies*	Living Infrastructure Objectives		
	Cooling	Water Connectivity & Quality	Biodiversity
Waterfront & Riparian Forest			
Resilient Parks & Open Space (Clean Water Parks)			
Bioretention & Bioinfiltration (Blue-green stormwater)			
Meadow / Turf Conversion			
Streetscape Greenways (Street Tree Canopy)			
Pollinator Gardens (May include Rainwater Harvesting)			
Shoreline & Edge Wetlands (Future)			

*Related nature-based strategies in Next Generation Plan

WATERFRONT & RIPARIAN FOREST

Restore natural hydrologic dynamics and diverse habitat to improve overall health and function of the river corridor.

PURPOSE

A healthy river corridor includes vibrant and well-vegetated margins alongside the active drainage. A high-functioning riparian zone is naturally complex and provides many habitat niches for plants and resident wildlife. The vegetation and soils work together to filter runoff, stabilize banks, and decrease erosion. Multi-tiered vegetation provides shade to both aquatic and terrestrial systems. Where the floodplain is well-connected to the river, floodwaters can expand into these areas during large storms, slow down and allow a place for silt to settle, and percolate slowly through the soil to groundwater. A robust riparian zone is also a natural greenway and connection to other natural resources in the UD.



Source: River Valley Ranch Buffer Establishment, Biohabitats

ECOLOGICAL & WELL-BEING BENEFITS

- Biodiversity support (aquatic & terrestrial) with complex habitat opportunities
- Primary ecological corridor in the UD (e.g Figures 2.8, 2.9)
- Stormwater management
- Heat refuge
- Recreational corridor

ECOLOGICAL DESIGN ELEMENTS & CONSIDERATIONS

The riparian corridor is the area alongside a river that is supported by its hydrology. Structural features such as downed trees, boulders, and woody material at the water’s edge (or submerged) can enhance user experiences and local ecological function.

Plant Selection & Habitat Types:

Species in the riparian zone span a broad range of hydrologic tolerance. More water-dependent species will grow closer to the water, upland species (but tolerant of occasional soil saturation) will grow further from the water, and species with intermediate water needs should be located in between . (See the Master Plant List in the Appendix.) If planting zones are designated, it is recommended that each zone includes species along a spectrum of hydrologic tolerance that can self-organize as they adapt to the site.

Multiple growth forms are appropriate for riparian areas: tall canopy trees, subcanopy trees, shrubs, and herbaceous understory including grasses and forbs . Generally, more structural diversity is better, although sometimes design limits shorter trees and taller shrubs to ensure safety in developed areas.

Plant Selection & Habitat Types
(cont.):

Additional principles for riparian areas are:

- Plant trees in clusters rather than long strips to maximize irrigation efficiency and so they shade each other throughout the day.
- Enhance fish habitat such as willows and woody material along edges for feeding opportunities and protection.
- Connect with other habitat opportunities whenever possible, prioritizing adjacent areas adjacent to existing habitat.

CONTEXT & SITE ANALYSIS

Riparian zones that extend gradually (not abruptly) away from the water can be divided into multiple zones including fringe wetlands, lower, and upper riparian. The edge of the Spokane River is steep in some places with little or no hydrologic gradient, but has other places to support wet meadows and other riparian habitat types.

Sizing: Size limitations depend on extent of hydrologic influence. Post-establishment plants will need to survive on water provided by the river.

MAINTENANCE
CONSIDERATIONS

For establishing and restoring new riparian habitat, the first 3–5 years are critical. Regular watering is important especially during the first growing season while plants are building their roots. Irrigation can be delivered by truck or another temporary system.

Canopy hazards should be adaptively managed according to safety concerns. Do a sweep for maintenance needs after major storms. If not presenting a hazard, leave standing dead and large downed logs (~12” or larger), which are good habitat.

Volunteer saplings should be supported if they are native. Clear competing plants from an area containing desirable saplings and seed with native herbaceous species if appropriate. Remove saplings that are non-native, unless they are desirable for future conditions (i.e., naturalized and non-invasive).

Weed Management: Monitor for and manage weeds monthly through the first full growing season in restored areas, and maintain regular monitoring for weeds throughout all riparian zones. Managers should decide on the best monitoring and weeding frequencies, depending on how recently a site was revegetated and the intensity (species and extent) of current weed stressors. Pull or dig weeds to remove the root, and remove weedy material from the site.

Pesticides should be a last resort, especially in these water-adjacent habitats. If pesticides must be used, use the most targeted product available and precise techniques.

Make sure all personnel read labels when using chemical products.

Follow weeding with native reseeding or replanting in the disturbed area.

ADDITIONAL RESOURCES

- [Spokane Riverkeeper](#)
- [Spokane River Forum](#)
- [Spokane Conservation District](#)



Source: <https://www.sacvalleycnps.org/riparian-forest/>

RESILIENT PARKS & OPEN SPACE

Create destination parks and open spaces that balance ecological and human interactions and inspire connections to place

PURPOSE

Parks and open spaces provide some of the best opportunities for delivering resilient solutions at meaningful scale while providing cultural amenities. These areas are important for ecosystem health because they can include combinations of nature-positive design elements that work together for increased function, while also more deeply connecting people to place through education and recreation. To meet the UD's 30% open space goal (~230 acres), dozens of additional acres need to be transformed, and several locations already have been identified as anchor sites¹.



Source: WCMGA Education Garden at PCC Rock Creek

ECOLOGICAL & WELL-BEING BENEFITS

- Biodiversity through multi-layered native plant communities to support diverse insects, birds, & small mammals
- Connectivity pathways for wildlife movement and people
- Stormwater management
- Heat island reduction
- Recreation
- Cultural connections

ECOLOGICAL DESIGN ELEMENTS & CONSIDERATIONS

A major consideration for parks and open space planning is to identify areas well-suited to protect and enhance ecosystem functions based on size, condition, and context of the site. Large areas in good condition will be most suitable for open space management, while smaller, disconnected areas are better suited for traditional parks. From a living infrastructure perspective, it is useful to set aside the natural areas and water flow pathways first, then overlay the existing infrastructure, park access, adjacencies, etc. to inform the vision and design of a site.



View of park and open space areas in Festival Park, Castle Rock Colorado. Source: Biohabitats.

Plant Selection & Habitat Types:

Parks and open spaces in the UD should support biodiversity by planting and supporting multiple layers of vegetation from canopy trees to mid-story shrubs to groundcover and herbaceous layers.

Canopy: Tree canopies help capture rainwater, support the water cycle, provide cooling, and improve air quality. Ponderosa pine groves and small-footprint forests (e.g., Miyawaki patches²) are well-suited to the open spaces of the UD, where they can deliver outsized ecological returns: rapid canopy closure, soil building, urban heat island reduction, and dense wildlife habitat structure within patches as small as a few hundred square feet.

Shrub and Herbaceous Layer: Native shrubs and forbs provide nectar, seed, fruit, and refuge for local pollinators, birds, and small mammals.³ They are also adapted to a wide range of soil conditions and establish in disturbed urban soils without root expansion and biomass turnover improve soil structure over time. Do not plant invasive species such as butterfly bush and lantana – they cause unintended harm even where they support some pollinators.

Soil: Distinguish between areas of soil compaction, shallow bedrock, and relatively undisturbed soils to design for the appropriate planting palette and methods.

Given the UD’s industrial land use history, assess areas of potential soil contamination early in site planning. Input from city stormwater engineers is recommended before designing living infrastructure strategies on brownfield or former industrial parcels, where soil removal or treatment maybe needed.

Consider minimum substrate depths: 8” for herbaceous species, and 18” for shrubs. Best practices for tree planting include:

- Diversify tree sizes
- Plant trees so that the crown (junction of aboveground and belowground biomass) is deeper than grade to encourage water to collect in the planting pit.

Do not add compost to poor urban soils – this encourages weeds over natives. Instead, plant native pioneer species that are easily adapted to poor soil types and overseed natives after those plants and associated mycorrhizal fungi have begun to naturally cycle and regenerate the soil below.

- Create a berm around the tree pit using excavated soil to aid in water retention around the tree.
- If the tree is installed on a slope, cut the upslope side of the tree slightly into the slope (but not so much to start erosion) and build up the soil above grade on the downslope side to help retain water.
- Soak soil around newly planted trees at initial watering and every several days for at least two (2) weeks. Increasing intervals between soakings every 2-3 weeks until watering is weekly for one month. Watering intervals should be increased adaptively, and very gradually, thereafter.
- Protect newly planted trees. After installation, protect new plantings from grazing or browsing animals with wrapping, chicken wire cages and/or other guards. Larger-caliper trees may need temporary (~1 year) stabilization with stakes.

Soil enhancement strategies include:

- Fence soil and plant protection areas to minimize disturbances and compaction.
- Salvage soils during any earthwork and reuse or spread onsite.
- Protect disturbed areas with a biodegradable erosion control blanket, crimped straw mulch, or other biodegradable erosion control.



Source: View of Sprague Avenue, Biohabitats.
50 | 2026 Living Infrastructure Design Guidelines

Soil (cont.):

- Minimize use of imported soils to the extent possible. If additional soil is needed, use regional sources (e.g., within 50 miles) that are responsibly developed and extracted, and are certified weed-free.
- Increase soil moisture retention with placement of fine organic mulch, squeegee (rock $\leq 1/4"$), or a combination around trees. Large ($>1"$) wood mulch takes a long time to break down, tends to absorb and hold water, and can lead to crown rot.
- Monitor closely for non-native plant establishment. Be especially aware of species that degrade soil chemistry and biodiversity.

Wildlife habitat: Parks and open spaces in the UD contribute most directly to wildlife that depend on connected habitat patches. Migratory birds, pollinators, bats, and other urban-adapted species all benefit from native plantings distributed strategically across the district’s open space network. Two federally proposed species warrant particular attention in design: Monarch Butterfly (*Danaus plexippus*, Proposed Threatened) and Suckley’s Cuckoo Bumble Bee (*Bombus suckleyi*, Proposed Endangered), both of which depend on diverse native forb communities maintained across connected patches.

The Spokane River riparian buffer, mapped as priority habitat by Washington Department of Fish and Wildlife, anchors the district’s ecological network (see Riparian typology); open space connectivity extending inland from this corridor amplifies habitat value for all species. Refer to Table X in the Living Infrastructure Framework Appendix for wildlife species documented in or near the UD that are most likely to benefit from open space habitat creation and connectivity.

CONTEXT & SITE ANALYSIS

When developing new parks and open spaces, evaluate adjacent land uses with a 5-year planning horizon to consider existing stormwater infrastructure connections and anticipate future connectivity. Evaluate opportunities for pollinator patch connectivity using the forage density map (Figure 2.8) to prioritize high-value corridor areas to protect or gaps to address.

Within the UD, the largest open space opportunity is the Sprague Way North/South corridor: a repurposed highway right-of-way planned as a large-scale stormwater facility planted with native sedges, trees, and connected by multi-use trails. Smaller interstitial open spaces (e.g., Figure 4.1) are distributed across the district and can be added and enhanced to provide stepping stones that create a more connected green network supporting wildlife, stormwater management, and a sense of place for the UD community.

Indigenous Connections: Parks and open spaces designed using cultural plantings can function as connections for cultural continuity. Selection and integration of cultural plantings are best done in consultation with the local representatives.

In the UD, the First Peoples of this Land are the Salmon People, the Spokane Tribal peoples. Other First Nation tribes such as the Schitsu’umsh (Coeur d’Alène Tribe), Ktunaxa ʔamakʔis, and the Confederated Tribes of the Umatilla Indian Reservation (Cayuse, Umatilla and Walla Walla) also had deep-seated historical ties to the landscape.

Plantings and design in the UD open space typology can be selected to reflect the seasonal round of gathering practices documented by Interior Salish peoples, creating spaces that create a sense of place, and serve to uphold ecological and cultural meaning.

The Gonzaga University Ethnobotanical Discovery Garden at Wildhorse Park provides a direct precedent in Spokane for organizing native plantings by seasonal round and ecotype, with storytelling circles, interpretive QR nodes, and community gathering spaces.⁴

As described in the Integrative Cultural Healing Model developed by Spokane-area tribal leaders, connection to land-based practices are foundational to Indigenous wellbeing.⁵

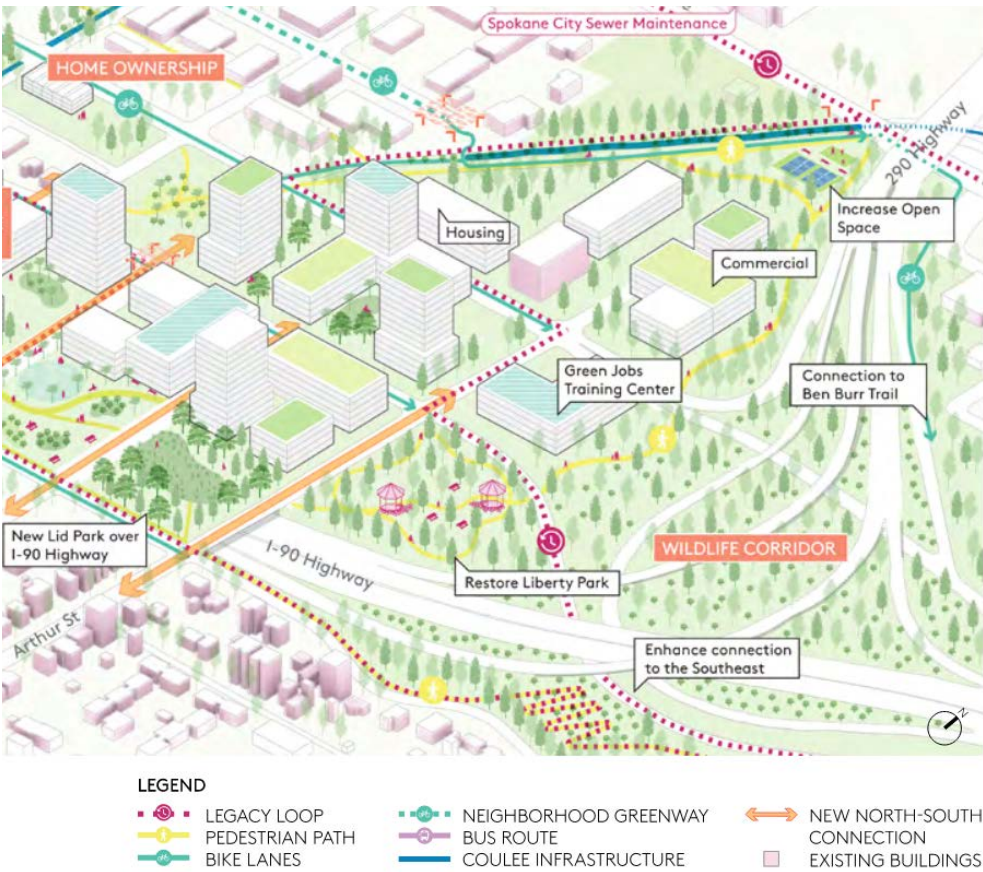


Figure 4.1 View of proposed UD park areas in Next Generation Plan.

Biophilic Experience: Approaches for integrating ecological design that enhances place-based connection and learning include biophilic experience themes or nodes. The following experience nodes are grounded in the wildlife and plant communities documented above and in the cultural landscape of the district.

Seasonal Food & Medicine Garden: Camas (*Camassia quamash*), balsamroot (*Balsamorhiza sagittata*), serviceberry (*Amelanchier alnifolia*), and wild strawberry (*Fragaria virginiana*) planted in a seasonal-round arrangement with interpretive signage connecting plant uses to Spokane Tribe and Schitsu’umsh traditions. This can be organized around the Interior Salish seasonal round framework used at the Gonzaga Ethnobotanical Discovery Garden.

Pollinator Corridor: Native forb and shrub plantings along the Sprague Way alignment connecting park patches and reinforcing the Beeline Pollinator Trail along Pacific Avenue.1 Species selected to support Rufous and Calliope Hummingbirds and native bee guilds. Signage keyed to NDVI-based forage density analysis identifying the south UD as a priority investment area.

Shrub Thicket & Berry Node: Dense shrub plantings of serviceberry, wild rose, Oregon grape, and red osier dogwood providing food and cover for Cedar Waxwing, Spotted Towhee, and American Goldfinch. Doubles as a cultural food and medicine node given the ethnobotanical significance of these species to Interior Salish peoples.6

Storytelling/Gathering Circle: Integrated into meadow or shrub edge; basalt seating, interpretive nodes, and ADA-accessible path. Precedent: Gonzaga Ethnobotanical Discovery Garden, Wildhorse Park.

MAINTENANCE CONSIDERATIONS

A moderate level of care will provide high quality and consistent visual character to the landscapes. Certain areas, such as gathering spaces, trails, and edges, may require more care to maintain than large natural vegetation areas. Coordination with facility or park management staff will be needed to allow for visual inspection of these landscapes at minimum weekly and after disturbances or events and periods of heavy use.

ADDITIONAL RESOURCES

1.

Mithun. University District Next Generation Conceptual Plan. Seattle, WA: Mithun, 2024, pp. 43–44. The primary open space site in the UD is the Sprague Way North/South corridor: a repurposed highway right-of-way planned as a multi-functional stormwater facility and habitat corridor connecting Liberty Park, the Ben Burr Trail, and the Beeline Pollinator Trail.1 Additional sites include the I-90 interchange area, the 5th Avenue Community Land Bridge corridor, the Cycle of Life Food Hub, a riverfront outlook near East Trent Avenue, and smaller interstitial open spaces across the district.

2.

Micro forest examples: <https://magazine.washington.edu/feature/a-micro-forest-grows-in-tacoma/> & <https://www.audubon.org/magazine/microforests-are-taking-root-across-country-making-urban-spaces-better-birds-and-people>

3.

The Miyawaki method, developed by Japanese botanist Akira Miyawaki, uses dense, multi-species plantings of locally native trees and shrubs to accelerate forest establishment, producing self-sustaining canopy in a fraction of the time required by conventional plantings. “Urban Forests: Restoring Nature Through the Miyawaki Method of Afforestation.” Nippon.com, January 2026. <https://www.nippon.com/en/in-depth/d00789/>

4.

Xerces Society for Invertebrate Conservation also has an extensive catalog of planting resources specific to the Pacific Northwest. <https://www.xerces.org/pollinator-resource-center/pnw>

5.

AHBL. Gonzaga University Ethnobotanical Discovery Garden: Design Concepts and Process. AHBL Project No. 2240897. Spokane, WA: AHBL, October 2025.

6.

American Indian Community Center. Full Proposal Narrative: Integrative Cultural Healing Model. Spokane, WA, c. 2024.

7.

Spokane Plant Gathering Seasons and Uses (Ross & Turner sources) . Biohabitats internal reference table .

8.

Tribal Advisory Council. “Braiding Indigenous Knowledge and Progressive Project Delivery.” University conference presentation, Washington state, c . 2025 .

9.

NatureServe Explorer: explorer.natureserve.org

The following plants, documented in Interior Salish ethnobotanical sources, are appropriate for UD open space plantings and carry cultural significance to tribal nations with ancestral ties to this area.

Common Name	Latin Name	Salish Name	Traditional Use	Gathering Season
Balsamroot	<i>Balsamorhiza sagittata</i>	<i>smukwa'shn</i>	Food, medicine, tobacco substitute	Spring–Fall
Camas	<i>Camassia quamash</i>	<i>etqhwé'</i>	Food, trade item	Late Spring
Serviceberry	<i>Amelanchier alnifolia</i>	<i>staq</i>	Food, digging stick	Summer
Yarrow	<i>Achillea millefolium</i>	<i>dmdmu'qeyni'</i>	Medicine	Summer
Wild Strawberry	<i>Fragaria virginiana</i>	<i>stsaqwm</i>	Food, medicine	Late Spring
Wild Rose	<i>Rosa woodsii</i>	<i>Lukw useli</i>	Medicine, body care	Year-round
Kinnikinnick	<i>Arctostaphylos uva-ursi</i>	<i>alchalpalqw</i>	Food, medicine	Year-round
Mock Orange	<i>Philadelphus lewisii</i>	–	Tools (digging stick)	Year-round
Red Osier Dogwood	<i>Cornus sericea</i>	–	Medicine, digging stick	Spring/Year-round
Oregon Grape	<i>Mahonia aquifolium</i>	<i>sqweyu'</i>	Medicine, food	Summer–Fall
Source: Spokane Plant Gathering Seasons and Uses (compiled from Ross & Turner ethnobotanical sources).				
Turner, N.J., Bouchard, R., and Kennedy, D.I.D. Ethnobotany of the Okanagan–Colville Indians of British Columbia and Washington. Victoria: British Columbia Provincial Museum, 1980. Turner, N.J. Food Plants of Interior First Peoples. Victoria: Royal British Columbia Museum, 1997. [Compiled by Biohabitats, 2025.]				

BIORETENTION & BIOFILTRATION

Improve biodiversity through thoughtful management of stormwater

PURPOSE

Bioretention and biofiltration features, such as bioswales, raingardens and stormwater planters, create a living network that collects and filters while supporting soils, plants and habitat for pollinators and other native wildlife.

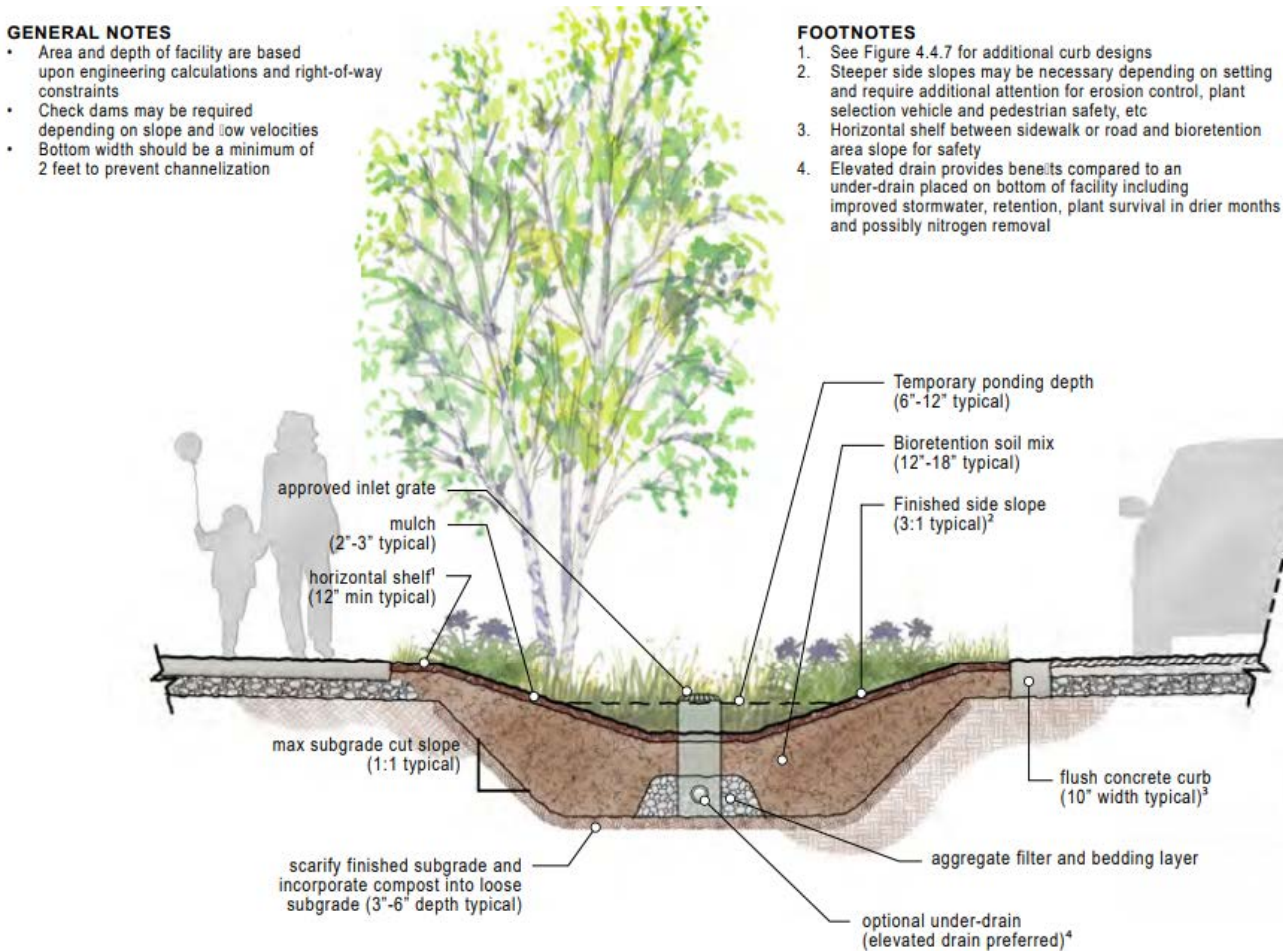


Figure 4.2. Conceptual bioretention basin with diverse plantings. Source: Washington State Department of Ecology 2013.

ECOLOGICAL & WELL-BEING BENEFITS

- Create habitat “stepping stones”
- Support native & climate-adapted plants vegetation
- High-functioning soils
- Capture pollutants
- Slow runoff
- Recharge aquifer
- Mitigate heat islands
- Protect Spokane River

These areas can offer the community oases for mental restoration, biophilic reconnection, and education.

ECOLOGICAL DESIGN ELEMENTS & CONSIDERATIONS

The major features of bioretention and biofiltration features are a shallow depression up to 1.5 ft deep containing high-performance filtration media and planted with vegetation. The combination of plants, associated microbes, and engineered soils remove pollutants through adsorption, filtration, metabolism, uptake, and sedimentation. Ideally, water retention time is often and/or long enough for these processes to be effective for ecological uplift. “Infiltration rates greater than 1 inch/hr promote healthy vegetation, create drought resilience, and greatly improve water quality benefits.”

Water: An inlet such as a curb cut conveys runoff or overland flow to the depression. Temporary ponding depth is up to 6 inches. Where suitable, water will infiltrate into the subsoil, or it may evaporate and possibly provide cooling benefits. If subsoil infiltration is not an option, then underdrains may be used to direct the infiltrate to a storm drain system.

Soil: Specially engineered soil media¹ are an important part of design. WQ goals indicate which soil layers are most appropriate. A 18” primary layer of sand, coir, and biochar is always included. Additional layers could be 12” of sand, activated alumina, and iron aggregate, which scrubs phosphorus, and possibly a 2” layer of compost.² Organic mulch improves water quality and soil health better than rock, but heavy storms can cause it to float. For basins prone to overtopping, secure the mulch beneath a layer of riprap. Ensure the riprap stones are at least 4 inches large, or scaled up depending on your design storm.

Plant Selection & Habitat Type: Ecologically, stormwater treatment systems can be biodiversity hotspots with pollinator gardens and even wetlands, depending on hydrology. See plant list for appropriate species as well as Tables D.3–D.5 in the [2013 Eastern Washington Low Impact Development Guidance Manual](#).

1. e.g., High-Performance Bioretention Soil Mixes are described in the Stormwater Management Manual for Eastern Washington and Guidance on Using New High Performance Bioretention Soil Mixes (both State of Washington Department of Ecology, 2024)
2. Compost should always be accompanied by both of the other layers as it can be a source of phosphorus.

Plant species can also be selected for other goals such as sensory experiences, nutrient uptake, and education. Salt-tolerant species should be used where the basin stores snow and/or receives parking lot runoff. Woody species are not recommended for bioretention and biofiltration since their roots can clog infiltration outlets and underdrains. Avoid planting trees near inlets, outlets, overflows, or inside basin bottoms. For optimal tree health and better basin performance, choose native species. Select trees grown in “tall pots” or “tree pots” to ensure they develop deep, robust taproot systems.

CONTEXT & SITE ANALYSIS

In the UD, ecological opportunities for bioretention and/or biofiltration vary depending on location.

On the north side of the Spokane River where the subsurface has more porosity bioinfiltration is possible for aquifer recharge.

On the south side of the River, shallow, impermeable basalt limits infiltration, so bioretention is more appropriate.

See also BMPs identified for UD (in Appendix C)

Developed area types that can be retrofitted to include bioretention or bioinfiltration include:

- Mixed use redevelopment
- Parking lot islands
- Raingardens from roof runoff



- ① CISTERN TYP.
- ② BIORETENTION BASIN TYP.
- ③ VEGETATED SWALE
- ④ FLUSH CURB TYP.
- ⑤ STORMWATER HARVESTING TYP.
- ⑥ CHECK DAM/ONE ROCK DAM TYP.
- ⑦ TREE PLANTING TYP.
- ⑧ DOMED OVERFLOW STRUCTURE
- ⑨ INFILTRATION TRENCH
- ⑩ SEDIMENT TRAP
- ⑪ ZUNI BOWL
- ⑫ SHEETFLOW SPREADER

Source: Green Stormwater Infrastructure and Low Impact Development Standard Details and Site Guidance, 2022

- Walkway gardens
- Tree lawns (the strip between a sidewalk and the street curb)
- See also Streetscape Greenways

Sizing: Optimal size of these strategies depends on site constraints and drainage area. They are generally appropriate for a drainage area up to but not exceeding 1 acre. Building setbacks, e.g., for a downspout disconnect, should be ≥10 ft.

MAINTENANCE CONSIDERATIONS

Irrigation: Irrigation for the first several growing seasons, and especially right after installation, will be necessary to support plant establishment and growth. Depending on stormwater inputs, continued irrigation will be needed for the long term. Irrigation should be programmed according to stormwater inputs and/or soil moisture, where irrigation doesn’t occur when there is precipitation and/or soil moisture is above a threshold.

Weeding: Herbicides should not be a weeding tool (which would add to WQ issues). Weeding should be done monthly during the establishment and first full growing seasons. All parts of a weed plant should be removed from the site. Over years 1-3, weeding should decline as the planted vegetation establishes.

Managers should decide on monitoring and weeding frequency as appropriate; it is suggested that monitoring occur monthly through the first full growing season, then every 6-8 weeks during the second growing season, and so forth. Weeding should follow monitoring as appropriate.

Sediment and Debris Removal: Sediment and debris removal should be scheduled after storm events and checked every spring. Managers should decide if more frequent checks are appropriate. SGI features can be collection points for litter.

Plants: From the standpoint that some of the planting design may be experimental, if a particular plant species does not perform well, a substitute may need to be planted as a replacement or supplement.

Replace Compost/Mulch: Compost or mulch layers will need to be replaced on an as-needed basis.

ADDITIONAL RESOURCES

- [2025 City of Spokane Stormwater Management Program Plan](#)
- [2024 Stormwater Management Manual for Eastern Washington](#)
- [2013 Eastern Washington Low Impact Development Guidance Manual](#)
- [UD Stormwater Plan](#)

MEADOW / TURF CONVERSION

Create habitat for insects, birds, and other small wildlife with opportunities in broad herbaceous spaces

PURPOSE

It doesn't take vast amounts of area to provide habitat opportunities for birds, insects, and other small wildlife. Locations not ideal for trees due to space or lack of irrigation could be planted with herbaceous species that provide nectar, seed, and refuge for important members of the food web. These can be some of the most colorful patches in a city and also be a beautiful alternative to extensive paving.



Source: Flewellen Creek Stream Restoration, Biohabitats. Credit: 2012 Jonnu Singleton SWA Group

ECOLOGICAL & WELL-BEING BENEFITS

- Biodiversity gains with habitat & wildlife that use it.
- Stepping stones and corridors improve green network connectivity (see Figure 4.5).
- Can help with stormwater management.
- Climate resilience via native & climate-adapted vegetation.
- Soils increase function, quality, and biodiversity over time.
- Look good even with heat, drought, excess rainfall. Improved aesthetic can support local businesses and increase property value.
- Local connection to place with native plantings.
- Cost savings via low-cost installation and low maintenance needs.
- Mitigation of urban heat



Source: Biohabitats.

ECOLOGICAL DESIGN ELEMENTS & CONSIDERATIONS

Meadows and turf areas are planted with herbaceous (non-woody) species that can take many different forms, whether a sustainable turf alternative to bluegrass or an expanse of colorful flowers. This habitat type is a native, low-growing, and drought-tolerant alternative to a tree canopy design. It offers less shade but can maximize plant species diversity due to the huge number of herbaceous possibilities. This habitat is also a good option where turf conversion is an objective.

Design can range from exclusively grasses to exclusively showy flowers, but usually is somewhere in between. Species can be chosen to display different colors throughout the growing season, to be consistent with a particular color scheme (e.g., white, yellow, purple), to focus on a wildlife guild such as hummingbirds or bees, and/or to provide year-round support to the greatest number of wildlife users. Shrubs can also provide anchor points if space allows, and ground covers such as thyme can cover interstitial spaces, or these spaces can be devoted to ground-nesting bees.

Soil: One benefit of planting native herbaceous species is that they are adaptable to a wide variety of soil types and conditions. If soil is considered “poor” (usually an agricultural designation), amendments such as compost are not recommended, as they tend to encourage weeds. Native species can establish in poor soils and over time will enrich soil with root expansion, biomass turnover, and growth of microbial communities. Although many native species can grow in minimal substrate, prairie species are known to develop substantial root biomass, often exceeding their aboveground biomass. Soils should be at least 8” deep (and if using shrubs, at least 18”). More rooting volume will support a more robust community.

Plant Selection & Habitat Types: See Appendix A for appropriate plant species. The [Xerces Society](#) also has an extensive catalog of resources including many [specific to the Pacific Northwest](#). Don’t plant invasive species such as butterfly bush and lantana even though they support some pollinators – they can cause unintended trouble.



Source: Biohabitats

CONTEXT & SITE ANALYSIS

Meadows and turf habitat can be planted universally in areas ranging from expansive landscapes to parking lot margins. They can enhance community parks and gardens, open space, spots that are awkward to mow, trails and road sides, and buffers along drainage ditches. They can be planted incrementally, for example, in a lawn or groomed garden slated for transition.

In choosing locations for meadows and turf, consider uses of the space adjacent to the patch, especially with a 5-year horizon. If next to a sports field, for example, lower-growing species will both support habitat and allow stray balls to be found. If in a spot that receives snowmelt, choose salt-tolerant species.

Sizing: This “universal planting type” doesn’t have size constraints. As with any landscaping, larger sizes usually have more up-front commitments (see Maintenance).

MAINTENANCE CONSIDERATIONS

Native meadows and turf are low-maintenance once installed. Seed can be raked into bare soil for establishment¹, and irrigation should be provided for the first couple of growing seasons to minimize stress and ensure root development. Irrigation can be delivered by truck or another temporary system.

1. See the Xerces Society’s Establishing Pollinator Meadows from Seed for recommendations on vegetation removal, seedbed preparation, and more

Weed Management: Like irrigation, weed management will be a primary need in the early years of establishment. Monitor for and manage weeds monthly during through the first full growing season. Pull weeds to remove the root, and remove weedy material from the site. Over the first few years 1-3, weeding should decline as the planted vegetation establishes. Managers should decide on monitoring and weeding frequency as appropriate; it is suggested that monitoring occur monthly through the first full growing season, then every 6-8 weeks during the second growing season, and so forth.

Pesticides should be a last resort. If pesticides must be used, use the most targeted product available and precise techniques.

Follow weeding with native reseeding or replanting in the disturbed area.

ADDITIONAL RESOURCES

- [SpokaneScape Turf Replacement Program](#)
- [Washington Native Plant Society Landscaping Resources](#)

STREETSCAPE GREENWAYS

Create habitat and shade along sidewalks and streets through well designed planting

PURPOSE

Landscaping enhancements along streets, such as tree beds and vegetated swales (Figure 4.3), provide relief from extensive paving and urban heat. Green streetscapes also create habitat opportunities for plants, pollinators, and birds in a cityscape.

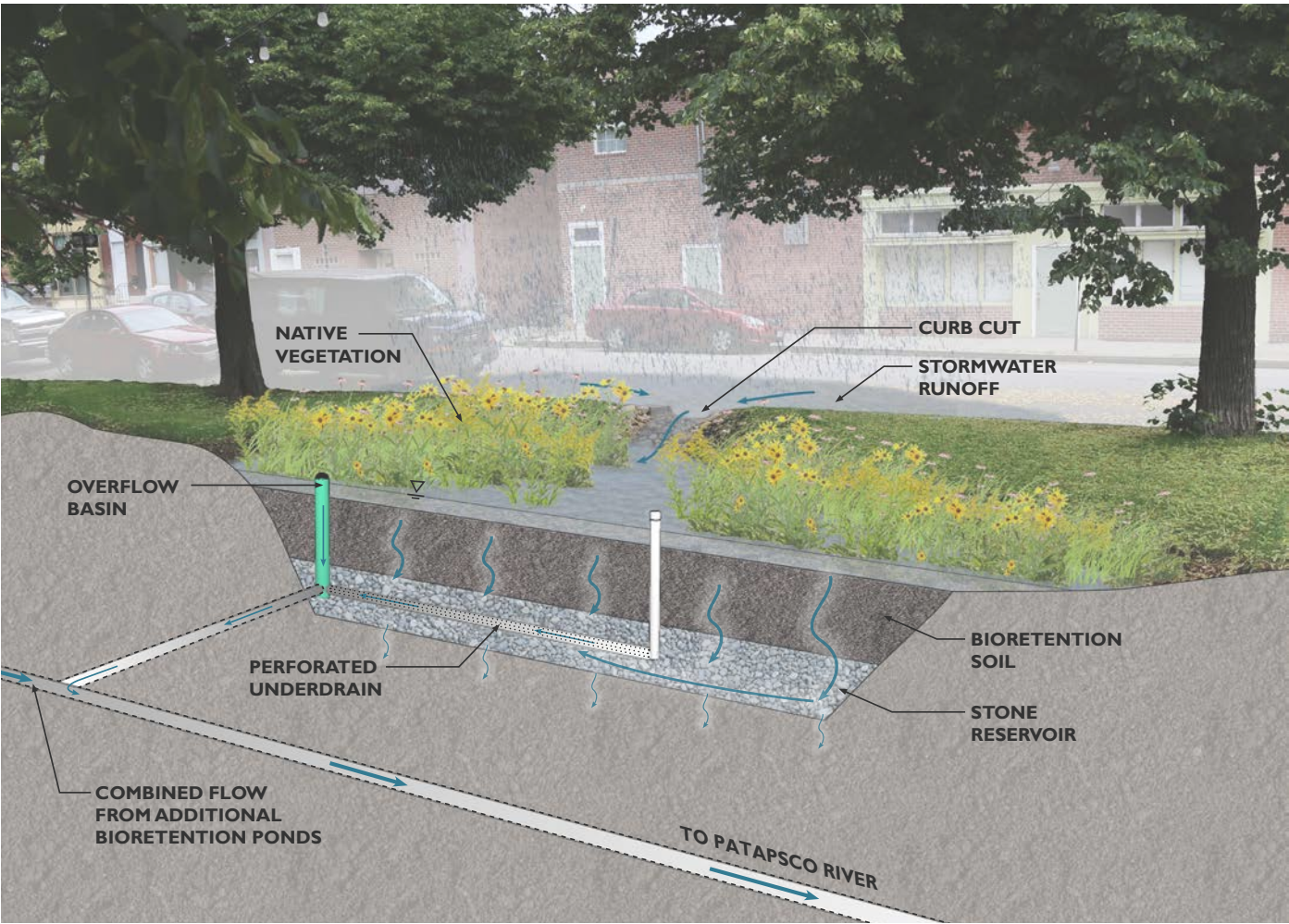
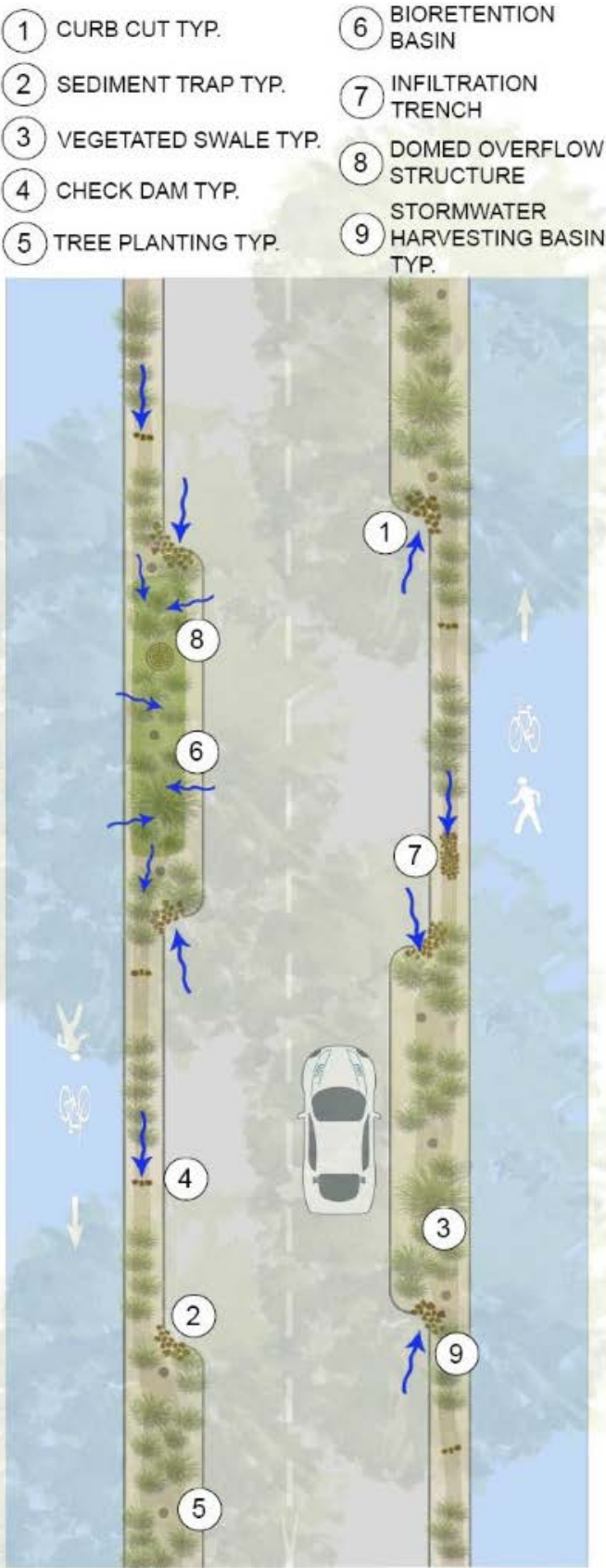


Figure 4.3 Stormwater Retrofit Design-Build (Library Square). Source: Biohabitats.

ECOLOGICAL & WELL-BEING BENEFITS

- Habitat corridors improve green network connectivity
- Support for native & climate-adapted vegetation
- High-functioning soils
- Capture airborne & possibly waterborne pollutants
- Mitigate heat islands
- Dampen street noise
- Outdoor seating along the street
- Can calm traffic
- Can separate bike and car lanes
- Improved aesthetic can support local businesses and increase property value



Source: Green Stormwater Infrastructure & Low Impact Development, Tuscon

ECOLOGICAL DESIGN ELEMENTS & CONSIDERATIONS

Streetscape greenways are created by planting areas between the sidewalk and the street or in the median (Figure 4.4). The plant communities can vary based how much water they receive, design goals, and other factors, and may include drought-tolerant pollinator gardens, multi-layered tree beds, and herbaceous swales. These greenways can also combine purposes, such as with bioretention and bioinfiltration (see fact sheet), especially if the street is crowned.

The major features of a streetscape greenway are curbs at least 6" high for traffic protection, underlying materials that allow drainage, and large enough planting areas to support above- and belowground plant growth.

Soil: Soil quality should have good horticultural qualities (pH, organic matter, nutrients, texture, etc.). Soils should be tested before planting to ensure they can support an installed plant community.

Soil should be at least 18" deep for herbaceous species and shrubs and at least 24" deep for trees. More rooting volume is generally better, especially for trees. Soil volume can be increased by increasing curb height, excavation, or using suspended pavement, e.g., Silva cells.

These engineered pavements meet street load requirements and sometimes can create more rooting volume than excavation. Additional benefits of suspended pavement are that it can help with stormwater capture (if desired), and tree roots won't cause sidewalk heaving.

Plant Selection & Habitat Types: Plants with appropriate mature heights and widths should be used, and laid out in consideration of pedestrian safety and driver views. Utility lines need to be considered for tree height, and if green streetscapes are to receive snowmelt, salt-tolerant species should be selected. See plant list for appropriate species.

Trees should share space with other trees and plants. Individual tree pits are not recommended, as these are low-biodiversity, stressful for the trees, and relatively high maintenance.

In addition to pollinator gardens, multi-layered mini-forests, and herbaceous swales, plant communities can be designed for other goals such as sensory experiences, nutrient uptake, and education.

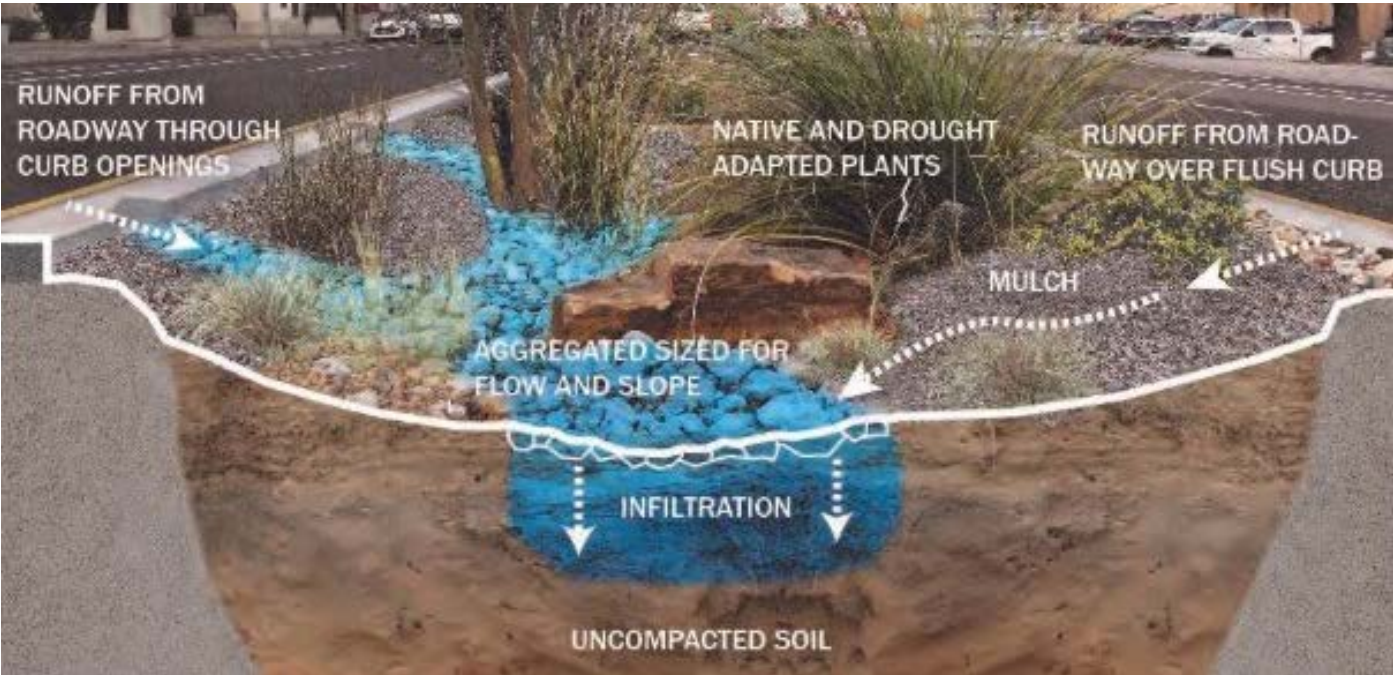


Figure 4.4 Depressed median for stormwater treatment
Source: Bernalillo County [NM] Technical Standards App. A, 2022

CONTEXT & SITE ANALYSIS

Street crossings can serve dual purpose as curb cuts. (See also excerpts on siting from local HDR¹ study)

Retrofit Assessments: Streets that are best candidates for retrofitting to have greenways include:

- Overly wide streets or needing a “road diet”
- In areas where biophilic opportunities are limited
- Connections between green spaces
- Roundabout centers can be a habitat stepping stone between greenways

Existing trees and their surrounding soils should be preserved if streetscape construction is a retrofit.

Sizing: Street greenways need to be deep and wide enough to ensure that the plant community grows and thrives, at least 3 feet. Length of the greenway is limited by site constraints (e.g., crossroads, crosswalks, other infrastructure) and maintenance resources.

1. HDR. 2018. *University District South Stormwater Site Suitability Assessment for Stormwater Management Design Planning: Final Report.*

MAINTENANCE CONSIDERATIONS

Planting adjacent to or in a road is challenging for vegetation and managers. These areas are hot and stressed by pollution, salt, and possibly foot traffic and dog waste. They also collect litter.

Irrigation: Irrigation is necessary for plant establishment, and the continued growth of those that are not drought-tolerant. Assume a 2-year establishment period for herbaceous species, 3–5 years for shrubs, and 5 or more years for trees. Irrigation should be programmed according to stormwater inputs and/or soil moisture, according to the needs of each planting.

Weeding: Weeding should be done monthly during through the first full growing season. Weeds should be pulled to remove the root. Over the first few years 1–3, weeding should decline as the planted vegetation establishes. Managers should decide on monitoring and weeding frequency as appropriate; it is suggested that monitoring occur monthly through the first full growing season, then every 6–8 weeks during the second growing season, and so forth. Weeding should follow monitoring as appropriate.

Debris and sediment removal:

Streetscape plantings will collect litter, which will need to be removed on a regular basis. If streetscapes are used for stormwater control, sediment and debris removal should be scheduled after storm events and checked every spring. Managers should decide if more frequent checks are appropriate.

Plants: From the standpoint that some of the planting design may be experimental, if a particular plant species does not perform well, a substitute may need to be planted as a replacement or supplement.

Replace compost / mulch: Compost or mulch layers will need to be replaced on an as-needed basis.

ADDITIONAL RESOURCES

- [NACTO Urban Street Stormwater Guide](#)
- [2013 Eastern Washington Low Impact Development Guidance Manual](#)
- [2025 City of Spokane Stormwater Management Program Plan](#)



POLLINATOR GARDENS

Create habitat for insects, birds, and other small wildlife with opportunities in smaller herbaceous spaces

PURPOSE

Habitat opportunities for birds, insects, and other small wildlife can be met in restricted spaces with supportive elements such as pollen and nectar, deposit spots for larvae (e.g., milkweed for monarchs), and dense herbaceous vegetation. Small wildlife that use these spaces can in turn be food for other animals and ultimately increase local biodiversity. Locations not ideal for trees due to lack of space or irrigation can be planted with herbaceous species and be a diversity hot spot, also an alternative to paving.

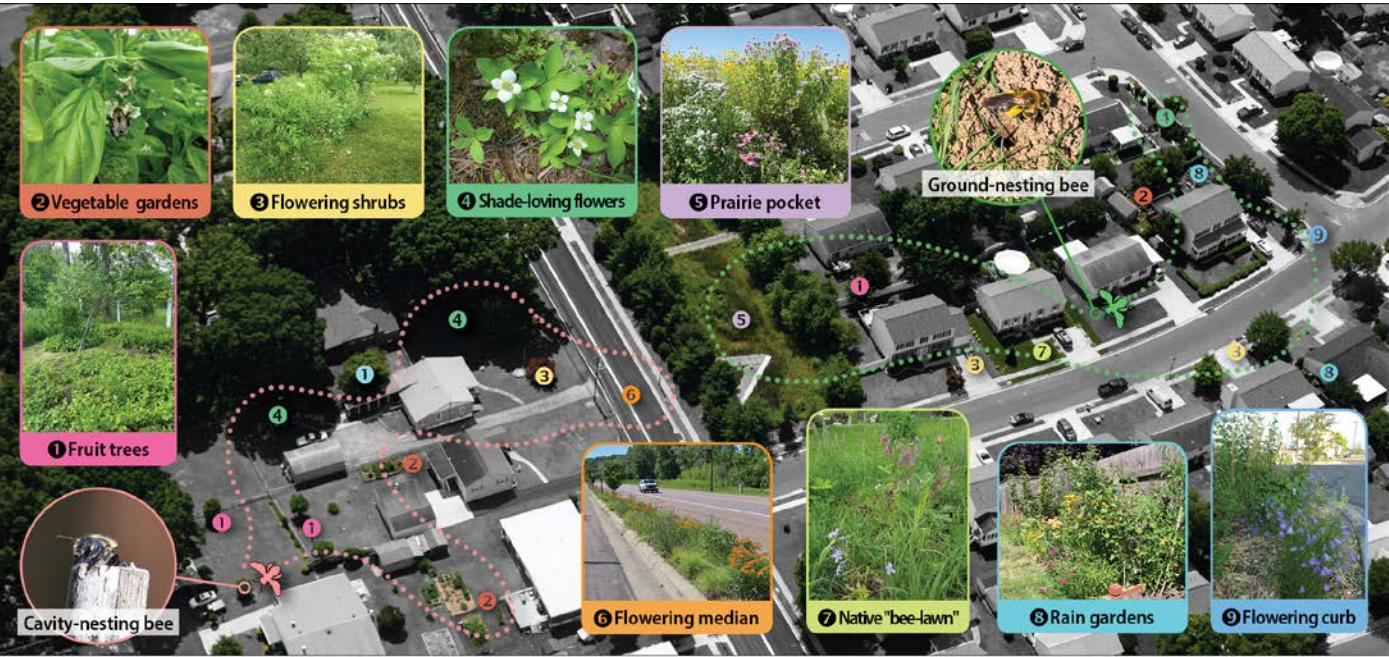


Figure 4.5. Source: © Xerces Society Pollinator Friendly Parks 2021. Credits: Nancy Lee Adamson (2), Sara Foltz Jordan (1,3,4,5,9), Toni Genberg (6), Emily May (7), Sara Morris (cavity-nesting bee), Matthew Shepherd (ground-nesting bee, 8), Will Parson, Chesapeake Bay Program / flickr.

ECOLOGICAL & WELL-BEING BENEFITS

- Biodiversity gains with habitat + resident wildlife.
- Stepping stones and corridors improve green network connectivity (Figure 4.5).
- Can help with stormwater management.
- Climate resilience via native & climate-adapted vegetation.
- Soils increase function, quality, and biodiversity over time.
- Design can ensure color throughout entire growing season.
- Look good even with heat, drought, excess rainfall. Improved aesthetic can support local businesses and increase property value.
- Local connection to place with native plantings.
- Cost savings via low-cost installation and low maintenance needs.

ECOLOGICAL DESIGN ELEMENTS & CONSIDERATIONS

Pollinator gardens can be an ideal option for limited spaces across a range of hydrologic conditions, from rain gardens to hell strips (or tree lawn, the narrow planting areas between sidewalks and streets). The central component of design is forbs, which are herbaceous (non-woody) species with showy flowers. Grasses, which support select pollinators, can make up some of the community, but forbs are a larger component of a pollinator garden mix than they are in an herbaceous meadow because they support so many pollinator species and bring a lot of color to a small area.

This habitat type can be the sole community designed for a project area or a vibrant understory for a tree canopy with the use of shade-tolerant species. The many species options of forbs allows design for vibrant blooms through the growing season. Native species are always recommended, but species adapted to increasingly warmer and drier conditions can be a good strategy in anticipation of climate change. Shrubs can also provide anchor points if space allows, and ground covers such as thyme can cover interstitial spaces, or these spaces can be devoted to ground-nesting bees. Design can also focus on a particular wildlife guild such as butterflies, and/or to provide year-round support to the greatest number of wildlife users.

Soil: Native herbaceous species are adaptable to a wide variety of soil types and conditions. If soil is considered “poor” (usually an agricultural term), amendments such as compost are not recommended, as they tend to encourage weeds. Native species can establish in poor soils and over time will enrich soil with root expansion, biomass turnover, and growth of microbial communities.

Although many native species can grow in minimal substrate, prairie species are known to develop substantial root biomass, often exceeding their aboveground biomass. Soils should be at least 8” deep (and if using shrubs, at least 18”). More rooting volume will support a more robust community.

Plant Selection & Habitat Types: See the Master Plant List (Appendix A) for appropriate species. The [Xerces Society](#) also has an extensive catalog of resources focused on pollinator support including many [specific to the Pacific Northwest](#). Don’t plant invasive species such as butterfly bush and lantana.

CONTEXT & SITE ANALYSIS

Pollinator gardens can be planted for virtually any setting in developed areas, but a wide variety of species (and color) will likely be most sustained in smaller areas where maintenance can be more focused. Like meadow community types, pollinator pockets can be very successful in parking lot margins, community parks and gardens, open space, spots that are awkward to mow, and trails and road sides.

Sizing: This planting type works in many settings, but very large pollinator gardens over time will probably become less diverse due to the practicalities of maintaining the site over the long term (see Maintenance Considerations below).

MAINTENANCE CONSIDERATIONS

Over the long term, the composition of a pollinator garden will reflect how closely it is maintained. Closely tended gardens, which are likely smaller, will maintain diversity and color due to frequent weeding and removal of encroaching rhizomatous grasses, whereas those receiving less attention will likely narrow their diversity to a small number of dominant species over time.

Seed can be raked into bare soil for establishment, and irrigation should be provided for the first couple of growing seasons to minimize stress and ensure root development. Irrigation can be delivered by truck or another temporary system.

Weed Management: Like irrigation, weed management will be a primary need in the early years of establishment. Monitor for and manage weeds monthly during through the first full growing season. Pull weeds to remove the root, and remove weedy material from the site. Over the first few years 1-3, weeding should decline as the planted vegetation establishes.



Source: Washington State Pollinator Garden. Credit: James Mahar

Managers should decide on monitoring and weeding frequency as appropriate; it is suggested that monitoring occur monthly through the first full growing season, then every 6-8 weeks during the second growing season, and so forth.

Pesticides should be a last resort. If pesticides must be used, use the most targeted product available and precise techniques.

Follow weeding with native reseeding or replanting in the disturbed area.

ADDITIONAL RESOURCES

- [Xerces Society](#)
- [Washington Native Plant Society Landscaping Resources](#)
- [Spokanescape Plant List](#)

4.2 PLANT COMMUNITY TYPES & PLANT PALETTES

Plants are the heart of living infrastructure and help tell the story of place by referencing historical vegetation, cultural plants, and the changing urban landscape (e.g., Spokanescape plant species). The purpose of this section is to help designers with plant selection and layout ideas for the various living infrastructure typologies. Five key plant communities inspired by the heritage landscapes discussed on pages 22–23 and 29 are listed in the table below and cross-referenced with appropriate typologies where they might occur.

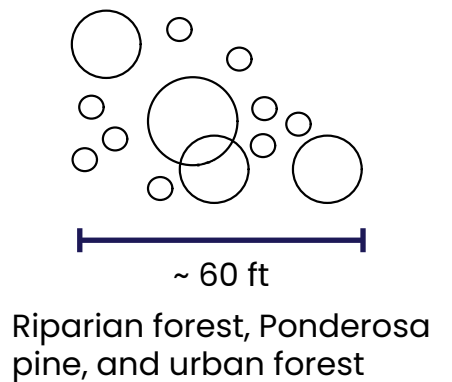
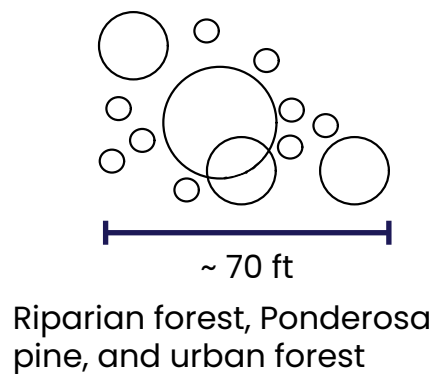
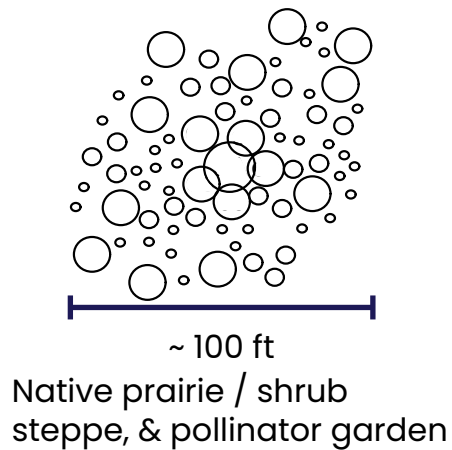
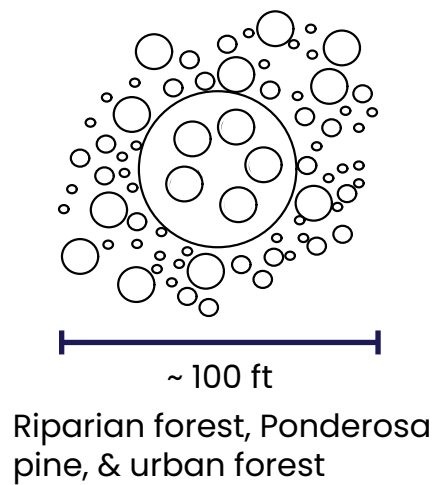
	Ecological Design Guide Typologies					
Plant Community	Waterfront & Riparian Forest	Resilient Parks & Open Space	Bioretention & Bioinfiltration	Meadow / Turf Conversion	Streetscape Greenways	Pollinator Gardens
Native Prairie / Shrub Steppe		✓	✓	✓	✓	
Pollinator Plantings	✓	✓	✓	✓	✓	✓
Riparian Forest	✓	✓				
Ponderosa Pine		✓			✓	
Urban Forest	✓	✓			✓	

Note: Shrub steppe plantings in Bioretention & Bioinfiltration should avoid woody species.

Installing plants in clusters rather than uniform spacing is recommended for a natural aesthetic as well as ecological function. Cluster planting is appropriate for all growth forms, i.e., trees, shrubs, and herbaceous species. It often works best when "field-fit" (by a person comfortable with the approach) according to species to be planted, how many of each as well and their growth form (i.e., tree, shrub, herbaceous), and on site conditions such as hydrology and topography. Some examples of how cluster planting might be laid out are below. Notice in most of these examples that each "pod" is anchored by a large tree, and clusters are planted around it.

Similar species should be planted in clusters of 3–5, with 1–1.5 feet separating each herbaceous individual in the cluster (recommended distance between shrubs of the same species depends on mature size of the shrub, but will generally be 3–5 feet). Appropriate distance between clusters should be judged in the field and depends on numerous site factors, but herbaceous clusters should probably be separated by at least 4 feet and shrub clusters by at least 8 feet.

The illustrations below are example cluster layouts for different plant communities discussed in this section. Larger circles represent trees, medium circles represent shrubs, and smaller circles are herbaceous or grasses.



NATIVE PRAIRIE & SHRUB STEPPE

Suited to Resilient Parks & Open Space, Streetscape Greenways, and herbaceous species to Bioretention & Bioinfiltration typologies

EXAMPLE PLANT PALETTE

Source: Wikimedia

SHRUBS



Big SagebrushAntelope BitterbrushRabbitbrush

GRASSES



Bluebunch WheatgrassNeedle and ThreadSquirreltailSandberg Bluegrass

FORBS



Nuttall's LarkspurLongleaf PhloxMariposa LilySilky LupineArrowleaf BalsamrootPursh's Locoweed

OVERVIEW

The prairie and shrub steppe plant community is a critical heritage habitats of the Columbia Plateau. Plants in this community are adapted to very low water and are heat-tolerant. This is also an important habitat type for pollinators.

Shrubs are the tallest component and provide habitat for ground-dwelling invertebrates. Herbaceous grasses and forbs provide erosion control and increase structural diversity. This typology can also be planted with herbaceous species only for a low-stature community.

Dominant native steppe species should establish well in low-water urban BMPs.



Source: <https://theplantnative.com/plant/rubber-rabbitbrush/>

POLLINATOR PLANTINGS

Suited to all Living Infrastructure typologies

EXAMPLE PLANT PALETTE

Source: Wikimedia

SHRUBS



Orange Honeysuckle Apache plume Hummingbird Mint Red-Flowering Currant Hairy Manzanita

HERBACEOUS



Sunflower Purple Sage Missouri Goldenrod Pale Evening Primrose Milkweed



Buckwheat Blanket Flower Broadleaf Stonecrop Munroe's Globemallow

OVERVIEW

This community type is focused on butterflies, beetles, native bees, and hummingbirds. Pollinator support plants are many, tend to be showy (although not always), and can be herbaceous or woody.

Pollinator gardens can be designed to meet different objectives, including water constraints, supporting specific pollinator guilds, and/or continuous blooming (see example bloom schedule in Appendix). They are well suited for transformation of non-functional turf areas for water conservation and habitat enhancement.

A layout example with additional species is the [native pollinator garden](#) designed by the WA Native Plant Society



Source: WCMGA Education Garden at PCC Rock Creek

RIPARIAN FOREST

Suited to Waterfront & Riparian Forest typologies

EXAMPLE PLANT PALETTE

Wetter Species

Drier Species

Source: Wikimedia

TREES



Black Cottonwood

Bigleaf Maple

Sitka Spruce

Western Hemlock

Red Alder

UNDERSTORY



Black Twinberry

Salmonberry

Serviceberry

Elderberry

Indian Plum

HERBACEOUS



Large-leaved Avens

Tufted Hairgrass

Maidenhair Fern

Great Camas

Fringed Willowherb

OVERVIEW

Riparian habitats (Figure 4.6) are important heritage ecosystems appropriate for buffer locations between waterfronts and uplands. They are important to both biodiversity and water quality by providing structurally complex vegetation, woody debris, and shade; cooling the water and the understory; filtering pollutants and nutrients from upland runoff before it drains into the river; and protecting streambanks from erosion. See the [Spokane Conservation District](#) for more information on healthy riparian areas and links to further information.

Riparian forest is ideally a multi-tier and highly biodiverse system, although structure can be modified in user areas where water access is also a priority. The active hydrology of natural riparian systems makes them adapted to periodic stress and regeneration.

Ideally, the width of the riparian forest along the Spokane River should be at least 200 feet wide, which maximizes habitat and water quality benefits. While the opportunities to restore this much riparian area are limited, it is recommended that UD managers continue to be watchful for possible areas to expand this important habitat type.

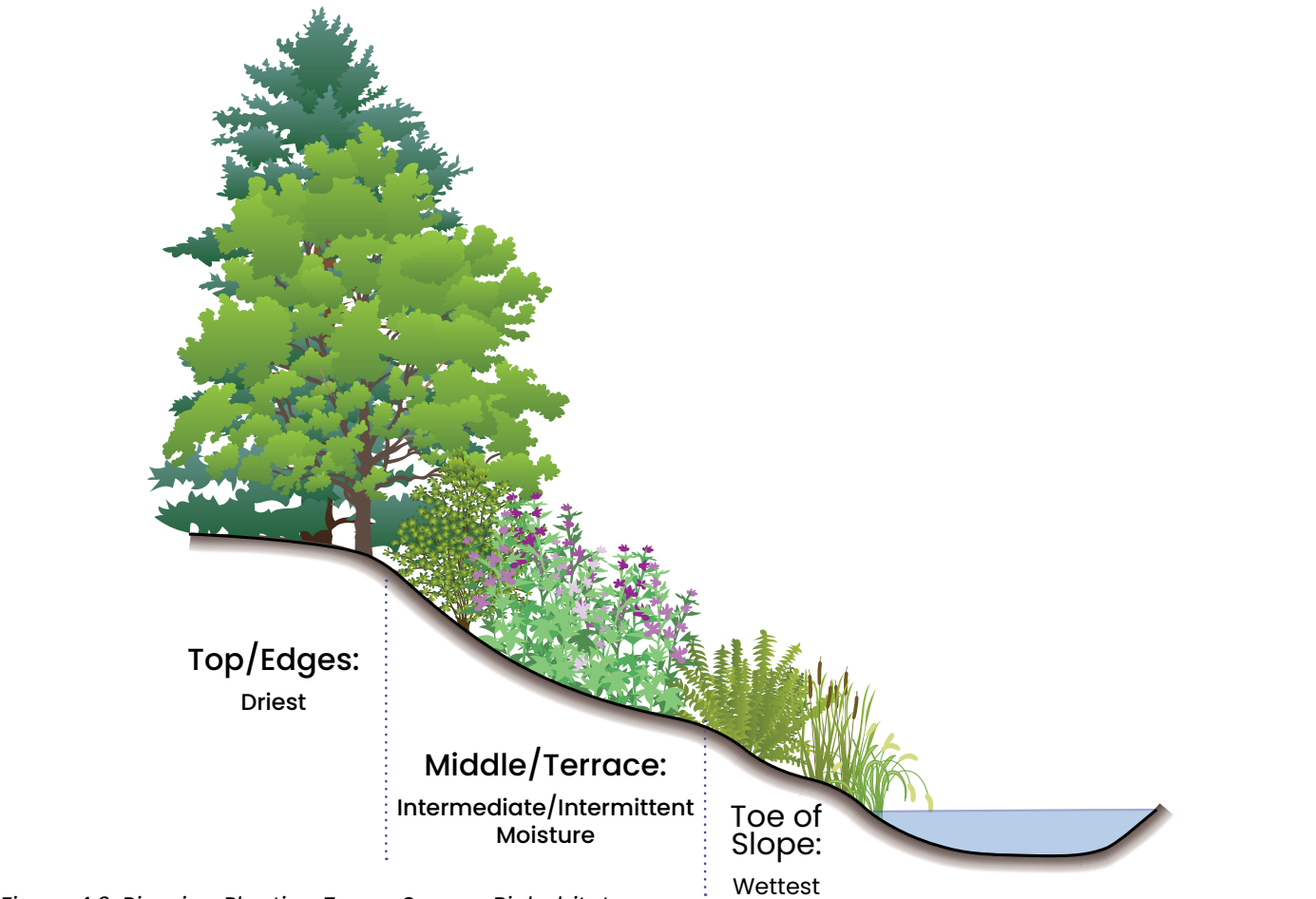


Figure 4.6. Riparian Planting Zones. Source: Biohabitats.

PONDEROSA PINE GROVE

Suited to Resilient Parks & Open Space typologies

EXAMPLE PLANT PALETTE

Source: Wikimedia

TREES



Ponderosa Pine Pinyon Pine Bristlecone Pine

SHRUBS



Juniper Buffaloberry Oregon Grape Kinnikinnick Nootka Rose

HERBACEOUS



Blue Fescue Little Bluestem Nodding Onion Black-Eyed Susan Prairie Smoke

OVERVIEW

Ponderosa-dominant woodland grove patches are important both as a heritage habitat and as a strategy for providing shade where water availability is low. Historic systems had widely spaced trees, but in the UD they could be planted as multi-tier systems for more cover and higher diversity.



Source: Wikimedia

URBAN FOREST

Suited to Streetscape Greenways, Waterfront & Riparian Forest and Resilient Parks & Open Space typologies

EXAMPLE PLANT PALETTE

Source: Wikimedia

TREES



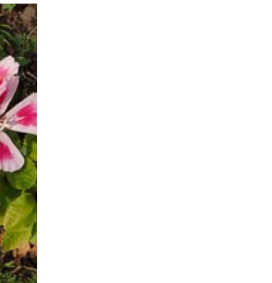
Honey Locust Scarlet Oak Kentucky Coffeetree Red Oak Bur Oak Catalpa

SHRUBS



Red-osier Dogwood Nootka Rose Oregon Grape Kinnikinnick Snowbrush Coast Penstemon

HERBACEOUS



Balsamroot Wild Strawberry Showy Jacob's Ladder Yarrow Satin Flower Farewell to Spring

OVERVIEW

Urban-adapted trees can provide good shade and biodiversity opportunities, are suitable for a variety of contexts, and can meet different needs by modifying tree size, density, and other design elements (Figure 4.7). The breadth of planting options allows design to be tailored to local hydrology, and design should select species that are naturalized and/or suitable for the specific hydrology of the BMP. Native and naturalized species should be able to function well alongside native species and provide additional niches to complement diversity.

Spokane’s [approved street trees](#) includes indications of whether species are appropriate for stormwater areas. The Appendix contains a table summarizing those recommended by Spokane’s Urban Forestry Department that are also appropriate for stormwater areas, and they are further organized by size.

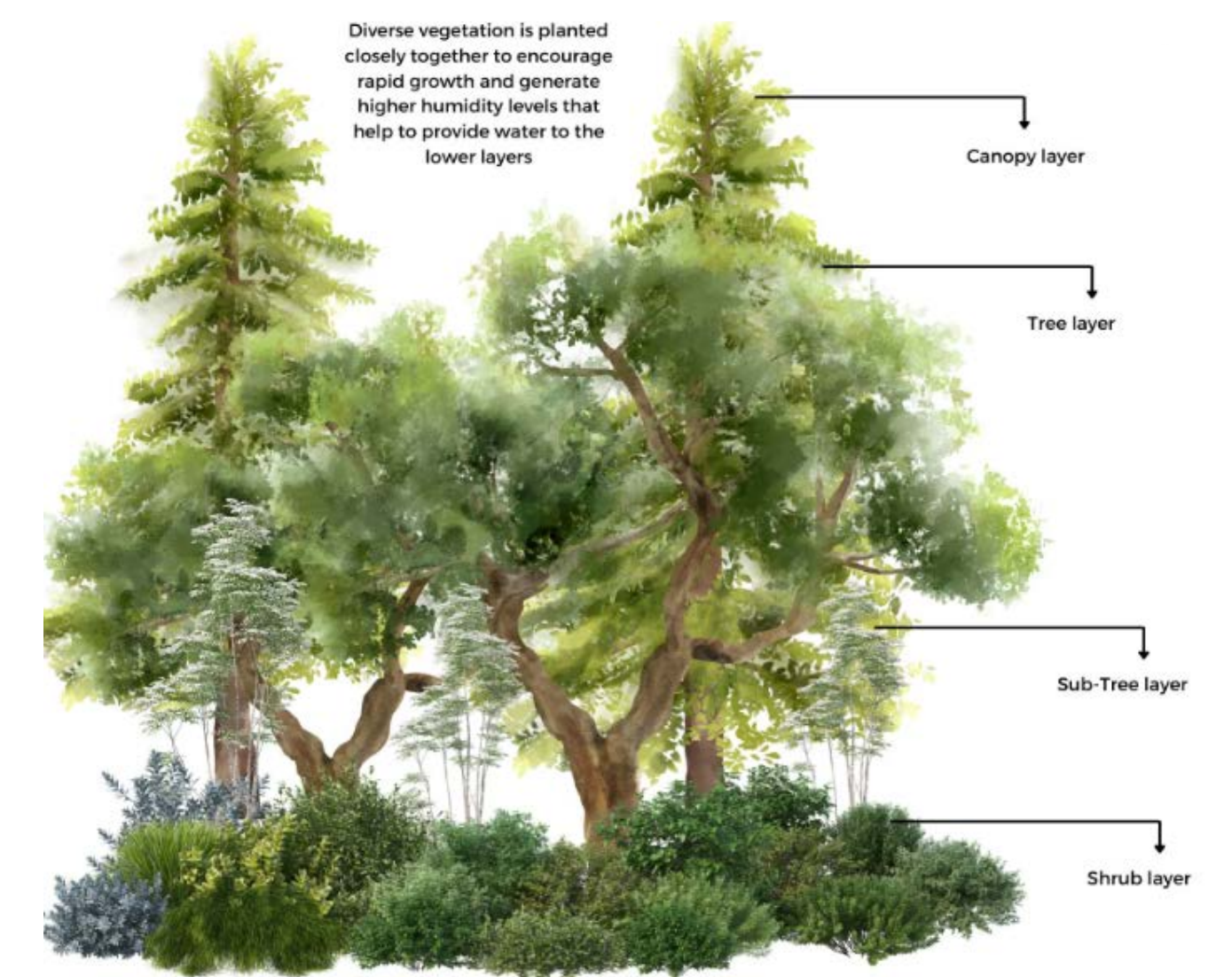


Figure 4.7. Layers of a Miyawaki Forest. Source: Geographyrealm.com. Credit: Catlin Dempsey.

4.3 Stewardship & Adaptive Management

One of the greatest resources in the UD is the diverse and thriving consortium of Universities. Unified around learning and supporting current and future generations, this community is an ideal place to create partnerships, foster stewardship, and bring the community even closer together. Youth corps groups and non-profits could expand partnerships with schools. Types of opportunities could include single-day workshops and cleanup events, research, adopt-a-space initiatives, pilot projects, citizen science, and more.

In addition to University partnerships, the State of Washington has an incentive program for private property owners to design, build, and maintain green stormwater infrastructure. This [Public-Private Partnership](#) is intended to offer a community-based approach to reducing stormwater pollution and building green space.

Because living infrastructure features are dynamic and changing, we recommend an adaptive management plan to support ongoing observations and discovery, awareness of the space over time and how people use it, and deep appreciation of this landscape and its evolution. The adaptive management plan should be developed after design is complete and before implementation work has begun.

An effective adaptive management plan will address ongoing support of existing desirable conditions as well as enhanced areas and include:

- (a) assessment schedules, with more frequent observations in early stages tapering to less frequent over time (see Table 1 for an example),
- (b) decision points based on field observations, and
- (c) recommended management actions when necessary.

Plan content will be guided by restoration treatments as well as ongoing concerns such as off-trail use and new occurrences of invasive species.

The plan can be organized in a table such as that shown in Table 2. A table like this is accompanied by narrative explaining the purposes of the adaptive management plan and relationship to living infrastructure areas, and managers or volunteers to lead the actions. A collective review of progress across the UD could be held annually or semi-annually to facilitate impact reporting and collaborative initiatives..

With site establishment, including some needs that diminish over time and others that emerge, an adaptive management plan should be updated every 3-5 years to be most responsive to existing conditions.

Table 1. Example monitoring schedule for a stewardship plan (Houston, TX).

Frequency	Monitoring
Continuous	Any recent revegetation
	Camera traps
Weekly	Responses in website forum to users' comments and questions
Monthly	Survival of new container plantings (monthly after installation for 6 months, then at 1 year)
	Erosion (monthly and after storm events and water releases from upstream); Off-trail use
	Organized community monitoring
	Website postings of activities, findings, management decisions, and adjustments to stewardship schedule; Evaluate signs for damage
Quarterly	Pollinator counts
Every 6 months	Climate planning research updates
Annual	Percent cover of native species by growth form Percent cover of non-native species by growth form Encroachment of woody species or vines in herbaceous habitats
TBD	Wildlife surveys

Table 2. Example adaptive management framework (Houston, TX).

Monitoring Frequency, Methods, & Indicators	Action Threshold	Management Actions
Objective: Increase native plant species cover and diversity		
<i>Indicators:</i> Percent cover of native species by growth form (canopy trees, mid-story trees, shrubs, herbaceous, vines) <i>Methods:</i> Survey each area on foot to visually estimate values site-wide. <i>Frequency:</i> Annual	Within a growth form, native species are <75% or have decreased by ≥10% of the last monitoring value (i.e., if the prior year cover of native shrubs was 80% and this year it is 71%, then management is warranted because 10% of 80 is 8).	Evaluate cause of decline and address source if possible. Reseed and/or replant with native species. Prioritize areas of bare soil, and prioritize planting species with broader tolerances to hotter temperatures and both wetter and drier conditions. Adhere to Flood Control District installation specs.
<i>Indicator:</i> Percent cover of non-native species by growth form (canopy trees, mid-story trees, shrubs, herbaceous, vines) <i>Methods:</i> Survey each area on foot to visually estimate values site-wide and at 4 m2 patch size. <i>Frequency:</i> Annual	Within a growth form, within a CMU, total non-native species cover is ≥20% Any patch ≥4 m2 where non-native species cover is ≥20% Any occurrence of a state-listed noxious weed	Weed control according to BBP best management practices. Integrated Pest Management prioritizing non-chemical control is preferred. Where herbicide use is most effective, spot- rather than broadcast-spray. Reseed and/or replant (see cell above).
<i>Indicator:</i> Encroachment of woody species or vines in grasslands or wildflower meadows <i>Methods:</i> Survey each area on foot to visually track for woody species and/or vines. Pay special attention to edges. Mark with flagging (and GPS if helpful), add notes to field form. <i>Frequency:</i> Annual	Any vines or seedlings or saplings of trees or shrubs. Mature trees may be left as landscape relics.	Remove woody seedlings and saplings with root extractor (such as an Uprooter) tool. Assess whether adjacent habitat (e.g., forest) should be cleared within several meters of margin.
<i>Indicators:</i> Survival of new container plantings by growth form (canopy trees, mid-story trees, shrubs, herbaceous) <i>Methods:</i> Track new individual installed plants with flagging, pin flags, and GPS (if helpful). Count individuals at each monitoring. <i>Frequency:</i> Monthly after installation for 6 months, then at 1 year.	Fewer than 85% of installed container plants are surviving or accounted for within a growth form or CMU.	Replace with same or another native species. Attempt to maximize species diversity with replacement plantings, prioritizing species with broader tolerances to hotter temperatures and both wetter and drier conditions.

Monitoring Frequency, Methods, & Indicators	Action Threshold	Management Actions
Objective: Increase community diversity by establishing/expanding wetlands		
<i>Indicators:</i> occurrences of wildlife species of concern <i>Methods:</i> camera traps, surveys by qualified herpetologist <i>Frequency:</i> cameras continuous, herp surveys per specialist advice	Any decreases in species population numbers from one year prior Any novel observations of species	Decreases: evaluate why population has decreased and address this cause if possible. Consult with Division of Wildlife and/or wildlife specialist. Novel species observations: - Establish habitat protections from users, managers, and management actions. - Change action threshold to monitor decreases in populations
Objective: Enhance native habitat for wildlife species of concern, migratory birds, and other wildlife conservation targets		
<i>Indicators:</i> Numbers of non-pest native and/or high-value or charismatic bird species <i>Methods:</i> - Day and night sound recordings, maintain species list in database. Species can be identified with Merlin® Bird Sound ID. - Monitor iNaturalist for community observations and monthly comparisons. <i>Frequency:</i> monthly, 12 mo/yr. Coordinating with the Audubon Christmas bird count can also engage stakeholders.	Compared to the same month from one year prior: Number of non-pest native bird species decreases by ≥10% High-value or charismatic local bird species are not observed	This will be species-dependent and may require consultation with an ornithologist. For species-specific concerns a first management action is to ensure that adequate habitat conditions are available; increasing appropriate habitat, e.g., subcanopy trees, may be an appropriate action.
<i>Indicators:</i> Counts of pollinators by guild (bats, bees, hummingbirds, butterflies, moths, wasps, flies, and beetles) and species when possible. <i>Methods:</i> - Monitor iNaturalist for community observations and quarterly comparisons.⁵ - For in-house monitoring the Xerces Society offers resources specific to Texas as well as surveying guidance. Surveys should be passive and not harm any pollinators. <i>Frequency:</i> quarterly	Within any CMU, guild numbers decrease by ≥10% compared to the same month from one year prior.	Plant more pollinator support species such as milkweed (for monarchs), diverse forbs, and flowering shrubs. Consult with the Xerces Society , Texas Wildlife & Parks Department , or other specialists to determine cause of decline. Possibilities could be habitat loss (e.g., specific nectar or larval plant species), light pollution, and pesticide use. Refer to Texas pollinator habitat improvements to identify actions that may improve pollinator habitat in the CMU of concern.



APPENDICES

A. UD Master Plant List

Species suggestions appropriate for different living infrastructure typologies in the Spokane University District. **List is not comprehensive;** also refer to sources in guide such as [Spokanescape](#), [Xerces Society](#), [Eastern Washington LID Guidance](#), and others.

Typologies

- Bioretention & bioinfiltration (**B**): Woody species are not recommended for this typology because their roots could interfere with drainage.
- Pollinator gardens: All herbaceous species are appropriate, and forbs should have more cover than grasses. but should have less than 10% cover.
- Meadow / turf conversion: All herbaceous species are appropriate, with recommended grass to forb cover of approximately 70:30%. Shrubs can also be used.
- Parks & Open Space (**P**): Any species are appropriate that meet the objectives of the site (e.g., shade, water conservation, color, etc.).
- Streetscape Greenways (**S**): The Spokane Department of Urban Forestry classifies tree recommendations for their appropriate uses (see table subheaders). In general, trees recommended for the UD will not have extremely tall stature and will be drought-tolerant. See greater detail in table.
- Waterfront & Riparian Forest (**W**). Most appropriate species for riparian areas range in water demand so this is a highly diverse community.

Moisture needs are on a scale of 1–5 where 1 is an upland plant and 5 is an obligate wetland plant requiring saturated soils. This is based on the Natural Resources Conservation Service wetland indicator status.

Approval: **SS** – Spokanescape, **UF** – Spokane Department of Urban Forestry

WOODY SPECIES						
SCIENTIFIC NAME COMMON NAME	APPROPRIATE TYPOLOGIES	HEIGHT	SPREAD	TREE CROWN FORM	MOISTURE NEEDS (NRCs)	APPROVAL
TALL CANOPY TREES						
40-120' TALL, 10-90' BROAD (URBAN FORESTRY CLASS III FOR PARKING STRIPS OVER 8 FT WIDE)						
<i>ALNUS RUBRA</i> RED ALDER	PW	60-90			4	
<i>CATALPA SPECIOSA</i> NORTHERN CATALPA	PW	40-60'	20-40'	I	2	SS, UF
<i>CATALPA X ERUBESCENS 'PURPUREA'</i> PURPLE CATALPA	PSW	40-45'	40'	R		UF
<i>CELTIS 'MAGNIFICA'</i> MAGNIFICA HACKBERRY	PSW	50'	40'	O, V		UF
<i>FAGUS SYLVATICA</i> EUROPEAN BEECH	PSW	50-100'	40-50'	O, R	1	UF
<i>GYMNOCLADUS DIOICUS</i> KENTUCKY COFFEETREE	PSW	60-75'	40-50'	I	1	SS, UF
<i>JUGLANS SP.</i> WALNUT (BUTTERNUT, BLACK AND ENGLISH)	PS	40-45'	50-75'	S	1, 2	UF
<i>LIRIODENDRON TULIPIFERA</i> TULIPTREE	PW	70-120'	35-80'	R	2	UF
<i>MAGNOLIA ACUMINATA</i> CUCUMBERTREE MAGNOLIA	PW	50-80'	40-80'	P, O	2	UF
<i>METASEQUOIA GLYPTOSTROBOIDES</i> DAWN REDWOOD	PSW	70-100'	25'	P	1	UF
<i>PINUS PONDEROSA</i> PONDEROSA PINE	PW	60-120'	25-40'	P, I	2	UF
<i>PICEA SITCHENSIS</i> SITKA SPRUCE	PW	100-200'			3	
<i>PLATANUS X ACERIFOLIA</i> LONDON PLANETREE	PSW	70-100'	65-80'	R		UF
<i>POPULUS TRICHOCARPA</i> BLACK COTTONWOOD	PW	70-100'				
<i>QUERCUS ALBA</i> WHITE OAK	PW	50-80'	50-80'	P, R	2	UF
<i>QUERCUS BICOLOR</i> SWAMP WHITE OAK	PW	50-60'	50-60'	P, R	4	UF
<i>QUERCUS COCCINEA</i> SCARLET OAK	PS	50-70'	40-50'	R	1	SS, UF
<i>QUERCUS IMBRICARIA</i> SHINGLE OAK	PS	50-60'	50-60'	P, R	2	UF
<i>QUERCUS MACROCARPA</i> BUR OAK / MOSSYCUP OAK	PS	70-80'	70-90'	I	2	SS, UF

WOODY SPECIES

SCIENTIFIC NAME COMMON NAME	APPROPRIATE TYPOLOGIES	HEIGHT	SPREAD	TREE CROWN FORM	MOISTURE NEEDS (NIRCS)	APPROVAL
<i>QUERCUS ROBUR</i> ENGLISH OAK	PS	75-100'	10-60'	C, R	1	SS, UF
<i>QUERCUS RUBRA</i> RED OAK	PW	60-75'	60- 75'	R	2	SS, UF
<i>QUERCUS SHUMARDII</i> SHUMARD OAK	PW	40-60'	40'	O, R	2, 3	UF
<i>SEQUOIA DENDRON GIGANTEUM</i> GIANT SEQUOIA	PSW	60-100'	20- 30'	P, S	1	UF
<i>TAXODIUM DISTICHUM</i> BALD CYPRESS	PW	50-60'	20- 30'	P, C, S, I	5	UF
<i>TSUGA HETEROPHYLLA</i> WESTERN HEMLOCK	PW	120- 170'			2	
<i>ZELKOVA SERRATA</i> JAPANESE ZELKOVA	PS	40-45'	20- 40'	C, V, R	1	UF

MEDIUM-HEIGHT CANOPY TREES

15-70' TALL, 10-70' BROAD (URBAN FORESTRY CLASS II FOR PARKING STRIPS)

<i>ACER CAMPESTRE</i> HEDGE MAPLE	PS	25-35'	25- 35'	R	1	UF
<i>ACER MACROPHYLLUM</i> BIGLEAF MAPLE	PW	30-60'			2	
<i>ACER MIYABEI</i> MIYABE MAPLE	PS	50-55'	35- 40'	C, O, R		UF
<i>CELTIS OCCIDENTALIS</i> HACKBERRY	PW	45'	35'	R, S	2	SS, UF
<i>CERCIDIPHYLLUM JAPONICUM</i> KATSURATREE	PS	40-60'	30- 50'	P, S, R	1	UF
<i>EUCOMMIA ULMOIDES</i> HARDY RUBBER TREE	PS	40-60'	40- 60'	R, C		UF
<i>GLEDITSIA TRIACANTHOS</i> VAR. <i>INERMIS</i> THORNLESS HONEYLOCUST	PW	30-70'	30- 70'	R, S	3	SS, UF
<i>LIRIODENDRON TULIIFERA</i> 'EMERALD CITY' EMERALD CITY TULIPTREE	PW	55'	25'	O, R	2	UF
<i>MAGNOLIA VIRGINIANA</i> 'JIM WILSON' MOONGLOW MAGNOLIA	PW	15-35'	10-15'	C, P, I	4- 5	UF
<i>NYSSA SYLVATICA</i> TUPELO OR BLACK GUM	PW	30-50'	20- 30'	P, I, R	3	UF
<i>PINUS ARISTATA</i> BRISTLECONE PINE	PS	20'	20'		1	SS
<i>PINUS EDULIS</i> PINYON PINE	PS	25'	20'	R	1	SS
<i>QUERCUS ACUTISSIMA</i> SAWTOOTH OAK	PSW	40-60'	45'	P, R	1	UF
<i>QUERCUS FRAINETTO</i> 'SCHMIDT' FOREST GREEN OAK	PSW	50'	30'	O	1	UF

WOODY SPECIES

SCIENTIFIC NAME COMMON NAME	APPROPRIATE TYPOLOGIES	HEIGHT	SPREAD	TREE CROWN FORM	MOISTURE NEEDS (NIRCS)	APPROVAL
<i>QUERCUS MACROCARPA</i> 'JFS-KW3' URBAN PINNACLE OAK	P W	50'	25'	C	2	UF
<i>QUERCUS MUEHLENBERGII</i> CHINKAPIN OAK	P W	40-45'	45'	R	2	UF
<i>QUERCUS ROBUR X BICOLOR</i> 'LONG' REGAL PRINCE OAK	P S	45'	18'	C	1	UF
<i>ULMUS X 'FRONTIER'</i> FRONTIER ELM	P S	40'	30'	P, V		UF
<i>ULMUS PROPINQUA</i> 'JFS-BIEBERICH' EMERALD SUNSHINE ELM	P S W	40'	25'	V		UF
<i>ULMUS WILSONIANA</i> 'PROSPECTOR' PROSPECTOR ELM	P S W	40'	30'	V	1	UF
<i>ZELKOVA SERRATA</i> JAPANESE ZELKOVA	P S	40'	30'	V	1	UF
<i>ZELKOVA SERRATA</i> 'MUSASHINO' MUSASHINO COLUMNAR ZELKOVA	P S	45'	15'	C	1	UF

SMALL TREES AND SHRUBS

TREES 15-30' TALL, 5-30' BROAD (URBAN FORESTRY CLASS I FOR UNDER POWER LINES)

<i>ACER GLABRUM</i> ROCKY MOUNTAIN MAPLE	Any except B	25'	10-20'	C	2	SS, UF
<i>AGASTACHE SP.</i> GIANT HYSSOP	Any except B				1	
<i>AMELANCHIER ALNIFOLIA</i> SERVICEBERRY	Any except B	6-15'	5-8'			SS
<i>AMELANCHIER LAEVIS</i> ALLEGHENY SERVICEBERRY	Any except B	15-25'	15-25'	R	1	UF
<i>AMELANCHIER X GRANDIFLORA</i> APPLE SERVICEBERRY	Any except B	15-25'	15-25'	R		SS, UF
<i>ARCTOSTAPHYLOS COLUMBIANA</i> HAIRY MANZANITA	Any except B	6'			1	
<i>ARCTOSTAPHYLOS UVA-URSI</i> KINNIKINNICK	Any except B	1'	3'		2	SS
<i>ARTEMISIA TRIDENTATA</i> BIG SAGEBRUSH	Any except B	4'			1	SS
<i>CARPINUS CAROLINIANA</i> AMERICAN HORNBEAM	Any except B	20-30'	15-25'	R, C	3	UF
<i>CEANOTHUS VELUTINUS</i> SNOWBRUSH	Any except B	8'	10'		1	
<i>CORNUS SERICEA</i> RED-OSIER DOGWOOD	Any except B	10'	15'		3	
<i>ERICAMERIA NAUSEOSA</i> / <i>CHRYSOETHAMNUS</i> <i>VISCIDIFLORUS</i> RABBITBRUSH	Any except B	4'			1	
<i>FALLUGIA PARADOXA</i> APACHE PLUME	Any except B	4-6'	4-6'		1	SS

WOODY SPECIES

SCIENTIFIC NAME COMMON NAME	APPROPRIATE TYPOLOGIES	HEIGHT	SPREAD	TREE CROWN FORM	MOISTURE NEEDS (NRCS)	APPROVAL
<i>HALESIA CAROLINA</i> CAROLINA SILVERBELL	Any except B	20-30'	20-30'	C, R	2	UF
<i>JUNIPERUS COMMUNIS</i> COMMON JUNIPER	Any except B	4'			2	SS
<i>LONICERA CILIOSA</i> ORANGE HONEYSUCKLE	Any except B				1	
<i>LONICERA INVOLUCRATA</i> (BLACK) TWINBERRY HONEYSUCKLE	Any except B	10'			3	
<i>MAACKIA AMURENSIS</i> AMUR MAACKIA	Any except B	20-30'	20'	R	1	UF
<i>MAHONIA REPENS</i> OREGON GRAPE	Any except B	2'	3'		1	SS
<i>MALUS</i> SP. FLOWERING CRABAPPLE	Any except B	15-25'	Var.	I		UF
<i>OEMLERIA CERASIFORMIS</i> INDIAN PLUM	Any except B	5-20			2	
<i>OSTRYA VIRGINIANA</i> AMERICAN HOPHORNBEAM	Any except B	25-30'	20-30'	R	2	UF
<i>PENSTEMON SERRULATUS</i> COAST PENSTEMON	Any except B	2'			1	
<i>PURSHIA TRIDENTATA</i> ANTELOPE BITTERBRUSH	Any except B	6			1	
<i>RIBES SANGUINEUM</i> RED FLOWERING CURRANT	Any except B	6'	4'		1	SS
<i>ROSA NUTKANA</i> NOOTKA ROSE	Any except B	5'	5'		2	
<i>RUBUS SPECTABILIS</i> SALMONBERRY	Any except B	12			3	
<i>SAMBUCUS</i> SP. ELDERBERRY	Any except B	15'	8-10'		2	SS
<i>SHEPHERDIA ARGENTEUS</i> SILVER BUFFALOBERRY	Any except B	6'	4-6'		2	SS
<i>SYRINGA RETICULATA</i> JAPANESE OR PEKING TREE LILAC	Any except B	15-25'	15-25'	O, R	1	UF
<i>STYRAX OBASIA</i> FRAGRANT SNOWBELL	Any except B	25'	20'	R, O		UF
<i>TAXODIUM DISTICHUM</i> 'LINDSEY'S SKYWARD' LINDSEY'S SKYWARD BALD CYPRESS	Any except B	20-25'	5-10'	C	5	UF
<i>ZELKOVA SERRATA</i> 'JFS-KWI' P.P.A.F. CITY SPRITE™ ZELKOVA	Any except B	24'	18'	V, O	1	UF

HERBACEOUS

APPROPRIATE FOR ANY TYPOLOGY WITH SUPPORTIVE HYDROLOGY

SCIENTIFIC NAME COMMON NAME	HEIGHT	SPREAD	FOR FLOWER COLOR	MOISTURE NEEDS (NRCS)	APPROVAL
<i>ACHILLEA MILLEFOLIUM</i> YARROW	1.5-2'	1.5-2'	(white flower)	2	SS
<i>ADIANTUM X TRACYI</i> MAIDENHAIR FERN	fern				
<i>ALLIUM CERNUUM</i> NODDING ONION	1'	1'		2	
<i>ASCLEPIAS SPP.</i> MILKWEED	2-3'			1-3	SS
<i>ASTRAGALUS PURSHII</i> PURSH'S LOCOWEED	inches			1	
<i>BALSAMORRHIZA SAGITATA</i> ARROWLEAF BALSAMROOT	2			1	
<i>CAMASSIA LEICHTLINII</i> GREAT CAMAS	2-3'	1-2'		4	
<i>CALOCHORTUS MACROCARPUS</i> MARIPOSA LILY	1.8			1	
<i>CLARKIA AMOENA</i> FAREWELL TO SPRING	0.5'			1	
<i>DELPHINIUM NUTTALLIANUM</i> NUTTALL'S LARKSPUR				3	
<i>DESCHAMPSIA CESPITOSA</i> TUFTED HAIRGRASS	3'		grass	4	
<i>ELYMUS ELYMOIDES</i> SQUIRRELTAIL	1.5'		grass	2	SS
<i>EPILOBIUM CILIATUM</i> FRINGED WILLOWHERB				4	
<i>ERIOGONUM SPP.</i> BUCKWHEAT	6-10"		(white flower)	1	SS
<i>FESTUCA GLAUCA</i> BLUE FESCUE	2.5'		grass	1	SS
<i>GAILLARDIA ARISTATA</i> BLANKETFLOWER	1'	2.25'		1	SS
<i>GEUM MACROPHYLLUM</i> LARGE-LEAVED AVENS	2'			4	
<i>GEUM TRIFLORUM</i> PRAIRIE SMOKE	0.5'	1.5'		2	SS
<i>HELIANTHUS SPP.</i> SUNFLOWER				1	
<i>HESPEROSTIPA COMATA</i> NEEDLE AND THREAD			grass	1	
<i>LUPINUS SERICEUS</i> SILKY LUPINE	2'			1	SS

HERBACEOUS					
APPROPRIATE FOR ANY TYPOLOGY WITH SUPPORTIVE HYDROLOGY					
SCIENTIFIC NAME COMMON NAME	HEIGHT	SPREAD	FOR FLOWER COLOR	MOISTURE NEEDS (NRCS)	APPROVAL
<i>OENOTHERA PALLIDA</i> PALE EVENING PRIMROSE	2'		(white flower)	1	
<i>PHLOX LONGIFOLIA</i> LONGLEAF PHLOX	1.2'		(white flower)	1	
<i>POLEMONIUM POLCHERRIMUM</i> JACOB'S LADDER	1'			1	
<i>POA SECUNDA</i> SANDBERG BLUEGRASS	1.5'		grass	2	
<i>PSEUDOROEGNERIA SPICATA</i> BLUEBUNCH WHEATGRASS	1.5'	1.5'	grass	1	SS
<i>RUDBECKIA SPP.</i> BLACK-EYED SUSAN	2.5'	2.5'		2	SS
<i>SALVIA DORRII</i> PURPLE SAGE	2'	2'		1	SS
<i>SEDUM SPATHULIFOLIUM</i> STONECROP	inches				SS
<i>SCHIZACHYRIUM SCOPARIUM</i> LITTLE BLUESTEM	2'	1.5'	grass	1	SS
<i>SOLIDAGO MISSOURIENSIS</i> MISSOURI GOLDENROD	3'			1	
<i>SPHAERALCEA MUNROANA</i> MONRO'S GLOBEMALLOW	2.5'	1.5'		1	SS

B. Living Infrastructure Framework Technical Memorandum

UNIVERSITY DISTRICT

LIVING INFRASTRUCTURE FRAMEWORK

TECHNICAL MEMORANDUM

Prepared for: Juliet Sinisterra, CEO – University District

Prepared by: Biohabitats, Inc

Date: January 2026

This purpose of this memorandum is to provide supplemental background information, analysis, and findings used to develop the Living Infrastructure Framework. Pilot project concepts are included to demonstrate how to integrate ecological function into stormwater best management practices and catalyst projects identified in other plans.

1. INTRODUCTION

1.1 RELATIONSHIPS TO OTHER PLANS

Several diverse UD plans have been prepared over the last 20 years by leaders in engineering, economics, and design of urban transformation projects (see Figure 1 examples). In these recent documents, such as *U Vision 2044 Strategic Plan* (2023) and *Next Generation plan* (2024, summarized below), early efforts covered strategic planning (2004), Sprague Corridor opportunities (2012), a market assessment (2014), a redevelopment strategy (2015), and visioning workshops (2016). Takeaways from the more recent and applicable documents are briefly described here to highlight how they informed the current plan.



Figure 1 Example selection of recent planning documents reviewed for the current project.

NEXT GENERATION PLAN (2024)

The *Next Generation Conceptual Plan 2065* (Mithun 2024) highlighted the importance of green infrastructure and conservation. It identified six key planning nodes (Figure 2) organized by three concepts:

- ***Reveal and Learn*** — Main Avenue Arts and Culture Corridor and the Sherman Heart and Cycle of Life Food Hub
- ***Rewild*** — Heal the River and Reforest and Sprague Way Trail
- ***Rise Together*** — Multi-Cultural Maker University District and the Innovation Commons

The Next Generation Plan also clarified the UD's goal of having 30% (231 acres) open space and tree canopy coverage, not including University open space. The UD currently has 128 acres of combined open space and riparian buffer. The Next Generation Plan proposed 65 acres of new open space and 8 acres of green infrastructure improvements. Additional conversion to open space and green infrastructure will be needed to meet the 231 acres.



Figure 2. 2065 Vision including six planning nodes from the 2024 Next Generation Plan.

ECOLOGICAL ASSETS AND PERFORMANCE STANDARDS STUDY (2024)

The recommendations and concepts of this Living Infrastructure Framework (Section 4) build on the concepts and strategies from *the 2024 Ecological Assets and Performance Standards Study* by Greene Economics. The 2024 report evaluated twelve ecosystem services based on the historic ecosystems of eastern Washington, functions to measure them, and design standard considerations. This framework addresses eight of the twelve identified in 2024 by incorporating select design standards as shown in Table 1.

Table 1. Select ecosystem services and design considerations applicable to this Living Infrastructure Framework from Greene Economics (2024). See Greene Economics (2024) for complete list of both.

Ecosystem Service	Design Considerations
Air filtration	Increase urban canopy
Biodiversity	Landscape design, wildlife connectivity
Carbon sequestration	Carbon-specific planting, increase green spaces
Nutrient cycling	Symbiotic planting, replicate pine savanna
Pollination	Pollinator-specific planting, protect pollinator habitats
Stormwater management	Green stormwater infrastructure, reduce impervious surfaces, mimic historical runoff patterns, increase infiltration
Temperature regulation	Vertical planting

The Greene (2024) study also used biomimicry principles rooted in the UD's historic ecosystems (ponderosa pine savanna, shrub-steppe, riparian corridors, and floodplains) as a basis for regenerative design recommendations, which are similar to the native plant communities further described in this framework.

Building on this work, the UD intends to focus on: biodiversity and pollinators, carbon sequestration; energy provision, temperature regulation; stormwater flow and water uses as well as recreation and community health (as an added "Joy Factor").

STORMWATER PLANS

UD uses resources from numerous regional and local agencies for improving urban stormwater management. Applicable guidance materials are listed below:

- **Washington State** is a national leader in natural resource management and green infrastructure. The *Eastern Washington Low Impact Development Guidance Manual* by the State Department of Ecology (2013) provides direction for regionally adapted Low Impact Development (LID), defined as "an approach to land development (or re-development) that works with nature to manage stormwater as close to its source as possible." The manual is written for stormwater managers, site designers, and design

reviewers and provides LID goals, objectives, and design of flow reduction and water quality treatment practices.

- The **City of Spokane** has developed and continually revised their own stormwater management guidance. The City of Spokane *Stormwater Management Program Plan* (2025) covers City programs, practices, and responsibilities to manage their municipal separate storm sewer system (MS4) along with the related work and coordination that the City of Spokane's Wastewater Management (WWM) Department and other departments have accomplished in stormwater management. The City also developed the *Integrated Clean Water Plan* (2014) to meet the following objectives:

- *To achieve a cleaner river faster, prioritizing work with the greatest potential to reduce pollution going into the river. The City is working to reduce phosphorus, PCBs, heavy metals, bacteria from sewage, and others.*
 - *To implement cost-effective and innovative approaches. The City will spend dollars wisely and include “green” technologies as they make sense.*
 - *To opportunistically address other critical infrastructure needs with Integrated Clean Water Plan projects.”*

- **University District** has been a specific focus for the City of Spokane as shown in the Final Report of the *University District South Stormwater Site Suitability Assessment for Stormwater Management Design Planning* (2018). The 2018 plan identifies stormwater BMPs and areas that are suitable for locating these features on public, private, and shared properties. These maps and BMP criteria were reviewed to select a subset of BMPs to be included herein.

In summary, this University District Living Infrastructure Framework is consistent with the prior stormwater plans with a the focus on the most applicable stormwater Best Management Practices (BMPs) that support diverse native plants, improve water quality and help mitigate urban heat island effects. (Section 2.1 *Regional and Climate Context*)

1.2 APPROACH SUMMARY

The Living Infrastructure Framework includes mapping and analysis of key features, approaches to combined planting and stormwater management, and identification of opportunity areas. Project phases are described below:

- **Phase 1: Discovery.** Review background planning and geospatial information; develop high-level understanding of conditions by integrating data for ecology,

hydrogeology, stormwater, and past planning inputs; site visit; interviews; analysis of opportunities and constraints.

- **Phase 2: Living Infrastructure Framework.** Identify stormwater green infrastructure criteria, develop strategies for combining with habitat enhancements, isolate opportunity areas, and conceptualize a University District approach (Living Infrastructure Framework Plan).
- **Phase 3** Ecological Guidelines development further describes the design process, living infrastructure typologies and planting palettes. and implementation considerations.

Members of the Biohabitats team (Sr. Ecologist Susan Sherrod, PhD, and Water Resources Engineer Sydney Salzwedel, PE) visited the University District October 14-16, 2025. Prior to the visits, base mapping and preliminary desktop analysis were completed including review and collation of geology, soils, vegetation, stormwater infrastructure, and iNaturalist observation data. Areas observed during the site visits focused on public properties and opportunity areas identified in past plans and interviews. (A map of the photopoints from the visit are in the Attachment A).

While in the UD and in follow-up conversations, Biohabitats discussed site history, management, opportunities, and stressors in interviews with Juliet Sinisterra (Spokane UD CEO), Greg Gordon (Gonzaga University Professor of Environmental Studies, *Rewilding the Urban Frontier* author), Happy Avery (ED, [Spokane River Forum](#)), Angel Spell (Asst. Director of Natural Resources, Parks & Recreation), Mark Papich & Colin Naake (City Integrated Capital Management Department), Wesley Hill ([Floralia Nursery](#)), Katherine Alexander ([Soil Smart-Soil Wise](#)), and Katelyn Scott (River Keepers). Discussion topics included rewilding opportunities and constraints, indigenous knowledge and support, maintenance practices, the city stormwater program, plant species selection, and potential river & trail connections, including a new kayak park.

Strategies shared in the interviews included:

- City-wide tree maintenance program, the UD as a dispersed botanic garden,
- The “*biotic pump*” concept (a microclimate model driving evapotranspiration and local precipitation via landform, healthy soil, and trees and other vegetation),
- The Miyawaki method (planting dense, multi-tiered micro-forests in rich soil), and
- Interest in additional stormwater pilot projects.

2. EXISTING CONDITIONS

This section describes the physical, hydrologic, biological, and stormwater infrastructure considerations for resilient planning and design in the UD. Multiple past plans, notably the Ecological Assets report (2024), describe major characteristics of the UD. Therefore, this section provides only a brief summary of key factors relevant for the Living Infrastructure approach.

2.1 REGIONAL AND CLIMATE CONTEXT

Spokane is located in the Spokane Valley Outwash Plains Ecoregion (EPA Level IV) of the Columbia Plateau. Its location in the rain shadow of the Cascades results in a relatively low annual precipitation of 16.5 inches. Seasonally, the patterns of winter and summer precipitation and air temperature are very distinct (*Figure 3*). While there is significant rain and cool weather in the winter, the summer is arid and warm. The temperate climate of Spokane with low overall rainfall is a critical characteristic for the native ecological systems and, by extension, for development of appropriate planting recommendations.

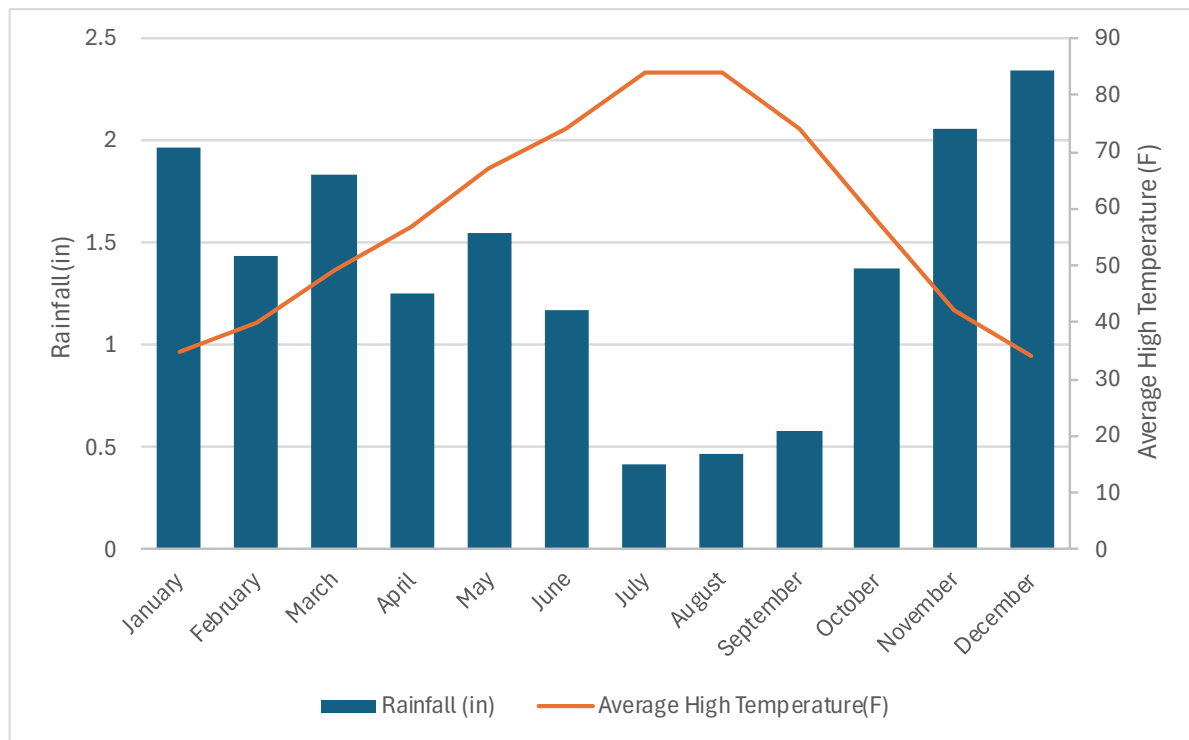


Figure 3. Average monthly precipitation (in.), Spokane, WA Source: U.S. Climate Data 1991-2020

Recent episodes of drought, extreme heat and precipitation, and flooding across the region underscore local vulnerabilities and the need to increase regenerative capacity and overall resilience. Urban heat intensity, in particular, is an identified concern in the UD. Mapping by Gonzaga University of afternoon temperatures across the University District show differences on either side of the river, with higher temperatures more prevalent in the southwest portion of the University District (refer to figure in Attachment A).

2.2 GEOLOGY AND SOILS

An overview of geologic conditions helps provide an understanding of the current and potential future of Living Infrastructure opportunities due to how these impact soil capacity, infiltration, and available organic matter. Three geologic units underlie the UD – basalt bedrock, glacial flood deposits, and alluvium, as described below (see also Figure 4).

- **Columbia River Basalt** is a dense, volcanic rock, which extends from the south, into the Spokane Valley. Spokane is located on the northern tip of the basalt range, with the UD located right on the eastern edge. The basalt is visible in outcrops throughout Spokane (Figure 4). The thickness of the bedrock layer can reach depths hundreds of feet below the surface. Basalt has low ability to infiltrate water, and low water storage or water supply potential.



Figure 4. Basalt outcrop along the edge of the Spokane River. Source: Biohabitats, 2024.

Soils forming over basalt are thin or nonexistent, and typically only support vegetation in areas where enough sediment has accumulated in the cavities or depressions in the rock. Creating beds where soils can be built up can help counter supplement thin soil areas.

- **Glacial Lake Missoula Flood Deposits** occur on the northern and eastern sides of the basalt outcropping that bisects Spokane. These deposits are characterized by a wide distribution of sizes from boulders down to gravel and sand. The deposit material was carried into the area by flood flows, which occurred when ancient ice dams in Idaho

repeatedly formed, melted, then failed, and the Glacial Lake Missoula drained out to the Pacific. Deposits are generally very porous and transmit water well.

Soils vary across these deposits, depending on how the ancient floodwaters behaved in the location. While some areas outside the UD received the flood backwaters where rich, fertile soils resulted, Spokane was closer to the active flood channel. Therefore, local soils are formed on coarse sand and gravelly outwash, with some silt and clay lenses.

- **Alluvium Deposits** are present near the river in the northern portion of the site. They are the newest deposits that the river has moved, sorted and redeposited. The majority of these deposits are comprised of a base of gravelly flood deposits, which in places is covered with a coarse “floodplain sand” that can be up to 2 feet thick. These deposits are not extensively present along the Spokane River, given the cobble and boulder bedform in this area.

Historical soils described above are still present in very localized areas, but the vast majority of the existing University District soils are highly disturbed and urban with low organic matter. Refer to Design Guideline Section 3 for a figure of contemporary urban soils in the UD.

2.3 SURFACE WATER & GROUNDWATER

Surface water and groundwater in the UD include the Spokane River, groundwater in the Spokane Valley-Rathdrum Prairie Aquifer, and Lake Arthur, each of which are described below. **Section 3.1 provides further description and illustrations of the interrelationships between these systems.**

SPOKANE RIVER & HISTORICAL FLOWS

The Spokane River bisects the UD and is a significant feature in the Spokane landscape. Long Lake Dam is located a short distance downstream of North Division Street, the western boundary of the UD, forming the 24-mile long reservoir called Spokane Lake (previously named Long Lake) that extends upstream through the UD reach. The dam was built in 1915 and is one of seven dams on the Spokane River constructed for hydropower production. Before these dams, the Spokane River would have responded freely to hydrologic conditions with a natural flow and sediment regime. The City’s *Integrated Clean Water Plan* (2014) provides more detail on Spokane River and Lake.

There is a long-standing river gage downstream of the UD (USGS 12422500; period of record 1891-present) with a contributing watershed of 4,290 square miles. The fluctuation of the mean monthly flows from the period of record demonstrate the river’s response to the

general rainfall and temperature pattern described earlier, with substantial peaks occurring in the spring after the cool, wet winters and then dropping significantly in the summer and early fall as the region dries out due to much lower rainfall and higher temperatures. There is also a river gauge upstream near Greene Street (USGS 12422000), but it has a much shorter period of record (2017–present).

In 2025, a reach of the river, upstream of the district went completely dry for about two weeks from late August to early September. The dry reach extended about 2.7 miles long between (Barker Rd and Sullivan Rd), which is more than 10 miles east of the UD. As described below, that section of the river is a “losing” reach, where the river recharges the aquifer, unlike the UD reach which is a “gaining” reach supplied by groundwater discharge.

Within the UD, the Spokane River is also the receiving water body for multiple point and non-point source discharges from the City of Spokane, including the city’s separate stormwater sewer system.

REGIONAL GROUNDWATER

The productive Spokane Valley–Rathdrum Prairie (SV–RP) Aquifer is a major source of groundwater in this region (Figure 5). It spans approximately 370 square miles between Washington and Idaho, with an estimated storage capacity of 10 trillion gallons of water. This is one of the fastest flowing aquifers in the country, where groundwater velocities can be up to 50 ft per day. The general direction of groundwater flow in the aquifer is to the southwest from its origin at Lake Pend Oreille to the City of Spokane, after which it turns toward the northwest.

Generally, precipitation that falls upon the mountain ranges to the northwest and southeast of the Spokane valley flows through streams and lakes to reach the valley bottom. From here, the water percolates downwards through permeable deposits such as sands and gravels and replenishes the aquifer. The interactions between the aquifer and the river are complex, and there is variability where small sections of the Spokane River will switch between a losing or gaining reach within a relatively small distance.

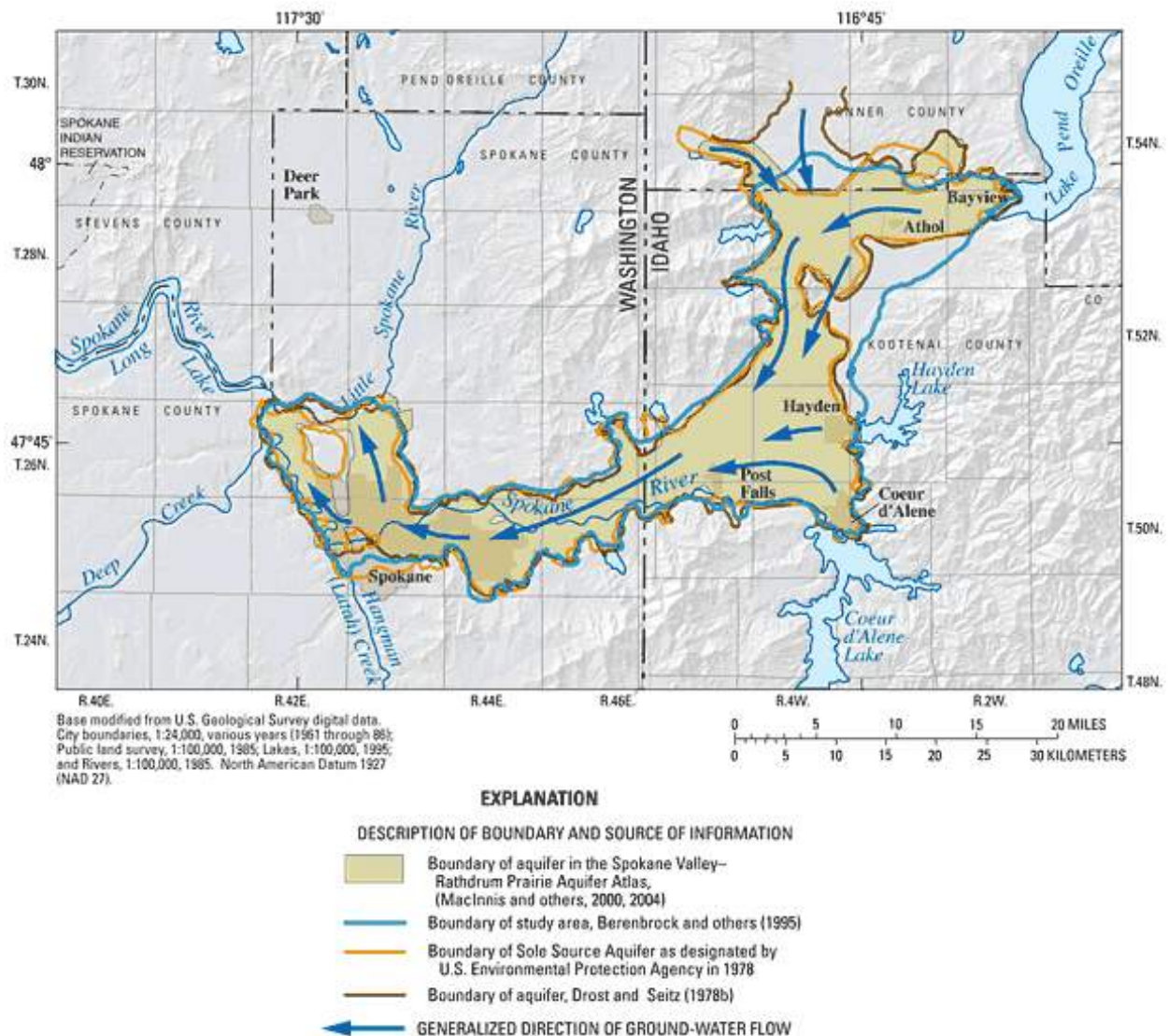


Figure 5 Spokane Valley-Rathdrum Prairie Aquifer extent and general direction of groundwater flow. Source: USGS 2005.

UNIVERSITY DISTRICT GROUNDWATER & SURFACE WATER

Groundwater. The SV-RP Aquifer is present beneath the UD in the northern and eastern portion of the University District, in the Glacial Lake Missoula flood deposits and alluvium, but it is generally absent in the southern and western UD areas that are underlain with basalt. The UD, as well as most of the City of Spokane, is within a Critical Aquifer Recharge zone (Source: Spokane County). Within the district, the direction of groundwater flow generally parallels the

river flow, moving to the west on the eastern side of the UD, and then to the north where it encounters the Columbia River Basalt (which acts like a barrier to groundwater flow).

Groundwater elevations in the vicinity of the UD are mapped at about 1860 to 1880 ft above sea level. Local information on depth to groundwater was reviewed from about 50 soil borings and well logs on the south side of the UD (HDR, 2018). Groundwater was not encountered in about half of the locations (primarily in areas of basalt). In the remaining locations, groundwater was encountered at depths ranging from about 4–22 ft below ground surface (with an average of about 15 ft). The depth to groundwater varies with the elevation of the land surface and typically will also fluctuate with seasonal patterns. But detailed information on local groundwater patterns can not be inferred from the existing data, because of the incomplete well coverage, varying sources of information, and different times of year of data collection.

In areas with shallow groundwater, restoration opportunities include revegetation and tree plantings, potentially combined with grading to create depressions in strategic locations.

Surface Water Bodies. Other than the Spokane River, the other surface water body in the UD is Lake Arthur, which was historically part of the Spokane River as a sort of bay or inlet. Some hydrologic connection is maintained today by culverts; the lake was separated by the construction of the railway through Spokane, which is now a trail.

Because of the very porous subsurface in the north and the impermeability of the basalt, there are not many surface-fed tributaries to the Spokane River, and none on the UD property. The inlets that exist are piped and were constructed to convey runoff after precipitation events.

2.4 LAND COVER

The historic Spokane landscape (described below) has been replaced with urban development; however, the integration of living Infrastructure provides opportunities to reintroduce native species and improve biodiversity. The living Infrastructure approach includes re-integrating elements of locally historic systems for ecological function and to honor site heritage. Plant species that are well-suited for urban conditions are explored more in the Design Guidelines document.

HISTORIC LAND COVER

Spokane is in the Spokane Valley Outwash Plains Ecoregion, which reflects features of the last continental glaciation as well as the Pleistocene Missoula floods such as glaciated foothills, lower mountain slopes and outwash terraces. Glacial till and outwash parent materials gave rise to coarse, gravelly, and younger soils in the northern valleys. In contrast, glacial lake sediment was the foundation of more loamy and arable soils in the southern Spokane Valley.

Soils also have some volcanic ash mixed in or on the surface. The mixed conditions of topography and soil types led to several key habitat types in the region as described below. All photographs accompanying descriptions are from reference habitats.

Key Habitat Types

Inter-Mountain Basin Big Sagebrush Shrubland & Steppe (Figure 6) historically occurred in the uplands on the north side of the UD and significant areas of the southern side. A native shrub steppe community has 10–60% shrub cover, while herbaceous cover ranges from 40 to 85%. Stand-replacing fires historically occurred every 95–98 years (USFS 2004, 2020a). Biological soil (cryptobiotic) crust is an important ecosystem component within this habitat type.

Dominant species (USFS 2004, 2020a):

- Shrubs: Mountain big sagebrush (*Artemisia tridentata* ssp. *vaseyana*), antelope bitterbrush (*Purshia tridentata*), mountain snowberry (*Symphoricarpos oreophilus*)
- Herbaceous: Idaho fescue (*Festuca idahoensis*), squirreltail (*Elymus elymoides*), western wheatgrass (*Pascopyrum smithii*), slender wheatgrass (*Elymus trachycaulus*), needle and thread (*Hesperostipa comata*), green needlegrass (*Nassella viridula*), muttongrass (*Poa fendleriana*), Sandberg bluegrass (*Poa juncifolia* var. *ampla*), sulphurflower buckwheat (*Eriogonum umbellatum*), rosy pussytoes (*Antennaria rosae*), arrowleaf balsamroot (*Balsamorhiza sagittata*), silver lupine



Figure 6. Sagebrush reference site in Moses Coulee, eastern Washington. Photo: Chase Gunnell, [Our Sagelands Heritage Program](#).

(*Lupinus argenteus*), Nuttall's larkspur (*Delphinium nuttallianum*), Rocky Mountain phlox (*Phlox multiflora*), Nuttall's violet (*Viola nuttallii*), scarlet globemallow (*Sphaeralcea coccinea*), American vetch (*Vicia americana*), yarrow (*Achillea millefolium*), plains pricklypear (*Opuntia polyacantha*)

Columbia Plateau Steppe (Figure 7) historically occupied a swath through the southern portion of the UD, mostly south of E Martin Luther King Jr. Way. These native systems are very similar to the big sagebrush shrubland and steppe except for the dominance of shrubs and a fire return interval of about 20 years.

Community composition of the steppe can vary based on location, with different geography yielding different dominant species. Indian ricegrass (*Achnatherum hymenoides*), squirreltail, thickspike wheatgrass (*Elymus lanceolatus* ssp. *lanceolatus*), needle and thread, Idaho fescue, junegrass (*Koeleria macrantha*), Sandberg bluegrass (*Poa secunda*), bluebunch wheatgrass (*Pseudoroegneria spicata*), spiny or carpet phlox (*Phlox hoodii*), sandwort (*Arenaria* spp.), *Astragalus* spp. (NatureServe 2025a) are examples of typical species for this habitat type.



Figure 7. Columbia Plateau steppe reference site at Yakima Training Center. Photo: Jay Kehne, [Conservation Northwest](#).

Ponderosa and Mixed Forests, Woodlands, and Savanna (Figure 8) historically occurred near the Spokane River channel as well as on uplands to the north. On a moisture gradient, the dry-mesic mixed conifer forest occurs just above the Ponderosa woodlands and savanna, although Ponderosa pine (*Pinus ponderosa*) characterizes the overstory of both, especially when maintained by fire. Absence of fire leads to infill of Ponderosa pine, Douglas-fir (*Pseudotsuga menziesii*), and grand fir (*Abies grandis*). Historic fire was frequent (approximately every 32 years) and was low-intensity such that open stands of widely spaced trees were maintained. Mixed-severity fires (approximately every 107 years) replaced some stands and resulted in landscape mosaics of older and younger patches (NatureServe 2025b, USFS 2020b).

Dominant species:

- Canopy: Ponderosa pine, Douglas-fir, grand fir
- Shrub and understory: Snowberry (*Symphoricarpos albus*) and mountain snowberry, white spirea (*Spiraea betulifolia*), big sagebrush (*Artemisia tridentata*), greenleaf manzanita (*Arctostaphylos patula*), kinnikinnick (*Arctostaphylos uva-ursi*), curl-leaf mountain mahogany (*Cercocarpus ledifolius*), mallow ninebark (*Physocarpus malvaceus*), antelope bitterbrush, chokecherry (*Prunus virginiana*), Saskatoon serviceberry (*Amelanchier alnifolia*), and *Rosa* spp.
- Herbaceous: Geyer's sedge (*S. geyeriana*), pinegrass (*Calamagrostis rubescens*)



Figure 8. Ponderosa pine savanna. Photo Aaron Theisen, [Washington Native Plant Society](#).

Montane riparian systems (Figure 9) surrounding the Spokane River are a type of woody wetland where tree cover can reach 100%. Replacement fires in these native systems occurred every 68–182 years on average, caused by ignition in adjacent systems (USFS 2020c,d). Flooding is also a reset mechanism in these riverside systems, at times mediated by beaver (*Castor canadensis*).

Dominant species:

- Canopy: narrowleaf, balsam, black, and Fremont cottonwoods (*Populus angustifolia*, *P. balsamifera*, *P. balsamifera* ssp. *trichocarpa*, *P. fremontii*); aspen (*P. tremuloides*); red birch (*Betula occidentalis*); white fir (*Abies concolor*); red and Goodding's willows (*Salix laevigata* and *S. gooddingii*); Rocky Mountain juniper (*Juniperus scopulorum*); Rocky Mountain maple (*Acer glabrum*); grey alder (*Alnus incana*); river hawthorn (*Crataegus rivularis*)
- Subcanopy and shrubs: red-osier dogwood (*Cornus sericea*); Wood's rose (*Rosa woodsii*); Saskatoon serviceberry; chokecherry; and coyote, arroyo, Lemmon's, yellow, Geyer's, Booth's, Drummond's shining, Bebb's, and Wolf's willows (*S. exigua*, *S. lasiolepis*, *S. lemmonii*, *S. lutea*, *S. geyeriana*, *S. boothii*, *S. drummondiana*, *S. lasiandra*, *S. bebbiana*, *S. wolfii*)
- Herbaceous: sedges (*Carex* spp.), rushes (*Juncus* spp.), tufted hairgrass (*Deschampsia caespitosa*), slender wheatgrass, fowl manna grass (*Glyceria striata*), false Solomon's seal (*Maianthemum stellatum*), Fendler's meadowrue (*Thalictrum fendleri*), large-leaved avens (*Geum macrophyllum*), tall fringed bluebells (*Mertensia ciliatus*), and field horsetail (*Equisetum arvense*)



Figure 9. Example montane riparian and wetland system reference, Columbia Plateau Trail State Park. Photo: [railtrailingblog](#), [TrailLink](#)

Existing Land Cover

Current land cover of the UD is a range of development intensities, including buildings, roads, and infrastructure (see Figure in Attachment A). Exceptions include the open water of the Spokane River and small, isolated patches of Ponderosa pine woodland and savanna, urban forest, and riparian woodland.

The intensity of development in the UD makes it especially important to understand the locations and availability of remaining permeable surfaces for stormwater management. Figure 10 shows the Normalized Difference Vegetation Index (NDVI) as a potential indicator of these spaces that may be focal points for providing hydrological connection within the University District.

Existing Tree Summary

A high level review of Spokane's tree data was conducted to understand the distribution of existing trees across the University District. A total of 2,337 trees were found in the UD with 66% broadleaf and 6% conifer. The available tree data is missing points along the river and on the

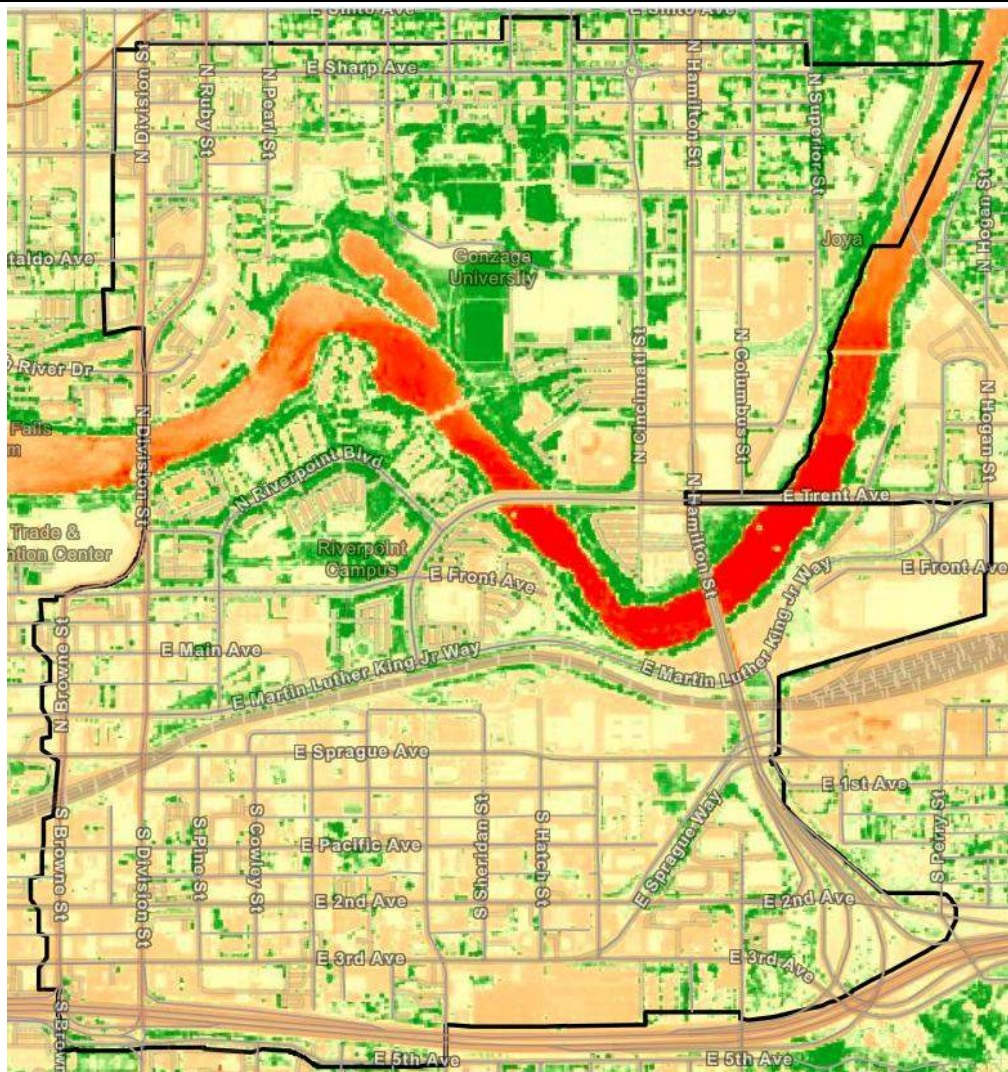


Figure 10. Normalized Difference Vegetation Index (NDVI) in the UD. Greener shades indicate higher plant density and better vegetative health. In this case, shades of red and orange are surface water of the river.

Gonzaga University campus, and some points are indicated where trees do not appear to be growing. Based on the available data, 899 trees are on the north side (297 acres) for a density of 3 trees/acre. 633 (70%) are broadleaf, 37 (4%) coniferous, and 229 (25%) not categorized. On the south side of the river (431 acres) there are 1,438 trees for a density of 3.3 trees/acre. 923 (64%) are broadleaf, 98 (7%) coniferous, and 417 (29%) unidentified.

Should trees per acre be a metric the UD wants to measure in the future, an updated tree inventory would be needed to further understand canopy cover and distribution of species within subareas, as well as effectiveness for urban heat island reduction measures.

OTHER AQUATIC FEATURES

HDR's University District stormwater report (2018) identified the presence of several "historical lakes circa 1883" based on City of Spokane research. Although the original data source for these lake features was not reviewed in the current study, it is likely that the largest lake in the glacial outwash area in the southeast (at the base of the basalt) was associated with high ground water. Based on an understanding of the site geology, the lakes on the surface of the basalt were likely areas where rainwater collected in depressions and where water probably evaporated in dry periods.

2.5 WILDLIFE HABITAT

Not including insects, 77 native wildlife species have been reported in the UD in iNaturalist. The Spokane River corridor and connected green spaces provide the most diverse wildlife habitat. Mammals and native fishes depend on the river, migratory birds rely on riparian and canopy structure, and pollinators use flowers. Reptiles and amphibians also use moist refugia and undisturbed edges that can be found along the river and at Lake Arthur.

The University District retains remnants of contributing habitat, with wildlife use concentrated in areas that maintain vegetation cover, riparian structure, and ecological connectivity. Brief summaries of wildlife observations by guilds are provided below and more detailed summary tables are in the Attachment B. All data are from iNaturalist and eBird.

WILDLIFE OBSERVATIONS

Mammals

Common urban and riparian mammals in the UD include larger species such as moose (*Alces alces*) and mule and white-tailed deer (*Odocoileus hemionus*, *O. virginianus*). The river corridor supports beaver (*Castor canadensis*), river otter (*Lontra canadensis*), mink (*Neogale vison*), and muskrat (*Ondatra zibethicus*).

More urban-tolerant species such as porcupine (*Erethizon dorsatum*), yellow-bellied marmot (*Marmota flaviventris*), raccoon (*Procyon lotor*), eastern cottontail (*Sylvilagus floridanus*), and squirrels (*Sciurus carolinensis*, *S. niger*) are found throughout the UD. Of note, the silver-haired bat (*Lasionycteris noctivagans*), is also documented and is considered Vulnerable (rank of S3) according to Washington's State Wildlife Action Plan.

Birds

The UD supports steady year-round avian use, and also has strong seasonal pulses of migratory birds. The year-round community of urban and riparian species includes American robin (*Turdus migratorius*), black-capped chickadee (*Poecile atricapillus*), and American dipper (*Cinclus mexicanus*), along with raptors such as the bald eagle (*Haliaeetus*

leucocephalus) and the peregrine falcon (*Falco peregrinus*), which is state-sensitive. Migratory species such as black tern (*Chlidonias niger*), calliope and rufous hummingbirds (*Selasphorus calliope*, *S. rufus*), and olive-sided flycatcher (*Contopus cooperi*) arrive in late spring and breed through mid-summer.

Insects

The UD insect community is diverse and includes native bumble bees (e.g., *Bombus huntii*, *B. rufocinctus*, *B. occidentalis*), which have long foraging ranges, and smaller specialist bees, which have short ranges. Butterflies, wasps, beetles, and other pollinators are also common. Non-native species like the western honey bee (*Apis mellifera*) and European woolcarder bee (*Anthidium manicatum*) are widespread. This rich pollinator assemblage relies on the ongoing availability of flowering plant species.

Fishes

There are a small number of native fishes in the UD reach of the Spokane River. These include largescale sucker (*Catostomus macrocheilus*), northern pikeminnow (*Ptychocheilus oregonensis*), redband shiner (*Richardsonius balteatus*), and both rainbow and Columbia River redband trout (*Oncorhynchus mykiss*, *O. mykiss gairdneri*).

Amphibians and Reptiles

The UD hosts a small, but typical, community of native reptiles and amphibians. The only amphibian documented is the long-toed salamander (*Ambystoma macrodactylum*), while reptile species are more numerous and include western painted turtle (*Chrysemys picta bellii*), northern alligator lizard (*Elgaria coerulea*), western skink (*Plestiodon skiltonianus*), and garter snakes (*Thamnophis elegans*, *T. elegans vagrans*).

POTENTIAL POLLINATOR FORAGE

Pollinators and their habitat were included in the UD assessment because their presence indicates plant species and food availability for insectivores and higher-level consumers. Potential UD pollinator habitat was evaluated using a GIS analysis of forage density to provide insight into habitat patterns that are not necessarily as clearly visible from other mapping (i.e., NDVI in Figure 10). For the high-level analysis, habitat needs of small to medium size bee species were used, and their potential habitat was defined as tree canopy and vegetated areas plus a 250-m buffer. The 250-m distance was based on known foraging distances for short-range bee species. Golf courses and athletic fields were not included, and the north and south sides of the river were separated.

Figure 11 illustrates where potential forage density is highest (green) and lowest (red) and the connectivity patterns across the University District and its boundaries. Noteworthy is the low forage density on the south side of the UD, which represents a potential focal area for improvement.

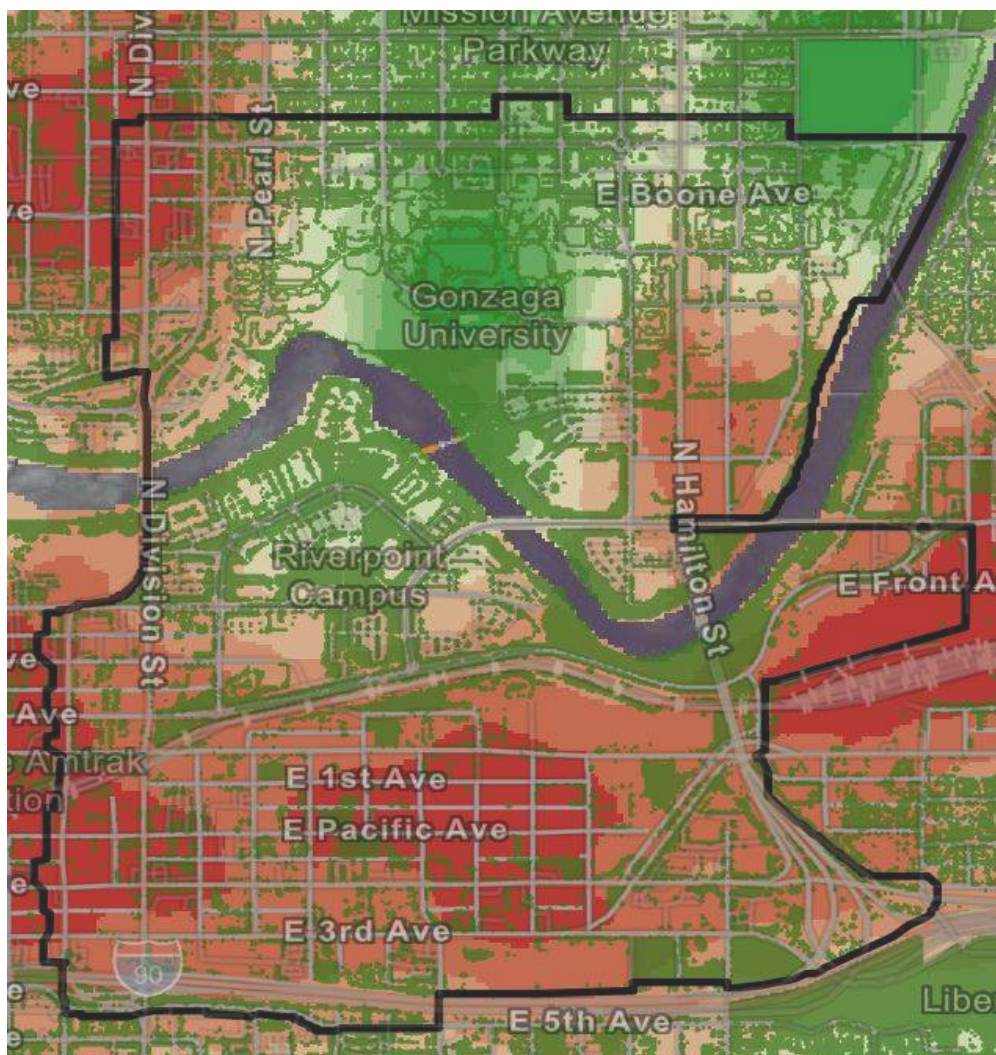


Figure 11. Potential pollinator forage density map. Green indicates denser vegetation and potential forage areas, while red indicates vegetation is absent or low density.

2.6 STORMWATER MANAGEMENT

CSO & MS4

Refer to the City of Spokane Stormwater Management Program Plan (2025) for a detailed description of the stormwater management system. In summary, it consists of the following elements:

- **Municipal Separate Storm Sewer System (MS4):** The MS4 is mostly located on the north side of the City and, in the UD, north of the river. Less than half of the City is served by the MS4. MS4s are regulated under the National Pollutant Discharge Elimination System (NPDES) Phase II Municipal Stormwater Permit.
- **Combined Sewer Overflow (CSO):** Stormwater flows into the CSO system mainly occur on the south side of the City and, in the UD, south of the river, where the basalt geology significantly limits infiltration. CSOs are regulated under an NPDES Waste Discharge Permit managed by the Riverside Park Water Reclamation Facility (RPWRF).
- **Infiltration (including underground injection controls (UIC) and evaporation):** Infiltration is the primary means of stormwater management on the margins of the City. Underground injection control (UIC) wells (also known as stormwater wells and dry wells) are sometimes used to optimize stormwater infiltration and are regulated by the Washington Department of Ecology (Washington State Department of Ecology, 2006); there are injection wells that are located in the UD.

EXISTING BMPS

The City has designed and installed a number of stormwater best management practices (BMPs) throughout Spokane, many of which have been monitored to assess their function and effectiveness. Some example projects are the following:

- **Lincoln Spokane Urban Runoff Greenways Ecosystem (SURGE) project** – series of rain garden bump outs along Lincoln Street between 19th and 29th Avenues. See SWMP (2018) for more detail.
- **Garland Avenue Storm Gardens** – Storm gardens installed with a biochar soil mix that was developed in partnership with University of Idaho. See the 2025 SWMP for more detail.
- **Finch Arboretum LID** – includes bioretention facility and porous asphalt parking lot (partnership with Washington State University).
- **Sharp Avenue project** – rebuilt road with sections of porous asphalt and pervious concrete, as well as a grassy stormwater swale in the center median.
- **Havana Street** – porous asphalt bike lanes and gravel swale for bioretention.
- **Riverside Park Water Reclamation Facility (RPWRF)** – retrofit involving installation of pavers in the entrance drives and parking area.

-
- Older permeable pavement projects: West Broadway, Liberty Park sidewalk, Hazel Creek trail, Olmsted Brothers Green.

Of the range of stormwater management used in Spokane, the most prevalent technique within the UD is grassy stormwater swales. Based on these observations and the available stormwater documents, many opportunities to increase diversity of treatments were identified. Recommendations for stormwater BMP plantings are discussed further in Section 3.8.1.

2.7 HYDROGEOLOGIC ZONES & FLOW PATHS

Hydrogeology combines an understanding of rock and soil formations with groundwater and surface water movement. The UD is located in a complex area at the interface between major hydrogeologic units, which influence how water moves naturally across the University District.

HYDROGEOLOGIC ZONES

Three main hydrogeologic zones have been identified with distinct hydrogeologic characteristics. These units are briefly described below and shown in **Error! Reference source not found.**¹².

- **Basalt Upland Zone** – The basalt uplands on the south side of the University District (and northwest edge) are characterized by thin soils, near surface bedrock, with very limited rainwater infiltration capacity. The low water retention likely contributes to the observation of higher afternoon temperatures in this area compared to elsewhere in the University District. Priority strategies for this zone will focus on detaining/storing/slowng stormwater runoff.
- **Spokane Valley–Rathdrum Prairie Aquifer Zones**–The glacial outwash and alluvial deposits occur on the east side of the University District, where permeable materials allow for infiltration of rainwater and aquifer recharge. Located on the west edge of the aquifer, these zones are therefore important areas to ensure water quality protection before the groundwater discharges to the river.

- **River Corridor** – The riverine zone includes the channel itself and a relatively narrow riparian buffer on either side. The river receives groundwater discharge from unconsolidated deposits in the east side of the University District. On the west side, however, basalt is present on either side, and therefore the river is not hydrologically connected to groundwater..



Figure 12. View to southwest of major geologic and hydrologic features in the University District. (Notice the direction of the north arrow lower right of figure).

FLOW PATHS

When precipitation falls on the UD, the ultimate receiving waterbody is the Spokane River. Under natural conditions, depending on the location, the route and timing of that flow varies considerably. In the southwestern UD, which is mostly south of the river, basalt bedrock dominates the landscape. The soils are relatively shallow with minimal infiltration, resulting in increased runoff volumes into the Spokane River with relatively minor storage. The northeastern UD (mostly north of the river), the deep Spokane Valley-Rathdrum Prairie Aquifer is the main feature, allowing much higher infiltration, which would result in decreased runoff volumes and a much slower subsurface pathway to the river. **Error! Reference source not found.** illustrates the general flow pathways through the landscape in UD.

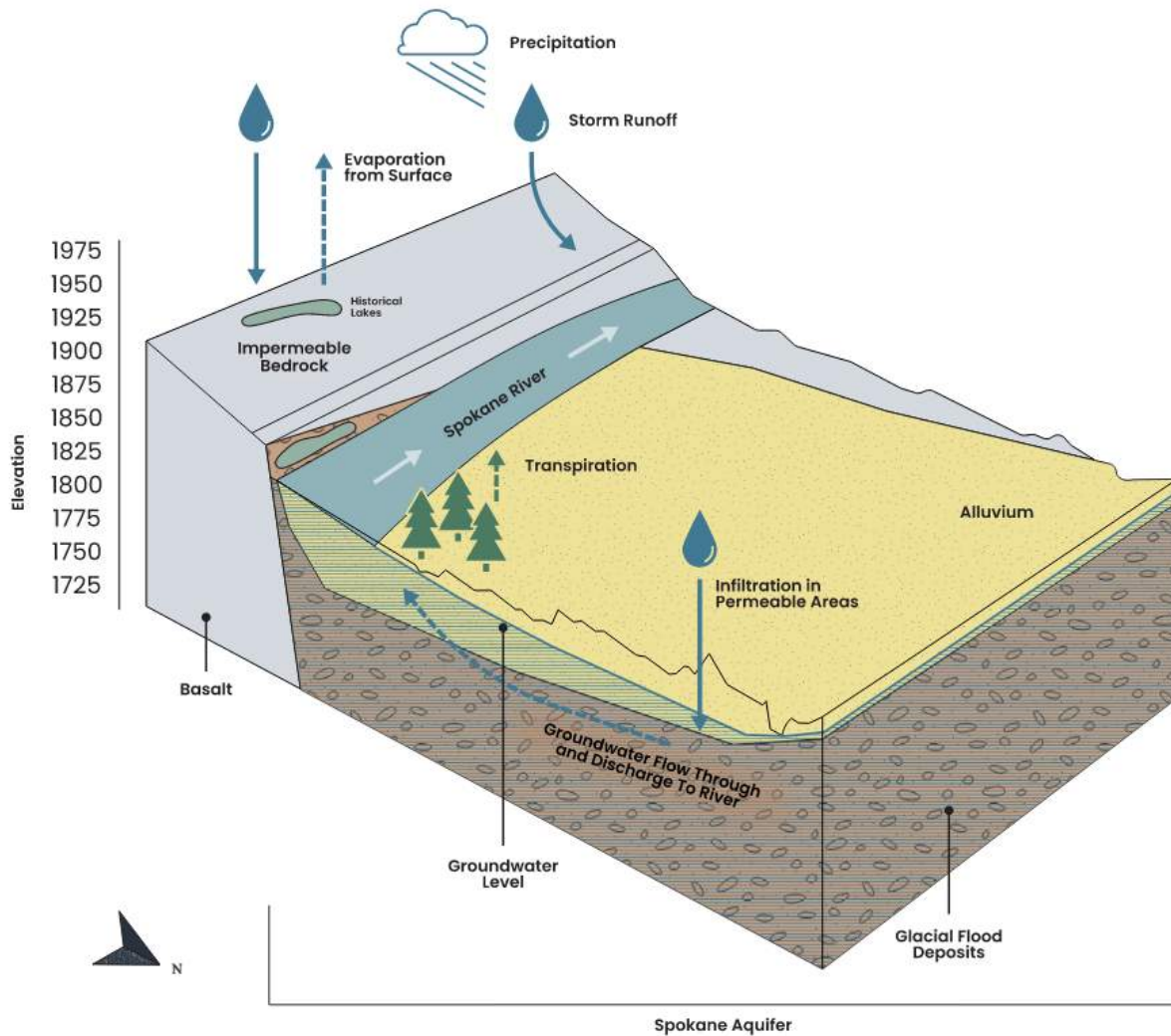


Figure 13. Conceptual cross section of the UD geology and water flow paths.

Establishment and growth of the City of Spokane resulted in a complex manmade drainage network, which interrupts and interacts with the natural conditions described above. Within the southwestern UD, much of the runoff is collected in the sewer and directed to the Riverside Park Water Reclamation Facility. When the combined runoff and sewage volume exceeds sewer capacity, the excess overtops the system's combined sewer overflow (CSO) weirs and is routed to the river. In the northeastern portion of the UD, runoff enters the municipal storm sewer system (MS4), where it is directed to detention areas and dry wells, providing attenuation and infiltration and eventually flowing to the river.

REGENERATIVE WATER SUPPLY OPTIONS

Given the arid conditions of the UD, additional water supply options were explored at a high level as summarized below.

Rain Water Capture

Rain water capture strategies for landscaping depend on the size of the roof or catchment area, soil characteristics, and the plant water needs. As shown in the following graph (Figure 14), in Spokane the water demand of trees peaks during the drier months when precipitation is lowest. Therefore, rain water harvesting needs to include cisterns for storage as described in available guidance such as *Eastern Washington Low Impact Development Guidance Manual (2013)*.

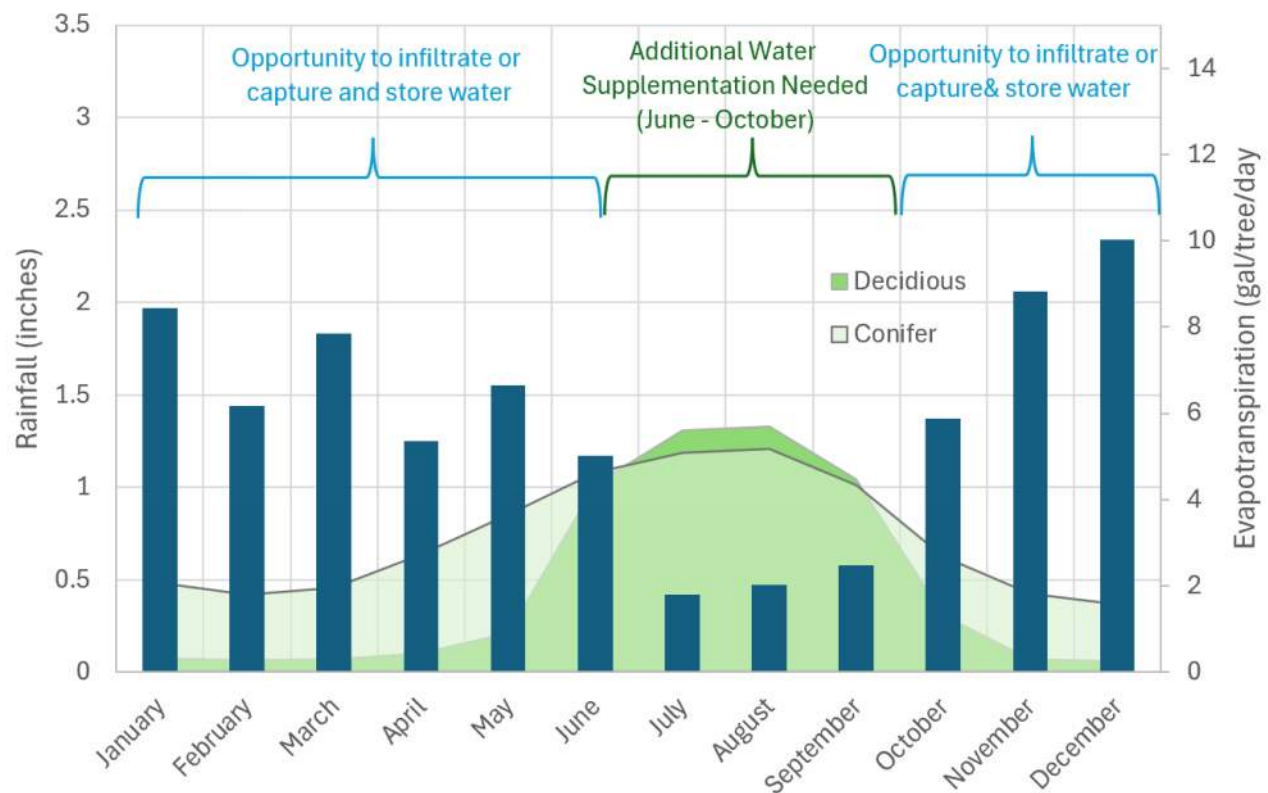


Figure 14. Annual precipitation, evapotranspiration separated by deciduous and coniferous species, and seasonal management strategies.

Greywater Considerations

Greywater from indoor water use, such as laundry discharge, provides a possible additional water supply for reuse in outdoor irrigation. In Washington State, these practices are regulated by [Chapter 246-274 WAC.](#), and the state offers practical resources for planting

considerations such as found here: [Irrigating Plants with Greywater | Washington State Department of Health](#)

General requirements for systems will vary with water sources, available space, and planting needs. A survey of possible sources, such as commercial or university operations, was beyond the scope of the current study. However, Denver's [Laundry to Landscape](#) (L2L) provides an example of how these systems can be promoted:

"Laundry to landscape systems are relatively inexpensive and easy to install and permits are available [online](#).

- Avoid contact with graywater, or soil irrigated with graywater. Graywater contains pathogens that can make you ill.*
- You may use graywater for landscape irrigation but use it in a way that it does not pool or run off your property.*
- Graywater from L2L systems must be distributed to a mulch basin or sent to the sanitary sewer immediately. Storage of graywater from L2L systems is not allowed.*
- Graywater cannot contain hazardous chemicals such as antifreeze, mothballs and solvents.*
- Do not include wash water from greasy or oily rags in your graywater. Graywater from washing diapers or other infectious garments must be discharged to the sanitary sewer."*

2.8 POTENTIAL PLANT COMMUNITY DESCRIPTIONS

Basic descriptions of six potential UD plant community types are below. These plant communities can be installed across the district in a variety of conditions as described in the Design Guidelines. Table 2 demonstrates some plant community types applicable to stormwater BMPs and Figure 15 depicts relative ecosystem services. Figure 16 shows

Table 2. Plant community types in relation to stormwater BMPs.

Plant Community Types	Select BMP Options
Gravel and Crevice gardens	Bioinfiltration (e.g., in basalt areas)
<i>Native Prairie / Shrub Steppe</i>	Bioinfiltration
Pollinator Meadow/Gardens	Bioinfiltration, Bioretention
Wetlands	Bioretention, floating wetlands in river, modular wetlands
Ponderosa Pine Grove	Bioinfiltration
Urban Trees	Silva cells or similar modular tree support system
Riparian Forest Buffer	Filter strips (not included in HDR 2018 report)

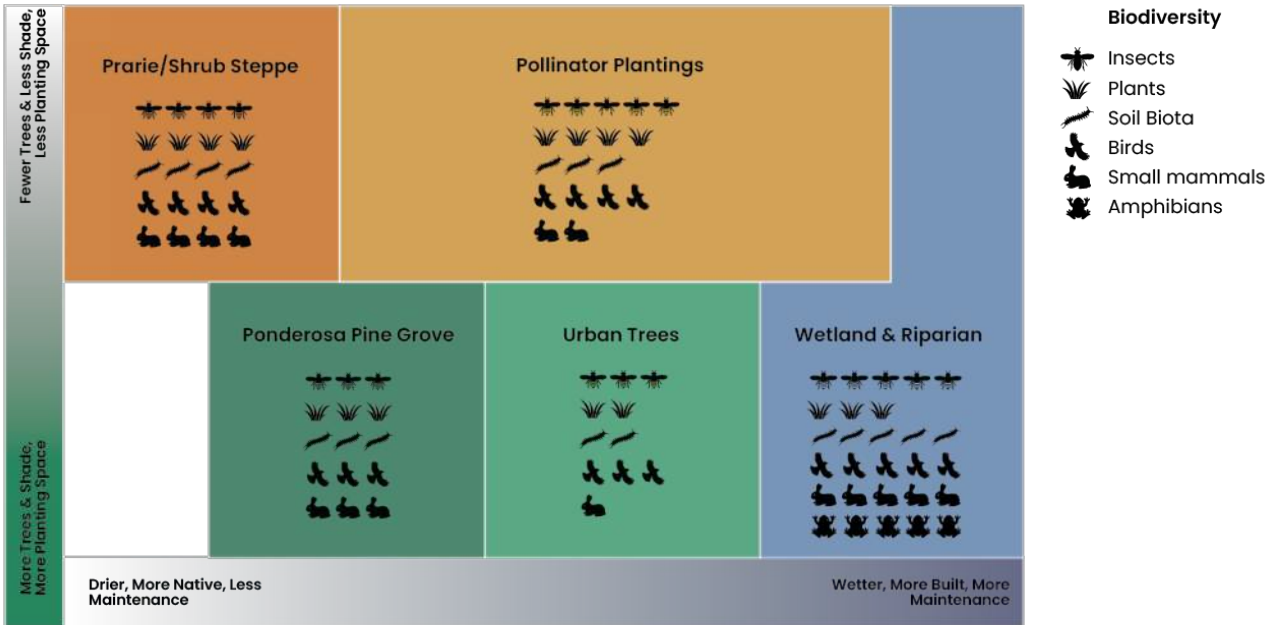


Figure 15. Conceptual gradients of planting space, tree opportunities, hydrology (and therefore water treatment potential), maintenance, and biodiversity for the different planting typologies, UD Living Infrastructure. Note that biodiversity depends on local and adjacent features, and the scales shown are best guesses.

Plant community descriptions are below, with typical plant species for each community type. Greater details are provided in the ecological design guidance.

Gravel and Crevice Gardens

BMP Option: Bioinfiltration (“non”-vegetated)

Typical species: Sedum (*Sedum* sp.), pink pussytoes (*Antennaria rosea*), buckwheat (*Polygonum* sp.), creeping phlox (*Phlox stolonifera*), juniper (*Juniperus* sp.)

These are gardens with a strong structural component such as local basalt or gravel intended to evoke Spokane’s geologic history. Planting these spaces with low-stature, drought-tolerant plants will increase District-wide biodiversity with a plant palette adapted to existing and modeled future conditions.



Gravel/crevice garden example. Photo <https://extension.wsu.edu/island/gardening/greenbank-educational-garden/crevice-garden/>

Native Prairie / Shrub Steppe

BMP Option: Bioinfiltration

Typical species: Big sagebrush (*Artemisia tridentata*), antelope bitterbrush (*Purshia tridentata*), rabbitbrush (*Ericameria nauseosa*), bluebunch wheatgrass (*Pseudoroegneria spicata*), needle and thread (*Hesperostipa comata*), squirreltail (*Elymus elymoides*), Sandberg bluegrass (*Poa secunda*), Nuttall’s larkspur (*Delphinium nuttallianum*), longleaf phlox (*Phlox longifolia*), Mariposa lily (*Calochortus macrocarpus*), silky lupine (*Lupinus sericeus*), arrowleaf balsamroot (*Balsamorhiza sagittata*), Pursh’s locoweed (*Oxytropis lambertii*; see **Error! Reference source not found.** for palette and layout example).



Washington State University Spokane County Extension Office. Photo © Pat Munts for The Spokesman-Review <https://www.spokesman.com/stories/2023/oct/05/gardening-step-by-step-instructions-for-creating-a/>

The prairie and shrub steppe systems, along with the Ponderosa pine and riparian habitats, are critical heritage habitats of the Columbia Plateau. These systems are adapted to very low water and are heat-tolerant. This is also an important habitat type for naturally adapted pollinators.

Shrubs are the tallest component and are important for capturing litter, which provides habitat for ground-dwelling invertebrates. Herbaceous grasses and forbs provide erosion control and increase structural diversity. This typology can also be planted with herbaceous species only for a low-stature community.

Dominant native steppe species should establish well in low-water urban BMPs. An example native palette and layout are below. SpokaneScape suggests additional species that can complement sagebrush and to further increase biodiversity.

Pollinator Meadow/Gardens

BMP Options: Bioinfiltration, Bioretention

Typical species: Russian sage (*Salvia yangii*), Apache plume (*Fallugia paradoxa*), yarrow (*Achillea* sp.), hyssop (*Agastache* sp.), milkweed (*Asclepias* sp.). Note: grasses and flowering woody species also support pollinators.

Airborne pollinators are the focus of this community type, such as butterflies, beetles, non-honeybees, and hummingbirds. Pollinator support plants are many, tend to be showy (although not always), and can be herbaceous or woody.

Pollinator gardens can be designed to meet different objectives, including water constraints, supporting specific pollinator guilds, and/or continuous blooming (see example bloom schedule in Attachment C). They are well suited for transformation of non-functional turf areas for water conservation and habitat enhancement.



Photo Susan Mulvihill <https://www.spokesman.com/stories/2021/jun/19/in-the-garden-pollinator-garden-provides-habitat-f/>

Wetland

BMP Options: Bioretention, floating wetlands in river, modular wetlands

Typical species: Willow (*Salix* sp.), birch (*Betula* sp.), alder (*Alnus* sp.), sedges (*Carex* sp. and related), rushes (*Juncus* sp.)

Wetland habitats are important heritage ecosystems appropriate for locations with high water availability. They can include herbaceous emergent and fringe habitats with woody species and discontinuous inundation. The hydrology of wetland systems supports highly dynamic soil processes, which is the basis for complex food web dynamics and high biodiversity.



Constructed wetlands at River Point Park, Spokane (top). Floating wetlands in Chicago's [Wild Mile](#).

Ponderosa Pine Grove

BMP Option: Bioinfiltration, planted tree pits

Typical species: Ponderosa, Pinyon, & bristlecone pines (*Pinus ponderosa*, *P. edulis*, & *P. longaeva*); juniper (*Juniperus* sp.); buffaloberry (*Shepherdia argentea*); Oregon grape (*Berberis aquifolium*); blue fescue (*Festuca glauca*); little bluestem (*Schizachyrium scoparium*); nodding onion (*Allium cernuum*), Black-eyed Susan (*Rudbeckia hirta*); prairie smoke (*Geum triflorum*)

Ponderosa-dominant woodland grove patches are important both as a heritage habitat and as a strategy for providing shade where water availability is low. Historic systems had widely spaced trees, but in the UD they could be planted as multi-tier systems for more cover and higher diversity.



Photo [Sparrowhawk Native Plants](#)

Urban Trees

BMP Options: Bioinfiltration, Silva cells or similar modular plantings, , sidewalk verge/curb plantings

Typical species: Kentucky coffee tree (*Gymnocladia dioica*), catalpa (*Catalpa speciosa*), honey locust (*Gleditsia triacanthos*), oak (*Quercus* sp.), mountain-ash (*Sorbus* sp.), cotoneaster (*Cotoneaster* sp.), spirea (*Spirea* sp.), snowberry (*Symphoricarpos* sp.), wide range of herbaceous



Photo <https://static.spokanecity.org/photos/2007/06/12/finch-arboretum/16x3/Full/finch-arboretum.jpg>

Urban-adapted trees can provide good shade and biodiversity opportunities. The breadth of planting options allows design to be tailored to local hydrology, and design should select species that are naturalized and/or suitable for the specific hydrology of the BMP. Native and naturalized species should be able to function well alongside native species and provide additional niches to complement diversity.

Spokane's [approved street trees](#) includes indications of whether species are appropriate for stormwater areas. Attachment B contains a table summarizing those recommended by Spokane's Urban Forestry Department that are also appropriate for stormwater areas, and they are further organized by size.

Riparian Forest Buffer

BMP Option: Bioretention

Typical species: Cottonwood (*Populus* sp.), willow (*Salix* sp.), birch (*Betula* sp.), alder (*Alnus* sp.), dogwood (*Cornus* sp.), serviceberry (*Amelanchier* sp.), sedges (*Carex* sp. and related), rushes (*Juncus* sp.)

Riparian habitats are important heritage ecosystems appropriate for locations intermediate to upland and aquatic areas. They are important to both biodiversity and water quality by providing structurally complex vegetation, woody debris, and shade; cooling the water and the understory; filtering pollutants and nutrients from upland runoff before it drains into the river; and protecting streambanks from erosion. The [Spokane Conservation District](#) has more information on healthy riparian areas and links to further information.

Riparian forest is ideally a multi-tier and highly biodiverse system, although structure can be modified in user areas where water access is also a priority. The active hydrology of natural riparian systems makes them adapted to periodic stress and regeneration.

It would be ideal if the Spokane River supported a riparian zone at least 200 feet wide, which maximizes habitat and water quality benefits. While the opportunities to restore this much riparian area are limited, it is recommended that UD managers continue to be watchful for possible areas to expand this important habitat type.



Photo <https://www.sacvalleycnps.org/riparian-forest/>

3 PILOT PLANNING AREAS

Multiple potential pilot location areas were identified by the UD to demonstrate how Living Infrastructure strategies could be combined to create a network of nature-based solutions. One area on the north side of the UD was selected as the initial pilot project for this effort (Figure 16) due to the proximity to the river and the variety of landscape features present. Within this pilot area, preliminary ecological design concepts were prepared for three subareas (Figures 17-19): .These concepts are preliminary illustrations of multiple approaches for integrating open spaces, roadsides, and stormwater features using a variety of native plant communities in e.g., vegetated swales, pollinator beds, and rain gardens.

- **Greenway open space** along Centennial Trail with scrub-shrub steppe plantings and Ponderosa Pine groves (**Error! Reference source not found.**17)
- **Living streets** with integrated tree plantings, pollinator bumpouts, pervious pavement, and rainwater harvesting features (*Figure 18*)
- **Spokane River riparian corridor** with created wetlands and expanded riparian buffer (19).

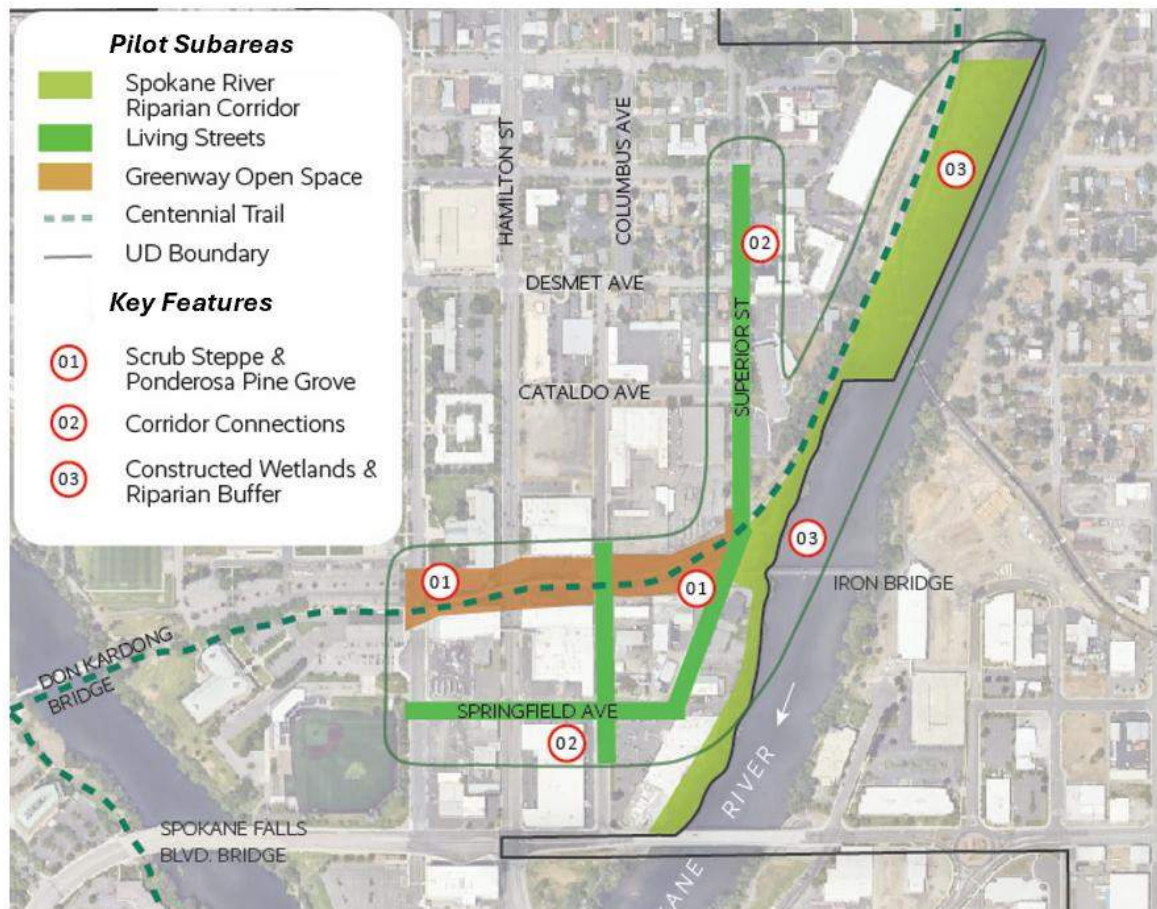


Figure 16. Overview of pilot area (outlined in green) with three sub areas (in light green, dark green, and brown) illustrating interconnecting living infrastructure features. Refer to Figures 17–19 for more



Figure 17. Greenway open space concept showing scrub steppe and ponderosa pine grove planting areas with integrated bioretention and connections to riparian enhancements. This concept connects to enhanced riparian area to the east (see Figure 19).



Figure 18. Concept for East Springfield living street elements including tree plantings, pollinator bumpouts, pervious pavement and rainwater harvesting features.



Figure 19. Concept for enhanced riparian area including floating wetlands and diverse (multi-tier) riparian buffer plantings around kayak launch. This approach connects to adjacent scrub steppe and pine grove to west (see Figure 17), and its elements can be integrated into future Iron Bridge River Gateway concept development.

4 IMPLEMENTATION CONSIDERATIONS

Upcoming tasks include the: Pacific Avenue review, ecological design guideline development, and developing implementation considerations such as communication, phasing, and possible funding partners for the living infrastructure framework.

5.1 PACIFIC AVENUE

As requested by the UD, Biohabitats provided input into the Phase 2 Pacific Avenue design in a summary memorandum. Comments on design, planting, and maintenance guidelines were provided.

5.2 IMPLEMENTATION CONSIDERATIONS

Several gaps will need to be considered when moving into implementation of the the living infrastructure framework in the UD programs.

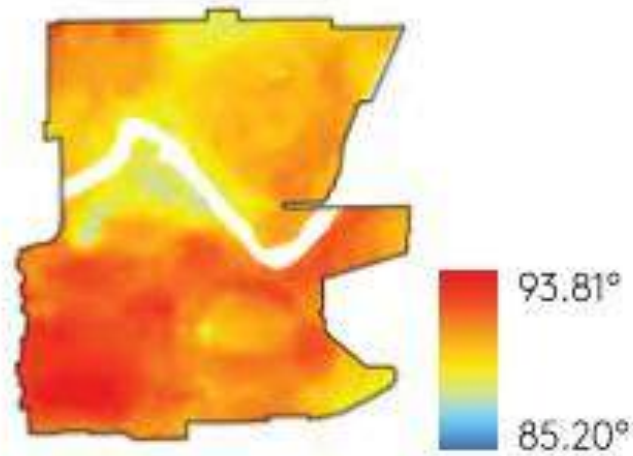
- **Maintenance.** Designating responsible parties and requirements to meet expectations will be needed to avoid tree loss and underperforming stormwater BMPs.
- **Funding.** Phased integration of the ecological design guidelines applied to catalyst projects would allow estimates of costs, while also allowing for refined approaches from experiences.
- **Measuring improvements.** An updated tree inventory would provide a baseline that could be used to compare to future tree density and heat island mitigation analyses used herein, e.g., for NDVI (Figure) and understanding water needs of existing vegetation.

ATTACHMENTS

Attachment A: Additional Ecological Assessment Information

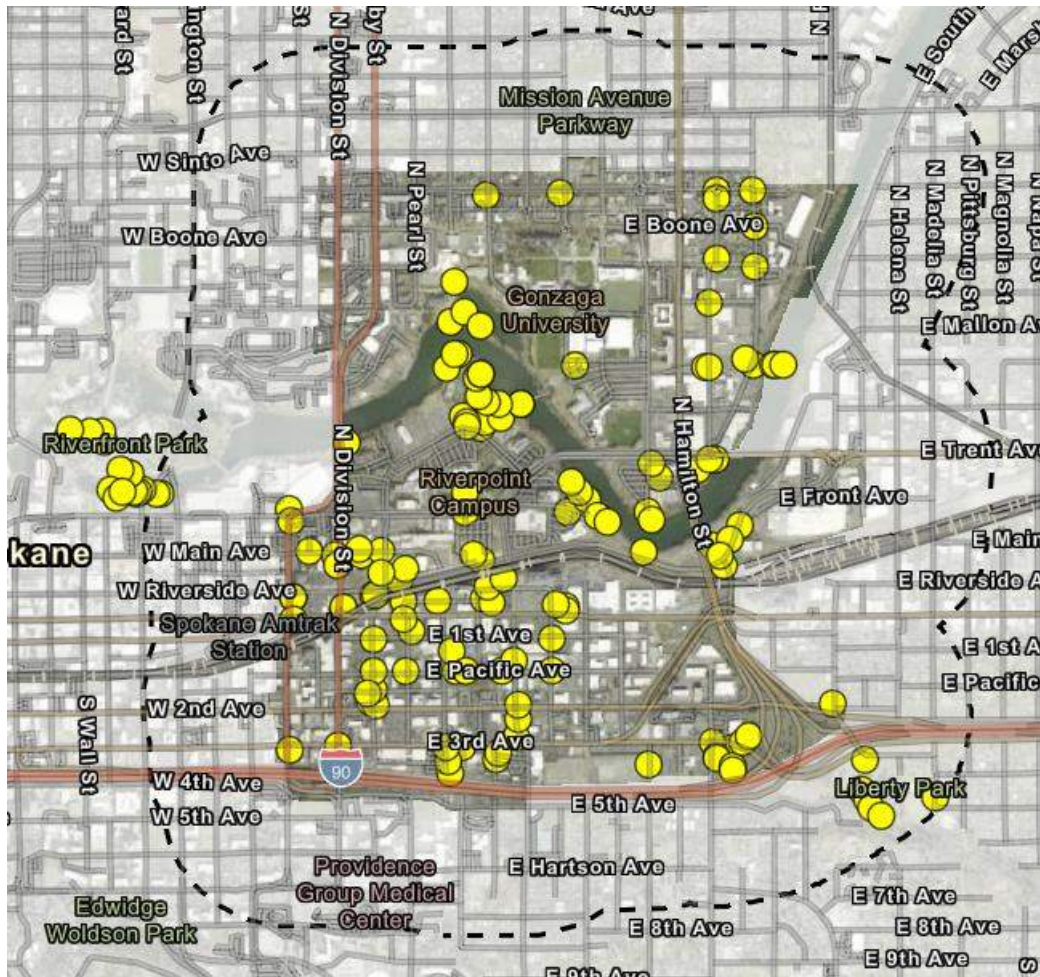
HEAT

Afternoon heat temperatures comparison.



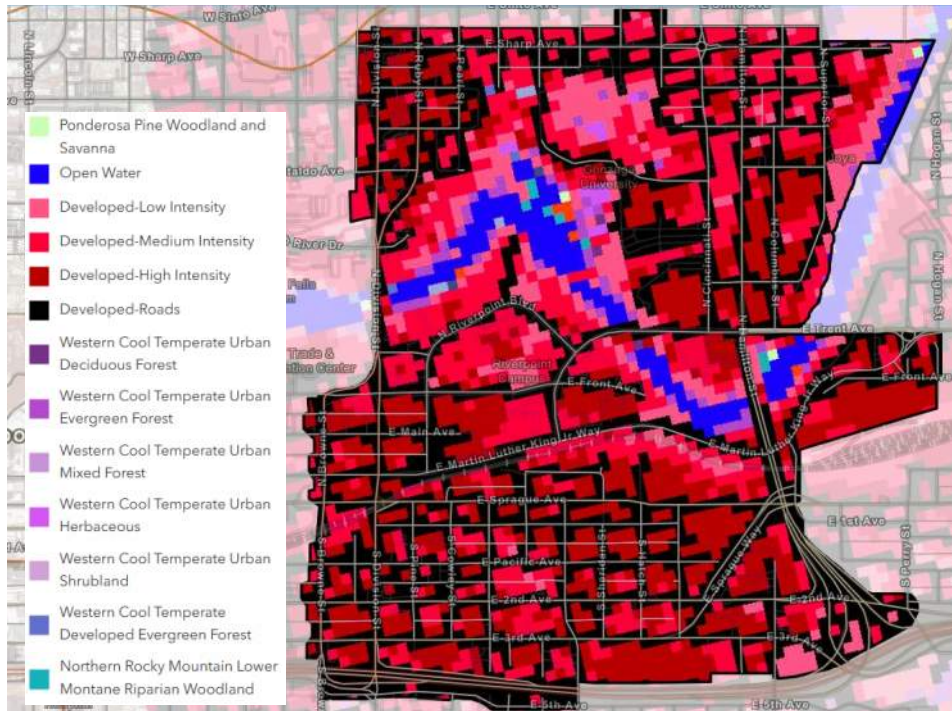
Source: Gonzaga Center for Climate, Society, and the Environment, 2022

Source: Mithun, 2024.



Field assessment observation points in the UD (2025).

Current land cover of the UD ([LandFire](#)) is a range of development intensities, including buildings, roads, and infrastructure. Exceptions include the open water of the Spokane River and small, isolated patches of Ponderosa pine woodland and savanna (light green), urban forest (shades of purple), and riparian woodland (teal).



Ecosystem Service	Target
Air filtration	AQI PM _{2.5} and PM ₁₀ in the urban core should not exceed that of native ponderosa pine savanna (in fire-free conditions).
Biodiversity	Environmental restoration activities will use species native to the ecosystem in appropriate locations in ratios similar to the original landscape.
Carbon Sequestration	CO ₂ emissions from energy generated from fossil fuels and building construction should not exceed the net primary productivity (Mg C/ha/year) of the surrounding landscaping/vegetation including any engineered sequestration that may become feasible, and/or offset credits.
Energy Provision	Energy produced by rooftop solar and other distributed energy sources (geothermal and wind) should produce the equivalent net primary productivity of a mature ponderosa pine savannah.
Fire adaptation	Plant and maintain native fire-adapted vegetation that produces a fuel load similar to savanna grasses that burns quickly to reduce the incidence of and/or damage caused by catastrophic fire. Structures should have fire-retardant outer materials like the Ponderosa bark, and vegetation should emulate the quick-burning grasslands.
Nutrient Cycling	Open space areas should have the same ratio of trees to shrubs and grass as the ponderosa pine savanna ecosystem to enhance nutrient interception by roots and protect the system against nutrient losses. Artificial media in non-vegetated areas can also be used to absorb and retain nutrients.
Pollination	UD vegetation should mimic native perennial grasslands by including plant species known to host native pollinator communities represented in ponderosa pine savanna.
Stormwater Management	Zero percent impervious services or equivalent.
Temperature Regulation	The amount of shade in the developed urban ecosystem should be the same as what was provided by the ponderosa pine savanna. Shade targets could be met by both vegetation plantings and built structures. In addition, shade trees should be distributed equitably, as low-income areas tend to have fewer trees, and arguably less income to pay for air cooling.
Waste Generation & Management	The ecosystem assets and features of the pre-development UD site would have managed waste in a closed loop, meaning that all waste created would have been decomposed and recycled back into the ecosystem.
Water Cycling	Water withdrawals should be calibrated to protect the aquifer and limit water withdrawal to support historic aquifer recharge rates.
Human Health & Wellbeing	The ongoing development theme is to preserve the "winter camp" status of the area, as it was a meeting place for indigenous people where people come to share knowledge and food and culture.

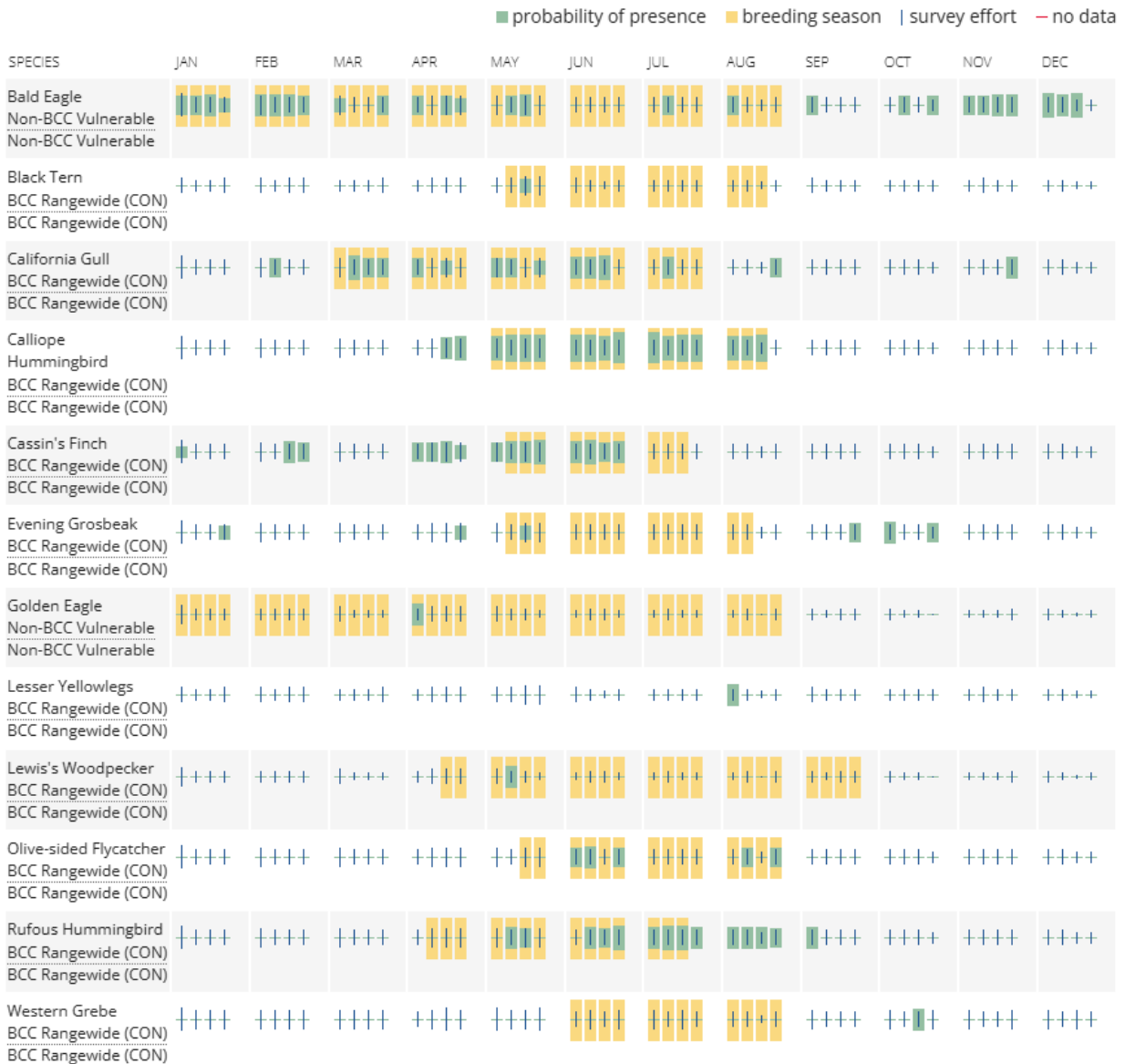
Attachment B: iNaturalist Observations

Scientific Name	Common Name	State Wildlife Action Plan Species of Greatest Conservation Need
MAMMALS		
<i>Alces alces</i>	Moose	
<i>Castor canadensis</i>	American Beaver	
<i>Erethizon dorsatum</i>	North American Porcupine	
<i>Lasionycteris noctivagans</i>	Silver-haired Bat	G5 S3
<i>Lontra canadensis</i>	North American River Otter	
<i>Marmota flaviventris</i>	Yellow-bellied Marmot	
<i>Neogale vison</i>	American Mink	
<i>Odocoileus hemionus</i>	Mule Deer	
<i>Odocoileus virginianus</i>	White-tailed Deer	
<i>Ondatra zibethicus</i>	Muskrat	
<i>Procyon lotor</i>	Common Raccoon	
<i>Sciurus carolinensis</i>	Eastern Gray Squirrel	
<i>Sciurus niger</i>	Eastern Fox Squirrel	
<i>Sylvilagus floridanus</i>	Eastern Cottontail	
BIRDS		
<i>Accipiter striatus</i>	Sharp-shinned Hawk	
<i>Aix sponsa</i>	Wood Duck	
<i>Anas platyrhynchos</i>	Mallard	
<i>Ardea herodias</i>	Great Blue Heron	
<i>Astur cooperii</i>	Cooper's Hawk	
<i>Bombycilla cedrorum</i>	Cedar Waxwing	
<i>Branta canadensis</i>	Canada Goose	
<i>Branta hutchinsii</i>	Cackling Goose	
<i>Cardellina pusilla</i>	Wilson's Warbler	
<i>Certhia americana</i>	Brown Creeper	
<i>Charadrius vociferus</i>	Killdeer	
<i>Cinclus mexicanus</i>	American Dipper	
<i>Colaptes auratus</i>	Northern Flicker	
<i>Corthylio calendula</i>	Ruby-crowned Kinglet	
<i>Corvus brachyrhynchos</i>	American Crow	
<i>Corvus corax</i>	Common Raven	
<i>Cyanocitta stelleri</i>	Steller's Jay	
<i>Dryobates pubescens</i>	Downy Woodpecker	
<i>Dryobates villosus</i>	Hairy Woodpecker	
<i>Euphagus cyanocephalus</i>	Brewer's Blackbird	
<i>Falco columbarius</i>	Merlin	
<i>Falco peregrinus</i>	Peregrine Falcon	State Sensitive; G4 S2B,S3N
<i>Fulica americana</i>	American Coot	
<i>Haliaeetus leucocephalus</i>	Bald Eagle	State Sensitive; G5 S4B,S4N

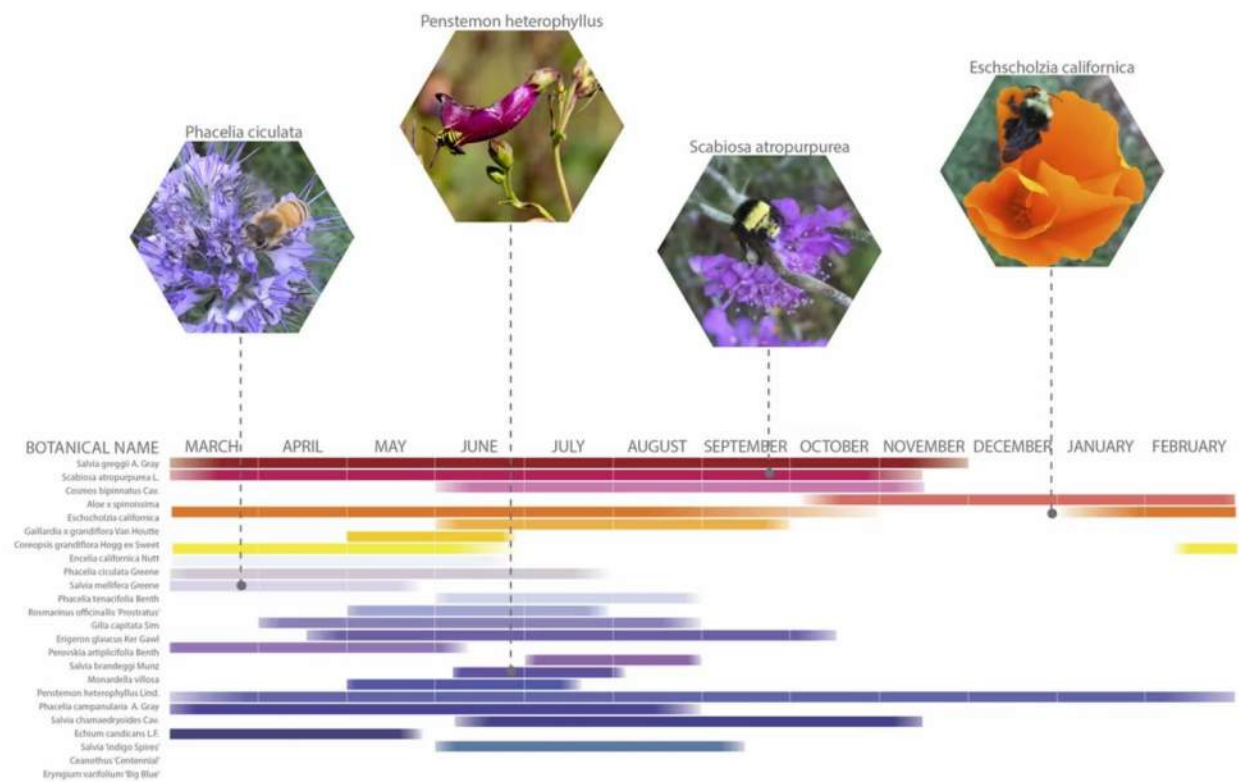
Scientific Name	Common Name	State Wildlife Action Plan Species of Greatest Conservation Need
<i>Ixoreus naevius</i>	Varied Thrush	
<i>Junco hyemalis</i>	Dark-eyed Junco	
<i>Larus delawarensis</i>	Ring-billed Gull	
<i>Leiothlypis celata</i>	Orange-crowned Warbler	
<i>Lophodytes cucullatus</i>	Hooded Merganser	
<i>Mareca americana</i>	American Wigeon	
<i>Melospiza melodia</i>	Song Sparrow	
<i>Mergus merganser</i>	Common Merganser	
<i>Nannopterum auritum</i>	Double-crested Cormorant	
<i>Pandion haliaetus</i>	Osprey	
<i>Pipilo maculatus</i>	Spotted Towhee	
<i>Piranga ludoviciana</i>	Western Tanager	
<i>Podilymbus podiceps</i>	Pied-billed Grebe	
<i>Poecile atricapillus</i>	Black-capped Chickadee	
<i>Poecile gambeli</i>	Mountain Chickadee	
<i>Poecile rufescens</i>	Chestnut-backed Chickadee	
<i>Selasphorus calliope</i>	Calliope Hummingbird	
<i>Selasphorus rufus</i>	Rufous Hummingbird	
<i>Setophaga coronata</i>	Yellow-rumped Warbler	
<i>Setophaga petechia</i>	Yellow Warbler	
<i>Sitta canadensis</i>	Red-breasted Nuthatch	
<i>Spinus tristis</i>	American Goldfinch	
<i>Spizella passerina</i>	Chipping Sparrow	
<i>Tachycineta thalassina</i>	Violet-green Swallow	
<i>Turdus migratorius</i>	American Robin	
<i>Zenaida macroura</i>	Mourning Dove	
<i>Zonotrichia albicollis</i>	White-throated Sparrow	
<i>Zonotrichia leucophrys</i>	White-crowned Sparrow	
FISHES		
<i>Catostomus macrocheilus</i>	Largescale Sucker	
<i>Oncorhynchus mykiss</i>	Rainbow Trout	
<i>Oncorhynchus mykiss gairdneri</i>	Columbia River Redband Trout	
<i>Ptychocheilus oregonensis</i>	Northern Pikeminnow	
<i>Richardsonius balteatus</i>	Redside Shiner	
AMPHIBIAN		
<i>Ambystoma macrodactylum</i>	Long-toed Salamander	
REPTILES		
<i>Chrysemys picta bellii</i>	Western Painted Turtle	

Scientific Name	Common Name	State Wildlife Action Plan Species of Greatest Conservation Need
<i>Elgaria coerulea</i>	Northern Alligator Lizard	
<i>Plestiodon skiltonianus</i>	Western Skink	
<i>Thamnophis elegans</i>	Western Terrestrial Garter Snake	
<i>Thamnophis elegans vagrans</i>	Wandering Garter Snake	

Probability of bird species presence by season.



Attachment C Example Bloom Schedule



Base Landscape Architecture bloom schedule for Dolores Pollinator Boulevard, San Francisco.
<https://www.baselandscapes.com/pollinatorboulevardgalleries-vision>

C. Excerpt: University District South Stormwater Site Suitability Assessment for Stormwater Management

APPENDIX C ADDITIONAL STORMWATER BMP BACKGROUND INFORMATION

Excerpted BMP suitability table from HDR, 2018. Refer to original document for full explanation.

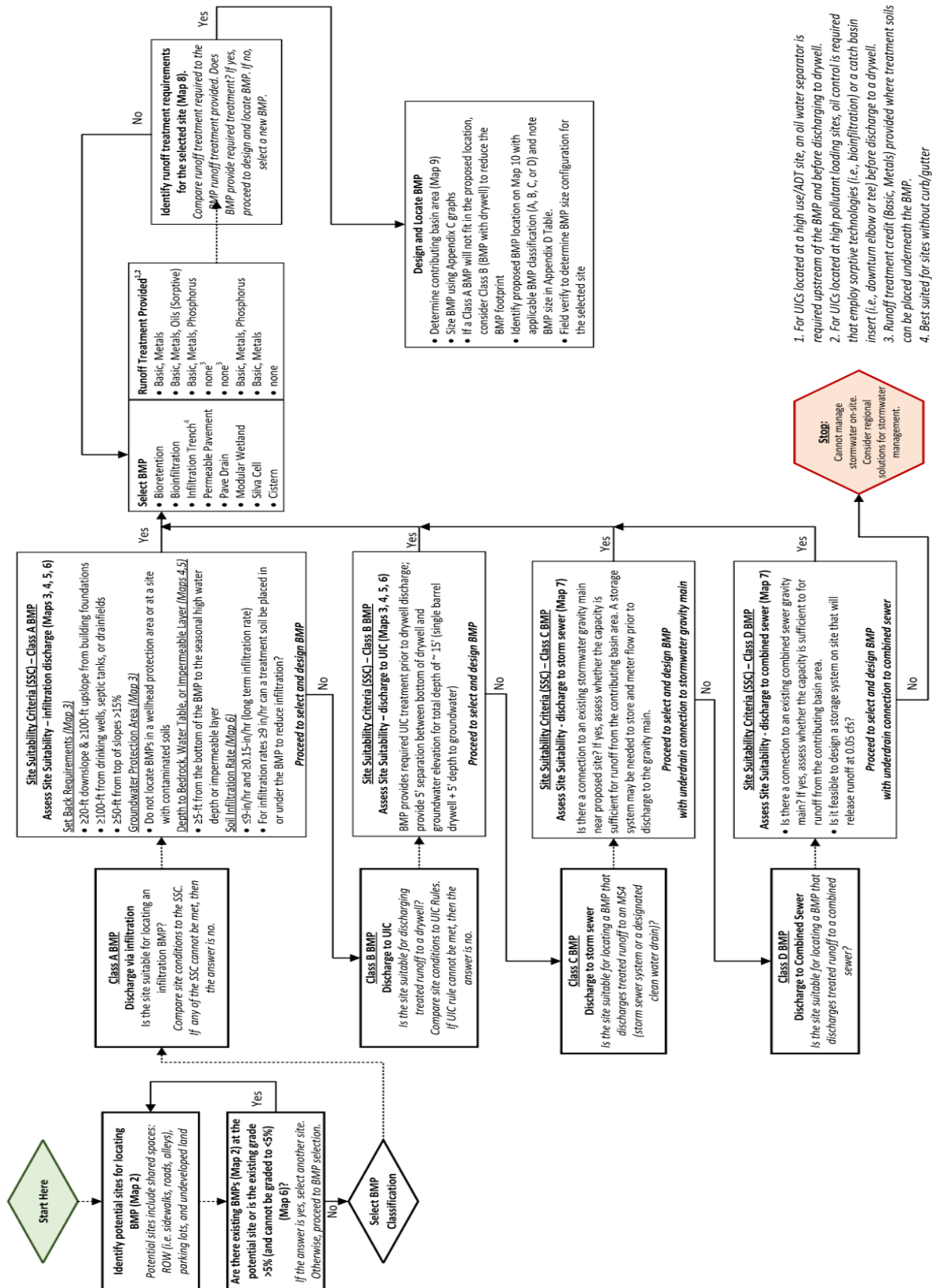


Figure 3. Site Suitability Assessment for Locating BMPs in the University District South

SITE SUITABILITY ASSESSMENT

A site suitability assessment was performed for the purpose of identifying potential areas for locating BMPs in the University District South. The site suitability assessment process essentially compares the site characteristics required to locate a BMP to the actual characteristics at the proposed site. If the actual site characteristics meet or exceed the required characteristics, the site is considered suitable for locating the BMP and the next step is to select and size a BMP. If the actual site characteristics do not meet the required characteristics, the site is not suitable for locating the BMP. The site suitability assessment process was developed to guide decisions that will determine suitability. The selected process is illustrated in Appendix A (Figure 3). The primary components of the assessment process are summarized below and the remainder of this section provides a discussion on each component.

- Define a BMP classification system that groups BMPs based on a hierarchy of preferred methods for discharging treated stormwater
- Define a site suitability criteria that identifies the site characteristics required for locating each BMP classification at a proposed site and meets the City's' NPDES MS4, UIC rule, and sole source aquifer protection requirements for stormwater management. These requirements are defined in the Spokane Regional Stormwater Manual (Spokane County, City of Spokane, and City of Spokane Valley, 2008) and the Ecology Guidance Manual for UIC Wells that Manage Stormwater (Ecology, 2006).
- Develop maps that identify the site characteristics needed to assess whether the site is suitable for locating each classification of BMPs

BMP Classification System

The BMP classification system groups BMPs based on a hierarchy of preferred methods for discharging treated stormwater runoff (Figure 4). Discharge methods identified for this project include: infiltration, infiltration via drywell, and discharge to storm or combined sewer. The following outlines four BMP classifications relative to the site suitability:

- **Class A BMP:** Site is Suitable for BMPs that infiltrate treated runoff
- **Class B BMP:** Site is suitable for BMPs that discharge treated runoff to a drywell
- **Class C BMP:** Site is suitable for BMPs that discharge treated runoff to a storm sewer
- **Class D BMP:** Site is suitable for BMPs that discharge treated runoff to a combined sewer

The BMPs are listed in order of preference. Class A BMPs are the most preferred because these BMPs manage stormwater by mimicking that natural processes, specifically infiltrating the runoff contributing to the BMP. Class C and D BMPs are the least preferred because runoff treated from these BMPs are collected and conveyed to another location which alters the natural hydrology of the site. This process of BMP selection is consistent the selection process outlined in the Ecology Stormwater Management Manuals.

The first step in the site suitability assessment is to determine which BMP Classification is suitable for the proposed site. The site suitability criteria is specific to each BMP class and the assessment starts with Class A BMPs and then proceeds to the next class until a the site is determined suitable

for locating that BMP Class. If the site is not suitable for any of the BMP classifications, then it is assumed that the site is not suitable for managing stormwater on-site and off-site options should be considered.

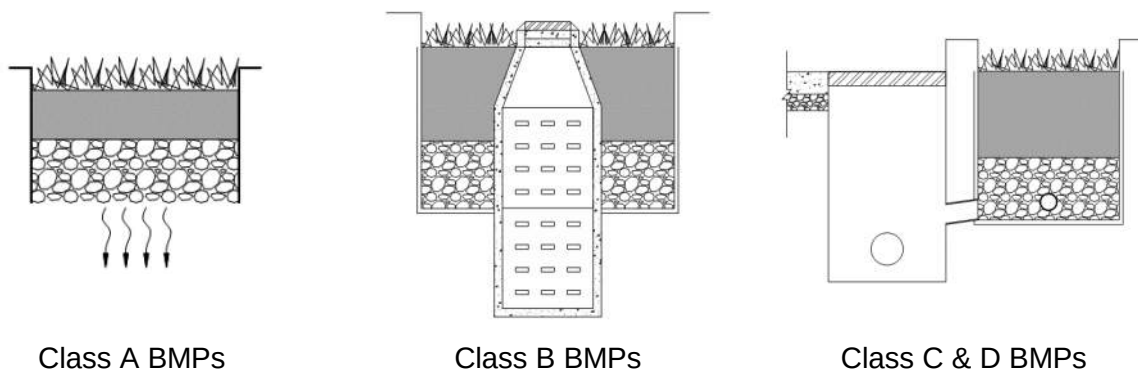
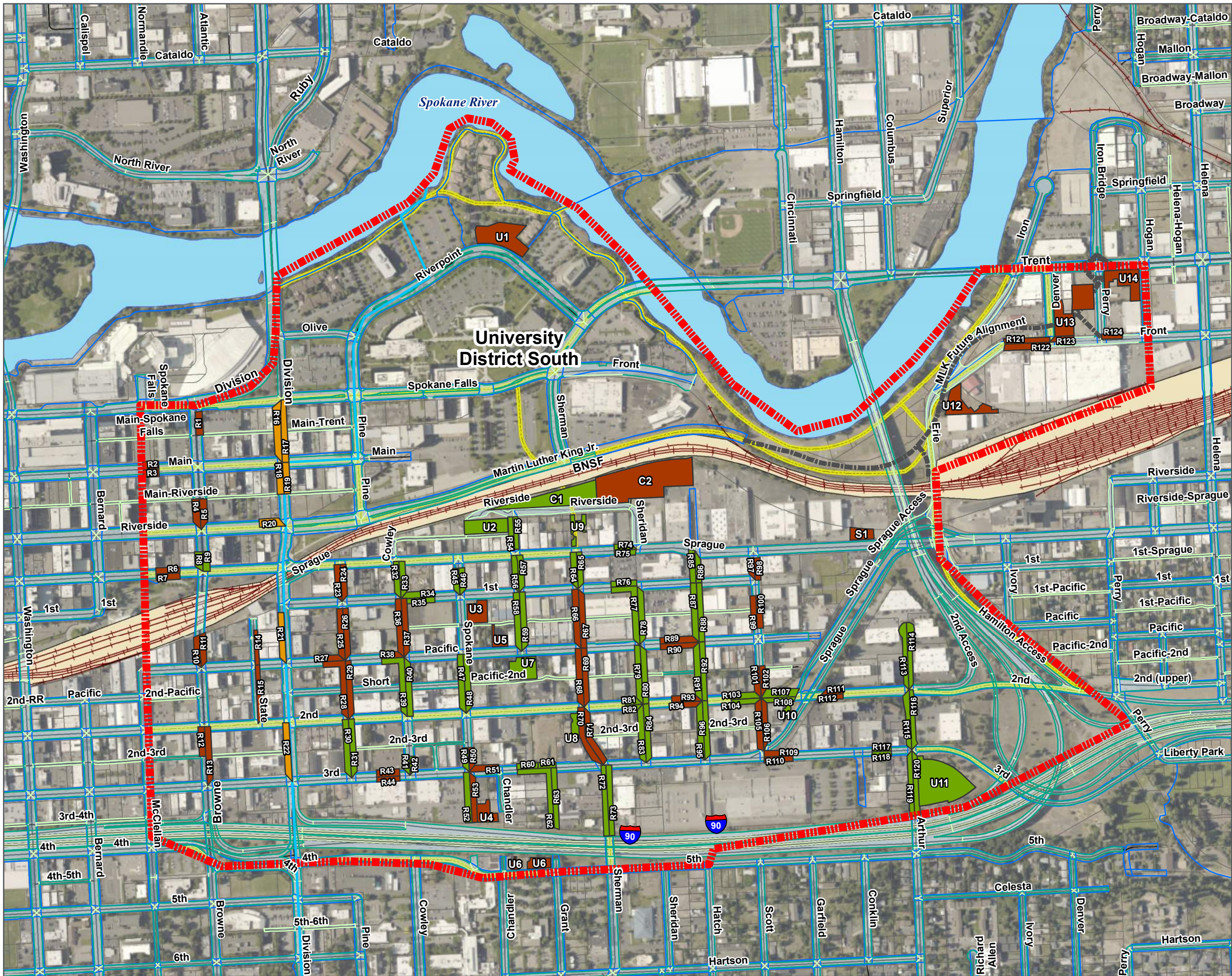


Figure 4. Example of BMP Classifications

NPDES and UIC Requirements

The site suitability criteria defined for each class of BMP aligns with the City's requirements for stormwater management as defined in the Phase II NPDES MS4 permit (Ecology, 2012), the Eastern Washington Stormwater Management Manual (Ecology, 2004), and the Ecology Guidance Document for UIC wells that Manage Stormwater (Ecology, 2006). Specifically, the site suitability criteria for Class A and B BMPs is the same criteria that is used to determine whether the site characteristics are suitable for locating an infiltration BMP in the Spokane Regional Stormwater Manual (Spokane County, City of Spokane, and City of Spokane Valley, 2008). In addition, the criteria defined in the UIC guidance document for determining the pre-treatment and vadose zone requirements for stormwater runoff to drywells, is also embedded in the site suitability criteria for this project. However the criteria with respect to UICs has been simplified. For this project BMPs will always be located upstream of a drywell and provide treatment of runoff from the water quality rainfall event (6 month 24 hour), which is equivalent to the volume of runoff from 91% of the rainfall events, prior to discharging to drywells. As such, the vadose zone requirements are achieved with this upstream BMP and only a 5-foot separation is required between the base of the drywell and groundwater or the impermeable layer. With this approach it is not necessary to assess the vadose zone treatment capacity relative to the pollutant loading to determine the pretreatment requirements or assess whether a separation greater than 5-feet is required between the base of the drywell and the groundwater or impermeable layer elevation. Instead a BMP is selected that provides the required treatment for the UIC based on the pollutant loading at the project site (Map 8) and the required treatment is provided before runoff is discharged to the UIC.



UNIVERSITY DISTRICT SOUTH: STORMWATER SITE SUITABILITY ASSESSMENT

Map 10: Proposed BMP Locations

LEGEND

- Project Location
- Railroad ROW
- Future Alignment of MLK Blvd
- Cowley Creek Clean Water Drain
- Proposed Bike Path
- Sidewalk
- Pavement
- Curbside**
 - No Curb
 - Curb Present

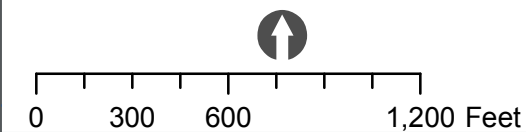
BMP Classification - Undeveloped Parcels

- Class "A"
- Class "D"

BMP Classification - ROW

- Class "A"
- Class "C"
- Class "D"

DATA SOURCES: City of Spokane GIS



Date: 6/14/2018



D. Example Assessment Checklist

Example Site Assessment Report Outline & Checklist

1 INTRODUCTION

- Project Description & Purpose
- Summary of Previous Plans
- Work Completed/Approach

2 SITE BACKGROUND & CONTEXT

- Location & General Property Description
- Geographic Setting & Topography
- Climate
- Geology & Soils
- Hydrology
- Regional Habitat Significance
- Historical Land Cover
- Past Site Use

3 EXISTING SITE CONDITIONS

- Recent Land Use & Management
- Water Resources: Surface Drainage, Wetlands and Riparian Areas
- Vegetation and Habitat Types
- Threatened or Endangered Species and/or Habitat
- Noxious Weeds
- Wildlife & Fisheries
- Adjacent Land Uses
- Infrastructure
- Land Use & Management

4 SITE ANALYSIS

- Constraints
- Opportunities: Goals & Objectives
- Best Management Practices: Living Infrastructure Typologies & Plant Communities
- Next steps

APPENDICES

Example Assessment Checklist:

High Performance Landscape Guidelines, City of NY Parks And Recreation

SITE ASSESSMENT CHECKLIST

The following is a general checklist of items that should make up a first stage site assessment. See the practices sections that follow for more specific information related to soil, water, and vegetation assessment.

INVENTORY: SITE HISTORY

- past site use
 - industrial use
 - archeology
 - filling, dumping, other soil disturbance
 - existing or abandoned utilities
- historic topography
- historic soils
 - contamination
 - levels of contamination (relates to NYS and EPA assessment)
- historic drainage
 - lowland or upland
 - floodplain or wetland
 - history of flooding or erosion
 - historical movement of water through the site
 - historic vegetation
 - forest, wetland, or marsh
- key resources
 - historic maps (even hand-drawn maps that can be overlain on a base plan may indicate historic streams and springs)
 - historic site photos and other archival materials
 - historic aerial photos
 - names of places related to historic conditions or uses (i.e., "Yellow Springs" or "Stony Run")
 - oral histories provided by former maintenance workers and caretakers

INVENTORY: SITE CONTEXT

- social factors
 - user behavior
 - user desires

- circulation
 - pedestrian
 - vehicular
 - service
 - bicycle
 - mass transit
- views
 - on site
 - off site
 - bad views to be hidden
- hydrology
 - watershed
 - water table
 - wetlands
 - drainage patterns
 - surface water features
 - tidal conditions
 - neighboring context
 - sewers, whether combined sanitary sewers or stormwater sewers
- wildlife impacts
 - insects, fish, birds, land mammals
 - rare or endangered species
- landscape character
 - historic landscape
 - natural area
 - woodland
 - disturbed
 - formal garden
 - river corridor
 - wetland
- legal factors
 - zoning requirements
 - waterfront
 - parking area treatments
 - code requirements
 - required property line set backs
 - wetland delineations
 - floodplains restricting building locations or requiring elevations
 - utility or roadway easements
 - presence of mapped streets (NYCDP restrictions)
 - waterlines (NYCDEP restrictions)
 - stormwater (NYCDEP restrictions)
 - private utility restrictions or suggested practices

- roadway and utility offsets
 - streetlights
 - hydrants
 - driveways
 - corner off-sets
- special natural area district (SNAD) requirements (Bronx and Staten Island)

INVENTORY: SITE CONDITIONS

- topography
 - slopes
 - low points
- soils/geology
 - geology, including depth to bedrock
 - subsurface and soil morphology
 - soil biology
- fertility analysis
- chemical analysis
 - percolation rates
 - hardpan
 - sinkholes
 - erosion potential
 - drainage rates
 - landfill or contaminated sites
- hydrology
 - existing streams and wetlands
 - setbacks and buffers, as necessary
 - floodplains and coastal erosion zones
- vegetation
 - existing vegetation
 - plant species
 - health of vegetation
 - plants as indicative of soil conditions
 - quality
 - rare
 - native
 - mixed native and/or invasive
 - invasive
 - trees
 - size
 - type
 - location
 - health
 - habitat presence
 - habitat type(s)
 - sort of habitat

- provided by plants
 - healthy and robust or unhealthy and stressed
- understory types
- stress indicators
 - small, scorched, or off-color foliage
 - early fall color or leaf drop
 - tip dieback
 - presence of insects or disease
 - suckering from the trunk
- climate
 - air quality, temperature, and humidity
 - sun/shade patterns and reflected heat
 - wind
 - precipitation rates for rain and snow
 - depth to frost
 - freeze and thaw
 - microclimate
 - fungus, mold, or insect problems
- urban
 - subsurface utilities
 - subsurface foundation remnants
 - subsurface transit ways
- noise

SITE ANALYSIS

- site opportunities and constraints
 - stormwater management
 - soil capacity
 - soil contamination
 - tree health and appropriate removals, pruning, and replacement
- design determinants and the capacity of the site to support program
 - appropriate planting strategies
 - fit of park into its larger context
- Best Management Practices to be applied
 - reduction of impervious surfaces
 - redirection of drainage to natural systems