RILEY PURGATORY BLUFF CREEK WATERSHED DISTRICT

D R A F T

Ecosystem Health Action Plan

August 2024

Riley Purgatory Bluff Creek Watershed District Adoption: X*

Prepared for
Riley Purgatory Bluff Creek Watershed District
By Barr Engineering Company

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Executive Summary

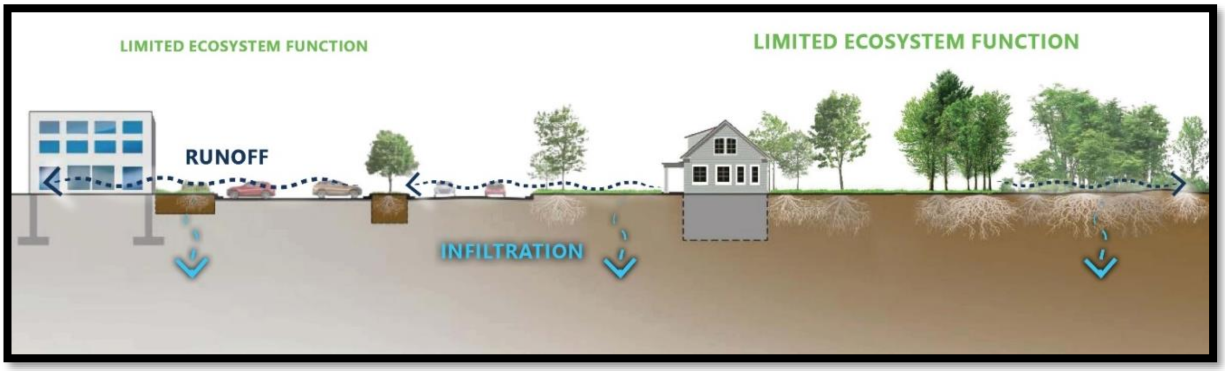
The land surface of the Riley Purgatory Bluff Creek Watershed District (District) has increasingly been sealing off and resisting stormwater infiltration. This is directly due to the construction of buildings and pavement across the District as well as due to the compaction of soils within lawns, woodlands, and other green spaces. Simply put, the watershed experiences more stormwater runoff and less infiltration. This stresses our streams, wetlands, and lakes with increased water volumes and the pollutants the water carries. It also reduces groundwater inputs and aquifer recharge, and decreases the base water flow to streams, wetlands, and lakes.

Despite decades of District stormwater management efforts, many water resources in the District continue to degrade or are in poor health. This plan looks beyond end-of-pipe stormwater solutions (i.e., stormwater treatment facilities) to address issues at their source: the watershed and its altered urban hydrology—taking the next step to protect and restore water resources and achieve a healthy urban ecosystem within the District.

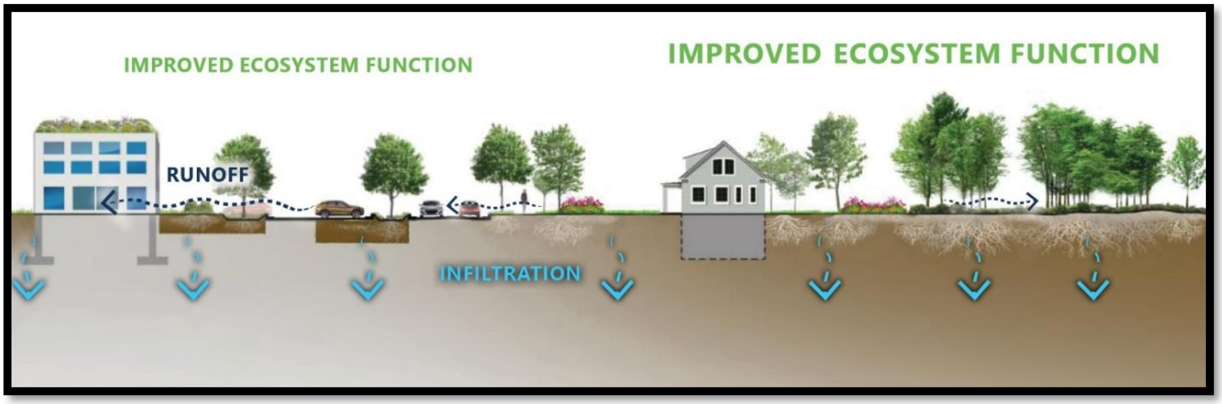
A healthy urban ecosystem establishes a balance between the built infrastructure of a community and the green spaces that it occupies. That balance is fluid yet should support the ecosystem elements upon which we depend: clean water, clean air, biodiversity, climate, connection to nature, and so much more. Ecosystem health is relative and should be the goal for every square foot of the watershed.

RPBCWD developed this plan to 1) identify ecosystem malfunctions and strategize for their recovery and 2) instate ecosystem approach to our work to address all aspects of a healthy ecosystem—to embrace the entire watershed, not just the water resources.

The purpose of this plan is to develop strategies to regenerate ecosystem health.



Schematic illustration of a typical suburban development, including an office building with its parking lot, a residential street, a residence, and adjacent natural parkland.



Land improvements can be introduced to bolster ecosystem function. These include, from left to right, a green roof; trees and rain gardens replacing unnecessary parking stalls; an expanded tree rooting area under the parking lot; reduced street width to eliminate an unused parking lane; the implementation of rain gardens, street trees, and a sidewalk; the reduction of front and back yard lawn through the planting of pollinator species; and the elimination of invasive buckthorn in the woodland.

Implementable Action Strategies

Through the advisory committee workshop series (see Appendix 1), staff vetting, and a literature review, District ecosystem health actions were identified and prioritized. Ecosystem management actions have been divided into categories summarized below. These are activities where the District can intervene on behalf of the ecosystem and the people who live there.

- **Regulations**—The District's regulations will be revised to more effectively address climate change impacts (such as increased precipitation) and climate resiliency, further protecting the ecosystem, water resources, and inhabitants of the District.
- **Climate resiliency initiatives**—The District will undertake climate vulnerability assessment and adaptation planning to address both our impact on the climate and the climate's impact on the District.

- **Land protection and regeneration**—The District will require additional analysis and protection for projects adjacent to high-risk erosion areas. Most of the District's land is privately owned. The District will continue to work with property owners to improve soils, increase stormwater infiltration, and improve biodiversity.

- **Surface water management**—Further stewardship, education, regulatory, and planning measures will be pursued to protect and restore wetlands and shorelines.

- **Education and outreach**—The District will expand education and outreach (E&O) efforts for ecosystem protection by prioritizing the education of decision-makers.

- **Partnerships**—The District will meet as often as possible with the staff of area cities to get involved in and provide ecosystem perspective on topics such as development, city code revisions, and comprehensive planning so they can better justify an ecosystem approach to their work.

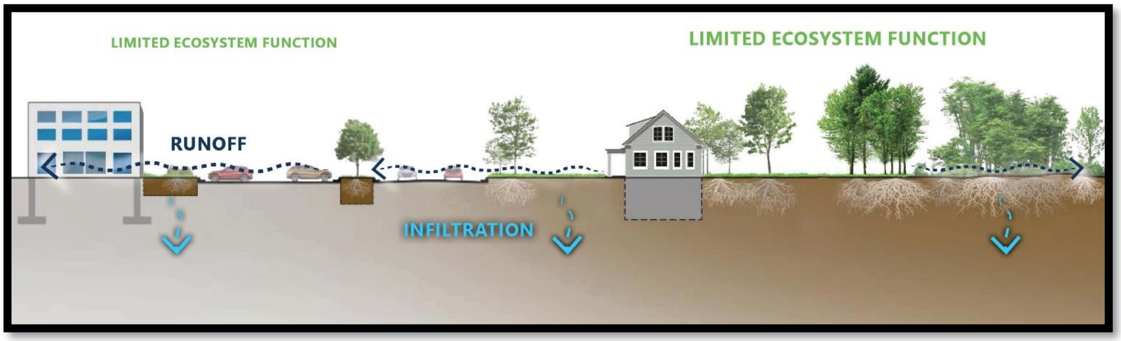
- **Data collection**—The program will be expanded to identify, collect, and analyze key ecosystem data (e.g., soils, groundwater, and vegetation).

1.0 Introduction

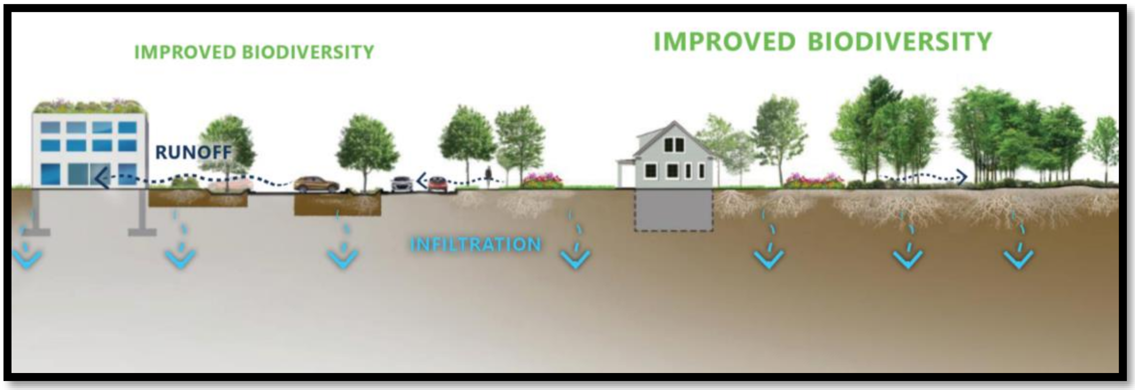
Riley Purgatory Bluff Creek Watershed District (the District) has developed this Ecosystem Health Action Plan to further address the degradation of its natural water bodies through an ecosystem approach to watershed planning. An ecosystem approach takes every physical and environmental aspect of the watershed into account to make decisions that benefit people and our environment.

A distinct connection exists between the human-caused disruption of the hydrologic, biologic, and nutrient cycles within the District's natural waterbodies and the watershed in which they reside. Changes within the upland ecosystem, such as urban development, soil compaction, biodiversity loss, urban heat island effect, and climate change, greatly impact natural water bodies by effecting the quality, volume, and rate of stormwater that reaches them.

The District has worked for decades to protect its natural waterbodies by regulating stormwater runoff as development occurs and through capital projects. Despite decades of stormwater management efforts, many water resources in the District continue to degrade or are in poor health. This plan has been developed to look beyond end-of-pipe stormwater solutions (i.e., stormwater treatment facilities) to address issues at their source: the watershed and its' altered urban hydrology—taking the next step to protect and restore water resources and achieve a healthy urban ecosystem within the District.



Schematic illustration of a typical suburban development, including an office building with its parking lot, a residential street, a residence, and adjacent natural parkland. Biodiversity is low in highly urbanized areas (right side) and increases with the amount of green space. Green space quality, however, must be nurtured in urban environments.

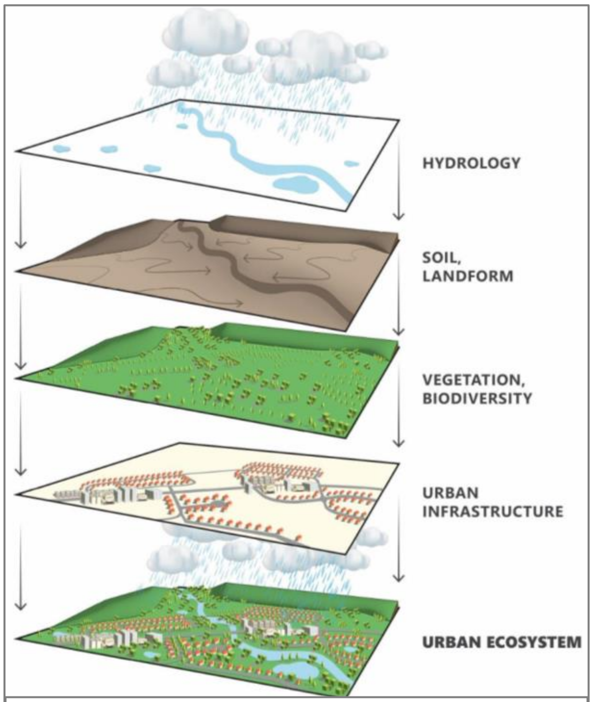


Land improvements can be introduced to bolster ecosystem function. These include, from left to right, a green roof; trees and rain gardens replacing unnecessary parking stalls; an expanded tree rooting area under the parking lot; reduced street width to eliminate an unused parking lane; the implementation of rain gardens, street trees, and a sidewalk; the reduction of front and back yard lawn through the planting of pollinator species; and the elimination of invasive buckthorn in the woodland.

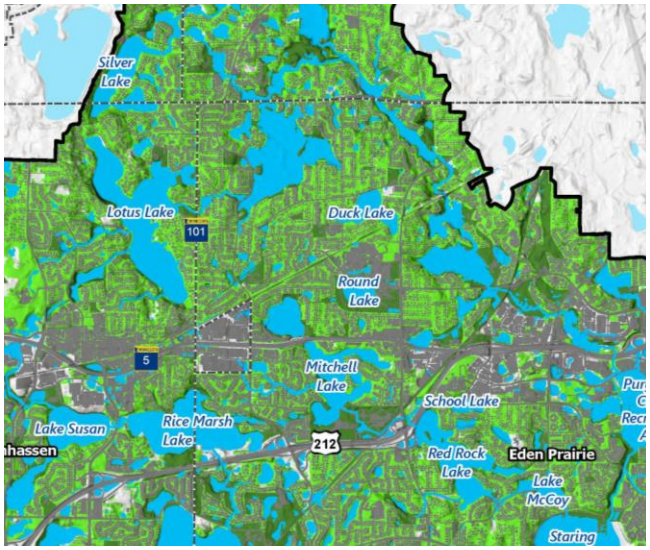
What is a healthy urban ecosystem?

An ecosystem is a biological community consisting of all living organisms and nonliving components (e.g., air, water, and mineral soil) with which the organisms interact (US EPA, 2023). Ecosystems can be of different sizes (like marine, prairie, or ephemeral wetland) and include the built environment—human-made surroundings. Ecosystem health refers to the quality of the system and the abundance of services it provides, as well as its positive impact on human health and quality of life.

A healthy urban ecosystem establishes a balance between the built infrastructure of a community and the green spaces that it occupies. That balance is fluid yet should support the ecosystem elements upon which we depend: clean water, clean air, biodiversity, climate mitigation, connection to nature, and so much more (see list below). Ecosystem health is relative and should be the goal for every square foot of the watershed. **The purpose of this plan is to develop strategies to regenerate ecosystem health.**



It is helpful to break down an urban ecosystem into its primary components. Even though all levels of this complex system are integral and typically addressed at the same time, they can be separated for better understanding. Once we understand the components of an ecosystem, we can develop solutions and work towards our goal of regenerating the ecosystem.



There are three types of land surface in the District. In this map, showing a portion of the District:

Green represents vegetation—lawn, woodlands, old field vegetation, and agricultural land of the watershed.

Grey represents hard surfaces: streets, highways, parking lots, driveways, buildings, and homes.

Blue represents natural water bodies—streams, lakes, and wetlands.

It's possible to improve ecosystem health by expanding the green areas and shrinking the grey to protect the blue.

The goal is to compensate for our built environment (the grey) by striking a better balance with green infrastructure. This can mitigate the impact of our built environment.

Why take an ecosystem approach to watershed planning and water resource protection?

As the population within the District continues to grow, green space is replaced by construction, water resources are degraded, and valuable ecosystem functions degrade. We can do better to retain and enhance ecosystem function for our own good.

Ecosystem services upon which people depend include the following:

- Clean water to drink, swim, and enjoy
- Clean air to breathe
- Productive soil to grow food, trees, and other essential plants
- Wildlife that provides a source of food and enjoyment
- Insects that pollinate
- Trees and vegetation for shade, wind protection, filtration, mitigation of urban heat island effect, and beauty
- Green spaces that provide a rejuvenating connection to nature
- Vegetation that photosynthesizes—removing carbon dioxide from the air and releasing oxygen to people
- Vegetation that provides food, fiber, pharmaceuticals, and fun
- Opportunities for recreation
- The absorption and decomposition of pollutants
- Erosion control and flood protection
- Spiritual and therapeutic benefits

Since its inception, the District has made significant progress in protecting its water resources. The ecosystem approach to watershed management builds on the "engineered" approach to water resource improvement. Currently, we build stormwater treatment facilities to address degraded water as it leaves a site rather than take a preventative approach that addresses the source of runoff—the surfaces where precipitation lands and from which water sheds. The ecosystem approach is a preventative approach to watershed management. Every square foot of the District is addressed through management planning along with, where necessary, treating stormwater at the end of the pipe.

We impact the ecosystem through much of what we do in our daily lives. This plan establishes how the District can further intervene on nature's (and our) behalf to achieve the District's mission and goals in the 10-year plan.

1.1 Goals for this Plan

The primary goals of this plan include the following:

1. To show the link between hydrologic function loss in natural water bodies and upland ecosystem issues such as soil health, biodiversity, habitat quality, urban heat island effect, urban forest degradation, and climate change
2. To identify where the District's ecosystem is impacted
3. To define a healthy urban ecosystem and identify where we can effectively intervene to improve water resources
4. **To identify strategies, programs, and projects that will be undertaken to initiate ecosystem recovery and protect/restore water resources**
5. To continue to identify partners and build relationships by working together to achieve ecosystem health

1.2 Workshops Supporting this Plan

An advisory panel of District partners was formed to advise this Ecosystem Health Action Plan. A series of four workshops were conducted by the District to identify ecosystem issues and discuss actions to improve ecosystem function within the District. The purpose of the workshops was to:

- Reinforce or establish relationships (due to considerable agency staff turnover) with District partners.
- Gather ecosystem management data, perspective, and priorities.
- Understand what is currently being done by each agency in the realm of ecosystem management.

- Determine gaps in ecosystem management.
- Determine how together we can improve the ecosystem of our District.

Advisory panel members included representatives from:

Board of Soil and Water Resources
Carver County Natural Resources
City of Bloomington Planning and Natural Resources
City of Chanhassen Planning, Water Resources, and Natural Resources
City of Chaska Planning and Water Resources
City of Deephaven Planning
City of Eden Prairie Planning, Administration, Water Resources, and Natural Resources
City of Minnetonka Planning and Natural Resources
City of Shorewood Planning
MN DNR Area Hydrologist
Hennepin County Water Resources and Natural Resources
Nine Mile Creek Watershed District
Riley Purgatory Bluff Creek Watershed District Board Representative, Citizens Advisory Commission Representative, and Staff
Barr Engineering Co. Ecologists and Engineer

The workshop series addressed the following:

Workshop 1:

- Defined a healthy urban ecosystem
- Identified primary challenges to a healthy urban ecosystem

Workshop 2:

- Inventoried what the advisory panel members are currently doing to achieve a healthy urban ecosystem
- Identified what's not being addressed

Workshop 3:

- Identified how we can address gaps in ecosystem protection/improvement
- Where can we be most effective (prioritization)

Workshop 4:

- How will we work together (commitment)
- Prioritization of initiatives

Information gathered in this workshop series is presented in Appendix 1.

2.0 Historic and Current Ecological Conditions

To accomplish ecosystem improvement, we first want to understand both the pre-European settlement ecosystem and its current condition. The following maps and descriptions illustrate these conditions.

2.1 Historical Vegetation

A model of ecological (native plant) communities present at the time of European settlement has been developed by the MN DNR. The source of data for this model was the original surveyor's notes (1846–1848), which recorded vegetation at section corners throughout Minnesota.

As shown in Figure 2-1, the District was primarily covered with deciduous forests of the sugar maple/basswood and oak forest associations. A spine of oak savanna through the lower center of the District was likely the result of intentional burning by indigenous peoples who were the original inhabitants prior to European settlers extirpating them from their land.

These native ecological communities functioned hydrologically like a sponge, holding precipitation on the land and allowing it to soak into the ground and slowly drain to nearby lakes, wetlands, and streams. Ecological communities were instrumental in the geochemical cycle, storing carbon and nutrients on the land and filtering runoff waters prior to discharging to lakes, wetlands, and streams.

Today, we use the historical vegetation model (Figure 2-1) as a template for ecological communities that can be regenerated within our built environment. *Our challenge is to gain ecosystem benefits through the regeneration and management of the native ecosystem while accommodating our modern, daily needs.*

Ecosystem Benefits

"Protecting ecosystems and the natural benefits that they provide is essential to the future of life on our planet and the well-being of humanity."*—National Geographic*

Some of the benefits of healthy ecosystems include the following:

1. Providing habitat to wild plants and animals
2. Promoting various food chains and food webs
3. Recycling nutrients between biotic and abiotic components
4. Maintaining the usual flow of energy including carbon cycle, energy cycle, nitrogen cycle, oxygen cycle, and water cycle
5. Providing clean air and clean water
6. Regulating the climate
7. Providing recreation and aesthetic value
8. Providing spiritual enrichment and cognitive development
9. Forming soil and providing food
10. Mitigating the impacts of climate change

The ecosystem serves us and we must serve the ecosystem to continue reap in these benefits. People cannot survive without them.

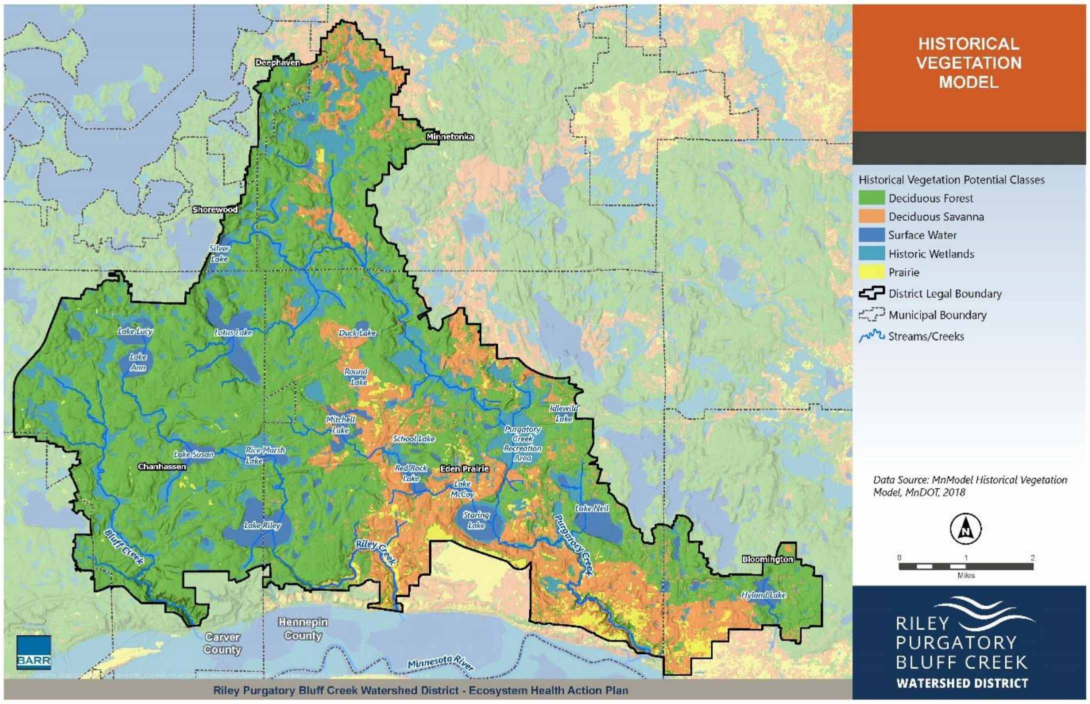


Figure 2-1 Historical Vegetation Model

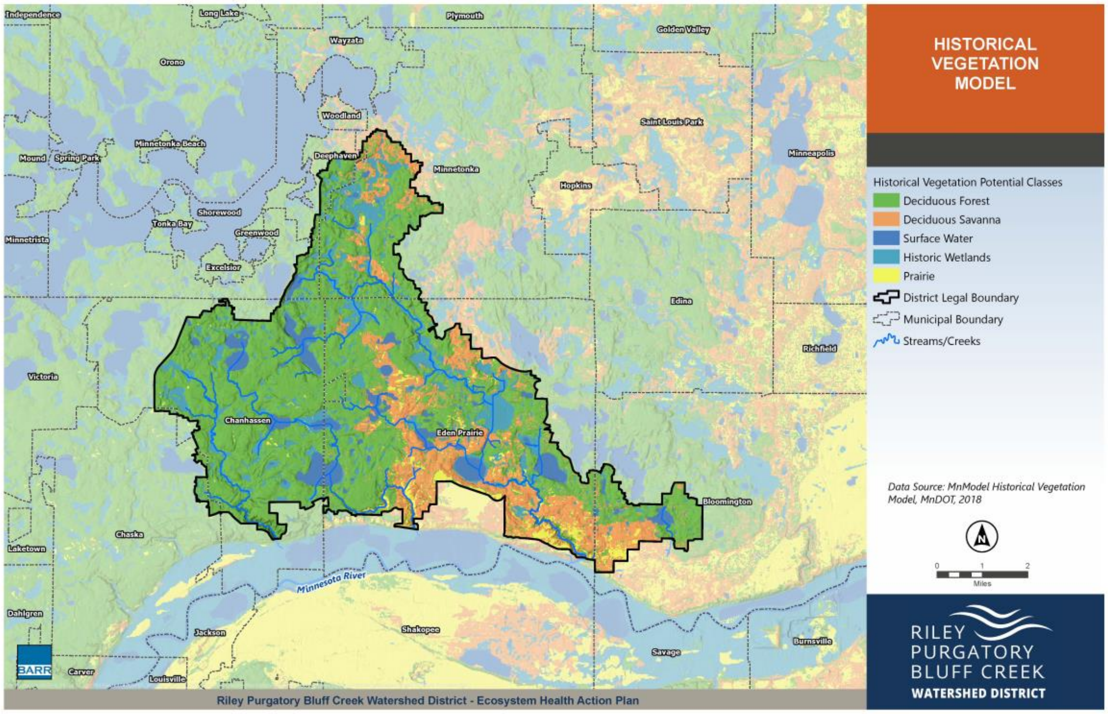


Figure 2-2 Context—Historical Vegetation Model

The District exists within a larger ecosystem of forests, savannas, and wetlands. This figure shows surrounding ecological communities prior to European settlement. Ecosystems have no clear boundaries and are significantly influenced by adjacent lands.

2.2 Historical Wetlands

The extent of wetlands, lakes, and streams is estimated in this historical map of conditions at the time of European settlement. Wetlands that have been drained leave their imprint today in soil type and topography, which was used to develop this map (Figure 2-3).

Wetlands retain and slowly release runoff, protecting streams from large volumes of runoff and providing stable wildlife habitat.

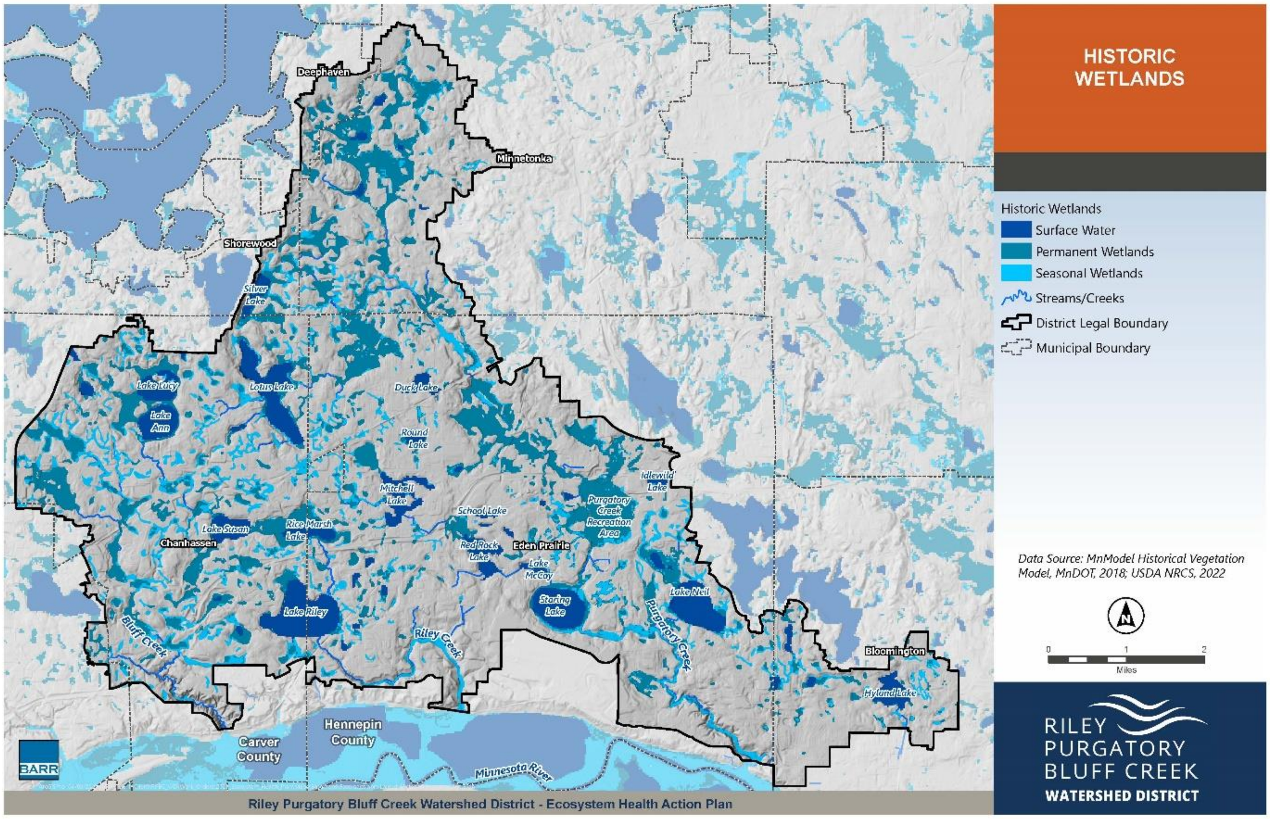


Figure 2-3 Historical Wetlands

2.3 Drained Wetlands

As European settlers colonized the District, they drained a significant number of wetlands (especially the seasonally flooded wetlands) to expose their rich soil for crops. A District-wide assessment found that most of the wetlands that remain have been degraded and/or have had their hydrology altered through changes to the surrounding landscape and outlet modifications. At the time of settlement, much more water was held on the land, where it infiltrated and recharged groundwater and aquifers. Today, streams carry much more water and have experienced bank cutting, sediment accumulation, bed aggradation, loss of floodplain connection, and loss of fisheries and aquatic macroinvertebrate habitat due to the additional runoff (Figure 2-4).

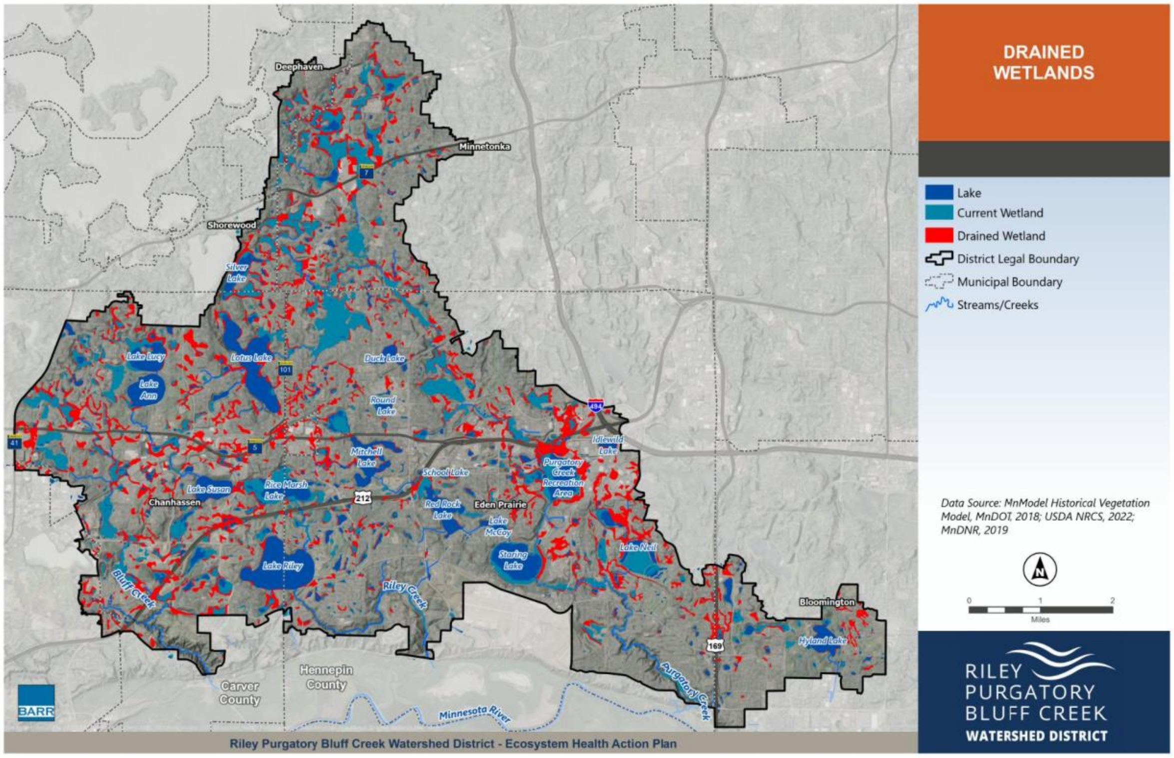


Figure 2-4 Drained Wetlands

2.4 Hydric Soils

Hydrologic soil groups are based on estimates of runoff potential and were developed from field work conducted in 1955 by the Natural Resources Conservation Service. Soils are assigned to one of four groups according to the rate of water infiltration when the soils are not protected by vegetation, are thoroughly wet, and receive precipitation from long-duration storms.

Figure 2-5 shows where stormwater infiltration capacity varies within the District. It also illustrates the extent of undrained (A/D, B/D, and C/D) soils, which were originally wetlands of some type. By overlaying the map of currently developed land (Figure 2-6) with the hydrologic soils group map, an estimate of drained wetlands is extrapolated (Figure 2-4).

Much of the soil within the District has been disturbed and compacted since 1955; the hydrology has been significantly altered, increasing stormwater runoff. Figure 2-6 (developed land) shows the current extent of soil disturbance.

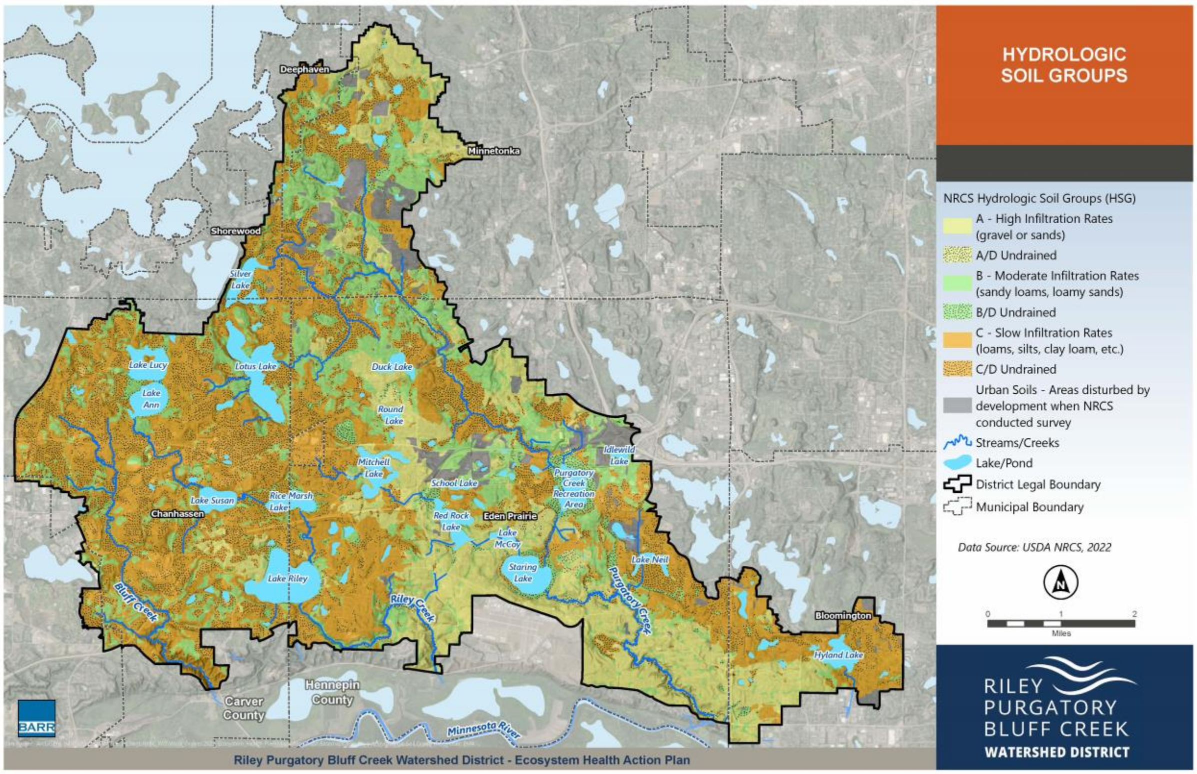


Figure 2-5 Hydrologic Soil Groups

2.5 Developed Land

The significance of this map is the implication of the extent of soil disturbance—decreasing stormwater infiltration, increasing stormwater runoff volume and rates, and resulting in the impairment of downstream water bodies (Figure 2-6).

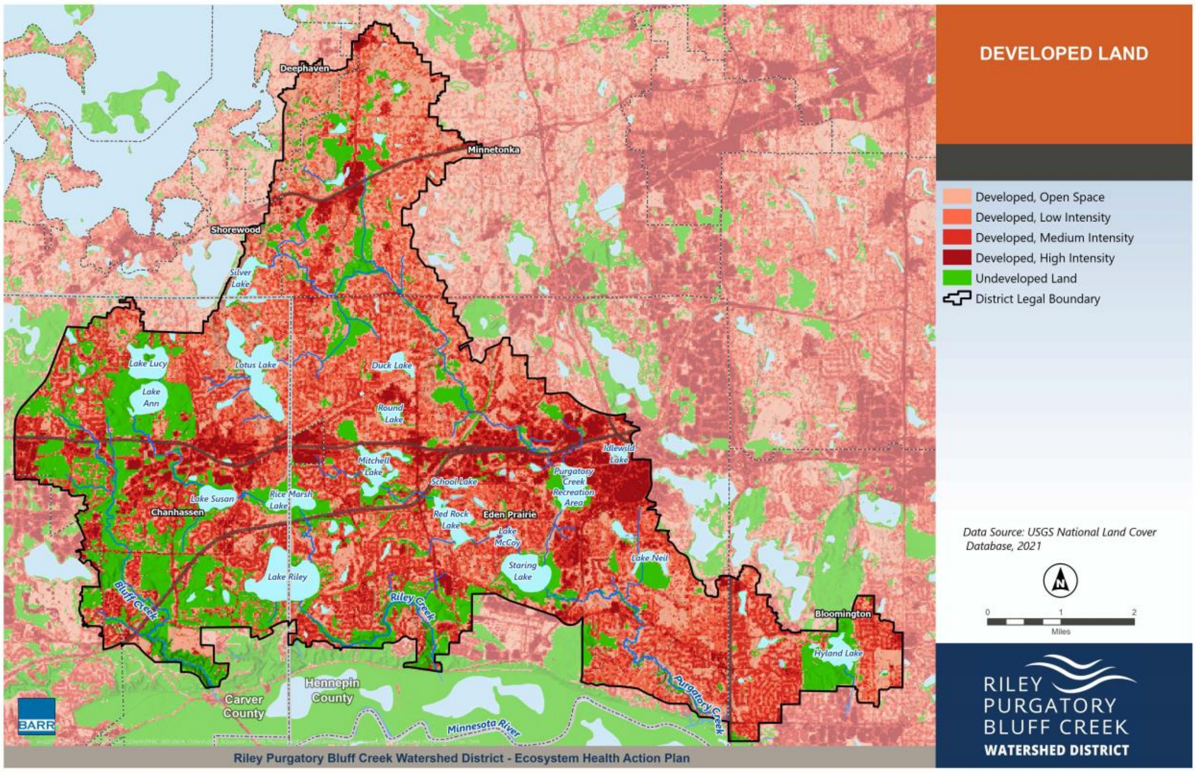


Figure 2-6 Developed Land

2.6 Historical Land Use

Early settlers were primarily subsistence farmers. They cleared forests, drained wetlands, established crop land, and grazed their cattle and horses. This alteration of the land had a significant impact on hydrologic and nutrient cycles. Clearing woodlands reduced or eliminated the forest "sponge" that held water and nutrients in uplands, the evapotranspiration potential, as well as leaf interception of rainfall. The plow mixed the soils of cleared land, reducing organic matter content and water infiltration capacity. Once mechanical equipment became available for cropping, the soil was further compacted. This resulted in a still greater reduction in water infiltration and greater runoff—often laden with sediment and nutrients. Grazing also compacted soil and adversely impacted the soil food web by limiting rooting that feeds the web and compacting soil that reduces air and water infiltration. Grazing is yet another factor that has reduced stormwater infiltration and nutrient availability to plants.

As a result, lakes and wetlands received a significant sediment load with accompanying nutrients. Streams experienced cutting and bank erosion from increased runoff. Biodiversity dropped in all habitats. Unintentionally, people also brought in weeds and invasive species, which took over native habitats weakened by disturbance. This altered the hydrology, slowly diminishing biodiversity and ecological function until we are left with a few small remnants of high-quality natural areas, primarily in the lower valleys (see Figure 2-12).

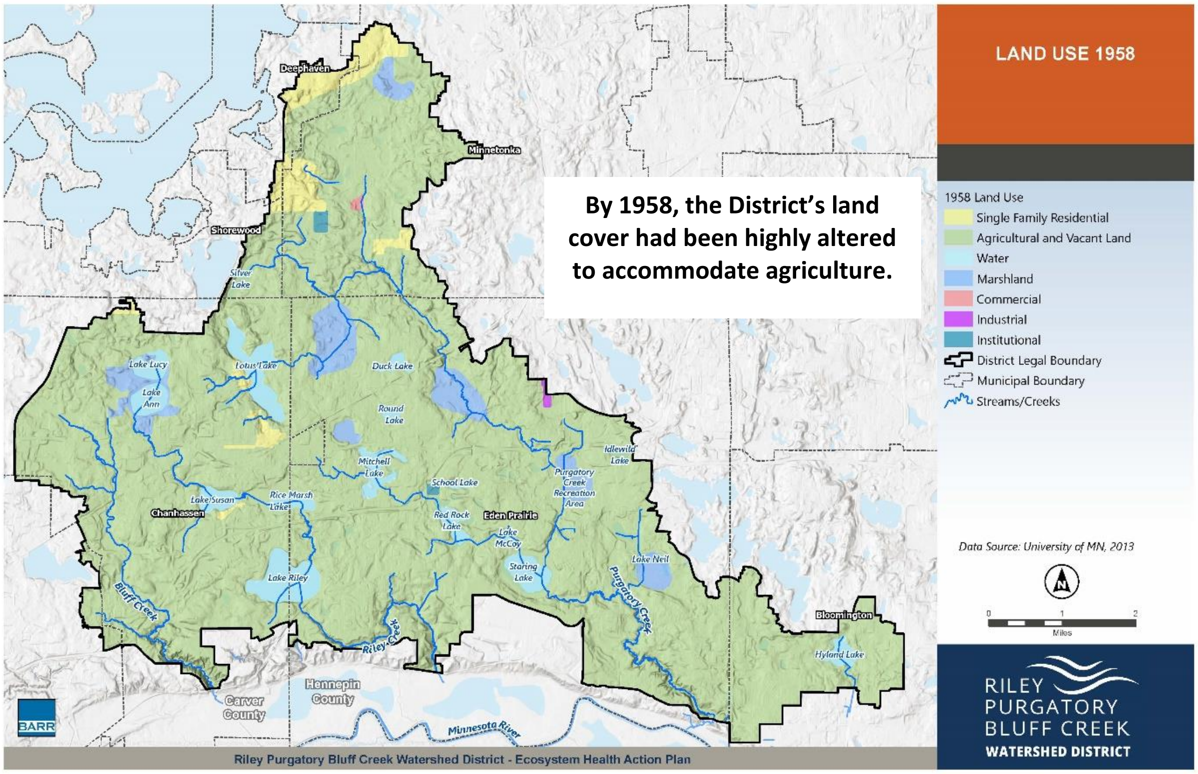


Figure 2-7 Land Use 1958

2.7 Current Land Use

The hydrology and ecology of the District were further altered as suburban development began to boom in the 1970s and continues today. Our population has grown, and people have built streets, homes, and businesses. This trend is predicted to continue. Single-family residential land use currently dominates the District, with a spine of multifamily/commercial/industrial use along the Highway 5 corridor. The District is now covered with approximately 24 percent impervious surface (roads, parking lots, buildings, etc., Figure 2-10) and about 40 percent lawn. This has greatly increased the volume and rate of stormwater runoff and corresponding pollutants while also greatly diminishing District-wide biodiversity.

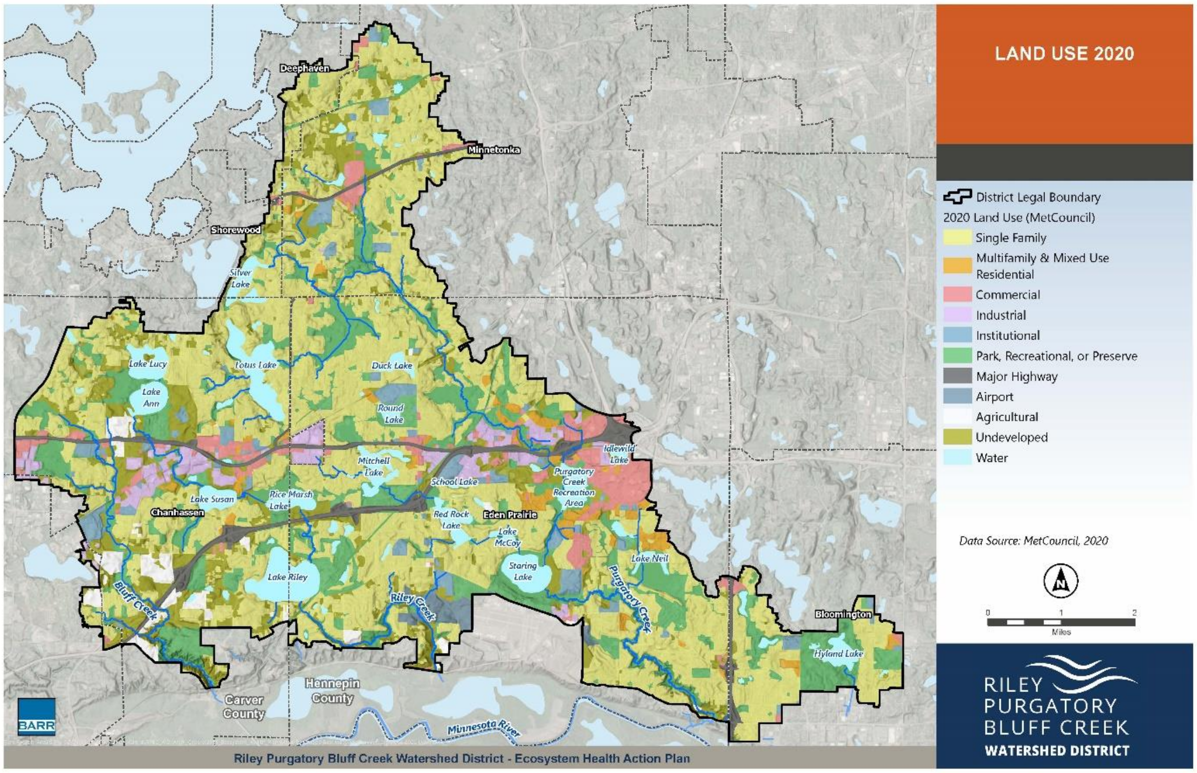


Figure 2-8 Land Use 2020

The District sits within a sea of similar development (see Figure 2-9 below), impacting the ecosystem within all surrounding communities.

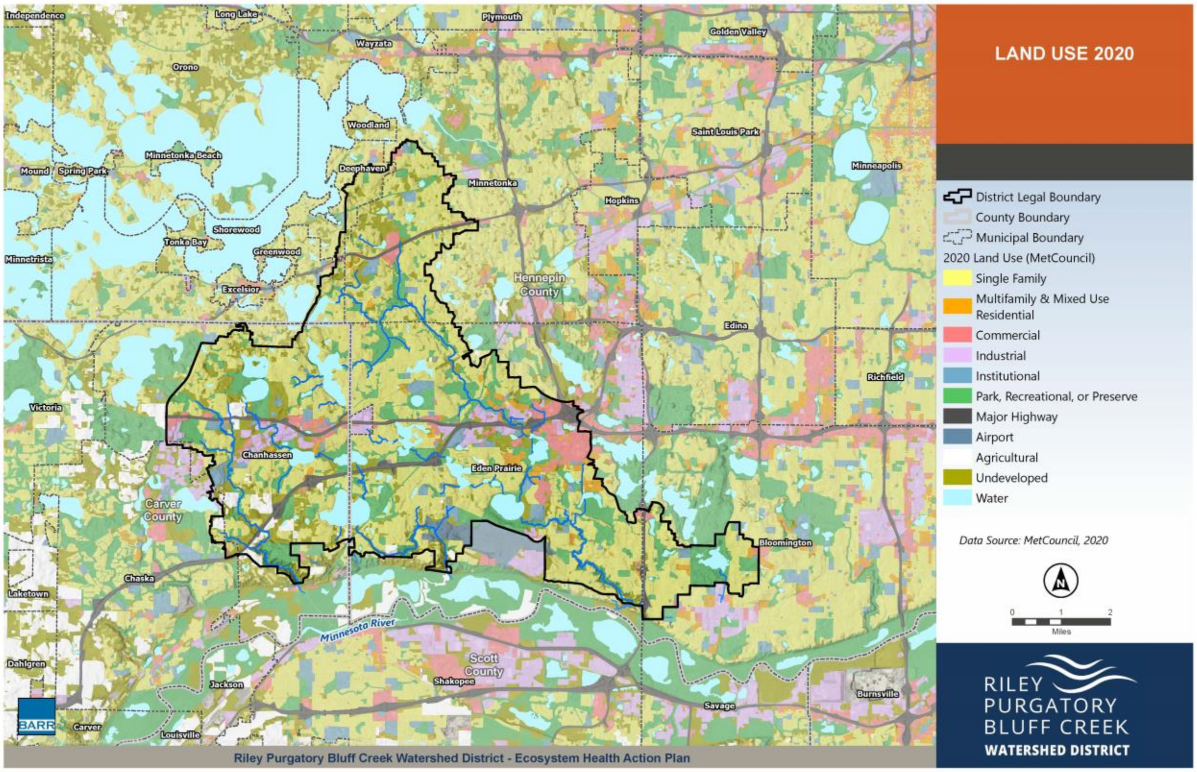


Figure 2-9 Land Use Context, 2020

2.8 Impervious Surface

As noted above, approximately 24 percent of the RPBC Watershed District is covered with impervious surfaces (buildings, parking lots, roads, etc.). This highly alters hydrologic function by dramatically increasing stormwater runoff compared to undeveloped conditions (Figure 2-10). The District has diligently worked from its inception to mitigate the impact of impervious surfaces on downstream natural water bodies. However, the benefits that these incremental, “after-the-fact” practices, such as stormwater ponds and other BMPs, can provide are limited. Impervious surfaces also collect heat and exacerbate the urban heat island effect (see Section 2.15), which negatively impacts natural water bodies (see Section 2.17). As we focus more on ecosystem protection, greater effort can be put into thoughtful development designed to be conservative with the extent of impervious surfaces. Retrofit projects can eliminate pavement, such as unused parking stalls, and reduce the width of oversized streets. Buildings can be built taller rather than wider. The goal is to preserve or create high-quality, pervious green space wherever possible.

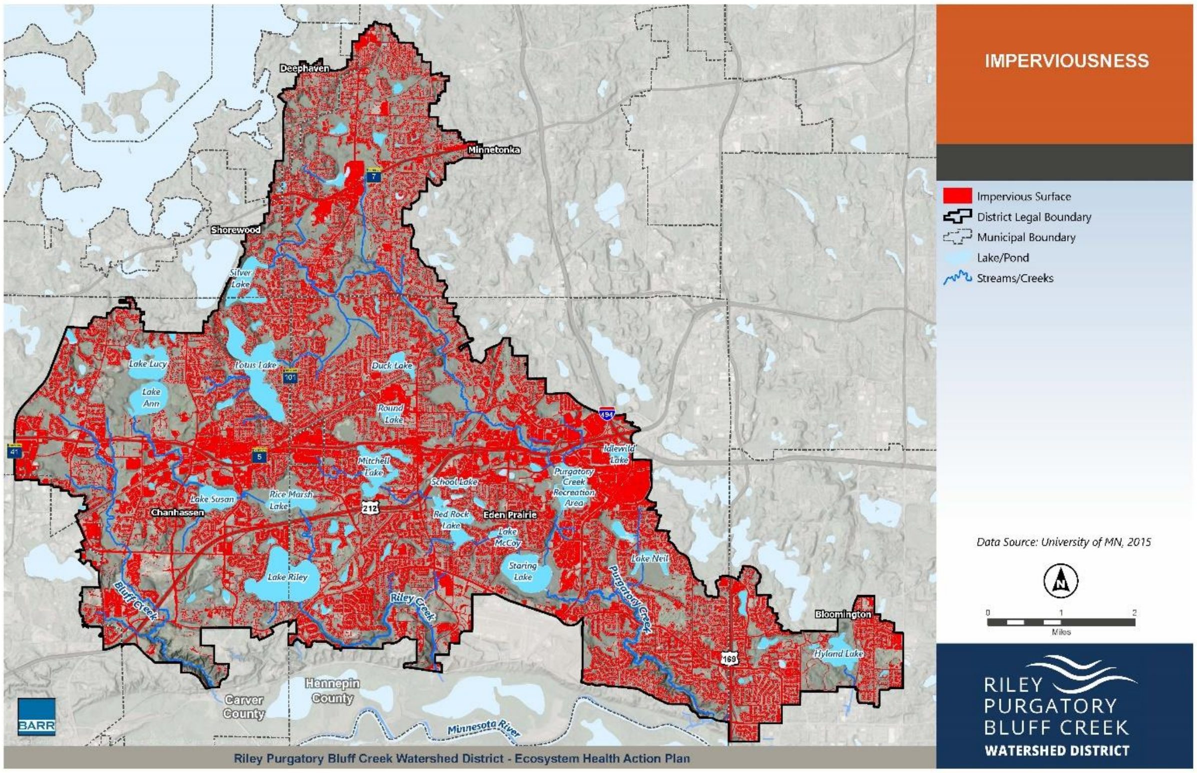
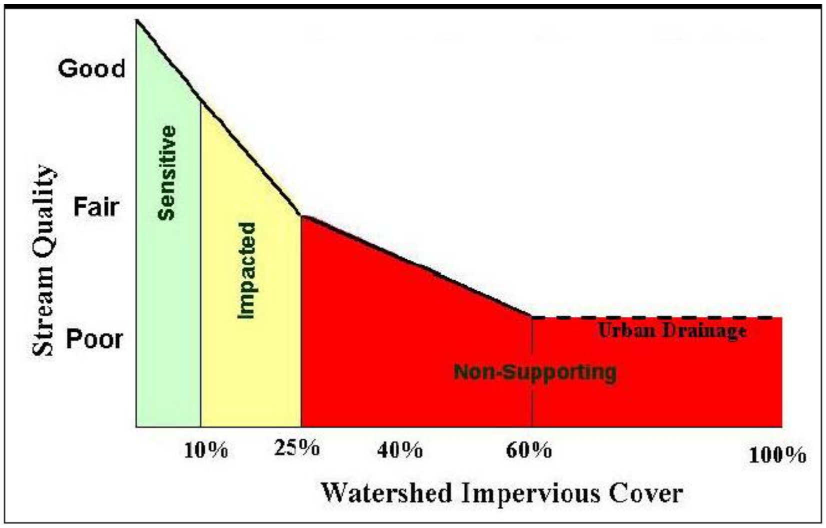


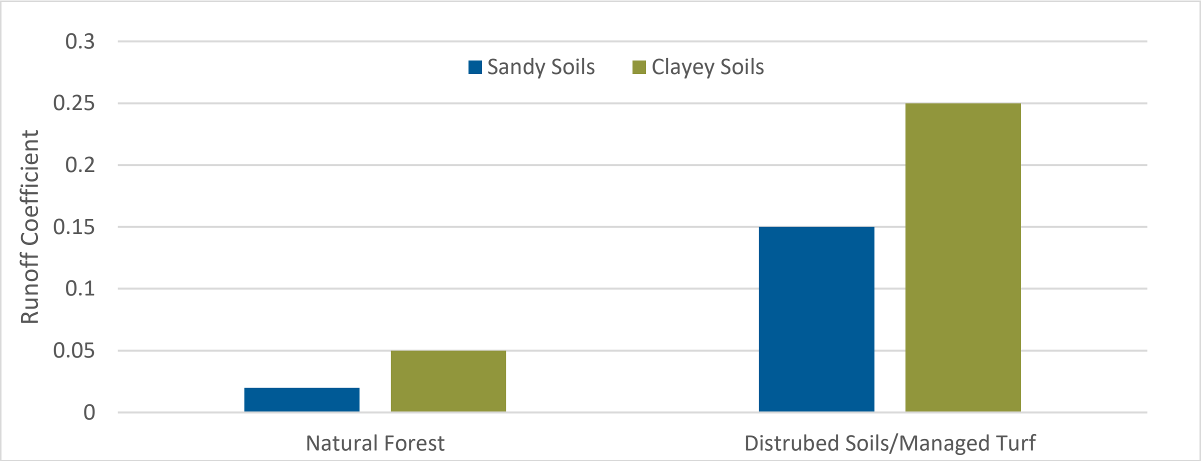
Figure 2-10 Imperviousness



Stormwater runoff from impervious surfaces begins to impact stream quality at only ten percent cover. At 25 percent cover, stream quality is significantly impacted. Source: Schueler, T. 1994a. "The Importance of Imperviousness." Watershed Protection Techniques 2(4): 100-111.

2.9 Lawn

Lawns comprise approximately 40 percent of the Watershed District and have an altered hydrology compared to native forests, prairies, or savannas (Figure 2-11). Because they are usually established in conjunction with construction projects, their soil is typically compacted by heavy equipment. Lawns shed much more runoff than native plant communities because of shallow root systems and compacted soil, and they support very little biodiversity. They have a negative impact on the ecosystem and consume significant natural resources through their maintenance (irrigation, fertilizer, pesticides, and fuel for mowing). All our small individual lawns add up to a lot of turf and can yield more than 5 times the amount of runoff compared to the natural woodlands once present in the landscape (see image below)!



The effect of grading, site disturbance, and soil compaction greatly increases the runoff coefficient compared to forested areas (Hirschman, 2008)

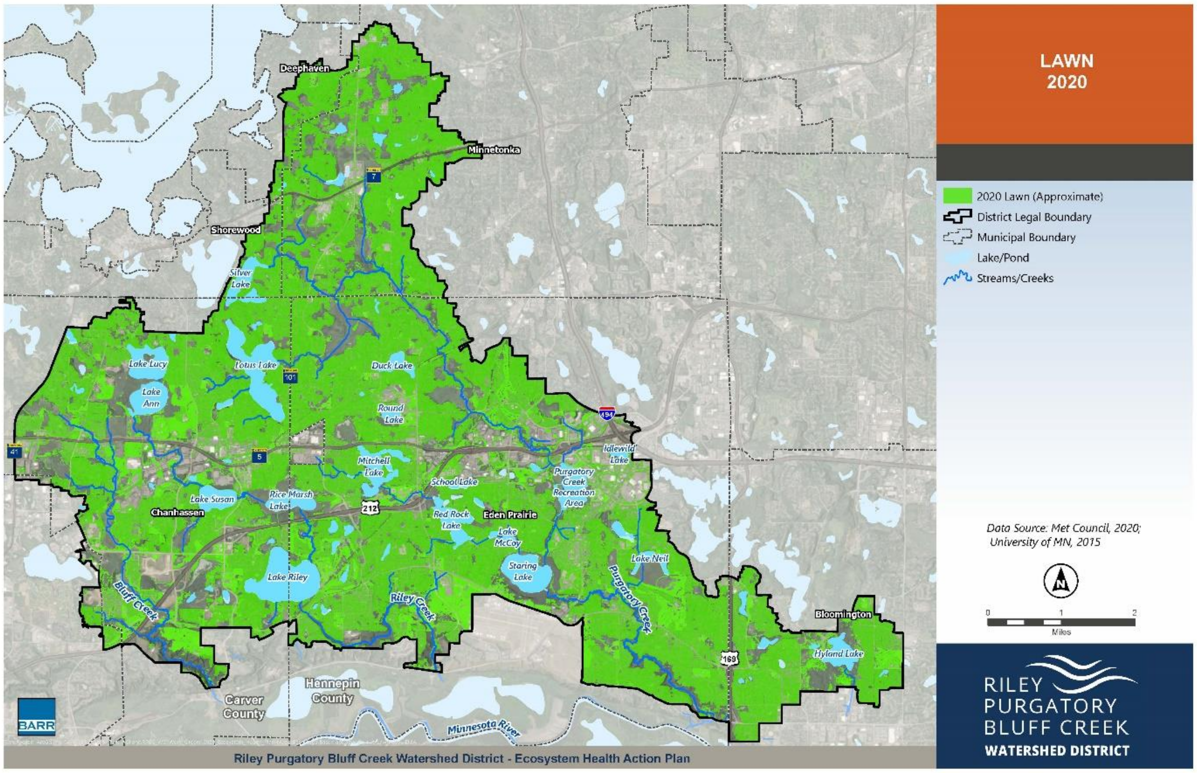


Figure 2-11　　Lawn 2020

2.10 Habitat Quality

Intact ecological communities (forests, savannas, prairies, and wetlands) today are limited to the extent shown in Figure 2-12. What remains is mostly degraded with diminished biodiversity and dominated by invasive non-native species. Many factors, such as cropping, grazing, logging, mowing, and motorized vehicles, have caused degradation. External factors have also impacted ecological communities, including climate change, urban heat island effect, invasive species encroachment, and habitat fragmentation through urban development. These factors should be viewed in concert. For instance, increased fragmentation creates "edge" conditions that are less resistant to colonization by invasive species. Edge conditions refer to edges of habitats like woodlands. With fragmentation, there is more edge of the habitat compared to the percentage of a stable core.

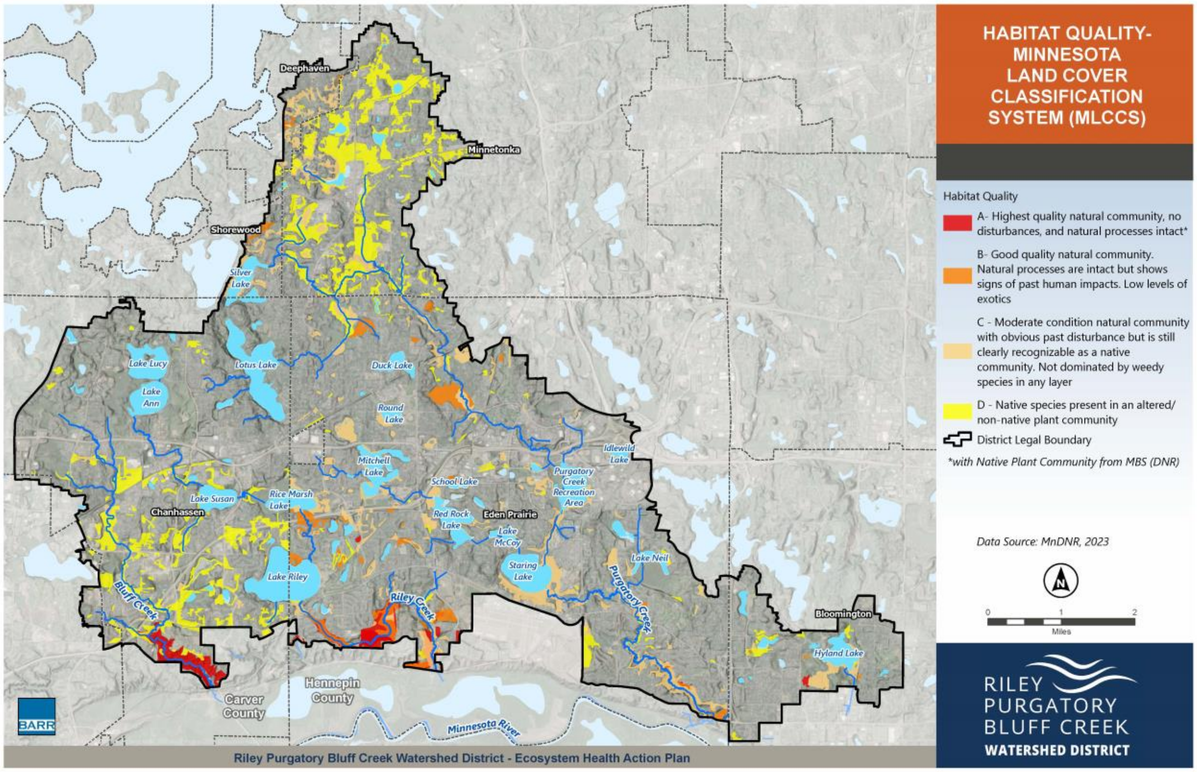


Figure 2-12 Habitat Quality—Minnesota Land Cover Classification System (MLCCS)

2.11 Impaired Waters

Decades of disturbance within the watershed have significantly impacted natural water bodies within the District (Figure 2-13). Many have been listed as impaired by the Minnesota Pollution Control Agency (MPCA) as required by the federal Clean Water Act (CWA). The list identifies water bodies that fail to meet water quality standards and is used by the District to set pollutant-reduction goals needed to restore impaired waters. It includes water bodies impaired by various pollutants, such as phosphorus, chlorides, mercury, pH, turbidity, high temperature, impaired biota, DDT, Dieldrin, Dioxin, and low dissolved oxygen. The absence of a water body from the Impaired Waters List does not necessarily mean it is meeting its designated clean water uses. This degradation of water quality has occurred despite the efforts of the District and our member communities to install practices to treat stormwater runoff from developed areas.

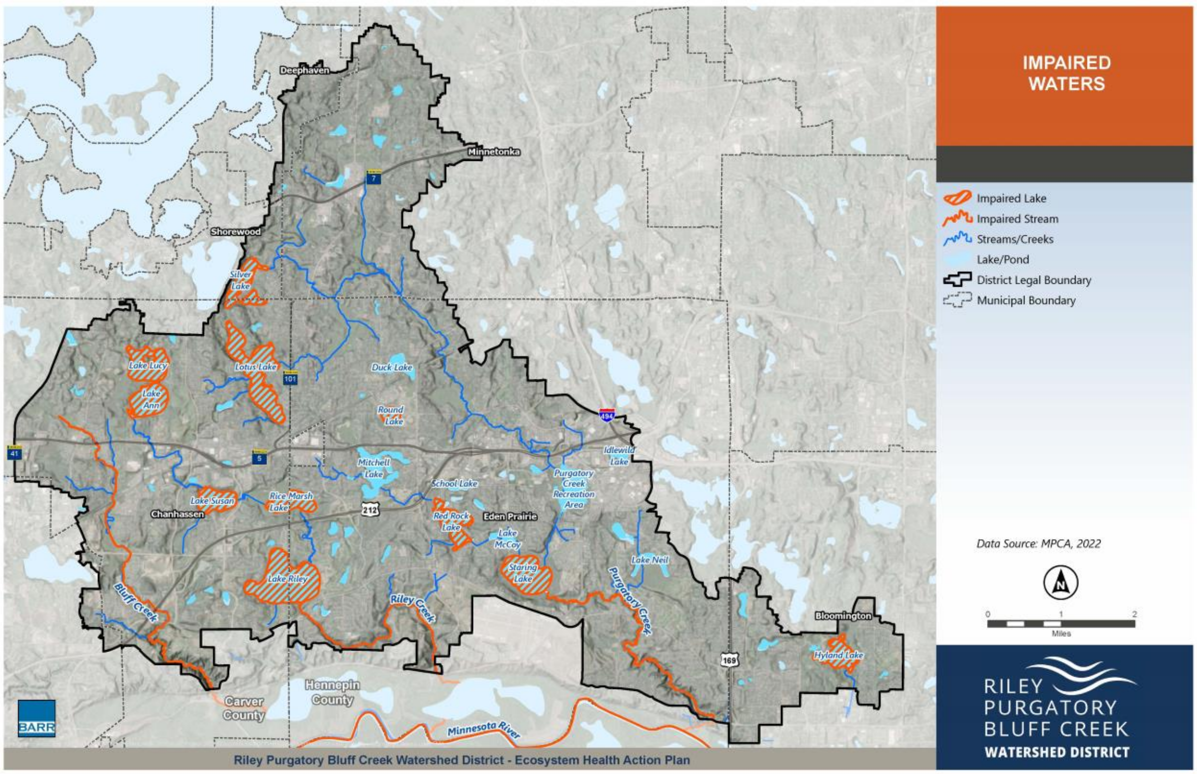


Figure 2-13 Impaired Waters

2.12 Steep Slopes

Steep slopes are erodible. When they fail or erode over time, property can be damaged, and sediment is deposited in downstream lakes, streams, and wetlands, degrading water quality and destroying habitat (Figure 2-14). Altering the hydrology by increasing water rates, volumes, or discharge locations can exacerbate the likelihood of failure. Increased flows in streams of all sizes can result in mass wasting, as can be seen in the escarpments throughout the lower valleys of our three namesake creeks.

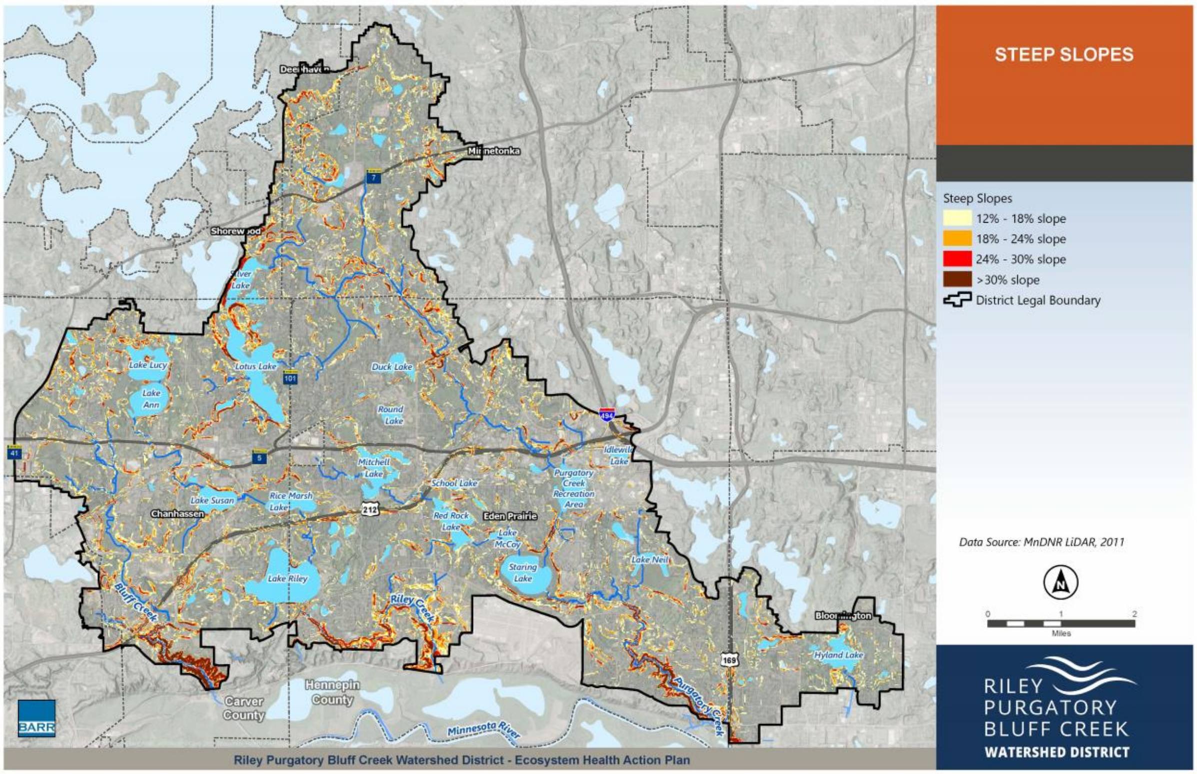


Figure 2-14 Steep Slopes

2.13 Tree Canopy

Approximately 37 percent of the District is covered with tree canopy (Figure 2-15). Trees provide many hydrologic and ecosystem functions. They intercept precipitation and facilitate its infiltration into the ground, reducing runoff. They shade paved surfaces, reducing runoff temperatures and protecting natural waterbodies from thermal pollution. They provide habitat, sequester carbon, provide energy savings, offer traffic calming benefits, increase property values, and reduce crime. In short, trees protect watersheds and improve the quality of life.

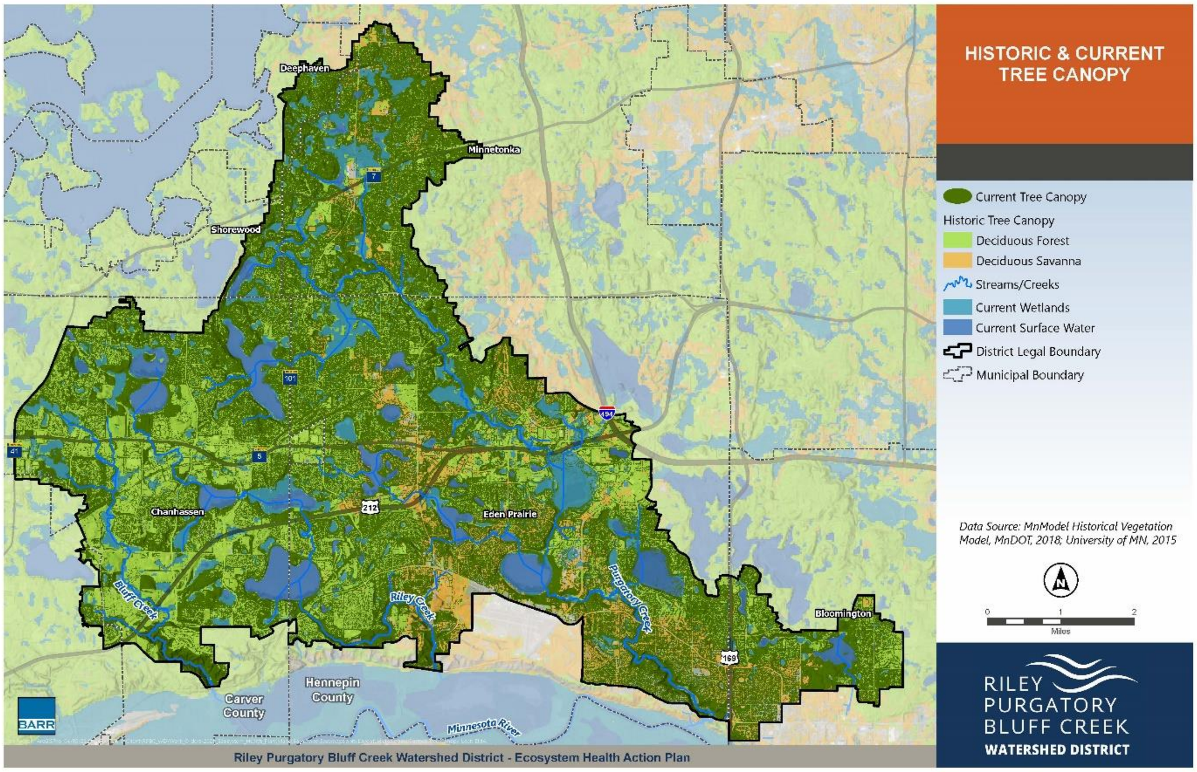


Figure 2-15 Historical and Current Tree Canopy

2.14 Undeveloped Land

Only a small percentage of the Watershed District is undeveloped (Figure 2-16). Opportunities still exist both to preserve this land as permanent open space and to develop it using low-impact development guidelines. The goal is to preserve/create as much high-quality, impervious, green space as possible to enhance ecosystem function.

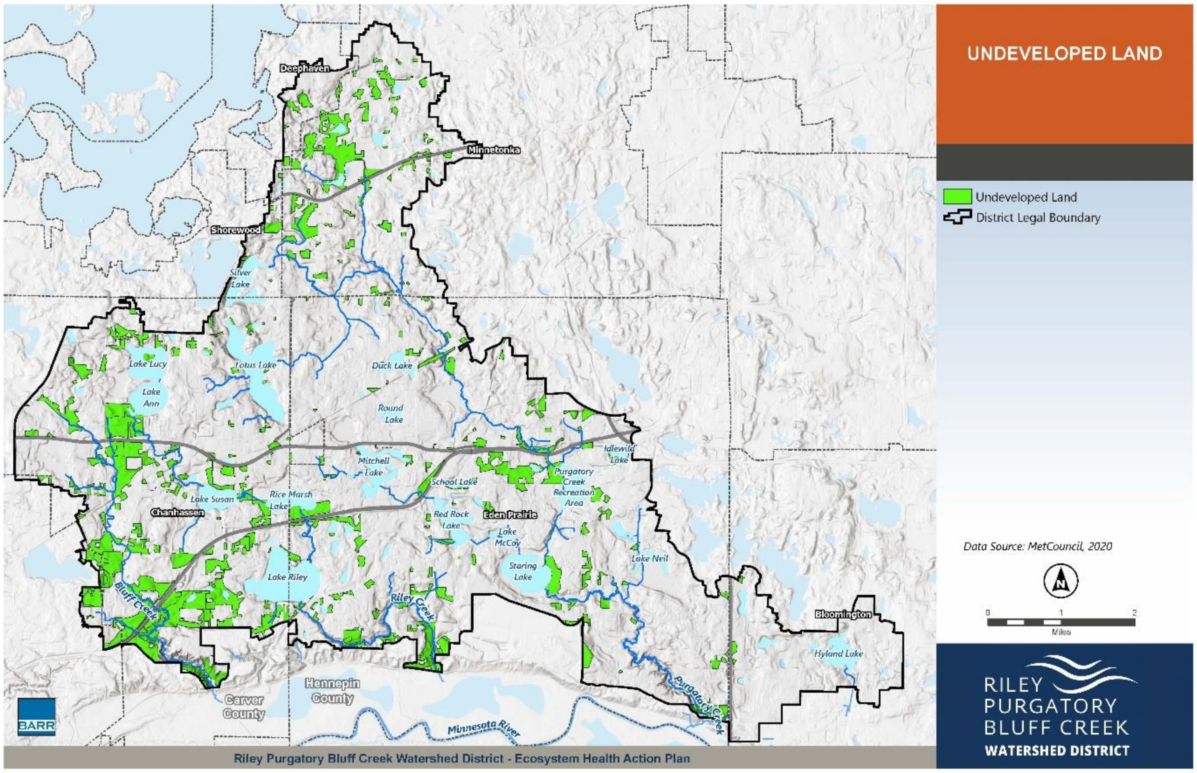


Figure 2-16 Undeveloped Land

2.15 Urban Heat Island Effect

The urban heat island effect is the buildup of solar heat within pavement and rooftops, increasing ambient air temperatures. The heat from automobiles and a lack of shading from trees also contribute to heat accumulation in urban areas. The urban heat island effect impacts local ecosystems and its residents in many ways (Figure 2-17). Warmed runoff water heats water bodies, increasing algal blooms and negatively (sometimes fatally) impacting aquatic life. Heat impacts human health and can damage many organisms within the ecosystem.

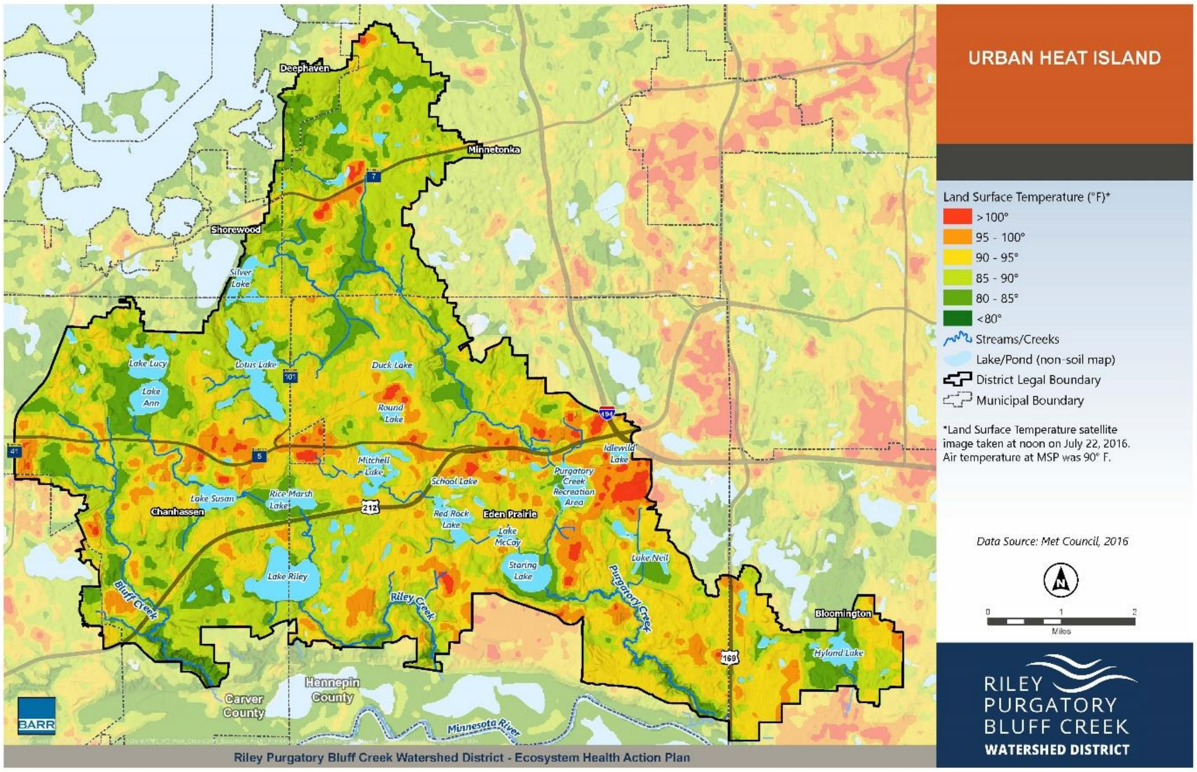
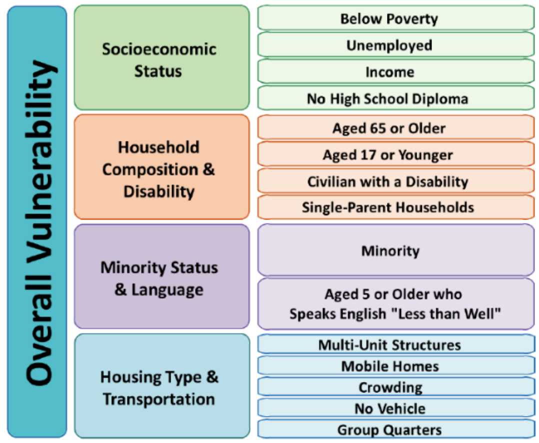


Figure 2-17 Urban Heat Island

2.16 Human Population Vulnerability

People are sensitive to the quality of the ecosystem in which we live. Figure 2-18 shows areas of vulnerable populations.

The Social Vulnerability Index is calculated based on the four "themes" and related variables summarized in the graphic to the right. Values for each variable are determined from 2018 census data and American Community Survey (ACS) data from 2014–2018 (5 years). Percentile values for each variable are calculated and combined to create a percentile rank for each "theme." The sum of all "theme" ranks is used to calculate the overall vulnerability ranking (RPL_THEMES).



The District has begun to recognize the need to use this data when prioritizing initiatives. Vulnerable populations/neighborhoods should be prioritized when planning future operations.

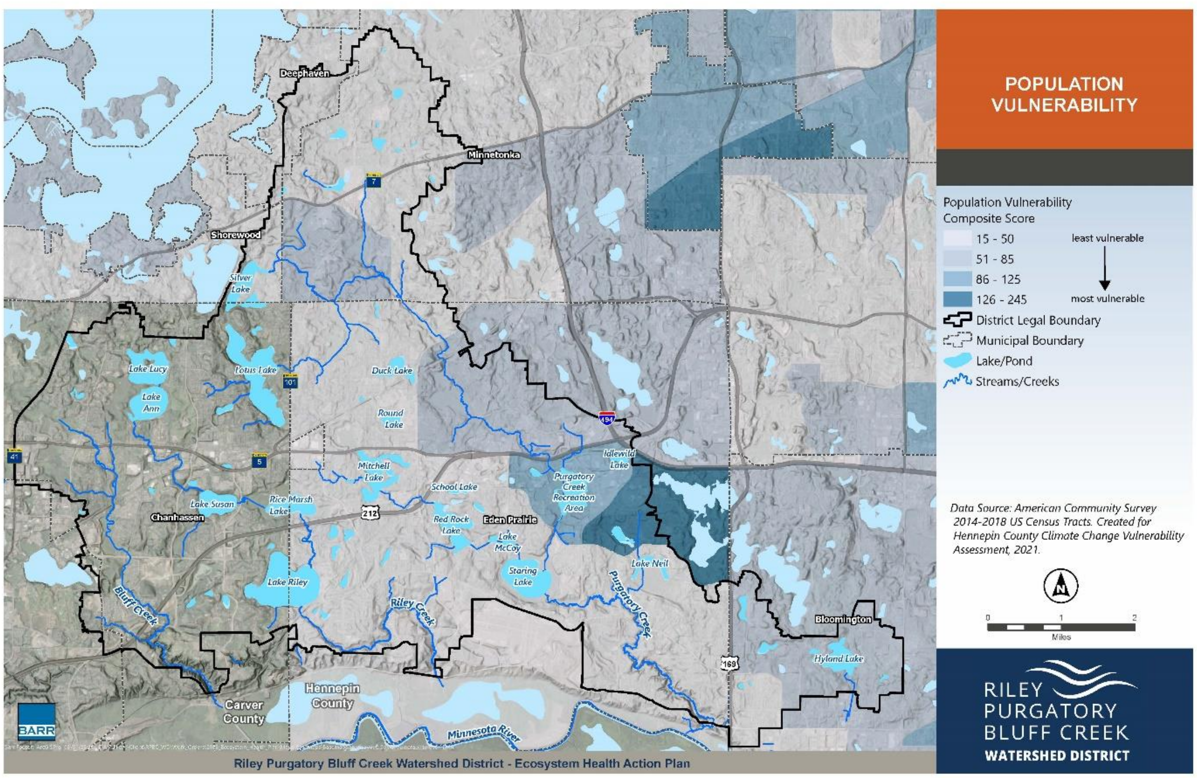


Figure 2-18 Population Vulnerability

2.17 Climate Trends

This section has been taken from the 2021 *Hennepin County Climate Vulnerability Assessment* developed by Barr Engineering Co. and used with permission.

Climate Trends

Hennepin County faces significant challenges resulting from the environmental, societal, and economic impacts of climate change. More and more, Hennepin County residents are noticing the effects of climate change, including warming winter temperatures, more rain and snowfall, and an increase in extreme precipitation events.

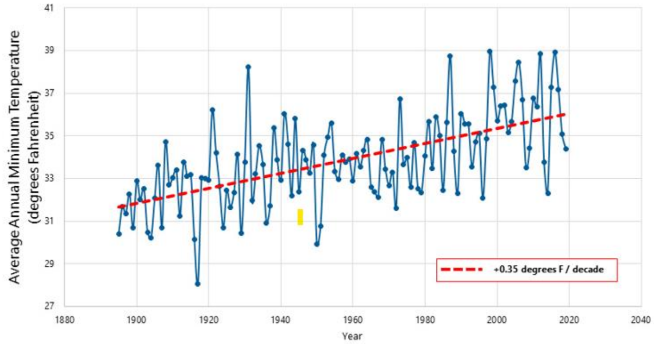


Figure A **Average annual minimum temperatures from 1895 to 2019 for Hennepin County (State Climatology Office)**

Warmer Winters

A distinct climate change trend occurring in Hennepin County is warmer winters, which are warming much faster than our summers. Specifically, winter minimum nighttime temperatures are distinctly warming. Based on data from 1895 through 2019, average minimum winter temperatures are increasing at a rate of 0.35°F per decade (Figure A), compared to average maximum summer temperatures increasing at a rate of 0.09°F per decade (Reference (State Climatology Office (Minnesota Department of Natural Resources), 2020)). Since 1969, however, the winter temperatures have increased at a surprising rate of approximately 2.2°F per decade based on data collected at the Minneapolis-St. Paul International Airport (Figure B). This rate is significantly faster than the rate of increase in maximum summer temperatures. With increased winter temperatures comes more freeze-thaw cycling, which can cause additional infrastructure damage. Although average annual snowfall is steady or increasing, warmer winter temperatures result in less snow cover, shorter snow-cover season, decreased snowpack thickness, and less lake ice cover. These conditions may impact ecosystem functions, timing of spring flooding, ice safety, recreation season expectations, etc.

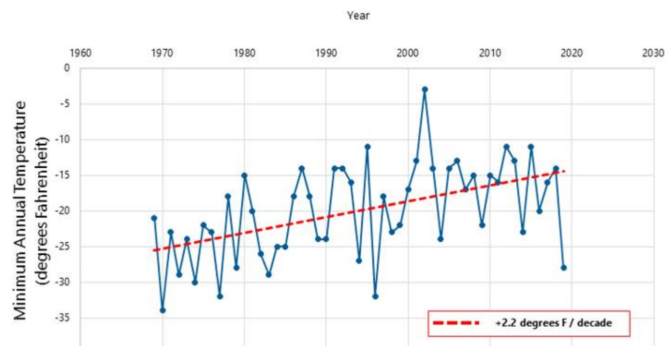


Figure B **Minimum annual temperature at Minneapolis-St. Paul International Airport 1969 to 2019 (NOAA)**

Extreme Precipitation

Hennepin County has been and will continue to experience more wet conditions caused by increased precipitation. In fact, 2010–2019 was the wettest decade on record statewide (Reference (Blumenfeld, 2020)). Precipitation increases are occurring in each season of the year, with the largest increases in spring and summer. Figure C shows how annual precipitation has been increasing since the 1890s.

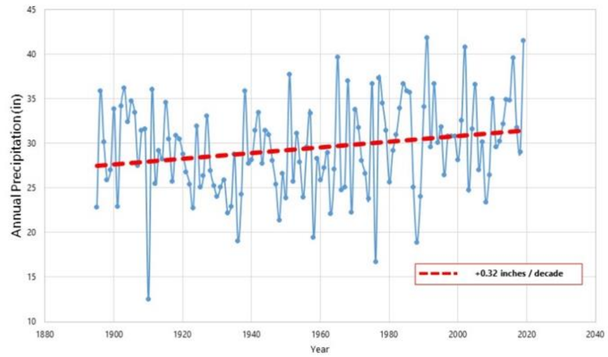


Figure C Average annual precipitation for Hennepin County from 1895 to 2019 (State Climatology Office)

Not only has the total precipitation increased, but the intensity and frequency of large events have also increased and are projected to continue increasing. Data indicates that the frequency of 2- to 3-inch rainfall events is increasing in Hennepin County, as shown in Figure D. According to *Adapting to Climate Change in Minnesota: Preliminary Report of the Interagency Climate Adaptation Team*, 1-inch rainfall events have increased by up to 26% from 1977 to 2017.

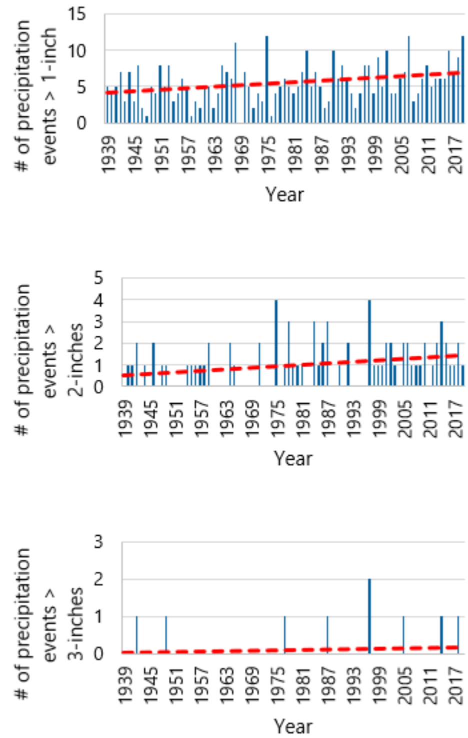


Figure D Number of precipitation events greater than 1, 2, and 3 inches each year at Minneapolis St. Paul Airport

They also report that the single heaviest rainfall amount recorded on a 10-year interval has approximately doubled during that same period, as shown in Figure E (Reference (Minnesota Pollution Control Agency, 2017)). Rainfall “super storms” are events in which 6 inches of rain cover more than 1,000 square miles and the core of the event tops 8 inches, occurring unpredictably and causing catastrophic flood damage. Minnesota Department of Natural Resources (MnDNR) observations indicate that the frequency of these super-storm events is also increasing in Minnesota (Reference (Minnesota Department of Natural Resources, n.d.)).

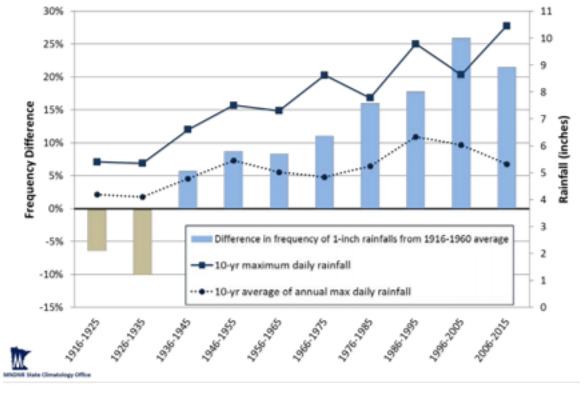


Figure E **Changes in the frequency of 1-inch rainfalls relative to the 1916 to 1960 average, from 40 long-term stations in Minnesota**

Shown in Figure E is the 10-year average (lower dotted line, right axis) and 10-year maximum values (upper solid line, right axis) of the heaviest single rainfall amount recorded each year at any of the 40 stations. Note that the 10-year maximum value has doubled from just over 5 inches at the beginning of the record, to just over 10 inches at the end of the record (State Climatology Office; MPCA, 2017).

Increased precipitation amounts, intensity, and frequency have significant impacts on Hennepin County operators and residents. Localized flooding and large-scale regional flooding are expected to increase in areas that are landlocked (i.e., topographically low areas without an outlet), along stream or river systems, adjacent to lakes, near wetlands, or other low-lying areas served by undersized infrastructure. Many drainage systems in the county were designed decades ago using older precipitation data that did not account for the increased, unpredictable timing of severe rainfall events. Flash flooding risk will increase. Landlocked areas are sensitive to the interaction of surface water and groundwater, as the increasing volume of seasonal precipitation can drive groundwater and lake levels upward.

The change in total snowfall amount is steady or increasing but at a slower rate than rainfall increases. Warmer winter conditions favor larger snowfall events, as evidenced in historical data. Figure F shows that the average annual snowfall is steady or increasing and that the number of days each winter with more than 4 inches of snowfall (i.e., large snowfall storms) has increased since the late 19th century (Reference (Blumenfeld, 2020)). Spring melt runoff and flooding will likely increase because of these larger and more frequent winter precipitation events. This depends on their timing, fall soil moisture leading into winter, winter warming patterns, and how the snowmelt thaw progression unfolds each spring. Intense rainfall

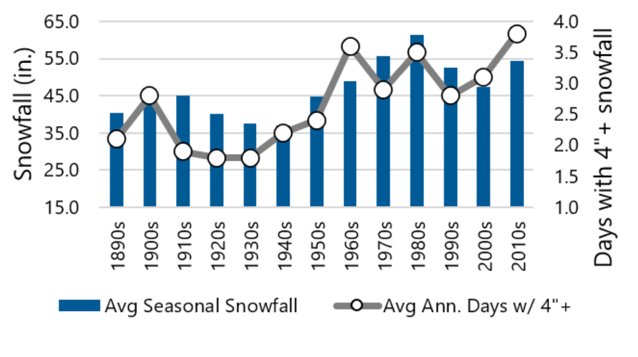


Figure F **Average annual snowfall by decade compared to the average number of days with 4 or more inches of snowfall using Minneapolis-St. Paul International Airport data (Reference (2))**

that coincidentally occurs at the same time as spring flooding can put a strain on community drainage systems.

Another consequence of increased winter temperatures and precipitation is more frequent ice storms (i.e., freezing rain). As precipitation falls from a warmer atmosphere, it forms super-cooled drops (water that is at freezing temperatures but not frozen) that freeze upon impact with cold surfaces rather than developing as snow. As this form of precipitation lands on surfaces with less snowpack, it has the potential to create a pedestrian hazard, dangerous driving conditions, and downed power lines—along with negative consequences for trees and wildlife.

Warming, Heat, and Humidity

Currently in Hennepin County, yearly average maximum temperatures are slowly increasing at a rate of 0.09°F per decade (Reference (State Climatology Office (Minnesota Department of Natural Resources), 2020)), as shown in Figure G. Though current trends do not show an increase in extreme heat events, projected climate scenarios show that the frequency and magnitude of hot days, warm nights, and heat waves are likely to increase by mid-century (Reference (Blumenfeld, 2020)). The change in the predicted number of days above 95°F by mid-century is shown in Figure H.

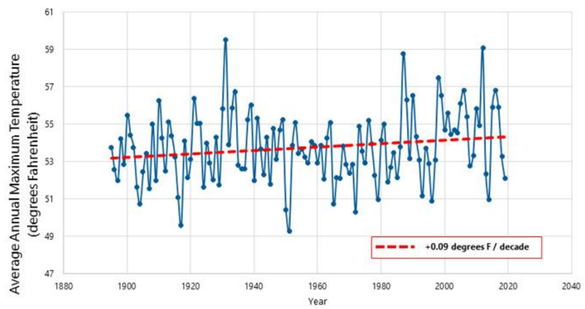


Figure G **Average maximum daily temperature for Hennepin County from 1895 to 2020 (State Climatology Office)**

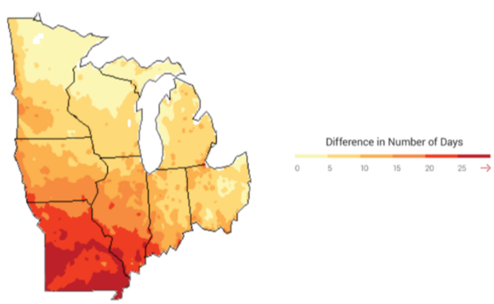


Figure H **Predicted change in number of days each year above 95 degrees for the Midwest by mid-century as compared to the 1971 to 2000 period (2014 National Climate Assessment, Midwest Chapter)**

In addition to warming, a primary indicator of climate change in Hennepin County is increased humidity, or dew point temperature, which is a measure of water vapor in the air. Data from the Minnesota Climatology Office shows that the number of days with dew point temperatures higher than 70°F is increasing. High humidity can exasperate heat-induced illnesses (Reference (Minnesota Department of Health, 2014)).

Increased heat and humidity create conditions that are favorable for the development of severe storms with high wind, hail, or tornados. Currently, these severe weather trends are not increasing. However, severe weather events are projected to increase in frequency beyond mid-century (Reference (Blumenfeld, 2020)).

Drought

Several historic droughts have occurred across Hennepin County dating back to 1863, including the Dust Bowl period in the 1930s. These events cause severe impacts on agriculture and the economy, as well as increasing wildfire potential. An increase in drought conditions has not been observed in current trends, and projected scenarios only show a slight possibility of increasing drought conditions by the mid-century (Reference (Blumenfeld, 2020)). Increased drought conditions may have negative consequences on the county's ecosystems, agricultural industry, water supply, and water quality and could increase the potential for flash flooding and erosion. Additionally, increased drought conditions across the country (e.g., wildfires) have the potential to adversely impact air quality in Hennepin County. It is important to remember that severe drought, such as the Dust Bowl period, is part of normal climate fluctuation and should be expected.

Conclusions

Climate records document that Hennepin County is getting warmer and wetter and will continue to get warmer and wetter—with more frequent heavy precipitation and warmer winter temperatures. Other climate change manifestations, such as increased occurrences of drought and severe weather (tornados and high wind events), have not yet been documented but are projected to increase by mid-century.

Local severe weather events create uncertainty and impact vulnerable residents, businesses, and county operations. One challenge that Hennepin County faces is that the dramatic climate change images seen in the news of wildfires, extreme heat waves, and rising ocean levels don't match up with how we are experiencing climate change in Minnesota. Because of this, it can be harder for people to grasp the threat that climate change poses to them and their communities. However, these events elsewhere do eventually impact Hennepin County and its residents when supply chains for food, fuel, and resources to/from afar are impacted. The increased costs and scarcity are often passed along to local consumers and businesses.

3.0 Ecosystem Function Impairment and Potential Recovery

An ecosystem is a community of interacting organisms associated with their physical environment (air, water, soil, etc.). As shown in Section 2.0, the ecosystem of the District has been greatly impacted since the time of European settlement. We have lost life-supporting services; discussed below. Many, however, can be recovered.

The following is a description of elements of the ecosystem that have been impacted, along with descriptions of how their functions may be recovered. These possible solutions can be enacted by both the District and its partners—cities, counties, DNR, MPCA, BWSR, etc.

3.1 Altered Hydrology of Natural Areas and Landscaped Green Space

The District has regulated stormwater runoff from impervious surfaces (paved hard surfaces including buildings, parking lots, driveways, sidewalks, etc.) for decades. Impervious surfaces comprise 24 percent of the District's ground surface (see Figure 2-10). The District's rules, permit requirements, and projects mitigate the effects of runoff with its pollutants. Yet non-paved surfaces (green spaces including lawns, old field grassland, and woodlands) also have an altered hydrology, resulting in decreased stormwater infiltration and increased stormwater runoff that carries sediment, nutrients, and chemical pollutants to natural water bodies.

Green space within the District has been altered through several factors which has resulted in reduced stormwater infiltration.

The Minnesota legislature recognized stormwater's influence on water resources and directed the MPCA to evaluate the effectiveness of stormwater management efforts in mimicking natural hydrology. This was done as part of the Minimal Impact Design Standards (MIDS) assessment. The MIDS legislative directive to the MPCA stated, "(c.) The agency shall develop performance standards, design standards, or other tools to enable and promote the implementation of low-impact development (LID) and other stormwater management techniques. For the purposes of this document, 'low-impact development' means an approach to stormwater management that mimics a site's natural hydrology as the landscape is developed. Using a low-impact development approach, storm water is managed on-site, and the rate and volume of predevelopment stormwater reaching receiving waters is unchanged. The calculation of predevelopment hydrology is based on native soil and vegetation." (Minnesota Statutes 2009, section 115.03, subdivision 5c)

The District is now striving to mitigate the altered hydrology of green spaces.

The hydrology of green spaces has been altered through human activity, resulting in decreased stormwater infiltration, increased runoff, and increased erosion of topsoil into waterways, resulting in the deposition of nutrients, pollutants, and sediment in natural water bodies downstream.

Significant alteration of the hydrology within the District began with disturbance by European settlement. Prior to this time, the watershed was primarily forested (see Figure 2-1); much of the land was either cleared for crops, cut for wood, or grazed by cattle and horses. Little of the watershed was left unaffected by settlement. Agricultural practices mixed and compacted the soil, resulting in decreased water infiltration, impacts on the soil food web, and degradation of downstream natural water bodies. The hydrology of the streams within the District was altered through increased runoff that deepened channels and eroded banks. The hydrology of wetlands was also altered by activity within the watershed, resulting in increased inundation and sediment accumulation. Direct impact through drainage was also common.

Land within the District was highly altered through agriculture. This resulted in significant hydrologic changes including decreased stormwater infiltration and increased runoff. Photos source: Minnesota Historical Society.

Suburban development, beginning in the 1960s and 1970s, further altered the watershed hydrology through construction practices. In areas left as green space, soil was often stripped, and the subsoil was compacted. A few inches of black dirt were typically spread on this subsoil and seeded with lawn. These construction practices limited stormwater infiltration, increased runoff from lawns and landscapes, and resulted in pollutant runoff and further altered streams and wetlands.

The following sections explain the altered hydrology occurring within the green spaces of the District: lawn, old field grassland, and woodlands.

3.1.1 The Altered Hydrology of Lawn

The process of suburban construction disturbs and compacts soils resulting in increased runoff and decreased stormwater infiltration.

Currently, approximately 40% of the District's land surface is vegetated with lawn (see Figure 2-11). Lawns are typically established around homes, businesses, and municipal properties after building construction. During construction, the topsoil is stripped, and the building process compacts the subsoil left in place. After construction, 2 to 6 inches of topsoil are typically spread over the compacted subsoil by heavy equipment. Bulk density is greatly reduced by the compaction, which reduces stormwater infiltration and root depth. Infiltration rates have been shown to decrease by 70 to 99 percent after construction activity (Gregory et al., 2006). Turf grass is typically established upon this compacted soil. Turf roots, although naturally somewhat shallow rooted, are limited to the depth they can penetrate the compacted soil, resulting in the need to irrigate during dry times to maintain green growth.

Lawn covers about 40% of the District. Compared to native forests and prairies, they shed a significant amount of stormwater and have greatly reduced stormwater infiltration.

Maintenance of turf grass – fertilization and herbicide application - further reduces soil porosity. This cocktail inhibits the proliferation of soil organisms that act to loosen soil over time and improve stormwater infiltration. All this adds up to dense soils with shallow-rooted grass, decreased stormwater infiltration, increased runoff, and pollutants such as nutrients and pesticides being carried to downstream water bodies (Woltemade, 2010). Increased runoff also causes flooding, stream channel erosion, decreased stream base flow, poor water quality, and reduced richness and abundance of fish species (Woltemade, 2010).

The planting of a diversity of deep rooted plants has been shown to increase soil porosity and stormwater infiltration. Research has revealed that root development could markedly enhance soil infiltration rates, saturated hydraulic conductivity, soil porosity, and soil organic matter content, particularly could notably promote increases in the rate of steady infiltration (Xiaoqing 2021).

3.1.2 Altered Hydrology of Old Field Grasslands

In many areas throughout the District, agricultural fields and pastures were abandoned and left to revegetate. Because native grasses and wildflower species have been so thoroughly eliminated, non-native weedy species colonize this land. Smooth brome, Kentucky bluegrass, and fescue typically establish along with some native species, such as Canada goldenrod and asters, and invasive species, such as spotted knapweed, reed canary grass, and leafy spurge. Typically, they become grasslands with low plant diversity and altered hydrology.

The root systems of native plants reach deep to absorb water and nutrients. Roots facilitate the infiltration of stormwater by leaving open channels when they die and decay.

Old fields typically contain soil that was disturbed by plowing and the operation of other machinery, mixing and compacting soils. Although the soils are currently in the process of recovering from these impacts, the hydrology (especially infiltration capacity) is reduced compared to the original forestland or prairie that existed prior to European settlement. Forestland has been shown to have 5.6 times the steady infiltration rate than that of grassland (Xiaoqing 2021).

3.1.3 Altered Hydrology of Woodlands

Woodlands within the District have been significantly altered from the original oak and maple-basswood forests that existed prior to European settlement. Upon settlement, lumbering and grazing of domestic animals (e.g., cows, horses, etc.) impacted the vegetative composition and soil structure. Today, four influences alter woodland hydrology: earthworms, invasive plants, white-tail deer herbivory (plant destruction due to over-population and over-grazing), and peoples' recreational activities. The combination of these forces eliminates vegetation, eliminates or greatly reduces the duff layer (the 2–6 inches of decomposing leaves and organic debris on the soil surface), and increases soil bulk density (compaction), resulting in decreased water infiltration and increased runoff carrying nutrients and sediment to downstream water bodies. Figure 3-1 and Figure 3-2 compare unaltered and altered woodland hydrology.

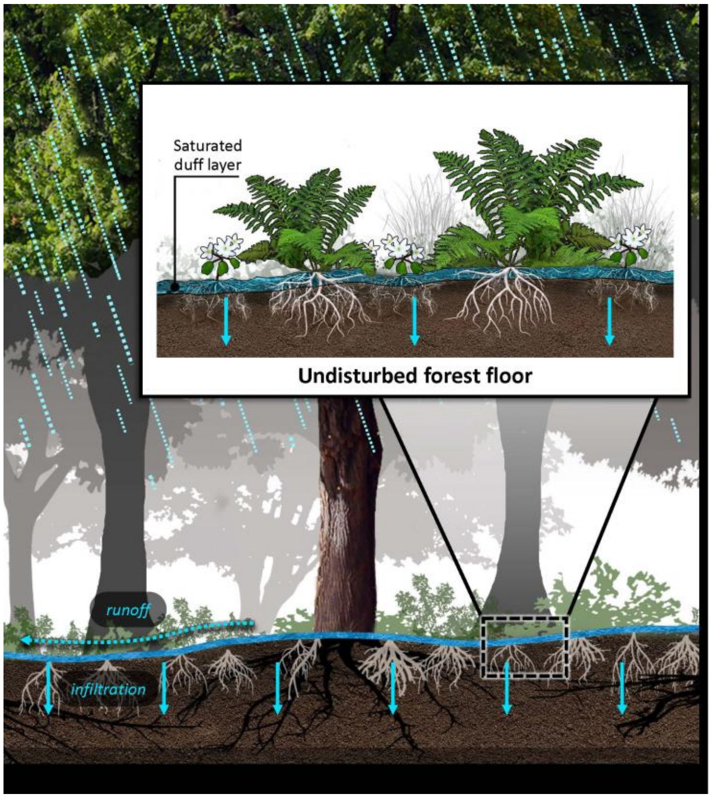


Figure 3-1 Unaltered Woodland Hydrology

Unaltered Woodland Hydrology

The physical components of an undisturbed woodland readily allow for stormwater infiltration which reduces runoff.
Here's how:

- Native plants and forest floor duff protect soil from the erosive energy of raindrops through interception allowing it to softly drip to the ground.
- Duff is the 2-6" layer of vegetative matter, such as leaves, twigs, dead logs, etc., that covers the ground in the forest located above mineral sail and below fallen leaves.
- When it rains, water is held like a sponge in the woodland floor duff layer. This reduces runoff as water can slowly infiltrate, especially in heavy downpours.
- As water moves down to the soil through the duff, it readily infiltrates into the soil due to its porosity maintained by soil organisms and root penetration. When roots die, they leave open channels through which water easily moves down deep into the soil. Soil organisms form soil crumbles that provide air space and ease for infiltration.
- Runoff does occur, but is filtered through healthy vegetation and duff to enter surrounding water bodies carrying minimal nutrients.
- Water infiltrating through the soil waters vegetation and recharges the groundwater and aquifers.

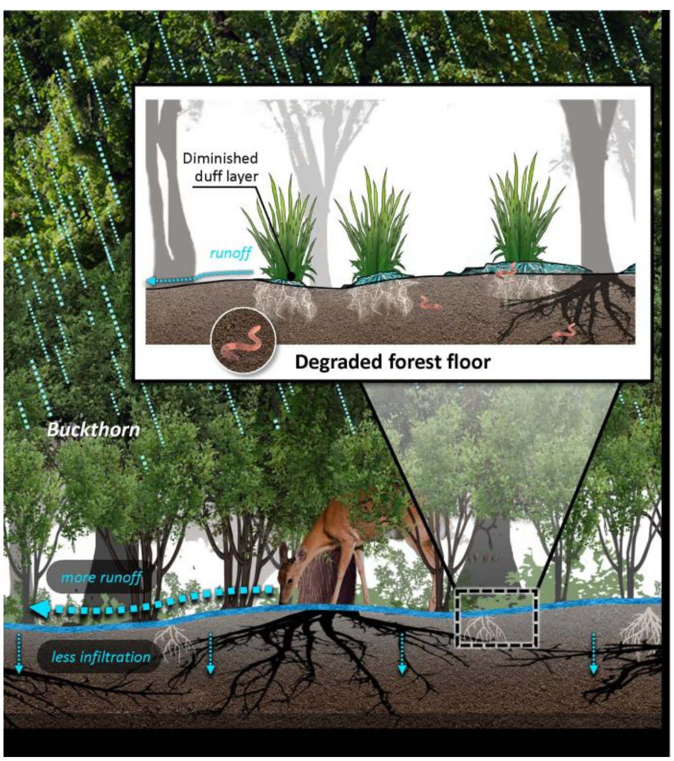


Figure 3-2 Altered Woodland Hydrology

Altered Woodland Hydrology

Woodlands can be disturbed by earthworms, deer herbivory, invasive species, and human foot traffic. The combination of these forces changes the physical components of the soil, preventing stormwater infiltration and increasing runoff. Here's how:

- Earthworms (not native to MN) devour forest floor duff leaving soil bare. Many species of native vegetation, including trees, are unable to reproduce without the protective cover of duff, therefore forest floor vegetation diminishes. This leaves forest soil open to crusting and erosion.
- Earthworms also compact the soil reducing stormwater infiltration capacity.
- Deer browse on woody and herbaceous vegetation, limiting their growth and preventing the reproduction of many trees and wildflowers. An overabundance of deer compacts the soil and decreases litter depth.
- The lack of vegetation and duff on the forest floor results in open soil that easily dries and becomes crusted from the impact of rain drops. Stormwater does not readily infiltrate into the soil, so water runs off carrying soil and organic material downstream.
- The resulting reduction in the amount of plant roots reduces water infiltration because of a lack of root channels and decreased soil food web activity.

Healthy diversity of forest floor vegetation.

Forest impacted by past grazing, earthworms, and deer browse.

Earthworms are not native to Minnesota. They are detritivores that rapidly consume duff on forest floors, leaving soils exposed. This limits the growth of plants that rely upon duff for moisture, nutrients, and protection while seedlings are first established. Earthworms also increase soil bulk density in woodlands because of their numbers and activity that breaks soil pedons collapsing pore space. In forests where earthworms have invaded, the loss of duff combined with an increase in soil bulk density leads to increased surface runoff and erosion (Hale et al., 2005). Earthworms also decrease soil porosity through bioturbation (reworking of soils or sediments). Eliminating the duff layer and increasing the bulk density results in increased overland flow and soil erosion (Frelich et al., 2019).

Earthworms cause a cascade of alterations and impacts on the woodland ecosystem. They have a disproportionately large effect on their natural environment by changing factors that ultimately affect the types and numbers of various other species in the woodland community. By consuming duff, they eliminate a critical nutrient source for trees and other plants, reducing their size and vigor and resulting in the leaching of nutrients. In turn, a multitude of other species (mammals, reptiles, amphibians, insects, and microbes) are unable to complete their life cycles and may be eliminated from woodlands. Jumping worms, a new arrival to the District, is especially destructive leaving soils the consistency of coffee grounds four inches deep in woodlands. Unfortunately, there are no known mechanisms to control or eliminate earthworm populations.

Earthworms, through their movement and degradation of soil structure, compact soil resulting in decreased stormwater infiltration.

Invasive plants can alter surface and subsurface stormwater flows, infiltration rates, soil bulk density, water holding capacity, and water residence times (Catford, J.A. 2017). Many invasive plants, including common buckthorn and garlic mustard, have properties that inhibit plant growth around them by releasing chemical compounds into the soil. This inhibits native vegetation and can leave the soil unprotected from the impact of raindrops. For example, garlic mustard grows thickly in the spring and then becomes dormant in late summer, leaving the earth exposed to the pounding rain of summer storms, causing soil crusting, decreased infiltration, and increased runoff.

Garlic mustard aggressively displaces native plants to overtake large areas within woodlands. The plants go dormant in August leaving the soil open to crusting and erosion. Lack of native vegetation impacts the soil food web, resulting in poor soil structure and decreased stormwater infiltration.

Buckthorn invades woodlands and out-competes ground vegetation and tree seedlings, leaving the soil open to crusting and erosion and resulting in decreased stormwater infiltration.

Buckthorn is an aggressive and successful invasive tree with European origins that flourishes in the District’s woodlands. Buckthorn alters the soil properties through its rapidly decomposing leaf litter, which can leave the soil surrounding the plant dry and exposed and result in erosion and a collapse in arthropod colonies (Knight et al., 2007). The rapid decomposition of leaf litter leads to more nitrogen within the soil, which in turn can attract more invasive earthworms. This contributes even further to bare soil conditions and altered soil and hydraulic conditions (Knight et al., 2007).

White-Tail Deer have experienced dramatic increases in population in the U.S., with high deer densities throughout Minnesota. The high number of deer can lead to an increase in soil compaction and a decrease in duff depth (Shelton et al., 2014). The higher compaction results in poorer infiltration, and a decrease in duff depth can leave the soil more exposed to drying and prone to erosion. Overconsumption of woody and herbaceous vegetation alters the native plant community (extirpating species in many areas) and increase the success of invasive plants. Deer have also been shown to alter the soil community by lowering soil organic matter, lowering soil moisture, and increasing soil pH (Enochs et al., 2022).

The combination of the forces mentioned above greatly impacts woodland hydrology. As described, earthworms diminish the duff layer, which results in reduced plant populations. The remaining plants are then heavily browsed by deer. Under these circumstances, invasive species flourish, further reducing vegetative cover. Altogether, this results in bare soils with increased compaction, decreased stormwater infiltration, increased stormwater runoff, and increased volumes of polluted stormwater degrading downstream natural water bodies.

These beautiful animals have become over populated in Minnesota and the District. This results in soil degradation and vegetation destruction, causing soil compaction and decreased stormwater infiltration.

3.1.4 Restoring Green Space Hydrology

Many measures may be taken to improve the hydrology of green space, including:

- Using low-impact design principles when designing new developments and when retrofitting existing facilities. Striving to preserve and create green space within developments.
    - Developing a process where District and city staff work with developers to explore alternatives for ecosystem-oriented development.
- Conducting a review of city codes that address parking stalls, driving lane widths, and other requirements that would result in impervious surface reduction. Incentivize impervious surface reduction by being flexible with requirements such as density and setbacks.
- Preserving undeveloped natural areas.

- Providing a stormwater volume credit for developments when preservation or restoration of habitat is achieved.
- Developing a program for impervious surface trading to negotiate for more green space in development projects in exchange for other ecosystem benefits.
- Transitioning of lawn to alternative native plantings to increase stormwater infiltration.
- Renovating lawns that remain to include drought-tolerant species. Planting bee lawns and discontinuing the use of pesticides on lawns.
- Learning about organic lawn care practices and how to vitalize the soil food web and increase stormwater infiltration. Eliminating the use of chemical-based fertilizers.
- Controlling invasive species in natural areas that negatively impact forest floor vegetation and lead to poor water infiltration (e.g., common buckthorn).
- Transitioning *degraded* woodlands to open plant communities with light reaching the ground plain to nurture a complete vegetative soil cover (this compensates for the earthworm issues). Thinning trees to establish a savanna plant community structure. Planting appropriate native herbaceous plants to develop a complete ground cover and restore native hydrology.
- Managing deer populations to prevent overgrazing and the destruction of native vegetation.
- Teaching property owners about both low-input landscape management and the management of natural areas they may own. Encouraging the restoration of native vegetation, the regeneration of soil, and the restoration of hydrologic function.

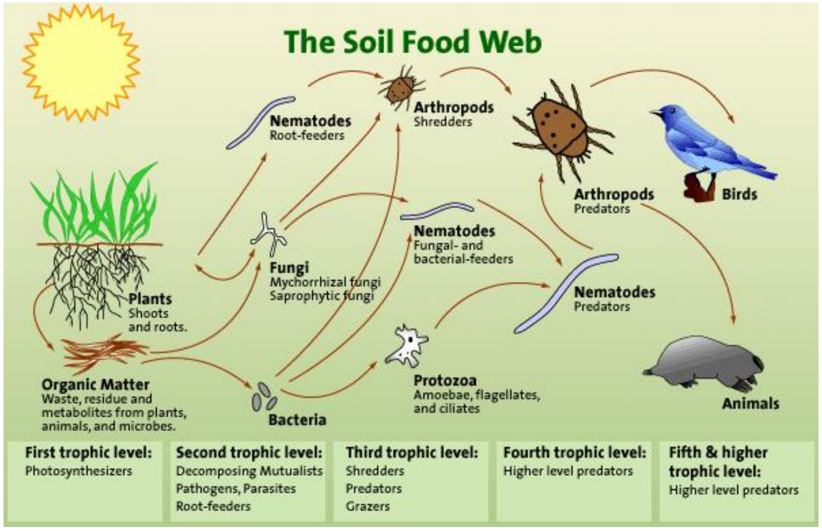
3.2 Degraded Soil

Because the adverse impacts of increased impervious surface on receiving waterbodies have been well documented, impervious cover is frequently used in watershed management, site design, and regulatory requirements (e.g., MIDS) as a primary indicator of stormwater impacts (Schueler, T. 1994a. “The Importance of Imperviousness.” Watershed Protection Techniques 2(4): 100 111. , CWP 2003). Research continues to shine the light on the importance of accounting for other land covers—such as disturbed soils and managed turf—that also impact stormwater quality (Law et al., 2008). Soil degradation has occurred in the District from soil mixing through plowing and bulldozing, compaction by the same, and the elimination of native vegetation that supports good infiltration through root penetration and support of the microbial community. Degraded soils have poor structure that limits stormwater infiltration while increasing runoff. With increased runoff often comes erosion with sediment and nutrients deposited into downstream water bodies.

3.2.1 Soil Health

Key Soil Health Principles

- Minimize disturbance
- Maximize soil cover
- Maximize biodiversity
- Maximize presence of living roots



It is critical to preserve or re-establish soil health to restore green space hydrology. Soil health is defined by the U.S. Department of Agriculture as the continued capacity of soil to function as a vital living ecosystem that sustains plants, animals, and people. Healthy soil provides clean air and water, bountiful crops and forests, diverse wildlife, and beautiful landscapes. Healthy soils have loft with considerable pore space that holds water and allows for oxygen exchange with the atmosphere, which is important for root growth. Soil loft is created by the action of a diversity of organisms in the soil food web, including everything from bacteria and fungi to nematodes and arthropods, and increasing further up the food web to voles and beetles. These organisms loosen soil and keep it open. They cause the development of soil pedons (crumbs) that allow for air space in soils. Pedons are important for stormwater infiltration and erosion resistance. The food web also allows for soil nutrients to be held in the soil and allows for their slow release to plants. The food web supports plant roots that reach deep down into the porous soils, holding soil in place and, over time, leaving open channels as they die and decay. These channels allow large volumes of water to readily infiltrate the soil.

This image is of an entrance to a badger den within a MN prairie that has never been tilled or otherwise disturbed by people. Visible are the pedons (soil crumbs) that naturally forms in soils through the action of root penetration and microbes. Pedons provide pore space where water is stored. Because of this pore space, 12 inches of a loam soil can store 3 inches of water. Fortunately, compacted soils in the District can be restored through loosening, the incorporation of organic matter, and the establishment of a diversity of plants.

Urbanization has a significant impact on soil health. Construction actions of soil stripping, mixing, and compacting negatively impact the physical and biotic components of soil (Cheng & Grewal, 2009). Compacted soils have profound environmental implications, and a failure to consider these impacts leads to poor stormwater management practices (Wotemade, 2010). Bulk density, the weight of dry soil per unit of volume, is one indicator of soil compaction and soil health. It affects infiltration, rooting depth/restrictions, available water capacity, soil porosity, plant nutrient availability, and soil microorganism activity, all of which influence key soil processes and productivity. Compaction increases bulk density, reduces vegetative cover, reduces soil porosity (i.e., the pore space in the soil), and limits root penetration, resulting in increased runoff and erosion (USDA, 2019) (Schueler, 2000). Table 3-1 illustrates the connection between bulk density and root penetration.

Table 3-1 Soil Bulk Density That Restricts Root Growth Based on Soil Texture (USDA, 2019)

Soil Texture	Bulk densities that restrict root growth (grams/cm3)
Sands, loamy sands	> 1.80
Sandy loams, loams	> 1.80
Sandy clay loams, clay loams	> 1.75
Silts, silt loams	> 1.75
Silt loams, silty clay loams	> 1.65
Sandy clays, silty clays, clay loams	> 1.58
Clays (> 45% clay)	> 1.47

The prevention of soil degradation is the best cure, and the good news is that degraded soil can be regenerated. Prevention should start by limiting the extent of soil disturbance during construction to only the area necessary to complete a project. Mechanical soil loosening after construction will allow air exchange with the atmosphere to regenerate compacted soil, while organic amendments provide both a food source for microbes and a sponge absorbing water. This allows roots to grow deep into the soil to keep soils open for efficient stormwater infiltration. Healthy roots mean dense, healthy plants that cover the ground and prevent soil erosion. Planting a diversity of native plants improves soil health. Plants have a symbiotic relationship with soil organisms (especially bacteria and fungi). These organisms provide the plants with carbohydrates and proteins derived through photosynthesis, which are excreted into the soil through roots in exchange for essential nutrients and moisture from microbes.

Organic lawn maintenance also supports the soil food web. The problem with conventional lawn care is that fertilizers significantly reduce bacterial populations, which form the bottom of the soil food web. In addition, pesticides kill many organisms. By providing only organic fertilizers and no or limited pesticides, the soil biome will flourish. Lawns are an excellent ground cover where they are used for people's relaxation and recreation, but most of the lawns in the District go unused. In these unused areas, other vegetation with diverse root systems can be planted and maintained to improve stormwater infiltration and protect natural water bodies.

3.2.2 Soil Regeneration

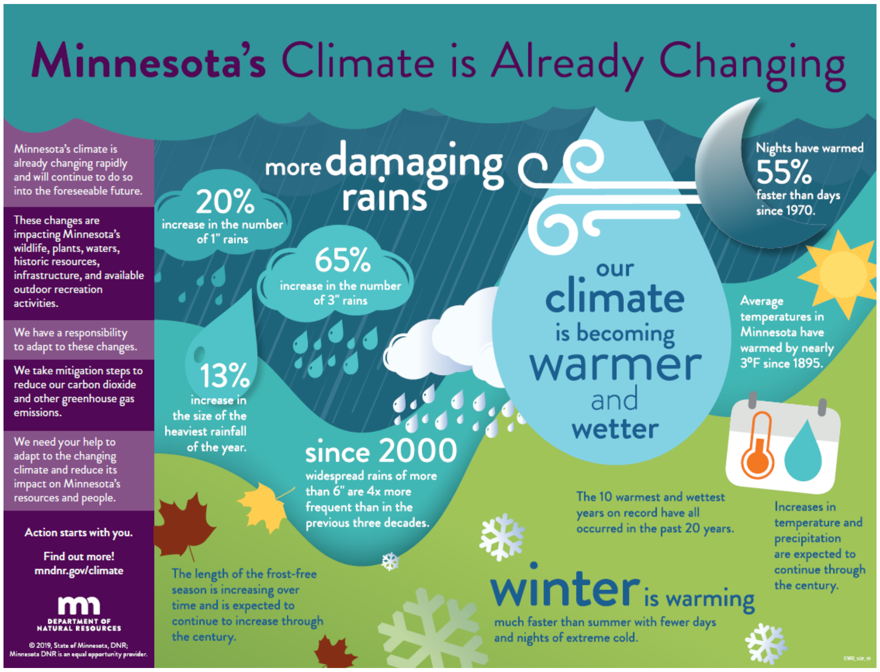
Soils can be regenerated through ripping, tilling (decompaction), amending with organic matter, and planting a diversity of deep-rooted plants. The District's current soil rule requires decompaction and soil amendment for all construction projects. It is possible to improve stormwater infiltration in all green spaces. Opportunities for soil regeneration include:

Stated another way, healthy soils with 1% organic matter in the top foot of soil can potentially hold up to 0.9 inches of rainfall, thus at 5% organic matter the soil might absorb the 4.5 inches of rainfall.

- Promoting soil protection and regeneration.
- Enforcing the District's soil regeneration rule. Currently, staff are unavailable to inspect sites during construction and landscaping, so hiring additional staff would be necessary.
- Requiring a percentage of native plantings as part of a required green space.
- Continuing to include soil regeneration as a priority on all District projects.
- Teaching the public about the soil food web, the importance of soil health, and how to improve soil health.
- Promoting the substitution of native vegetation and soil regeneration for unused lawns. Forty percent of the District is covered with lawn. Converting a percentage of this would greatly increase stormwater infiltration and improve water quality in natural water bodies.
- Promoting/teaching organic lawn management. Fertilizers and pesticides greatly impact the soil food web, reducing stormwater infiltration and polluting natural water bodies.
- Requiring soil improvement for all vegetation-related cost-share initiatives.
- Establishing a jumping worm education program.

3.3 Climate Change

Climate change is impacting the District and will increasingly impact the region. This is described in Section 2.17 above. Climate change exacerbates all the ecosystem impairments described in this section. As the District experiences greater swings in temperature and precipitation, living organisms, including people, insects, birds, trees, wildflowers, and soil microorganisms, are forced to tolerate conditions beyond those through which they have evolved. Diseases more readily occur in stressed plants and animals. Some native plant species are predicted to die out, with invasive species taking their place. Thus, we lose our rich natural heritage and critical ecosystem function.



The MNDNR published this infographic highlighting the changing climate in Minnesota. Both historical data and models predict that temperatures will increase, frequency of extreme weather will surge, and the rate and intensity of rainfall will increase. In general, these trends will increase urban flooding, erosion of degraded soils, pollutant load to waterbodies, and damage to infrastructure.

The National Oceanic and Atmospheric Administration (NOAA) recently updated their precipitation frequency values (published in *Atlas 14* (Perica, et al., 2013) to include precipitation data from the last 60 years. Precipitation frequency values are used within the District to size stormwater treatment facilities. Atlas 14 documents a significant increase in rainfall within the District compared to the precious atlas (TP-40) published in 1957. The 100-year, 24-hour rainfall depth has increased by approximately 25% since 1961 (see Figure 3-1). As a result of these precipitation updates and subsequent modeling within the District, flood risk has been identified in four areas previously unaffected by floodwaters. Work completed by Latham Stack and Michael Simpson (Stack LJ, et al., 2014), assessing long-term extreme weather trends, predicted that precipitation amounts would increase significantly over what is historically used in floodplain assessments and infrastructure design. Moderate and pessimistic (i.e., upper estimate) mid-21st century estimates for the 100-year, 24-hour rainfall event are summarized in Figure 3-1.

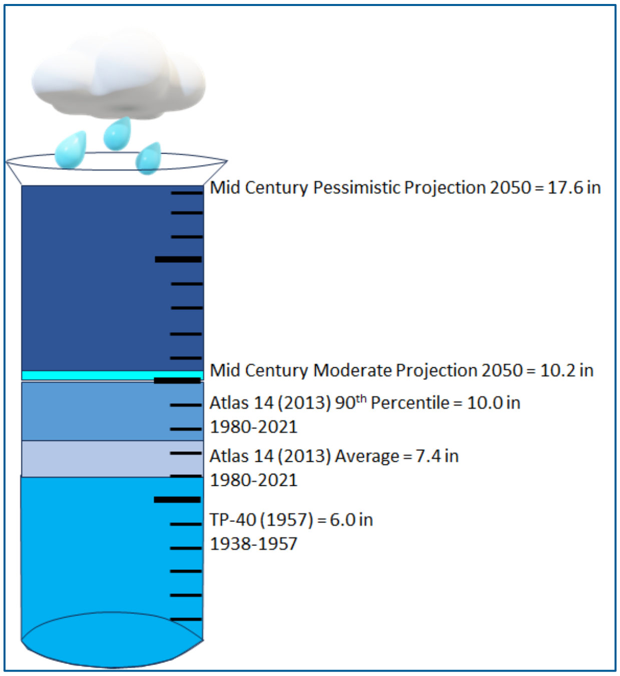


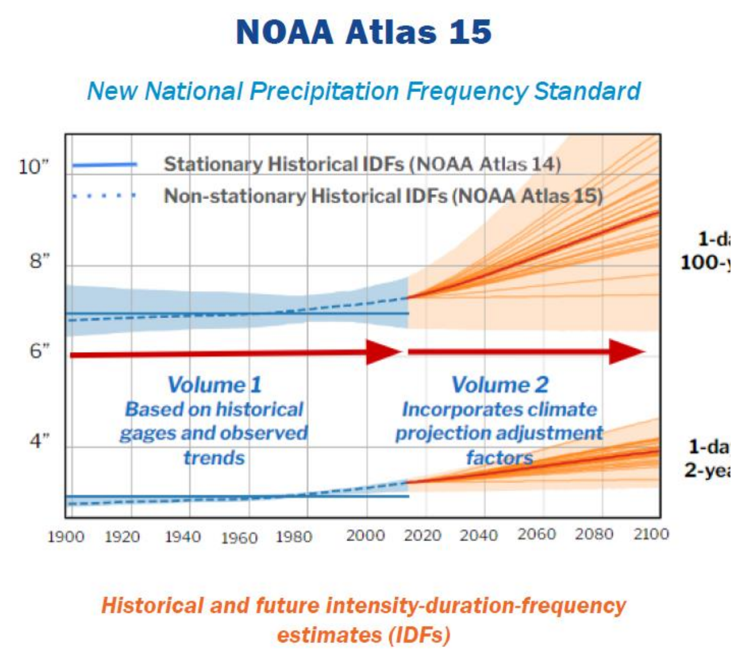
Figure 3-3 100-Year, 24-Hour Duration Rainfall Depth Comparison

3.3.1 Adapting to a Changing Climate

We must be alert to the effects of climate change and take proactive action to address and prevent negative impacts. Opportunities to improve climate resiliency throughout the District include:

- Implementing all opportunities listed throughout this section of the Plan. Climate change affects all ecosystem functions and every square foot of the District.
- Working with District communities to develop Climate Action Plans to address climate mitigation and adaptation.
- Creating commissions (sustainability, environment, etc.) if they don't already exist.
- Establishing wetland protection and mitigation above and beyond the Wetland Conservation Act (WCA). The goal of WCA is to provide for no-net-loss of wetlands within the state, not within the Watershed. Current and proposed projects can fill wetlands and use "banking" to offset their loss.
- Preserving existing flood storage and requiring greater than 1:1 compensatory flood storage replacement whenever stormwater storage is proposed to be filled.
- Developing a stormwater resiliency fund focused on small-scale stormwater retention and habitat enhancement projects.
- Requiring green infrastructure, living streets, and low-impact development to the maximum extent possible.
- Considering a stormwater utility fee to incentivize and fund healthy green space.
- Protecting existing natural areas within the District from soil degradation and invasive species.
- Promoting species migration and including "near natives" in District capital projects.

- Revising stormwater quantity and quality management regulations to factor in climate change and taking into consideration more frequent and intense storms and precipitation projections. For example, require the use of the 90% percentile Atlas 14 rainfall depth, and once available, adopt Atlas 15. Additionally, consider the requirement of flow duration analysis, increased low-flow freeboard, stormwater runoff cooling, and incorporate extreme rainfall event design considerations.
- Completing climate vulnerability and risk assessments in Chanhassen and Minnetonka, similar to what has been completed for Bloomington and Eden Prairie.
- Identifying and setting aside areas for future storage and management capacity up to the 0.1 or 0.2-percent 24-hour rainfall event.
- Adopting an abstraction requirement based on the projected 95th percentile rain event depth for the year 2100.
- Identifying at-risk critical infrastructure and remedial flood mitigation measures.
- Educating policymakers and leadership on all issues of climate change and ecosystem management.
    - Conduct tours
    - Provide workshops
    - Demonstrate how development can co-exist with green space/ecosystem components
- Teaching residents about the impacts of climate change and instruct them on how they can act through volunteer activities.



NOAA is currently working to update the Atlas 14 precipitation frequency to account for temporal non-stationarity (i.e., statistical properties of hydrologic variables are changing with time) and the integration of future climate projections as part of Atlas 15 using funding under the Bipartisan Infrastructure Law. source: [NOAA_Atlas_15_Flyer.pdf (weather.gov)]

Flooding at Lake Ann.

3.4 Urban Heat Island

Hard (impervious) surfaces such as streets, parking lots, and buildings are necessary for urban life, yet they accumulate heat and release it back into the atmosphere, increasing air temperatures. Temperatures at all times of year in urban areas can be measured at 2 to 10 degrees higher than in rural areas. This heat stresses people and the urban ecosystem. When it rains, accumulated summer heat warms streams, wetlands, and lakes, alters biological systems, and can cause toxic algal blooms. Heat island effects impact wildlife and outdoor workers and increase energy consumption with additional air conditioning. High summer temperatures also facilitate the formation of air pollutants such as ozone.

Street trees prevent the accumulation of heat within pavement.

Heat island occurs year-round. Warmer winter temperatures allow for the overwintering of plant pathogens and extend the season for ticks and mosquitos that may carry human pathogens. Lakes tend to freeze for shorter periods during the winter, providing an advantage to aquatic invasive species.

The urban heat island effect can be reduced, and the District's ecosystem and quality of life for its inhabitants can be improved by limiting the amount of new impervious surfaces constructed, reducing unnecessary impervious surfaces, shading pavement, creating green space, and expanding natural areas. In the not-too-distant future, opportunities to remove pavement may increase as people spend more time working and shopping from home, resulting in fewer cars on the streets and in parking lots. The eminent advances in autonomous vehicles will also reduce traffic and the need for parking spaces. Watershed managers and city planners must be ready to advocate for green space and green infrastructure as pavement removal becomes a good option.

3.4.1 Opportunities for Urban Heat Island Mitigation

- Preserve green space and implement low-impact development.
- Implement requirements of stormwater features to lower discharge temperature to that of the ambient soil.
- Create an urban heat island overlay district by identifying heat islands, as shown in Figure 2-17. Within heat islands, require mitigation or establish stormwater credits or cost incentives to motivate mitigation measures.
- Require rather than recommend green infrastructure practices.

- Conduct a review of city codes related to parking stalls, driving lane width, and other requirements that result in impervious surfaces. Review the purpose of the codes and revise them for impervious surface reduction. Incentivize impervious surface reduction by being flexible with requirements such as density and setbacks. Consider impervious surface transfers.
- Plant trees along streets and in parking lots. This may require changes in policy to allow street trees to be planted within tree boulevards.
- Promote the implementation of green roofs as a viable BMP within the District.
- Continue planting trees with each District capital project, especially in areas that shade buildings and pavement.
- Promote soil health to extend the life of trees in the urban environment.
- Teach property owners about the advantages of planting trees and their ideal locations to protect natural water bodies, produce energy savings, and shade pavement.
- Promote the use of white roofs.
- Strengthen landscape ordinances to preserve existing trees and require the replacement of removed trees at a greater ratio.
- Consider developing a heat-island-mitigation bank for projects where there is not enough space to replace pre-existing trees. Funds deposited in the heat-island-mitigation bank would be used for planting trees in difficult areas with high percentages of impervious surfaces.
- Ensure the longevity of street and parking lot trees by providing adequate soil volumes in highly paved areas.

3.5 Wetland Health

Wetlands within the District have a long history of degradation from both direct and indirect impacts (from their watersheds). Some wetlands have been drained and tiled for agricultural use. Many were filled for development prior to the Wetland Conservation Act (see Figure 2-4). A vast majority of those remaining have been impacted indirectly by increased runoff volumes (flooding) and pollutants from suburban development.

Wetlands within developed watersheds experience unnatural water level fluctuations and long durations of high water levels that kill vegetation and prevent wildlife species like birds and amphibians from completing their life cycles. Many wetlands have experienced large influxes of sediment and nutrients from agriculture and suburban development, which made them inefficient in filtering stormwater and destroyed plant and animal habitats. Toxic deicing salts also collect in wetlands. Most wetland impacts today are indirect and ongoing, caused by alterations and activities within their watersheds.

Restoring wetlands is an onerous task because considerable improvements within their watersheds are necessary first to prevent repeated impact from suburban runoff.

Since 2018, RPBCWD has been methodically assessing District wetlands to categorize their value. Most have been assessed using the Minnesota Routine Assessment Method (MnRAM). MnRAM is a systematic way of documenting wetland functions and values, as well as physical characteristics such as size, water depth, soils, topography, vegetation type, buffer widths, wildlife habitat, and human impacts, including structures, wetland alterations, and wildlife movement barriers. Inventorying wetlands provides data for future efforts in prioritization of protection, management, and restoration efforts.

Table 3-2 provides the definitions of wetland value within the District, and Figure 3-4 maps wetland value distribution in the District.

Table 3-2 Wetland Value Classifications

Value Classification	General Description	Quantity
Exceptional	Wetland has a large buffer area or buffer shoreline. High plant diversity. Little or no alteration of soils and plants. Water quality is good. Provides fish and/or amphibian habitat. Significant recreational, educational, and/or cultural value.	35
High	Wetland with buffer or provides a buffer for the shoreline. Provides floodwater attenuation. Better-to-good water quality. Water deep enough to provide overwintering amphibian habitat. May provide fish habitat. Moderate plant diversity.	89
Medium	Wetland may have been excavated or serves as a stormwater pond. Low plant diversity. Minimal educational, aesthetic, or recreational opportunity. Deeper water may provide overwintering wildlife habitat.	418
Low	Associated with agricultural or high-intensity land use. Very low species diversity and dominated by invasive species. Poor water quality is usually due to high inputs of untreated stormwater runoff. Has alteration or excavation. Little or no recreational or cultural value.	143
Unclassified		332
TOTAL		**1,017**

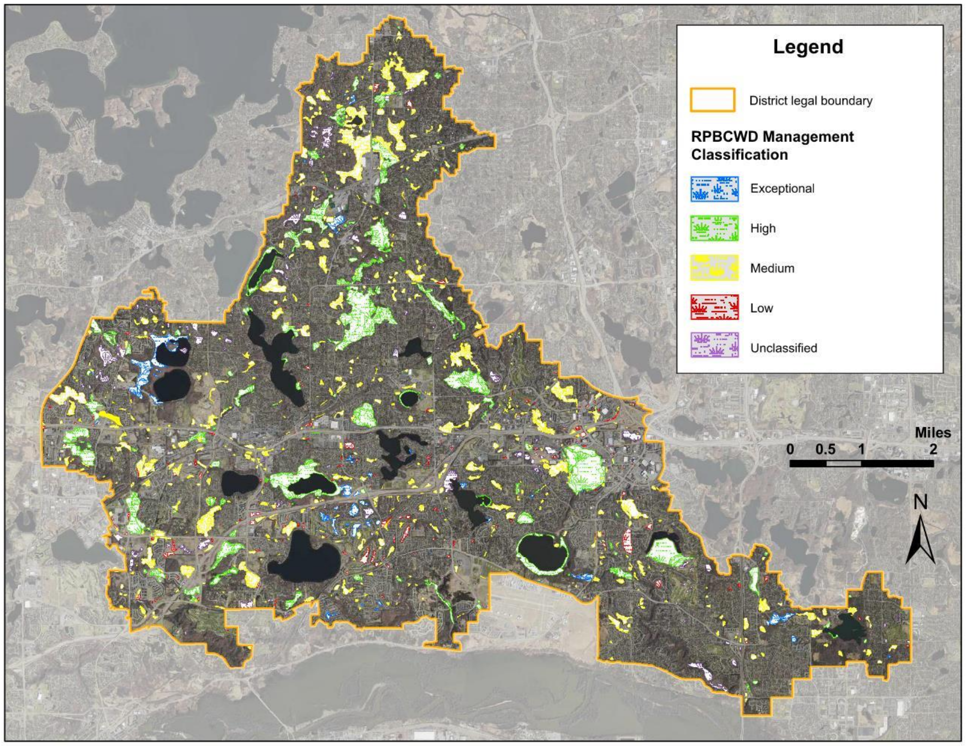


Figure 3-4 Classification of Wetlands Assessed by RPBCWD as of 2023

3.5.1 Wetland Protection and Restoration

Opportunities to improve wetlands in the District include:

- Amending the District's stormwater rules to require restoring hydrology to presettlement conditions.
- Revising rules to require managing stormwater from an entire development site rather than just the impervious surfaces.
- Requiring (as opposed to recommending) the implementation of low impact development and green infrastructure development practices.
- Developing a stormwater utility fee to fund the protection and restoration of natural water bodies.
- Continuing efforts to teach about improved deicing methods.
- Requiring the replacement of wetland functions and values when wetlands are directly impacted through development; replacement should be on-site, and if that is not possible, within the same creekshed. Primary functions to be mitigated include flood storage, biodiversity, and water quality.
- Developing wetland protection zones (overlay districts) where additional wetland protection can be required for specific high-value wetlands.
- Continuing to educate on the value of wetlands and what people can be doing on their properties to infiltrate stormwater and prevent pollutant runoff.

3.6 Lake Health

Lake Riley

Public engagement survey data collected to develop the District's 10-year watershed management plan—*Planning for the Next Ten Years (2018-2027)* (the Plan)—showed that nearly 90% of all respondents considered lakes to be very important to the quality of life in the community. In implementing the Plan, the District committed to "expand its emphasis on the role of ecological indicators in overall lake health, as well as the feedback mechanisms between these indicators (e.g., aquatic plant index of biological integrity (IBI), fish IBI, lakeshore habitat assessments, etc.)." Many lakes within the District have been listed by the MPCA as impaired (see Figure 2-13). As is the case with wetlands, much of the problem with lake degradation stems from the quality and volume of water shedding from their developed watersheds (the upland ecosystem).

The following is a summary of the lake ecosystem function impairments found in lakes throughout the District:

- Excess nutrients contained in stormwater runoff, especially phosphorus and nitrogen, fertilize lake algae, reducing clarity and suppressing other life within lakes. Poor water quality also reduces the recreational value of District lakes (see Figure 3-5).

Blue-green algae in Lake Susan.

- Destructive concentrations of deicing salts are rising dramatically in District lakes. (RPBCWD, 2023)
- Surface runoff volume discharging into lakes has increased due to urbanization of the watershed and can result in flashier changes in water levels and increased durations of high water.
- Non-native, invasive species (both plant and animal) impact lake nutrient cycles and their food webs. At least one non-native aquatic plant species has been established in each of the District lakes. Three lakes contain zebra mussels, and half of the lakes contain common carp (RPBCWD, 2023).
- Four of the lakes in the District contain five or fewer native aquatic plant species, suggesting a lack of biodiversity and habitat for aquatic organisms (RPBCWD, 2022).
- The native shoreline woodland that once surrounded District lakes has been replaced with lawn for most lakes. Submergent and emergent aquatic vegetation has been removed in many areas, resulting in fish habitat destruction. The establishment of lawns and the lack of submergent and emergent vegetation have resulted in eroded shorelines. Wave action (wind-driving and boat-induced), shoreland erosion, and ice action result in a release of sediment and nutrients into lakes, degrading water quality.
- Degraded shorelines around most of the lakes provide poor habitat and stress fish, as shown in the Score Your Shore assessment (RPBCWD, 2023). There is a need for shoreline buffer establishment, shoreline restoration, and aquatic vegetation regeneration.
- Lake Riley and Lotus Lake have been listed as impaired for aquatic life use based on the MNDNR's fish IBI. The assessment ranked riparian development along the lakeshore as a moderate stressor. The MNDNR report suggests that "Projects and policies that restore or enhance riparian lakeshore habitat complexity should be promoted." (MNDNR, 2017)

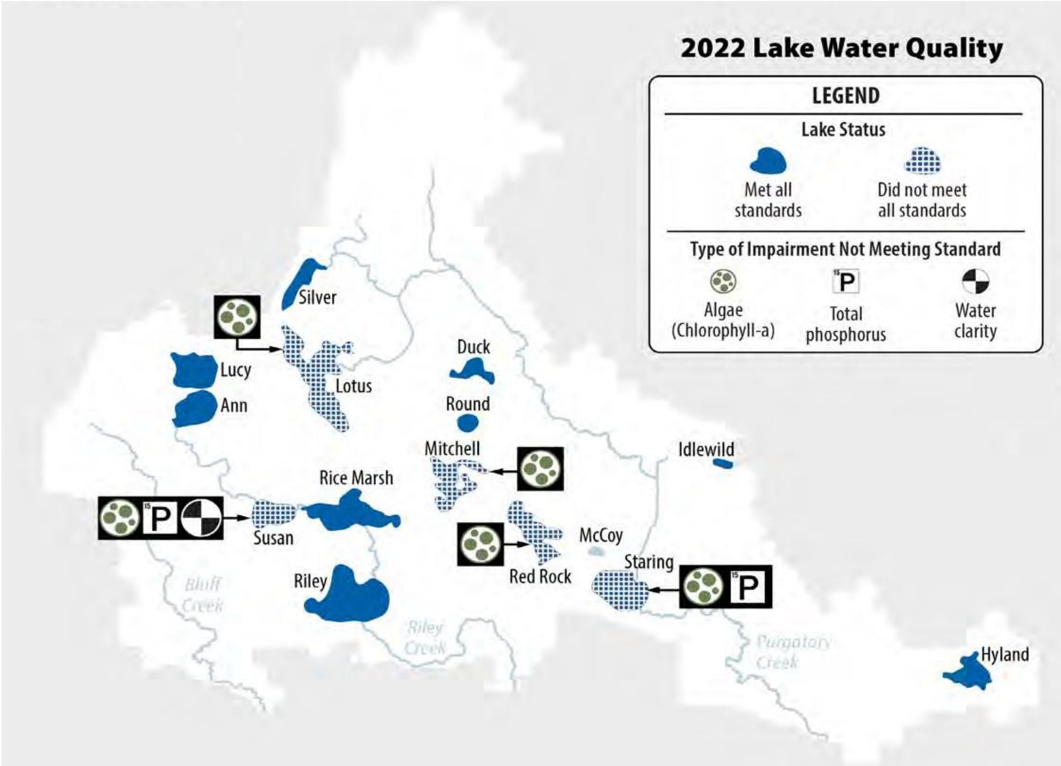


Figure 3-5 Lake Water Quality Impairments (RPBCWD, 2023)

3.6.1 Lake Protection and Restoration

Much can be done to protect and restore lakes. Opportunities include:

- All the opportunities listed for wetlands above (Section 3.5.1).
- Developing an official definition of shoreland as the zone reaching from 15 feet above the ordinary high-water line (OHW) down to below the OHW to a water depth of 24 inches.
- Requiring the stabilization of eroding shorelines and protection of shoreline habitats.
    - Cities and/or the District can establish more stringent shoreline regulations than the DNR.
- Requiring licensure for chloride applicators.
- Teaching about DNR regulations that prohibit the destruction of submerged aquatic plants.
- Working with appropriate authorities to develop a wake boat rule to manage their use.
- Developing a shoreland restoration funding program where the District would fund and potentially construct restorations in exchange for a recorded declaration that would require the preservation and maintenance of the restored buffer zone.
- Continuing and amplifying the District's aquatic invasive species control program.
- Continuing to work with lake associations to provide education, conduct volunteer events, and provide shoreline cost-share funds.

3.7 Creek Assessments

The three namesake creeks of the District have been significantly altered since the time of European settlement due to changes in land use that have increased stormwater runoff. Over the past century, the creeks have experienced bank erosion and undercutting, tree and vegetation loss, macroinvertebrate and fish impacts, as well as water quality problems due to the significantly increased volume and degraded quality of water that runs off the watershed. The culprit once again is suburban development. Creeks have experience extremes of flow due to fast runoff volumes that suddenly gush down streams; however, during drought, streams dry out because not enough water has soaked into the ground to provide creek baseflow from groundwater (see Section 3.8).

Increasing volumes of stormwater runoff erode streams (Bluff Creek shown here). This is due to both the runoff from impervious surface as well as runoff from green space where compacted soils increasingly shed stormwater.

Creek assessments confirm these impacts. The District conducted the following studies to assess creek degradation:

- 1999 Proposed Statement of Need and Reasonableness (Barr, 1999) (a.k.a. the Bluff Creek Assessment)
- Upper Riley Creek Assessment (Barr, 2016)
- Creek Restoration Action Strategy study (RPBCWD, 2017)
- Bluff Creek Watershed Total Maximum Daily Load: Turbidity and Fish Bioassessment Impairments (MPCA, 2013)
- Lower Minnesota River Watershed TMDLs

These studies document increases in the volume and rate of stormwater runoff causing soil erosion from the watershed, resulting in the transport of sediment to creeks, wetlands, and lakes. Causes of increased stormwater in the District runoff include:

- Increased impervious surface (buildings, streets, parking lots, etc.)
- Decreased stormwater infiltration across the watershed due to soil compaction and soil health degradation that occurs during construction and through other human activities
- Piping stormwater to streams through storm sewers that rapidly conduct water to streams in large volumes
- Climatological shifts that have resulted in an increase in precipitation and the intensity of storms

Table 3-3 lists the District's impaired waters where erosion has been identified as one of the sources of degradation.

Table 3-3 MPCA Identified Impaired Waters within the RPBCWD Where Erosion Has Been Identified as a Source of Pollution

Waterbody	Pollutant or Stressor	Erosion Source
Bluff Creek	Turbidity	Watershed, Streambank and Ravines
Riley Creek	Turbidity	Watershed, Streambank and Ravines
Lotus Lake	Nutrients/Eutrophication	Watershed, Steep Slopes and Ravines
Silver Lake	Nutrients/Eutrophication	Watershed and Western Steep Slopes
Lake Susan	Nutrients/Eutrophication	Watershed and Streambank
Staring Lake	Nutrients/Eutrophication	Watershed and Streambank

The creeks within the District provide many services, from providing valuable wildlife corridors for birds, invertebrates, fish, and other species that require an unbroken habitat to the prevention of flooding and recreation. Figure 3-5 illustrates the impairments observed along the District’s creek corridors.

The creek corridors in the District are regularly assessed using a process established in the 2017 Creek Restoration Action Strategy (CRAS) Study (Barr Engineering Co., 2017). In the CRAS, creek reaches are prioritized for stabilization and restoration (see Figure 3-5). Low-priority reaches are those that are generally stable yet receive monitoring to track degradation. A reach with a severe priority rating indicates significant ecological degradation and risk to infrastructure. provides a summary of the number and percentages of sub-reaches within each category. Over one-third of the reaches assessed had overall scores within the high/severe rating, meaning significant benefit could be derived from stream improvements in these locations. Figure 3-5 summarizes RPBCWD 2023 CRAS inventory and restoration potential.

Table 3-4 CRAS Summary of Tier 1 Results by Category and Total Score

Priority Rating	Infrastructure Risk		Erosion & Channel Stability		Ecological Benefit		Water Quality		Combined Rating	General Conditions
Low	52	58%	15	17%	1	1%	0	0%	30%	Good
Moderate	31	35%	22	25%	22	25%	25	28%	34%	Fair
High	5	6%	27	30%	63	71%	48	54%	27%	Poor
Severe	1	1%	25	28%	3	3%	16	18%	9%	Severe

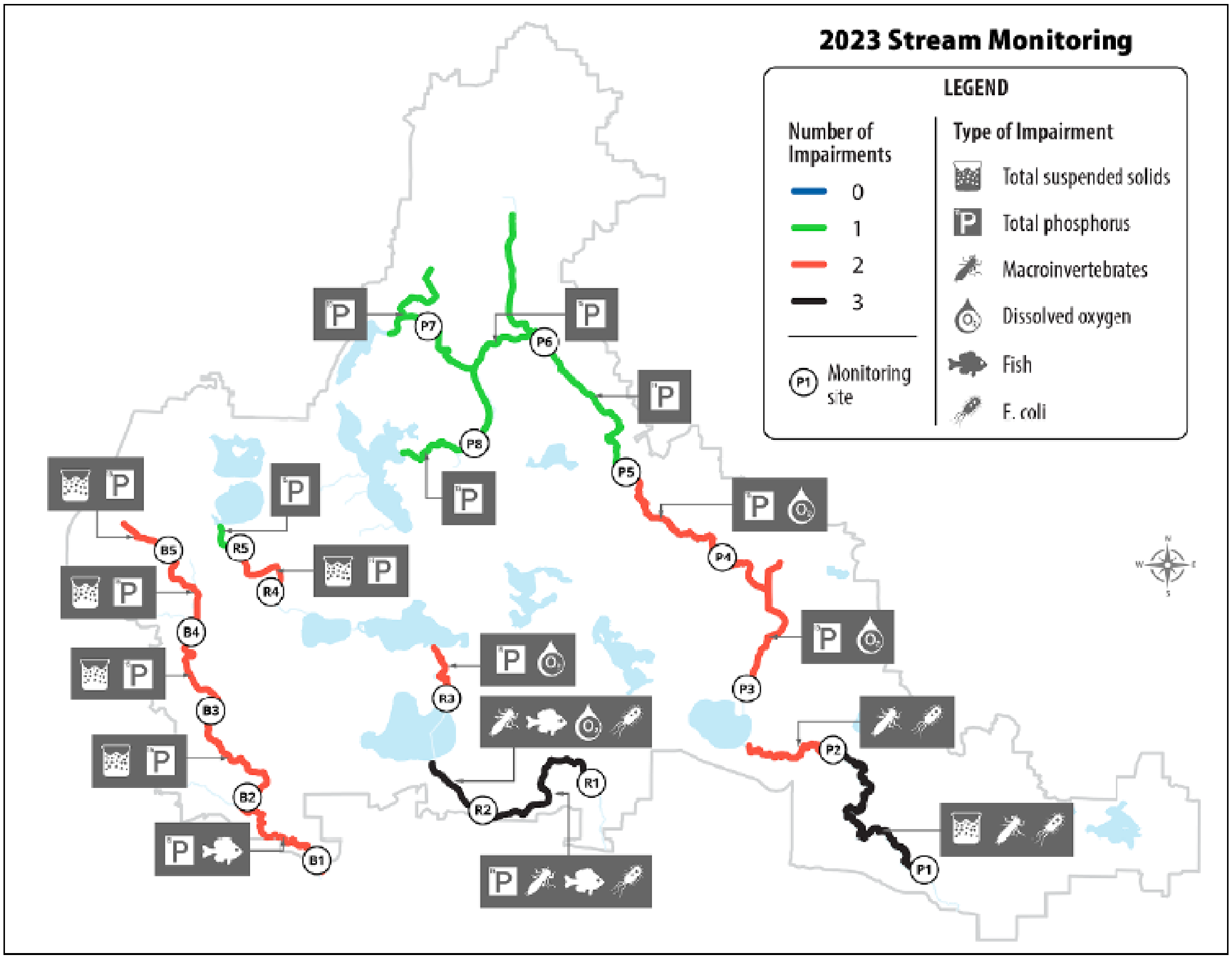


Figure 3-6 2023 Stream Water Quality Data from Bluff Creek, Riley Creek, and Purgatory Creek in the Riley Purgatory Bluff Creek Watershed District as Compared to MPCA Water Quality Standards (RPBCWD, 2023)

3.7.1 Stream Protection and Restoration

Suburban development is predicted to increase over the next few decades. This will result in more construction and more impervious surfaces with downstream ramifications. Much can be done, however, to protect and restore Riley, Purgatory, and Bluff Creeks. Opportunities include:

- All the opportunities listed in Section 3.5.1 (Wetlands) and 3.6.1 (Soil Regeneration). Improving watershed conditions is imperative to the recovery of stream ecosystems.
- Develop stream protection rules. Require abstraction or extended detention if abstraction is not possible.
- Provide a stormwater volume credit for developments when preservation or restoration of habitat is achieved.
- Protect steep slopes, many of which flank the District's streams:
  - Redefine steep slopes to include slopes outside the stream buffer.

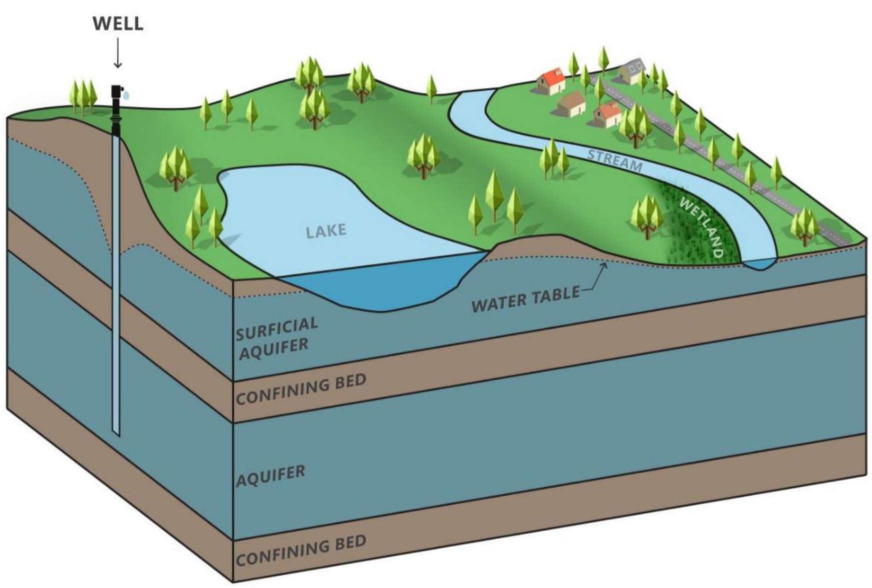
- Redefine high-risk erosion areas. Require additional analysis and protection for projects adjacent to high-risk areas.
- Regulate for more protection.

- Teach about the value of streams and the impacts causing degradation. Focus on how watershed conditions can be improved.
- Identify property owners with steep slopes and teach them about slope value and protection.
- Cost-share with property owners to establish stream buffers.

3.8 Groundwater Surface Water Interaction

One of the District's primary missions is to promote the sustainable management of groundwater to ensure the stability of natural water bodies and protect drinking water.

As previously emphasized in this document, stormwater infiltration has decreased, and stormwater runoff has greatly increased within the District since the time of European settlement. We are effectively sealing off the surface of the ground, preventing water from soaking in due to the extent of impervious surface (approximately 24 percent of the District) and due to the compaction of soil and the altered hydrology of green space (see Section 3.1). This has reduced the volume of water reaching surface aquifers and impaired the function of natural water bodies.

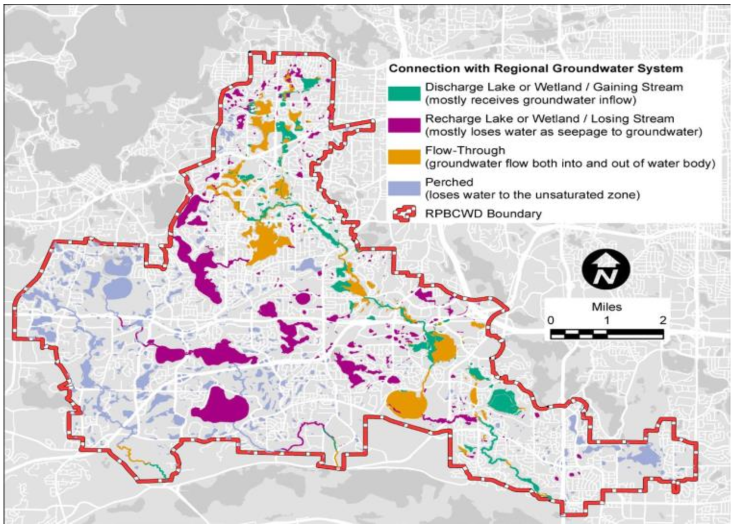


Water bodies interact with surficial aquifers (ground water) through water inflow and outflow. Impervious surfaces and compacted soil within the watershed impedes stormwater infiltration reducing the amount of cool, clean water that reaches water bodies through groundwater.

The District's streams, lakes, and wetlands receive water directly from runoff and through groundwater. The depth of the water table (the upper-most surface of surficial aquifers) across the District varies typically on the order of tens of feet below the ground surface. Surficial groundwater moves laterally to provide base water flow for streams. It also supplies lake water, in many cases keeping the water levels stable. Groundwater also keeps many wetlands hydrated, preventing them from drying out during drought. With urban development, the volume of water soaking into the ground and moving to natural waterbodies has been greatly reduced, resulting in longer periods of drawdown and dry-out in natural water bodies. When it does rain, larger volumes of water damage streams with erosive force, over-inundate wetlands with floodwaters, and cause lakeshore erosion—not to mention the increased pollutant and sediment loads carried to these water bodies.

Nearly all residents within the District obtain their drinking water from groundwater, which comprises the glacial drift surficial aquifers and underlying bedrock aquifers. Drinking water is typically taken from the bedrock aquifers (also known as regional aquifers). Because surficial aquifers are more susceptible to pollution, they are generally not used for municipal wells.

Recharge to the surficial aquifers occurs primarily through the downward percolation of local precipitation. Streams, ponds, lakes, and wetlands throughout the watershed may also recharge the groundwater, depending on the gradient between the waterbody and the local water table. In 2017, the District conducted a study of groundwater/surface water interaction (entitled *Regional Groundwater/Surface Water Interaction Study)*. This study:



Surface water features in the western part of the District interact with ground water differently than surface waters in the eastern and northern part of the District. In the west, lakes and wetlands are mostly perched or recharge the groundwater system. In the east and north, lakes and wetlands mostly gain water from the groundwater system or are flow-through features.

- Evaluated the connection of regional groundwater and surface water across the District.
- Describes the vulnerability of surface waters to changes in the regional groundwater system.
- Identified areas conducive to large-scale infiltration.
- Evaluated slope stability and identified areas where the risk of slope failure would be greatest if infiltration was increased.

3.8.1 Protecting and Improving Surface Water/Groundwater Interaction

Some of the opportunities to improve the protection and restoration of surface water/groundwater interaction include the following:

- Re-establish a monitoring well network within the District and implement a groundwater monitoring program. Priority should be given to areas likely to experience groundwater drawdown and those near surface waters classified as vulnerable to changes in the groundwater system.
- Require rather than suggest the use of green infrastructure practices in projects the District permits. Implement surficial groundwater conservation and recharge measures, including

infiltration basins, stormwater reuse systems, permeable pavement, rainwater harvesting and reuse systems, and vegetation management as part of the District's regulatory program.

- Implement strategies suggested in Section 0 to improve the hydrology of green space.
- Require developers to fund/develop ecological quality improvements beyond current stormwater management requirements.
- Develop overlay districts for which unique rules, planning strategies, or funding mechanisms are enacted. These could be:
    - Based on the protection of sensitive water resources.
    - Based on the preservation or restoration of natural areas.
    - Based on heat islands.
    - Used to incentivize developers.

  In addition, opportunity funds could be budgeted for potential projects.
- Establish baseflow thresholds for the creeks within the District. The downstream reaches of Riley Creek and Purgatory Creek were identified as most vulnerable to groundwater system changes and should be prioritized for establishing baseflow thresholds.
- Establish thresholds for those lakes identified as vulnerable to changes in the groundwater system. Thresholds may be either lake stage or outlet discharge.
- Establish target flow conditions for wetlands identified as vulnerable to changes in the groundwater system.
- Develop a groundwater-surface water model for the District to improve the understanding of land changes on the groundwater-dependent resources.

3.9 People's Perception of Natural Resources

The topic of ecosystems is confusing because they include complex physical and biological relationships within our environment. This complexity often leads to ecosystem degradation because people misunderstand how their actions impact the ecosystem. Our ecosystems to support our lifestyles, but we must also give back to continue to reap the benefits. This plan begins to explain this complexity and put forth initiatives to protect and replenish the ecosystem.

Some people see the District as a natural landscape woven between a myriad of lakes and wetlands and within a beautiful urban forest. Others see a degraded and fragmented, highly paved environment infested by invasive species, with diminishing species diversity and plummeting water quality. This leads to conflict when making efforts to protect resources. Conflicting ecosystem perceptions and values often results in a lack of action.

Many people perceive ‘green is good’ in the landscape. Ecological degradation can be green - as in the case of this buckthorn invasion in the left image - but biodiversity and tree reproduction are in jeopardy. The image on the right shows a diverse woodland understory where trees can readily reproduce.

Misperceptions observed in the District are not unique and apply to most areas of the U.S. They include:

Misperception	Results
Everything is pretty much okay in the environment. People don’t understand how degraded our ecosystems are or what a healthy urban ecosystem could look like.	• People choose not to support efforts to protect or regenerate the environment. • People negatively impact the ecosystem without awareness. • People have misguided intentions related to wildlife, such as feeding geese and deer.
Green is good. A perception that nature takes care of herself, and people don’t need to intervene on nature’s behalf.	• Degraded plant communities infested with invasive species that are perceived as pristine and not in need of improvement. • The perception that every tree is sacred and harvesting efforts that result in forest regeneration is an irreplaceable loss. • Stormwater runoff issues lead to impaired lakes, streams, and wetlands.
People are separate from nature. We are not part of the ecosystem.	• An attitude that we don’t need to invest in our ecosystems. • Abuse of natural areas and natural resources.
The ecosystem is outside of urban areas.	• Protective actions are not taken because the suburbs are sacrificial areas inhabited by people.
Technology will save us. An impending new technology will clean our lakes and air and reverse climate change.	• Results in inaction.

3.9.1 Addressing People's Perception of Natural Resources

The following actions can be taken to address perceptions of natural resources.

- Build upon current education efforts to deepen the understanding of the District's ecosystem.
- Continue to demonstrate good stewardship through capital projects.
- Engage citizenry through multiple media for their participation in activities that allow them to learn about the environment.
- Engage leadership in educational programs and on-the-ground efforts.

3.10 Habitat Fragmentation

Suburban development bisects and isolates habitats. This is called habitat fragmentation. This diagram illustrates how habitat fragmentation can occur over time. Habitat fragmentation results in isolated 'islands' of habitat that are highly vulnerable to disturbances and stressors. (graphic source: Minnetonka Natural Resources Master Plan)

Across the country and within the District, original landscapes have been bisected by highways, homes, industrial and commercial developments, and parking lots. This supports our lifestyles and economy yet has greatly diminished habitat and ecosystem function, resulting in negative impacts on clean water, clean air, soil productivity, wildlife, natural heritage, and beautiful vistas. The process of bisecting and isolating habitats is called habitat fragmentation and results in isolated "islands" of habitat that are highly vulnerable to disturbances and stressors. Life cycles of many species cannot be completed in fragmented habitats because of exposure to predators, lack of cover, or lack of food sources. The young of many species cannot move to form new territories because of obstacles.

As our climate changes, heat, heavier precipitation, and drought further stress our remaining habitat islands. Climate change is forcing some species out of the region and is pushing new, more southern species to colonize the District. A solution to habitat fragmentation is to create corridors of habitat that connect islands of natural areas. Making this happen within the District is tremendously difficult because it means removing portions of the urban fabric. However, the District's three namesake creeks provide valuable unbroken habitat corridors north of the Minnesota River Valley. A viable alternative to removing portions of the urban fabric is to introduce new species to islands of habitats, especially plant species, to facilitate ecological changes in response to climate change.

3.10.1 Compensating for Habitat Fragmentation

Opportunities include:

- Identifying key ecosystem corridors and developing overlay districts to guide habitat improvement.
  - Providing incentives to developers who protect or create natural areas.
  - Enacting stricter urban development and shoreland protection rules.
- Considering referenda for voters to approve land purchase.
- Protecting existing natural areas within the District through the funding of restoration and land purchases.
- Establishing a path for land trusts for development projects.
- Expanding native plant community restoration efforts. Focus on expanding habitat along stream corridors.
- Increasing public awareness of habitat fragmentation through education and outreach.
- Encouraging residents to create habitat through planting in their yards. Expand the District's native plantings cost-share program.
- Expanding the District's invasive species control program. Invasive species will likely fill niches left open as native species no longer tolerate changing growing conditions.
- Monitoring for new and disappearing species from the District so that assistance measures can be identified.
- Determining which species native to warmer regions south of the District might best colonize to improve biodiversity as the climate continues to change.
- Developing plans to assist the migration of plant species through District capital projects. Trees and herbaceous plants are a good place to begin because they are the basis for wildlife habitats.

3.11 Loss of Native Species Diversity (Biodiversity)

From wildlife to native plants to fungi, the diversity of species within the District has greatly diminished over the last 150 years. Species have been directly eliminated through hunting (like the bison) and plowing, and others have been lost through habitat degradation, such as wetlands that receive larger quantities of urban runoff and woodlands impacted by herbivores. Many species are unable to complete their life cycles because critical habitat elements no longer exist.

A diversity of plant, animal, and microbial species supports multiple ecosystem functions. Runoff water is filtered through vegetation and soils, which are stabilized by diverse root systems that are dependent on a plethora of microbes. In intact ecosystems, clean water reaches lakes, wetlands, and streams. The diversity of root systems and microbes supports healthy soils that readily infiltrate water, contributing to stream base flow and aquifer recharge. Plants take up water through their roots as a critical aspect of the hydrologic cycle that releases water to the atmosphere through evapotranspiration, cooling the land and generating rain. Plants and microbes also play a critical role in the nutrient cycle, holding nutrients that might otherwise be water pollutants within their tissues and tight within the soil. Plants and microbes sequester carbon. It is important that a diversity of species—rather than just a few species—work together to fill niches and provide ecosystem function in the District that supports people on this planet.

Opportunities to improve biodiversity abound in suburban neighborhoods including the capture of stormwater in rain gardens planted with native vegetation, replacement of lawn with native vegetation, and the narrowing of streets to recover green space.

3.11.1 Recovering Biodiversity

Within this suburban watershed district, much can be done to regenerate biodiversity, including:

- Protecting existing natural areas and habitats.
- Requiring a percentage of native plantings as part of required green space.
- Better enforcing ordinances such as weed and landscape ordinances.
    - Conservation easements are often not enforced.
    - Potentially release easement information to the public.
- Identifying and re-introducing locally extinct plants as appropriate to increase species diversity.
- Improving natural area biodiversity by managing invasive species and planting a diversity of native plants. On-going maintenance is critical to keeping invasive species at bay.
- Working with the MN DNR to get more invasive plants listed on the noxious plant list.
- Monitoring for newly arriving invasive species (e.g., round-leaf bittersweet in woodlands and common reed grass in wetlands). It is inexpensive to manage a few new arrivals but very expensive to manage them once they have become established throughout the District.
- Providing incentives for private landowners to control invasive plants and animals on their property. Introducing cost-share programs for landowners who plant native plants.
- Introducing "near-native" plant species (those native south of here) to assist the migration of native plants as our climate is warming.
- Using low-impact design principles when designing new developments to better preserve and restore native plant communities. Working with developers to plan for a significant amount of green space (including green roofs), to regenerate soils, and to hold stormwater on the land where it can support life and not be a burden to downstream water bodies.
- Reduce unnecessary impervious surfaces in existing developments, streets, and parking lots. These are often great spaces for vegetated bioretention basins and tree planting.

- Replacing unused lawns with a diversity of native plants and maintaining them to retain plant diversity.
- Preserving and restoring a diversity of habitat types. Each habitat supports different species.
- Restoring soils after every construction project. Healthy soils are the foundation of species diversity.
- Controlling deer populations.
- Showing cost savings and advantages of native landscaping as opposed to standard lawn practices.
- Providing hands-on maintenance workshops for cost-share recipients and others.
- Teaching about the protection, restoration, and management of public lands (parks, ROW, other public spaces).
- Partnering with organizations and community members to achieve biodiversity and stormwater management goals.
- Establishing long-term maintenance funding while a project is being approved.
- Developing clear, stepwise maintenance plans.

3.12 Invasive Species

Plant and animal invasive species within the District occupy upland, lowland, and aquatic habitats. Invasive species reproduce quickly and dominate a habitat, displacing native species and interrupting ecosystem functions such as the hydrologic and nutrient cycles. An example of an invasive species altering the hydrologic cycle is earthworms, which consume forest floor duff. This prevents plants from reproducing, leaving soil vulnerable to erosion, and unable to infiltrate stormwater. An example of an invasive species that alters nutrient cycles is garlic mustard, which invades forest floors and densely covers the ground, outcompeting native vegetation. It is a biannual plant and dies in mid-summer, leaving forest floors bare and exposed to erosion until new garlic mustard seedlings germinate in the fall. Soil nutrients are lost through erosion during summer storms and deposited in nearby natural water bodies.

Common reed grass *Phragmites australis* is a species invasive to wetlands that is just arriving in the District. It is very aggressive and tall, easily outcompeting native vegetation.

One particular invasive species just arriving in the District that may become an exceptional problem for water resources is jumping worms. Jumping worms have been imported for fast composting in bins and have escaped. These unusually active earthworms aggressively devour the duff layer in woodlands and organic mulches in landscapes. They destroy soil structure, leaving the soil the consistency of coffee grounds to a depth of 4 to 6 inches. The soil is then subject to erosion, with nutrient runoff to natural water bodies. There is no known control for jumping worms. Preventing their spread is critical.

Invasive species greatly diminish biodiversity; once established, they are difficult and expensive to remove.

3.12.1 Controlling Invasive Species

Most invasive species can be controlled. They likely will not be eradicated, but ecosystem function can be restored when they are minimized. Opportunities to address invasive species include:

- Monitoring for new invasive species within the District. It is most effective to control invasive species when they first arrive, and their numbers are few. Learn what species are just arriving and those that will likely arrive soon. Our warming climate is allowing many invasives to move in from warmer, southern regions; previously, winter minimum temperatures would have killed these species. Common reed *Phragmites australis* is an example of a very aggressive invasive wetland plant just arriving in the District that should be diligently controlled. It spreads very quickly, destroying the habitat of many species.
- Developing a Pest Detector Program, using volunteers to scout and report new invasive species to the MN DNR and District staff.
- Establishing a jumping worm awareness program to alert residents to the hazard of importing potentially infested soil and plants into their landscapes.

- Continuing to restore native plant communities to promote native plant diversity and potentially out-compete some invasive plants.
- Teaching about invasive species and conducting invasive species control events.
- Expanding the District's invasive species program for further control.
- Providing incentives for the removal of invasive species.
- Adequately funding maintenance on all District projects to prevent the encroachment of invasive species.
- Establishing a BMP inspection program that includes the identification of invasive species.
- Using integrated pest management principles to guide thoughtful and limited pesticide use.

3.13 Wildlife

3.13.1 Wildlife in Upland Habitats

No survey was conducted to determine the current status of upland wildlife in the District. It is assumed that wildlife populations are those of typical urban, developed landscapes. Wildlife often found within the Minnesota River Valley and nearby urban areas include residential and migratory birds (Canada geese, mallards, blue-winged teals, robins, etc.), reptiles (common garter snakes, red-eared sliders, snapping turtles, etc.), mammals (white-tailed deer, coyotes, raccoons, opossums, bats, etc.), and amphibians (salamanders, frogs, and toads). These species are often generalists that can adapt to human populations and fragmented habitats.

An area of particular concern in recent years is the plummeting populations of pollinators and other beneficial insects. Threats to these species are primarily due to loss of habitat and habitat fragmentation. Native woodlands and oak savannas, once full of rich nectar and pollen-producing plants, have been replaced with buildings, pavement, and lawns. Although natural areas currently in the District help support pollinator populations, degraded habitat, invasive species, and lack of native plant species limit the resources required to support an abundance of pollinators.

The increase in urban development has caused wildlife populations to differ greatly from the species that would historically have been found here. Natural disturbances, such as fire, have often been eliminated from urban settings, negatively impacting habitats dependent on these disturbances. Additionally, the presence of people has increased the potential for human-wildlife conflict and the labeling of certain species as nuisance animals or pests. These include white-tailed deer, raccoons, woodchucks, skunks, and squirrels.

Due to the extirpation of many predator species in the area, certain wildlife populations often grow unchecked, resulting in more human-wildlife conflicts and critical impacts on habitats. For example, white-tailed deer in the District lack natural predators, and populations are difficult to control. This has led to an increase in damages caused by herbivory, resulting in soil compaction and decreasing stormwater infiltration. Additionally, geese often become pests by congregating on lawns near water bodies. With no native vegetation buffer along the shore, feces can be washed into the water body. The reduction in suitable habitat and habitat fragmentation has led to a lowered wildlife populations and localized extinctions within the District, limiting how many species or individuals of species can be supported.

Trumpeter swans on Staring Lake.

3.13.2 Aquatic Wildlife

Fish - Fish species diversity and populations within District lakes are typical of lakes in urban environments. Generally diminished water quality along with shoreline habitat and emergent/submergent vegetation destruction have impacted the aquatic system. Riley and Lotus lakes do not meet the fish IBI and are impaired for fish. One destructive force are carp which occur in several District lakes. At this point, however, their populations are below a threshold where control is necessary. Also of concern are Cyanobacteria, also known as blue-green algae, blooms within Staring Lake and Lake Susan. This is occurring nearly every year in late summer. It can be toxic for people and animals and can cause lake water oxygen depletion and fish kills.

Bluff Creek and lower Riley Creek have significantly reduced habitat value. This is primarily due to low water levels nearly every summer. See section 3.8 on the discussion of how groundwater feeding water to District streams has been impacted by urban development.

Macroinvertebrates – Macroinvertebrate levels are greatly reduced in lower Riley Creek and lower Purgatory Creek. This is due to low water levels.

Reptile and Amphibians – These species are not monitored in the District.

The status of aquatic wildlife within the District is discussed in more detail in the 2023 RPBCWD Annual Water Resources Report.

3.13.3 Wildlife Population Recovery

Opportunities to address wildlife issues include:

- Restoring native plant community habitat wherever practicable.
- Providing a stormwater volume credit for developments when preservation or restoration of habitat is achieved.
- Expanding aquatic and upland invasive species control programs to preserve habitat.
- Transitioning unused manicured lawns to native plant communities. Use cost incentives.
- Teaching about and implementing cost shares to establish water body buffer plantings.
- Teaching District residents about how they can positively contribute to wildlife diversity, health, and populations. For example, discourage them from feeding deer and waterfowl, encourage them to keep cats in the house, and control invasive species that destroy habitat.
- Partnering with nonprofit organizations and other governmental agencies to preserve existing habitats either through land purchase or by establishing conservation easements.

4.0 Ecosystem Protection and Management Strategies

Through the advisory committee workshop series (see Appendix 1), staff vetting, and a literature review, ecosystem health strategies to be developed by the District were identified and prioritized as described below. These are activities where the District can intervene on behalf of the ecosystem and the people who live there.

Ecosystem management strategies have been divided into categories, including regulations, climate resiliency initiatives, land protection and regeneration, surface water management, education and outreach, partnerships, and data collection. These are described in the sections below.

4.1 Prioritization Scoring Definitions

The following scoring definitions used in the strategy tables presented in this Section were used to prioritize ecosystem strategies. The scoring was developed such that high values represent higher benefits; thus, a higher total score indicates strategies with more benefits relative to the others presented.

Ecosystem effectiveness: The degree to which a strategy can protect or regenerate ecosystem function, e.g., hydrologic cycle, soil biology, nutrient cycling, biodiversity, etc. Scoring:

1—Protects the ecosystem in specific areas

3—Widely regenerates the ecosystem

5—Significantly regenerates the ecosystem throughout the District

Level of Effort—People: Ease of implementation, human effort

1—Significant effort to implement an initiative using a new hire or consultants for more than 12 months

3—Efforts to implement an initiative will be part-time and can be completed within 12 months, as well as requiring part-time attention into the future

5—Efforts to implement an initiative will be part-time with existing staff and can be completed within 6–10 months

Level of Effort—Budget

1—Initial high expense with ongoing high expense

3—Initial high expense with ongoing low expense or initial low expense with ongoing high expense

5—Low initial expense or ongoing low expense

Interdependency: The number of subsequent activities reliant upon completion of the program

1—No other programs are reliant upon completion of this

3—One to two other programs are reliant upon completion of this

5—More than two other programs are reliant upon completion of this

4.2 Regulations

As a result of this plan, the District will undertake rules revisions to better protect the District's ecosystem and water resources. Regulatory changes that the District plans to undertake are listed in Table 4-1. Overarching conclusions of regulatory revisions (see Table 4-1) include:

- Climate change impacts (such as increased precipitation) and climate resiliency will be incorporated into regulatory revisions to further protect the ecosystem, water resources, and inhabitants of the District.
- These regulatory revisions will be developed, vetted, and implemented in 2024/2025.
- The regulatory revision process will involve close collaboration with the cities within the District to develop rules that are achievable and enforceable.
- A primary goal of the revisions is to mitigate and restore the hydrologic cycle functions impacted by land alterations. One mechanism by which this is attained is by holding stormwater where it lands and allowing it to soak into the ground through the restoration or mimicking of natural conditions.

Table 4-1 Regulatory Strategies for Ecosystem Improvement

Regulatory Strategies	Votes	Ecosystem Effectiveness	Level of Effort - People	Level of Effort - Budget	Interdependency	Total Score	Timeline
Revise stormwater quantity and quality management regulations to factor in climate change. Take into consideration more frequent and intense storms, as well as precipitation projections. For example, require the use of the 90% percentile Atlas 14 rainfall depth, and once available, adopt Atlas 15. Additionally, consider the requirement of flow duration analysis, increased low flow freeboard, stormwater runoff cooling, and incorporate extreme rainfall event design considerations.	12	5	3	3	5	16	2024-2025
Redefine steep slopes to include slopes outside the stream buffer.	4	3	5	5	3	16	2024-2025
Develop overlay districts for which unique rules, planning strategies, or funding mechanisms are enacted. Overlay districts could be based on the protection of sensitive water resources, based on the preservation or restoration of natural areas, or based on heat islands. Opportunity funds could be budgeted for potential projects.	1	5	3	3	5	16	2024-2025

Regulatory Strategies	Votes	Ecosystem Effectiveness	Level of Effort - People	Level of Effort - Budget	Interdependency	Total Score	Timeline
Develop stream protection rules. Require abstraction or extended detention if abstraction is not possible.	2	5	4	3	3	15	2024-2025
Adopt an abstraction requirement based on the projected 95th percentile rain event depth for the year 2100.	0	3	4	5	3	15	2024-2025
Develop a stormwater credit program for impervious surface trading to negotiate for more green space/habitat preservation or other ecosystem benefits.	24	5	2	3	3	13	2024-2025
Require green infrastructure, living streets, and low-impact development to the maximum extent possible.	6	4	2	4	3	13	2024-2025
Amend the District's stormwater rules to require restoring hydrology to pre-settlement conditions.	0	5	3	4	1	13	2024-2025
Revise rules on managing stormwater from the entire development site rather than just the impervious surfaces.	2	4	3	4	1	12	2024-2025
Enforce the District's soil health rule. This would require additional staff.	8	5	2	3	1	11	2024-2025
Require construction observers to be on-site when BMPs are installed. Would require additional staff.	0	3	2	4	1	10	2024-2025
Implement requirements of stormwater features to lower discharge temperature to that of the ambient soil.	3	3	2	3	1	9	2024-2025
Implement a stormwater utility fee to fund healthy green space.	1	4	1	3	1	9	2024-2025
Provide flexibility for developers to do the right thing instead of checking boxes.	1	1	1	4	1	7	2024-2025

4.3 Climate Resiliency Initiatives

As a result of this plan, the District will undertake climate resiliency initiatives to better protect the District's ecosystem and water resources. These are listed in Table 4-2 below. Overarching objectives for resiliency initiatives include:

- Climate change is affecting almost everything within the District ecosystem. At the same time, we affect climate change through our actions that result in altered hydrology, microclimate impacts, and the release of greenhouse gases. Moving forward, the District will incorporate resiliency/adaptation into all its efforts and attempt to reduce the carbon footprint of District work.
- The District will undertake climate vulnerability assessments and resiliency planning.
- With current and predicted increases in precipitation, increased flood storage is necessary and is a continuing priority for the District.
- Our warming climate amplifies the urban heat island effect. The District will work to reduce stormwater runoff temperatures to slow the warming of lakes, streams, and wetlands.

Table 4-2 Climate Resiliency Strategies

Climate Resiliency Strategies	Votes	Ecosystem Effectiveness	Level of Effort - People	Level of Effort - Budget	Interdependency	Total Score	Timeline
Update the Ten-Year plan to include ecological health metrics in the CIP prioritization process.	NA	4	4	4	5	17	
Preserve existing flood storage and require greater than 1:1 compensatory flood storage replacement whenever stormwater storage is proposed to be filled.	12	4	5	5	1	15	
Complete climate vulnerability and risk assessments in Chanhassen and Minnetonka, similar to what has been completed for Bloomington and Eden Prairie.	5	2	4	4	5	15	
Determine which species native to warmer regions south of the District might best colonize to improve biodiversity as the climate continues to change.	5	5	4	4	1	14	
Promote species migration and include 'near natives' in District capital projects.	0	3	5	5	1	14	
Develop a stormwater resiliency fund focused on small-scale stormwater retention and habitat enhancement projects.	7	4	5	3	1	13	
Establish baseflow thresholds for the creeks within the District. The downstream reaches of Riley Creek and Purgatory were identified as most vulnerable to groundwater system changes and should be prioritized for establishing baseflow thresholds.	8	5	2	2	3	12	
Consider developing a heat island mitigation bank for projects where there is not enough space to replace pre-existing trees. Funds deposited in the heat island mitigation bank would be used for planting trees in difficult areas with high percentages of impervious surface.	5	3	3	3	3	12	
Identify at-risk critical infrastructure and implement flood mitigation measures.	3	4	3	1	3	11	
Identify and set aside areas for future stormwater storage and management capacity up to the 0.1 or 0.2 percent 24-hour rainfall event.	3	3	4	2	1	10	
Create an urban heat island overlay district by identifying heat islands, as shown in Figure 2-17 . Require mitigation or establish stormwater credits or cost incentives to motivate mitigation measures within heat islands.	12	3	3	2	1	9	
Develop a District-specific climate action plan.	3	1	3	3	1	8	

4.4 Land Protection and Regeneration

The District will further pursue upland (the watershed) regeneration to improve ecological function and water resources health. Land protection initiatives that the District plans to undertake are listed in Table 4-3. Overarching objectives for land protection initiatives include:

- Undeveloped land within the District is a dwindling resource. Few undeveloped tracts of land exist today. The District is prioritizing the protection and promoting sustainable development of undeveloped lands.
- Tree canopy is an important aspect of the District's ecosystem. The District will work with cities to influence and fund tree canopy regeneration and protection.
- Invasive plant and animal species significantly impact soil stability and water quality. The control of upland and aquatic invasive species will continue to be addressed and prioritized through District programs.
- Most of the land within the District is privately owned. The District will continue to work with property owners to improve soils, increase stormwater infiltration, and improve biodiversity.

Table 4-3 Land Protection and Regeneration Strategies

Land Protection and Regeneration Strategies	Votes	Ecosystem Effectiveness	Level of Effort - People	Level of Effort - Budget	Interdependency	Total Score	Timeline
Redefine high-risk erosion areas. Require additional analysis and protection for projects adjacent to high-risk areas.	12	3	5	4	5	17	
Strengthen tree removal and replacement ordinances.	4	4	3	5	1	13	
Establish a land purchasing policy to protect undeveloped natural areas.	13	5	5	1	1	12	
Encourage residents to create habitat through planting in their yards. Expand the District's native plantings cost-share program.	11	4	4	3	1	12	
Work with the MN DNR to get more invasive plants listed on the noxious weed list maintained by the MN Dept of Agriculture.	2	1	5	5	1	12	
Monitor for newly arriving invasive species, such as round-leaf bittersweet in woodlands and common reed grass in wetlands. It is inexpensive to manage a few new arrivals, but it is very expensive to manage them once they have become established throughout the District.	2	3	4	4	1	12	
Develop a Pest Detector Program, using volunteers to scout for new invasive species and report to the MNDNR and Minnetonka natural resources staff.	1	3	4	4	1	12	
Adequately fund maintenance on all District projects to prevent the encroachment of invasive species.	11	3	4	3	1	11	
Establish a BMP inspection program that includes the identification of invasive species.	2	3	3	3	1	10	

4.5 Surface Water Management

The District will further pursue the protection and management of its lakes, wetlands, streams, and groundwater, as well as the ecosystem of which they are a part. Surface water management initiatives that the District will undertake are listed in Table 4-4. Overarching objectives include:

- The "sealing" of the District's land surface through soil compaction and the construction of impervious surfaces have resulted in reduced stormwater infiltration, reduced groundwater recharge, and altered ecosystem hydrology. Through a variety of programs, the District will work to protect and restore groundwater levels.
- District wetlands continue to degrade for a myriad of reasons. Further regulatory and planning measures will be pursued.
- Lake shorelines continue to degrade, reducing water quality and impacting aquatic biota. Shoreline protection, stabilization, and vegetation restoration will continue to be a priority for the District.
- Aquatic invasive species (AIS) threaten all natural water bodies in the District. Controlling these species and preventing the establishment of additional species is a continued priority for the District.

Table 4-4 Surface Water Management Strategies

Surface Water Management Strategies	Votes	Ecosystem Effectiveness	Level of Effort - People	Level of Effort - Budget	Interdependency	Total Score	Timeline
Strengthen wetland protection and mitigation rules beyond the Wetland Conservation Act.	10	5	4	4	5	18	
Wetlands directly impacted by development require the replacement of wetland functions and values first, on-site, and if that is not possible, within the same creekshed. Primary functions to be mitigated include flood storage, habitat, biodiversity, and water quality.	12	5	4	5	3	17	
Develop a shoreland restoration funding program where the District would fund restoration in exchange for a recorded declaration that would require the preservation and maintenance of the restored buffer zone.	6	5	4	3	3	15	
Establish target hydrographs for wetlands identified as vulnerable to changes in the groundwater system.	1	4	3	3	5	15	
Develop an official definition of lake shoreland as the zone reaching from fifteen feet above the ordinary high-water line (OHW) down to below the OHW to a water depth of twenty-four inches.	0	3	4	5	3	15	
Develop holistic lake management plans	9	5	2	2	5	14	
Create AIS resident monitoring program	2	3	5	5	1	14	
Develop wetland protection zones (overlay districts) where additional wetland protection can be required for specific high-value wetlands.	7	4	3	3	3	13	
Amplify the District's aquatic invasive species control program.	1	4	4	4	1	13	

Surface Water Management Strategies	Votes	Ecosystem Effectiveness	Level of Effort - People	Level of Effort - Budget	Interdependency	Total Score	Timeline
Require the stabilization of eroding lake shores and protection of shoreline habitats.	11	5	2	2	1	10	
Work with appropriate authorities to develop a wake rule to manage the use of boats.	1	2	2	4	1	9	
Establish thresholds for those lakes identified as vulnerable to changes in the groundwater system. The threshold may be either lake stage or outlet discharge.	5	1	1	1	1	4	

4.6 Education and Outreach

The District will expand education and outreach (E&O) efforts for ecosystem protection. E&O initiatives the District will undertake are listed in Table 4-5. Overarching objectives include:

- Prioritizing the education of decision-makers.
- Cities within the District have requested that District staff have a greater presence at critical meetings to be the ecological voice in the room. District staff will provide ecological/water resource protection perspectives to city staff.
- The District will continue to focus on private property owner education to improve upland watershed function through teaching about soils, lawns, native plants, trees, native habitat regeneration, invasive species, climate change, and much more.
- A greater focus will be given to the training of professionals to improve landscape function which may include the hiring of a restoration ecologist.

Table 4-5 Education and Outreach Strategies

Education and Outreach Strategies	Votes	Ecosystem Effectiveness	Level of Effort - People	Level of Effort - Budget	Interdependency	Total Score	Timeline
Educate policymakers and leadership on all issues of climate change and ecosystem management.	15	5	3	5	1	14	
Promote the management of deer populations with city staff.	6	4	4	5	1	14	
Promote/teach organic lawn management.	6	3	4	5	1	13	
Teach the public about the soil food web and the importance of soil health. Also, instruct on how to improve soil health.	12	3	3	5	1	12	
Provide ecological restoration and management training.	9	3	3	5	1	12	
Provide native landscape maintenance training.	4	3	3	5	1	12	
Promote the implementation of green roofs as a viable BMP within the District.	3	3	3	5	1	12	

Education and Outreach Strategies	Votes	Ecosystem Effectiveness	Level of Effort - People	Level of Effort - Budget	Interdependency	Total Score	Timeline
Establish a jumping worm awareness program to alert residents to the hazard of importing potentially infested soil and plants into their landscapes.	3	3	3	5	1	12	
Provide turf management training	2	3	3	5	1	12	
Assist with the formation of ecologically oriented landscape businesses, possibly through Hennepin County's small business development program.	2	3	3	5	1	12	
Identify property owners with steep slopes and teach them about slope value and protection.	3	3	3	4	1	11	
Teach residents about the impacts of climate change and instruct them on how they can act through volunteer activities.	3	2	3	5	1	11	
Provide a course for designing hardscapes for low salt use.	3	2	3	4	1	10	

4.7 Partnerships

The District will deepen partnerships/relationships with area cities and other agencies. Partnership strategies the District will undertake are listed in Table 4-6. Overarching objectives include:

- Meet as often as possible with city staff members and get involved in and provide ecosystem perspective on topics such as development, city code revisions, and comprehensive planning.
- Provide expertise and data to cities so they can better justify an ecosystem approach to their work.
- Work with developers to show them alternative development scenarios that better protect the ecosystem.
- Synchronize cost-share programs with cities and agencies for better efficiency.

Table 4-6 Partnership Strategies

Partnership Strategies	Votes	Ecosystem Effectiveness	Level of Effort - People	Level of Effort - Budget	Interdependency	Total Score	Timeline
Work with cities to review their codes in relation to parking requirements, street design, and other requirements that would result in impervious surface reduction. Incentivize impervious surface reduction by being flexible with requirements such as density and setbacks.	16	5	4	5	3	17	
Participate in cities' Comprehensive Plan process.	0	3	4	5	5	17	
Develop a process where the District and city staff work with developers to explore alternatives for ecosystem-oriented development.	9	4	3	5	3	15	
Low salt street design	1	4	3	3	5	15	

Partnership Strategies	Votes	Ecosystem Effectiveness	Level of Effort - People	Level of Effort - Budget	Interdependency	Total Score	Timeline
Meet regularly with city natural resources, planning, and water resources staff members to (see rows below):	14	4	4	5	1	14	
a. Understand cities' perspectives by reviewing and understanding Comprehensive Plans, Capital Improvement Plans, and Climate Action Plans.	0	2	4	5	1	12	
b. Discuss where city and District goals align.	0	3	4	5	1	13	
c. Discuss ordinance and policy changes to address ecosystem health.	0	3	4	5	1	13	
d. Discuss impervious surface reduction.	0	3	4	5	1	13	
e. Meet monthly with cities to discuss potential projects early before design begins.	0	3	4	5	1	13	
f. Attend cities' pre-development meetings.	0	1	4	5	1	11	
Cost share with property owners to support the transition of lawns to native plantings.	9	4	4	3	3	14	
Develop a program with cities to convert wells, lift stations, R/W, etc. to native prairie/woodland	4	4	4	3	3	14	
Produce LID urban development guidelines for staff to share with developers.	0	3	4	4	3	14	
Provide data that supports LID for cities to justify design requests.	2	4	3	3	3	13	

4.8 Data Collection

The District's extensive data collection program will be expanded to identify, collect, and analyze key ecosystem data (e.g., soils, groundwater, and vegetation). Data collection action items the District will undertake are listed in Table 4-7.

Table 4-7 Data Collection Initiatives

Data Collection Initiatives	Votes	Ecosystem Effectiveness	Level of Effort - People	Level of Effort - Budget	Interdependency	Total Score	Timeline
Re-establish a monitoring well network within the District and implement a groundwater monitoring program.	15	3	5	4	5	17	
Develop and implement a program to quantify the impact of soils on hydrology	9	3	3	5	5	16	
Develop a groundwater-surface water model for the District to improve the understanding of land changes on groundwater-dependent resources.	8	4	3	2	5	14	
Develop and implement a program to quantify the impact of vegetation on hydrology	1	1	4	3	3	11	

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Appendices

Appendix 1

EHAP Advisory Panel Workshops Summary

Appendix 1 EHAP Advisory Panel Workshops Summary

Appendix 1
Advisory Panel Workshops Summary

A series of four workshops have been conducted with Advisory Panel members as part of the Ecosystem Health Action Plan. The purpose of these workshops was to:

- Reinforce or establish relationships (due to considerable agency staff turnover) with potential partners.
- Gather ecosystem management opinions, data, and priorities of partner organizations.
- Sort through what is being done by each agency in the realm of ecosystem management.
- Determine gaps in ecosystem management.
- Determine how together we can improve the ecosystem of the District.

The Advisory Panel consisted of District partners to advise the EHAP. Members include:

Name	Organization	Title
Paul Erdmann	BWSR	Ecologist
Paul Moline	Carver County	Planning & Water Dpt. Manager
Mike Wanous	Carver SWCD	Administrator
Seth Ristow	Carver SWCD	Landscape Restoration Specialist
Dave Hanson	City of Bloomington	Natural Resources Manager
Jack Distel	City of Bloomington	Water Resource Specialist
Michelle Lincoln	City of Bloomington	Planning Division
Nick Johnson	City of Bloomington	City Planner
Eric Maass	City of Chanhassen	Planning Director
Karli Wittner	City of Chanhassen	Forestry & Natural Resources Supervisor
Joe Seidl	City of Chanhassen	WR coordinator
Brent Alcott	City of Chaska	WR coordinator
Julie Klima	City of Eden Prairie	Community Development Director
Karli Wittner	City of Eden Prairie	Forestry &Natural Resources Supervisor
Lori Haak	City of Eden Prairie	Water Resource Specialist
Leslie Yetka	City of Minnetonka	Natural Resources Manager
Loren Gordon	City of Minnetonka	City Planner
Marie Darling	City of Shorewood	City Planner
Taylor Huinker	DNR	Area Hydrologist
Ann Marie Journey	EntoVentures	Soil Health Coordinator
Karen Galles	Hennepin County	Land and Water Supervisor
Kristine Mauer	Hennepin County	Conservation Ecologist

Name	Organization	Title
Brett Eidem	Nine Mile Creek Watershed Dist.	Natural Resources Manager
Annie Kinkopf	NRCS (Carver County)	Forester
Alaina Portoghese	RPBCWD	GreenCorps
Bonnie Nelson	RPBCWD	Citizen Advisory Committee
Jeff Weiss	RPBCWD	Citizen Advisory Committee
Jill Crafton	RPBCWD	Board Member
Liz Forbes	RPBCWD	Communications Manager
Terry Jeffery	RPBCWD	Administrator
Zach Dickhausen	RPBCWD	Natural Resources Coordinator
Andy Forbes	USFWS	Migratory Bird Program

The workshop series addressed the following:

Workshop 1:

- Defined a healthy urban ecosystem
- Identified primary challenges to a healthy urban ecosystem

Workshop 2:

- Inventoried what are all of the advisory panel members are currently doing to achieve a healthy urban ecosystem
- Identified what's not being addressed

Workshop 3:

- Identified how we can address gaps in ecosystem protection/improvement
- Where can we be most effective (prioritization)

Workshop 4:

- How will we work together (commitment)

1.0 Workshop One

During workshop one, the advisory panel members worked together to describe what a healthy urban ecosystem looks like. This formed the basis for the goals of this EHAP. In the group's description of how a balance can be struck between urban development and nature, we paint a picture of a healthy urban ecosystem. The second question addressed the most significant challenges to the District's ecosystem. From this we address in workshop two how these challenges can be addressed.

Results to Questions Posed to the Advisory Panel

Question 1: Describe what a healthy urban ecosystem looks like within the District.

Characteristics of healthy ecosystem:

- Biologically diverse, layered, and connected aquatic, terrestrial, and subterranean habitats
- Diverse wildlife including mammals, birds, fish, reptiles, amphibians, invertebrates
- Resilient to climate change including intense storm events (runoff, erosion, flooding) and warming average temperatures
- Offsets climate change by storing carbon in the form of native vegetation and roots
- Functioning ecosystem services including intact water cycle, nutrient cycling, and food webs
- Healthy soils (soil sponge) capture and store stormwater
- Welcomes all people into the natural environment through trails, parks, mini-parks, and other natural spaces for leisure and recreation
- Alternative lawns such as bee lawns and meadow lawns are more common than high maintenance turfgrass lawns
- Diversity of tree species in built environments to provide shade, reduce stormwater runoff, provide habitat, and provide human health benefits
- Clean air and clean water
- Limited impervious surfaces

We can support ecosystem health through:

- Regulations and policies that support ecosystem health (e.g. reducing unnecessary pavement/asphalt)
- Protection of undeveloped land
- Dedicated funding to restore and maintain natural resources
- Education of stakeholders (decision makers, residents, business owners, property managers, youth, etc.) about a wide variety of topics: ecosystem health, invasive species, limiting use of pesticides/herbicides, reducing runoff, reducing winter salt use, landscaping with native plant species, promote natural areas
- Collaboration between local government units (LGU) at all levels
- Urban design that minimizes footprint of developed and redeveloped spaces and includes green infrastructure and enhances community walkability and access to public transit
- Cost share and technical expertise programs for property owners to support ecosystem health and services: natural shoreline restorations, meadow lawns, raingardens, permeable pavers, native plant landscaping, healthy urban forest, etc.

- Dark sky initiatives including reducing lighting and switching to less intrusive lighting
- Reduce bird collisions by treating reflective surfaces
- Surface and groundwater protection and conservation programs
- Monitor and manage to enhance biodiversity and control invasive species.

Results from question 1 can be summarized as follows. Healthy ecosystems integrate:

- Functional ecosystem services such as water cycling, nutrient cycling, and food webs.
- Biologically diverse, layered, and connected aquatic, terrestrial, and subterranean habitats, and wildlife.
- Resilient to climate change including intense storm events and warming average temperatures.
- A balance of natural and developed spaces.
- Developed spaces incorporate green infrastructure to mimic natura ecosystem functions.
- Ecologically knowledgeable population of residents, business owners, and property managers.
- Integrates people into the natural environment through trails, parks, and natural spaces for leisure, recreation, and travel.
- Native wildflowers, grasses, shrubs, and trees are incorporated into the built environment.
- Lawns are minimized and alternative lawns such as bee lawns and meadow lawns are more common than turfgrass

Question 2: What challenges are we facing to maintain and enhance the District ecosystem?

In this exercise participants were asked to list ecosystem challenges. These were then voted upon to determine which are perceived to be the most important ecosystem challenges within the District.

White Board Category	Votes	General Category
Lack of big picture mind set	18	Human/societal dimension
Development pressure (profit driven)	15	Regs
Climate change	12	Ecology
Lack of funding & staff	12	Budget
Policy & conflicting ordinances	12	Regs
Lack of public awareness/disgruntled attitude	11	Human/societal dimension
Habitat fragmentation	8	Planning
Lack of long term maintenance ($)	7	Budget
Altered hydrology	5	Regs/Ecology
Identifying decision makers? How to get them to prioritize ecosystems? Conflicting leadership priorities.	4	Bias
Lack of education, information, communication, and knowledge	3	Human/societal dimension

White Board Category	Votes	General Category
Natural areas management	3	Planning/$
Difficult politics - at all levels	2	Bias
Unknown issues yet to occur	2	Planning
Siloing within and outside of agencies	2	Planning/Bias
Chemical footprint; lawn & deicing	1	Ecology
Generational priorities and expectations	1	Bias
Lack of contractor availability	1	Budget
Lack of flexibility - need adaptive	1	Planning
Lack of green infrastructure	1	Planning/Regs
Late stage capitalism	1	Budget
Regional impacts	1	Planning
Heavy clay without topsoil	0	Ecology
Invasive species	0	Ecology
Kick the can	0	Planning
Poor soils	0	Ecology

Sorted by Category

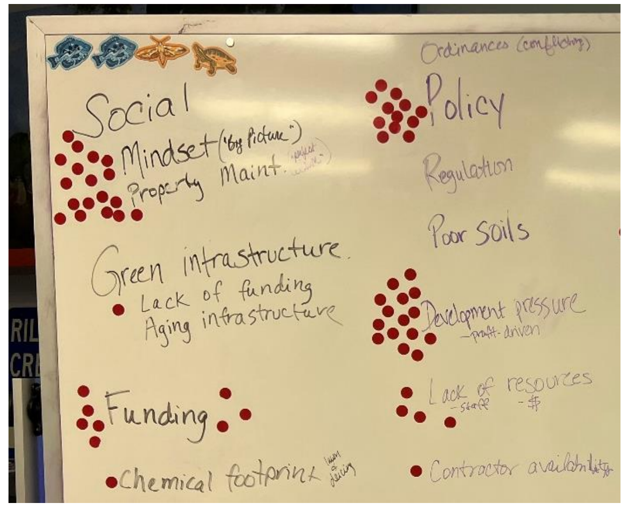
Whiteboard Category	Votes	General Category	Total Votes/Category
Development pressure (profit driven)	15	Policy	
Policy & conflicting ordinances	12	Policy	
Altered hydrology	5	Policy	
Identifying decision makers? How to get them to prioritize ecosystems? Conflicting leadership priorities.	4	Policy	
Siloing within and outside of agencies	2	Policy	**38**
Lack of big picture mind set	18	Human/societal dimension	
Lack of public awareness/disgruntled attitude	11	Human/societal dimension	
Lack of education, information, communication, and knowledge	3	Human/societal dimension	
Difficult politics - at all levels	2	Human/societal dimension	
Generational priorities and expectations	1	Human/societal dimension	**35**

Sorted by Category

Whiteboard Category	Votes	General Category	Total Votes/Category
Lack of funding & staff	12	Budget	
Lack of long-term maintenance ($)	7	Budget	
Lack of contractor availability	1	Budget	
Late-stage capitalism	1	Budget	**21**
Habitat fragmentation	8	Planning	
Natural areas management	3	Planning/$	
Unknown issues yet to occur	2	Planning	
Lack of flexibility - need to be adaptive	1	Planning	
Regional impacts	1	Planning	
Lack of green infrastructure	1	Planning/Regs	
Kick the can	0	Planning	**16**
Climate change	12	Ecology	
Chemical footprint; lawn & deicing	1	Ecology	
Heavy clay without topsoil	0	Ecology	
Invasive species	0	Ecology	
Poor soils	0	Ecology	**13**

1.1 General Conclusions of Workshop One

A primary conclusion that can be drawn from prioritizing ecosystem challenges is that they are the result of human inaction and insufficient policy including a lack of big picture thinking is coupled with profit driven development pressure and conflicting ordinances. There is a lack of ecosystem funding and a lack of public awareness. These are issues that can be overcome.



2.0 Workshop Two

The goal of workshop two was to identify gaps in policies, regulations, planning initiatives, CIP projects, and education and outreach efforts that communities have in place to address ecosystems improvement. During the workshop advisory panel members first listed initiatives/requirements within each category. This then allowed the group to identify gaps in the categories of jurisdiction in which work is conducted. The results (below) have been used to: 1. Identify rules, policy, education, etc. in which the District can improve, and 2. Identify where local agencies can improve their ecosystem operations, rules, etc.

Participants divided themselves into groups across six stations. For their first tour of the stations, they were asked what they were doing now to support a healthy urban ecosystem. During the second tour, they identified gaps in what they were doing.

Station	What are we doing?	What are the gaps?
Projects	• Incorporating • Restoring/maintaining • Reinforcing • Influencing others	• Need to redefine aesthetics • Designing site to regs instead of to site (cost limitation) • Lack of funding • Cities cannot require greener practices or to maintain these practices • Pushback for increased cost • Need to rethink roads
Resources	• Provide funding • Provide resources other than funding (volunteers, etc.) • Leveraging funds, grants, & fees	• Funding isn't long-term: either money only received for phase 1 or money dries up • Competition for funds, staff, & contractors • Need to increase public/private partnerships • Need to base fees upon ecological impacts (i. e. not all wetlands are created equal) • Finding and applying for grants is confusing
Planning	• Doing some long-term planning	• Need plans that address growing human population as well as ecosystem health • Lack of climate change planning policy [POLICY] & incorporation into rules • Lack of planning that considers/supports ecosystem health • Lack of climate mitigation and adaptation planning • Lack of bold planning to redevelop to support ecosystem health (restoring function) • Lack of long-term planning (100 years down the road) • Plans in plain languages, summarized, accessible • Develop natural resources plans and keep them updated • Are plans being put into use?

Station	What are we doing?	What are the gaps?
		• Lack of inter & intra organizational communication • Need plans that motivate change and are visionary • Ineffective maps and graphics • Need watershed plans that incorporate upland protection • Not incorporating adaptability in plans • Need to continually update data (e.g. Atlas 14 to 15) • Plans not resilient to political change • Plans are not resilient or adaptive • Competing plans or plan elements • Plans difficult to understand for most people (too long, etc.) • Plans are boilerplate & not creative
Education & Outreach	• Lots of education & outreach is already happening	• Not reaching the right audiences (decisionmakers, etc.) • Not tailoring content for different audiences • Not always addressing attitudes, beliefs & values to impact behaviors • Teach about heat island mitigation, dark skies, and ecosystems improvement • Educate decision makers • Incentivize interest and participation • Teach the real estate community about regulations • Combat bad information • Change the vision of the perfect lawn • Reach a diversity of groups
Rules & Regs	• Rules/regs for water, runoff, hydrology • Rules/regs for development • Stormwater rules & shoreline ordinances • Bluff & steep slope restrictions	• Rules and regulations are sometimes reactionary as opposed to being proactive for ecosystem protection. • There is a lack of enforcement or enough teeth to the rules. • Regulations are in place that require maybe more than necessary impervious surface: parking requirements, driveways, dual sidewalks, road widths, etc. • There is a lack of awareness or rules/regs. • There is a lack of pesticide regulations. • When most aspects of the ecosystem are impacted, there is no requirement for equivalent replacement based upon ecosystem values/services (wetlands, trees, etc.); physical features (trees); • Not enough green space is protected (planning/zoning). Overlay districts could be developed. • No groundwater protection rules (only wellhead protection zones).

Station	What are we doing?	What are the gaps?
		• No native plant requirements (ecosystem value) • Need to remove or update regs that do not support ecosystem health (e.g. lawn height requirement) • Need to incorporate flexibility into rules/regs to maximize ecosystem function • Current framework not based on asset • Not responsive to loss of ecosystem services (value of loss) • For loss, using acre-to-acre match instead of function-to-function match • Need to incorporate time and flexibility (current approach is too reactionary) • Rules & regs are outdated
Policies	• Large variety that has been in place for a long time • Some relatively new policies	• Policies are not ecosystem-oriented; people are usually the focus; not thinking about the long-term • Policies ignore climate change • Policies focus on development with little green space restoration • Need policies that balances human and ecosystem needs • Implement overlay districts as a tool for stricter environmental policy • Need a policy/program to identify and purchase high value undeveloped land • Lack of ability to direct development to benefit ecosystem health • Lack of procurement policies for sustainable purchasing (appliances, tools, etc.) • Need policies for the improvement of soil health (pre-development and redevelopment) • Need to reevaluate policies from an ecosystem perspective; find and revise competing policies • Lack of collaboration during policymaking • Need to educate policymakers • Lack of meaningful shoreland protection. Recreational use (wakeboards) is doing a lot of damage to some District lakes. • Policies often lack creativity • A policy needs a champion

3.0 Workshop Three

The purpose of workshop three was for the technical advisory group to identify potential strategies and programs for ecosystem protection and improvement, building from the gaps identified in workshop two.

Participants answered these questions at stations located around the room and recorded them on posterboards:

- How can we address these gaps (identified in workshop two)?
- What can be addressed better? What could we be doing more of?

The questions were answered for the following categories:

- Policies & Regulations
- Planning
- Projects
- Education & Outreach

Results:

Policies and Regulations

- Conduct a code review of impervious surface requirements. When were they last updated? Talk with stakeholders.
    - Review the purpose of the code; are we solving for a nuisance or being proactive? Review fire code from other parts of the country. Can smaller fire trucks be purchased? This may include requiring more sprinklers, so a large fire truck is not required.
    - Revise codes that require less impervious surface.
    - Incentivize impervious surface reduction by being flexible with things such as density and setbacks. Consider impervious surface transfers.
- Provide a volume credit for restoring or preserving habitat (reducing lawn). In Chaska an easement is created.
- Require heat island mitigation. Identify heat islands on regional maps.
- Regulate irrigation use.
- Require a percentage of native plantings as part of required green space.
- Establish stricter project design standards within rules.
- Establish soil regeneration requirements (tilling and topsoiling).
- Better define steep slopes. Regulate for more protection.

- Cities can establish more stringent shoreline regulations than the DNR stipulates.
- Need better enforcement tools (e.g. weed ordinance, compliance ordinance, stop and desist?).
    - Conservation easements are often not enforced or backed up.
    - Potentially release easement info to the public.
- Work with DNR to get more weeds listed as noxious.
- Relax policies for weed tolerance. For example, Bloomington sets standards for weed tolerances in playing fields.
- Develop a bluff Creek overlay district for additional protection.
- Require licensure for chloride applicators.
- Consider a pesticide ordinance such as developed in CO. Establish a minimum education requirement.

Planning

- Make ecosystems approach part of all plans developed.
- Develop climate mitigation and adaptation plans.
- Develop an approach/system where District and City staff can explore frameworks, ideas, and alternatives for development design with developers.
- Develop overlay districts:
    - Based on the preservation or restorability of natural areas
    - Based on heat islands
    - Could be used to incentivize developers
    - Opportunity funds could be budgeted for potential projects
- Identify key ecosystem corridors and develop overlay districts to guide habitat improvement.
- Develop a program for impervious surface trading to negotiate for more green space in development projects.
- Consider referenda for voters to approve land purchase.
- Develop long-term natural areas management plans.
- Develop public-private partnerships.
- Establish a path for ecological land trusts for development projects.
- Set regional ecological health goals.
- Create commissions (sustainability, environment, etc.) if they don't already exist.

Education & Outreach

- Educate policy makers:
    - Take policymakers (e.g. watershed district board members and city councils) on tours for hands-on exposure of ecological degradation and ecological enhancement projects.

    - Provide workshops and work sessions.
    - Show how development can co-exist with green space/ecosystem components.
- Provide realtor CEU classes and other information they can share with their clients. Help them show that nature within developments is an asset.
    - Distribute a welcome packet of natural resources education for new homebuyers
    - Teach about easements (drainage/utility, conservation, and scenic)
- Teach developers and builders about practices such as bioretention, soil regeneration, and wetland mitigation.
- Organize more volunteer events that get people outside in nature to learn and have hands-on experience.
- Utilize existing events such as Neighborhood Night Out to educate.
- Train children/teens (e.g. Minneapolis Green team) and adults (e.g. volunteers) on natural resource management – possibly paid training.
- Develop new citizen science programs (e.g. CAMP, WHEP)
    - Utilize them if they exist.
- Provide a native landscaping annual tour.
- Show cost savings of natural resources as opposed to the standard lawn practices.
- Provide hands-on maintenance workshops for cost share recipients and others.
- Teach about the protection, restoration, and management of public lands (parks, ROW, other public spaces).
- Teach property owners about bluffs/steep slopes.

Projects

Funding

- Require developers to fund/develop ecological quality improvements beyond current stormwater management requirements.
- Work with partners (public and private) to fund functional improvements that also meet their environmental/social goals.
- District could fund and implement demonstration projects.

Compliance

- Provide at the time of property sale, compliance checks for natural resources easements, wetland boundaries, cultural resources, etc. (like Minneapolis televising sewer pipes).
- Provide early design coordination with developers and builders to get better compliance with existing rules.

Design

- Identify ecological corridors prior to project design to establish ecological goals.

- Identify heat islands on regional maps and incentivize mitigation.
- Prior to design identify natural assets within a project area and designate their protection.
- Incentivize developers for ecological improvements.
- Developers to implement certification programs such as LEED, Sites, and Envision.

Maintenance

- Establish long-term maintenance funding while a project is being approved.
- Develop clear, stepwise maintenance plans.

X.4

4.0 Workshop Four

The purpose of the fourth workshop was to focus in on specific ecosystem protection actions the advisory panel found to be the most practical and implementable. This workshop involved three focus groups segregated by professions; 1. Natural resources specialists, 2. Planners, and 3. Water resources specialists and engineers. Each group was asked the following questions:

1. How can we proactively initiate Low Impact Development (LID) and Redevelopment? How can we make LID the new normal?
2. What regulations or ordinances could be developed or improved?
3. How can we better work together to enforce existing regulations and avoid variances?
4. How can we best work with leadership to make this happen?
5. How can we best team?
6. Of all the things we've discussed here today, what are your top two implementable initiatives?

Three primary themes reoccurred during the focus group sessions:

1. Cities find that maintaining natural areas and stormwater features is expensive. They request assistance in these endeavors.
2. Cities request that any changes to District regulations include flexibility in the application of those rules.
3. Cities request frequent communication and support from District staff to support ecosystem supporting initiatives.

Specific actions the focus groups suggested include:

1. Meet regularly with city natural resources, planning, and water resources staff to:
    a. Understand cities' perspective by reviewing and understanding cities' Comprehensive Plans, Capital Improvement Plans, and Climate Action Plans.
    b. Discuss where city and District goals align.
    c. Clearly present the Districts goals and objective to city staff.
    d. Participate in cities' Comprehensive Plan process.
        i. Use the Comprehensive Plan as a tool to identify environmentally important/sensitive areas and set guidelines/targets.
    e. Synchronize incentives.
    f. Discuss ordinance and policy changes to address ecosystem health.
        i. Provide a restrictive tree ordinance to protect natural areas (see Mtka. tree ordinance).
        ii. Cities have adopted the abstraction portion of MIDS but not other aspects of MIDS that could benefit ecosystem health.

iii. Replace traditional curbs with ribbon curbs and an overland infiltration/drainage system.

g. Meet monthly with cities to discuss potential projects early before design begins.

h. Incorporate topics such as equity, housing, etc. in ecosystem conversations.

i. Attend cities' pre-development meetings.

i. Provide recommendations for development, redevelopment, and infill sites; recommendations for stormwater, trees, slopes, bluffs, wildlife, native plantings, etc.

ii. Provide recommendations for street improvement projects.

j. Be a resource for cities and developers:

i. Produce urban development guidelines for staff to share with developers.

ii. Provide data that supports LID for cities to justify design requests.

iii. Get everyone speaking the same language.

9. District to serve the role of convener to get natural resources partners together to talk about needs, opportunities, and accomplishments.

a. Conduct a twice-yearly meeting with watershed partners to review upcoming capital projects and understand their needs.

b. Develop a shared spreadsheet to record what was discussed and to be built upon at successive meetings.

3. Develop an initiative to meet regularly with developers to:

a. Develop a positive rapport.

b. Attend and present to the Sustainable Development collaborative.

c. Provide guidelines on the best practices for Plant Unit Developments (PUD) and other developments.

d. Provide standard plans, details, and specifications for stormwater and landscape features.

4. Provide flexibility for developers to do the right thing instead of checking boxes.

5. Enforce the District's soil health rule. This would require additional staff.

6. Provide a volume credit for preserving woodland and other natural areas.

7. Consider a regional stormwater credit program.

10. Maintenance of stormwater facilities, low input landscapes, and natural areas is expensive.

a. Provide grant funds to cities to for maintenance.

b. Provide maintenance training.

11. Address shorelands by promoting the stabilization of shorelines. Expand natural water bodies buffer zone establishment projects to include work further up the immediate watershed.

10. Help with urban, small-scale property with conservation practices.

11. Provide training for ecological restoration and management, and yard maintenance that is ecologically sound.
12. Provide course for designing hardscapes for low salt use.
13. Assist with the formation of ecologically oriented landscape businesses possibly through Hennepin County's small business development program.
14. Provide training modules for volunteer groups.

These actions and others identified through the workshop series were then presented to the Board of Managers and the Citizens Advisory Committee (CAC) to obtain their reaction and to prioritize the proposed actions.

5.0 Board of Managers and CAC Workshop

A joint Board of Managers and CAC workshop was conducted on March 11, 2024 for the purpose of reviewing ecosystem protection and improvement action and to prioritize actions for implementation. Results of this workshop are the recommended strategies presented in the tables in Section 4.