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Effects of the Operating Environment on Watershed Management

Purpose

To evaluate how significant characteristics of the operating environment effect water management activities to determine the nature, capability and tendencies of the problems, issues, and concerns.

Outcomes

- Map and table of problems, issues, and concerns
- Map of sensitive lands and critical resources
- Description of the effects of the landscape on both problems, issues and concerns and management activities
- Operational hydrology chart
- Precipitation frequency and return
- Hydrologic effects chart
- Civil considerations table

Description of How the Problems, Issues and Concerns That Can Effect the Public Health, Safety and Welfare

The problems issues and concerns (PICs) listed below have their origin in the required and implied tasks of the governing statutes and the comments received from review agencies and the public.

PICs[1]	Definition	Occurrence	Location	Effect
Aquatic Invasive Species	An organism that has spread or been introduced beyond its native range and is either causing harm or has the potential to cause harm.	There are various pathways of invasion. Sometimes species are deliberately introduced, but more often they are unintentionally introduced. They can become inadvertent hitchhikers on or in boats, ballast water, packing materials, soil or gear.	Lakes, wetlands, and streams	Can cause costly economic and ecological damage including crop loss, clogging of water facilities and waterways, wildlife and human disease transmission, threats to fisheries, increased fire vulnerability, and adverse effects for property owners.
Flooding	The covering or submerging of normally dry land with a large amount of water	Can occur from heavy rains, rapid snow melt, rises in groundwater, or failure of infrastructure causing an obstruction to flow or rapid release of water.	Along streams From high groundwater levels	Floods can cause power, water, and gas outages; disrupt transportation routes and commercial supplies; pollute drinking water systems; damage homes, buildings, and roads; and cause severe environmental problems including landslides and mudslides and damage or loss of habitat.
Groundwater recharge	The movement of water from the surface of the land through the root zone to groundwater.	Occurs as precipitation falls on the land surface, infiltrates into soils, and moves through pore spaces through the root zone to the water table. It can also occur as leakage or loss from rivers, streams, lakes, and wetlands.	Occurs in areas on the landscape that allow a high volume of water to penetrate the surface.	Recharge can help replenish water quantity preventing impacts such as dry wells, land subsidence or the drying of surface waters. Recharge can harm water quality through the

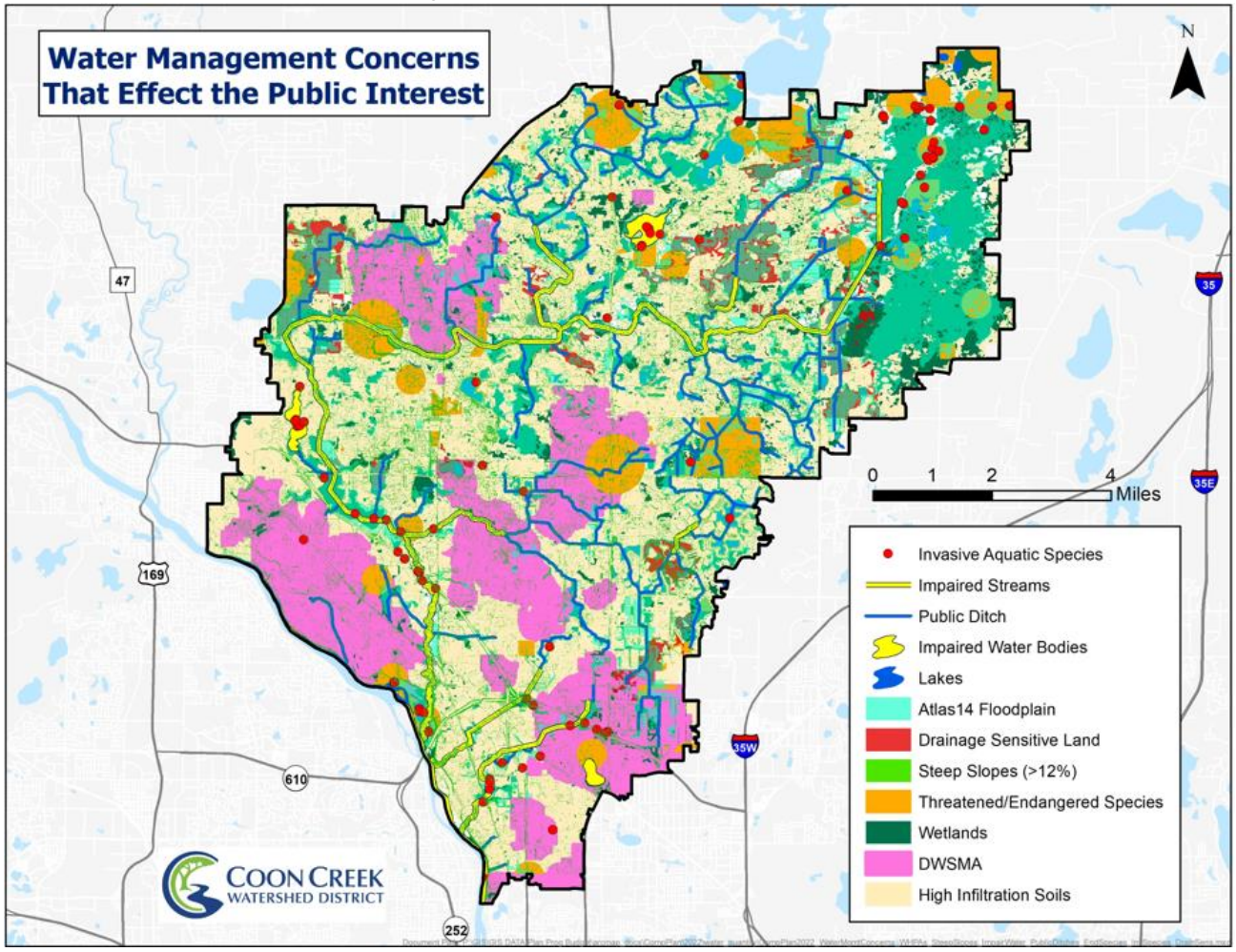
PICs[1]	Definition	Occurrence	Location	Effect
				introduction of pollutants to drinking water and surface water resources.
High Infiltration soils	Soils that have high porosity and permeability. Porosity is how much water the soil can hold. Permeability is how fast water can flow into ground.	Areas characterized by fine to coarse sands and gravels where infiltration occurs at greater than 6 inches per hour	Areas characterized by fine to coarse sands and gravels where infiltration occurs at greater than 6 inches per hour	A high infiltration rate is generally desirable for plant growth and the environment. In some cases, soils that have unrestricted water movement through their profile can contribute to environmental concerns if misapplied nutrients and chemicals reach groundwater and surface water resources via subsurface flow.
Mass Wasting	The movement of rock and soil down slope under the influence of gravity There are three main types in the District slumps, slides, and earthflow.	Are event based and typically lubricated by rainfall or agitated by seismic activity (including vibrations from trains or other regular traffic), these events may occur very rapidly and move as a flow.	Along the Mississippi River bluff. Can occur along large creek banks and cuts.	Leads to Property damage and loss of life. Formation of scars which may leave the land exposed to agents of erosion. Soil erosion leaving the land bare and infertile. Formation of new landforms.
Public drainage	A system of ditch or tile, or both, to drain property, including laterals, improvements, and improvements of outlets. The system was established and constructed by a drainage authority. Public drainage system includes the improvement of	They occur in areas of poorly drained soil and/or high groundwater that could be profitably farmed with sufficient removal of water.	Found throughout the upper 80% “flat” portion of the watershed. Usually involves the efficient and effective connection of organic soils.	Drainage helps by increasing crop yields on poorly drained soils by providing a better environment for plants to grow, especially in wet years. Drainage harms by lowering the water table and altering the volume and timing of flows and hence

PICs[1]	Definition	Occurrence	Location	Effect
	natural waterways and any part of a flood control plan.			contributing to flooding.
Soil Erosion	The denudation or wearing away of the upper layer of soil. It is a form of soil degradation.	This natural process is caused by the dynamic activity of factors such as wind and water. Generally, the vulnerability to erosion is determined by: - rainfall and runoff amount - soil texture - soil erodibility - slope length and steepness - vegetative cover - best practices	Steep slopes, Creek and Ditch Banks Construction sites	Reduced ability of the soil to store water and nutrients. Exposure of subsoil, which often has poor physical and chemical properties. Higher rates of runoff, shedding water and nutrients otherwise used for crop growth. Loss of newly planted vegetation. Deposits of silt in low-lying areas. Contribution of suspended solids to surface waters Property damage.
Unique habitats	The specific, unique area and requirements that support plants, animals, and any other biological forms of life. Typically applied to endangered, threatened of rare species or plant communities.	These habitats can occur anywhere but most often appear in areas that are lightly or not actively used and infrequently visited. They often contain or express unique or rare biogeochemical conditions or processes vital to the sustainment of the species or community.	Many, but not all of these areas have been mapped by the DNR Natural Heritage program. Their exact location is not generally divulged.	When a habitat is destroyed, the carrying capacity for indigenous plants, animals, and other organisms is reduced so that populations decline, sometimes up to the level of extinction.
Water Quality	The physical, chemical, biological and organoleptic (taste-related) properties of water. Context: A classification of the	Water pollution is the contamination of water bodies, usually because of human activities. Effected water bodies include lakes, streams, and groundwater.	Water pollution and the impairment of its beneficial uses exists on the following water bodies:	Impairments within the District adversely affect. <u>Aquatic Life</u> Chlorides Macroinvertebrates Fish

PICs[1]	Definition	Occurrence	Location	Effect
	quality of watercourses or water bodies according to the uses	Water pollution results when contaminants are introduced into these water bodies. Within the District those have been identified as Altered Hydrology Chloride Dissolved oxygen E. coli Poor habitat Total Phosphorus Total Suspended Solids	• Coon Creek • Ditch 11 • Ditch 58 • Sand Creek • Ditch 41-4 • Pleasure Creek • Springbrook Creek • Mississippi River • Crooked Lake • Ham Lake • Laddie Lake	Total suspended solids Dissolved oxygen <u>Aquatic Recreation</u> E. coli Fecal coliform <u>Aquatic Consumption</u> Mercury in fish tissue PCBs in fish tissue <u>Surficial Groundwater</u> Arsenic Chloride Floride Manganese Nitrate
Water Quantity	The timing and total yield of water from a watershed and is measured by total yield and peak flow over a specified period.	Water occurs within the District in four forms. a liquid a solid, as in snow and ice, groundwater, In the atmosphere, as in clouds and invisible water vapor (Humidity).	Liquid form can be found in lakes, stream and wetlands and comprises an estimated 17,000 acres of the District. Groundwater occurs under the entire District. It is within five to ten feet of the land surface over approximately 75% of the watershed.	Too much water leads to flooding. Too little water leads to drought.
Wetlands	Are areas that are inundated or saturated by surface or ground water at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions.	Wetlands occur: In floodplains along rivers and streams In isolated depressions surrounded Along the margins of lakes and ponds, In low-lying areas where the groundwater intercepts the soil surface or where precipitation	Locating wetlands on the landscape involves identifying and documenting three parameters using the mandatory technical criteria for (1) Vegetation. (2) Soil. (3) Hydrology	Wetlands, and their ecological functions of Retaining or Detaining water Infiltrating or out letting groundwater Fostering habitat for a variety of plants and animals. Capture and/or uptake of pollutant is solution or suspension.

PICs[1]	Definition	Occurrence	Location	Effect
		sufficiently saturates the soil. On large gently sloped areas where groundwater is at or near the surface of the land.		Provide a variety of benefits such as food and habitat for fish and wildlife, water quality improvement; flood storage; shoreline erosion control; economically beneficial natural products for human use; and opportunities for recreation, education, and research

Problem/Issue/Concern Overlay



How the Landscape Effects Problems, Issues, Concerns and Water Management

Landscape effects on Water Management

Aspect	Effect
Drainage Area	Drainage area is the basic hydrologic unit considered in analyzing surface water runoff and hydrology. It defines and serves as the catchment for the volume of water received through precipitation. A drainage basin is the source for water and sediment that moves from higher elevation through the river system to lower elevations as they reshape the channel forms.
Surficial geology	Groundwater flow provides the base flow component of streams that sustains their flow between storms. The "flashy" response of streamflow to individual precipitation events may be ascribed to either subsurface storm flow or overland flow.
Soils	Soils play an important role in local hydrology, including buffering the precipitation signal (P) and storing incoming water. At the scale of soil pedon, a field or a forest stand, the moisture status of soils, the vegetation and the groundwater dynamics impact each other. The ability of soils to convey or store water is a function largely of their texture (the relative mix of sand, silt, and clay).
Topography	Topography influences how water is precipitated on, evaporated from, stored in, and routed through the landscape, often because of long-term evolutionary processes. The steeper the slopes the higher runoff water velocity. This increases its erosive energy (remember that erosive energy of runoff is a function of runoff velocity and volume). When the slope is longer (length), surface area for water collection also increases and therefore increases the run-off volume.
Ponding & Depression Storage	Depression storage refers to small low points in undulating terrain that can store precipitation that otherwise would become runoff. The precipitation stored in these depressions is then either removed through infiltration into the ground or by evaporation.

Aspect	Effect
	Ponding is either the pooling or accumulation of water in a place or a reference to a constructed area whose purpose is to retain or detain water.
Land use and cover	Land use changes, which are mostly induced by human activities, affect hydrological processes such as evapotranspiration (ET), interception and infiltration, resulting in alterations of surface and subsurface flows. Land use changes, which are mostly induced by human activities, affect hydrological processes such as evapotranspiration (ET), interception and infiltration, resulting in alterations of surface and subsurface flows.

Effects of Landscape Elements on the Public Health, Safety and Welfare

Element	Effect
Drainage Area	Drainage area most prominently effects • The size and cost of public infrastructure. Principally pipes and ponds.
Surficial geology & Groundwater flux	The proximity of groundwater to the surface of the land and the degree to which it fluctuates has effects: • Water source for a significant number of lakes, wetland, and streams • Fluctuation frequency and duration effects the hydroperiod that the surface is wet, thus influencing soils and vegetation. • The cost of construction by effecting either the cost of dewatering, the cost to reroute or mitigate high water levels or most prominently the cost of site correction and how much fill must be purchased and transported to raise building pads to a safe elevation. • Home repair and insurance by contributing to wet basements. • The size and cost of operating a sump pump. • The cost of drinking well construction • Groundwater flux also influences the location and cost of required infiltration storm water facilities and septic systems due to the requirements for separation between the bottom of the device and the high ground water elevation.

Element	Effect
Soils	Soils can effect both public health and welfare by • Retaining or bonding with select chemicals. This can be positive if the need is to retain or filter harmful chemicals. It can be a detriment if the soil does not chemically bond and or facilitates the passage of harmful pollutants. • They can both increase and decrease the cost of construction by either having to be replaced or not. • They can adversely affect the public welfare, depending on their texture and erodibility by being easily transported into structures or waterways, contributing to obstruction through accumulation and requiring removal through maintenance. • By becoming suspended in the water, inhibiting light penetration, thus influencing plants and habitat and /or burying habitat or aquatic life. • Loosely bonding with chemical pollutants which may become more mobile once they enter the water column and are exposed to varying temperatures, levels or oxygen availability and/or pH, all of which can induce chemical reactions allowing the pollutant to become more mobile.

Topography	Topography effects public health, safety, and welfare by:
	• Determining the rate at which water moves from or through a site.
	  ○ Flat grades, such are found in the watershed, can accumulate algae and bacteria unsafe to humans and other creatures.
	  ○ Steep grades can generate velocities capable of moving people, equipment, and structures.
	• Topography also influences the type and frequency and therefore cost of maintenance. Flat grades allow sediment to settle out and accumulate, potentially preventing future flows and creating and compounding flooding.
	• Topography influences the size and shape of floodplains and the meander behavior, belt, and alignment of stream channels.

Ponding & depression storage	Ponding and depression storage effect the public health safety and welfare by: • Detention ponding and some wetlands can hold water and gradually release it thus regulating both rate and

Element	Effect
	volume of flow leaving a given point on the landscape and in the conveyance system. • Combined, ponds can alter the peak flows and time of concentration downstream to prevent or reduce flooding or create volume within the channel to allow other flow to enter the stream. • By retaining water, ponds and depressional areas can reduce the volume of water flowing down stream and hold any pollutants captured within the pond, unless infiltration is expected. • In either case, holding water subjects the water to evaporation to the atmosphere or infiltration into the ground, reducing the volume of runoff and potentially recharging ground water. • Ponding increases the overall cost of storm water management and flood prevention. • Wetlands can provide natural depressional areas on the landscape that may be factored into local storm water plans.
Land use and cover	Land use and cover influence the volume and rate at which water runs can infiltrate and runoff. • Land use is often characterized by the percent of imperviousness directly affecting the amount of water queued to runoff. • Land use also has a roughness to it which effects the efficiency and timing of the runoff. • The plants that are grown further act to intercept, store, retain or detain precipitation effecting the volume and timing of runoff. • Differing land uses also have different associated chemicals that either accumulate on hard surfaces, are imported, and used on the site or are a byproduct of site activities. These chemicals can become available for transport by water to a receiving body resulting in pollution.

Effects of The Landscape on Water Management

Management	Effect
Observation	Observation/Monitoring Points • Road, street, and trail crossings and bridges with observation greater than 25 feet • Storm and sanitary sewer easements • Recreational trails • Manholes • Across creek or river (opposite side) Critical Regulable Resources • Likely monitoring sites at first road crossing upstream from confluence • Likely tree removal sites in lower third, forested areas • Likely bank failure sites on outside bends of streams • Likely erosion sites at construction sites on sandy soils in dry breezy weather • Likely sand accumulation and obstructions above South Coon Creek Drive and above Jefferson on Sand Creek • Likely problem wildlife obstructions in Coon Rapids Dam Regional Park, Coon Creek above Radisson, ponds either side of Main Street
Access	• Road and bridge ROWs • Public Drainage and Utility easements • Utility roads • Slopes less than 15%
Key Landscape Features	• Aquatic Invasive Species • Ditches & Streams • High Infiltration soils • Highly erodible soils • Floodplains • Lakes • Receiving waters • Steep slopes • Wetlands
Obstacles & Obstructions	• Beaver dams • Debris • Dense creek bank vegetation where efficient conveyance in an objective • Dense vegetation in channel where efficient conveyance in an objective

Management	Effect
	• Garbage • Sand bars • Trees in channel deflecting flow
Legal Basis, Cause and Standing	<u>Inspections</u> • To enter property to conduct inspections of construction compliance with District and Federal rules provided by MS 103D.335 Subd. 14 & MNG440000 • To enter property to conduct inspections, surveys, and investigations to accomplish the purposes of the watershed district is provided by MS 103D.335 Subd. 14 <u>Conduct Work</u> • To enter property to reasonably and responsibly conduct work related to removing obstructions is provided by M.S. 103E.081 Subd 2 • To conduct work removing aquatic invasive species is provided by M.S. 103A.201 Subd 1 • To conduct work involving access and regulation of wetlands is provided by M.R. 8420.

Effects of Hydrology on Problems, Issues and Concerns and Water Management

Aspects of Hydrology

Aspect	Effect
Precipitation	Precipitation is any liquid or frozen water that forms in the atmosphere and falls back to the earth. It comes in many forms, like rain, sleet, and snow. Along with evaporation and condensation, precipitation is one of the three major parts of the global water cycle. Precipitation is needed to replenish water to the earth. Without precipitation, this planet would be an enormous desert. The amount and duration of precipitation events affect both water level and water quality within an area.
Runoff	Is the water available as runoff after interception, depression storage, and infiltration have taken place.

Aspect	Effect
	Runoff keeps rivers and lakes full of water, but it also changes the landscape by the action of erosion. Runoff picks up fertilizer, oil, pesticides, dirt, bacteria, and other pollutants as it makes its way through storm drains and ditches - untreated - to our streams, rivers, lakes and the ocean. Polluted runoff is one of the greatest threats to clean water.
Runoff Curve Number or curve number	An empirical parameter used in hydrology for predicting direct runoff or infiltration from rainfall excess. It is related to land use, land treatment, hydrological condition, hydrological soil group, and existing soil moisture condition in the drainage basin.
Flooding	The condition of becoming filled or covered with a large amount of water. A flood is an overflow of water that submerges land that is usually dry.
Bank Full Condition	The elevation of the water surface when rising water completely fills the active channel and first begins to spill onto the local floodplain. An active channel is the natural waterway that contains all streamflow's at and below the bank full discharge.
Time of Concentration	Is the time required for runoff to travel from the hydraulically most distant point in the watershed to the outlet. It is used to measure the response of a watershed to a rain event. It is a function of the topography, geology, and land use within the watershed needed for forecasting of the peak discharge rate and the timing of the flood event.
Peak Discharge	Is the maximum instantaneous rate of water passing a given point, during or after a rainfall event or snowmelt. Peak discharge plays an important role in triggering flooding, flash flooding and. The rainfall regimes and rainfall characteristics have been demonstrated to have important influences on peak discharge. Peak discharge is determined by the area of the catchment above the structure and the rate of runoff expected from that catchment under the conditions for which the structure is

Aspect	Effect
	designed. Runoff is a sporadic occurrence. Most runoff is the result of occasional intense storm events.
Storage Volume	"storage capacity" means the volume of water or other liquefied material, which is or may be impounded by a structure at a given elevation above the natural stream bed or above the natural elevation of a pond.

Operational Hydrology & Precipitation Frequency Estimates

Variables	Now (Inches)	Projected to 2034
Precipitation		
Days with more than 1 inch	7	8
Liquid	23.4 – 38.7	23.2 – 38.4
Solid	1.7 – 6	1.7 – 5.9
Snow-Water Equivalents	5% - 20%	4.8% - 19%
Soil Moisture		
Sands	1.5 – 3.7	1.3 – 3.5
Silty Loams	4.2 – 5.8	4.0 – 5.6
Evapotranspiration per day	0.10 - 0.22	0.10 – 0.22
Operational Precipitation		
Catastrophic Flooding	7.2 inches	
Nuisance Flooding	4 inches	
Erosive flows	0.9 feet/second	

PDS-based precipitation frequency estimates with 90% confidence intervals (in inches)[1]										
Duration	Average recurrence interval (years)									
	1	2	5	10	25	50	100	200	500	1000
5-min	**0.358** (0.277-0.462)	**0.421** (0.325-0.544)	**0.526** (0.406-0.681)	**0.616** (0.473-0.799)	**0.742** (0.556-0.987)	**0.842** (0.619-1.13)	**0.944** (0.676-1.29)	**1.05** (0.728-1.46)	**1.19** (0.803-1.69)	**1.30** (0.859-1.87)
10-min	**0.524** (0.406-0.677)	**0.616** (0.477-0.796)	**0.770** (0.594-0.997)	**0.901** (0.692-1.17)	**1.09** (0.814-1.45)	**1.23** (0.907-1.65)	**1.38** (0.990-1.89)	**1.54** (1.07-2.14)	**1.75** (1.18-2.48)	**1.91** (1.26-2.73)
15-min	**0.639** (0.495-0.826)	**0.752** (0.581-0.971)	**0.940** (0.724-1.22)	**1.10** (0.844-1.43)	**1.33** (0.993-1.76)	**1.50** (1.11-2.02)	**1.69** (1.21-2.30)	**1.87** (1.30-2.61)	**2.13** (1.43-3.02)	**2.33** (1.54-3.33)
30-min	**0.908** (0.702-1.17)	**1.07** (0.830-1.39)	**1.35** (1.04-1.75)	**1.58** (1.21-2.05)	**1.90** (1.43-2.53)	**2.16** (1.59-2.90)	**2.42** (1.73-3.30)	**2.68** (1.86-3.73)	**3.04** (2.05-4.31)	**3.32** (2.19-4.74)
60-min	**1.18** (0.913-1.52)	**1.39** (1.07-1.79)	**1.75** (1.35-2.26)	**2.07** (1.59-2.68)	**2.53** (1.91-3.40)	**2.92** (2.15-3.94)	**3.32** (2.39-4.56)	**3.75** (2.61-5.24)	**4.35** (2.94-6.20)	**4.83** (3.19-6.92)
2-hr	**1.45** (1.13-1.86)	**1.70** (1.33-2.18)	**2.15** (1.67-2.75)	**2.55** (1.98-3.28)	**3.16** (2.41-4.23)	**3.68** (2.74-4.94)	**4.22** (3.07-5.77)	**4.82** (3.39-6.71)	**5.67** (3.86-8.03)	**6.35** (4.22-9.03)
3-hr	**1.61** (1.26-2.06)	**1.88** (1.47-2.40)	**2.37** (1.86-3.03)	**2.84** (2.21-3.64)	**3.57** (2.75-4.77)	**4.19** (3.15-5.63)	**4.87** (3.56-6.65)	**5.62** (3.98-7.81)	**6.69** (4.59-9.47)	**7.58** (5.06-10.7)
6-hr	**1.88** (1.49-2.37)	**2.19** (1.73-2.76)	**2.78** (2.19-3.51)	**3.34** (2.62-4.24)	**4.23** (3.30-5.64)	**5.01** (3.81-6.70)	**5.87** (4.34-7.98)	**6.82** (4.88-9.44)	**8.21** (5.68-11.6)	**9.35** (6.28-13.2)
12-hr	**2.14** (1.71-2.68)	**2.51** (2.00-3.14)	**3.19** (2.53-4.00)	**3.83** (3.03-4.82)	**4.83** (3.79-6.37)	**5.70** (4.36-7.54)	**6.64** (4.94-8.94)	**7.68** (5.53-10.5)	**9.19** (6.40-12.8)	**10.4** (7.05-14.6)
24-hr	**2.46** (1.98-3.05)	**2.84** (2.29-3.53)	**3.56** (2.86-4.43)	**4.24** (3.39-5.29)	**5.29** (4.18-6.90)	**6.19** (4.77-8.12)	**7.18** (5.38-9.57)	**8.26** (5.98-11.2)	**9.82** (6.89-13.6)	**11.1** (7.57-15.4)
2-day	**2.88** (2.34-3.55)	**3.23** (2.62-3.98)	**3.91** (3.16-4.82)	**4.57** (3.68-5.65)	**5.62** (4.48-7.29)	**6.54** (5.09-8.52)	**7.56** (5.72-10.0)	**8.70** (6.37-11.8)	**10.4** (7.34-14.3)	**11.7** (8.07-16.2)
3-day	**3.17** (2.59-3.88)	**3.52** (2.87-4.31)	**4.19** (3.41-5.14)	**4.85** (3.93-5.97)	**5.90** (4.74-7.61)	**6.83** (5.35-8.86)	**7.86** (5.98-10.4)	**9.02** (6.63-12.1)	**10.7** (7.61-14.7)	**12.1** (8.35-16.6)
4-day	**3.39** (2.78-4.13)	**3.76** (3.08-4.59)	**4.47** (3.65-5.46)	**5.14** (4.18-6.31)	**6.22** (5.00-7.97)	**7.15** (5.61-9.23)	**8.19** (6.24-10.8)	**9.33** (6.88-12.5)	**11.0** (7.84-15.0)	**12.4** (8.57-16.9)
7-day	**3.90** (3.22-4.72)	**4.39** (3.62-5.32)	**5.26** (4.33-6.38)	**6.03** (4.94-7.34)	**7.19** (5.77-9.06)	**8.15** (6.40-10.4)	**9.16** (7.00-11.9)	**10.3** (7.58-13.6)	**11.8** (8.44-16.0)	**13.0** (9.09-17.8)
10-day	**4.39** (3.64-5.28)	**4.97** (4.12-5.98)	**5.95** (4.92-7.18)	**6.80** (5.59-8.24)	**8.02** (6.44-10.0)	**9.00** (7.09-11.3)	**10.0** (7.67-12.9)	**11.1** (8.20-14.6)	**12.5** (8.99-16.9)	**13.7** (9.58-18.6)
20-day	**5.96** (4.99-7.11)	**6.68** (5.59-7.98)	**7.86** (6.56-9.41)	**8.85** (7.35-10.6)	**10.2** (8.24-12.6)	**11.3** (8.92-14.0)	**12.3** (9.48-15.6)	**13.4** (9.96-17.4)	**14.8** (10.7-19.7)	**15.9** (11.2-21.4)
30-day	**7.37** (6.20-8.74)	**8.21** (6.91-9.75)	**9.57** (8.03-11.4)	**10.7** (8.92-12.8)	**12.2** (9.87-14.9)	**13.3** (10.6-16.4)	**14.4** (11.1-18.2)	**15.5** (11.6-20.0)	**16.9** (12.3-22.4)	**18.0** (12.8-24.2)
45-day	**9.20** (7.78-10.9)	**10.3** (8.67-12.1)	**11.9** (10.0-14.1)	**13.2** (11.1-15.7)	**15.0** (12.1-18.1)	**16.2** (12.9-19.9)	**17.4** (13.5-21.8)	**18.5** (13.9-23.8)	**20.0** (14.5-26.2)	**20.9** (14.9-28.0)
60-day	**10.8** (9.16-12.7)	**12.1** (10.2-14.2)	**14.1** (11.9-16.6)	**15.6** (13.1-18.4)	**17.5** (14.3-21.1)	**18.9** (15.1-23.0)	**20.2** (15.7-25.1)	**21.4** (16.0-27.2)	**22.7** (16.5-29.7)	**23.6** (16.9-31.5)

Effects of Watershed Hydrology on Management

PIC[1]	Precipitation	Evapotranspiration	Infiltration	Runoff
Aquatic Invasive Species	The likelihood of more extreme precipitation events increases the risk of water quality issues such as erosion, sedimentation, and nutrient runoff. These events can degrade water quality and fuel the transportation and growth of non-native invasive plants and weedy native species.	Some invasive plant species, once they achieve critical densities, have been found to significantly increase the evapotranspiration of the entire plant community	The effect of invasive plants on infiltration depends largely on the physiognomy of the species within the existing plant community structure.	Invasive species can either decrease or increase flows and erosion leading to hyper-eutrophication.
Flooding	The most immediate impact of heavy precipitation is the potential of	Evaporation does not increase from an influx of floodwaters unless the inundation is	A few studies suggest that infiltration rates within streambeds increase during the	Flooding has increased in some areas because water can't soak slowly into the

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	flooding. This risk can be heightened in urban areas where non-permeable pavement forces water to quickly run off into sewer systems.	accompanied by a concomitant increase in net radiation.	flood season due to an increase in the stream stage and the remove of the clogged streambed.	ground. Instead, it runs off hard surfaces and, in a heavy rain, can lead to flooding, erosion and property damage.
Groundwater recharge	Rainfall controls the groundwater table. When rainfall is less than normal for a long period, the water flow in rivers and streams slows down, and the water level falls in lakes, wetlands, and ultimately, wells.	In a warming climate, increased evapotranspiration may shift the fraction of precipitation that runs off as surface water or infiltrates to the subsurface as recharge. Long-term shifts in recharge patterns can change groundwater levels and subsequently groundwater surface water interactions and soil moisture.	Infiltrating water is designated potential recharge because it may return to the atmosphere by evapotranspiration; migrate as near-surface interflow and emerge as runoff; or remain suspended in the vadose zone. Infiltration and net recharge vary temporally and spatially by season, storm water intensity, stream stage, soil type, vegetation type and cover, elevation, slope, temperature, solar radiation and other factors, including the presence of buildings, paved surfaces and drainage culverts.	Groundwater recharge or the rate at which aquifers are replenished is one of the most difficult components of the water budget to quantify. Recharge rates are impacted by the amount and intensity of precipitation, soil and vegetation types, geology and topography.
High Infiltration soils	If precipitation is greater than infiltration capacity, surface runoff occurs. If precipitation is less than the infiltration capacity, all moisture is absorbed. When a soil has been saturated by water then allowed to drain by gravity, the soil is said to be	Some infiltration stays near the land surface, which is where plants put down their roots. Plants need this shallow groundwater to grow, and, by the process of evapotranspiration, water is moved back into the atmosphere.	Highly aggregated soil has increased pore space and infiltration. Soils high in organic matter also provide good habitat for soil biota, such as earthworms, that through their burrowing activities, increase pore space and create continuous pores linking	High Infiltration reduces runoff and increases recharge, and Low Infiltration is Bad because it increases runoff, increases erosion, decreases aquifer recharge, decreases dry season stream flow, and other problems.

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	holding its field capacity of water.	Higher infiltration rates make less water available for those plants.	surface to subsurface soil layers.	
Mass Wasting	Heavy rain accelerates mass wasting. Mass wasting is the downward movement of rock and soil material under the influence of gravity. It is accelerated by heavy rain because the rainwater lubricates the material meaning it experiences less frictional force that retards its movement.	Evapotranspiration and its associated trees. Increase resistance to shearing through the mechanical action of their roots, ET also alters the water content of the soil	Adding water increases slope instability through increased weight and lubrication. However, a small amount of water in the soil can aid slope stability because of increased surface tension.	Mass wasting is a rapid form of erosion that works primarily under the influence of gravity in combination with other erosional agents.
Public drainage	A decrease in the mean groundwater table in the fields. In addition, the number of days on which groundwater table will be above the level of the drainage network will decrease. The increase in rainfall intensity in the near and far future will result in a fivefold increase in surface outflow in comparison to the present situation.	In the absence of additional rain, evapotranspiration (soil evaporation plus plant transpiration) will begin to dry out the soil.	The purpose of drainage is to remove excess soil water, groundwater and infiltrating water before the cropped plants undergo stress, thus reducing yields.	Runoff volume is typically increased due to both the increased volume (surface + sub-surface waters) and the straightening of the conveyance channels delivers greater volumes to a location per unit time.
Soil Erosion	The cumulative impact of millions of raindrops hitting the ground in a hard-hitting spring storm rainfall can be incredible, dislodging soil particles and	The effect of soil water content on ET is conditioned primarily by the magnitude of the water deficit and the type of soil.	Soil particles plug soil pore space or empty spaces.	As storm water runoff water moves down a slope, it increases in velocity and increases the potential for erosion. The volume of

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	"splashing" them up to 3-5 feet away. The splashed particles clog soil pores, effectively sealing off the soil surface and leading to poor water infiltration.	The drier the soil the erodible it becomes.		sediment also increases because the transported particles scour and dislodge more soil particles.
Unique habitats	Affects food supply, it also can affect foraging behavior, reproductive and population growth rates, and competitive interactions.	Increases in evapotranspiration result in changes in local humidity levels which can discourage certain plants.	Native plants and communities tend to have deeper and more extensive plant root development which can facilitate infiltration.	Areas of plant cover have greater retention and detention qualities due to greater total surface area and adhesive qualities for water, thus slowing the rate of runoff.
Water Quality	Rainfall and other precipitation washes nutrients from human activities like agriculture and fossil fuel combustion into rivers and lakes. When these nutrients overload waterways, a process called eutrophication, the results can be dangerous.	Increases in evapotranspiration may shift the fraction of precipitation that runs off as surface water or infiltrates to the subsurface as recharge. Long-term shifts in recharge patterns can change groundwater levels and subsequently groundwater surface water interactions and soil moisture.	Infiltration decreases both the volume of water available for runoff and the pollutants found in that water. However, those pollutants remain available and unless treated will pollute the groundwater they are being carried towards.	Runoff picks up fertilizer, oil, pesticides, dirt, bacteria and other pollutants as it makes its way through storm drains and ditches - untreated - to our streams, rivers, lakes and the ocean.
Water Quantity	In areas where precipitation increases sufficiently, net water supplies might not be affected, or they might even increase. If the precipitation remains the same or decreases though, net water supplies would decrease.	On average 67% percent of precipitation, returns to the atmosphere through evapotranspiration.	Infiltration at the land surface significantly affects the timing and amounts of high and low watershed flows. Infiltration during rainfall events is affected by soil type, porosity, texture, vegetative cover, land management, preferential flow in soil and bedrock due to roots,	Runoff is the natural conveyance of a quantity of water. Too much or too fast can cause problems: Fast-moving runoff can erode stream banks, damaging hundreds of miles of aquatic habitat. Runoff can push excess nutrients

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			cracks, and soil fauna.	from fertilizers, pet waste and other sources into rivers and streams.
Wetlands	Changing precipitation patterns can increase evapotranspiration and lead to water losses.	Water losses to the atmosphere from wetlands are a combination of evaporation and transpiration by emergent macrophytes. Wetland surfaces may be permanently or periodically saturated, with periods of shallow standing water.	Infiltration in wetlands within the watershed tends to be low to zero because groundwater tends to be at or near the surface.	Wetlands can reduce runoff depending on their area, effective storage depth and outlet.

Effects of Civil Considerations on Water Management

Operating Environment Factor	Variable	Problems	Opportunities	Effects
Politics and Law	Legislation	Prescribed law increasing or adding to existing requirements.		Requires additional time and money with unknown benefit.
		Legislative and court decisions reshaping existing water management approaches.	To define and articulate local requirements, needs and reasonableness in their application.	Additional time and money involved in.
	Legal action	Water conflicts driven by • Resource protection needs. • Economic or regulatory disparities • Ideological differences.	To clarify and articulate the sensitivity, value of and consequences of poor water resource management.	Underscores the need for direct action focused on consequences.
Management	Priorities	Increased legislative and council focus on unconstrained	Redevelopment and establish stormwater infrastructure in large areas.	Increased need to understand and track the physical,

Operating Environment Factor	Variable	Problems	Opportunities	Effects
		economic development.	Press the immediate financial costs and public health and safety issues of developing sensitive lands.	social, and political economic situation. Increased complexity and dynamics in juggling priorities
	Decision Making	Reliance on the certainty of scientific research will not be a viable option for an increasing number of problems.	For collaborative situationally based adaptive planning and management.	Choosing the best direction and actions will require strong practical vision, leadership, and common understanding.
	Funding	The future of dedicated revenue sources will become more uncertain and burdened with requirements.	Renewal or replacement of the Clean Water Fund will be a legislative topic.	Legislative involvement
		Increases in property taxes and utility fees will be tied to a need for certainty and control.	To focus on the larger long-term costs and economic benefits	Will require increased agility in operations. Will need to articulate and advocate for the prevention of future costs.
	Staffing	Increased difficulty in attracting and retaining qualified staff.	To collaboratively team for select skills and services.	Increased risk of miscalculation resulting in adverse conditions.
Economic	Increased demands for water quantity and quality.	Increased demand for a variety of beneficial uses.	There are no economic substitutes for water	Decreased public confidence and increasing the risk of political instability and decision making driven by expediency and convenience.
Social	Population growth to an estimated 200,000	Increased conflicts between social and political groups, industries, and cities		

Operating Environment Factor	Variable	Problems	Opportunities	Effects
	Increased concern about water quantity, water quality, and flooding.	Problems clouded by a high degree of distrust and skepticism.		
	Increased public activism involving direct public action and expectations to directly and immediately address demands.	Increased risks of societal divisions, broader enforcement, and less coherent policies.		
		Responses founded on either: • appeasement of public demands • actively cutting off or eliminating avenues for activism.		
Information & Technology	Availability of monitoring and AI systems adapted to stormwater management and monitoring	Increased vulnerability and risk due to equipment failure, Increased complexity	Provision of more accurate, better connected, faster, longer range, and more effective practices and treatment devices.	Will make management more responsive but not necessarily more effective.
Infrastructure	Conveyance systems	12.2 miles of ditch and pipe will need replacement or significant repair by 2034.		Increased organization and investment in planning and financing capital assets
	Stormwater Treatment practices	736 stormwater structures will need replacement or rehabilitation by 2034		
	Enhancement	Asset age and space involved may not allow achievement of all required enhancements.	Marginal cost is less than asset replacement	Extension of asset utilization and optimization
	Resiliency of storm water assets	Increased questions and requirements by citizen's, grant providers and	Expansion of asset management approach.	Increased requirements to address resiliency and recovery of water assets by

Operating Environment Factor	Variable	Problems	Opportunities	Effects
		insurance companies.		

Collaborators, Cooperators Managing Water within the District

Agency	Mission/Goal	Activities
Federal		
Environmental Protection Agency	Clean Water Act: To restore and maintain the chemical, physical and biological integrity of the Nation's waters.	• Evaluate and approves action under Section 303(d) of the Clean Water Act (CWA) including Impairments and Toal Maximum Daily Loads (TMDLs) • Provides funding for nonpoint source pollution mitigation via the 319 programs. • Issuance of State Non-Point Discharge Elimination System (NPDES) Permit o Evaluates TMDL reduction plans. • Issuance of Section 401 of CWA addressing violations of state water quality standards set under the Clean Water Act in Waters of the United States (WOTUS). • Monitors USACOE administration of Section 404 of CWA.
U.S. Army Corps of Engineers	To regulate the discharge of dredged or fill material into waters of the United States, including wetlands.	Implementation of Section 404 of the CWA Evaluate • The accuracy of wetland delineations • Potential adverse impact from proposals • Adequacy of sequencing for proposed impacts

Agency	Mission/Goal	Activities
		• Probable success of wetland mitigation
U.S. Geologic Survey	To collect analyze and provide reliable scientific information to describe and understand the Earth; minimize loss of life and property from natural disasters; manage water, biological, energy, and mineral resources; and enhance and protect our quality of life.	• Develop rating curves • Monitors select streams
State		

Board of Water & Soil Resources	To improve and protect Minnesota's water and soil resources by working in partnership with local organizations and private landowners.	<u>Administers'</u>
		• Buffer Law
		  ○ Buffer establishment guidelines
		  ○ Buffer Enforcement
		• Grant programs including
		  ○ Clean Water Fund
		  ○ Local Capacity Grants
		• Metropolitan Water Management Act
		  ○ M.R. 8410
		  ○ Plan review
		  ○ Plan approval
		• Wetland Conservation Act
		  ○ M.R. 8420
		  ○ Technical Evaluation Panel
		  ○ Delineation review
		  ○ Sequencing evaluation
		  ○ Training

Department of Natural Resources	To work with Minnesotans to conserve and manage the state's natural resources, to provide outdoor recreation opportunities, and to provide for commercial uses of natural resources in a way that creates a sustainable quality of life.	Administers • Aquatic Invasive Species Program • Aquatic Plant Management Program • Floodplain program • Works in the bed of public waters permits. • Ground water appropriation permits.

Agency	Mission/Goal	Activities
		• Endangered and Threatened species Takings permits. • State Critical Areas program and rules
Pollution Control Agency	To protect and improve the environment and human health. To protect, conserve and improve our environment and enhance our quality of life.	Administers • Section 303d Water Quality Impairment designation • Section 319 program • Section 401 of the Clean Water Act • State water quality standards • National Non-Point Pollution Discharge Elimination System (NPDES) requirements • Training
Regional		
Metropolitan Council	To foster efficient economic growth for a prosperous metropolitan region.	• Management of Metropolitan Systems • Review of Watershed Plans • Review and approval of City Comprehensive Plans including stormwater
Local		
Anoka County Parks	To positively impact the quality of life in Anoka County by providing parks, outdoor recreation, and leisure services for the public. Our mission encompasses protection of the natural environment, improving the health of citizens, and supporting a strong local economy.	• Administers County Wide Aquatic Invasive Species Prevention Program.

Anoka Conservation District	To holistically conserve and enhance Anoka County's natural resources for the benefit of current and future generations through partnerships and innovation.	• Outreach and Public Engagement
		• Monitoring, Inventory and Subwatershed Assessments
		  ○ Wetland hydrology monitoring network
		  ○ water quality monitoring
		  ○ Subwatershed assessments

Agency	Mission/Goal	Activities

		• Wetland Evaluation and Restoration
		  ○ Technical Evaluation Panel
		• Projects
		  ○ Raingardens
		• Financial, Technical and Grant Assistance

Cities • Andover • Blaine • Columbus • Coon Rapids • Fridley • Ham Lake • Spring Lake Park	To serve as administrative, commercial, religious, and cultural hubs for their surrounding areas, provide essential public services and protect and provide for the public health, safety, and welfare.	• Flood prevention through storm water management. • Provide drinking water where demanded. • Provide for sewage disposal. • Address non-point source pollution as a Municipal Separate Storm Sewer System
Interagency, Intergovernmental and Nongovernmental Organizations		

Technical Evaluation Panel	To pursue
	• No net loss in the quantity, quality, and biological diversity of existing wetlands.
	• Increases in the quantity, quality, and biological diversity of wetlands by restoring or enhancing diminished or drained wetlands.
	• Avoidance of direct or indirect impacts from activities that destroy or diminish the quantity, quality, and biological diversity of wetlands.
	• Replacement of wetland values where avoidance of activity is not feasible and prudent.
		make technical findings and recommendations regarding.
		• Wetland applications,
		• The scope of MR 8420
		• The applicability of exemption and no-loss standards,
		• Wetland functions and the resulting public value,
		• Direct and indirect impacts
		• Possible violations of MR 8420
		• Enforcement
		  ○ Preparation of replacement/restoration plans
		• Review of replacement applications for
		  ○ public road projects
		  ○ banking projects

Crooked Lake Area Association	To protect and enhance the long-term health of Crooked Lake	• Comprehensive Lake Management planning • Public involvement and engagement • Treatments, Studies, Plant Surveys • Regular inspections

Agency	Mission/Goal	Activities
Ham Lake Lake Association	To preserve and maintain the health of the lake.	• Cost sharing on inventories & treatments