WATER AND CLIMATE CHANGE: IMPACTS ON WATER AND WATER UTILITIES IN THE TWIN CITIES METROPOLITAN AREA

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Draft Research Paper - February 7, 2023

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Acronyms and abbreviations

AFOLU – Agriculture, forestry and other land use

CO_2 – carbon dioxide

CH_4 – methane

EPA – Environmental Protection Agency

F-gases— fluorine containing halogenated substances

I/I – inflow and infiltration

IPCC – Intergovernmental Panel on Climate Change

HFC – hydrofluorocarbons

MPCA – Minnesota Pollution Control Agency

N – nitrogen

N_2O – nitrous oxide

SF_6 – sulfur hexafluoride

SLCPs – short-lived climate pollutants

UNFCCC – United Nations Framework Convention on Climate Change

Policy research approach

The Metropolitan Council (Met Council) is charged by state statute to develop plans for the growth and economic development of the seven-county Twin Cities metropolitan area (metro area). Publications like the metropolitan development guide (***Thrive MSP 2040***) and associated system plans, including the ***Water Resources Policy Plan***, are the primary vehicle for us to share our vision and goals for the region. They are updated every ten years but have a twenty five-year planning horizon to allow for long-term development of the region. Each iteration of regional planning builds upon the previous effort, while adjusting our actions, policies, and vision to address current issues, mitigate future risks, and optimize regional opportunities.

The 2050 Water Resources Policy Plan, like the 2040 plan before it, will be an integrated plan that supports our core mission to operate and manage the regional wastewater system, provide water supply planning, and provide surface water planning and management throughout the region. It will serve as our guide to address issues affecting our waters, and to protect these resources for future generations.

This research paper is part of a series investigating current and future water concerns for the metro area. Together, these papers will inform our 2050 Water Resources Policy Plan. The paper topics are:

- Protecting source water areas
- Rural water concerns
- Water and climate
- Water availability, access, and use
- Water reuse
- Water quality
- Wastewater concerns

The project intent is to share our current understanding of issues, identify current policy connections or gaps, and to propose future policies and strategies to ensure sustainable water resources. Not all the recommendations included in the papers will move forward for inclusion into the Water Resources Policy Plan, and conversely, the Water Resources Policy Plan may include policies not discussed in these papers. The intent is to begin to develop a shared understanding and conversation about topics that are connected to all aspects of our core services.

Research paper topics were investigated using three core principles:

- **One Water, integrated water management:** The metro area is water-rich, and that water holds immense value. Integrated water management, also known as "One Water", addresses water as it moves from water supply, through wastewater systems and into surface waters. The ultimate goal of integrated water management is sustainable, high-quality water in the region.

- **Utilize existing systems:** The metro area has a robust water planning and wastewater operations system with many actors – community water and wastewater utilities, watershed management organizations, and regional, county, state, and federal agencies. Coordination and collaboration between these groups is necessary to protect our water for future generations.

- **Metric-based policies:** It is hard to quantify policy success without accountability. We will provide policy options with associated metrics and measurable outcomes where possible, to demonstrate the effectiveness of our water policies and actions.

Introduction and background

Climate change is a current reality within our region. Climate impacts will continue to increase and intensify over the coming decades, even with substantial reductions in global emissions. These changes will impact public health, the built environment, our natural systems, and the regional economy. The burden of these impacts will weigh on vulnerable communities the most.

Climate change manifests itself in many ways including rising sea levels, extended growing seasons, and weather events such as heatwaves, extreme precipitation, prolonged drought, and stronger tropical cyclones. The magnitude and frequency of extreme events has intensified since 2014, and this change has been directly attributed to human influence (IPCC, 2021). While climate change is a global phenomenon, the effects are observed and experienced locally.

At the more local level, our winter temperatures are warming, and the frequency and intensity of storm events have shifted from the pattern in our historical record (DNR, n.d.a). Moving forward, our region is projected to experience more extreme heat and drought events. These shifts in climate and weather patterns impact our natural systems by altering the length of growing seasons, endangering biodiversity and the integrity of our ecosystems. Climate change will continue to occur rapidly, and its effects will worsen. Under intermediate climate scenarios, Midwest temperatures are expected to increase between 3°F and 5°F relative to 1986–2015 averages by the year 2050, with more than an 8°F increase projected by the end of the century under a very high scenario (Hayhoe et al., 2018).

The consequences of climate change impact communities in many known and unforeseen ways. They threaten the productivity of agricultural fields and the reliability of supply chains (MDA, n.d.). They impact personal safety and health during winter activities due to degraded ice conditions (Sharma et al. 2020) or when working outside in extreme heat. They add additional stress to aging infrastructure as freeze-thaw cycles increase the use of road salts and water chemistry changes impact treatment and water delivery systems. Individual mental health and community well-being are also at risk (WHO, 2022; Bjornestad et al. 2021), especially for people and places that are already vulnerable or have been historically underserved. (US Department of Health & Human Services, 2022).

Over the past two centuries, human activities have dramatically increased the production of greenhouse gases – such as carbon dioxide, methane, and nitrous oxide – that warm the atmosphere. The primary source of greenhouse gases is the burning of fossil fuels. Additional human activities that have released carbon stored in vegetation and soils as greenhouse gases include deforestation, farming, and industrial processes. Once in the atmosphere, these greenhouse gases create an imbalanced global climate system that have devastating consequences.

Current atmospheric carbon dioxide concentrations are now above 420 parts per million (ppm) - a condition not previously experienced by humans (**Figure 1**). To limit the most negative impacts, immediate action must be taken to reduce greenhouse gases. Globally, this requires a 50% reduction in carbon dioxide by 2030 (from 2005 levels) and achieving net-zero emissions by 2050 (IPCC, 2021). At the same time, we must prepare for and adapt to the significant changes that will continue to occur so that our region is resilient, and the lives of future generations are more secure.

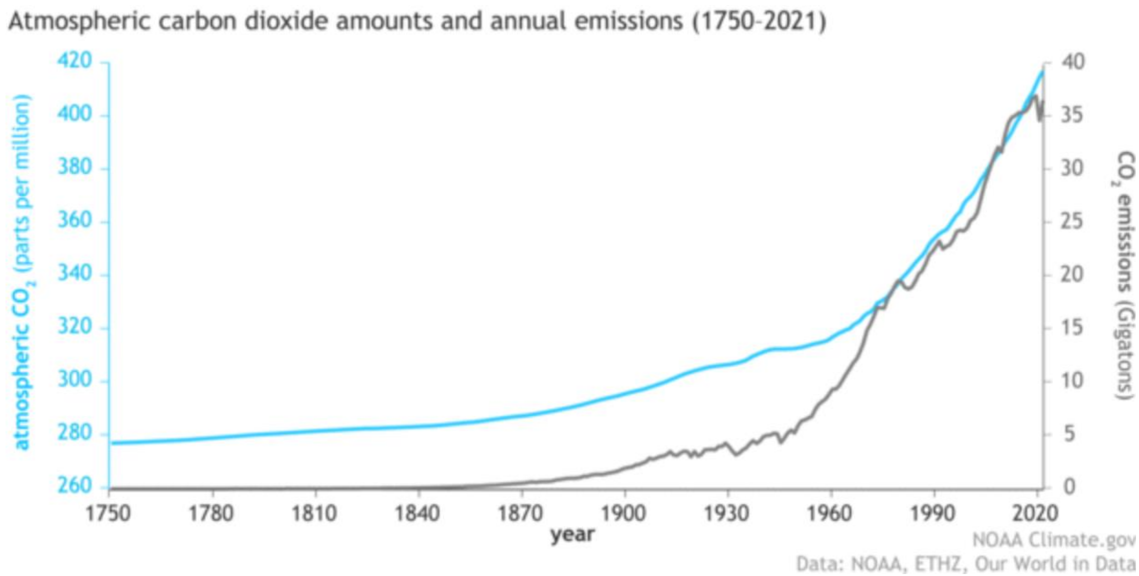

Figure 1: Atmospheric CO2 concentrations and CO2 emissions (1750-2021) showing a rapid and continual increase since the mid-19th century.
(NOAA, 2022)

Planning for climate action

Despite the many economic, political, and social challenges, we at the Metropolitan Council along with state agencies, tribal governments, watershed organizations, county and municipal governments, and Minnesota residents are responding in ways that offer hope for the future. The responses fall into two general categories:

> **Mitigation**: Actions focused on reducing greenhouse gases and increasing stored carbon in soils and vegetation.
>
> **Adaptation**: Actions focused on how to change policies and practices to adjust to ongoing and future impacts of climate change.

Examples of mitigation and adaptation activities already occurring throughout the metro area include:

- Mitigation actions to reduce carbon and greenhouse gas emissions.
- Water storage in open lands like forested lands, wetlands, and parks
- Widespread adoption of Minimal Impact Design Standard[1] design practices
- Acknowledgment of the role and implementation of green infrastructure
- Risk assessment and vital infrastructure protection
- Climate-smart agriculture and best management practices

[1] Minimum Impact Design Standards (MIDS) were developed by the Minnesota Pollution Control Agency to minimize storm water runoff and pollution and thereby help maintain natural resources health. They are a prerequisite for and guide the selection of best management practices required for each individual site. They must be applied in a way to mimic each site's natural hydrology and protect features such as riparian buffers, wetlands, steep slopes, mature/healthy trees, floodplains, woodlands, and highly permeable soils (MPCA, 2023).

- Awareness of social and economic impacts especially on vulnerable communities

A resilient metro area is the desired outcome of good, coordinated mitigation and adaptation strategies and actions. Resiliency planning recognizes the difficulty of predicting impacts of climate change and emphasizes increasing our flexibility to survive and thrive regardless of how climate change develops. Resilience also includes the need for behavioral and organizational change to quickly pivot or reassess our priorities as conditions change.

Greenhouse gas connection

The most important greenhouse gases emitted by human activities are carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), and the so-called F-gases — fluorine containing halogenated substances such as hydrofluorocarbons (HFCs) and perfluorocarbons (PFCs) — and sulfur hexafluoride (SF_6). These are the six greenhouse gases recognized in the United Nations Framework Convention on Climate Change, which the United States signed and ratified in 1992 (United Nations, 1992).

Carbon dioxide

Carbon dioxide accounts for 79% of U.S. greenhouse gas emissions, with fossil fuel combustion for energy (including transportation, electricity generation, and industrial, commercial, and residential heating) accounting for 94% of these emissions. Other notable sources of CO_2 emissions include non-energy uses of fossil fuels (e.g., petroleum products used to manufacture plastics, fertilizers, chemical and other industrial products) and other industrial processes (e.g., iron and steel and cement production) (EPA, 2022). Importantly, certain agricultural, forestry, and other land-use (AFOLU) activities can increase atmospheric CO_2 levels. Stored carbon is released when soils and vegetation are disturbed for development or resource extraction. Likewise, restoration and preservation of soil and forest carbon can help to offset carbon emissions. In the U.S., AFOLU activities result in a net offset carbon emissions primarily through increases in carbon stored in long-lived forest vegetation and forest soils (EPA, 2022).

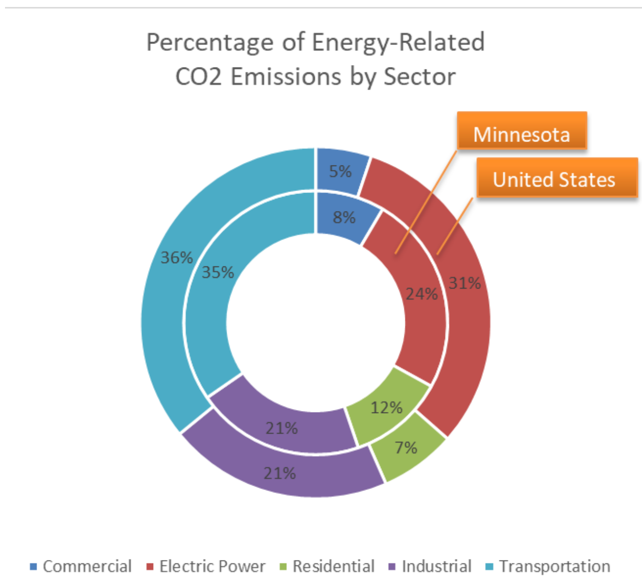

Figure 2: Percentage of energy-related CO2 emissions by sector (data from EIA, 2022)

The pattern of CO_2 emissions in Minnesota (**Figure 2**) is like the U.S. as a whole. In Minnesota, energy uses (electricity, transportation, and heating) account for 96% of CO_2 emissions (MPCA, 2021). Though in Minnesota, AFOLU activities do not result in a net offset of carbon emissions. This is because of the significant use of carbon-rich, wetland soils drained for agricultural activities and development over the past 150 years. The disturbance of these peatlands is the 4th largest source of CO_2 emissions (MPCA, 2021). Notably, the restoration of wetland soil carbon can both reduce emissions and improve water quality. However, development and economic pressures limit the viability of wetland restoration in the region (Bjorhus, 2022).

Methane and hydrofluorocarbons

While CO_2 is the largest emitted greenhouse gas in both the U.S. and Minnesota, other emissions are of particular concern because of their relative global warming potential and their short-lived duration in the atmosphere (Table 1). The global warming potential of a greenhouse gas is the relative contribution of that gas to global warming compared to carbon dioxide over a specific timeframe. However, because many high warming potential gases (so-called short-lived climate pollutants) do not persist in the atmosphere for the same duration as CO_2, actions to reduce these emissions will have a significant impact on curbing global warming over the short-term. Short-lived climate pollutants currently account for 14% of U.S. greenhouse gas emissions – with methane (CH_4) emissions accounting for 11% and F-gases the remaining 3%.

Table 1: Lifetimes, radiative efficiencies, and metric values of greenhouse gases (Myhre et al., 2013)

Greenhouse gas	Chemical Formula	20-year Global Warming Potential	100-year Global Warming Potential
Carbon dioxide	CO_2	1	1
Methane	CH_4	84	28
Nitrous oxide	N_2O	264	265
Sulphur hexafluoride	SF_6	17,500	23,500
R-407c	R-32/R-125/R-134a (23%/25%/52%)	4,011	1,624
R-22 (HCFC-22)	$CHClF_2$	5,280	1,760
R-32 (HFC-32)	CH_2F_2	2,430	677
R-125 (HFC-125)	CHF_2CF_3	6,090	3,170
R-134a (HFC-134a)	CH_2FCF_3	3,710	1,300
R-143a (HFC-143a)	CH_3CF_3	6,940	4,800
R-410a	R-32/R-125 (50%/50%)	4,260	1,924
R-404A	R-125/R-143a/R-134a (44%/52%/4%)	6,437	3,943

Methane emissions

Methane emissions are driven by agricultural practices such as enteric fermentation from beef cattle production and animal manure management (35% of CH_4 emissions) followed by the production and distribution of natural gas and petroleum products (32% of CH_4 emissions) and waste from homes and businesses disposed of in landfills (17% of CH_4 emissions) (EPA, 2022).

Globally, significant CH_4 is stored in frozen and wetland soils and continental shelf sediments. As the atmosphere continues to warm, soil and ocean conditions change, releasing stored CH_4 and creating a positive feedback loop that forces further warming. Historical wetland loss in North America, including Minnesota, has contributed CH_4 to this feedback loop. Wetlands continue to be drained for agricultural or urban development in the metro area as the region grows, increasing carbon emissions and lessening the quality and quantity of groundwater recharge (Topp and Pattey,1997).

F-gases emissions

In the U.S., the leakage of hydrofluorocarbon (HFC) gases used in refrigeration and air conditioning equipment in building and facilities is the leading source of F-gases in the atmosphere. Other sources include F-gas manufacturing and their use in products such as aerosol propellants, foam-blowing agents, and fire suppressants (EPA, 2022). The U.S. Environmental Protection Agency – at the direction of Congress – has developed regulations to phase down the use of HFCs by 85% by 2036. The rule includes the two most common refrigerants: R134A used primarily in vehicles, and R410A used primarily in HVAC systems.

Nitrous oxide

Nitrous oxide (N_2O) is another highly potent greenhouse gas and accounts for 7% of U.S. greenhouse gas emissions. The primary source of N_2O emissions is fertilizer applications for agricultural soil management (74%). Other notable sources include wastewater treatment (6%), stationary combustion (6%), manure management practices (5%), and mobile combustion (4%). In Minnesota, agricultural practices – soil and manure management - account for 94% of N_2O emissions, followed by mobile and stationary combustion (5%), and waste, including wastewater, (1%). The difference between the U.S. and Minnesota's N_2O distribution may be attributed to variations in greenhouse gas accounting methods for wastewater.

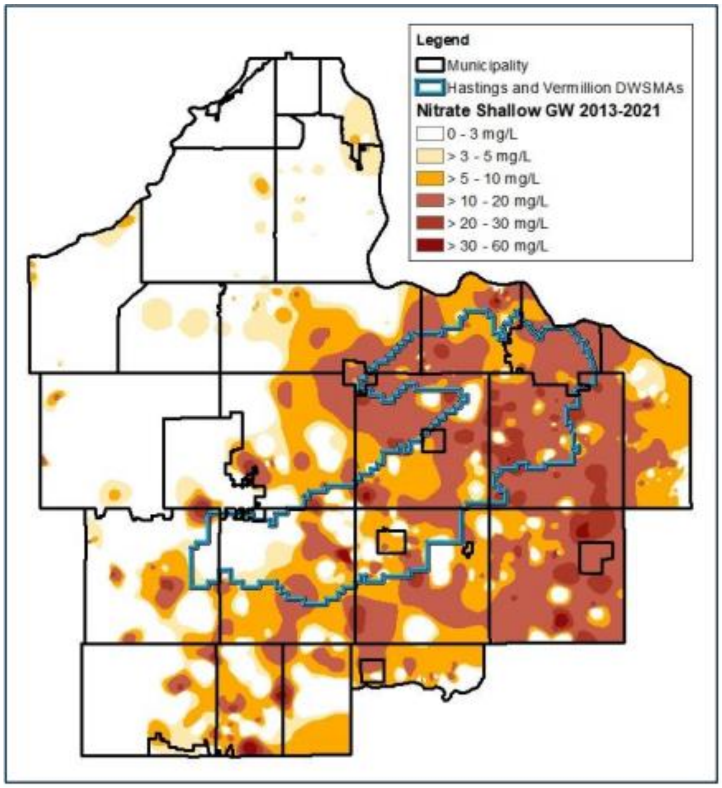

Figure 3: Interpolation of shallow groundwater nitrate concentrations (in mg/L NO3-N), adapted from Dakota County ACRE Plan (Dakota County, 2022)

There is an important intersection between water quality and the agricultural practices that give rise to N_2O emissions. The same fertilizer applications that lead to excessive N_2O emissions also impact water quality. Efforts to reduce N_2O emissions from agriculture have the co-benefit of improving water quality. Where the use of animal waste or synthetic nitrogen (N) is widespread and poorly controlled, N_2O emissions increase. Further, after application or heavy rain the nitrogen added to soils to improve crop yield may leach into drainage ditches, streams, rivers, and eventually estuaries; creating significant water quality issues that negatively impact ecosystems, aquatic plants and animals, and people. Nitrogen fertilizer, as well as pesticide and herbicide by-products, also leach into groundwater. Once in the groundwater system, these chemicals can be long-lived, moving very slowly through groundwater. Many rural areas rely on groundwater wells for drinking water. These wells are often privately owned and operated by individual landowners or permit holders. In the metro area, Dakota County (and others) has been identifying trends in nitrate (NO_3) contamination in wells. **Figure 3** shows areas where nitrate levels in wells have been approaching or exceeding drinking water standards (10 mg/L NO_3-N).

Projected climate changes

Climate change has several physical and chemical effects on the air, water, and land that are interconnected and complex. Likewise, the way humans directly alter and influence landscapes and natural resources has consequences that can either promote or limit the impacts of climate change. Change to these connected systems and cycles affects weather patterns including shifts in the duration, intensity, and frequency of storm events, warmer winters, heatwaves, or drought. Over the longer-term, these changes have drastic impacts on ecosystems and social structures that our modern lives depend on.

Extreme precipitation

One of the more well-documented connections between climate change and water is an increase in storm intensity and frequency. Intense storms that drop large amounts of precipitation over a short period of time are occurring more often in the metro area. These intense storm events lead to flooding and increased run-off due to the over-saturation of soils and increased impervious areas (such as rooftops, parking lots, sidewalks and roads) due to urbanization. Direct precipitation inputs to surface waters increase, and with additional overland flow and rapidly rising water tables, shorelines grow, streambeds fill, and flooding occurs (**Figure 4**).

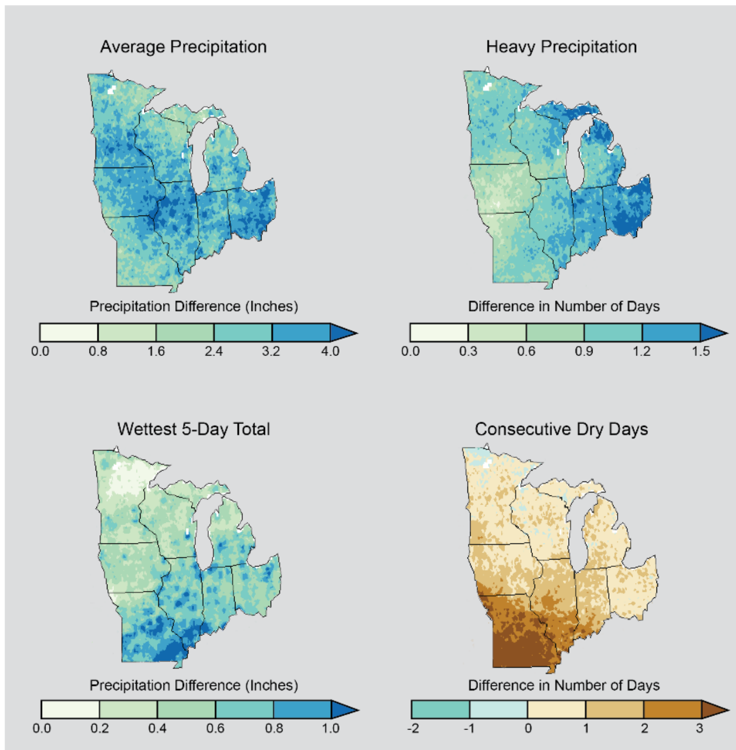

Figure 4: Projected precipitation change for the middle of the current century (2041-2070) relative to last century (1971-2000) in Midwest.
(National Climate Assessment, 2014)

As storm events continue to become more intense, they may exceed the capacity and resiliency of our natural and built environments to handle the flow rate and volume of stormwater. Extreme precipitation events can reduce the amount of water that infiltrates down through soils to recharge aquifers below. If this pattern of rain falling in intense bursts becomes more likely than slower, longer duration events, it can lead to less groundwater recharge. The 2012 flooding in Duluth was an example of how an extreme storm event (7.25" of rain over two days) overwhelmed systems and caused serious and costly damage to municipal infrastructure (National Weather Service, n.d.). Numerous roads were washed out, the zoo flooded and animals drowned, dams failed, and residents sustained injuries. The repairs to city and state infrastructure were estimated to cost $120 million.

Acute flooding events also increase the likelihood of groundwater contamination. When stormwater systems fail, surface pollutants can concentrate where water pools and enter the ground as recharge, potentially contaminating shallow drinking water supplies. Similarly, in an area with an unsealed well or a well that is overtopped, polluted stormwaters can enter aquifers directly, putting water supplies at risk.

Prolonged wet periods

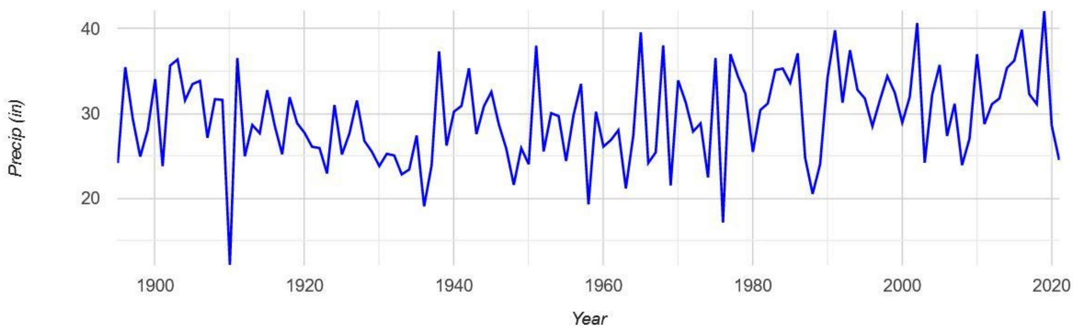

Figure 5: Annual precipitation totals for the seven-county metro area 1895-2022 (DNR, 2023)

Although droughts have had a significant influence on water, water services, and regulations in the U.S. and Minnesota, extended periods of increased precipitation have been occurring since the 1930s, and have become more common during recent decades. Between 2013 and the drought of 2021, the metro area experienced the wettest period on record, including the three largest annual totals (**Figure 5**).

A prolonged increase in precipitation has numerous ramifications for metro area water resources and infrastructure mostly related to excess water and consistent saturation of near surface sediments. Infiltration during these periods initially increases allowing shallow groundwater levels to rise improving recharge rates in some areas. As pore-space in bedrock aquifers and overlying sediments becomes saturated, it is harder for additional water to move down into deeper aquifers below, leading to less water entering the system. As water tables rise, more shallow groundwater is contributed to surface waters. Streambanks fill, lake levels rise, and wetlands expand. In developed landscapes across the metro area, this additional water at the surface saturates the ground, causes localized flooding, damages in-ground infrastructure and basements, and mobilizes surface and near surface contaminants. Repairing these damages is costly for us at the Met Council, the cities, and the individual property owners. Burdens are most severe for traditionally disadvantaged communities and individuals.

Increased wet weather events leads to additional non-point source pollution runoff and increased watershed turbidity and erosion, washing in additional pollutants such as phosphorus and nitrogen (Malik, 2003). Increased non-point source pollution threatens water quality progress made by water resources professionals to reduce pollution from entering waterways.

Warmer winters

Over the past century, much of the warming observed in Minnesota has occurred during the winter months. Six of the ten warmest winters have occurred since 2000, indicating the rate of warming may be increasing (**Figure 6**). The lowest winter temperatures are now higher on average, and there are less extreme cold nights, decreasing the extent and duration of the ice over period. This has the potential to increase freeze-thaw cycles and could affect application pattern and loading of deicing salt, both of which can strain storm and wastewater infrastructure (Ceylan, 2022) and contaminate groundwater and surface water features.

The slow melting of winter snow and ice pack in late spring is our primary source of groundwater recharge. This occurs after the frost leaves the soil and before major plant growth kicks in. The snowmelt sinks into soils and travels to aquifers instead of running off into stormwater systems and into surface waters or being intercepted by plant roots. Warmer winters may cause mid-winter snow to melt and run off over frozen soil; or the frost in/out dates might change and increase recharge.

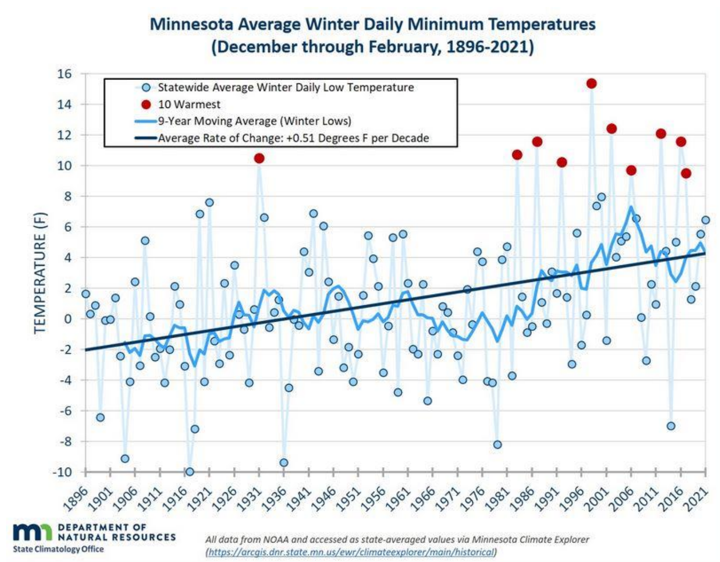

Figure 6: Minnesota average daily winter temperatures, 1896-2021

Heat waves

We currently build our water supply infrastructure to meet summertime, outdoor water demand. Periods of unusually hot weather outside of historical averages, lasting a few days or more, have become more frequent in recent decades. These extreme heat events have several significant health impacts and strain energy systems as demand increases. Water resources are stressed during these periods. Evaporation from water bodies and transpiration from plants also increase.

In periods of high demand, more water is used. Groundwater levels decline, stream and river levels can drop, and shorelines retreat. Lowering groundwater levels can lead to well interferences and less baseflow in streams and other surface waters that rely on groundwater inputs. High water demand imparts stress on water supply systems. As water suppliers pump more water to supply the drinking water system, it requires more energy use and more treatment, which increases costs and lowers efficiency. Water supply treatment and distribution systems are designed and built to cope with these stresses, however significant acute events can impose extreme stresses that test those systems. These costs can be lessened through efficient water practices and water conservation activities. However, extreme heat events perpetuate inefficient water practices, stressing systems, and increase the need (and expenditure) for additional infrastructure.

Drought

Drought is a deficiency in precipitation over an extended period of time. Over the past 50 years the metro area has experienced several severe droughts (**Figure 7**). Major droughts occurred in the 1970s, late 1980s and as recent as 2021. They had significant impacts on water resources, water use behaviors, water services, and water utility operations. Other shorter but intense periods of drought during the 2000s also had observable impacts.

When drought stresses water resources and water utilities, many confounding issues arise. For instance, during a drought precipitation is limited, lowering groundwater recharge and direct inputs to surface waters. Water demand generally increases because the weather tends to be warmer and drier increasing outdoor water use or water used for cooling. This causes more water to be extracted from groundwater and area rivers that are already stressed, further lowering water levels. This can lead to well interferences and the loss of recreation opportunities. Groundwater dependent ecosystems like trout streams and fens are negatively impacted when increases in nearby pumping reduces the flow of upwelling groundwater into these surface water systems.

Water quality challenges also arise during periods of drought. As water levels and flows lower, pollutants become more concentrated. For natural waters, a greater concentration of nutrients or other contaminants can cause harmful algal blooms, increase fish toxicity, and cause die-offs resulting in a loss of recreation opportunities, economic activity, and important food sources for some metro area residents.

Groundwater inputs are the primary source for most surface waters. During periods of drought, when there is a lack of direct precipitation inputs and runoff, the groundwater inputs allow surface water systems to continue to function. If groundwaters are contaminated, this could drastically impact the quality of the waters – potentially lowering dissolved oxygen, increasing levels of ammonia, and introducing pollution that would have been diluted during wetter periods.

Increased groundwater pumping in some areas could shift contamination plumes or force wells to be drilled in areas of lower groundwater quality. Arsenic is a common,

naturally occurring toxic metal in Minnesota aquifers. During periods of drought, arsenic can become concentrated in wells, which is of particular concern for more than 60,000 domestic well owners in the metro area.

Additionally, prolonged periods of dry weather could result in less water inputs to the wastewater system due to source management and conservation practices (Marleni et al., 2012). Lower influent flows to the wastewater system can increase plant loading concentrations and influent temperatures, creating conditions that can disrupt treatment processes (Henze et al., 2008). We at the Met Council have a permit obligation to aerate effluent during periods of lower flows and low in-river dissolved oxygen concentrations to maintain ecological function in our receiving waters. Prolonged dry weather conditions will adversely impact the receiving waters where treatment plants discharge in a similar fashion. This may lead to more stringent permit requirements (Tolkou et al., 2015).

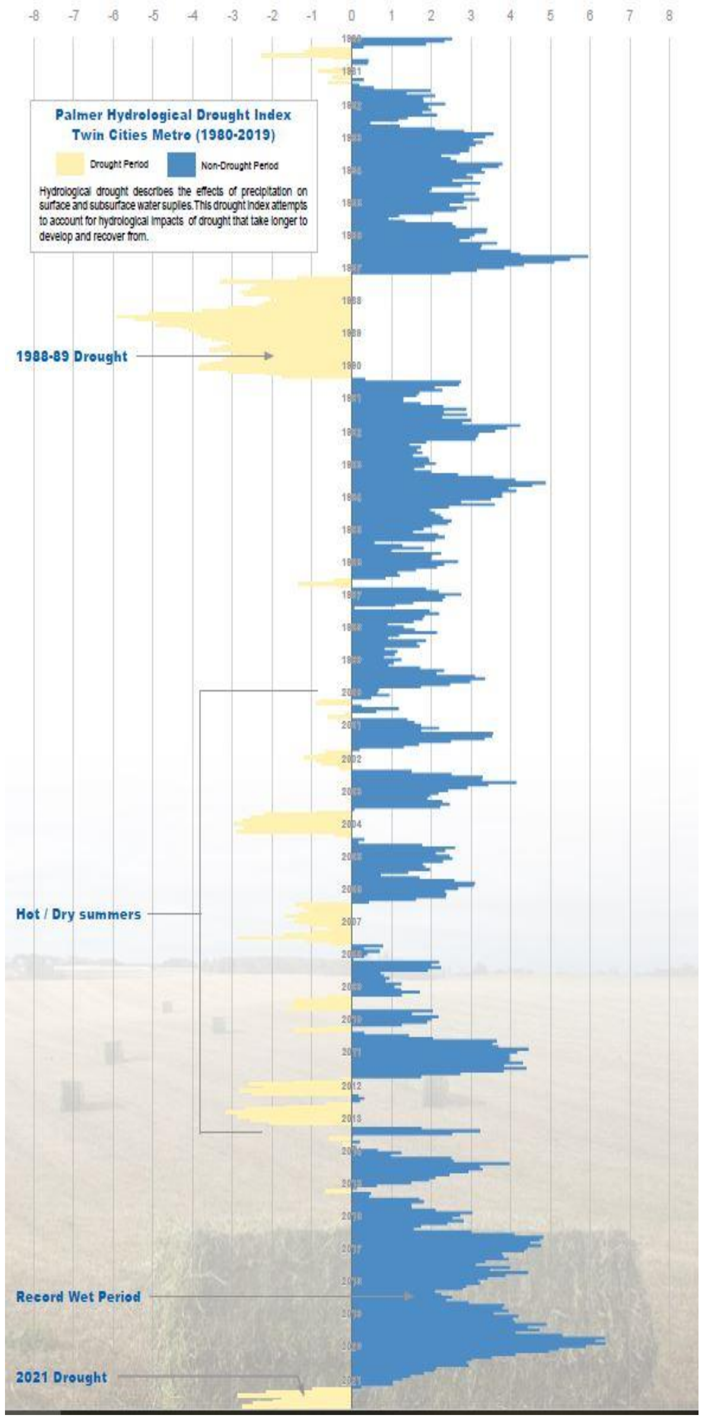

Figure 7: Palmer hydrological drought severity index 1980-2021 for the Twin Cities metro area.

Periods of drought are indicated in yellow and correspond to a negative index value. Non-drought periods are indicated in blue and correspond to a positive index value.

Operational adjustments and costly plant upgrades may be necessary to effectively treat higher concentration influent wastewaters. Failure to adapt treatment processes can lead to permit violations. Lower flows may also increase problems in conveyance infrastructure, namely increased septicity and settling (Chapelle et al., 2019). Increased hydrogen sulfide levels can increase odor complaints, corrosion in pipes and maintenance hole structures, while increased settling can result in more frequent maintenance required for additional cleaning or problems from resulting blockages (Yuan, 2010). Smaller rural treatment plants may not have the capital or resources to meet these more stringent treatment requirements and request to be served by us, adding additional strain on conveyance or treatment infrastructure and requiring significant and costly upgrades, or posing risk of overwhelming the system.

Ecosystem and social disruptions

Ecosystems provide many life-sustaining services – cultural and spiritual heritage, food provisioning, clean water and air, fertile soils for crop production, flood control, and recreation. They are vital to environmental and public health, but are often overlooked. These ecosystems and the services derived from them are also at risk as the climate changes. Natural systems have some built-in resiliency to disruption. The plants, animals, air, and water we all depend on are now changing so quickly that these systems do not have the time to adapt, potentially leading to the immeasurable loss of species and ecosystem function. In anticipation of this ecosystem change, we need to acknowledge the benefits that we have and strengthen their resiliency and capacity to adapt through land and water management. This will sustain these services now and into the future.

In addition to supporting the sustainability of our natural ecosystems, we need to evaluate the impacts of climate on our social structures. Climate change will be a significant driver on socioeconomic factors such as health and well-being, livelihood security, climate migration, and loss of cultural identity (World Bank, n.d). Vulnerable and marginalized communities will feel these impacts the greatest because they do not have equal access to wealth or resources needed to build or support resiliency (Sullivan, 2021). These changes come with extreme costs for society that will only increase as the magnitude of impact grows. Warming impacts vary over time and from region to region depending on the ability of different social, political, and environmental systems to adapt to change and mitigate negative outcomes.

The severity of climate change is predicated on our global ability to take decisive action to reduce emissions and our ability to adapt. While climate change is a global phenomenon, the consequences are going to continue to manifest regionally. We at the Met Council have the opportunity to take leadership of our regional response to reduce our contribution to global emissions, but also to ensure that communities within the region have equitable resources to moderate the climate impact on our socioeconomic factors and the people of the region.

Issue statement

Climate change poses immediate risks and future challenges on both the natural and built environments. The livability, prosperity and sustainability of the region are threatened by the effects climate change on water resources, water infrastructure, and water services. Public health, ecosystem function, economic growth, and community and individual well-being are facing increased pressures, all which can affect outcomes for our residents. These impacts are especially costly and exacerbate disparities for vulnerable communities in the region.

Limiting the most severe impacts of climate change necessitates both immediate and sustained action to reduce greenhouse gas emissions (mitigation) and to implement resilient climate design (adaptation) within our regional water infrastructure, water planning, and social systems that support our ability to thrive. Achieving the scale of reductions required will result in a substantial transformation across every sector of the economy, bringing both challenges and opportunities.

Our role

As the regional wastewater system operator and wastewater, surface water, and water supply planning agency for the seven-county metro area, we strive to ensure sustainable water resources through intentional planning and operations. Our wastewater treatment plants continually meet National Pollutant Discharge Elimination System Permit requirements. Our wastewater, surface water and water supply planning functions work to promote sustainable water resources while addressing the pollution and other factors that impacts those resources. Clean water for drinking, recreating, and treated by our wastewater treatment plants all are important parts of the region's livability and prosperity. We work with our partners, our regional influence, and perform our statutory responsibilities to protect and preserve our water.

We have three primary water planning focuses supported by state and federal statute.

- **Wastewater:** We prepare a comprehensive development guide consisting of policy statements, goals, standards, programs, and maps prescribing guides for the orderly and economical development of the region. The regional wastewater collection and treatment systems are one of the four regional systems included in this effort (Minn. Stat. § 473.145).

- **Water Resources Management:** State and federal law requires us to adopt a water resources plan and a regional management plan to address pollution from point sources, such as treatment plant discharges, and nonpoint sources, such as stormwater runoff (Minn. Stat. § 473.157; 33 U.S.C. §1288).

- **Water Supply Planning:** We are required to create plans to address regional water supply needs, including the regional Master Water Supply Plan, developing and maintaining technical information related to water supply issues and concerns, providing assistance to communities in the development of their local water supply plans, and identifying approaches for emerging water supply issues (Minn. Stat. § 473.1565).

As a part of our statutory authority, we are required to review and comment on Local Comprehensive Sewer, Local Surface Water Management, and Local Water Supply Plans (as described in Minn. Stat. § 103G.291, subd. 3) to ensure that they are in conformance and compliance with the regional plans.

Statutory authorities, state and regional climate planning

Climate change is not specifically addressed in Council statutes. To meet our statutory obligations to provide wastewater services and meet permit requirements, however, we need to ensure that our infrastructure is resilient and can withstand the impacts of climate change. The Council is further charged with planning for the orderly and economic development of the seven-county metro area while recognizing and encompassing physical, social, or economic needs of the metropolitan area and those future developments which will have an impact on the entire area (Minn. Stat. §473.145). To achieve this outcome, climate change effects must be integrated into regional wastewater system planning, water supply planning and water resources management and planning efforts. Additionally, we have other statutory authorities that address regional water concerns and climate change threats (**Table 2**).

Table 2: Examples of climate-related water statutes for Environmental Services

Minnesota Statute	Water and Climate Connections
Policy Plans for Metropolitan Agencies Minn. Stat. § 473.146	The Council shall adopt a long-range comprehensive policy plan for transportation and wastewater treatment. The plans must substantially conform to all policy statements, purposes, goals, standards, and maps in the development guide developed and adopted by the council under this chapter.
Water Resources Plan Minn. Stat. § 473.157	To help achieve federal and state water quality standards, provide effective water pollution control, and help reduce unnecessary investments in advanced wastewater treatment, the Council shall adopt a water resources plan that includes management objectives for watersheds in the metropolitan area.
Urban Research Minn. Stat. § 473.242	Where studies have not been otherwise authorized by law the Metropolitan Council may study the feasibility of programs relating but not limited to water supply, refuse disposal, surface water drainage, communication, transportation, and other subjects of concern to the peoples of the metropolitan area, may institute demonstration projects in connection therewith, and may accept gifts for such purposes as otherwise authorized in this section.
Total Watershed Management Minn. Stat. § 473.505	The Metropolitan Council may enter into agreements with other governmental bodies and agencies and spend funds to implement total watershed management. "Total watershed management" means identifying and quantifying at a watershed level the (1) sources of pollution, both point and nonpoint, (2) causes of conditions that may or may not be a result of pollution, and (3) means of reducing pollution or alleviating adverse conditions. The purpose of total watershed management is to achieve the best water quality for waters of the state receiving the effluent of the metropolitan disposal system for the lowest total costs, without regard to who will incur those costs.
Sewer Service Function Minn. Stat. § 473.511	[T]he Council shall assume ownership of all existing interceptors and treatment works which will be needed to implement the council's comprehensive plan for the collection, treatment, and disposal of sewage in the metropolitan area … and shall thereafter acquire, construct, equip, operate and maintain all additional interceptors and treatment works which will be needed for such purpose.

Municipal Plans and Programs Minn. Stat. § 473.513	As soon as practicable after the adoption of the first policy plan by the Council … each local government unit shall adopt a similar policy plan for the collection, treatment and disposal of sewage for which the local government unit is responsible, coordinated with the council's plan ...
Metropolitan Area Water Supply Planning Activities; Advisory Committees Minn. Stat. § 473.1565	As a part of Council planning activities, the agency must develop and maintain a base of technical information needed for sound water supply decisions including surface and groundwater availability analyses, water demand projections, water withdrawal and use impact analyses, modeling, and similar studies.

In addition to being a regional planning authority, we at the Met Council are part of the Governor's cabinet which is charged with upholding and enacting state efforts to address climate change within the metro area. In 2020, the Environmental Quality Board released a climate and water-focused interagency State Water Plan. This plan has five distinct goals to transition Minnesota (over the long-term) to become more resilient to climate change and prepare for its impacts on water (EQB, 2020). In 2022, the Governor's Climate Subcabinet followed up with the adoption of the Minnesota Climate Action Framework. This framework takes a proactive approach to address and prepare for climate change. It identifies immediate, near-term actions that must be implemented to achieve a carbon-neutral, resilient, and equitable future (Climate Change Subcabinet, 2022). Like the State Water Plan, the Climate Action Framework has distinct goals and strategies to set Minnesota on a resilient and sustainable path, but it has a broader scope to include all state agencies, not just those focused on water planning and management (**Table 3**).

Table 3: State Water Plan and Climate Action Framework goals

2020 State Water Plan: Water and Climate	2022 Minnesota Climate Action Framework
Goal 1: Ensure drinking water is safe and sufficient.	Goal 1: Clean transportation
Goal 2: Manage landscapes to protect and improve water quality.	Goal 2: Climate-smart natural and working lands
Goal 3: Manage built environment and infrastructure for greater resiliency.	Goal 3: Resilient communities
Goal 4: Manage landscapes to hold water and reduce runoff.	Goal 4: Clean energy and efficient buildings
Goal 5: Promote resiliency in quality of life.	Goal 5: Healthy lives and communities
	Goal 6: Clean economy

We have a role in achieving all the goals outlined in both state plans through our efforts in water resources, water supply, transportation, parks and natural resources, and land use planning, in addition to the operation of the public transportation and wastewater collection and treatment systems.

As a member of and the largest consumer of energy and fossil fuels in the Governor's cabinet, we also have an important role to play to help meet the State of Minnesota's goals articulated in

Executive Order 19-27 to reduce greenhouse gas emissions and energy and fuel consumption in government operations (Minnesota Executive Department, 2019). In 2022, the Metropolitan Council adopted the internal Climate Action Work Plan (Met Council, 2023). The Climate Action Work Plan builds on work that we have already done to reduce our emissions, build resiliency, and help communities become more resilient to climate change. There are five commitments at the heart of this plan:

1. Incorporate environmental justice principles as we plan, implement, and evaluate our climate action work.
2. Accelerate emissions reductions from our operations to achieve carbon neutrality.
3. Accelerate regional emissions reductions through existing and new partnerships.
4. Reduce risks and impacts of climate change hazards to our facilities and services.
5. Support and collaborate with partners to advance regional climate adaptation efforts.

The content and the implementation of the Climate Action Work Plan will set up partnerships and opportunities that can be leveraged in the 2050 regional policy plans, including the Water Resources Policy Plan.

Regional collaboration

Water and climate challenges are increasingly more complex and multi-dimensional, and require large-scale collaboration between the public, private, and non-profit sectors. These multiple perspectives allow for a wider understanding of regional climate challenges. It is in the region's interest for our team at the Met Council to convene regional water and climate stakeholders (e.g., federal, state, and local agencies, non-profits, academia, professional organizations) to share knowledge and understanding, develop regional expectations, and collaborate on building a resilient region. It's also in the region's interest for us to lead on these issues by breaking down traditional barriers that have limited local community input into climate change policies and decision-making around mitigation and adaptation actions. Doing so increases the likelihood that actions and strategies will better meet the needs of local communities and lead to equitable outcomes.

The metro area has several levels of water governance with municipal, county, watershed, regional, state, and federal agencies that are affected by a changing climate. Cross-agency coordination and partnerships are key to successful, sustainable management of water resources, which do not always align with jurisdictional boundaries (**Figure 8**). These collaborative partnerships broaden our reach and influence to achieve regional water and climate goals. For example, we adaptively manage water resources to identify the impact of climate in partnership with watershed organizations and communities by:

- Long-term monitoring of regional river, lake, and stream water quality and flows.
- Assessing surface water and groundwater trends and conditions.
- Providing technical support and guidance on source water protection and surface water management through research, advisory committees, plan reviews, and other activities that support cities, townships, and watershed organizations.
- Assisting communities through grants to implement water efficiency, stormwater, and inflow and infiltration (I/I) programs.

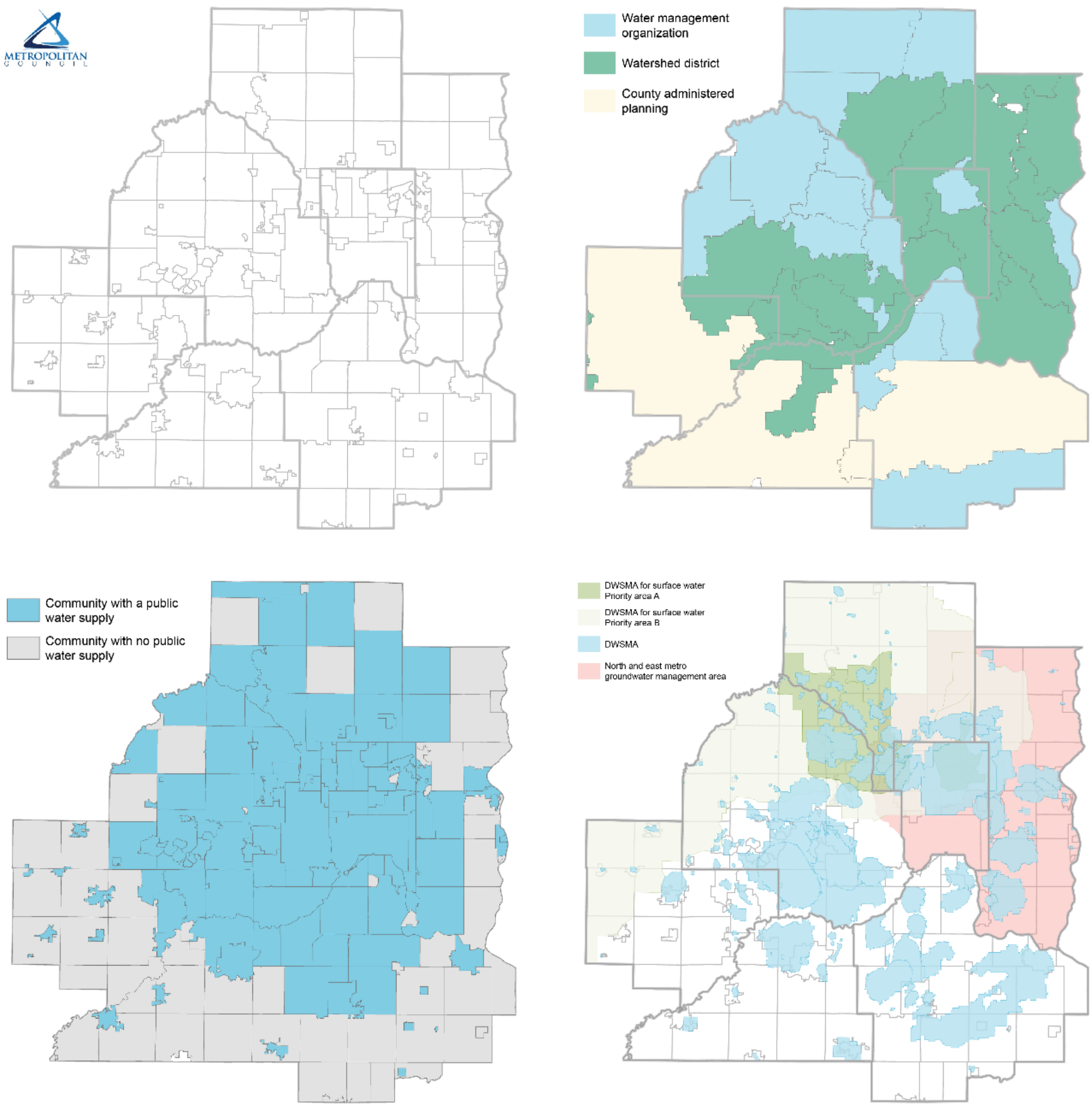

Figure 8: Water planning boundaries

Political boundaries (top left), watershed boundaries (top right), communities with public water supply (bottom left), and drinking water supply management area boundaries (bottom right).

Crucial concerns

As described earlier, we are already experiencing altered local weather patterns, which have heavily influenced the amount and quality of water in the region. These effects may occur over the short-term during a single extreme weather event or accumulate over the long-term after several years of increased heat, evaporation, precipitation, or drought. The severity of impact varies from place to place and is dependent on the local landscape and environmental conditions. It also depends on our ability and willingness to take mitigation and adaptation actions. Mitigation and adaptation strategies work together, over the short and long-term, to make the region sustainable and ensure positive outcomes for residents. By ensuring those managing our waters have what they need and are actively addressing climate change, our water utilities, infrastructure, and resources can be resilient in the face of the challenges posed by climate change.

As we become a more resilient region, we must consider how changing weather patterns and events influence our natural resources, our land use decisions, and how our relationship with water may change in the future. We must also understand how these impacts affect water treatment and utility services, and what the cumulative impact means for residents and our communities.

Resilient water resources and water utilities ensure the prosperity, sustainability, and livability of our region. This requires preparation and intervention to build natural and built environment cross-system resiliency. This means that the current consequences of a changing climate are addressed, the potential for future impacts is understood, and mitigation or adaptation opportunities and strategies for our natural and built water systems are identified.

Mitigating water sector greenhouse gas emissions

In the United States, it is estimated that the energy associated with water use is responsible for about 5% of total carbon dioxide emissions, or the equivalent of 53 million passenger vehicles (Congressional Research Service, 2017). Within the water sector 70% of this energy use is from water heating, 18% from wastewater treatment, 8% from water supply, and 6% from agricultural activities. These emission estimates do not include the direct emissions from the conveyance and treatment of wastewater, or the indirect emissions embodied in the concrete and steel used to build the infrastructure.

In recognition of the sector's contributions to greenhouse gas emissions and the sector's vulnerability to climate hazards, there is increasing momentum for utilities to take action to reduce their own emissions but also leverage the embodied energy in wastewater to help meet collective climate action goals. In the United Kingdom, water and wastewater suppliers have pledged to reach net zero emissions by 2030 (UK Water, 2020). The International Water Association has launched Climate Smart Utilities Initiative to support the sector's work to achieve carbon neutrality (International Water Association, 2022). Water Europe has called for a net-zero carbon water sector by 2050 (Water Europe, 2021). And in the United States, the US Water Alliance issued a call to action to achieve net-zero greenhouse gas emissions by 2050 (US Water Alliance, 2022).

Climate change is creating challenges, increasing costs, and negatively affecting water utilities and water resources in the metro area. This emphasizes the need for regional action at the individual, community, and organizational levels, including our work at the Met Council, to mitigate greenhouse gas emissions. Without greenhouse gases emission reduction, the climate will continue to become more volatile, leading to further impacts and new or evolving water challenges in the future that will require regional water utilities and communities to adapt to limit negative consequences for metro area residents and businesses.

The greenhouse gas emissions associated with our Environmental Services operations fall into three categories referred to as "scopes".

- **Scope 1** emissions are the release of greenhouse gases from activities directly controlled by the organization. The largest source of Scope 1 emissions is from the combustion of fossil fuels for building and process heating requirements. Other Scope 1 emission sources include biosolids incineration and process emissions. Process emissions are greenhouse gases released as a by-product of the wastewater treatment process. The combustion of fossil fuels in our on- and off-road vehicle and equipment fleet is also included in Scope 1, but is not a significant source.

- **Scope 2** emissions include the greenhouse gases associated with the purchase of electricity. This is our largest source of greenhouse gas emissions.
- **Scope 3** emissions are the greenhouse gases associated with activities in the value-chain of an organization. These typically include the embodied emissions from the purchase of goods and services, business and employee travel, and the management of waste and other by-products. To date, we have not quantified our Scope 3 emissions. However, there is a growing recognition within the water sector of the need to quantify and manage these emissions – especially as it relates to embodied emissions in construction materials (e.g. steel and concrete) and chemical inputs (e.g. lime).

The following table (**Table 4**) further describes some of our Scope 1 process emissions.

Table 4: Environmental Services greenhouse gases

Greenhouse Gas	Description
Carbon Dioxide (CO_2)	To date, the release of CO_2 emissions from wastewater treatment plants have been characterized wholly as a “biogenic” emission source that is part of the natural carbon cycle and therefore not a contributor to global warming. This includes CO_2 released from the combustion of biosolids and biogas and the biological treatment process. However, there is a growing body of evidence in the scientific literature suggesting a fraction of degradable carbon in wastewater is non-biogenic - from sources such as cosmetics, surfactants, detergents, and other industrial by products (IPCC, 2019). This carbon source can range of up to 50% of influent carbonaceous biochemical oxygen demand being non-biogenic. A recharacterization of these emissions would increase scrutiny of the sector’s role in potential carbon regulatory schemes.
Methane (CH_4)	Under current greenhouse gas accounting practices, wastewater treatment facilities (domestic and industrial) only account for 2.8% of U.S. methane emissions (EPA, 2023). However, emerging scientific literature suggests that domestic wastewater treatment methane emissions are significantly undercounted. Potential sources of unaccounted-for methane emissions in centralized wastewater treatment systems include methane formation and release in sewer collection systems and in treatment headworks, the anaerobic decay of settled solids in primary treatment, digested sludge storage and dewatering, incomplete biogas combustion, and biosolids management (Ye et al., 2022).
Hydrofluorocarbons (HFCs)	While Environmental Services is not a large consumer of HFCs, this phaseout will increase the operating and maintenance costs of HFC-based HVAC systems in the form of additional compliance requirements and higher prices as these materials become scarcer.

Nitrous Oxide (N_2O)	Nitrous oxide emissions from wastewater originate from nitrification/denitrification processes that occur within a treatment plants biological nutrient removal process. These emissions are highly variable and dependent on the specific facility design and operating conditions. As a result, wastewater utilities increasingly rely on direct measurement of these emissions. While some N_2O formation is inevitable in secondary treatment via autotrophic nitrification and subsequent air stripping effects from aeration, researchers continue to investigate reduction potential (Law et al., 2012). Another source of N_2O emissions is from the incineration of biosolids. The emission factor Environmental Services relies on to estimate these emissions is derived from a U.S. EPA rule that was not developed for wastewater biosolids incineration. That emissions factor is 18 times smaller than the default factor recommended by the Intergovernmental Panel on Climate Change (IPCC).

We know that we can never fully remove greenhouse gas emissions from our process. We can however, actively work to improve our energy consumption and employ alternative technologies to reduce greenhouse gas emissions to help meet the state goal of carbon neutrality by the year 2050. Additionally, the regional water utility sector (local water suppliers and public works) has an opportunity to reduce their greenhouse gas emissions as well.

These climate change risks exacerbate current issues, social and economic disparities that have large influence on the water sector broadly, the sustainability of the region, and the ability of residents and communities to prosper. We must work together to create water policies that are explicit, intentional, and adaptable to address the complex, interwoven issues. Collectively, our willingness and ability to invest in greenhouse gas mitigation activities will determine whether the metro area is able to continue to grow, prosper, and provide a high quality of life.

Mitigation recommendations

- The Metropolitan Council will have net zero emissions by 2050, in alignment with the Minnesota Climate Action Framework.
- The Metropolitan Council will maximize energy efficiency, electrification, energy recovery, water conservation, and renewable energy opportunities in the planning, design, procurement, operation, and maintenance of its assets.
- The Metropolitan Council will account for the social cost of both direct and indirect greenhouse gases when conducting cost-benefit analyses.
- The Metropolitan Council will invest in efforts to quantify and monitor process and fugitive emissions and will pursue opportunities to minimize these emissions.
- The Metropolitan Council will collaborate to advance nature-based solutions and other best management practices that achieve dual reductions in nutrient loading and greenhouse gas emissions.
- The Metropolitan Council will support the development and piloting of innovative approaches to reduce emissions in our own or the region's emissions.
- The Metropolitan Council will provide assistance and resources where feasible to support local water suppliers and local wastewater systems to reduce their greenhouse gas emissions.

Water and land management

As the region and communities plan for future economic and population growth and land development and redevelopment, we must do so within the context of a changing climate. The metro area population has doubled from 1960 to 2020 (**Figure 9**), climbing from 1.5 million residents to 3.2 million residents, and it is forecast to continue to increase to slightly over four million by 2050. This growth will affect our land use in addition to placing additional stresses on the physical, chemical, and social aspects of our water. At the same time, climate change will have a great influence on water resources, ecosystem function, and water utilities. If these pressures and stressors on water sustainability are not considered together in policy and planning decisions, the region will be unable to meet the current and future water needs of communities and residents.

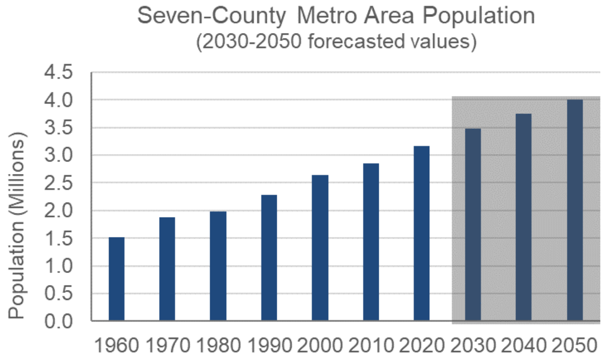

Figure 9: Seven-county metro area population and forecasts, 1960-2050

(US Census Bureau, n.d.; Metropolitan Council, 2021)

As land is developed or redeveloped within the region, we and our partner organizations need to keep climate in consideration. We need to use climate adaptive design, as we manage our natural spaces and develop and redevelop our built environments. For example, under the projected warmer and wetter climate we expect more frequent, larger volumes of water that will mobilize pollution (e.g., nutrients, oils, pet waste, fertilizers, pesticides) from our streets, lawns, and agricultural fields into surface water and groundwater. Our water quality will also be impacted as winters warm, creating more freeze-thaw cycles, and increasing the need for road de-icing salts for public safety. One way to prevent these pollutants from contaminating our waters is to use low impact design or best management practices (including green infrastructure) that slow down water runoff and that promote the treatment and infiltration of stormwater runoff before it enters our surface or groundwater. For permanent pollutants, like chloride, we must change our behaviors to only apply salts when it will be most effective, in advised amounts, and collect what remains behind before it dissolves and is transported. Please see the Water Quality research paper for further discussion.

If the quantity of water is large enough it can result in localized flooding on community streets or agricultural fields, elevated lake levels, stream and riverine flooding, and associated costly property damage and restoration expenses. There have been many examples of this occurring in the metro area between 2014-2019, the wettest span of years on record. During that five year time span, the region experienced the equivalent of seven years of precipitation. For instance, in 2014, a long winter, late snowmelt, and an extremely wet spring and summer caused $500,000 in flooding damage to trails and stream reaches along Minnehaha Creek in Minneapolis (Schaufler, 2018; **Figure 10**). As a part of the repairs, the Minnehaha Creek Watershed District worked to ensure a balance between the built and natural environment to create thriving communities, improve water quality and flood resilience, and enhance ecological integrity.

This localized flooding event also affected homeowners in and around nearby Lake Nokomis (Du, 2022). This area was developed during a drier period in the early 20th century. Wetlands in the area were drained and filled so that housing and infrastructure could be built. The last half of the 20th century and early 21st century have been wetter. Combined with the record rainfalls of the last decade this landscape has become more and more saturated, leading to flooded basements and damage to streets and other infrastructure. While the ongoing weather events cannot be controlled, they point to the need to consider climate, climate change, and its relationship to water and our landscapes in regional and local decision making now to avoid negative outcomes and higher costs in the future.

Figure 10: Bike riders tackle a flooded path along Minnehaha Creek in Minneapolis on Sunday, June 1, 2014.
(Image from Van Denburg, 2014)

Adaptive responses to create flood resilience includes a commitment to smart design and the integration of nature-based solutions into our designs – restoration of wetlands or development of additional park areas, planting and maintaining trees and other vegetation along surface waters, installation of water retention, infiltration, or storage in upland areas, and not siting of vital infrastructure or buildings in floodplains.

The expected heat waves and drought due to future climate change can also impact the quality and quantity of our water resources. Warmer air temperatures cause our rivers, lakes, and streams to warm due to air-water convection, but also if stormwater runoff flows over warm, impervious surfaces (pavements, roofs, or other water-resistance surfaces) on the way to our waters. Over time, as we develop or redevelop in the region, it is imperative to reduce imperviousness. This requires a change in expectations about our built environment's surfaces including designing narrower streets, smaller parking lots, or increased development density.

If we cannot change the landscapes in upland areas, we may have to avoid contact with affected waters. Calm, warm surface waters above 75 °F are the ideal conditions for harmful algal blooms. These blooms produce cyanotoxins that can make human and animals sick or die if they swallow, have skin contact, or breathe in airborne water droplets while recreating in waters (MDH, 2022). Currently, we do not have a method to stop harmful algal blooms from occurring, and we may experience them more as our climate warms.

Drought conditions can affect our waters, and in turn have public health and economic implications. Prolonged dry periods can reduce the amount of water volume in our aquifers, rivers, lakes, and streams. This also concentrates the pollution present and may cause stagnation of once flowing systems. It could also cause well interference, when a public water supply loses access to water because a nearby high-volume water appropriation causes the water table to drop. During 2021-2022, the metro area experienced prolonged periods of drought causing water scarcity (Stanley, 2022) and the activation of the Minnesota Statewide Drought Protection Plan and the implementation of metro-wide water restrictions (DNR, 2009).

Water reuse, including storm and wastewater, is a tool to help reduce our reliance on potable waters for non-potable uses (irrigation, toilet water, etc.). However, stormwater reuse does require that stormwater is available for collection which is difficult during drought conditions. Alternatively, wastewater reuse and indirect recharge are created from a consistent water source – wastewater effluent. Currently, we have one treatment facility, East Bethel Water Reclamation Facility, that indirectly recharges surficial aquifers in the north metro area. It is worth exploring the potential for expanding the technology at our other facilities to reuse water or augment surficial aquifers for non-potable uses.

We at the Met Council own and maintain numerous land parcels along our major rivers and within the metro area. This provides us with an opportunity manage these lands in a way that demonstrates regional climate leadership. Where appropriate, we can reduce impervious surfaces, integrate green infrastructure, convert traditional lawn areas to native plantings which are more drought tolerant and promote water infiltration, and reduce the cost and emissions involved in traditional turf grass lawn care.

Water and land management recommendations

- The Metropolitan Council strongly supports low impact design and the integration of nature-based solutions into regional development to adapt to projected climate impacts on our land and waters.
- The Metropolitan Council will understand and quantify the impacts of land use change on water resources as the climate changes.
- The Metropolitan Council will connect to, partner with, and learn from other water utilities and other planning organizations as we all tackle water and climate issues.
- The Metropolitan Council will promote stormwater and wastewater reuse as viable alternatives to augment non-potable water uses.
- Environmental Services will manage our land holdings to reduce impervious surfaces, integrate green infrastructure and nature-based solutions within our stormwater management systems, install native plantings where possible, and be a regional leader in climate-focused land management.
- The Metropolitan Council will prioritize inter-agency collaboration to understand the effectiveness of infiltration as a stormwater management practice, particularly under a range of potential climate futures (high and low water tables).
- The Metropolitan Council will research to better understand metro area water balances during both wet and dry periods.
- The Metropolitan Council will use the latest research to improve and update stormwater infiltration requirements and recommendations around practices, particularly in vulnerable drinking water supply management areas.

- The Metropolitan Council will work towards securing funds to provide grants promoting regional water quality improvement and volume reduction best management practices.

Safeguarding water infrastructure

A foundational service to any prosperous region is the ability to provide clean, safe drinking water to residents, and the collection and treatment of wastewater so that it can be returned safely to the environment. Water is essential to every household, and economically vital to industries like manufacturing, health care, and food production. These water services cannot be accomplished without water infrastructure – the pipes and pumps that move water through the systems and the treatment facilities that create clean water. Much of this infrastructure was installed decades to centuries ago. It is buried underground or located at the edges of city boundaries, often out of sight and usually out of the public's mind.

Water suppliers and wastewater operators are the stewards of this infrastructure. This aging and deteriorating infrastructure requires maintenance to ensure the quality of our drinking waters and environmental safety. Nationwide, there is a chronic underinvestment in our water systems. It is estimated that the U.S. needs to invest a total of $109 billion per year in infrastructure over the next 20 years (in 2019 dollars) to close the water infrastructure gap (ASCE, 2019). In the metro area, some of the earliest parts of the regional wastewater system were installed in the late nineteenth century, making it almost 150 years old. To allow for and support growth of the region, we in Environmental Service, on average, invest $110 million per year to maintain, replace, and expand wastewater treatment facilities. This investment does not include drinking water or municipal wastewater infrastructure, so overall the regional water infrastructure maintenance and operations cost is much larger.

Stormwater system management is also a part of the regional water infrastructure story. In the 1960s, Minneapolis and Saint Paul started to separate their combined sewer system into sanitary and stormwater sewer systems, and in the early 1980s the region decided to separate as well. The project was completed in the 1990s with a total investment of $430 million dollars (Met Council, 2018). This effort has greatly paid off. It has saved the region from costly investments to build capacity for treatment and storage and has contributed to the protection of water resources - there has not been a combined sewer overflow into the Mississippi River since 2010. This is a case study on the benefits of upfront investment to avoid later costs due to acute shocks and chronic stresses. It should be celebrated, but we also must acknowledge that this system requires continued investment to maintain and operate to keep our stormwater conveyed safely to rivers, lakes, and streams.

Climate change only exacerbates the need for water infrastructure investments due to acute shocks (i.e., flashy rain events) and chronic stresses (declining surface water flows and aquifer recharge) (Brown et al., 2019). Wastewater infrastructure is also made vulnerable by a climate shifting toward more frequent and intense wet weather patterns. Low-lying wastewater infrastructure, typically located adjacent to or in floodplains, face increased flood risks in terms of both frequency and intensity. This could potentially affect operational performance and prove costly to protect.

Rising shallow groundwater would require more dewatering in underground construction and operations, working directly against energy and emission reduction goals. Facilities not at a direct risk of flooding may still encounter challenges in the face of more frequent higher intensity storm events. Such events often result in increased inflow and infiltration – excessive clearwater making its way through cracks and defects in pipes and maintenance holes – further exacerbating any structural flaws and consuming needed hydraulic capacity. When this capacity is overwhelmed in a wastewater system, residents may experience basement back-ups, and communities may see sanitary sewer overflows, polluting the environment and posing a threat to human health (Lai, 2008). Lift stations can be overwhelmed in both hydraulic and energetic capacities due to greater pumping demand. Flooded stormwater infrastructure often compounds these issues.

Prolonged severe storms can also disrupt critical inputs necessary for operations such as supply chain disruptions and regional power outages. Maintaining adequate inventories and back-up power capacity are costly and stress facilities' storage capabilities. Operating without such redundancies poses risk of widespread system failure. As we make investments in existing or new water infrastructure, we need to take the opportunity to incorporate climate resilient design to ensure this essential infrastructure lasts for many more centuries with growing and thriving communities.

Safeguarding infrastructure recommendations

- The Metropolitan Council will consider future climate scenarios when evaluating the Inflow and Infiltration (I/I) Program.
- The Metropolitan Council will periodically reevaluate and assess climate vulnerability and risk of our facilities and infrastructure as we refine climate projections.
- The Metropolitan Council will make investments to safeguard our regional wastewater system to ensure its viability in a changing climate.
- The Metropolitan Council will partner with research organizations to create planning tools and resources to identify risk to current infrastructure and help site new local water infrastructure.
- The Metropolitan Council will assess and provide recommendations on the creation of funds to help close the investment gap in water (stormwater, water supply, and wastewater) infrastructure.

Aligning and supporting local climate planning and action

Climate change is a global condition with local community impacts to water resources and water utilities. We are well-situated to align broader greenhouse gas mitigation and climate adaptation objectives, goals, and strategies with local water planning efforts. Further, there is a need to discern and connect broad climate and water policy so that local policy implementors can be empowered to take effective actions.

The inherent variability and uncertainty of climate change means the effects will develop differently for different communities. Further, the effects of climate change on water resources, utilities, and residents are not the same in each community. Therefore, our policies must consider climate change impacts across the diverse rural, suburban, and urban landscapes of the metro area. One size fits all approaches are often less locally implementable and lack the flexibility needed to address continually evolving challenges.

Climate planning approaches

Climate change is the cumulative outcome of multiple human activities and behaviors. Due to these interconnected influences, decision-makers need to address and discern the best adaptation solution to climate change within a wide range of uncertainty.

Local climate-impacted decisions, like where to site and size infrastructure, is supported by imperfect information. Uncertainty cannot and should not preclude any organization from reaching a decision, however tools and analyses can provide context for the uncertainty. Some useful approaches and principles to employ when making adaptation decisions with inherent uncertainty in the underlying knowledge may include (Climate Adapt, n.d.):

- **Adaptive Management:** Adaptive management involves the selection of a strategy that can be altered to better achieve results as one learns more about the issues at hand and how the future is unfolding. Very rarely is the 'right' strategy selected the first time. A key feature of adaptive management is that decision makers are open to being responsive to new information and flexible to modify strategies. Planning, implementing, learning, and adjusting are key elements of this approach and should be actively incorporated into decision-making.

- **Scenario Planning:** Faced with uncertainty, decision makers may choose to consider multiple plausible outcomes. This is the approach taken by scenario analyses. Scenarios present a set of different, plausible future conditions. Decision analysis is then undertaken to compare how well alternative policy decisions perform under these different future conditions. In addition to providing a useful description of uncertainty, scenarios can also bring clarity regarding the trade-offs made within the decision-making process.

- **Robust or Resilient Strategies:** This approach builds off scenario planning and helps to identify strategies that will work reasonably well across the range of conditions. A robust strategy can be defined as one that performs well over a very wide range of alternative futures.

The results of these approaches can provide enough information for decision-makers to make the best-informed decision that will help build a more climate resilient region.

Climate planning recommendations

- The Metropolitan Council will integrate and center state and regional climate objectives into our wastewater operations and water resources and supply planning within the region.
- The Metropolitan Council will convene water and climate-focused conversations to ensure regional priorities are represented and shared. This includes state agencies, climate policy experts, watershed organizations, water suppliers, community planners, and residents.
- The Metropolitan Council will partner with and support university and research organizations to generate metro area- specific climate information and best understand the potential future climate based on current science and models.
- The Metropolitan Council will, with the assistance of our partners, monitor and assess the quality of regional lakes and rivers and the quality and flow of regional streams. Long-term water quality trends and climate-related concerns will be identified.
- The Metropolitan Council will evaluate and quantify the risks to our regional waters, ecosystems, and water utilities through scenario planning, adaptive management, and the creation of robust strategies and plans.
- The Metropolitan Council will share climate research with local governments and decision-makers to incorporate the information in tools and resources to encourage local risk assessments, evaluation, and action.

Economic, social, and cultural challenges

When water and water resources are negatively impacted, expenses rise, lives are disrupted, and trust in services may be lost. Residents and communities with the least ability to do so often bear the brunt of these negative outcomes (US Water Alliance, 2021). Water managers and policy makers are left to address confounding global economic, environmental, and social issues within local political boundaries (Islam & Winkel, 2017). Addressing these challenges requires flexible, holistic approaches that allow water managers, services providers, and residents to collaborate across diverse communities.

This also means that our most vulnerable and underserved communities and residents have what they need to thrive, to be resilient, and are not more adversely impacted than others. This includes Black, Indigenous, and communities of color, lower income, health-compromised, and rural communities that may not have as much access to infrastructure, resources, or support systems.

Failing to adapt our strategies and practices to address the effects of a changing climate will be harmful to the region and have larger consequences for our most vulnerable residents. Negative impacts to the quantity and quality of water or the ability to provide water services must be limited for our region to be sustainable and continue to develop and grow economically, socially, and culturally.

Within the metro area, climate impacts have already begun to influence communities and their socioeconomic dimensions. For example, in 2019, rural roads were destabilized during the spring thaw and saturated soil conditions kept most of the area's agricultural fields too wet for planting well into the planting season (Zdechlik, et al., 2019). In July 2019, the heat index value hit 115 °F at Minneapolis-Saint Paul International Airport which tied for the second highest value on record (DNR, 2019). This combination created grave consequences for the region's ability to transport goods and people, caused strains on the economic and mental health of agricultural producers, and contributed to stress on all people without access to cooling or shelter.

While the above impacts are some of the most well-understood outcomes of climate change, there exist numerous uncertainties, many of which could have severe repercussions for wastewater infrastructure. For example, the metro area could see unprecedented growth due to climate migration (Howard, 2021), as people from around the globe are forcibly displaced by weather-related events. Both conveyance and treatment infrastructure are sized based on forecasts outlined in communities' comprehensive plans. If a large influx of residents were to occur rapidly it may lead to a divergence from these plans, causing exceedances in hydraulic capacity or may require significant expenditures upsizing our infrastructure or building parallel pipes.

Global supply chain issues could also result from a changing climate, straining both water supply and wastewater treatment and conveyance infrastructure (Kagawa et al., 2015). Numerous chemicals and supplies are needed to effectively operate treatment systems, and a variety of materials are required to preserve and sustain interceptor infrastructure. Disruption of these supplies can lead to a failure to treat water and wastewater to an acceptable level, leading to permit violation and risk to environmental and public health. Delay of imminent repairs could result in excessive deterioration of pipes and potential risk of sanitary sewer overflow. If certain energy or power sources become unavailable, overall failure across the system may result.

Socioeconomic and cultural recommendations

- The Metropolitan Council will work to identify social, economic, and cultural impacts of water-related climate change impacts on vulnerable communities within the region.
- The Metropolitan Council will partner with organizations to alleviate socioeconomic impacts where they intersect with the regional water sector.
- The Metropolitan Council will consider climate migration and its impacts on water resources and water utility systems to the metro area as we plan towards regional resiliency.
- The Metropolitan Council will assess our operational supply chain to build in resiliency from climate disruptions and ensure that we continue to achieve permit compliance at all our wastewater treatment plants and facilities.

Equity Considerations

Climate change presents a multitude of risks to our water resources, utilities and services, and residents of the region. Most often the resulting vulnerabilities are felt uniquely and disproportionately. There is a growing environmental justice effort (nationally) among water resource managers to reassess current levels of service, goals, and policies to ensure the benefits of water quality and quantity are free from discrimination, bias, and inequity (Vanderwarker, 2013). Overburdened, underserved, and disadvantaged populations including Black, Indigenous and people of color, low-income communities, persons with disabilities, and the elderly typically have lesser resources to prepare for and respond to climate threats and feel an unequal and greater risk. Nationally, Black, Indigenous, and people of color face some of the highest racial disparities here in Minnesota due to a legacy of discrimination including redlining practices, racial covenants, land use and zoning decisions, and restricted employment availability (MnDEED 2020, Hoffman et al., 2020). These communities already face some of the greatest environmental impacts resulting from location and proximity to hazardous industries, heat risks, air and noise pollution, brownfield contamination, reduced tree canopy cover, and energy vulnerability. Many of these effects will be exacerbated through climate change (CEED, 2015).

Moving forward, we will need to build upon the framework developed by our Environmental Justice Task Force including acknowledging past and current inequities, making an honest effort towards reconciliation, and conducting outreach and listening sessions with these communities and local organizations to ensure we are integrating environmental justice principles into our programs and policies and protecting those most vulnerable. Equitable planning practices help everyone, as protecting communities most strongly affected by climate risks also protects adjacent communities.

Water, climate, and equity recommendations

- The Metropolitan Council will listen and make an honest effort towards reconciliation with communities most impacted by environmental injustices relating to wastewater, water planning functions, or other experienced water inequities.
- The Metropolitan Council will work to develop relationships with community members to build trust.
- The Metropolitan Council will co-create solutions with impacted communities to best alleviate water and climate burdens.
- The Metropolitan Council will partner and support metro area organizations with a water equity focus.
- Environmental Services will integrate equity metrics into our programs, projects, and services.
- Environmental Services will partner and collaborate with other Met Council divisions to address equity efforts that overlap regional systems.

Connections to current policy

The 2040 Water Resources Policy Plan contains 11 separate policies. Seven of these policies indirectly address water and climate, as denoted below.

Policy on Watershed Approach
The Met Council will work with our partners to develop and implement a regional watershed-based approach that addresses both watershed restoration (improving impaired waters) and protection (maintaining water quality in unimpaired waters).

Policy on Sustainable Water Supplies
While recognizing local control and responsibility for owning, operating, and maintaining water supply systems, the Met Council will work with our partners to develop plans that meet regional needs for a reliable water supply that protects public health, critical habitat and water resources over the long-term.

Policy on Assessing and Protecting Regional Water Resources
The Met Council will continue to assess the condition of the region's lakes, rivers, streams, and aquifers to evaluate impacts on regional water resources and measure success in achieving regional water goals.

Policy on Water Conservation and Reuse
The Met Council will work with our partners to identify emerging issues and challenges for the region as we work together on solutions that include the use of water conservation, wastewater and stormwater reuse, and low-impact development practices in order to promote a more sustainable region.

Investment Policy
The Met Council will strive to maximize regional benefits from regional investments.

Wastewater Sustainability Policy
The Met Council will provide efficient, high-quality, and environmentally sustainable regional wastewater infrastructure and services. The Met Council shall conduct its regional wastewater system operations in a sustainable manner as is economically feasible. Sustainable operations relate not only to water resources but also to increasing energy efficiency and using renewable energy sources, reducing air pollutant emissions, and reducing, reusing, and recycling solid wastes.

Inflow and Infiltration Policy
The Met Council will not provide additional capacity within its interceptor system to serve excessive inflow and infiltration.

The Met Council will establish inflow and infiltration goals for all communities discharging wastewater to the regional wastewater system. Communities that have excessive inflow and infiltration in their sanitary sewer systems will be required to eliminate the excessive inflow and infiltration within a reasonable time period.

Draft policy proposals and implementation strategies

Mitigation actions are our commitment to lessen the regional and global impact of climate change. We must actively reduce this pollution to shift the magnitude of future negative outcomes. However, we know that climate change is already affecting our region, and we must adapt our operational and planning practices to have the best regional climate outcomes. There are climate connections inherent in our existing policies, but it is important to be explicit in our commitment towards climate efforts. Below are draft policies and proposed actions that will help the region become more resilient in the face of climate change.

Mitigation Policies

Proposed policy recommendation:

The Metropolitan Council prioritizes the mitigation of greenhouse gas emissions and their climate consequences in its operations, facility management, and planning functions.

Proposed actions:

- The Metropolitan Council will have net zero emissions by 2050, in alignment with the Minnesota Climate Action Framework.
- The Metropolitan Council will maximize energy efficiency, electrification, energy recovery, and renewable energy opportunities in the planning, design, procurement, operation, and maintenance of its assets.
- The Metropolitan Council will work to implement a methodology to account for the social cost of greenhouse gases when conducting cost-benefit analyses.
- The Metropolitan Council will invest in efforts to quantify and monitor process and fugitive emissions and will pursue opportunities to minimize these emissions.
- The Metropolitan Council will collaborate to advance nature-based solutions and other best management practices that achieve dual reductions in nutrient loading and greenhouse gas emissions.
- The Metropolitan Council will support the development and piloting of innovative approaches to reduce emissions in our own or the region's operations emissions through demonstration projects.
- The Metropolitan Council will support local water suppliers to reduce their greenhouse gas emissions.

Adaptation Policies

Proposed policy recommendation:

The Metropolitan Council will support, partner, and create information to better understand the impacts of climate change on the natural and built environments within the metro area.

Proposed actions:

- The Metropolitan Council will convene water and climate-focused conversations to ensure regional priorities are represented and shared. This includes state agencies, climate policy experts, watershed organizations, water suppliers, community planners, and residents.
- The Metropolitan Council will partner with and support university and research organizations to generate metro area-specific climate information and best understand the potential future climate based on current science and models.
- The Metropolitan Council will, with assistance of our partners, monitor the quality of regional lakes and rivers and the quality and flow of regional streams.

- The Metropolitan Council will assess and evaluate long-term water quality trends for the region's lakes, streams, and rivers and identify climate-related issues to be addressed.
- The Metropolitan Council will prioritize inter-agency collaboration to understand the effectiveness of infiltration as a stormwater management practice, particularly under a range of potential climate futures (high and low water tables).
- The Metropolitan Council will research to better understand metro area water balances during both wet and dry periods.
- The Metropolitan Council will use the latest research to improve and update stormwater infiltration requirements and recommendations around best practices, particularly in vulnerable drinking water supply management areas.
- The Metropolitan Council will share climate research with local governments and decision-makers through tools and resources to encourage local risk assessments, evaluation, and action.

<u>Proposed policy recommendation:</u>

The Metropolitan Council will consider the climate vulnerabilities and risks within our facilities and reduce the impact of climate on water resources, land management, water planning, and regional wastewater services now and into the future.

Proposed actions:

- The Metropolitan Council will integrate and center state and regional climate objectives into our wastewater operations and water resources and supply planning within the region.
- The Metropolitan Council will connect, partner, and learn from other water utilities and planning organizations as we take on water and climate challenges.
- The Metropolitan Council will evaluate and quantify the risks to our regional waters, ecosystems, and facilities through scenario planning, adaptive management, and the creation of robust strategies and plans.
- The Metropolitan Council will consider future climate scenarios when evaluating the Inflow and Infiltration (I/I) Program.
- The Metropolitan Council will periodically reevaluate and assess climate vulnerability and risk to our facilities and infrastructure as we refine climate projections.
- The Metropolitan Council will make investments to safeguard our regional wastewater system to ensure its viability in a changing climate.
- The Metropolitan Council will be a regional leader in climate-focused land management by managing our facilities and land holdings to reduce impervious surfaces, integrate green infrastructure and nature-based solutions within our stormwater management systems, install native plantings where possible.
- The Metropolitan Council will assess our operational supply chain to build in resiliency against climate disruptions and ensure that we continue to achieve permit compliance at all our wastewater treatment plants and facilities.

<u>Proposed policy recommendation:</u>

The Metropolitan Council will support and collaborate with local communities and partners to understand regional climate risk, including the associated economic, social, and cultural consequences, and adapt land use and water infrastructure to ensure sustainable water resources and resilient regional growth.

Proposed actions:

- The Metropolitan Council strongly supports low-impact design and the integration of nature-based solutions into regional development to adapt to projected climate impacts on our land and waters.
- The Metropolitan Council will understand and quantify the impacts of land use change on water resources as the climate changes.
- The Metropolitan Council will evaluate and quantify the risks to our regional waters, ecosystems, and local water utilities through scenario planning, adaptive management, and the creation of robust strategies and plans.
- The Metropolitan Council will partner with research organizations to create tools and resources to identify risk to new and existing local water infrastructure.
- The Metropolitan Council will share climate research with local governments and decision-makers through tools and resources to encourage local risk assessment, evaluation, and action.
- The Metropolitan Council will promote stormwater and wastewater reuse as viable alternatives to augment non-potable water uses.
- The Metropolitan Council will identify social, economic, and cultural impacts of water-related climate change impacts on vulnerable communities within the region.
- The Metropolitan Council will consider climate migration (people forcibly moved by climate-related events) and its impacts on water resources and water utility systems to the metro area as we plan towards regional resiliency.
- The Metropolitan Council will work towards securing funds to provide grants promoting best management practices in regional water quality improvement and volume reduction.
- The Metropolitan Council will assess and provide recommendations on the creation of funds to help close the investment gap in water (stormwater, water supply, and wastewater) infrastructure.

Climate-Equity Policies

Proposed policy recommendation:

The Metropolitan Council recognizes that climate change exacerbates current and future regional disparities and will work with impacted communities to co-create water and climate solutions that fit regional objectives and best benefit the community.

Proposed actions:

- The Metropolitan Council will listen and make an honest effort towards reconciliation with communities most impacted by environmental injustices relating to wastewater, water planning functions, or other experienced water inequities.
- The Metropolitan Council will work to develop relationships with community members to build trust.
- The Metropolitan Council will co-create solutions with impacted communities to best alleviate water and climate burdens.

- The Metropolitan Council will partner and support metro area organizations with a water equity focus.
- Environmental Services will integrate equity metrics into our programs, projects, and services.
- Environmental Services will partner and collaborate with other Metropolitan Council divisions to address equity efforts that overlap regional systems.

Next steps

Climate change is not a distant threat, but a current reality within our region. Climate impacts will continue to increase and intensify over the coming decades, even with substantial reductions in global emissions. These impacts are costly, disrupting natural and built water systems, and exacerbate current disparities. Public health, ecosystem function, economic growth, and the well-being of communities and individuals are influenced by our ability to respond and adapt to this challenge. It is our intent that this paper begins to address the issue and provides some recommendations to move us towards regional resiliency.

This topical research paper is the first step in the process of creating regional water policies to safeguard our waters and to protect the livability and prosperity of the region (**Figure 11**). The ideas in this paper are intended to spark discussion and generate additional water-focused policy recommendations to provide the foundation of the 2050 Water Resources Policy Plan. This paper was created and reviewed by Met Council staff. Our planned next step is to gather and include vital perspectives from our partners on needed policy recommendations.

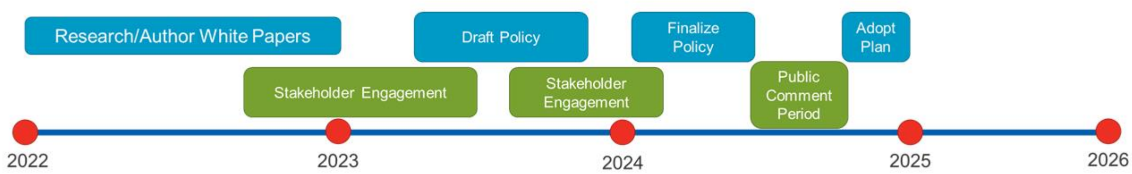

Figure 11: Water Resources Policy Plan timeline

After this additional information is gathered, Met Council staff will update the draft policy recommendations through an iterative process of drafting policies, listening to stakeholder feedback, and integrating the information collected to assist the Council Members to develop, evaluate, refine, and adopt policies. Alternating between engagement and policy creation will allow stakeholders to participate and shape plan content from the very beginnings of policy research and development through the public comment period prior to the adoption of the plan. This proposed process is an intentional attempt to bring in more voices and perspectives to help the Met Council produce polices and implementation strategies that are reflective of the region's water priorities.

If you have any questions or feedback about the content of this paper, please contact Jennifer Kostrzewski at ***Jennifer.kostrzewski@metc.state.mn.us***.

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