APPENDIX B:
Summary of Climate and Precipitation Projections

Table 1. Climate Impacts and Indicators

Changing Condition and Description	Resource Impacts	Indicators
More Extreme Water-Related Events By late century (2060-2079), Washington County is projected to experience: Between 0.5 to 3.3 inches more annual precipitation compared to historical simulations (1995-2014). These increases are projected to vary seasonally with more precipitation occurring in the Spring and Fall seasons, with modest increases in Winter, and precipitation decreases in Summer of between 0.6 to 1.4 inches. Between 8.2 to 9.0 days where precipitation is greater than 1 inch (an increase of 0.1 to 0.9 days) and 2.8 to 3.4 days (an increase of 0 to 0.7 days) where precipitation is greater than 2 inches. Source: *climate.umn.edu v1.0 beta*	**Increased Variation in Water Levels:** Particularly in wetlands, too much water can create lifeless zones reducing the ability of this resource to support wildlife and plant life that performs water quality and quantity management functions. **Increased Change in Water Chemistry:** Changes in water chemistry, particularly in lakes and wetlands, can occur with the rapid introduction of more water and when water levels are lower. **Increased Thermal Loading:** Warm runoff water entering lakes, rivers, creeks, and wetlands raises the temperature of these waters impacting species that depend upon cool or cold-water habitats to survive. **Increased Erosion and Sediment Transport:** Erosion destroying habitat for aquatic and semi-aquatic animals (such as amphibians, fish, and birds) particularly in rivers, creeks, and lakes. This includes the disruption of fish, amphibian, reptile, and insect spawning sites due to smothering of eggs and larvae by deposited sediments. Loss of topsoil and plant cover providing crucial shelter and food sources. These impacts are worse in sloped and deforested areas. **Decreased Ecological Health:** Disturbed landscapes and flooded areas can become ideal for invasive species to spread, often outcompeting native plants. Wildlife and plant species that require specific conditions (e.g., dry soil, stable hydrology) may be outcompeted by more generalist species, leading to a decline in biodiversity. **Increased Introduction of Pollutants:** Extreme rainfall washes nutrients (like nitrogen and phosphorus from fertilizers) and pollutants (like pesticides, heavy metals, and waste) into water bodies. **Increased Infrastructure Stress and Flooding Potential:** Extreme rainfall and rapid snowmelts push the functional capacity of existing infrastructure to or beyond their intended design which can result in failure. **Increased Stream Channel Instability:** Large precipitation and melt events increasing channel forming flows (bank-full flows) increasing erosion and sediment transport potential. Channel erosion resulting in accelerated channel migration impacting adjacent riparian areas. **Increased Erosion and Sediment Transport:** Erosion destroying habitat for aquatic and semi-aquatic animals (such as amphibians, fish, and birds) particularly in rivers, creeks, and lakes. This includes the disruption of fish, amphibian, reptile, and insect spawning sites due to smothering of eggs and larvae by deposited sediments). Loss of topsoil and plant cover providing crucial shelter and food sources. These impacts are worse in sloped and deforested areas. **Decreased Groundwater Recharge:** High volume precipitation events occurring over a short period of time are poorly suited to slowly infiltrate to recharge groundwater. Rapid saturation of near surface soil resulting in runoff preventing more thorough groundwater infiltration to recharge aquifers.	Increased risk of flooding Increased variability of streamflow Increased velocity of water during high flow periods Increased evaporation Reduced temperature regulations Reduced oxygen levels Increased waterbody stratification Increased pollutant levels at monitoring sites Changes in precipitation impacts wetland hydrology (bounce and duration)
Warming Temperatures By late century (2060-2079), Washington County is projected to experience: Between 29.0 to 41.8 fewer days below 32 degrees Fahrenheit compared to historical simulations (1995-2014). Winter temperatures are projected to increase by 6.6 to 8.4 degrees Fahrenheit, an increase that is more than any other season. Between 15.2 to 22.0 fewer days with snow cover depth greater than 1 inch compared to historical simulations (1995-2014). Between 1.1 to 1.5 degrees Fahrenheit increase in the annual temperature at lake bottom. With the greatest increases in Spring and Fall ranging from 1.2 to 3.4 degrees Fahrenheit warmer. Source: *climate.umn.edu v1.0 beta*	**Decreased Water Retention:** Precipitation that would normally fall as snow delivered as rain. Reduced snowpack results in immediate runoff, which may not be stored as effectively as snow increasing the risk of spring flooding. **Increased Thermal Loading:** As water temperatures rise, the balance of species in freshwater ecosystems can shift, with consequences for the entire aquatic food web, including fish, aquatic insects, and the animals that depend on them. **Increased Introduction of Pollutants:** Faster snowmelt and increased rain during winter can wash pollutants such as fertilizers, pesticides, and urban runoff into downstream waterbodies. **Increased Evaporation:** Without ice cover, lakes may experience higher rates of evaporation during the winter, leading to reduced water levels and changes in water chemistry. **Decreased Temperature Regulation:** Many aquatic species depend on ice cover for temperature regulation and protection from predators. Fewer cold days can increase stress on these species, particularly cold-water fish. **Decreased Oxygen Content:** Longer summer stratification contributes to declines in dissolved oxygen leading to hypoxic conditions that can stress or kill aquatic species. **Decreased Winter Stratification Time:** Water bodies like lakes typically experience a process called thermal stratification, where layers of water of different temperatures form during the summer and winter. Fewer cold days can shortens winter stratification and longer summer stratification, disrupting the cycles of mixing of nutrients and oxygen between winter and summer stratifications. This can lead to oxygen-deprived "dead zones" in lakes and reservoirs, harming fish and other aquatic organisms. **Decreased Ecological Health:** Fewer cold days may promote the spread of invasive species, which are often better adapted to warmer conditions. This can affect native wildlife by altering habitat structure and resource availability. Plants and insects that emerge earlier due to fewer cold days may not synchronize with the life cycles of their pollinators or herbivores.	Reduced snow cover depth Increased average daily temperature Reduced days meeting minimum temperature thresholds Later ice-in and earlier ice-out dates Harmful algae blooms (HABs) Species die-off Increased *E.Coli* advisory days on lakes
Drought By late century (2060-2079), between May and September (growing season) Washington County is projected to experience: A maximum of between 16.5 to 16.9 consecutive days of less than 0.01 inches of precipitation. This represents an increase of 1.8 to 2.2 consecutive days compared to historical simulations (1995-2014). Source: *climate.umn.edu v1.0 beta*	**Increased Variation in Water Levels:** Extended period(s) of no or minimal precipitation impacting the supply of water. **Decreased Ecological Health:** Lower water levels affect plant species accustomed to being fully or partially submerged resulting in plant die off. Plant die-off reduces habitat and ecosystem functions; these plants provide for water filtration. Drought can also lead to long-term shifts in species composition and biodiversity, favoring drought-tolerant species over more sensitive ones. Reduced water levels and higher temperatures can drastically affect fish, amphibians, and invertebrates. **Increased Erosion and Sediment Transport:** Drought weakens plant root systems, increasing soil erosion and leading to long-term vegetation loss. The loss of vegetation increases soil erosion, which can lead to the degradation of habitats, particularly in areas prone to wind or water erosion. **Decreased Soil Quality:** Heat and drought can degrade soil health, leading to erosion, reduced fertility, and the loss of organisms that contribute to nutrient cycling. This can have long-term consequences for ecosystem productivity and resilience **Decreased Groundwater Recharge:** Drought prevents the recharge of groundwater resources.	Decreased precipitation Increased evaporation rates

	Increased Habitat Fragmentation: Increased development in the watershed leads to further habitat fragmentation that directly or indirectly affects wildlife (e.g., more roads lead to increased vehicle strikes, forest or prairie fragmentation may disrupt breeding and survival of offspring).	
Extreme Heat By late century (2060-2079), Washington County is projected to experience between 23.9 to 35.3 more days that exceed 90 degrees Fahrenheit than historical simulations (1995-2014). Source: *climate.umn.edu v1.0 beta*	**Increased Heat Stress:** Higher temperatures lower reproductive success and offspring survivability. For example, heat waves can cause nest abandonment or reduce the success of the hatching eggs in birds, reptiles, and amphibians. Cold water fish in the trout stream depend on colder water temperatures for fish survival, as these waters warm they survivability of these cold water dependent species decreases. **Increased Variation in Water Levels:** Water resources drying up due to lack of surface and groundwater recharge. This carries the compounding impact of concentrating pollutants in water resources due to decreased water volume. Increase in water loss due to evaporation. **Increased Demand for Water:** Higher demand for water for drinking water, irrigation, agriculture, and cooling energy production impacting surface and groundwater sources where water is drawn from. **Decreased Ecological Health:** Reduced water levels in rivers, lakes, and streams can threaten macrophytes, fish and other aquatic organisms, as these species depend on specific water conditions for survival. **Decreased Oxygen Content:** Warmer water temperatures can reduce dissolved oxygen levels, stressing or killing aquatic life. **Increased Spread of Invasive Species:** Some invasive species, including certain plants, insects, and animals, thrive in hotter conditions and may outcompete native species, altering ecosystems and threatening biodiversity. Invasive insects, such as bark beetles, have devastated forests weakened by heat stress. **Increased Public Health Risk:** Vector-borne diseases can be spread through warm waters that support the proliferation of bacteria and disease hosts (e.g. mosquitos) that can spread to humans and animals.	Increased evaporation rates Reduced water levels Increased presence of invasive species Lower in-stream temperature Lower fish IBI Lower macroinvertebrate IBC Decrease in stream oxygen levels. Decreasing groundwater depth in municipal wells Lower baseflows in groundwater supplied resources

Table 2 Severity of Climate Change Impacts by WMP Issue Area

Changing Condition	Stormwater Runoff Management	Erosion Prevention and Sediment Control	Stream Management	Lake Management	Wetland Management	Floodplain Management	Groundwater Management	Ecological Health	Monitoring and Data Collection	Regulations	Recreation	Education, Outreach and Stewardship	Land Conservation	Funding	Pollutants of Emerging Concern
More Extreme Water-Related Events	High	High	Medium	Medium	Medium	High	Medium	Medium	High	High	Low	High	Medium	High	Medium
Warming Temperatures	High	Low	Medium	High	Medium	High	Low	High	High	Low	Low	Low	Low	Medium	Low
Increases in Water Pollution Problems	High	Low	High	High	Medium	Low	Medium	Medium	Medium	High	Medium	High	Low	High	High
Water Boundary Movement and Displacement	Medium	High	High	High	High	High	Low	Low	High	High	Low	Medium	Low	High	Low
Changes to availability of Drinking Water Supplies	Low	Low	Low	Low	Low	Low	High	Low	High	High	Low	High	Low	Medium	High
Drought	Medium	Low	High	Medium	High	Low	High	Medium	Medium	Low	Low	High	Medium	Low	Low
Extreme Heat	Low	Low	Medium	Medium	Medium	Low	High	Medium	Medium	Low	High	Medium	Medium	Low	Low