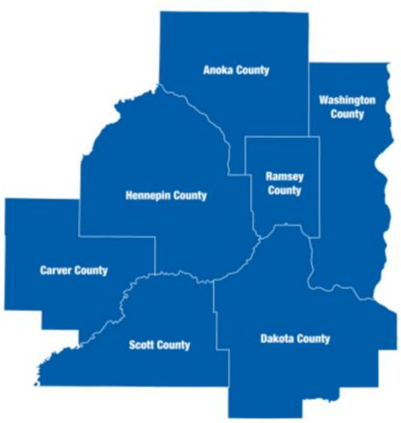
REGIONAL CLIMATE VULNERABILITY ASSESSMENT

Part 1: Localized Flood Risk Introduction

METROPOLITAN COUNCIL

February 2018

The Council's mission is to foster efficient and economic growth for a prosperous metropolitan region



The Metropolitan Council is the regional planning organization for the seven-county Twin Cities area. The Council operates the regional bus and rail system, collects and treats wastewater, coordinates regional water resources, plans and helps fund regional parks, and administers federal funds that provide housing opportunities for low- and moderate-income individuals and families. The 17-member Council board is appointed by and serves at the pleasure of the governor.

On request, this publication will be made available in alternative formats to people with disabilities. Call Metropolitan Council information at 651-602-1140 or TTY 651-291-09

Table of Contents

Localized Flooding - Introduction

Climate Change in Minnesota

In his 2016 State of the State address, Governor Mark Dayton made the following observation about climate change: “From kids concerned that pond hockey doesn’t start until January to farmers trying to predict growing seasons, to folks wondering why this year’s March blizzards have turned into sixty-degree days, many thousands of Minnesotans have expressed their concerns about the growing impacts of climate change.” The Governor wasn’t speaking of distant ice caps and threats to polar bears, but rather to climate changes that we are experiencing regionally and locally, right here in Minnesota.

The most recent National Climate Assessment (NCA) produced by the U.S. Global Change Research Program (2014), synthesizes climate change impacts by sector and by region. The Midwest regional chapter of the NCA Report highlights current and future impacts related to climate change within the Twin Cities metropolitan region. The fourth NCA is set to be released in late 2018. The most pertinent statewide document detailing current and future likely climate change hazards is the Interagency Climate Action Team’s 2017 Report entitled *Adapting to Climate Change in Minnesota.*

Climatologists identify a diverse range of climate-related hazards that can be exacerbated by climate change. This Regional Climate Vulnerability Assessment (CVA) focuses on climate hazards related to **localized flooding** and **extreme heat.** More information can be found in the *Regional Climate Vulnerability Assessment Introduction* found on the CVA webpage: *https://metrocouncil.org/CVA*

The long-term trends of our Minnesota climate have been changing outside the bounds of typical, temporary variations. In the years and decades ahead, winter warming and increased extreme rainfall will continue to be Minnesota’s two leading symptoms of climate change (see Table 1). Heat waves will also likely occur with more frequency, coverage, and duration.

Table 1. Climate Change Trends in Minnesota through 2099*

Hazard	*Projections Through 2099*	*Confidence in Projected Changes*
Warming Winters	Continued loss of cold extremes and dramatic warming of coldest conditions	**Highest**
Extreme Rainfall	Continued increase in frequency and magnitude; unprecedented flash-floods	
Heat Waves	More hot days with increases in severity, coverage, and duration of heat waves	**High**
Drought	More days between precipitation events, leading to increased drought severity, coverage, and duration	**Moderately High**
Heavy Snowfall	Large events less frequent as winter warms, but occasional very large snowfalls	**Moderately Low**
Severe Thunderstorms & Tornadoes	More “super events” possible, even if frequency decreases	

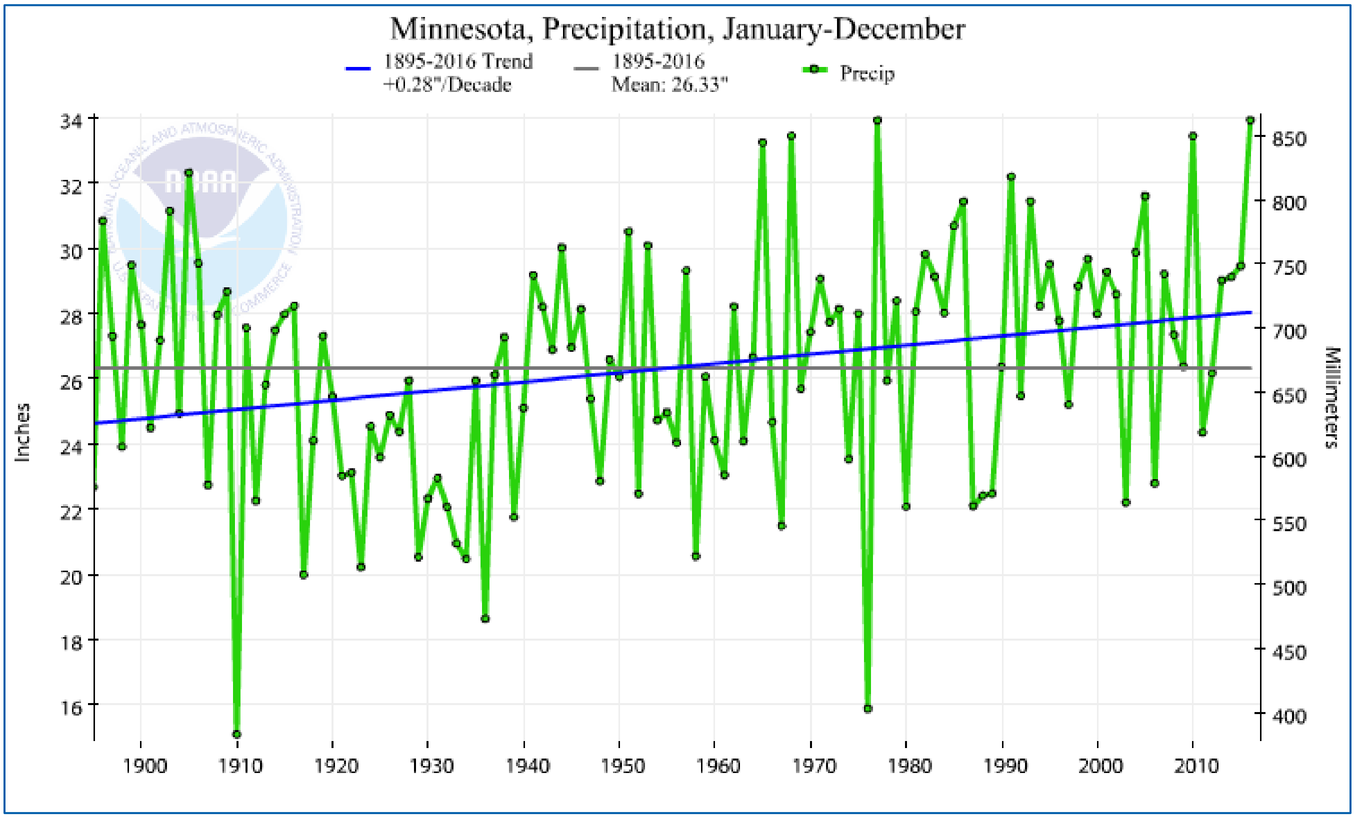
**Source: ICAT (2017). Projected and expected trends among common weather hazards in Minnesota, and confidence that those hazards will change through the year 2099 in response to climate change. Graphic based on information from the 2014 National Climate Assessment.*

Extreme Rainfall

A changing Minnesota climate has shown that more energy and more moisture in the atmosphere has the potential to create more rainfall.

Precipitation has been increasing in Minnesota over the last century, as shown in Figure 1 which illustrates historic annual precipitation.

Figure 1. Minnesota Annual Precipitation, 1895-2016*



**Source: NOAA National Centers for Environmental Information. Climate at a Glance: U.S. Time Series, Precipitation. (April 2017). Retrieved on April 27, 2017, from http://www.ncdc.noaa.gov/cag/*

The blue trend line in Figure 1 shows that annual precipitation amounts have been steadily increasing, which is compounded by increasing rainfall totals for specific, isolated storms. There has been a marked increase in what the State Climatologist terms, ‘mega rain events.’ These mega rain events are defined as a 6 inches or greater rainfall event covering at least 1000 square miles, with a peak rainfall amount of 8 inches or greater. Historically, fourteen of these mega rain events have been recorded since 1866, with half of these events occurring within the last fourteen years.

These extreme rainfall trends put a strain on stormwater infrastructure and other surface water conveyance or retention efforts. Given the fact that much of the stormwater infrastructure within the Twin Cities metro was designed to convey surface water based on technical standards and rainfall estimations adopted in 1960, the increasingly short, intense rainfalls present a challenge for communities and for the Metropolitan Council.

The National Climate Assessment states that the Midwest has already experienced a 37% increase in these larger rain events of 2.5 inches or greater (US Global Change Research Program, 2014). The extreme rainfall changes in the Midwest are only second to those of the Northeast US between 1958 and 2012.

Why Focus on Localized Flooding?

From an asset management perspective, the financial implications of inaction are well researched and documented. According to the US Federal Emergency Management Agency (FEMA), federal insurance claims for flooding damage averaged $1.9 billion a year annually between 2006 and 2015, making flooding the costliest and most common type of natural disaster in the US (Planning Magazine, 2017).

This assessment focuses on the climate hazard of localized flooding for several reasons, including:

1) Increases in extreme rainfall have already occurred, and this trend shows the highest probability of continuing in the future (See Table 1).

2) Council assets are susceptible to vulnerabilities from potential localized flooding, including disruptions to the transit system, increase in inflow/infiltration to our wastewater infrastructure, adverse effects to water supply and water quality, and health and safety concerns for the region, for our customers, and for our employees.

Until now, no regional screening tool has been created to assess the potential impacts from localized flooding. The assessment allows the Council to screen regional assets for potential flood risk and subsequent vulnerability. In addition, the data analysis may provide leverage in advancing further regional and local analysis and tools. For example, this assessment may advance the interest in creating a regional stormwater dataset.

Localized Flooding Approach

The common understanding of flood impacts is related to riverway flooding, but there are actually different types of flooding. The purpose of this assessment is to consider a form of flooding that is occurring more often and is less understood – localized flooding. Localized flooding is often referred to as surface water flooding or pluvial flooding. Distinct from riverine flooding, localized flooding occurs when rain overwhelms drainage systems and waterways, making its way into basements, yards, and streets. It leads to multibillion-dollar damages but often lacks regulatory oversight.

Before describing our localized flooding (bluespot) approach, it is necessary to highlight existing forms of flood modeling and flood study.

Riverine Flooding

The Metropolitan Council Climate Vulnerability Assessment (CVA) examines risks due to two types of flooding: riverine flooding and localized flooding.

Riverine flooding is evaluated using the FEMA 100-year and 500-year floodplain information from FEMA Digital Flood Insurance Rate Maps (DFIRM). The CVA does not attempt to update the FEMA maps or evaluate the accuracy of the maps or appropriateness of the layers for future flooding due to changing climate. Rather, this project evaluates how to use the FEMA flood maps to investigate climate vulnerability on an asset-by-asset basis.

Atlas 14 Data

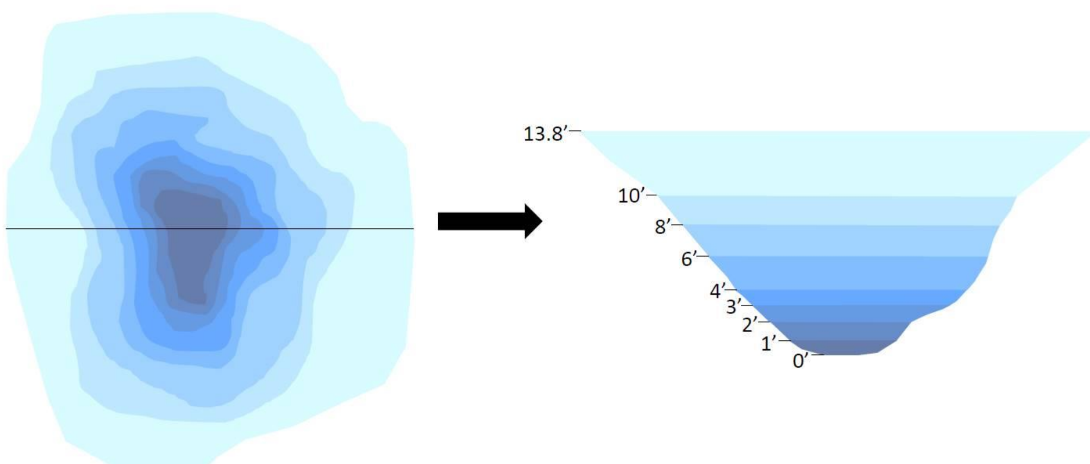
Atlas 14 is an update to precipitation frequency estimates (including depth and rainfall distribution) for the Midwestern states compiled and released by the National Oceanic and Atmospheric Administration (NOAA). It is used to estimate peak stormwater discharges and runoff volumes, which are used to design storm sewer and pond facilities, and estimate high water levels of ponds, small streams, county ditches and determine flood plain areas. Atlas 14 replaces the precipitation data under Technical Paper 40 (TP40). TP40 was published in 1960, and the new Atlas 14 data represents a more accurate measure of rainfall to assist in stormwater modelling. In Minnesota, watershed districts, watershed management organizations, and soil and water conservation districts, in collaboration with agencies and communities, are using the Atlas 14 data to better plan for present and future flooding events.

This bluespot, localized flooding analysis does not use Atlas 14 data to project flood risk based on rainfall totals for various rain events. The purpose of the bluespot analysis is to provide communities and agencies with another tool that can be used to screen areas of potential localized flood risk. Bluespot analysis can be used in conjunction with Atlas 14 data and FEMA floodplain information to add rigor to assessment work.

Bluespot (Localized Flooding)

Following an example from the Danish Road Institute, our team evaluated localized flooding in low spots on the landscape, which the Danish study called “bluespots” (Danish Road Institute, 2010). Bluespots are areas that are expected to flood during short-term, extreme rain events. The Council’s bluespot analysis uses information about the topography of the earth contained in the State of Minnesota’s 3-meter digital elevation model (DEM) built from the state’s LIDAR data. Bluespots are determined solely based on depressions in the DEM; no data of existing stormwater infrastructure is considered because this information does not currently exist at a regional scale. Using the Hydrology toolset within Spatial Analyst of ArcGIS 10.3.1, low points in the landscape are identified and depressions are filled with water. From this information, the maximum water rise in a bluespot is determined, along with the surface area that will flood when the water in a bluespot rises to certain heights. To illustrate, an example bluespot is shown below in Figure 2. The bluespot has a max water rise of 13.8 feet before it spills over to the next bluespot. A vertical cross-section of the bluespot is shown on the left, and the aerial view of the bluespot on the right.

Figure 2. Bluespot Cross-Section and Aerial Example

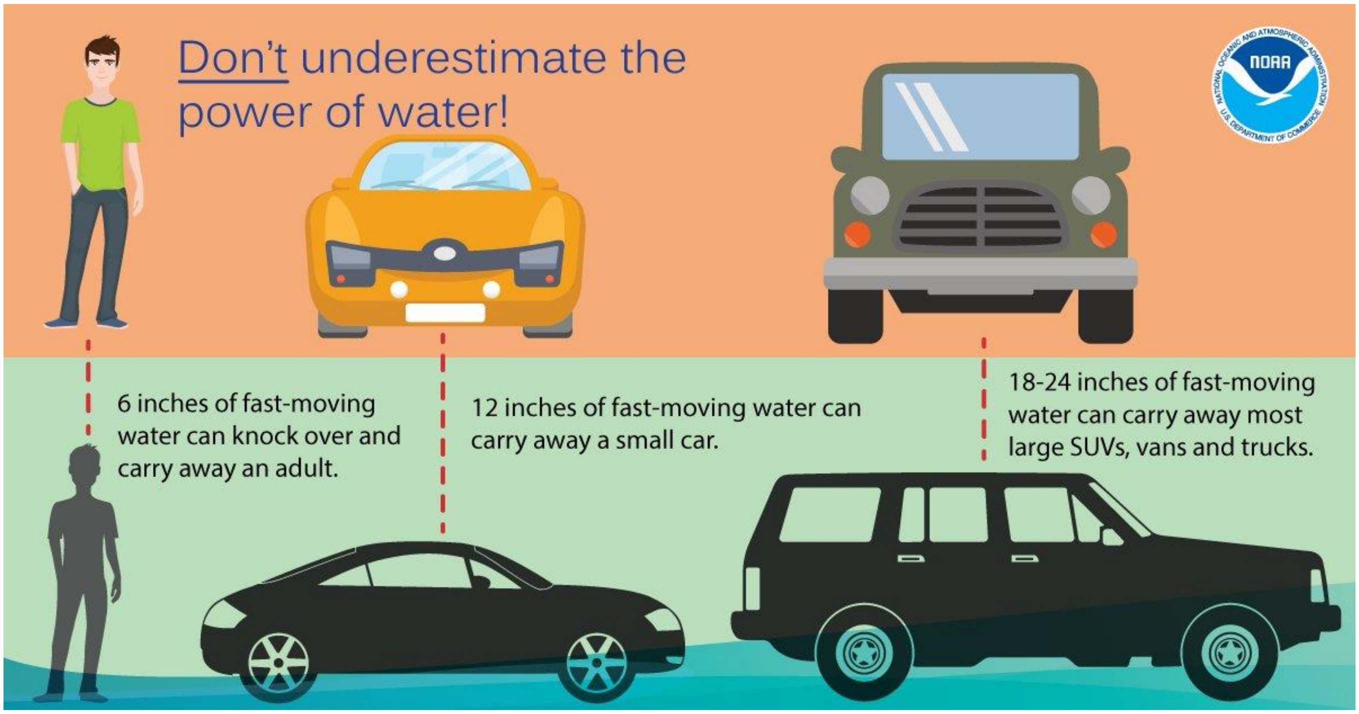


Bluespots were categorized as either “Shallow” or a range of water rise (0-1 foot, 1-2 feet, etc.). Shallow bluespots are those with a maximum depth of 3 inches to 1 foot that are generally low risk for all assets in this analysis. When water rises to the maximum depth of a bluespot, it spills over to the next bluespot, so the water rise can never get higher than the maximum depth. Imagine a bathtub: no matter how much water you add to a bathtub, it can never rise above the tub’s overflow because the water just flows out of the drain above that height.

Depressions with a depth less than 3 inches were not included as bluespots because of their low risk and because they were within the range of error of the source data.

Using several sources and internal subject matter experts, the team selected a cut-off for shallow bluespots of 1 foot. As illustrated in the NOAA-produced graphic below differing levels of floodwaters, even at apparently shallow levels, can pose risks for vehicles and pedestrians (Figure 3).

Figure 3. NOAA Flood Hazard Infographic



(National Weather Service, 2018)

Bluespots below 1 foot in depth can be a danger to pedestrians, and certain assets can be undermined by small depths of water, such as infrastructure damage due to submergence, or any ponded water at all. Bluespots below 1 foot in depth are of lower risks to vehicles.

Bluespots with a maximum depth greater than 1 foot are of greater concern than shallow bluespots. because water can rise beyond 1 foot, there is increased danger to people and vehicles, as well as increased potential for impact on properties and infrastructure. For bluespots with a 1-foot maximum depth or greater, the danger depends on how high the water rises. An individual bluespot might be able to fill up to a maximum depth of 10 feet, but it is much more likely to partially fill up during a smaller storm than to fill all the way to 10 feet during a catastrophic storm. Both situations are dangerous, but the relative risk of the bluespot filling 4 or 10 feet can vary significantly. Our analysis does not predict the likelihood of a certain bluespot filling over another, nor does it predict the likelihood of partial to complete filling or where the bluespot will likely be the deepest and most dangerous.

Flood Hazard Categorization & Symbology

To streamline the analysis and to better assess the relative flood hazard and vulnerability of our assets, the Council categorized the bluespots in groups of 1-foot increments of water rise. Assigning risk based on the bluespots is based on the Council's identified needs and potential risks. A community or an agency may wish to categorize flood depths in a different manner to better suit their own asset evaluation.

For Council assets, bluespots have been categorized into four flood hazards: Shallow, Primary, Secondary, and Tertiary. As stated previously, Shallow bluespots are separate, isolated low areas generally considered low risk, but this depth may still be a concern for certain types of infrastructure. The remaining 3 flood hazards are usually contiguous and represent the deeper bluespots of the Flood Impact Zone (FIZ). Primary are the first areas to fill with water (after the stormwater infrastructure has been overwhelmed). Secondary are the second areas to fill, and Tertiary are the last areas to fill.

Table 3. Flood Impact Zone (FIZ) and Bluespot Symbology

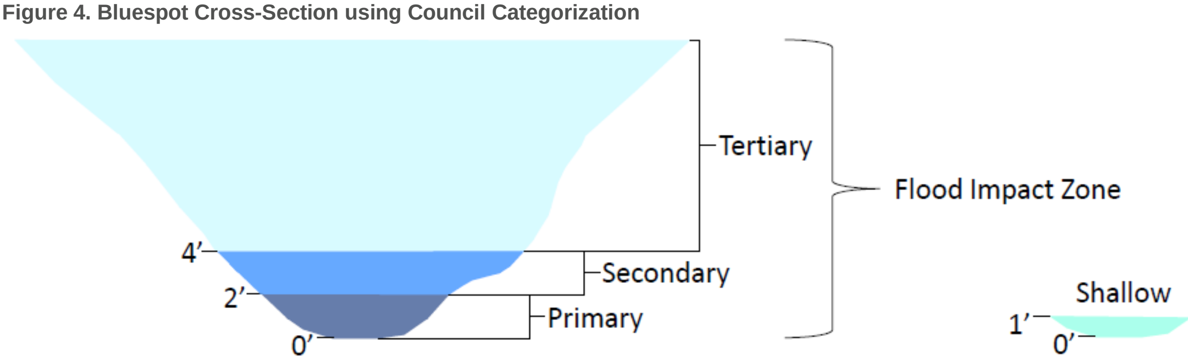
Bluespot Depth	Flood Hazard Category	Bluespot Symbology
3in -1 foot	Shallow	
0-1 feet	Primary	
1-2 feet	Primary	
2-3 feet	Secondary	
3-4 feet	Secondary	
4-6 feet	Tertiary	
6-8 feet	Tertiary	
8-10 feet	Tertiary	
>10 feet	Tertiary	

Isolated 3in – 1ft Bluespots (3in -1 foot, Shallow)

Flood Impact Zone (FIZ) (0-1 feet through >10 feet)

Every bluespot is different and has different stormwater infrastructure and a unique depth to volume relationship. That means one bluespot might fill up to 2 feet with a 2-year rain event, while another bluespot will not fill at all during a 100-year rain event. These bluespot flood zones were selected to assign general or potential risk, with the understanding that in-depth analysis using stormwater infrastructure information should be completed for bluespots of particular interest. Figure 4 shows a cross section of a bluespot using the Flood Impact Zone hazard categorization.

Figure 4. Bluespot Cross-Section using Council Categorization



Vulnerability Symbology and Assessment

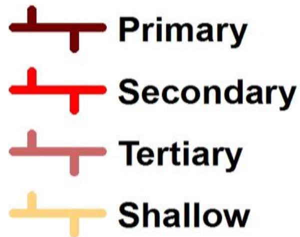
In all cases in this report, the asset vulnerability is always shown using a red palette. This color scheme is used to display the system locations impacted by the intersection or overlay with the bluespots.

Depending on the asset being evaluated, we either used a binary determination of vulnerability ('in' or 'out' of a bluespot) or a weighted determination.

Binary 'In' or 'Out' Determination of Vulnerability

For some assets, the Council performed its analysis based on whether the asset was 'in' or 'out' of a bluespot. In these cases, the vulnerability is based entirely on the hazard level, with Primary being the greatest flood hazard and therefore creating the highest vulnerability (shown in deep red). The legend example in Figure 5 shows the color scheme for this type of analysis.

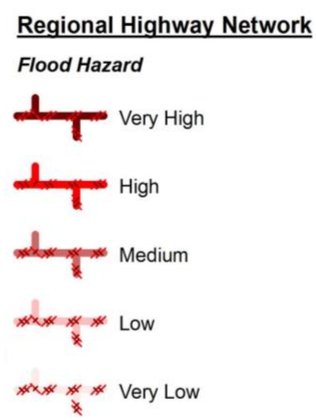
Figure 5. Binary Determination of Vulnerability



Weighted Determination of Vulnerability

The Council assigned a level of vulnerability, from 'very low' to 'very high' using a sensitivity/exposure matrix for analysis of certain assets (see Figure 6). For instance, we placed a high weighting on arterial roads with a higher classification because the sensitivity and exposure of these areas to flood impact creates a higher vulnerability.

Figure 6. Weighted Vulnerability based on Sensitivity/Exposure



Asset Flood Analysis

Each asset is analyzed independently and should be treated as such. The depth of flooding that affects one asset may not affect another asset in the same manner.

Data Limitations

The project focuses on identification of vulnerable areas, infrastructure, populations, and assets. However, give the regional scale of the assessment and other limitations, the assessment does not accomplish what a more localized, scaled down assessment can achieve. The reader should be aware of the project limitations regarding the data, discretion on the evaluation, and level of detail in the project, as detailed below.

Data

- The project scope reflects data availability and data application. For instance, the absence of a region-wide stormwater dataset limits our ability to rigorously analyze potential localized flooding impacts.
- There is difficulty in obtaining reliable and verifiable data to inform the study, and the Council has refined the scope of this project in recognition of these constraints.
- The data used in this assessment is static. The analysis represents a snapshot in time and is not dynamic. The assessment will need to be renewed to remain current and relevant to everyday planning and investment decisions.
- The Council does not have data sources for locally-owned infrastructure. The Council's work on CVA will primarily assess Council assets.
- The LIDAR data which creates the digital elevation model (DEM) needed for the bluespot data layer is from 2011. Developments or topographical changes that occurred after 2011 may not

show accurate bluespots. Also, there are some areas within the data that may not be correct due to other errors within the data.

Discretion

- The assigning of hazard thresholds was determined internally and is discretionary, based primarily through staff discussions and review of agency literature on, for instance, flooding hazards at various depths.
- The weighting of hazards in relation to exposure/sensitivity values was determined internally and is discretionary, varied by asset, and was decided through discussions with subject matter experts.

Detail

- The basemaps are useful as a screening and planning tool for community or stakeholder use. We encourage users to perform more site-specific analysis to ground-truth data. Users are encouraged to create their own hazard thresholds, vulnerability weightings, and strategies based on their own priorities and scope.

Metro Green Line LRT track after a rain storm.

Localized Flooding Example

Metropolitan Council Employment Center Facilities

Rationale

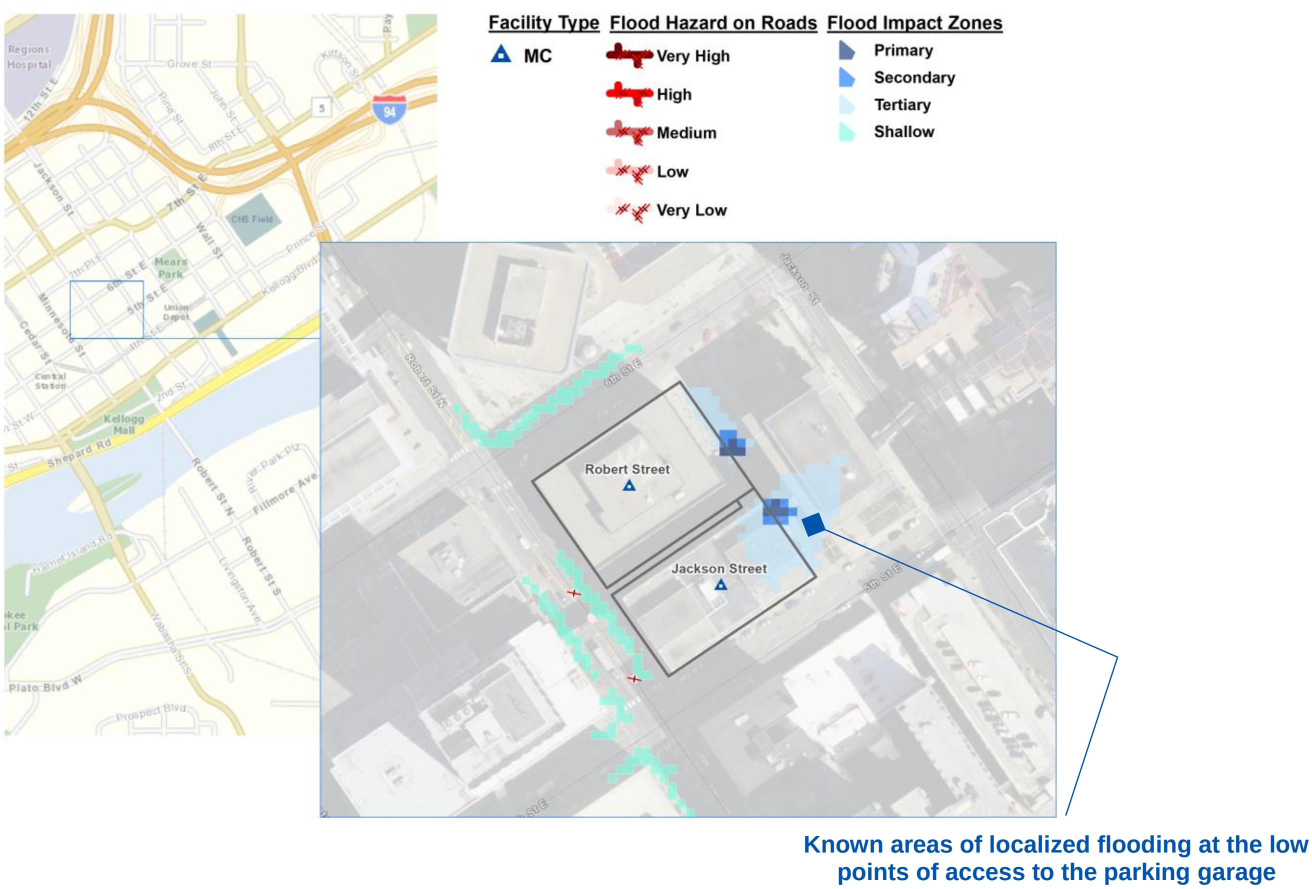
The Metropolitan Council employs approximately 4,250 staff, and most of these staff are transit operators or work at eight wastewater treatment facilities. The two main buildings for Council administration are Regional Administration, 390 N. Robert Street in downtown St. Paul and Metro Transit's administrative headquarters at the Heywood Office, 560 6th Ave North, Minneapolis. The Heywood Office, Metro Transit's headquarters, employs 725 administrative and clerical staff. The analysis here focuses on the main employment center facilities of the Metropolitan Council, including Metro Transit. An analysis of transit facilities and wastewater facilities is included in the Transportation & Transit Chapter and the Wastewater Chapter of the CVA, respectively.

Methodology

The employment center facilities analysis is performed by determining the percent of facility parcel covered by the Flood Impact Zones (FIZ). Each FIZ represents a different level of vulnerability and was treated separately during analysis. The complete FIZ layer was added to the site to capture only the FIZ locations on the facility site. The area of each FIZ within a parcel was divided by the total area of the site, to calculate percent coverage of each Flood Impact Zone at each facility.

Employment center facilities - Robert Street, Jackson Street, Metro 94, and the Regional Maintenance Facility - were analyzed. Employment center facilities have heavy car and pedestrian traffic to and from parking areas. Small amounts of flooding can have a detrimental impact on accessibility to a building because as little as 6 inches of flowing water can pose a risk for pedestrians, especially children.

Figure 7. Robert and Jackson Street Offices - Potential Localized Flood Vulnerability



Analysis

Potential localized flooding impact is relatively low to all employment center facilities; the highest percentage FIZ is 18.62%, at Jackson Street. Most of the Jackson Street potential impact is Tertiary or Shallow. Tertiary flooding is unlikely to occur as the Primary and Secondary areas would need to flood first. The Regional Maintenance Facility carries 2.84% Primary FIZ coverage, with a total coverage of 5.79% for all FIZ. This a low level of coverage for a facility site, but the Primary areas should be closely analyzed given the potential impact to pedestrians trying to access the site.

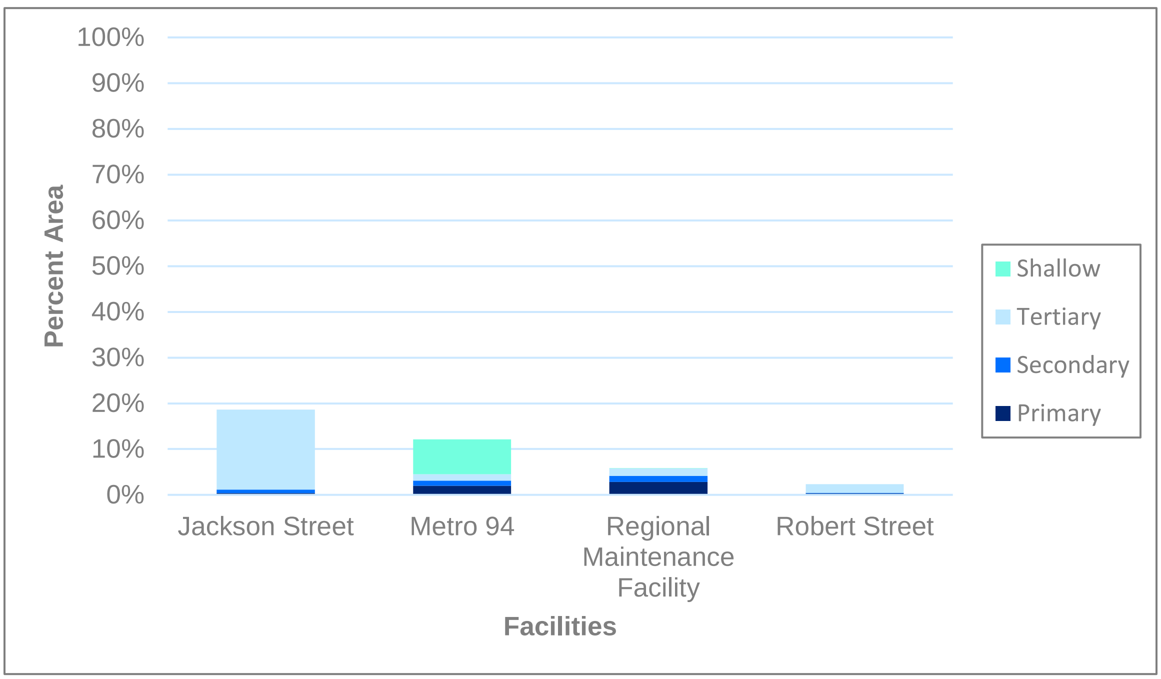
Table 4. Percent of Employment Centers Facility Parcel Area Covered by FIZ.

Facility	Primary % Parcel	Secondary %	Tertiary %	Shallow %	Total FIZ %
Jackson Street	0.37%	0.75%	17.50%	0.00%	18.62%
Metro 94	2.02%	1.11%	1.35%	7.64%	12.12%
Regional Maintenance Facility	2.84%	1.30%	1.60%	0.05%	5.79%
Robert Street	0.33%	0.10%	1.94%	0.00%	2.37%

Considerations

Flood hazards may impact access to facilities via roads. There is little impact present near Robert Street and Jackson Street, as seen in Figure 7. However, known areas of localized flooding (Primary FIZ) appear near access to the below grade parking garage. Metro 94 has potentially impaired road access to the northeast of the facility. The Regional Maintenance Facility does not have impaired road access in close proximity of the facility. The potential risk posed by FIZ to facilities and road networks differs by facility type, function, and employment level.

Figure 8. Percent of Employment Center Facility Parcels within Flood Impact Zones



Existing Strategies

The Metro Transit Security and Emergency Preparedness Plan functions to ensure internal and external coordination and preventative measures that embrace hazard mitigation in line with an all-hazards approach to emergency management across Council facilities.

Potential Strategies

While Metropolitan Council has robust protocols and procedures in place for hazard mitigation, it is advised that the localized flooding data be used for a focused, site-by-site assessment of potential localized flooding risk at all employment center facilities. The localized flooding data should also be utilized to ensure employee safety at all facility locations, both within the buildings and employee parking areas.

Metropolitan Council may consider the following:

- ☐ Conduct a more detailed analysis to address potential impact to employment center facilities
- ☐ Develop strategies to reduce impacts from high vulnerability flood areas
- ☐ Develop specific adaptation strategies to address vulnerabilities on different portions of facility sites (for example, the below grade parking garage at Robert Street)
- ☐ Leverage local knowledge within analysis and strategies, and prioritize interventions at facilities that show higher vulnerability to potential flooding

Shallow flooding in front of Metropolitan Council's Robert Street office, after a rain event. See Figure 7 for map verification of the Shallow FIZ at this location.

Glossary of Terms and Acronyms Used in this Report

CVA Terms

Adaptation – Adaptation focuses on how to change policies and practices to adjust to the effects of climate change.

Adaptive Capacity – Adaptive Capacity is the ability of a system to adjust to changes, manage damages, take advantage of opportunities, or cope with consequences. This assessment does not consider adaptive capacity of particular assets, though this would provide a better estimate of specific vulnerability.

Asset – For the purposes of this analysis, Asset refers to a part of a system – for example, a piece of infrastructure, a bus route, or an arterial roadway.

Bluespot – The bluespot analysis is based on a Danish Road Institute study which uses a GIS fill tool to inundate topographical areas with water to assess areas potentially at risk of flooding. The Council assigned levels of hazard to different flood increments for its bluespot data layer.

Climate – Climate consists of the average weather conditions at a particular place over a long period of time.

Climate Change – A change in global or regional climate patterns that can be identified (e.g., by using statistical tests) and lasts for an extended period, typically decades or longer. According to the Intergovernmental Panel on Climate Change (IPCC), climate change may be due to natural internal processes or external forces such as modulations of the solar cycles, volcanic eruptions, and persistent anthropogenic changes to the composition of the atmosphere or in land use.

Equity – Equity connects all residents to opportunity and creates viable housing, transportation, and recreation options for people of all races, ethnicities, incomes, and abilities so that all communities share the opportunities and challenges of growth and change. For our region to reach its full economic potential, all of our residents must be able to access opportunity. Our region is stronger when all people live in communities that provide them access to opportunities for success, prosperity, and quality of life.

Exposure – Exposure is a degree of climate stress upon a particular asset or indicator; it may be represented as either long-term change in climate conditions, or by changes in climate variability, including the magnitude and frequency of extreme events. In the case of this assessment, sensitivity of a given asset is combined with exposure to produce a relative metric for asset risk.

Flood Impact Zone – The remaining 3 flood hazards divide up the deeper bluespots and make up the Flood Impact Zone (FIZ). Primary are the first areas to fill with water (after the stormwater infrastructure has been overwhelmed). Secondary are the second areas to fill, and Tertiary are the last areas to fill.

Flood Hazard – For this assessment, the Flood Hazards refer to our groupings of bluespots into depth increments, from Shallow to Tertiary.

Hazard Mitigation – Hazard Mitigation is defined as any sustained action taken to reduce or eliminate the long-term risk to life and property from hazard events. It is an on-going process that occurs before, during, and after disasters and serves to break the cycle of damage and repair in hazardous areas.

Indicator – Indicator is used interchangeably with the term ‘asset.’ When the term ‘indicator’ is used, it typically refers to a particular demographic or social group.

Localized Flooding – Distinct from riverine flooding, localized flooding occurs when rain overwhelms drainage systems and waterways, making its way into basements, yards, and streets. It leads to multibillion-dollar damages but often lacks regulatory oversight and is far less studied.

Mitigation – Mitigation focuses on minimizing contributions to climate change – for example, reducing energy use that leads to greenhouse gas emissions.

Potential Impact – The potential impact is a combination of exposure and sensitivity in light of a climate hazard. The potential impact can be offset by adaptive capacity (bounce back).

Resilience – Resilience recognizes the difficulty of predicting what the impacts of climate change will be and emphasizes increasing our flexibility to survive and thrive regardless of how climate change develops. Resilience is the ability of a social or ecological system to bounce back after experiencing a shock or stress. Resilient systems are usually characterized by flexibility and persistence.

Sensitivity – The degree to which a built, natural, or human system will be impacted by changes in climate conditions. In the case of this assessment, sensitivity of a given asset is combined with exposure to produce a relative metric for asset risk

System – Systems that are analyzed are comprised of assets. For instance, the transportation system is comprised of different road classifications, all of which would be considered assets within the system.

Thrive MSP 2040 – Thrive is the Regional Development Framework for the Twin Cities Metropolitan Region. The policy document was adopted in 2014.

Strategies – Strategies are recommendations based on best practices for asset management.

Sustainability – Sustainability means projecting our regional vitality for generations to come by preserving our capacity to maintain and support our region's well-being and productivity over the long-term.

Urban Heat Island Effect – An urban heat island (UHI) is an urban area or metropolitan area that is significantly warmer than its surrounding rural areas due to human activities. The main cause of the urban heat island effect is from the modification of land surfaces. Waste heat generated by energy usage is a secondary contributor.

Vulnerability – The degree to which a system is susceptible to, and unable to cope with, adverse effects of climate change, including climate variability and extremes. Vulnerability is a function of the character, magnitude, and rate of climate change and variation to which a system is exposed, its sensitivity, and its adaptive capacity.

Weather – The daily conditions of the atmosphere in terms of temperature, atmospheric pressure, wind, and moisture.

Acronyms

BNSF – Burlington Northern Santa Fe Railroad
BRT – Bus Rapid Transit
CFR – Code of Federal Regulations
CVA – Climate Vulnerability Assessment
DEM – Digital Elevation Model
DFIRM – Digital Flood Insurance Rate Map
GIS – Geographic Information Systems
GHG – Greenhouse Gas
FEMA – Federal Emergency Management Administration
FAA – Federal Aviation Administration
FIZ – Flood Impact Zone
FRA – Federal Railroad Association
ICS – Incident Command System
LiDAR - Light Detection and Ranging
LGU – Local Governmental Unit
LST – Land Surface Temperature
LRT – Light Rail Transit
MAC – Metropolitan Airports Commission
MC-MTS – Met Council - Metropolitan Transportation Systems
MSP – Minneapolis-St. Paul International Airport
MVTA – Minnesota Valley Transit Authority
NOAA – National Oceanic and Atmospheric Administration
NIMS – National Incident Command System
RBTN – Regional Bicycle Transportation Network
SOP – Standard Operative Procedure
SSPP – System Safety Program Plan
TCC – Transit Control Center
TPP – 2040 Transportation Policy Plan
TP40 – Technical Paper 40 - Rainfall Frequency Atlas
UHI – Urban Heat Island Effect

References

Dayton, Governor Mark. (2016, March 9). *State of the State Address.* Retrieved from https://www.leg.state.mn.us/docs/2016/other/160350.pdf

Danish Road Institute. (2010). *The Blue Spot Method: Development of a Screening Method to Assess Flood Risk on Highways.* Report 183-2010. Retrieved from http://www.klimatilpasning.dk/media/364640/the_blue_spot_model_report_183.pdf

ICAT. (2017). *Adapting to Climate Change in Minnesota: 2017 Report of the Interagency Climate Action Team.* Retrieved from https://www.pca.state.mn.us/sites/default/files/p-gen4-07c.pdf

Metropolitan Council. (2014). *Thrive MSP 2040 – One Vision, One Metropolitan Region.* Retrieved from https://metrocouncil.org/Planning/Projects/Thrive-2040.aspx

National Weather Service. (2018). *Infographic – Power of Water.* Retrieved from https://www.weather.gov/wrn/spring2017-flood-sm

NOAA National Centers for Environmental Information. (2017, April). *Climate at a Glance: U.S. Time Series, Precipitation.* Retrieved from https://www.ncdc.noaa.gov/cag/

Planning Magazine. (2017). *Flood Ready.* Retrieved from https://www.planning.org/planning/2017/nov/floodready/

US Global Change Research Program. (2014). *National Climate Assessment.* Retrieved from http://nca2014.globalchange.gov/report

METROPOLITAN COUNCIL

390 Robert Street North
Saint Paul, MN 55101-1805

651.602.1000
TTY 651.291.0904
public.info@metc.state.mn.us
metrocouncil.org

Follow us on:
twitter.com/metcouncilnews
facebook.com/MetropolitanCouncil
youtube.com/MetropolitanCouncil