

DRAINAGE SYSTEMS ANALYSIS

Flooding Topic Area | Drainage System Capacity Risk Area Prioritization

December 2020

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Flooding Topic Area

Technical Memorandum

Project: Drainage Systems Analysis

Topic Area: Flooding

Deliverable: Drainage System Capacity Risk Area Prioritization

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Abbreviations

BC	Brown and Caldwell
BHC	BHC Consultants, LLC
cf	cubic feet
DSA	Drainage System Analysis
DWW	drainage and wastewater
DWWi	Drainage and Wastewater Investigations
FOMS	Field Operations Mapping System
GIS	geographic information system
NA	not applicable/available
ORC	Operations Response Center
ROW	right-of-way
SPU	Seattle Public Utilities
TM	technical memorandum

1. Introduction

Seattle Public Utilities (SPU) is completing a Drainage System Analysis (DSA) to provide data collection and technical analyses that support the development of the *Shape Our Water Plan* (formerly the *Vision Plan* and *Integrated System Plan)* for the Drainage and Wastewater (DWW) line of business. The DSA will compile and update existing information related to SPU's drainage system and receiving waters, as well as perform new analyses that focus on flooding, climate change impacts, and water quality issues. The DSA efforts are divided into multiple topic areas, including a flooding topic area.

SPU has contracted with Brown and Caldwell (Consultant) to perform technical analyses to support the DSA. SPU staff and the Consultant (collectively, the "DSA Team") worked together to complete several analyses for the flooding topic area. The primary goal of this analysis is to identify and prioritize drainage system capacity risk areas. Risk areas represent areas or locations in the city where inadequate capacity in SPU's drainage system could result in flooding impacts.

The DSA Team identified risk areas through reported incidents, drainage system capacity modeling, and community outreach. Information and approximate geospatial extents for the risk areas were compiled into a Flooding Inventory and prioritized for use in the *Shape Our Water Plan*.

This technical memorandum (TM) documents the Flooding Inventory and the scoring methods used to prioritize the risk areas included in that inventory. Specifically, this TM describes:

- The structure of the Flooding Inventory (Section 2)
- The processes used to identify risk areas and populate data for risk areas in the Flooding Inventory (Section 3)
- The criteria and methods used to score risk areas for prioritization (Section 4)
- The prioritization of drainage system capacity risk areas (Section 5)

2. Flooding Inventory Structure

The Flooding Inventory consists of two elements: a Microsoft Excel workbook and geographic information system (GIS) data. The DSA Team used Microsoft Excel to develop a workbook (i.e., a collection of worksheets) for the Flooding Inventory. The Excel workbook serves as central repository for the data collected on each of the flooding risk areas, as well the prioritization described in this TM. Each entry in the Flooding Inventory represents an identified risk area and is assigned a unique Site ID. The Site ID is used to link entries in the Excel workbook with polygon features, representing the spatial location and extent of each risk area, in the GIS data. Table 2-1 describes how the Excel workbook and GIS data function together and comprise the Flooding Inventory.

Table 2-1. Basic Functions and Structure of the Flooding Inventory

Functions of Excel Workbook	Functions of GIS Data
• Document the purpose and objectives of the Flooding Inventory • Store relevant data and information for risk areas • Characterize potential flooding impacts for each risk area • Calculate risk score with a consistent approach • Sort risk areas according to calculated risk score • Provide summary results, graphs, and visuals • Cite sources of data and information • Provide supplemental information regarding confidence in the original data sources • Maintain data for back-checks and quality reviews • Document procedures for updating and adding new risk areas to the Flooding Inventory	• Show location and spatial extent of risk areas • Preserve Site IDs to link to the Excel workbook • Facilitate geospatial analyses based on overlays with other GIS data layers

2.1 Excel Workbook Structure

The Excel workbook is designed to be a data tool that will be continually maintained and updated over time to track existing and new risk areas. The Excel workbook includes multiple worksheets that are described in this section. Table 2-2 summarizes the worksheets within the Flooding Inventory workbook, grouped by function and listed in order of how they appear in the workbook. The 'Flooding Sites Data' worksheet is the main data input sheet for all information for all risk areas. Data for each site is populated in one of two ways: manual entry or drop-down menus with categories or lists.

The other worksheets perform functions related to the data from 'Flooding Sites Data' worksheet. The colors used in Table 2-2, which match the workbook, identify these functional worksheet groups:

- GREEN: Four worksheets house the information for all drop-down lists and assigned values that are used for scoring throughout the workbook. This include: 'Lists', 'Category Thresholds', 'Ranking Weights', and 'Confidence Criteria.'
- PINK: Three worksheets perform calculations based on the data in 'Flooding Sites Data' worksheet. These include 'Risk Calculations', 'Confidence Calculations', and 'Background-DSA Sites'.
- LIGHT BLUE: Three worksheets summarize or sort the data for all sites in the 'Flooding Sites Data' workbook. These include 'All Sites Data_View & Sort' which shows the data in rows, 'All Sites Data Summary' which shows the data in summary tables, and 'All Sites Dashboard' which shows the data in charts.

Table 2-2. Descriptions of the Worksheets within the Flooding Inventory Workbook

Worksheet Name	Description or Purpose
Mapping	Used to update the GIS data with current attributes for corresponding risk areas. Presents data about each risk area pulled from subsequent worksheets, formatted to facilitate updating the attributes of the GIS data.
ReadMe	Explains the purpose and objectives of the Flooding Inventory. Contains definitions and descriptions of all the worksheets in the workbook as well as definitions and descriptions of data fields used within the worksheets. Provides guidance on how to use each worksheet.
Lists	Consists of drop-down categories used in the 'Flooding Sites Data' worksheet.
Category Thresholds	Lists the relative risk categories (i.e., critical, high) and corresponding overall risk scores (see Section).
Ranking Weights	Defines weighted score for each component of the overall risk score (see Section 4).
Confidence Criteria	Defines confidence levels for some data fields as well as risk areas overall (see Appendix A).
Flooding Sites Data	Catalogs flooding risk areas across the city and characterizes the potential flooding extent and impacts. This worksheet provides the data needed to calculate the risk score (see Section 2.2).
Risk Calculations	Calculates a risk score for each risk area based on the criteria in the Ranking Weights worksheet and data in the 'Flooding Sites Data' worksheet
Confidence Calculations	Assigns confidence levels for each data field and each risk area overall based on the matrix in the Confidence Criteria worksheet and using data from the 'Flooding Sites Data' worksheet.
Background-DSA Sites	Provides a list of risk areas that are categorized as either *Capacity Limitation* or *Incomplete System* in the 'Category of Flooding Problem' data field on the 'Flooding Sites Data' worksheet.
All Sites Data_View & Sort	Lists all risk areas and select information intended for use by the drainage program.
All Sites Data Summary	Provides a tabular summary of the risk area component risk scores, and other select information, as well as summary tables to populate charts in the dashboard.
All Sites Dashboard	Provides visual summaries of the risk area component risk scores.
Removed Flooding Sites	Lists the sites, and information from the 'Flooding Sites Data' worksheet, that were removed from the inventory for several reasons including, (a) the site has been resolved, and (b) the site was further investigated and found to not be an issue.

2.2 Flooding Inventory Data Fields: Flooding Sites Data Worksheet

This section describes the data fields included in the 'Flooding Sites Data' worksheet of the Flooding Inventory. Table 2-3 lists most of the data fields used in the worksheet in the order included in the inventory. See Table 2-4 for information on data sources and notes fields, and Appendix B for a snapshot of the Flooding Sites Data worksheet. Table 2-3 provides the data field name, drop-down categories options, if any, and a description.

Table 2-3. Flooding Sites Data Fields and Descriptions

Data Field	Drop-Down Categories	Description
Site ID	none	The unique ID number, assigned sequentially
Point Address	none	An approximate point address for the risk area location.
Description of Risk Area Extent	none	A brief description of the risk area flooding extent based on available data.
Brief Description	none	Short description of the risk area.
Category of Flooding Problem	• Capacity Limitation • Asset Condition • Maintenance Issue • Incomplete System • Grading Issue • Private Property Issue • Natural Resource Issue	The cause of flooding, to the extent that it is known. Category definitions: • Capacity Limitation: System is undersized, system capacity limitation • Asset Condition: Drainage system damaged, broken, or in poor condition • Maintenance Issue: Debris blocking or clogging inlet, catch basin, pipe, ditch, etc. • Incomplete System: No system exists; system ends (i.e. "pipe to nowhere"). • Grading Issue: Area too low to drain, street settling, improper street grading. • Private Property Issue: Problem generated on private property, private pipe or catch basin causing problem. • Natural Resource Issue: Natural drainage path onto private property; creek issue; groundwater issue.
Additional Information	none	Additional qualitative information not included elsewhere in the inventory
Reviewer	none	Name of the person who reviewed the site – either through a site visit or desktop review for filling the site data fields.
Link to Site folder	none	A link to the network location of a folder, if available, containing information on the risk area.
Type of Property Impact	• Living or commercial space(s) impacted • Crawlspaces, cars, garages, retaining walls, etc. impacted • Driveways, yards, or parking areas impacted • No impact to private property	Potential or documented type of impact on private property. Category definitions: • Living or commercial space(s) impacted: finished interior space damage caused by flooding • Crawlspaces, cars, garages, retaining walls, etc. impacted: unfinished interior space damage, or higher-cost improvements or assets damaged by flooding. • Driveways, yards, or parking areas impacted: low-impact private property areas or lower-cost assets damaged by flooding.

Table 2-3. Flooding Sites Data Fields and Descriptions

Data Field	Drop-Down Categories	Description
Number of Properties Impacted	• More than 5 properties impacted • 2-4 properties impacted • 1 property impacted • No properties impacted	Potential or documented number of properties impacted.
Access to Property	• Access impacted • Access not impacted	Potential or documented impact to access to private property. Category definitions: • Access impacted: flooding makes safe entrance to residential properties or businesses difficult. • Access not impacted: no properties are blocked by flooding
Type of Roadway ROW Impact	• Full Travel Lane • Partial-Travel Lane • Non-Travel Lane • No Impacts in ROW	Potential or documented level of impact on vehicle travel on streets. Category definitions: • Full Travel Lane: Flooding impacts full travel lane: Vehicles must merge out of lane to avoid the flooding. • Partial-travel Lane: Vehicles may be able to avoid or drive through the flooding hazard with care without merging into another lane. • Non-travel Lane: Parking side of road, not affecting drivers directly.
Number of Street Areas in the Right-of-Way (ROW) Impacted	• More than 2 street areas impacted • 2 street areas impacted • 1 street area impacted • No impacts	Potential or documented number of ROW street areas impacted. A "street area" can be a portion of a block up to one block. If flooding at an intersection affects more than one block, then each block it affects is counted as a separate "street area."
Personal Health & Safety Threat	• Threat to personal safety, dangerous conditions caused by flooding not related to mobility (e.g., deep flooding) • No threat to personal safety or public health	Potential or documented flooding impacts create a personal health and safety threat (a hazard that a reasonable, able-bodied person would consider dangerous), mainly due to deep interior flooding. For example, if flooding in a basement is deep enough that a person cannot see the floor, it creates a personal health and safety threat.
Flooding Location: *Critical Facility Impacts*	• Critical facility impacted • No critical facility impacted	Potential or documented flooding impacts a critical facility. A critical facility provides essential services related to human health and safety for people at that location, and can be categorized as one of the following: • emergency service • high population • human services • medical • protective • support • vulnerable populations See Appendix C for information on the primary uses of these facilities.

Table 2-3. Flooding Sites Data Fields and Descriptions

Data Field	Drop-Down Categories	Description
Flooding Location: *Street Type*	• Arterial • Non-Arterial	The type of street with a potential or documented flooding impact.
Flooding Location: *Pedestrian Path*	• Impact occurs on a pedestrian path • No impact occurs on a pedestrian path	Potential or documented flooding impacts pedestrian areas of the ROW. A pedestrian path is defined as a sidewalk or City-installed or marked pedestrian path in the ROW.
Flooding Location: *Bicycle Route*	• Impact occurs on a City-identified bicycle route • No impact occurs on a City-identified bicycle route	Potential or documented flooding impacts City-identified bicycle facilities in the ROW.
Flooding Location: *High-Use Area*	• Impact occurs in an identified high-use area • No impact occurs in an identified high-use area	Potential or documented flooding impacts areas that have high density of pedestrian use. It consists of the following land uses and ROW buffers: • Residential and Hub Urban Villages, including a 50-foot ROW buffer • Urban Center, including a 50-foot ROW buffer • Hospital campuses, including a 50-foot ROW buffer • Colleges and universities, including a 50-foot ROW buffer • Public and private schools, including a 50-foot ROW buffer • Link light rail stops, including a quarter mile ROW buffer • High frequency bus stops, including a 50-foot ROW buffer • Neighborhood greenways
Future Impact	• Difference between existing and future conditions • No difference between existing and future conditions • Unknown	Potential for the risk area to get worse in the future.
Flooding Frequency	• Flooding impacts 4+ times a year • Flooding impacts 1-3 times a year, up to an ~2-year event • Flooding impacts @ 2-year+ event • Flooding impacts @ 5-year+ event • Flooding impacts @ 10-year+ event • Flooding impacts @ 25-year+ event	The frequency at which the flooding impacts are likely to occur. Note that these categories equate to the thresholds used in SPU's DWWi & SPOT programs as follows: • "Flooding impacts 4+ times a year" equates to "During small to moderate rain events (4+ times a year, every year)" • "Flooding impacts 1-3 times a year, up to an ~2-year event" equates to "During moderate to heavy rain events (once a year to three times a year- every year)" • "Flooding impacts @ 2-year+ event" equates to "During infrequent to annual rain events (less than once a year to once every 5 years)" • "Flooding impacts @ 5-year+ event" equates to "During infrequent rain events (once in more than 5 years)"
Equity	• High disadvantage and priority • Medium-high • Medium • Medium-low • Low disadvantage and priority	The relative racial and social equity disadvantage level.

Table 2-3. Flooding Sites Data Fields and Descriptions

Data Field	Drop-Down Categories	Description
2020 DSA Source	• Simulated • DSA outreach • Reported • Reported + simulated • Reported + outreach • Reported + simulated + outreach • Simulated + outreach	The source(s) of information used to identify the risk area and populate the data fields. Category definitions: • Simulated: identified through modeling only (Section 3.2) • DSA outreach: identified through outreach only (Section 3.3) • Reported: identified through incident reporting only (Section 3.1) • Reported + simulated: identified through reporting and overlapping with simulation results • Reported + outreach: identified through reporting and overlapping with outreach response(s) • Reported + simulated + outreach: identified through reporting and overlapping with simulation results and outreach response(s) • Simulated + outreach: identified through modeling and overlapping with outreach response(s)
Crew Hot Spot	• Crew Hot Spot • {blank}	Locations provided through interviews with crew members.

Each of the data fields that are populated with drop-down categories also have up to two adjacent data fields: Data Sources and Notes. These categories, described in Table 2-4, are data fields used consistently throughout the inventory.

Table 2-4. Data Sources and Notes for Flooding Sites Data Fields		
Data Field Descriptor	**Drop-Down categories (multiple-selection allowed)**	**Description**
Data Sources	• Researched Report (with storm info) • Documented Observation (with storm info) • Institutional Knowledge (no storm info) • Customer Knowledge • Desktop Review • Modeling Results • NA	The mode of acquisition for its associated data field. Data sources are used to develop a confidence level in the data. Category definitions: • Researched Report (with storm info): A formal researched report of the flooding site, with the storm level identified. • Documented Observation (with storm info): Documents that clearly record the flooding impact at an identified storm (e.g., dated photos with a written description of the impacts). Documents may be provided by a variety of sources (e.g., customer input, SPU staff site visit, etc.) • Institutional Knowledge (no storm info): Information from SPU staff or consultants with historical knowledge and no dated documentation of the flood impacts. • Customer Knowledge: Information from customers' knowledge of a flooding site, with no dated documentation of the flood impacts. Information may be provided by a variety of sources (e.g., SPU outreach effort, calls to Operations Response Center (ORC), report to Find-It-Fix-It, Service Requests, conversation with a neighbor during a SPU site visit, etc.). • Desktop Review: SPU staff or consultant desktop review of GIS, ortho photos, Google Street View; Field Operations Mapping System (FOMS), and/or a site visit during dry weather with no visible signs of extents of flooding, etc. • Modeling Results: Modeling results that exceed the DSA Performance Threshold. • NA: no data source is available.
Notes	none	Additional information on how the corresponding data field was populated.

3. Drainage System Capacity Risk Areas and Data Fields

The DSA Team identified risk areas based on three sources of information:

- Reported flooding incidents
- Drainage system capacity modeling
- Community outreach

The sources were used to build out the Flooding Inventory, in the order presented above and described in Sections 3.1, 3.2, and 3.3. Reported flooding incidents were the first source of identifying risk areas. After the DSA Team populated the Flooding Inventory with reported flooding incidents, drainage system capacity risk areas identified through modeling were added, and lastly risk areas identified through Community Outreach were added. With each new data source, SPU reviewed areas of overlap and made judgements on how to populate each data field from the available sources. The Flooding Inventory includes the sources used to populate each data field (see Table 2-4).

This section describes how each data source was used to identify and spatially delineate risk areas and populate data fields in the Flooding Inventory. Several additional data fields were populated through a geospatial analysis. That effort is explained in Section 3.4.

3.1 Reported Flooding Incidents

Reported flooding incidents were one source of information used to identify and delineate risk areas. The sections below describe the process to identify and screen reported incidents using available data to include in the Flooding Inventory. Throughout the duration of the DSA, new flooding incidents, identified through community outreach or internal reports were included at the time they were reported. Information on incidents were also updated throughout the DSA if additional information became available.

3.1.1 Data Consolidation

In mid-2018, SPU collected and consolidated information about possible flooding issues throughout the city. This information was both current and historical. Documented sources of information were located in disparate locations throughout SPU's electronic files and systems. SPU staff also had additional undocumented knowledge about flooding issues that was collected through brainstorms and interviews. These sources of information consisted of:

- Localized Flood Control Program issue list from 2012, updated in 2017 (SPU 2018)
- Various locations on SPU's X, J, and Q internal network drives (see Appendix D)
- Several brainstorms from current and past SPU staff, conducted by Susie Walson in 2019 and 2020
- Interviews with SPU office staff familiar with flooding issues, including Sahba Mohandessi, Joe Starstead, Holly Scarlett, Ryan Manning, and Timothy Lowry
- Interviews with SPU surface water maintenance crew chiefs and staff, including Shelly Effrig, Kaniteli Puloka, Logan Lexow, Joo Kim, and Ruby Edwards
- Records of sites previously transferred to Localized Flooding Program, from Drainage and Wastewater Investigations (DWWi) and Spot Drainage programs

- Fact sheets from 2015 produced by a consultant for SPU's Natural Drainage Systems program, specific to flooding in the Thornton and Longfellow creek basins

SPU reviewed these sources of information to determine if they indicated potential flooding and moved all potential sites and relevant information into a single file organized by site ID. This effort resulted in a single, compiled list of 232 potential flooding sites.

3.1.2 Screening Potential Sites for Inclusion in the Flooding Inventory

Next, SPU further screened these potential sites using available data and engineering judgement. This screening included several steps that cumulatively were used to determine if a site should be included in the Flooding Inventory:

- Determining if surface water has a clear pathway to flow into the drainage system without causing flooding issues. This was done by reviewing GIS information of existing drainage infrastructure and topography and/or looking at Google Earth. If it appeared the topography and available infrastructure were adequate, the site was considered for exclusion from the Flooding Inventory.
- Determining if there has recently been a change or development that may have solved, created, or impacted the flooding problem. This was done by reviewing aerial photos in GIS and Google Earth. Aerial views were reviewed in chronological order, if needed. If it appeared the change may have improved or mitigated a flooding issue, the site was considered for exclusion from the Flooding Inventory. If it appeared the change may have caused or worsened a flooding site, the site, with notes, was added to the Flooding Inventory.
- Determining if there have been consistent reports of flooding at this site over the past five years. This was done by reviewing several sources of information, including: GIS data showing the DWW investigations, Spot Drainage, and Spot Drainage archives programs, the "Potential Flooding Areas" GIS layer from the 2012 Localized Flood Control Program list, and drainage-related claims, as well as SPU crew flooding/ponding related workorders in FOMs. If it appeared that the flooding issue may have been a low-level or one-off complaint, the site was considered for exclusion the Flooding Inventory.
- Considering if the site is located in an equity priority area. If a site is located in a relatively high disadvantaged area, consider including the site in the Flooding Inventory when other factors lead to a consideration of excluding the site.
- Determining if the issue has likely been resolved. This was done by reviewing whether it appeared that drainage repair work had been completed to mitigate the flooding issue and also checking that no further complaints had been received after this drainage repair work was completed. If so, the site was considered for exclusion from the Flooding Inventory.
- Determining if separate sites should be combined. Flooding sites in the same location were combined into one site.

This screening effort reduced the number of potential sites from 232 to 111 sites.

3.1.3 Desktop Reviews and Site Visits

The Consultant reviewed the 111 flooding sites that passed SPU's screening by performing desktop reviews. Desktop reviews included reviewing photos, reports, research notes, supporting documents, and if available, correspondence related to the reported flooding incident(s) compiled in each site folder. The Consultant also performed a virtual site walk using Google Earth to help understand the conditions, characterize the problems, assess potential flooding extents, and describe potential impacts. The Consultant used the information and findings from the desktop reviews to populate Flooding Inventory relevant data fields.

In the fall of 2018, SPU staff performed site visits at 19 flooding sites to gather additional information. The sites were chosen primarily based on the level of missing data and the confidence level of the existing data (see Appendix A). Sites with the most data gaps were prioritized for site visits. The site visits were performed by SPU staff familiar with drainage systems field work. The staff were provided with a site information packet with basic information about the flooding site and specific questions to answer from the site visit, as well as a standardized site visit write-up template to complete. SPU staff mobilized for these site visits during rain events when possible. After site visits were concluded, the information gathered was used to update the data in the Flooding Inventory for each site.

3.1.4 Risk Area Delineation

After the desktop reviews, site visits, and populating the data fields were completed, the Consultant used the Point Address and Flooding Sites Data worksheet of the Flooding Inventory to delineate a risk area polygon (see example in Figure 3-1). The Consultant delineated polygons for risk areas that are categorized as either *Capacity Limitation* or *Incomplete System* in the 'Category of Flooding Problem' data field. The DSA Team reviewed the findings and discussed combining overlapping risk areas. Flooding incidents that appeared to be the same problem were combined into a single entry in the Flooding Inventory. The boundaries of those considered separate were revised to not be overlapping. The work described above resulted in a total of 84 drainage system capacity risk areas in the Flooding Inventory.

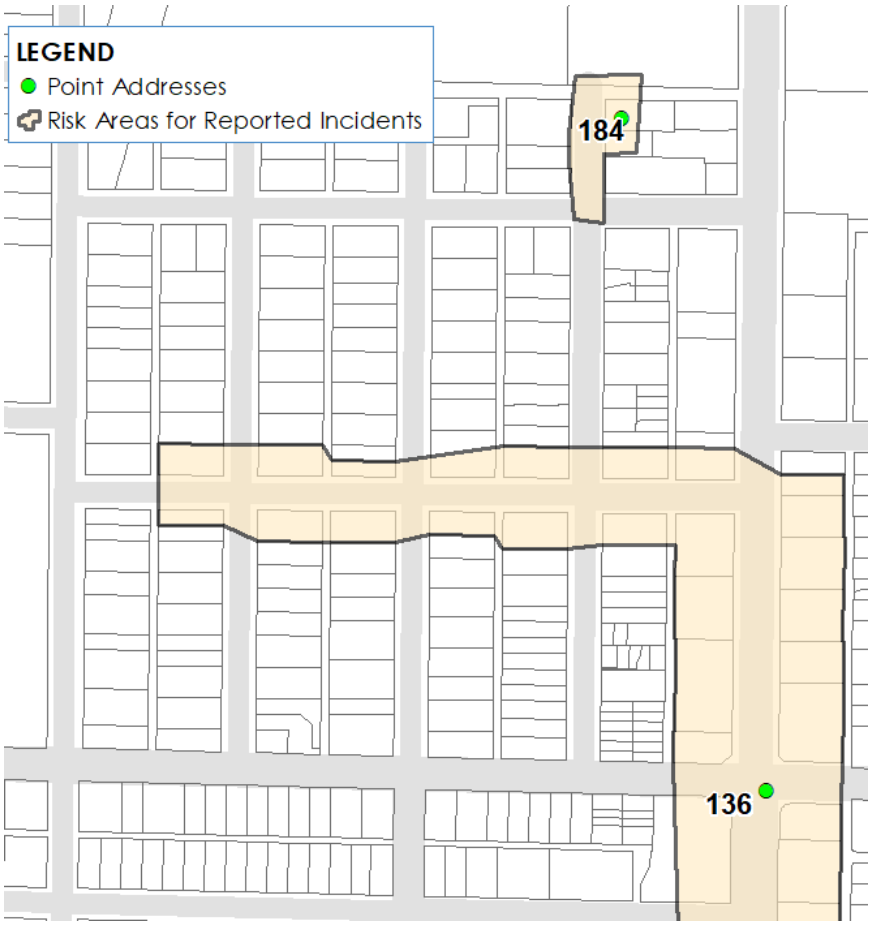


Figure 3-1. Example of Point Address and Polygon Extent of Risk Areas for Reported Incidents

3.2 Capacity Simulation Results

Capacity simulation results were another source of information used to identify and delineate risk areas. SPU has established performance goals for the drainage system:

- Provide adequate capacity in the public drainage system to minimize the risk of flooding into private property.
- Provide adequate capacity in the public drainage system to minimize the risk of flooding in the public ROW.

Performance Thresholds define adequate capacity relative to these performance goals. The DSA Team selected Performance Thresholds for the drainage system, then the Consultant performed hydrologic and hydraulic simulations to evaluate system capacity according to the Performance Thresholds (Brown and Caldwell 2020). The Consultant then used those results to delineate risk areas based on the model results.

SPU developed guidelines for risk area delineation:

- Each risk area should consist of a single polygon that contains at least one SPU-owned asset that exceeds the Performance Thresholds.
- All drainage assets contained within a risk area should be hydraulically connected.
- Risk areas should not overlap.

- The extent of risk area depends on the potential impacts. Where the exceeded Performance Threshold is associated with:
  - ROW impacts, the risk area should match the width of the ROW within which lies the asset.
  - with ROW and private property impacts, the risk area should match the width of the ROW within which lies the asset and the boundaries of the adjacent parcels.
- Risk areas may include assets that meet Performance Thresholds, and the risk area extents along those assets should match the width of the ROW. This was done based on engineering judgment when the pipes on either side were suspected to be related to the same issue.

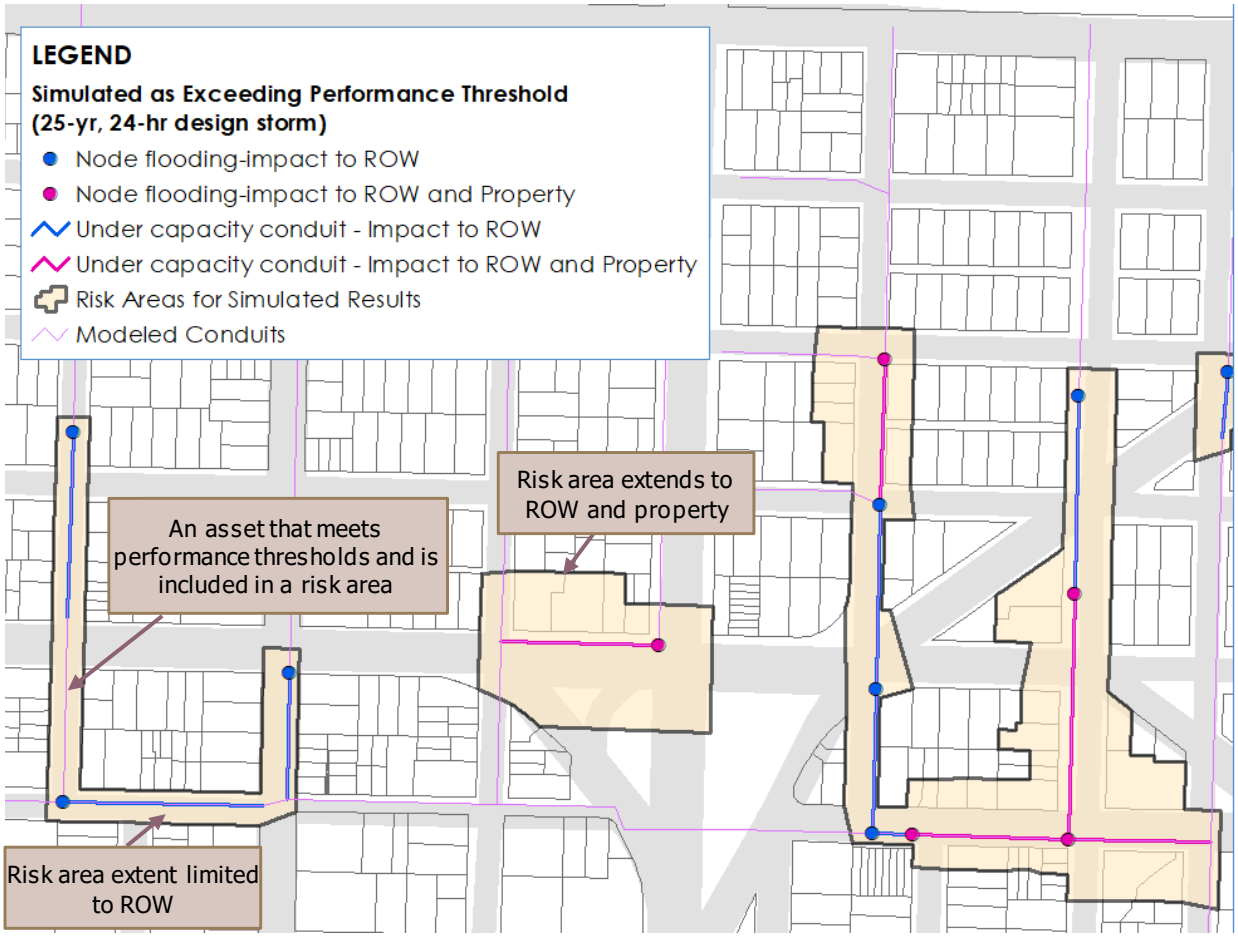


Figure 3-2. Example of Risk Area Delineations for Assets Exceeding Performance Thresholds

The Consultant also excluded isolated, short, smaller diameter conduits (less than 15 feet in length) at the upstream ends of the drainage network. Three hundred and fifteen risk areas were delineated based on the capacity simulation results. After risk area delineations were completed, the Consultant performed geospatial analyses to query simulation results for multiple synthetic storm events, consisting of the 2-, 5-, 10-, 25-, and 50-year, 24-hour design storms under existing conditions and the 25-year, 24-hour design storm under future conditions (Brown and Caldwell 2020).

The query results were used to summarize the following modeling results within each risk area:

- Total flood volume in cubic feet (cf), from all maintenance holes
- For assets that exceed the performance parameters in the Performance Thresholds:
  - Number of pipes
  - Length (ft) of pipes
  - Number of ditches or culverts
  - Length (ft) of ditches or culverts
  - Number of creek culverts
  - Length (ft) of creek culverts
  - Number of ponds

SPU reviewed the simulation-derived risk areas with the reported flooding incident-derived risk areas. Where overlap or close proximity existed, the reported flooding incident-derived risk area data were reviewed considering the simulation results and the drainage system layout. If SPU determined they were the same risk area, the reported flooding incident-derived risk area boundaries were revised and the frequency of the simulation was added to the Flooding Inventory 'flooding frequency' data field. SPU added all non-overlapping simulation-derived risk areas to the Flooding Inventory and used modeling results and geospatial analysis to populate the inventory data fields as shown in Table 3-1.

Table 3-1. Flooding Inventory Data: Risk Areas Identified through Capacity Simulation Results

Inventory Data Field	How Field was Assigned or Populated
Site ID	Assigned after all risk areas were identified and delineated. A unique number was assigned in the geographical order of southwest (SW), southeast (SE), northwest (NW), to northeast (NE).
Point Address	Not used.
Description of Risk Area Extent	Not used.
Brief Description	Assigned: *Simulated risk area based on DSA Performance Threshold.*
Category of Flooding Problem	Assigned: *Capacity limitation.*
Additional Information	Not used.
Reviewer	Not used.
Link to Site folder	Not used.
Type of Property Impact	• *Living or commercial space(s)* impacted assigned if total flood volume >20,000 cf. • *Crawlspaces, cars, garages, retaining walls,* etc., impacted assigned if Total flood volume <20,000 cf and >10,300 cf. • *Driveways, yards, or parking areas* impacted assigned if total flooding volume <10,300 cf.
Number of Properties Impacted	Populated through GIS overlay (Section 3.4).
Access to Property	Assigned: *Access not impacted.*

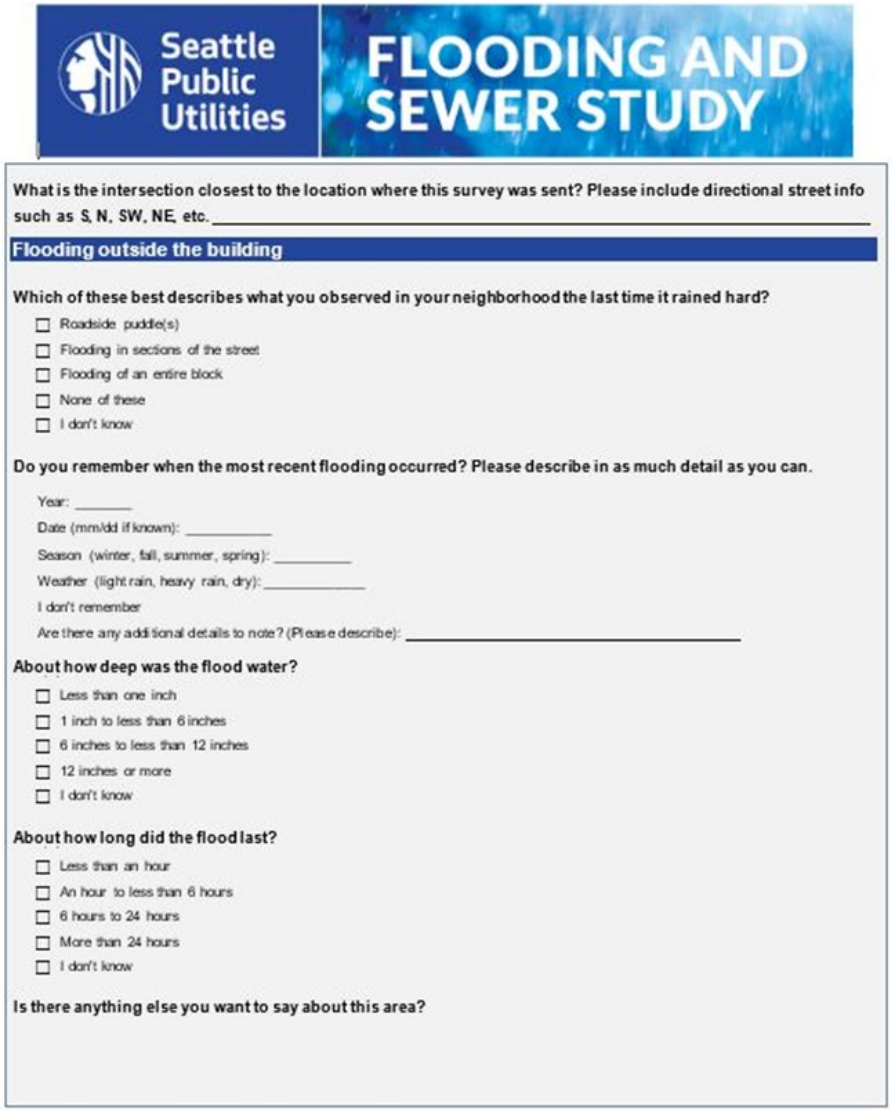
Table 3-1. Flooding Inventory Data: Risk Areas Identified through Capacity Simulation Results

Inventory Data Field	How Field was Assigned or Populated
Type of Roadway ROW Impact	• *Full Travel Lane* assigned if any pipes exceeded the Performance Threshold. • *Non-travel Lane* assigned if the Performance Threshold exceeded by any non-pipe asset.
Number of Street Areas in the ROW Impacted	Populated through GIS overlay (Section 3.4).
Flooding Location: • Critical Facility Impacts • Street Type • Bicycle Route • High-Use Area	Populated through GIS overlay (Section 3.4).
Future Impact	• *Difference between existing and future conditions* assigned if any additional assets, from future conditions modeling, within the risk area exceed the Performance Threshold. • *No difference between existing and future conditions* assigned if no additional assets with the risk area exceed the Performance Threshold.
Frequency	Assigned one of the following, based on the most frequent for which the Performance Threshold was exceeded for any of the assets within the risk area: • *Flooding impacts @ 2-year+ event* • *Flooding impacts @ 5-year+ event* • *Flooding impacts @ 10-year+ event* • *Flooding impacts @ 25-year+ event*
Equity	Populated through GIS overlay (Section 3.4).

3.3 Community Outreach

Community outreach was a third source of information used to identify risk areas and populate data fields. The DSA included community outreach activities to supplement the capacity analysis and previously reported flooding incidents. Residents and businesses were identified based on modeling analysis results that indicated a higher likelihood of experiencing flooding and then were refined based on several factors. A description of the outreach efforts, including outreach goals and methods, can be found in *Drainage System Analysis, Flooding Topic Area, Community Outreach* (SPU 2020a). Responses from residents and business owners helped SPU determine if they experienced flooding due to drainage system capacity issues. This section provides an overview of the primary outreach tool, responses received, and how the responses were used to update risk areas, identify new risk areas, and populate Flooding Inventory data fields.

Outreach data were primarily collected using a questionnaire. The questionnaire served multiple purposes outside the DSA. The drainage system capacity related questions are shown in Figure 3-3.



Seattle Public Utilities FLOODING AND SEWER STUDY

What is the intersection closest to the location where this survey was sent? Please include directional street info such as S, N, SW, NE, etc. _____

Flooding outside the building

Which of these best describes what you observed in your neighborhood the last time it rained hard?

- ☐ Roadside puddle(s)
- ☐ Flooding in sections of the street
- ☐ Flooding of an entire block
- ☐ None of these
- ☐ I don't know

Do you remember when the most recent flooding occurred? Please describe in as much detail as you can.

Year: _____
Date (mm/dd if known): _____
Season (winter, fall, summer, spring): _____
Weather (light rain, heavy rain, dry): _____
I don't remember
Are there any additional details to note? (Please describe): _____

About how deep was the flood water?

- ☐ Less than one inch
- ☐ 1 inch to less than 6 inches
- ☐ 6 inches to less than 12 inches
- ☐ 12 inches or more
- ☐ I don't know

About how long did the flood last?

- ☐ Less than an hour
- ☐ An hour to less than 6 hours
- ☐ 6 hours to 24 hours
- ☐ More than 24 hours
- ☐ I don't know

Is there anything else you want to say about this area?

Seattle Public Utilities FLOODING AND SEWER STUDY

Flooding in your home or workplace

Have you ever experienced flooding in your home or workplace at this location?: yes, no, I don't know

The last time it flooded, what did you observe? Please check all that apply.

- ☐ Backup through floor drain or toilet
- ☐ Leaking or dripping into basement
- ☐ Burst water pipe
- ☐ Water came in from outside
- ☐ I don't remember
- ☐ Other (Please describe): _____

Do you remember when the most recent flooding occurred? Please describe in as much detail as you can:

- ☐ Year: _____
- ☐ Date (mm/dd if known): _____
- ☐ Season (winter, fall, summer, spring): _____
- ☐ Weather (light rain, heavy rain, dry): _____
- ☐ I don't remember
- ☐ Are there any additional details to note? (Please describe): _____

Where did the flooding occur? Please check all that apply.

- ☐ Ground floor/first floor
- ☐ Basement
- ☐ Garage
- ☐ Space under house (crawlspace)
- ☐ Living space
- ☐ Yard, side walkway or driveway
- ☐ Other (Please describe): _____
- ☐ I don't know

Did flooding cause property damage?: yes or no

How many times has flooding occurred in the past year?

- ☐ Not within the past year
- ☐ Once
- ☐ Twice
- ☐ Three or more times
- ☐ I don't know

To your knowledge, this is an issue that affects...

- ☐ Only your property
- ☐ Nearby neighbors also
- ☐ I don't know the extent of the issue

Figure 3-3. Drainage System Capacity-Related Questions on Community Outreach Survey

Outreach responses were compiled into an Excel spreadsheet and organized by the questionnaire subgrouping. Responses to "Flooding outside the building" were considered to represent impacts to the ROW. Responses to "Flooding in your home or workspace" were considered to represent impacts to private property. Responses were reviewed and given an initial category from the 'Category of Flooding Problem' drop-down categories of the Flooding Inventory (Table 3-2). In all instances, if the type of problem could not be determined, it was assigned to the DSA Capacity Limitation category so that it would be included in responses to be further reviewed.

Table 3-2. Initial Problem Categories Assigned to Outreach Responses

Initial Category	Basis of Assigning Initial Category	Response Type	
		Private Property	ROW
DSA Capacity Limitation[a]	• Response indicated flooding impacts where there is a pipe, ditch, or culvert. • If the response did not clearly fit into any of the other categories, it was assigned to this category.	✔	✔
DSA Incomplete System[a]	Response indicated flooding impacts where: • there is no pipe, ditch, or culvert, and • the wastewater system permitted flow is sanitary.	✔	✔
WWSA and DSA Capacity Limitation[a]	In the separated system and based on responses of: • a backup through a floor drain or toilet • water coming in from the outside	✔	
Grading Issue	Response indicated: • street settling near inlets • not enough inlets • flat streets		✔
Maintenance Issue	Response indicated debris/leaves blocking or clogging an inlet or culvert.	✔	✔
Natural Resource Issue	Response indicated flooding due to groundwater (year-round) or a creek.	✔	✔

a. Included in DSA drainage system capacity risk areas.

The responses were mapped as GIS point locations based on geospatial data provided and written responses. The responses categorized as a potential capacity problem (initial categories of DSA Capacity Limitation, DSA Incomplete System, and WWSA and DSA Capacity Limitation) were reviewed with maps of risk areas already in the Flooding Inventory:

- **Where overlap existed** (based on a 50-foot buffer around the response point), the previously mapped risk area data were reviewed with the outreach response and drainage system layout data in UtiliView, SPU's general purpose GIS viewer and research tool. If information indicated they were the same risk area, the boundaries of the risk area were reviewed and modified, if needed, and information from the outreach response was added to the Flooding Inventory.
- **Where no overlap existed,** the outreach response was reviewed with the drainage system layout data in UtiliView and Google Street View to determine if it should be included as a new capacity risk area. New capacity risk areas were delineated using all the information in the response and according to the general approach based on responses to specific questions, as shown in Table 3-3.

Table 3-3. General Approach for Delineating Risk Area Extent from Outreach Responses

Response Data Point(s)	Risk Area Extent[a]

Single property response	• If point is on a parcel:
	  • Draw boundary around the parcel.
	  • If the response indicated the issue affects nearby neighbors also, draw boundary around two or more adjacent parcels.
	• If point is at intersection (most of them):
	  • If the response indicated only one property was impacted, draw boundary around parcels in each corner and the ROW in between.
	  • If the response indicated the issue affects nearby neighbors also, draw boundary around two or three parcels on each block of the intersection and the ROW in between.

Single ROW response	• Point location. • Response to description of what was observed: flooding in sections of the street or flooding of an entire block. • Response to: Is there anything else you want to say about this area?
Grouped responses data	• Review responses to determine if same issue. • Follow same approach for a single point. • Join the areas with the adjacent ROW.

a. For all Risk Area extent delineations, outreach response location and response were reviewed with UtiliView and Google Street View

When the delineations were complete, there were 447 drainage system capacity risk areas in the Flooding Inventory–102 of them were informed by outreach responses. The Flooding Inventory data fields were populated based on the entire response, or responses, if there were multiple responses used to delineate the risk area. Table 3-4 shows how each data field was assigned or populated. When more than one answer was given to explain the flooding impact (e.g. flooding occurred in a basement and a living space), the data field was populated with the response that represented the greater impact.

Table 3-4. Flooding Inventory Data for Risk Areas Identified through Community Outreach

Data Field	How Field was Assigned or Populated[a]
Site ID	Assigned after all risk areas were identified and delineated. A unique number was assigned in the general geographical order of SW, SE, NW, NE.
Point Address	Populated based on address information provided in the response or the closest intersection as surveys requested respondents provide this.
Description of Risk Area Extent	Populated based on all the information in the response.
Brief Description	Not used.
Category of Flooding Problem	• *Capacity Limitation*, *Incomplete System*, or *Grading Issue*; individually or a combination of two or more. • *Maintenance Issue* with one or more of the above categories. Based on all the information provided, and reviewed drainage system GIS data and Google Street View.
Additional Information	Not used.

Table 3-4. Flooding Inventory Data for Risk Areas Identified through Community Outreach

Data Field	How Field was Assigned or Populated[a]
Reviewer	Name of SPU engineer who populated the data fields based on the survey response.
Link to Site folder	Not used.
Type of Property Impact	Based on the response to "Where did the flooding occur?" • *Living or commercial space(s) impacted assigned when response was one of the following:* - Living space - Ground floor/first floor • *Crawlspaces, cars, garages, retaining walls, etc., impacted assigned when response was one of the following:* - Basement - Garage - Space under house (crawlspace) - Yard, side walkway or driveway When more than one response was provided, the response that resulted in a larger score was assigned.
Number of Properties Impacted	Based on the response to "To your knowledge, this is an issue that affects (1) I don't know the extent of the issue; (2) Nearby neighbors also; (3) Only your property." • *1 property* impacted assigned when response was one of the following: - I don't know the extent of the issue. - Only your property. • *2-4 properties impacted assigned when the response was: Nearby neighbors also.* • *No properties impacted assigned when the response was about ROW impacts only.*
Access to Property	Assigned *Access not impacted* or *NA* (if unknown).
Type of Roadway ROW Impact	• *Full Travel Lane*, *Partial Travel Lane*, *Non-travel Lane* assigned based on review of complete response, drainage system layout and topography. • *No impacts in ROW* assigned when response was about private property impacts only.
Number of Street Areas in the ROW Impacted	Populated through GIS overlay (Section 3.4).
Flooding Location: • Critical Facility Impacts • Street Type • Bicycle Route • High-Use Area	Populated through GIS overlay (Section 3.4).
Future Impact	Assigned *NA*
Frequency	Based on responses to the following questions: • "How many times has flooding occurred in the past year?" • "Do you remember when the most recent flooding occurred?" Assigned *@ the 10-year+ event* when response was "not within the last year"
Equity	Populated through GIS overlay (Section 3.4).
Data Source	Assigned *Customer Knowledge (no storm info).*

a. Full survey responses were reviewed when determining how to assign or populate the data fields.

Table 3-5 summarizes the number of outreach responses received and used to inform risk areas, taking into account that grouped responses may have provided information for a single risk area.

Table 3-5. Number of Outreach Responses Used to Inform Risk Areas

Responses	Number
Received	868
Received, that indicated no problem	625
Used to inform a risk area	171

Table 3-6 shows the number of risk areas informed by outreach responses.

Table 3-6. Number of Risk Areas Informed by Outreach Responses

Risk Area Basis	Number
Outreach responses only	70
Reported flooding incident, with overlapping outreach responses	711
Capacity simulation results, with overlapping outreach responses	212
Reported flooding incident and capacity simulation results, with overlapping outreach responses	4

3.4 Geospatial Analysis

After risk areas were identified and delineated, and data fields populated with the available information, the remaining data fields were populated through geospatial analysis. The Consultant used geospatial tools in ArcGIS (Esri 2020) to overlay risk area polygons with the other spatial data to generate data field inputs. For example, intersecting tax parcel polygons (King County 2018) with risk area polygons provides an estimate of the number of impacted properties.

Table 3-7 lists each of the geospatial overlays with the source data and methods used to populate each data field. For risk areas identified through reported flooding incidents and community outreach, geospatial data were only included if the data field was empty.

Appendix E provides the ArcGIS Model Builder inputs, outputs, and geoprocesses flowchart for each data field. Appendix C provides additional information on the source data.

Table 3-7. Geospatial Methods Used to Populate Flooding Inventory Data Fields

Data Field	Source Data[a]	Methods
Number of Properties Impacted	King County parcels	• Intersect parcel polygons with risk area polygons • Count intersected features
Number of Street Areas in the ROW Impacted	street type	• Intersect street polygons with risk area polygons • Count intersected features
Critical Facility Impacts	critical facilities	• Intersect critical facility parcel polygons with risk area polygons • Check if intersect = true

Table 3-7. Geospatial Methods Used to Populate Flooding Inventory Data Fields		
Data Field	**Source Data[a]**	**Methods**
Street Type	street type	• Intersect street type polygons with risk area polygons • Check for snow and ice routes with intersect = true, then "arterial" • Check for other street routes with intersect = true, then "non-arterial"
Bicycle Route	bicycle route	• Intersect bicycle route polygons with risk area polygons • Check if intersect = true
High-Use Area	high use area	• Intersect high use area polygons with risk area polygons • Check if intersect = true
Equity	Racial and Social Equity Composite Index-2018	• Intersect equity polygons with risk area polygons • Assign equity category (1-5) based on intersected area with highest category of disadvantage

a. See Appendix C for detailed information on source data.
b. Intersected areas small then than threshold were excluded.

3.5 Drainage System Capacity Risk Areas Identified

Table 3-8 summarizes the number of risk areas based on the combination of data sources that informed the identified and delineation of risk areas. The work described above resulted in a total of 447 drainage system capacity risk areas in the Flooding Inventory.

Table 3-8. Number of Drainage System Capacity Risk Areas by Data Source	
Data Source(s)	**Number of Risk Areas**
Capacity simulation results only	272
Community outreach only	70
Reported flooding incidents only	55
Reported + simulated	18
Reported + outreach	7
Reported + simulated + outreach	4
Simulated + outreach	21
All	447

4. Risk Scores

SPU developed an approach to calculating risk scores based on factors of consequence, likelihood, and equity. Scoring methods and criteria were developed based on methods outlined in SPU's *Risk Assessment Framework* (SPU 2007), staff subject matter expertise, and a review of past prioritization criteria developed and applied by SPU (SPU 2020b).

The basic equation for calculating risk scores is as follows:

$$Risk\ Score\ = (Consequence\ Score\ \times\ Likelihood\ Score) + Equity\ Score$$

where

Maximum consequence score = 5
Maximum likelihood score = 5
Equity score ranges between 1 and 5

The resultant maximum possible risk score is 30. The consequence score is a sum of all the consequence components, which are each a data field in the Flooding Inventory. When the component scores were developed, scoring methodologies from existing and previous flooding programs were considered, as well as the method developed for the WWSA.

Table 4-1 lists numerical scores for each of the consequence, likelihood, and equity data fields in the Flooding Inventory. Not are all data stored in the inventory are used in the risk score.

Table 4-1. Scores for Flooding Inventory Data Fields

Inventory Data Field	Drop-Down Category	Score
Consequence		
Type of Property Impact	Living or commercial space(s) impacted	0.85
	Crawlspaces, cars, garages, retaining walls, etc., impacted	0.5
	Driveways, yards, or parking areas impacted	0.25
Number of Properties Impacted	More than 5 properties impacted	0.55
	2-4 properties impacted	0.5
	1 property impacted	0.25
Access to Property	Access impacted	0.15
Type of Roadway ROW Impact	Full Travel Lane	0.85
	Partial-travel Lane	0.75
	Non-travel Lane	0.25
Number of Street Areas in the ROW Impacted	More than 2 street areas impacted	0.7
	2 street areas impacted	0.5
	1 street area impacted	0.25
Flooding Locations:		
Critical Facility Impacts	Critical facility impacted	0.6
Street Type	Arterial	0.6
	Non-arterial	0

Table 4-1. Scores for Flooding Inventory Data Fields		
Inventory Data Field	**Drop-Down Category**	**Score**
Bicycle Route	Impact occurs on a city-identified bicycle route	0.3
High-Use Area	Impact occurs in an identified high-use area	0.3
Future Impact	Difference between existing and future conditions	0.1
Likelihood		
Flooding Frequency	Flooding impacts 4+ times a year	5
	Flooding impacts 1-3 times a year, up to a ~2-year event	5
	Flooding impacts @ 2-year+ event	4
	Flooding impacts @ 5-year+ event	3
	Flooding impacts @ 10-year+ event	2
	Flooding impacts @ 25-year+ event	1
Equity		
Equity	High disadvantage and priority	5
	Medium-high	4
	Medium	3
	Medium -low	2
	Low disadvantage and priority	1

5. Capacity Risk Area Prioritization

Risk areas were prioritized using the risk scores calculated as described in Section 4. Before the risk scores were finalized, SPU held a workshop with internal SPU stakeholders of the Flooding Inventory and completed a Racial Equity Toolkit. Highlights of these two efforts are included in Sections 5.1 and 5.2

5.1 Risk Score Review

The process to review the risk scores included a workshop with internal SPU stakeholders. Aspects of the inventory that were considered during the workshop included:

- Confirm weighting of consequence components was reasonable based on a sensitivity analysis.
- Review distribution of risk scores from several perspectives to determine if the distributions seemed appropriate.
- Define relative risk categories based on ranking score.

Workshop participants ultimately made no adjustment to either the components or the overall risk scores. Relative risk categories were assigned based on the risk scores as shown in Table 5-1. See Appendix F for additional details about the workshop.

Table 5-1. Risk Categories and Scores

Relative Risk Category	Risk Score Range
Low	0–6
Medium Low	6–9
Medium	9–12
High	12–15
Critical	>15

5.2 Racial Equity Toolkit

SPU completed a modified Racial Equity Toolkit to evaluate the impact of implementing the Equity Strategy for Analysis Projects (Appendix H) on the drainage system capacity risk areas prioritization. The toolkit consisted of the following:

- Reviewing several SPU and City Racial Equity Toolkit resources for use when thinking through equity in our work
- Reviewing several project resources to provide background on the drainage system capacity risk area prioritization
- Reviewing a series of maps and discussing:
  - What were the impacts of how we implemented the equity strategy?
  - Is the approach setting us up for addressing disparate system impacts with our *Shape Our Water* planning effort?
  - Are there recommended improvements?

The toolkit showed that that implementation of the equity strategy resulted in:

- The identification of risk areas that would not have been identified otherwise.
- Increased prioritization of risk areas in Highest Disadvantaged areas.
- No recommendation to adjust the prioritization for the DSA.
- Recommendation to evaluate the use of racial and social equity data at a scale finer than the census tract, for *Shape Our Water*.

See Appendix G for additional details about the Racial Equity Toolkit.

5.3 Risk Area Prioritization

Overall distribution of scores for consequence, likelihood, equity and total risk score are summarized in Figure 5-1. In summary:

- 1% of the risk areas had a consequence score greater than 4.
- 11% of the risk areas had a likelihood score of 5, signifying flooding impact several times a year.
- 38% of the risk areas fell in the highest priority/most disadvantaged category of the equity score.
- Risk scores ranged from about 2.5 to 24 with most of the risk areas having scores in the range of 5.5 to 8.5.
- The distribution was a right-skewed distribution curve, meaning there are more lower-scoring risk areas than higher-scoring risk areas.
- 54 risk areas (12% of the total number of risk areas) were categorized as critical and received a combined risk score greater than or equal to 15.
- Risk areas, by relative risk category, are shown in Appendix I. Areas mapped as "very low" risk fall within SPU's drainage basin models and were found to meet the Performance Thresholds. Risk areas categorized as critical made up 44% of the total area of all risk areas.
- Risk areas are closely split between the south end and the north end of the city. The south end has approximately 20 more risk areas and these fall mainly in the medium-low and low risk categories.

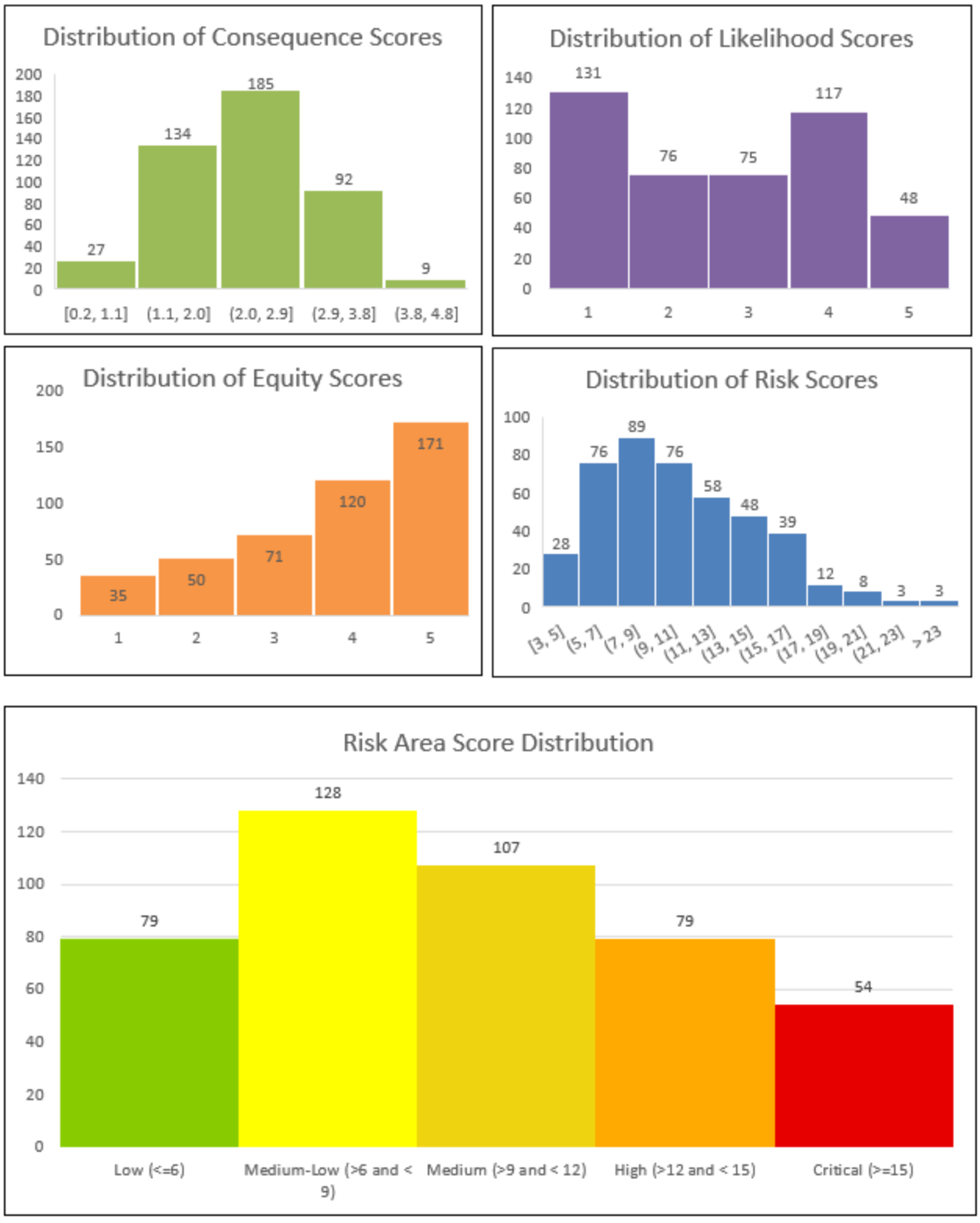


Figure 5-1. Distribution of Consequence, Likelihood, Equity, and Total Risk Score

References

Brown and Caldwell (2020). *Drainage Systems Analysis, Flooding Topic Area, Drainage System Capacity Evaluation*. Prepared for Seattle Public Utilities, September 4, 2020.

Esri (2020). ArcMap 10.8 Software with Spatial Analyst Extension.

King County (2018). King County Open Data ArcGIS. Downloaded from website on June 21, 2018: *https://gis-kingcounty.opendata.arcgis.com/datasets/8058a0c540434dadbe3ea0ade6565143_439*

SPU. 2020a. *Drainage System Analysis, Flooding Topic Area, Community Outreach*. October 2020.

SPU. 2020b. GIS data for Risk Mapping and Prioritization for the System Analyses Projects. Memorandum from Colleen O'Brien to project file, dated July 17, 2020.

SPU. 2018: *Localized Flooding Database*. Last updated on 8/16/2018 by Susie Walson. Available at: https://seattlegov.sharepoint.com/sites/spu-D1/DSA/PPL/2018-08-16_DataMigrationSiteList_password%20is%20DSA.xlsx

SPU. 2007. Risk Assessment Framework

Appendix A: Data Confidence

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As described in Section 3 of this TM, the DSA team used multiple data sources to populate the data fields in the Flooding Inventory. The DSA team assigned a confidence level to each data source. Table A-1 describes how confidence levels were assigned based on the data sources used to populate the fields. Since the Flooding Inventory is set up to allow multiple data sources to be selected, the highest confidence level of all the sources selected was used.

Table A-1. Descriptions and Confidence Levels for Each Data Source

Data Source	Description	Confidence Level
Researched Report (with storm info)	A formal researched report of the flooding site, with the storm level ID'd. The report may be prepared by SPU or a consultant.	High
Documented Observation (with storm info)	Documents that clearly record the flooding impact at an identified storm (e.g., dated photos with a written description of the impacts). Documents may be provided by a variety of sources (e.g., customer input, SPU staff site visit, etc.).	High
Institutional Knowledge (no storm info)	Information from SPU staff or consultant's historical knowledge of a flooding site, with no dated documentation of the flood impacts.	Low
Customer Knowledge (no storm info)	Information from customers' knowledge of a flooding site, with no dated documentation of the flood impacts. Information may be provided by a variety of sources (e.g., SPU outreach effort, calls to ORC, report to Find-It-Fix-It, service requests, conversation with a neighbor during a SPU site visit, etc.)	Low
Desktop Review	SPU staff or consultant inferred scoring (desktop review of GIS, ortho photos, Google Street View; mapping tools, site visit during dry weather with no visible signs of extents of flooding, etc.).	Low
Modeling Results	Modeling results that exceed the DSA Performance Threshold.	Low

The DSA team also assigned a confidence level, or group, to each risk area. The confidence group of a risk area is based on whether all data fields had an entry, and if there were any high confidence level data sources. Table A-2 describes how each confidence group is determined.

Table A-2. Descriptions Risk Area Confidence Groupings

Confidence Group	Description
0	No data gaps, and all data fields have high-level confidence data sources.
1	No data gaps, and some data fields have high-level confidence data sources.
2	No data gaps, and all data fields have low-level confidence sources.
3	Some data gaps, and some data fields have high-level confidence data sources.
4	Some or all data gaps, and all data fields have low-level confidence data sources.
5	No data available for all data fields.

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Appendix B: Flooding Inventory, Flooding Sites Data Snapshot

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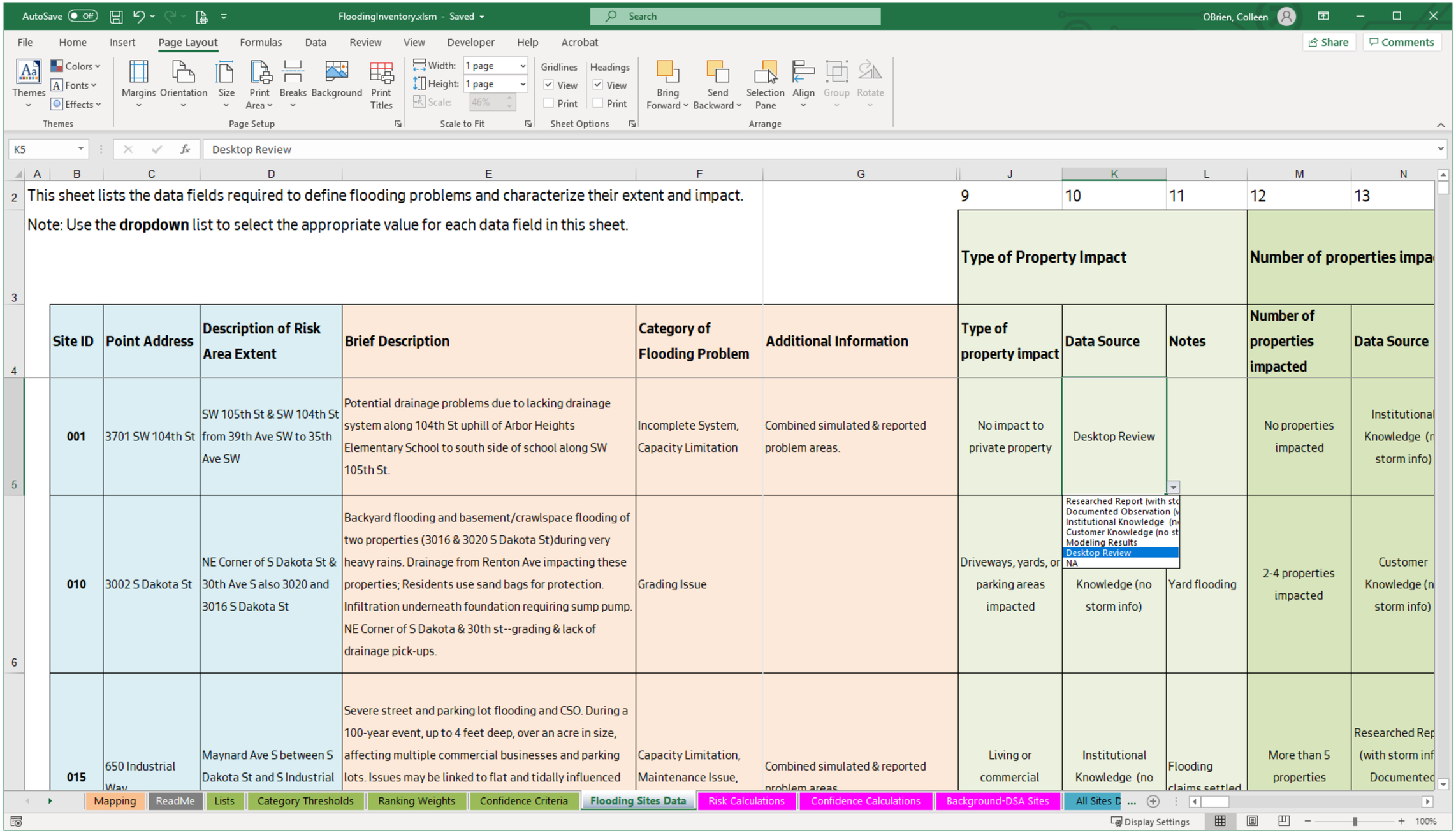

Figure B-1. Flooding Inventory, Flooding Site Data Worksheet Snapshot

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Appendix C: GIS Data Sources

Technical Memorandum: GIS data for Risk Mapping and Prioritization for the System Analysis Projects July 17, 2020

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Seattle Public Utilities

Memorandum

Date: 7/17/20

To: Project File

From: Colleen O'Brien

Re: GIS data for Risk Mapping and Prioritization for the System Analyses Projects

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This memorandum describes the GIS data used in developing risk scores for Drainage System Analysis (DSA).

For each data set it includes:

- For the source data, summarized in Table 1:
  - Description
  - Source and date
  - Storage location
  - What data set it became part of or was used to create (process data) for an analysis or map
- For processed data, summarized in
- Table 2:
  - Description, including how it was modified from the source data
  - Storage location (includes network drive location and may include a SharePoint location)
  - Date of the file
  - Which analysis it was used in

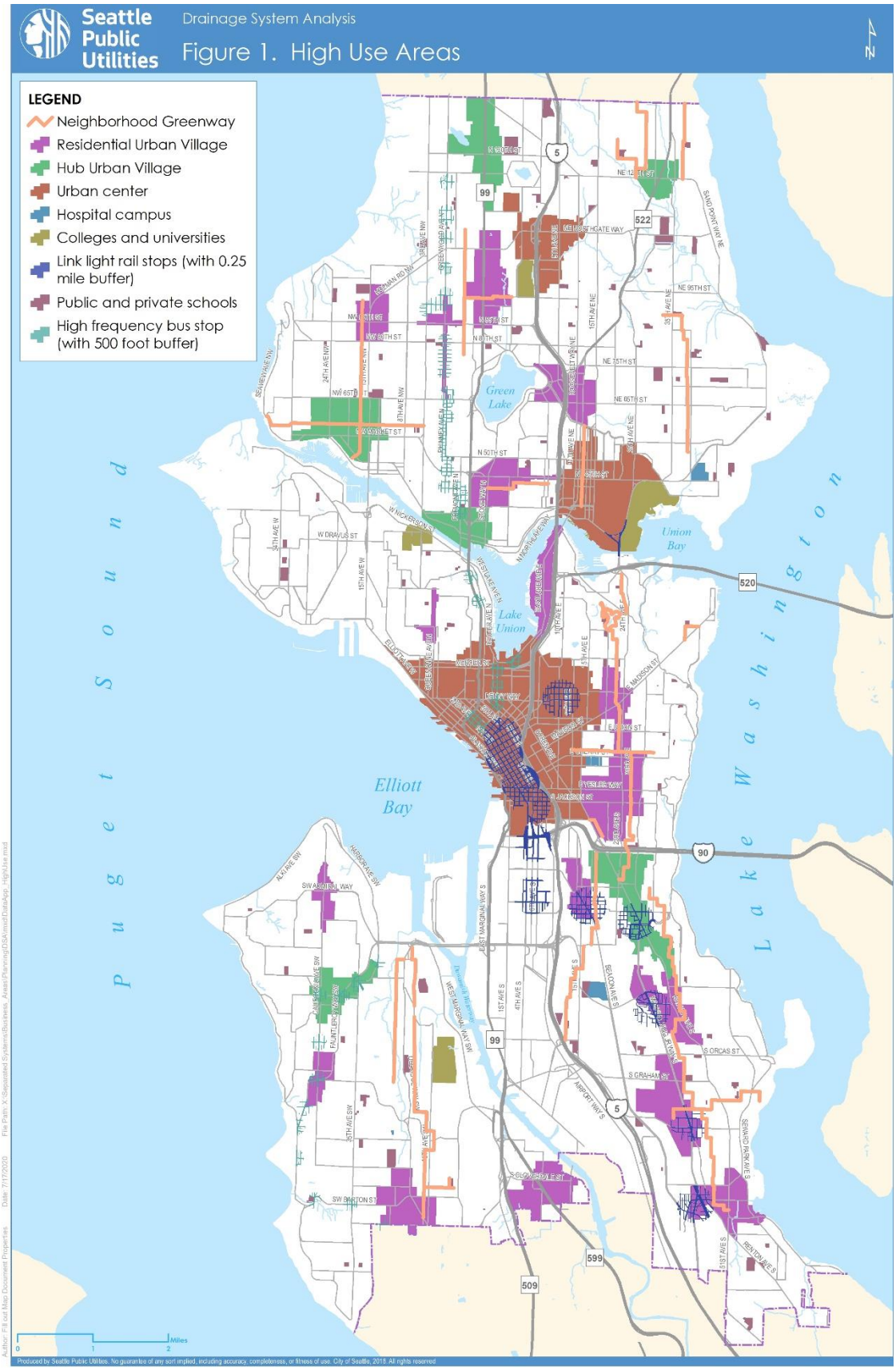
Table 1. GIS Source Data used in Risk Mapping and Prioritization

Name	Description	Source	Date	Storage Location	Name of Analysis Data Set Used In
Colleges and universities (Figure 1)	Boundaries of colleges and universities in the city of Seattle.	City	Sept 2018	*Seattle Tools*, Colleges and Universities (CARTO.COLLEGE)	high use area
Critical facilities (Figure 2)	Provide services and functions essential to a community, especially during and after a disaster.	OEM	10/8/2018 (received from OEM)	*X:\Separated Systems\Business_Areas\Planning\DSA\analysis\CriticalFacilities* Critical Facilities (OEM).txt	critical facilities
Existing Bike Facilities (Figure 3)	Bicycle related street and off-street (trail) improvements which consist of markings and hardscape that are intended to improve the movement of bicycles through the city. Existing facilities include all infrastructure currently on the ground (with the exception of Neighborhood Greenways) and vary from dedicated off street trails to shared roadway markings (sharrows).	SDOT	1/23/2020 (downloaded from Seattle Tools)	*DWW GIS Library (DSA) on SharePoint* Existing_Bike_Facilities_DSA.lpk *X:\Separated Systems\Business_Areas\Planning\DSA\data\Impacts\archive* Existing_Bike_Facilities.shp	bicycle route
High frequency bus stops (Figure 1)	On-street location where transit vehicles stop inline to pick-up and discharge passengers.	KC Metro	Sept 2018	*Seattle Tools*, King County Metro Bus Stop, Active & In Service (KCGIS.TransitStop_point)	high use area
Hospital campuses (Figure 1)	Boundaries of licensed acute care hospitals and associated buildings.	City	Sept 2018	*Seattle Tools*, Hospitals (CARTO.HOSPITAL)	high use area
King County parcels	Tax parcels polygons in King County.	KC	1/14/2018 (downloaded from website)	*https://gis-kingcounty.opendata.arcgis.com/datasets/8058a0c540434dadbe3ea0ade6565143_439*	properties and critical facilities
Link light rail stops (Figure 1)	Contains the entire set of existing Central Link, University Link, and Airport Link light rail station points located in the City of Seattle from Northgate Mall to SeaTac Airport.	ST	Sept 2018	*Seattle Tools,* Sound Transit Link Light Rail Stations (CARTO.LinkStations)	high use area
Neighborhood Greenways (Figure 1)	Safer, calmer residential streets that can include: • easier crossings of busy streets with crosswalks, flashing beacons, or crossing signals • speed humps to calm traffic • stop signs for side streets crossing the greenway • signs and pavement markings to help people find their way • 20 mph speed limit signs	SDOT	Sept 2018	*P:\PrjMgmt\C316073 2018 Wastewater System Analysis\02-Plan Inputs\G-GIS\To Aqualyze* Prioritization-Layers.mpk	high use area
Public and private schools (Figure 1)	Parcels that contain kindergarten through 12th grade public and private schools approved through the Washington State Board of Education.	City	Sept 2018	*Seattle Tools*, Public School and Private School (CARTO.PRIV_SCH and CARTO.PUB_SCH)	high use area

Name	Description	Source	Date	Storage Location	Name of Analysis Data Set Used In
Racial and Social Equity Composite Index (Figure 4)	Census tract-based data that consists of a composite of the following sub-indices: • Race, English Language Learners, and Origin Index ranks census tracts by an index of three measures weighted as follows: (shares of population who are) - persons of color (weight: 1.0) - English language learners (weight: 0.5) - foreign born (weight: 0.5) • Socioeconomic Disadvantage Index ranks census tracts by an index of two equally weighted measures: (shares of population with) - income below 200 percent of poverty level - educational attainment less than a bachelor's degree • Health Disadvantage Index ranks census tracts by an index of seven equally weighted measures: - no leisure-time physical activity - diagnosed diabetes - obesity - mental health not good - asthma - low life expectancy at birth - disability	OPCD	2018 (DSA) 2017 (WWSA)	DSA *DWW GIS Library (DSA) on SharePoint* Racial and Social Equity Composite Index – 2018.zip (RaceSECCI_2018.shp) *X:\Separated Systems\Business_Areas\Planning\DSA\data\Impacts* RaceSECCI_2018.shp WWSA *P:\PrjMgmt\C316073 2018 Wastewater System Analysis\02-Plan Inputs\G-GIS\To Aqualyze* Prioritization-Layers.mpk	Racial and Social Equity Composite Index
Residential and Hub Urban Villages (Figure 1)	Areas in the city with residential development as well as a broad mix of uses with lower densities than urban centers. (See the Comprehensive Plan 20-year Growth Strategy, http://www.seattle.gov/Documents/Departments/OPCD/OngoingInitiatives/SeattlesComprehensivePlan/CouncilAdopted2016_CitywidePlanning.pdf)	OPCD	Sept 2018	*Seattle Tools*, Urban Centers, Villages, Manufacturing Industrial Centers (CITYPLAN.URBAN_VILLAGE_CENTER_MIC)	high use area
Snow and ice routes (Figure 5)	City of Seattle streets covered under SDOT's Winter Storm Response Plan, showing snow and ice removal routes.	SDOT	9/21/18 (downloaded from Seattle Tools)	*DWW GIS Library (DSA) on SharePoint* SDOT_snowice.zip (SDOT_snowice.shp) *X:\Separated Systems\Business_Areas\Planning\DSA\data\Impacts* SDOT_snowice.shp	major transportation routes and street type
Streets	The City's Street Network Database showing driveable public streets within the Seattle city limits.	SDOT	1/24/2020 (downloaded from Seattle Tools)	*Seattle Tools*, Streets (SDOT.STREETS)	streets

Name	Description	Source	Date	Storage Location	Name of Analysis Data Set Used In
Urban center (Figure 1)	Densest developed areas in the city with the widest range of land uses. (See the Comprehensive Plan 20-year Growth Strategy, http://www.seattle.gov/Documents/Departments/OPCD/OngoingInitiatives/SeattlesComprehensivePlan/CouncilAdopted2016_CitywidePlanning.pdf)	OPCD	Sept 2018	*Seattle Tools*, Urban Centers, Villages, Manufacturing Industrial Centers (CITYPLAN.URBAN_VILLAGE_CENTER_MIC)	high use area

OPCD = Office of Community Planning and Development
City = City of Seattle
ST = Sound Transit
KC = King County
SDOT = Seattle Department of Transportation
OEM = Office of Emergency Management
DWW GIS Library (DSA) on SharePoint = *https://seattlegov.sharepoint.com/:f:/r/sites/spu-D1/Planning/DWW%20GIS%20Library/DSA/Data/SPU?csf=1&web=1&e=UBk4k2*


Seattle Public Utilities
Drainage System Analysis
Figure 1. High Use Areas
LEGEND
Neighborhood Greenway
Residential Urban Village
Hub Urban Village
Urban center
Hospital campus
Colleges and universities
Link light rail stops (with 0.25 mile buffer)
Public and private schools
High frequency bus stop (with 500 foot buffer)
Puget Sound
Lake Washington
Elliott Bay
Green Lake
Lake Union
Union Bay
Miles
0
1
2
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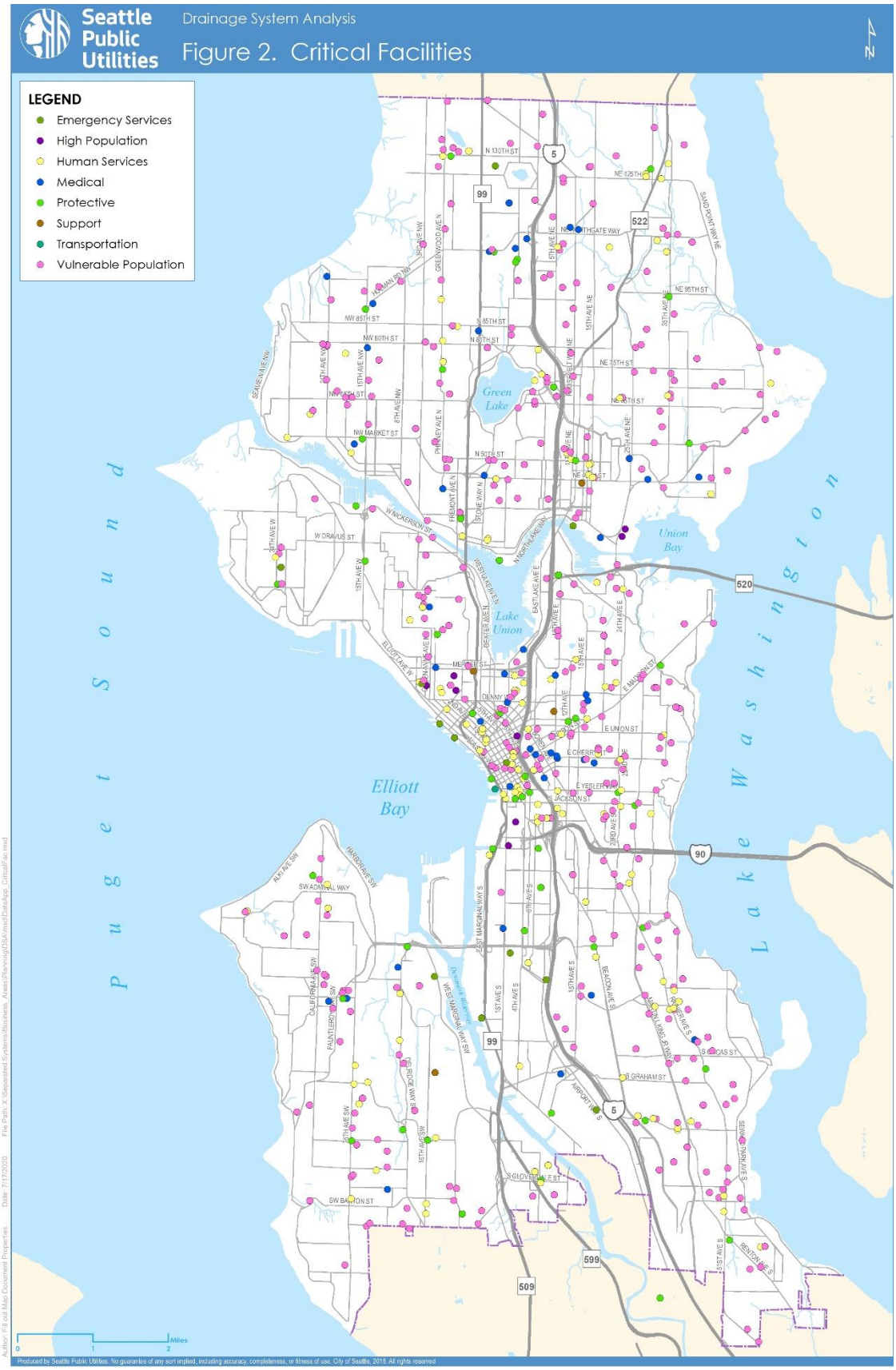
Seattle Public Utilities
Drainage System Analysis
Figure 2. Critical Facilities
LEGEND
Emergency Services
High Population
Human Services
Medical
Protective
Support
Transportation
Vulnerable Population
Puget Sound
Lake Washington
Elliott Bay
Green Lake
Lake Union
Union Bay
Miles
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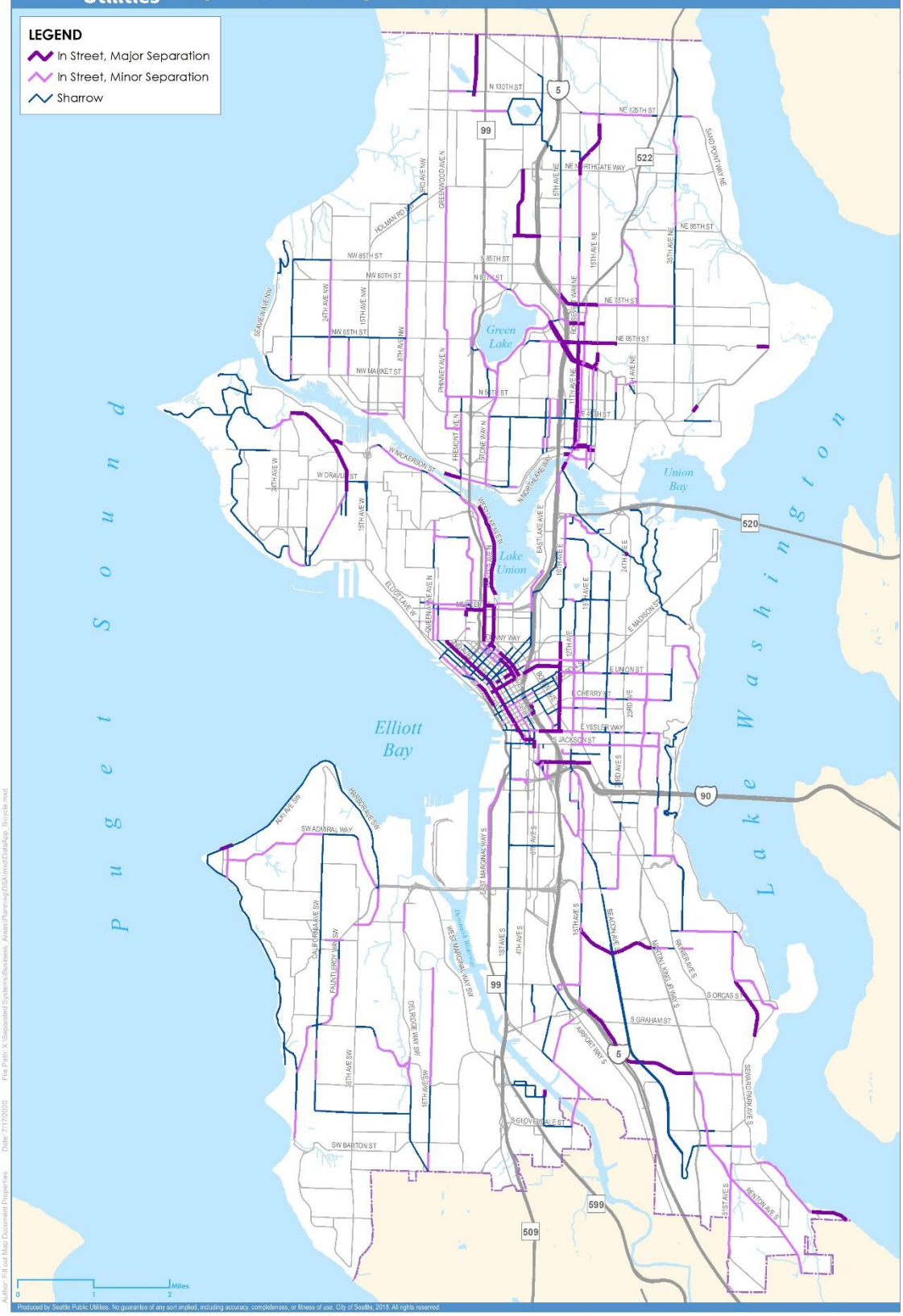
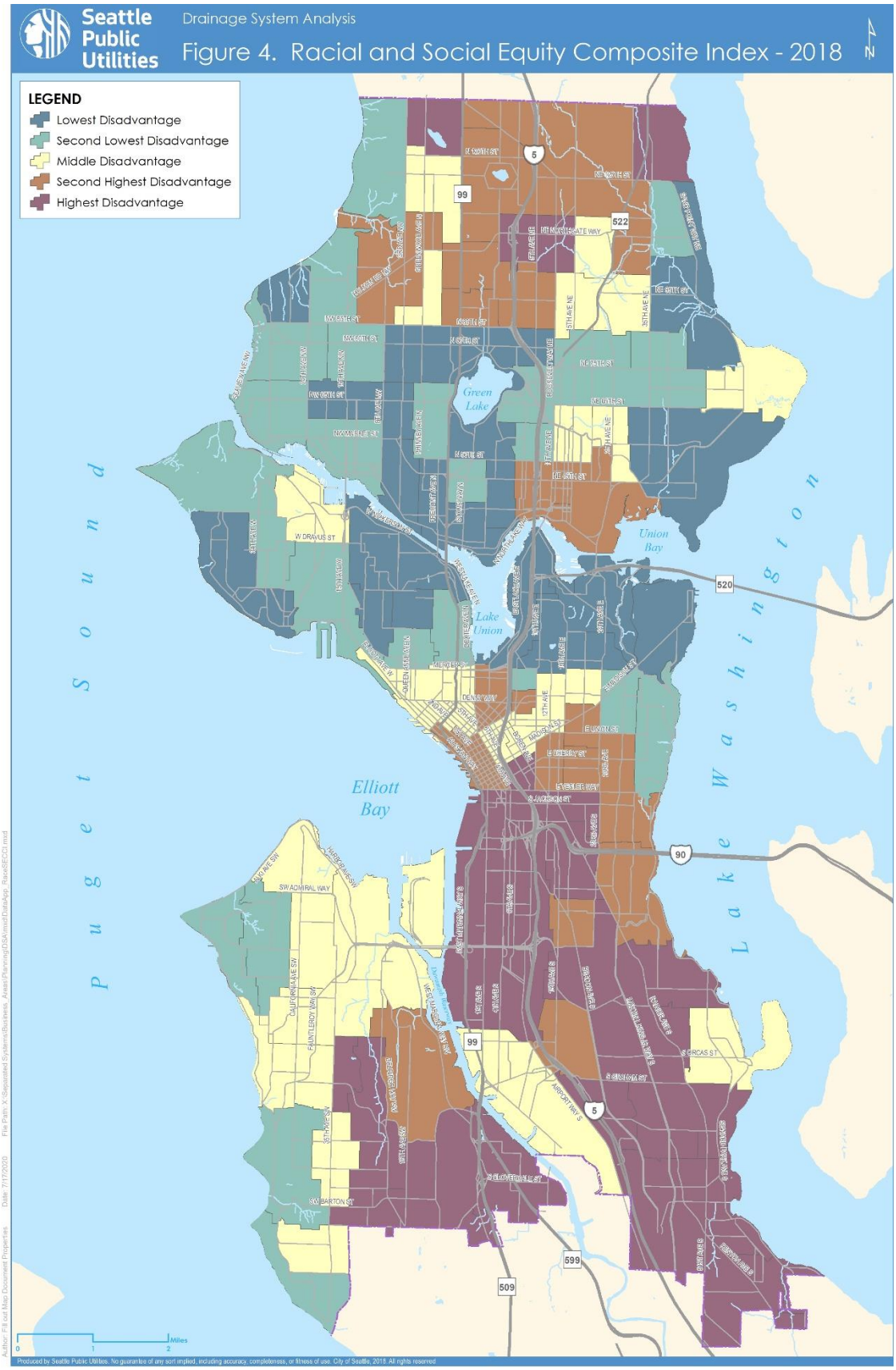
Seattle Public Utilities

Drainage System Analysis

Figure 3. Existing Bike Facilities



Author: FB and Map Document Properties Date: 7/17/2020 File Path: X:\Separated Systems\Business Areas\Planning\DSA\mxd\FlatApp_Bicycle.mxd


Seattle Public Utilities
Drainage System Analysis
Figure 4. Racial and Social Equity Composite Index - 2018
LEGEND
Lowest Disadvantage
Second Lowest Disadvantage
Middle Disadvantage
Second Highest Disadvantage
Highest Disadvantage
Puget Sound
Lake Washington
Green Lake
Union Bay
Lake Union
Elliott Bay
Miles
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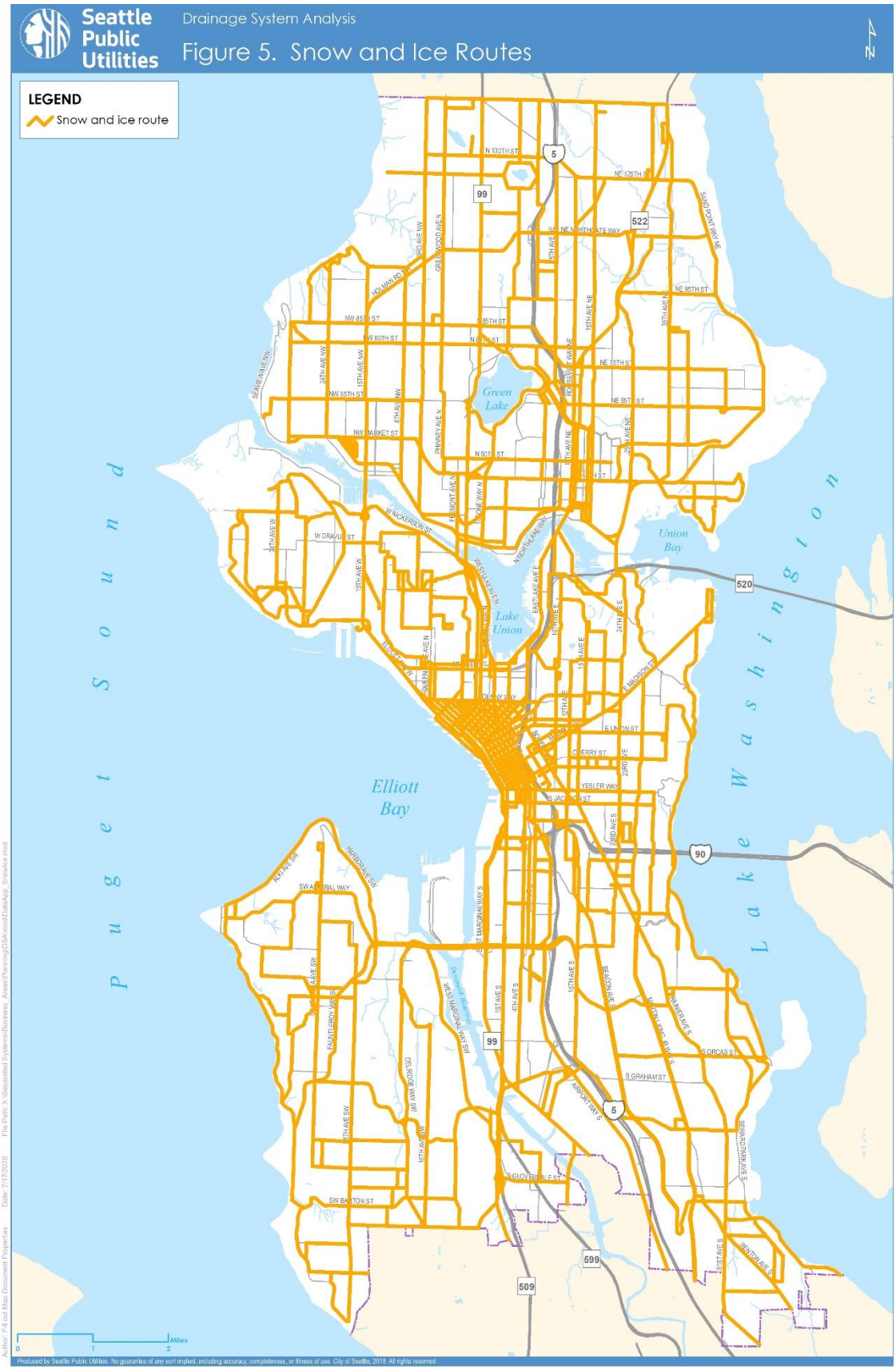
Seattle Public Utilities
Drainage System Analysis
Figure 5. Snow and Ice Routes
LEGEND
Snow and ice route
Puget Sound
Lake Washington
Green Lake
Union Bay
Lake Union
Elliott Bay
5
99
522
520
90
599
509
Miles
0
1
2

Table 2. Processed Data used in the Systems Analyses Projects

Name	Description	Storage Location(s)*	File Name	Data Type	File Date
bicycle route	Existing bike facilities of the following types: • in street, major separation • in street, minor separation • sharrow	*DWW GIS Library (DSA) on SharePoint* *Project files*	Existing_Bike Facilities_DSA.shp	polyline	1/24/20 (SP) 1/23/20 (Project files)
bicycle route	Existing_Bike Facilities_DSA were buffered by the ½ of street surface width with the attribute "SURFACEWID" equating to an area equal to the street surface width centered on the street polyline.	*Project files*	BicycleRoutes_DSA.shp	polygon	5/5/20
critical facilities	Point data of the following types of critical facilities: • emergency serviced • high population • human services • medical • protective • support • vulnerable populations The raw data were mapped by lat/long. Sites that mapped outside a parcel, were moved to the parcel based on the address and mapping review. The list was paired down to reflect facilities related to human health and safety for people at that location. See additional information below, after the tables. Exact duplicates were removed. List consists of 746 facilities on 612 unique parcels.	*DWW GIS Library on SharePoint* *Project files*	CriticalFac_rev.zip/.shp	point	12/21/18
critical facilities	King County parcel data developed from the critical facilities point data. Consists of parcels with at least one critical facility point within it.	*Project files*	CriticalFacility_parcels.shp	polygon	5/5/20

Name	Description	Storage Location(s)*	File Name	Data Type	File Date
high use area	An area likely to have a large number of pedestrians traveling in or through it relative to other areas of the city. It consists of the following land uses and right-of-way (ROW) buffers: • Residential and Hub Urban Villages, including a 50-foot ROW buffer • Urban Center, including a 50-foot ROW buffer • Hospital campuses, including a 50-foot ROW buffer • Colleges and universities, including a 50-foot ROW buffer • Public and private schools, including a 50-foot ROW buffer • Link light rail stops, including a quarter mile ROW buffer • High frequency bus stops, including a 50-foot ROW buffer • Neighborhood greenways After each polygon data were buffered, they were merged into one data set.	*DWW GIS Library on SharePoint*	Pedestrian_Areas_for_Prioritization.mpk	polygon and polyline	1/7/19
high use area	Neighborhood greenways were buffered by the ½ of right-of-way width with the attribute "ROWWIDTH", equating to an area equal to the right-of-way width centered on the street polyline. The resulting polygon data were merged with the polygon data set of the other high use areas.	*Project files*	HighUseAreas.shp	polygon	7/15/20
Racial and Social Equity Composite Index	See Table 1. Source data were used unmodified.	DSA: *Project files* WWSA: *P:\PrjMgmt\C3 16073 2018 Wastewater System Analysis\02-Plan Inputs\G-GIS\To Aqualyze*	DSA: RaceSECCI_2018.shp WWSA: Prioritization-Layers.mpk	polygon	DSA: 8/11/19 WWSA: 1/16/19

Name	Description	Storage Location(s)*	File Name	Data Type	File Date
street type	Streets_DSA polyline data were buffered by the ½ of right-of-way width (attribute "ROWWIDTH") equating to an area equal to the right-of-way width centered on the street polyline. Snow and ice routes were identified through a spatial join. Major transportations are the routes with attribute "Type" = "SnowIceRoute". Non-arterial streets have the attribute "Type" = "Non-arterial".	*Project files*	StreetType_DSA.shp	polygon	5/5/20
streets	Street with right-of-way widths added to attribute ROWWIDTH, where missing, when near a risk area. ROWWIDTHs added were based on aerial photo review.	*DWW GIS Library on SharePoint* *Project files*	Streets_DSA.zip/.shp	polyline	1/24/20

*_DWW GIS Library on SharePoint_ = _https://seattlegov.sharepoint.com/sites/spu-D1/Planning/DWW%20GIS%20Library/Forms/AllItems.aspx_
DWW GIS Library (DSA) on SharePoint = _https://seattlegov.sharepoint.com/:f:/r/sites/spu-D1/Planning/DWW%20GIS%20Library/DSA/Data/SPU?csf=1&web=1&e=UBk4k2_
Project files = X:\Separated Systems\Business_Areas\Planning\DSA\data\Impacts

Table 3 Critical Facilities Included in Analyses

Category	Primary Use	Count
Emergency Services	Emergency Cache	4
Emergency Services	Fire - Support	1
Emergency Services	Government Function	2
Emergency Services	Medical	1
Emergency Services	Parking Garage	1
Emergency Services	Police Station	3
High Population	Conference Center	2
High Population	Landmark	1
High Population	Stadium	6
Human Services	Community Center	31
Human Services	Customer Service	4
Human Services	Family Center	7
Human Services	Food Bank	30
Human Services	Food Distribution Center	1
Human Services	Library	26
Human Services	Meal Program	17
Human Services	Non-Profit	10
Human Services	Shelter	22
Human Services	Support	4
Human Services	Teen Center	1
Medical	Blood Center	5
Medical	Dialysis Center	7
Medical	Hospital	12
Medical	Medical	1
Medical	Public Health	2
Medical	Urgent Care Clinic	17
Protective	Coast Guard Station	1
Protective	Fire - Support	1
Protective	Fire Headquarters	1
Protective	Fire Station	34
Protective	Joint: Fire Station / EOC	1
Protective	Joint: Fire Station / Senior Center	1
Protective	Joint: Police and Courts	1
Protective	Offices	1
Protective	Parking Garage	2
Protective	Police - Support	6
Protective	Police Harbor Patrol	2
Protective	Police Station	6

Category	Primary Use	Count
Support	Backup EOC	5
Transportation	Ferry Terminal	1
Vulnerable Population	Child Care Center	252
Vulnerable Population	Nursing Home	25
Vulnerable Population	School	90
Vulnerable Population	School - 6-12	2
Vulnerable Population	School - 6-8	10
Vulnerable Population	School - 9-12	13
Vulnerable Population	School - Gym	1
Vulnerable Population	School - K-5	59
Vulnerable Population	School - K-8	11
Vulnerable Population	School - Service School	2

Appendix D: Reported Flooding Incidents Data Sources

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Table D-1. Locations of Data Sources for Reported Flooding Incidents			
SPU Network Drive Description	**Network Drive Location**	**Description of Content**	**Primary Owner or Stakeholder**
X: Flood Control\Drainage Investigations\Northeast_Qtr, Northwest_Qtr, Southeast_Qtr, and Southwest_Qtr	\\Spushare03\e\USMGIS\Flood Control\Drainage Investigations	2012 'Localized List' sites of the Localized Flood Control Program, organized by city quadrant.	Holly Scarlett
Q: Flood BCL_LFCP\Referred from DWWI, SPOT	\\spushare1\DWW_LOB\Programs_Capital\C380-Flooding, Sewer Backup and Landslides\LFCP\Referred from DWWI, SPOT	Information on sites previously transferred from DWWi and SPOT programs, confirmed they were in Risk Area folders.	Don Anderson
NDS-Localized Longfellow 2015 C315082	P:\PrjMgmt\C315082 Localized Longfellow 2015\01-InitiationAndOptionsAnalysis\Deliverables\Final Deliverables	Fact sheets from NDS program within Longfellow Creek watershed.	April Mills
NDS-Localized Thornton 2015 C315083	P:\PrjMgmt\C315083 Localized Thornton 2015\01-InitiationAndOptionsAnalysis\Deliverables\Thornton South Data Sheets\Finals for review	Fact sheets from NDS program within Thornton Creek watershed.	April Mills
Q: DWWi program folder	\\spushare1\DWW_LOB\Programs_Services\DWW_Investigations\Priority Sewer and Drainage Fact Sheets	Fact sheets from DWWi program--that had been transferred to the Localized Flood Control Program.	Timothy Lowry
X: Flood Control\ DWW_Onsite_Triage\ Locations	\\Spushare03\e\USMGIS\Flood Control\DWW_Onsite_Triage\Locations	Old SWAMP program sites.	Scott Reese
J: USM\WS722\Public\Drainage Projects Active, Done, and On Hold	\\spufs01\Common\USM\WS722\Public\Drainage Projects	Old SWAMP program sites.	Scott Reese
P: Potential CIP Drainage Projects (2005+) CIP A List, CIP A4 List, Flood Control Drainage	\\wdcnas01\spucad data\cadd\PrjMgmt\Potential CIP Drainage Projects (2005+)	2012 Iterations of the 'Localized List', prioritized and organized by 2012 program goals. All data at this location was previously recorded in the site folders in the X:, no new data and therefore were not added to the Flooding Inventory.	Holly Scarlett

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Appendix E: Geospatial Processing Workflow

ArcGIS Model Builder Flow Charts

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Number of Properties Data Field

- Intersect parcel polygons with Risk Area polygons
- Count intersected features

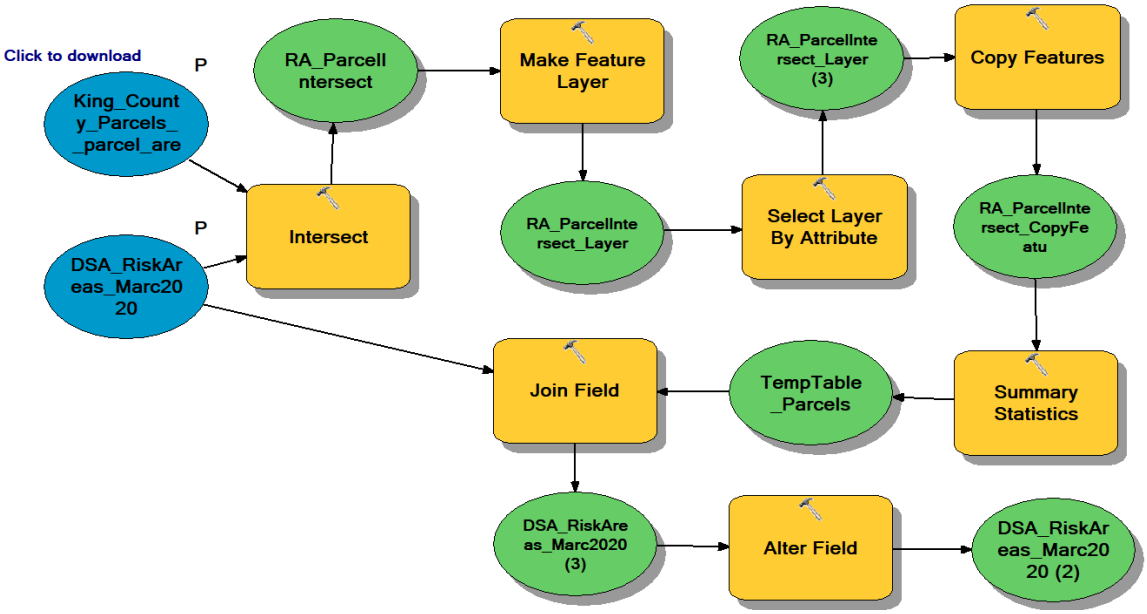

Figure E-1. Flow chart for the number of properties data field

Number of Streets Data Field

- Buffer streets by ROW width (attribute = ROWWIDTH)
- Intersect buffer polygons with Risk Area polygons
- Count intersected features
- Remove sliver areas less than 7 square feet

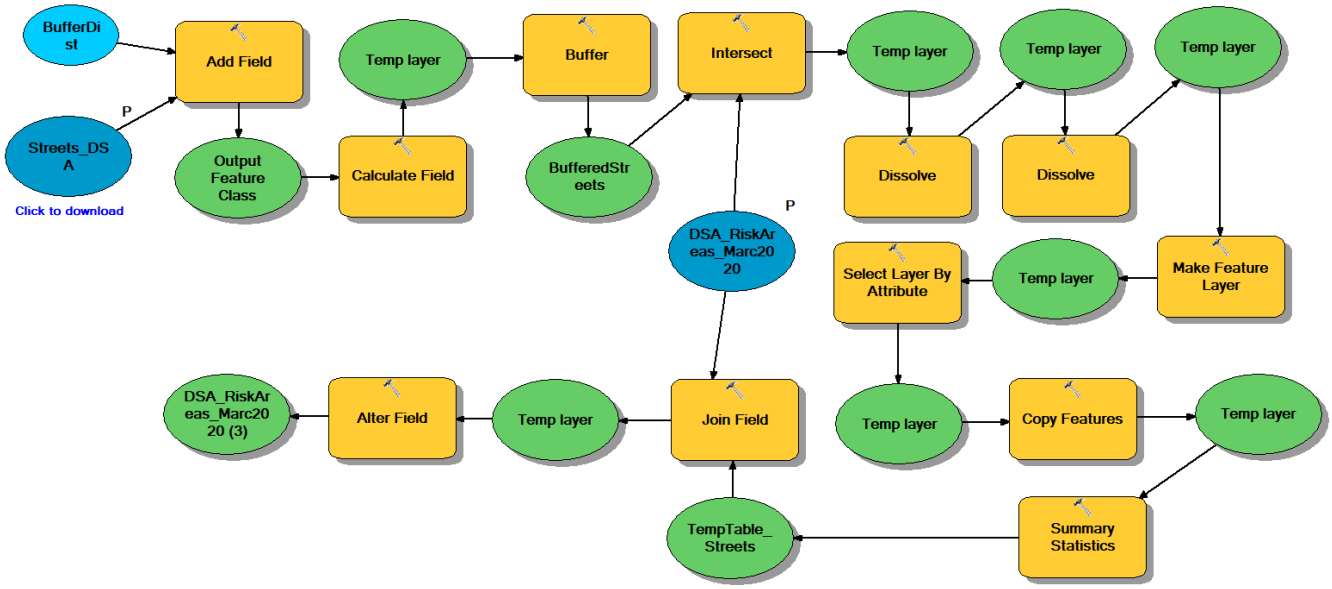

Figure E-2. Flow chart for the number of streets data field

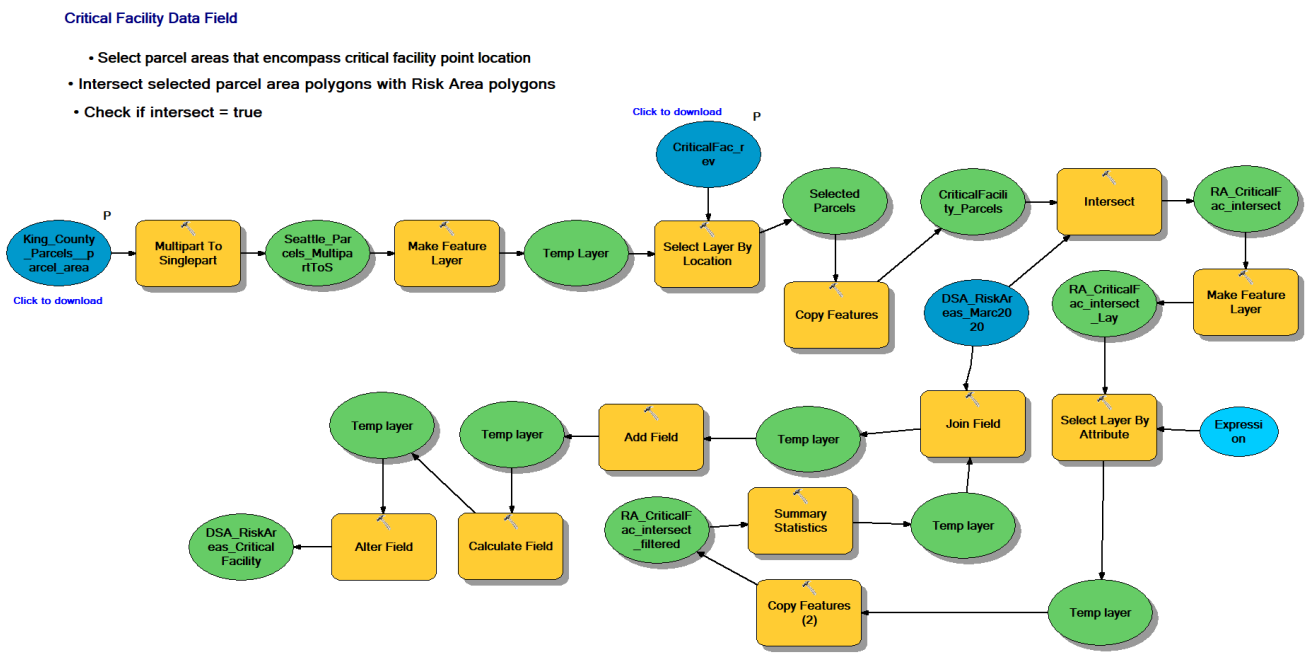

Figure E-3. Flow chart for the critical facility data field

Street Type Data Field

- Join snow and ice route features with streets features
- Buffer streets and snow and ice route features by ROW width (attribute = ROWWIDTH)
- Intersect buffer polygons with Risk Area polygons
- Check for buffered snow and ice routes that intersect = true, then "arterial"
- Check for other street routes that intersect = true, then "non-arterial"

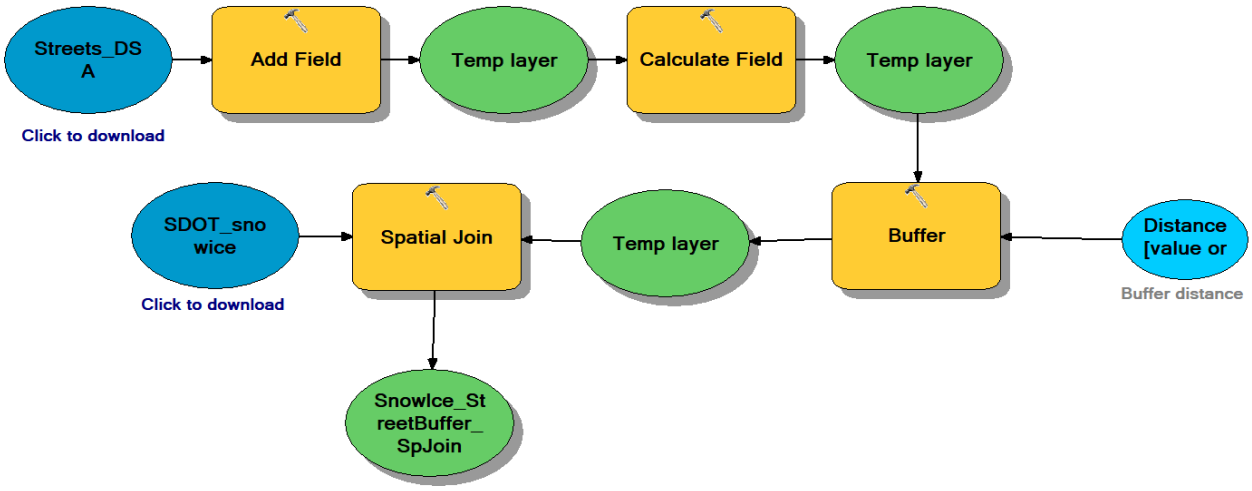

Figure E-4. Flow chart for the street type data field

Bicycle Routes Data Field:

- Buffer routes by surface width (attribute = SURFACEWID)
- Intersect buffer polygons with Risk Area polygons
- Check if intersect = true

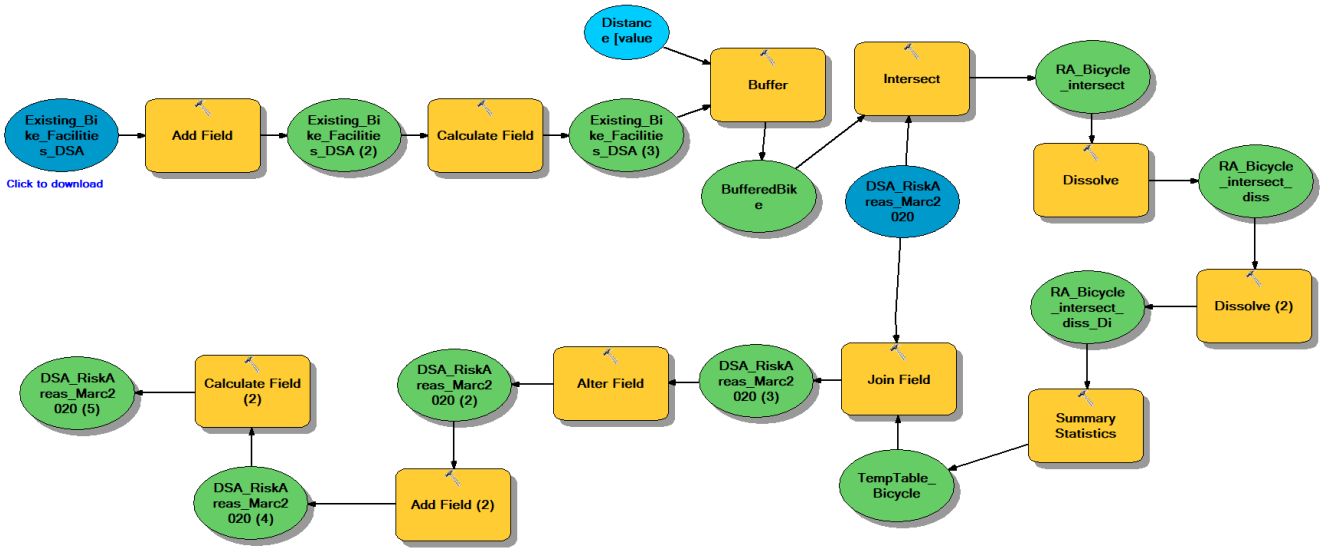

Figure E-5. Flow chart for the bicycle route data field

High Use Areas data field

- Merge high pedestrian usage and neighborhood greenways polygons
- Intersect merged polygons with Risk Area polygons
- Calculate percent of Risk Area intersected

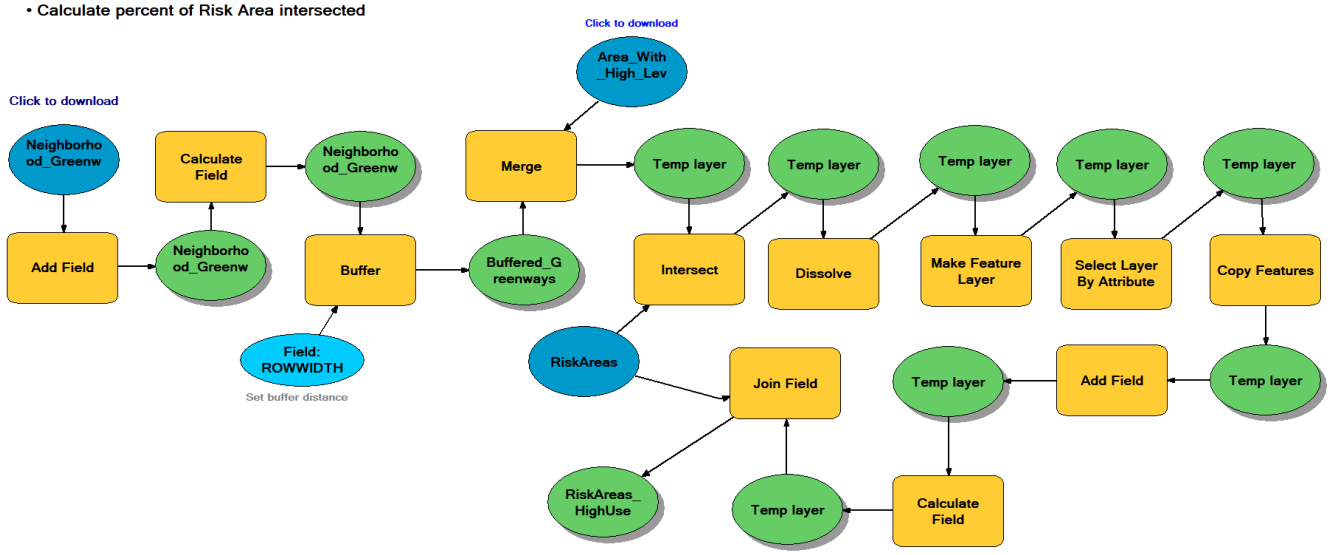

Figure E-6. Flow chart for the high use area data field

Equity Data Field:

- **Intersect equity polygons with Risk Area polygons**
- **Assign equity category (1-5) based on intersected area with highest category of disadvantage**

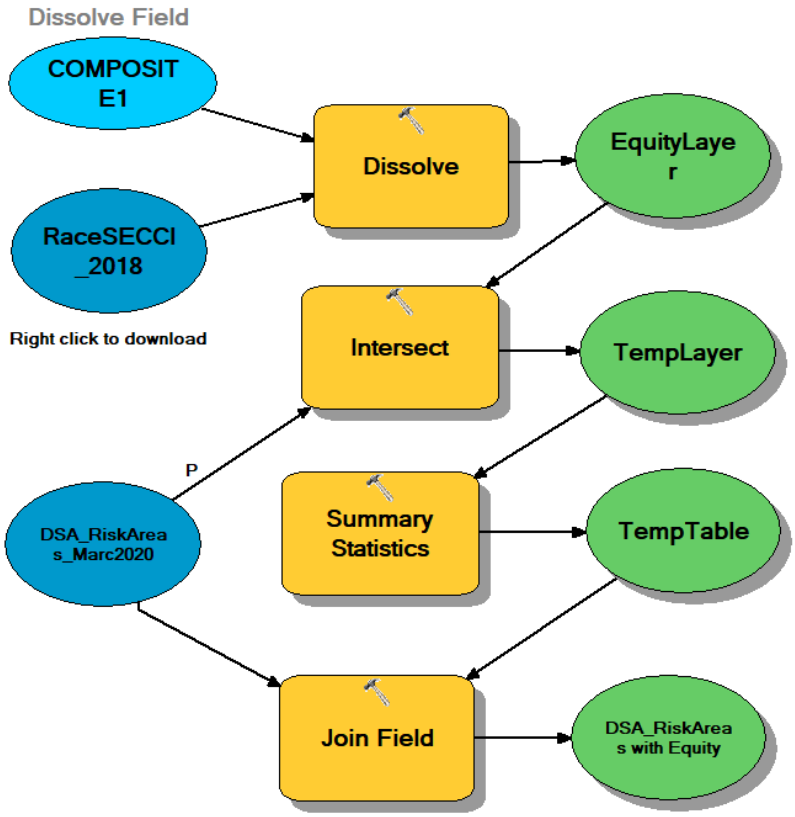

Figure E-7. Flow chart for the equity data field

Appendix F: Prioritization Workshop

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Before the risk scores were finalized SPU held a workshop on July 8, 2020 with internal SPU stakeholders of the Flooding Inventory, including Don Anderson, Justin Twenter, Colleen O'Brien, Holly Scarlett, and Susie Walson. The objectives of the workshop included:

- Confirm scoring weighting of consequence attributes was reasonable based on a sensitivity analysis.
- Review distribution of risk scores from several perspectives to determine if the distributions seems appropriate.
- Define relative risk categories based on risk scores.

Sensitivity Analysis of Consequence Scores

Two sensitivity analyses were completed and discussed at the workshop:

- Groupings of component scores relative to each other
- Contribution of each component score on the total risk score

The component scores were grouped into three categories: ROW Priority, Private Property Priority, and Impact Type. The maximum values of each category (as shown in Table F-1) were reviewed to determine if (a) they were comparable to the WWSA prioritization criteria, and (b) if any category was weighted disproportionately. The workshop participants concluded that the maximum score for each category was acceptable.

Table F-1. Maximum Consequence Component Scores

Flooding Sites Data	Maximum Score
ROW Components Score	1.55
Type of roadway ROW impact	0.85
• Number of Street Areas in the ROW Impacted	0.7
• Private Property Components Score	1.55
Type of property impact	0.85
Number of properties impacted	0.55
Access to Property	0.15
Impact Type Components Score	1.9
Critical Facility	0.6
Street Type, Arterial	0.6
Bike Route	0.3
High-Use Area	0.3
Future Impact	0.1

For the second sensitivity analysis, each component score was removed, one by one, from the total risk score, and the resulting changes to the distribution and mean risk score for all risk areas was discussed. The distribution of the consequence scores was a bell curve (see Figure F-1). Throughout the sensitivity analysis, the distribution, in general, continued to be shaped as a bell curve.

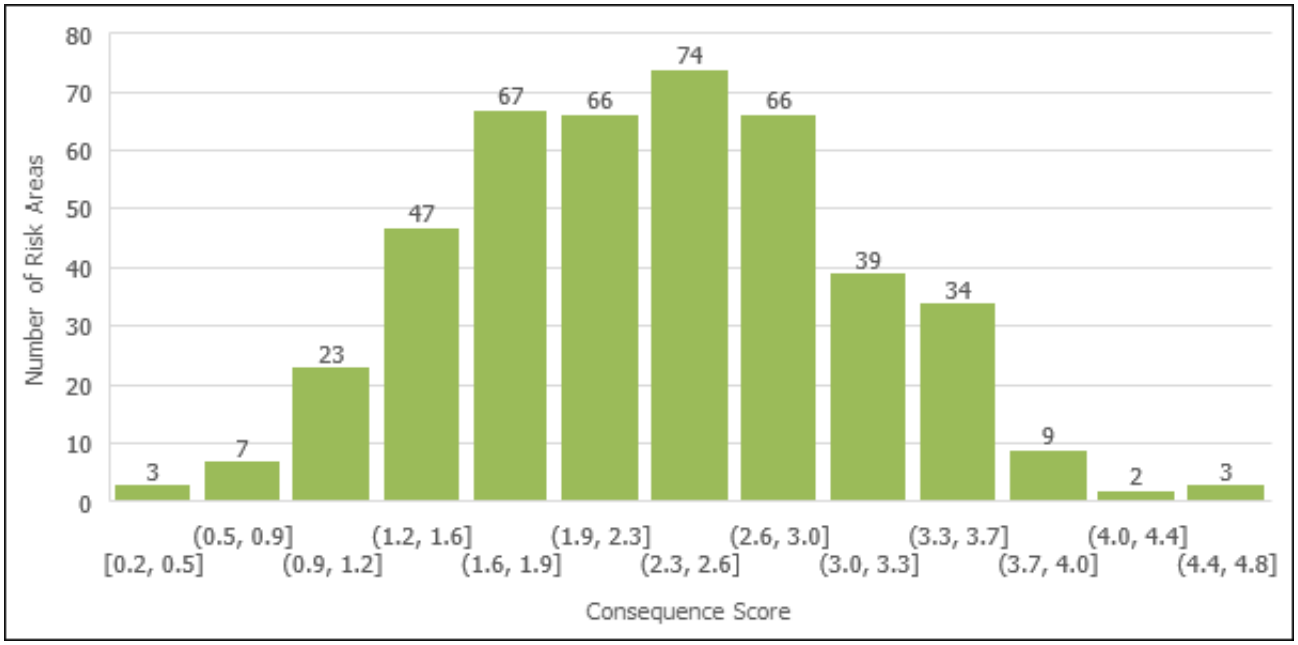

Figure F-1. Distribution of Consequence Scores

The average scores of the Type of roadway ROW impact and Number of Street Areas ROW contributed most, 0.66 and 0.52 points respectively, to the mean score of 2.3 for all risk areas. The average values of all other components ranged from 0.01 to 0.33 points.

The workshop participants felt that the higher contributions of the components in the ROW category was acceptable given that the overall category scores were balanced. And since no one component seemed to drastically impact the data curve, the component scores were not adjusted.

Review of Distribution of Risk Scores

The workshop participants reviewed the distribution of risk scores. The distribution of the total risk score was a right skewed distribution curve, meaning there are more lower-scoring risk areas than higher-scoring risk areas (see Figure F-2). Risk scores ranged from about 2.5 to 24, with the most scores in the range of 5.5 to 8.5. Scores over 16 comprised of only 7.6% of the total number of risk areas.

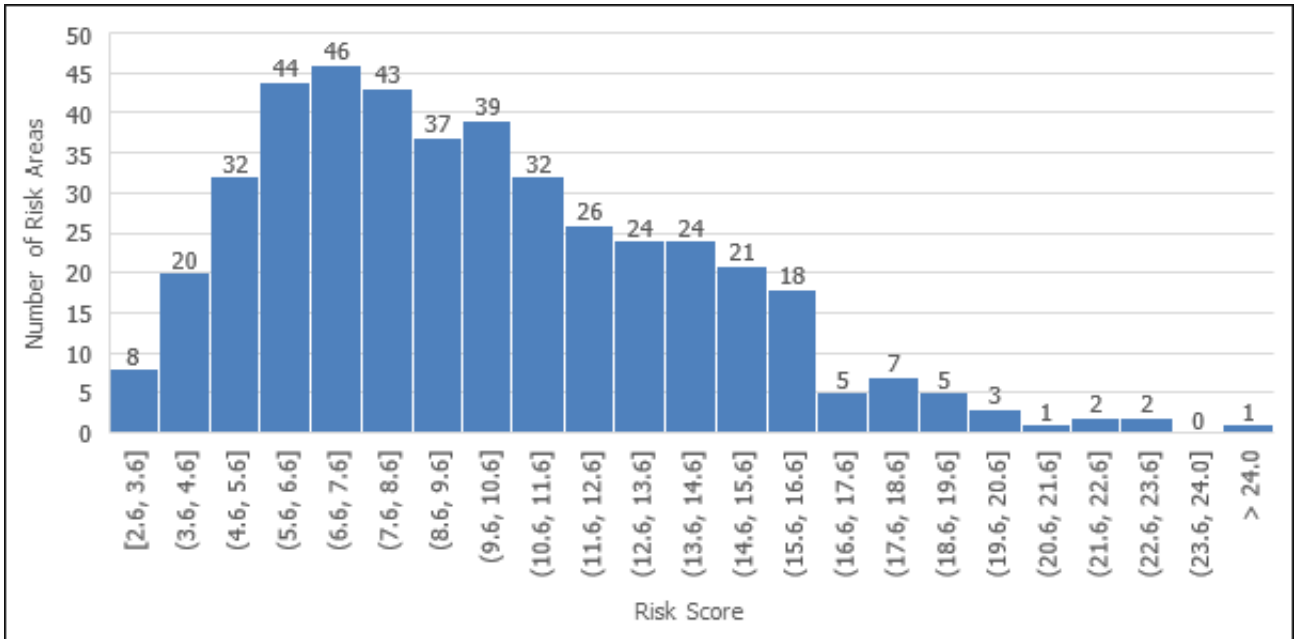

Figure F-2. Distribution of Risk Scores

The workshop participants supported this distribution of total risk scores, as it represented the collective understanding and experience of drainage system operations, in that there are more smaller issues than larger issues.

Defining Relative Risk Categories

The workshop participants considered multiple options of how to define relative risk categories based on the risk scores, where the risk categories are: Low, Medium Low, Medium, High, Critical[1]. The options considered are shown in Table F-2. The option of Low given 6 lowest points (0-6) and the remaining categories assigned based on 3-point intervals (Medium Low [6-9], Medium [9-12], High [12-15], Critical [>15]) was considered to best represent the total risk score distribution.

Table F-2. Options for Assigned Relative Risk Categories based on Risk Scores

Description of How Risk Scores Were Divided	Relative Risk Categories Risk Scores				
	Low	Medium Low	Medium	High	Critical
4-point intervals	0-4	4-8	8-12	12-16	>16
Natural breaks	0-6	6-9	9-12	12-16	>16
Low given 6 lowest points, all other categories at 3-point intervals*	0-6	6-9	9-12	12-15	>15
Low given 8 lowest points, all other categories at 3-point intervals	0-8	8-11	11-14	14-17	>17
Low given 8 lowest points, all other categories at 4-point intervals	0-8	8-12	12-16	16-20	>20

**Selected Relative Risk Category definition*

[1] These categories correspond to the DWWi categories in the following way: Critical = A, High = B, Medium = C, Medium Low = D and Low = E.

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Appendix G: Racial Equity Toolkit

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The Drainage System Analysis (DSA) will provide a technical analysis of the drainage system to support the development of *Shape Our Water*, a 50-year plan for Seattle's water resilience. One objective of the DSA is to identify and understand drainage system capacity needs. To meet this objective, the DSA Team identified and prioritized drainage system capacity risk areas. Risk areas will be one piece of information used during *Shape Our Water* to identify and guide our work in the near and long term.

SPU completed a modified racial equity toolkit (RET) to evaluate the impact of the Equity Strategy for Analysis Projects (Appendix H) on the drainage system capacity risk areas prioritization. This document summarizes the process, findings, and recommendations of the RET.

Equity Strategy

The equity strategy had two main components:

- Instead of relying on existing customer reporting of problems, use city wide models and focused community outreach
- Build equity into the prioritization

These components were implemented through the identification of risk areas and the prioritization of risk areas described in the following sections.

Identification of Risk Areas

The DSA team built a Flooding Inventory to store site information on drainage system capacity risk areas. Three sources of information were used to identify risk areas:

- Reported flooding incidents
- Capacity simulation results
- Community outreach

Reported flooding incidents came from various sources that were reviewed for the DSA (Section 2 of this report). Incidents that made it through a screening verification process were spatially mapped into risk areas based on the available information and to consolidate multiple reports about the same problem. Capacity modeling was completed with SPU's 66 drainage basin models (Brown and Caldwell, 2020). The results were used to identify and delineate areas at risk for not meeting drainage system performance goals. Community outreach was completed to confirm capacity simulation results and identify risk areas where there are unmodeled drainage assets or where there are no drainage assets (SPU, 2020). Outreach methods included:

- Direct outreach through Community Connections Program partner organizations
  - Chinese Information Service Center
  - Horn of Africa Services
  - Environmental Coalition of South Seattle
- Postcard mailings
- Multi-lingual door-to-door canvassing
- Targeted social media advertising
- Direct outreach to business and industrial groups

We received approximately 860 community outreach responses, 625 of which indicated there was no problem. Approximately 170 indicated a drainage system capacity problem that was used to inform a risk area. Table G-1 summarizes the number of risk areas identified, by their data source.

Table G-1. Number of Drainage System Capacity Risk Areas by Data Source

Data Source(s)	Number of Risk Areas
Capacity simulation results only	272
Community outreach only	70
Reported flooding incidents only	55
Reported + simulated	18
Reported + outreach	7
Reported + simulated + outreach	4
Simulated + outreach	21
All	447

Prioritization of Risk Areas

Each risk area was given a risk score, where scoring methods and criteria were developed based on methods outlined in SPU's *Risk Assessment Framework* (SPU 2007), staff subject matter expertise, and a review of past prioritization criteria developed and applied by SPU (SPU 2020). The basic equation for calculating risk scores is:

$$Risk\ Score = (Consequence\ Score \times Likelihood\ Score) + Equity\ Score$$

Including an equity score was how equity was built into the prioritization method. The equity score is based on the Office of Community Planning and Development's (OPCD) Racial and Social Equity Composite Index - 2018 data (See Figure G-1). The Racial and Social Equity Composite Index - 2018 data has polygons representing 136 census tracts throughout the city. When developing these data, OPCD assigned an index to tracts based on racial diversity, demographics, health outcomes, and socioeconomic factors provided by the U.S. Census Bureau, American Community Survey, Centers for Disease Control and Prevention, and Washington State public health agencies. The range of indices was divided into five equity categories that reflect relative levels of disadvantage. For the DSA, the tracts were assigned a score based on the level of disadvantage, as shown in Table G-2.

Table G-2. Equity Scores for the DSA

Level of Disadvantage	Equity Score
Highest	**5**
Second highest	**4**
Middle	**3**
Second lowest	**2**
Lowest	**1**

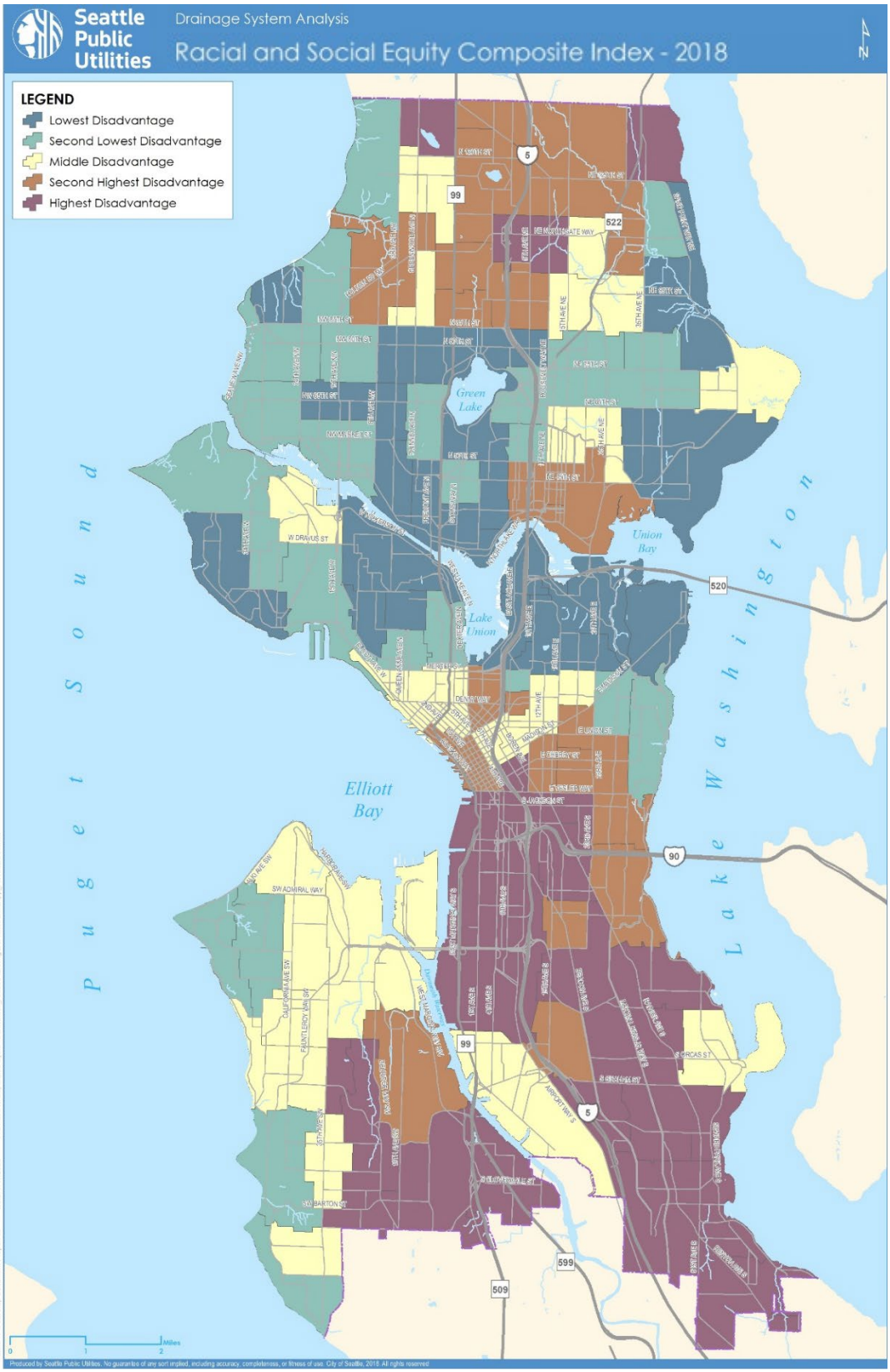

Figure G-1. Race and Social Equity Composite Index - 2018

Equity Toolkit

The toolkit consisted of preparing for and participating in a workshop. The toolkit participants were:

Jonathan Batara -	DWW O+M Coordinator
Cayce James -	OPCD Outside Citywide Manager
Annalisa McDaniel -	Wastewater System Analysis (WWSA) and Shape Our Water Project Manager
Vera Njuguna -	Department of Neighborhoods (DON), Community Liaison Program Manager
Colleen O'Brien -	DSA Flooding Task Co-Lead
Vicky Raya -	Environmental Justice and Service Equity (EJSE) Racial Equity Advisor
Justin Twenter -	DWW Investigations & Modeling Manager
Susie Walson -	DSA Flooding Task Co-Lead

Participants were given the following to review prior to the workshop:

- Several SPU and City racial equity toolkit resources for use when thinking through equity in our work (Attachment 1)
- Several project resources to provide background the drainage system capacity risk area prioritization (Attachment 2)
- A series of maps that show the drainage system capacity risk areas with:
  - Draft prioritization
  - Revised prioritization if we had not incorporated an equity score into the risk score
  - Revised prioritization based on fewer sites if we had not added sites through community outreach
  - Revised prioritization if we had not incorporated an equity score into the risk score nor conducted outreach

At the workshop, a presentation was provided with the project background information as well as charts that summarized the information on the maps. Figure G-2 is an example chart, which shows the difference in overall risk scores when equity was included in the risk score and when it was not included.

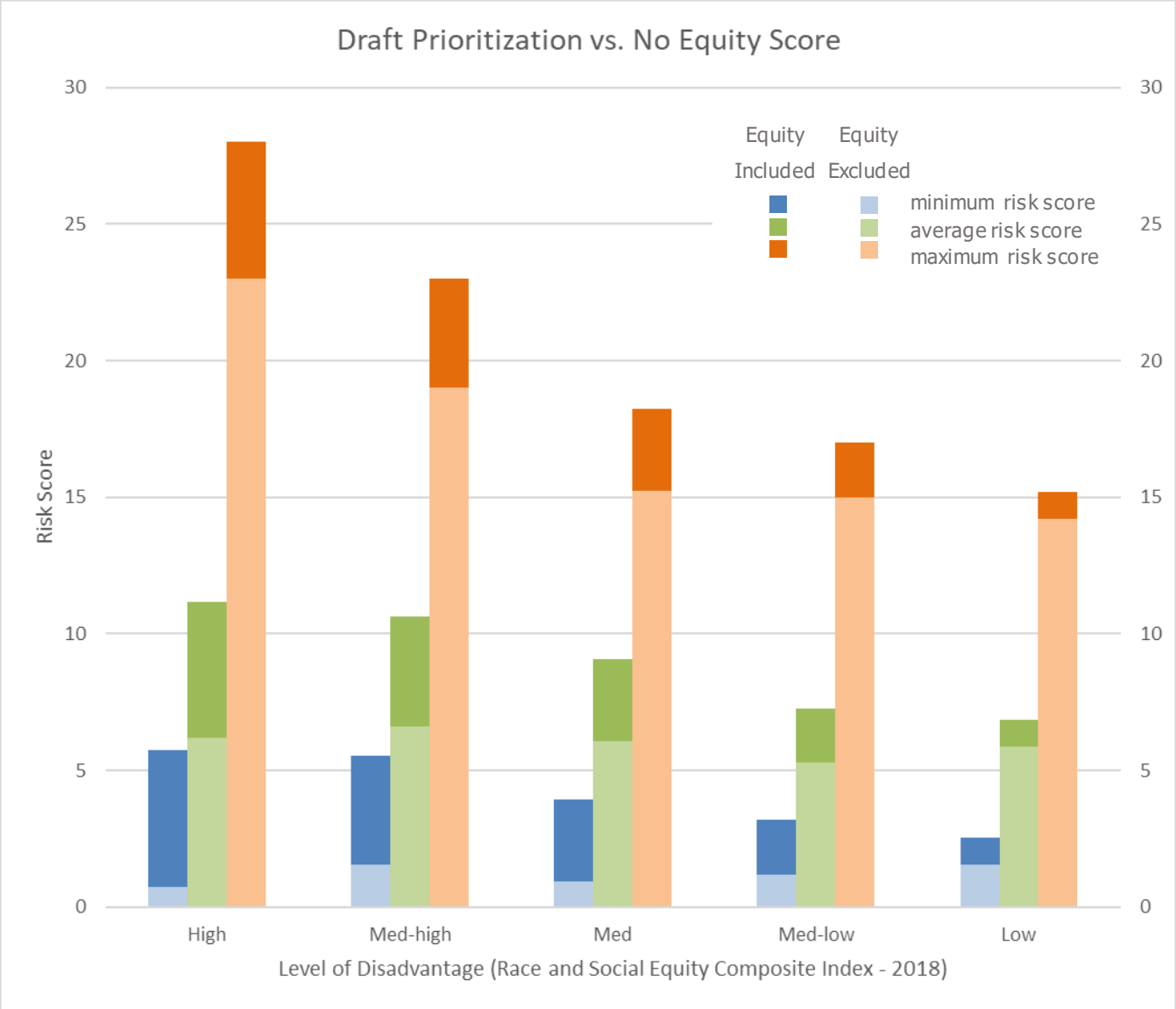

Figure G-2. Example RET Chart - Difference in risk scores when equity was included with the Race and Social Equity Composite Index

The presentation also included where we have gaps in our risk area identification as:

- the capacity simulation results do not cover all drainage assets
- there are some areas with no drainage system
- our community outreach did not cover every gap in our capacity simulation results, nor every area lacking a drainage system; although the latter are being identified in a separate analysis to be used in Shape Our Water.

Also, as with any model, there are uncertainties in the simulation results related to model inputs (precipitation and asset data) as well as the models' ability to model the drainage system.

Then the participants discussed the maps and summary charts, considering the following questions:

- *Did the equity strategy impact the identification and scoring of the drainage system capacity risk areas?*

- *Is the approach setting us up for addressing disparate system impacts with our Shape Our Water planning effort?*
- *Are their recommended improvements?*

Outcomes and Summary Recommendations

The outcomes of the toolkit were that the implementation of the equity strategy resulted in:

- The identification of risk areas that would not have been identified otherwise, as, for example, 70 were identified through community outreach
- Increased prioritization of risk areas in Highest Disadvantaged areas

We also identified a mismatch between the scale of the risk areas and Race and Social Equity Composite Index data. Within the census tracts, there is variability in the level of disadvantage that is not captured when the data are averaged across the census tract. For example, a census tract assigned an equity score of 3 may have highly disadvantaged areas that overlap with risk areas.

The recommendations were:

- Accept the prioritization method for the DSA, since it is the best we can do at this time.
- A suggestion to consider increasing the equity score. It was decided to consider this during the Shape Our Water cross-issue prioritization.
- For Shape Our Water, when completing the data synthesis and cross-issue prioritization consider:
  - the use of race and social equity data at a scale finer than the census tract
  - the identification and definition of focus areas, and who lives/works there
  - more emphasis on equity (increasing the equity score)
  - community engagement on prioritization, working with the DON Community Engagement Coordinators, Strategic Advisors on the Strategic Initiative team, and Community Liaisons
  - OPCD input on specific neighborhoods

References

Brown and Caldwell (2020). *Drainage Systems Analysis, Flooding Topic Area, Drainage System Capacity Evaluation*. Prepared for Seattle Public Utilities, September 4, 2020.

SPU (2020). *Drainage System Analysis, Flooding Topic Area, Community Outreach*. October 2020.

Attachment 1
City of Seattle Racial Equity Toolkit Resources

The resources listed below are intended to show the unique needs and gaps within various Seattle neighborhoods. Specifically, these resources are meant to center communities comprising a high percentage of immigrants, refugees, people with low-incomes, English language learners and communities of color as we improve, develop and design SPU infrastructure, policies, plans, programs, and services.

Resource	Description	Location	DSA Project Notes
Community-identified priorities in racially diverse Seattle neighborhoods: *Equity and Environment Agenda 2016* Office of Sustainability and the Environment	Developed with community members, the Equity & Environment Agenda provides goals and strategies which serve as a blueprint for the City to lead by example and for sectors to work together to advance environmental equity in Seattle. The agenda focuses on those most affected–communities of color, immigrants, refugees, people with low incomes, youth, and English language learners–to lead on solutions.	Equity and the Environment Agenda PDF	The agenda consists of five Priority Areas: 1. Healthy Environments for All 2. Jobs, Local Economies & Youth Pathways 3. Equity in City Environmental Programs 4. Environmental Narrative & Community Leadership 5. Opportunities for Government, Environmental Organizations, Community & Philanthropic Leadership *Question: What is this works' role in advancing the agenda?*
Racial and Social Equity Composite Index Office of Planning and Community Development (OPCD)	The Racial and Social Equity Composite Index is a census tract-based tool for assessing geographic patterns related to equity as an aid in identifying City planning, program, and investment priorities. This composite index includes sub-indices of the Race, English Language Learners, and Origins Index, Socioeconomic Disadvantage Index, and Health Disadvantage Index.	https://seattlegov.sharepoint.com/sites/spu-D1/Planning/DWW%20GIS%20Library/Forms/undefined	These data are used in our risk area prioritization method. *Question we are looking to answer through this toolkit:* *How did including it affect the prioritization?*
Outside Citywide Map Tool OPCD	As part of the Public Space Initiative, this web map tool shows which areas of Seattle are best served by our existing public space system (including Seattle parks, Port parks, campuses, privately-owned plazas, etc.) and what areas we should prioritize for new investments when factoring in other disparities.	Outside Citywide Interactive Map Tool	• These data have not been used for this work. • These data have been included in another analysis project: Social and Environmental Systems Analysis (SESA) • The SESA will be used in *Shape Our Water*.
Seattle 2035 Comprehensive Plan: Utility Element OPCD	The Utilities element of the Comprehensive Plan outlines goals and policies for service delivery, resource management, and facility siting and design that will guide City decisions about providing and updating services; it also addresses emerging issues that utilities face.	http://www.seattle.gov/Documents/Departments/OPCD/OngoingInitiatives/SeattlesComprehensivePlan/CouncilAdopted2019.pdf	Consider the following two policies: • Utility Facility Site and Design Policy U 3.7: "Consider and address disproportionate impacts of climate change on communities of color and low-income communities when prioritizing projects." • Service Delivery Policy U 1.1: "Provide equitable levels of service by account for existing community conditions, considering how decisions will impact varied geographic and socioeconomic groups, and making service equity a criterion in decision-making."
SPU Racial Equity Toolkit: Service, Project, or Program Development Equity Planning Tool FAQs EJSE	Equity planning guide that is a good primer for racial equity toolkits.	https://seattlegov.sharepoint.com/sites/SPU-T1/EquityTools/SitePages/Home.aspx	Read it. It is 2 pages long.

Attachment 2
Drainage System Analysis Racial Equity Toolkit Resources - August 2020

The resources listed below are intended to provide context for this Drainage System Analysis (DSA) racial equity toolkit (RET).

Resource	Description	Bullets
ISP Fact Sheet	High level overview of the DWW 50-year planning effort known as Shape Our Water	• Shape Our Water was previously referred to as the Integrated System Plan (ISP). • This work (DSA) is in the first blue box, "Prioritize drainage and wastewater risks and opportunities" • SPU is currently in the Visioning and Planning stages • This work will be the basis of the alternatives that are available for consideration and selected.

DWW LOS Framework	Level of Service Policy Stakeholder Analysis & Inclusive Outreach Equity Toolkits memo	• This was one of the first steps in the planning process.
		• It laid the groundwork for DSA drainage capacity risk area prioritization, where we determined:
		  • What is a problem?
		  • How do we prioritize problems?

Equity Strategy for Analysis Projects	This identified the steps that would be taken to embed equity in the DSA part of the planning effort.	Read please! For this RET we will be determining the impacts of this strategy on the drainage capacity risk area prioritization.
Equity Toolkit for Wastewater System Analysis Performance Target Selection	RET completed during the WWSA.	• Equity Strategy for Analysis Projects called for a RET at the same point in this project (DSA) as completed for the WWSA. • We later decided to apply a RET at a different point in the project (right now). • The learnings from the WWSA RET were applicable to the DSA, and we reviewed at the time.

Appendix H: Equity Strategy for Analysis Projects

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Equity Strategy for System Analysis Projects
Draft Date: 8/2/2018

Document Purpose: This document outlines a strategy to examine how elements of the Wastewater System Analysis and the Drainage System Analysis, such as performance targets, problem identification, and problem prioritization, may impact, either positively or negatively, the City's commitment to eliminate racial disparities and achieve racial equity in Seattle.

Goals:

- Incorporate analysis of equity impacts into the WWSA and DSA in a meaningful way.
- Build shared understanding among the project team members and project leadership that considering equity early in the integrated system planning process is valuable.
- Reinforce that equity is an important factor every time DWW makes a decision or selects a preferred option.
- Lay groundwork for DWW Vision and Integrated System Plan equity strategy.

Recommendations on when/where to incorporate equity considerations in analysis projects:

Note: An equity toolkit was completed by the DWW LOS Policy team in 2016. The recommendations of the toolkit have been incorporated into this strategy as they are directly applicable to the WWSA and DSA.

WWSA and DSA

- Core Team completes 'SPU Equity Toolkit for Service, Project, or Program Development' during the selection of the final performance target. See WWSA example here (LOB Rep or Topic Area Lead is the lead for this, as appropriate).
- Add demographic/race layer to current condition maps on summary sheets to provide context (LOB Rep or Topic Area Lead is the lead for this, as appropriate).
- Incorporate equity into prioritization tool(s) and tasks in a meaningful way (Holly is the lead for this).
- Incorporate applicable findings of the DWW Branch Equity Team Customer Response sub-committee analysis into these efforts (Annalisa is the lead for this).

WWSA

- Evaluate equity as one consideration in table that identifies pro/cons of each performance parameter.
- Include Racial and Social Equity Index on sub-basin summary sheets and problem sheets, either graphically or by including a yes/no check box.

DSA

All Topic Areas

- Include a section in the final Topic Area Technical Memoranda that describes how the project team evaluated equity as part of their analysis, describes any relevant findings of this evaluation, and identifies equity impacts that may result in the integrated system planning phase. This section should be included in the TMs even if this document does not have any specific recommendations for the topic area.

Task 2: Flooding

- Task 2.3: Performance Targets
    - Apply a modified racial equity toolkit to help select final performance targets. Please see to the WWSA example.
- Task 2.5: Extreme Storm Impact Analysis

    - "Develop analysis methods to evaluate the impacts of extreme events in both separated and combined sewer areas using the preliminary draft planning benchmarks. Method shall include developing criteria that define when and where an extreme storm event causes a problem and a metric for comparing potential impacts at different locations."
        - Extreme events will impact people, and this should be considered. There should be a discussion around who will be disproportionately impacted by extreme events such as communities of color, residents with limited mobility, etc. and how this influences the definition of a "problem". Even if a solution is not proposed in this phase of the planning effort, this task is laying the foundation for future planning work that will result in proposed solutions.
- Task 2.6: Sea Level Rise and Wave Inundation
    - Perform a high-level analysis of sea level rise and wave inundation to identify potential areas of concern and evaluate the impacts during selected planning level benchmarks.
        - Please see comment for Task 2.5. Impacts to people need to be considered.
- Task 2.9: Investigate and Prioritize Flooding Issues
    - Identify if a flooding issue is located in a 'high disadvantage and priority area' identified in the Racial and Social Equity Index. This can be shown on a map or a Y/N column in a spreadsheet, depending on the format of the deliverables.
- Task 2.10: Further Evaluate High-Priority Flooding Problems
    - Task 2.10.2: Include Racial and Social Equity Index layer in the high priority problems fact sheets to provide context.

<u>Task 3: Water Quality & Flow Control (Aquatic Life)</u>

- No recommendations, topic area team to discuss.

<u>Task 4: Fish Passage Barriers, Task 5: Floodplain Reconnection Opportunities, and Task 6: Aquatic Habitat Opportunities</u>

- No recommendations, topic area team to discuss.

<u>Task 7: Surfacing Groundwater</u>

- No recommendations, topic area team to discuss.

<u>Task 8: Landslide Mitigation</u>

- No recommendations, topic area team to discuss.

<u>Task 9: System Layout Challenges</u>

- No recommendations, topic area team to discuss.

Communications/Outreach

- Incorporate City of Seattle equity expectations and recommendations into the Public Involvement Plan, specifically:
    - Level of Service Policy Equity Toolkit recommendations
    - Race and Social Justice Initiative Equity Strategies
    - SPU's Environmental and Social Justice goals and strategies
- Set clear expectations for the consultant about implementation of equity-focused communications and outreach best-practices, including:
    - Dedicate outreach funding specifically for low-income communities and communities of color.

    - When resources are limited, prioritize outreach contract resources for outreach to low-income communities and communities of color
    - When time is limited, prioritize outreach to low-income communities and communities of color in the schedule
    - Ensure demographic information is gathered as part of public outreach to determine if our efforts are successfully targeting a diverse range of community members.
    - Provide information about SPU generally, in addition to gathering information on problems. Use this as an opportunity to share information on surfacing groundwater (DSA Task 7) as this is a problem type that residents may not be aware that they can report.
- Ensure coordination between WWSA and DSA outreach and other overlapping SPU outreach efforts to ensure that communities of color are not overburdened by outreach efforts.
- Build a partnership with SPU's Community Connections Program that works on outreach strategy, planning, materials and implementation.
- At the end of the project, hold a debrief to review the outreach process and identify if we reached communities of color. If we did not reach communities of color as well as we intended, identify what could we have done differently and apply lessons learned to upcoming planning efforts.

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Appendix I: Prioritized Risk Areas Maps

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Seattle Public Utilities

Drainage System Analysis

Prioritized Drainage System Capacity Risk Areas

southwest

N

LEGEND

Relative Risk Category

- Very Low
- Low
- Medium Low
- Medium
- High
- Critical

Elliott Bay

Puget Sound

Schmitz

Pelly

Longfellow

Puget Ridge

Duwamish Waterway

Faunleroy

Seola Beach

Hamm

location key

0 0.5 1 Miles

Author: C O'Brien Date: 12/11/2020 File Path: X:\Separated Systems\Business_Areas\Planning\DSA\mxd\DSA_CapacityRiskAreas_tabloid.mxd

Seattle Public Utilities

Drainage System Analysis

Prioritized Drainage System Capacity Risk Areas

southeast

N

LEGEND

Relative Risk Category

- Very Low
- Low
- Medium Low
- Medium
- High
- Critical

Elliott Bay

Lake Washington

Puget Ridge

Longfellow

Duwamish Waterway

Hamm

Mapes

Taylor

location key

0 0.5 1 Miles

Author: C O'Brien Date: 12/11/2020 File Path: X:\Separated Systems\Business_Areas\Planning\DSA\mxd\DSA_CapacityRiskAreas_tabloid.mxd

Seattle Public Utilities

Drainage System Analysis

Prioritized Drainage System Capacity Risk Areas

northwest

N

LEGEND

Relative Risk Category

- Very Low
- Low
- Medium Low
- Medium
- High
- Critical

Broadview

Littles

Venema

Victory

Pipers

Licton Springs

Puget Sound

Green Lake

Wolfe

Salmon Bay

Lake Union

Elliott Bay

location key

0 0.5 1 Miles

Author: C O'Brien Date: 12/11/2020 File Path: X:\Separated Systems\Business_Areas\Planning\DSA\mxd\DSA_CapacityRiskAreas_tabloid.mxd

Seattle Public Utilities

Drainage System Analysis

Prioritized Drainage System Capacity Risk Areas

northeast

N

LEGEND

Relative Risk Category

- Very Low
- Low
- Medium Low
- Medium
- High
- Critical

Littles
Littlebrook
Thornton - N Branch
Victory
Kramer
Thornton - S Branch
Mock
Thornton - Mainstem
Maple
Matthews
Venema
Pipers
Licton Springs
Green Lake
Ravenna
Yesler
Lake Washington
Union Bay
Lake Union
Washington Park
Elliott Bay

location key

0 0.5 1 Miles

Author: C O'Brien Date: 12/11/2020 File Path: X:\Separated Systems\Business_Areas\Planning\DSA\mxd\DSA_CapacityRiskAreas_tabloid.mxd