

DRAINAGE SYSTEMS ANALYSIS

Geologic Hazards

Technical Memorandum

October 26, 2020

PHOTO CREDITS from top left:

Salmon in Longfellow Creek, Seattle. Holli Margell, 2009. http://nativelightphoto.com/

Thornton Creek Confluence Restoration, Seattle. Natural Systems Design, 2014. http://naturaldes.com Flooding in South Park, Seattle. Sheila Harrison, Seattle Public Utilities, 2009.

Lake Union, Seattle. Seattle Public Utilities Photo Archive, date unknown.

Geologic Hazards

Technical Memorandum

Date: October 26, 2020

Deliverable title: Geologic Hazards Topic Area Summary

Task No.: 8

To: Holly Scarlett, SPU Project Manager

From: Ingrid Wertz, Geologic Hazards Topic Area Lead
Seattle Public Utilities

Prepared by: Ingrid Wertz, Geologic Hazards Topic Area Lead

With contributions from:

Don Anderson, Bill Benzer, Mike Brennan, Brian Landau, Jim Lee, Annalisa McDaniel, Juan Carlos Ramirez, David Shin, Keith Ward, and Leslie Webster

Approved by: Leslie Webster (Nov 5, 2020 16:19 PST) 11/05/2020

Leslie Webster, Planning Program Manager, SPU

Table of Contents

Figures

Tables

Abbreviations

BC	Brown and Caldwell
City	City of Seattle
ECA	Environmentally Critical Area
DSA	Drainage System Analysis
DWW	Drainage and Wastewater
GIS	Geographic information system
ISP	Integrated System Plan
SDOT	Seattle Department of Transportation
SIA	Stability Improvement Area
SPU	Seattle Public Utilities

Executive Summary

This Geologic Hazards Topic Area Technical Memorandum (TM) presents a summary of information available for known landslide areas and liquefaction prone areas in the Seattle area.

The objectives of the Geologic Hazards topic area analysis are to summarize landslide areas, present information on landslide mitigation area prioritization and projects, and summarize liquefaction-prone areas. Liquefaction-prone areas are sites with loose, saturated soil that lose the strength needed to support loads during earthquakes. Drainage and wastewater infrastructure in these areas are at risk of damage from an earthquake.

The Geologic Hazards Topic Area TM identifies the best GIS layers to use for identifying landslide-prone areas and liquefaction areas to be used for Shape Our Water Plan purposes. This TM also provides a summary of areas of known concern and of the major slope stability mitigation projects performed by Seattle Public Utilities and the Seattle Department of Transportation. If additional information is needed on specific areas for the Shape Our Water Plan, more research and analysis will likely need to be completed.

The information associated with this DSA TM can be used by the Shape Our Water Plan to help identify areas where Drainage and Wastewater infrastructure is at risk from geologic hazards. In addition, this information can help identify geologic hazards associated with prioritized drainage and wastewater problems.

Outside of the Shape Our Water Plan, this information can benefit the authors of both new and updated Asset Management Plans, which have not typically included the vulnerability of the asset class to geologic hazards in their respective assessments.

1. Introduction

This Geologic Hazards Topic Area TM summarizes the work completed by Seattle Public Utilities (SPU) as part of the Drainage System Analysis (DSA) program for Task 8. The TM includes background information, a discussion of analysis methods used to complete the work, and a discussion of the results. Recommendations on how these results could be used, both within the Shape Our Water Plan (formerly the Integrated System Plan [ISP]) or outside of the Plan, and information on data gaps and potential future work associated with geologic hazards, are also provided.

Related information on peat-settlement prone areas is presented in DSA's System Layout Challenges TM. In addition, as part of the Shape Our Water Plan, a seismic risk assessment is being conducted to evaluate SPU's wastewater system to identify the facilities and pipelines at higher risk in a seismic event and prepare initial preliminary risk ratings to categorize high-risk facilities and pipelines for future planning efforts. At this time, this task is limited to the wastewater system only and does not evaluate seismic risks to SPU's drainage system.

2. Background

Landslides that occur within the city of Seattle, tend to occur primarily within steep slope areas and are a result of both natural and human factors Drainage and wastewater infrastructure located in these areas is at risk of damage from these slides. In addition, leaking drainage and wastewater infrastructure can contribute to slope instability in these areas.

The Seattle area experienced significant landslide events as the result of two successive rainy seasons (1995-1996 and 1996-1997). In 2000, at the request of SPU, Shannon & Wilson, Inc., completed two studies designed to collect additional information on these slides: the *Seattle Landslide Study* (Shannon & Wilson, January 2000), included a geodatabase of the location, date, landslide type, geologic conditions, and possible contributing factors for 1,326 Seattle area landslides. The second study was the *Seattle Landslide Prioritization Study* (Shannon & Wilson, May 2000), which established Stability Improvement Areas (SIAs) to identify and assess the extent of landslide remediation advisable to the City of Seattle (City).

In 2003, the initial *Seattle Landslide Study* was updated by Shannon & Wilson to include approximately 110 additional landslides reported through March 2003 in the SIA matrices. The landslides identified in the 2000 and 2003 studies are shown in Figure 2-1.

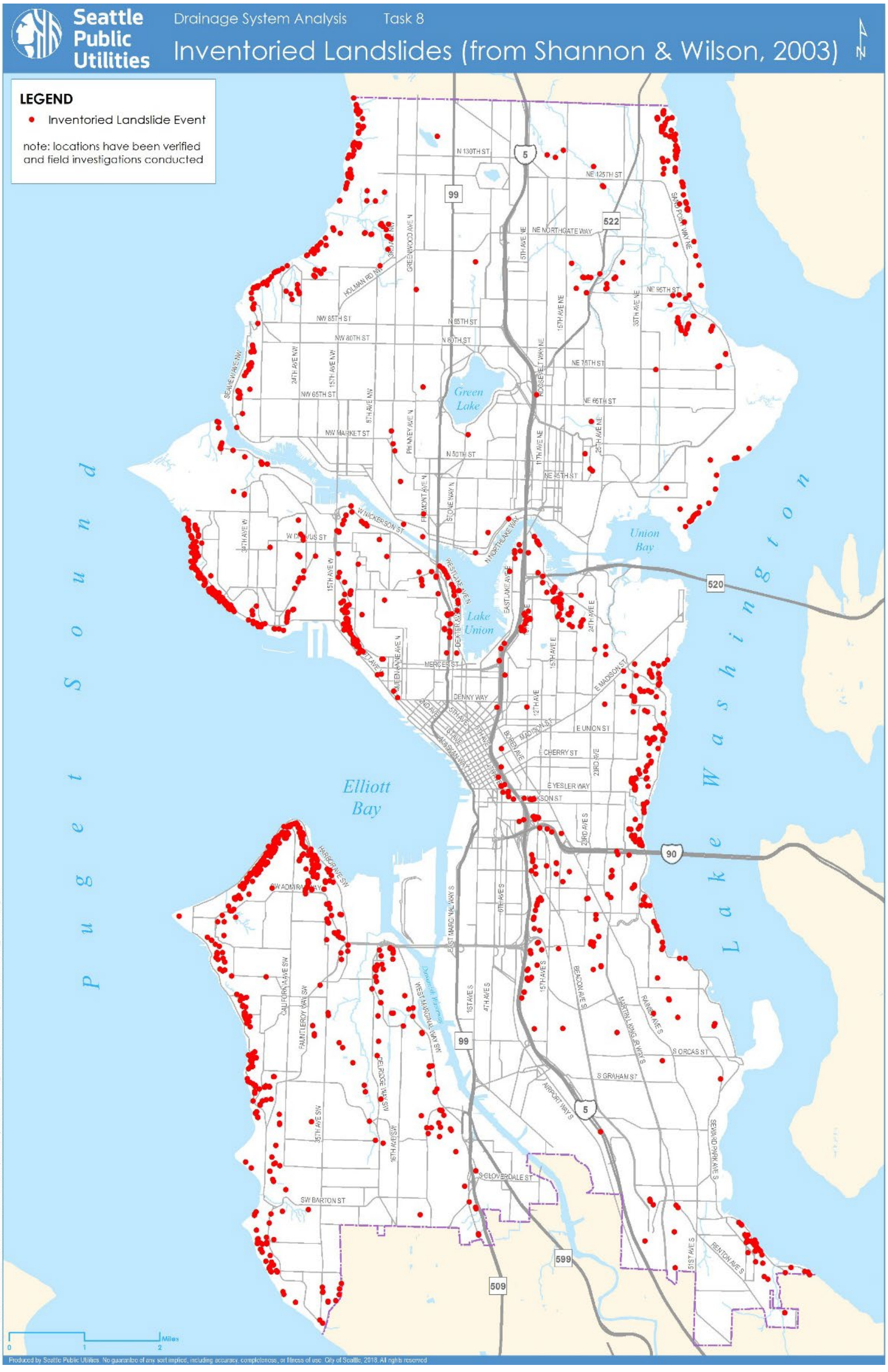

Figure 2-1: Inventoried Landslides

Landslides inventoried between 1997 - March 2003

The *Seattle Landslide Study Prioritization Report* (Shannon & Wilson, 2000) prioritized 50 landslide mitigation projects in 31 SIAs identified in the 2000 *Seattle Landslide Study (Shannon & Wilson, 2000)* based on the following 11 criteria:

- Size of slope failure
- Likelihood of failure
- Slope modification
- Mitigation cost
- Ownership
- Vulnerability of facility
- Public safety
- Public inconvenience
- Environmental consequences
- Type of facility
- Neighborhood plans

Seventeen landslide mitigation sites were identified where SPU was the primary beneficiary of the mitigation (i.e., landslide mitigation would protect or reduce damage to SPU assets). The Seattle Department of Transportation (SDOT) (formerly SEATRANS) was identified as an additional beneficiary from mitigation efforts at 15 of the 17 sites.

Between 2000 and 2010, SPU and SDOT implemented projects at several of these sites. SDOT also contracted for the completion of a separate landslide risk-assessment for structures on or near arterial streets. The results of this study and status of any projects completed are not included in this TM due to the information not being readily available.

It is important to note that, although SPU has completed many smaller landslide mitigation projects outside the area of these 17 sites, they are not documented in this TM. Currently, smaller landslide projects (estimated at less than $300k), are prioritized and addressed through SPU's Drainage and Wastewater (DWW) Small Landslides Program.

Information on liquefaction prone areas included in this TM is based on the information available in the ECA Liquefaction Prone Area GIS layer.

3. Method

Available sources of information were reviewed to determine the most appropriate information to use for planning to identify landslide-prone areas as well as areas with high liquefaction potential. For landslide-prone areas, the following ECA GIS layers were evaluated: potential landslide layer, known landslide layer, and steep slope erosion hazard layer. For liquefaction areas, only the ECA liquefaction prone area GIS layer was evaluated. Maps (Figure 2.1 and Figure 4.1) were generated using data available in December 2019. The date of the dataset used is noted in the bottom left border of each map.

To determine the status of the 17 landslide mitigation sites where SPU was the primary beneficiary identified in the *Seattle Landslide Study Prioritization Report (Shannon & Wilson, 2000)*, SPU staff that had worked on landslide mitigation projects between 2000 and 2010 (i.e., Bill Benzer, Jim Lee, and Keith Ward) were interviewed.

4. Results

Based on a review of the available ECA data on landslide-prone areas and on information provided in the Shannon & Wilson studies, it was determined that the best GIS layers to use for planning purposes for landslide-prone areas were the ECA 'potential landslide area' layer and the 'SIA' layer from the 2003 *Seattle Landslide Study* (Shannon & Wilson, 2003). The ECA 'known landslide area' layer was determined not to be as robust as the other layers, and the ECA 'steep slope layer' did not provide any more value for identifying potential landslide-prone areas than did the other two layers.

Based on the review of the ECA 'liquefaction-prone area' layer, it was determined to be well-suited to planning needs. Figure 4-1 shows these three layers (areas).

Follow-up interviews with City staff determined that the City has completed projects to mitigate landslide risks at 11 of the 17 highest prioritized project sites that pose risks to SPU assets. See Table 4-1 for a summary of the status of the various mitigation projects based on the *Seattle Landslide Prioritization Report* (Shannon & Wilson, May 2000).

SPU completed 8 projects and SDOT completed 3 projects. The scope of the projects completed were modified from the initial project scopes identified in the Seattle Landslide Study. Specifically, SPU field investigated and evaluated all the prioritized sites to determine which projects posed the greatest risk to SPU assets and chose to mitigate the sites accordingly based upon site and project conditions.

In all cases, the proposed project identified in the *Seattle Landslide Study Prioritization Report* was modified to a smaller mitigation project. SPU chose not to conduct projects at the remaining 6 project sites based on evaluations of the site or other considerations. The completed projects are not well documented, and/or the documentation is difficult to access; some information on completed projects can be found in the PowerPoint Landslide Mitigation Program presented by Bill Benzer (SPU, 2008).

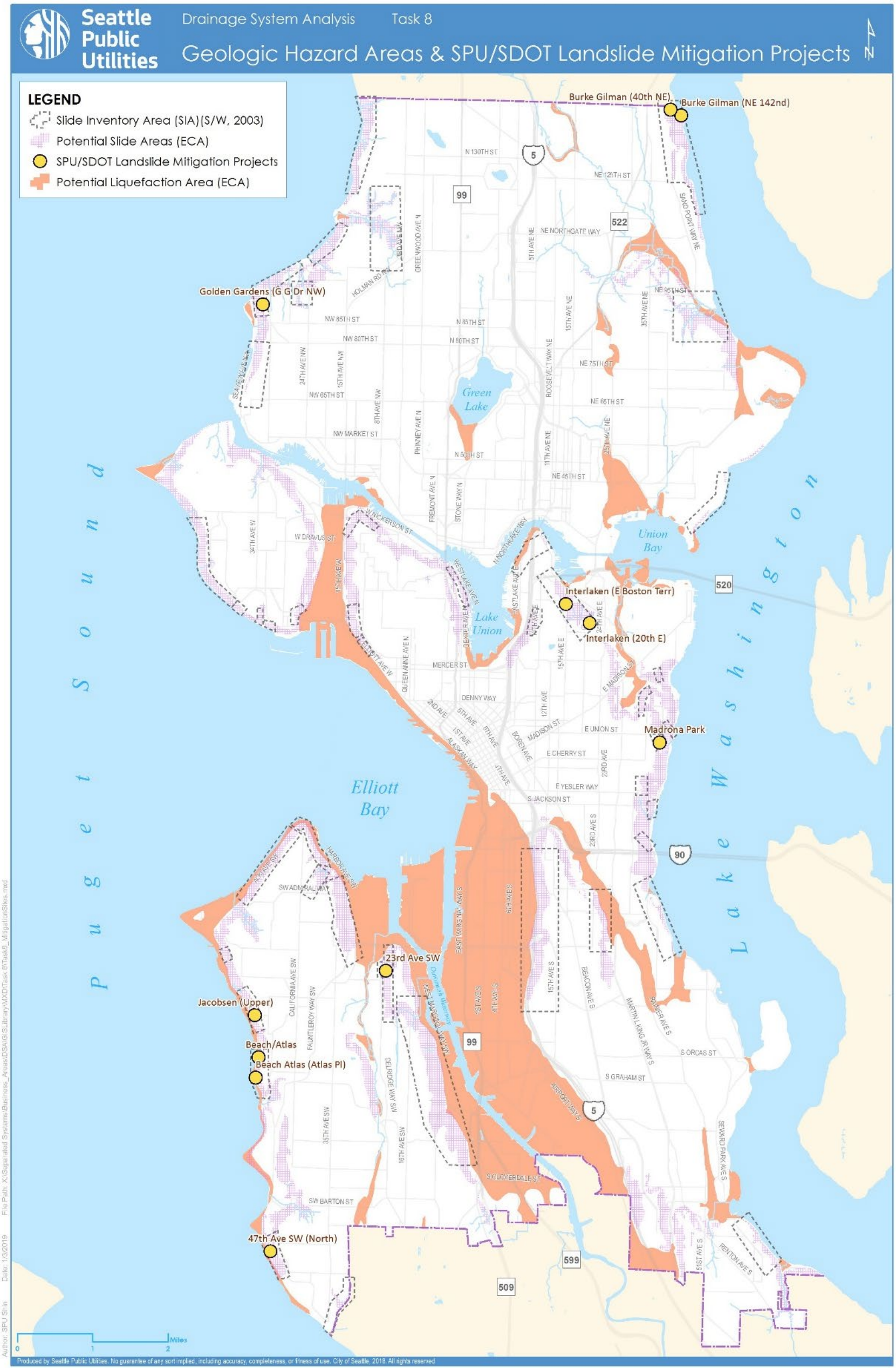

Figure 4-1: Geologic Hazards Areas

Table 4-1: Status of Landslide Mitigation Sites			
Project Rank (2000)	**Project Name**	**Stability Improvement Area**	**Project Status**
1	Beach Atlas (Atlas Pl)	Beach Dr/Atlas Pl	Completed
2	Interlaken (E Boston Terr)	Interlaken	Completed
3	Burke Gilman (40th NE)	Burke-Gilman	SDOT Project
4	Burke Gilman (NE 142nd)	Burke-Gilman	SDOT Project
5	Lake Dell	Lake Dell	No Project
6	Golden Gardens (G G Dr NW)	Golden Gardens	Completed
7	Rainier Beach (North)	Rainer Beach	No Project
8	Interlaken (20th E)	Interlaken	Completed
9	Interlaken (Retreat Center)	Interlaken	No Project
10	32nd Ave E	32nd Ave E	No Project
11	32nd Ave W	32nd Ave W	No Project
12	Madrona Park	Madrona Park	Completed
13	Jacobsen (Upper)	Jacobsen	Completed
14	47th Ave SW (North)	47th Ave SW	Completed
15	23rd Ave SW	23rd Ave SW	Completed
16	Hillside Dr E (East)	Hillside Dr E	No Project
17	Beach/Atlas	Beach Dr/Atlas Pl	SDOT Project

Source: Seattle Landslide Study Prioritization Report (Shannon & Wilson, 2000)

The following GIS layers were used as the basis for figures in this TM and will be used for future planning:

- ECA Potential Landslide Areas
- ECA Liquefaction-Prone Areas
- The Slide Event Inventory (Shannon and Wilson, 2003). It includes a comprehensive geodatabase of all inventoried landslides including decade of slide, location, neighborhood, type of slide, human influence, etc.
- For this TM, SPU created a layer that shows the 17 priority sites that pose risk to SPU assets from the *Seattle Landslide Prioritization Report*; this layer is called **LndSldMtgtnSites**.

The GIS layers referenced in this TM can be found at the following link:

https://seattlegov.sharepoint.com/sites/spu-D1/Planning/DWW%20GIS%20Library/Forms/AllItems.aspx?viewpath=%2Fsites%2Fspu%2DD1%2FPlanning%2FDWW%20GIS%20Library%2FForms%2FAllItems%2Easpx&id=%2Fsites%2Fspu%2DD1%2FPlanning%2FDWW%20GIS%20Library%2FDSA%2FData%2F%5FDeliverables%2FTask%208

The pathway to this location is: **DWW Planning Sharepoint -> DWW GIS Library -> DSA -> Data -> _Deliverables -> Task 8**

5. Discussion

This TM identifies the best GIS layers to use to identify landslide-prone areas and liquefaction areas to be used for Shape Our Water purposes. This TM also provides an update on the status of the major slope stability mitigation projects performed by SPU and SDOT that were identified in the *Seattle Landslide Study Prioritization Report* (Shannon & Wilson, 2000). It is important to note that the DWW Small Landslide Program has also mitigated numerous smaller slide areas throughout the City to protect SPU assets that are not included in this TM. In addition, SDOT (and potentially other City departments) have conducted landslide mitigation projects that are not included in this TM.

This TM identifies areas of concern and known problems. If additional information is needed on specific areas for the Shape Our Water Plan, more research and analysis will need to be done. Additional sources of information related to specific locations is in the GIS Layer Slide Event Inventory (Shannon & Wilson, 2003).

Some information on completed projects in Table 4-1 can be found in the PowerPoint *Landslide Mitigation Program* presented by Bill Benzer (SPU, 2008).

Racial and service equity was not considered in the evaluation of the existing GIS layers which are science-based. The *Seattle Landslide Study Prioritization Report* did consider impacts to people in its criteria; however, not through a service equity lens. A further discussion of how equity could be considered in Shape Our Water Plan is included in Section 6.1.

6. Recommendations for Future Use

6.1 How information could be used for Shape Our Water

The information associated with this TM can help identify areas where DWW infrastructure is at risk from geologic hazards. In addition, this information can help identify geologic hazards associated with prioritized drainage and wastewater problems. For example, drainage or wastewater pipes that are identified as capacity constrained that are in liquefaction or potential slide areas may need to be mitigated differently than less hazard-prone areas. In addition, the information about DWW assets in these geologic hazard areas increases awareness of DWW system vulnerabilities than can allow for improved resiliency planning and management of these assets.

As discussed in Section 5, equity was not considered in the prioritization of landslide areas. Equity is a concern in relation to the demographics of customers that live in potential landslide-prone and liquefaction areas where the potential impact to utility services may be greater. The potential landslide and liquefaction areas, when not situated along shorelines, are predominantly located in aeras of high racial and social disadvantage. As part of the Shape Our Water Plan, the potential impacts of geologic hazards should be looked at through an equity lens.

6.2 How information could be used outside of Shape Our Water

The information generated from this assessment could be used in the development and update of Asset Management Plans. Most Asset Management Plans have not assessed the vulnerability of the asset class to geologic hazards.

7. Additional Information

7.1 Related DSA Topic Areas

Related information on peat-settlement prone areas are found in the DSA System Layout Challenges TM. In addition, as part of the Shape Our Water Plan, a seismic risk assessment is being conducted to evaluate SPU's wastewater systems to identify the facilities and pipelines at higher risk in a seismic event and prepare initial preliminary risk ratings to categorize high-risk facilities and pipelines for subsequent planning. At this time, this study is limited to the wastewater system only. Seismic risks to SPU's drainage system are not included.

7.2 Additional Work/Data Gaps

As noted above, the information on landslide mitigation projects summarized in this TM is limited to SPU projects. Additional information about landslide mitigation projects conducted by other City departments would need to be collected, if needed, for the Shape Our Water Plan.

Additional work could be done to identify priority locations where drainages and wastewater infrastructure is densest in geologic hazard areas. A geologic hazard assessment could be conducted that identifies the miles of drainage, wastewater, and water mainlines present in SIAs and liquefaction areas. The SIA or liquefaction areas with the greatest density (ft/acres) could be identified. Although outside the original scope of this task, this analysis was initiated; preliminary results can be found on the DSA SharePoint site. However, due to staffing limitations and the lack of a clear need for this information for the Shape Our Water Plan, this work was not further developed or included in this Geologic Hazards Topic Area TM.

References

Seattle Public Utilities, 2008. *Landslide Mitigation Program* (PowerPoint presentation). Presenter: Bill Benzer. April 2008. https://seattlegov.sharepoint.com/sites/spu-D1/DSA/PPL/SPU%20Landslide%20Mitigation%20prog%204-4-08.ppt

Shannon & Wilson, Inc, 2003. *Seattle Landslide Study (2003 Update)*. August 2003. Q:\Planning\System Planning\Drainage System Planning\Drainage System Analysis\Project Management\T- Topic Area Teams\Geologic Hazards\Background\2003 Landslide Study

Shannon & Wilson, Inc., 2000. *Seattle Landslide Study Prioritization Report*. May 2000. https://seattlegov.sharepoint.com/sites/spu-D1/DSA/PPL/Seattle-Landslide-Prioritization-Report-May-2000.pdf

Shannon & Wilson, Inc., 2000. *Seattle Landslide Study*. Prepared for Seattle Public Utilities. January 2000.