DRAFT

ASSET MANAGEMENT PROGRAM – YEAR 2

Vulnerability Assessment

B&V PROJECT NO. 199340
B&V FILE NO. 40.0000

PREPARED FOR

County of San Diego

8 FEBRUARY 2018

BLACK & VEATCH

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Executive Summary

Sanitary sewer infrastructure located within proximity to streams and water bodies is inherently vulnerable. Any spill or leakage from these vulnerable segments can rapidly diffuse through the environment. From a practical standpoint, aligning sewers in these environments is largely unavoidable as both sewer pipes and drainage pathways share the same physical constraint of gravity flow. However, with careful planning and management, these risks can be mitigated to a large extent.

Overview

This vulnerability assessment provides a framework for identifying and minimizing risk on some of the most vulnerable segments of the County of San Diego Sanitation District (District) sewer collection system. This study focuses on a snapshot in time of identified stream crossings and vulnerable adjacent pipelines. Available data sources were reviewed and used to identify 92 pipe segments for consideration. Vulnerabilities were defined, which led to the development of a desktop and field work plan to gather data. Field work was conducted to evaluate access, erosion, pipe and manhole condition, and other factors contributing to the vulnerability of the system. Criteria were then defined to establish a risk-based approach for assessing and prioritizing the risk of each segment.

Scope of Work

The scope of this study included:

- Reviewing creek crossings (and adjacent high-risk pipes) identified by District staff.
- Assessing the available data for those pipelines.
- Performing field inspections of the sewer infrastructure and the watershed. Determining if the sewers are accurate in the GIS and accessible. Performing observations of both the sewer system and the watershed that affects the sewer system.
- Providing a risk-based prioritization process that categorizes the sewer pipeline vulnerabilities based on Likelihood of Failure (LoF) and Consequence of Failure (CoF).
- Summarizing observed risks.

Assets included in the Analysis

The District identified 92 pipe segments to be included in this study, including vulnerable water body crossings and pipelines adjacent to water bodies. 53 pipelines cross water bodies (52 are gravity pipelines and one pipe is a force main attached to a bridge crossing). In addition to the 53 crossings, 39 adjacent pipelines were also included to form a broader picture of vulnerabilities. A list of pipelines and figures showing them are included in Section 2 of the Study.

The District recognizes that there may be additional pipelines (or other assets) within the District's system that may be vulnerable and warrant additional assessment. While this study is not intended to be comprehensive of all pipelines and their vulnerabilities, the District has discussed using this study as a basis for expanding vulnerability assessments if additional at-risk assets are identified.

Vulnerabilities Considered

The Study focused on evaluating each pipeline against the vulnerabilities summarized below.

- **Natural Events.** Natural events including wet weather events, seismic events, and wildfires. Wet weather events were considered the most likely vulnerability.
- **Vandalism.** Unauthorized tampering and obstruction of District assets.
- **Access Restrictions.** Inability to readily access, observe, and maintain sewer crossings, or to respond to spills.
- **Pipeline and Manhole Physical Vulnerabilities**. Predominantly the age, material, and carrying capacity of the pipelines.
- **Operations and Maintenance Vulnerabilities.** Systems and procedures to ensure proper operation and maintenance.
- **Power, Telemetry and Instrumentation Risks.** Power or control related risks.

Field Assessment

The District's GIS, CCTV, and as-built records were reviewed as part of this study. This information was used to both identify gaps and to plan field inspections. The field work for this study took place over a six day period in July 2018. Through the collaborative effort of Black & Veatch and District employees, all 92 sites throughout Spring Valley, Lakeside, Alpine, and Julian—encompassing approximately 60 miles of San Diego County—were inspected.

Stream Bed Erosion Analysis

A stream bed erosion analysis was conducted to evaluate the stream bed degradation and bank erosion severity. In accordance with relevant guidelines, the erosion extent and potential were determined from field inspections based on average bank height, bank slope, bank material, vegetation protection and visual evidence of stream degradation, bank erosion and scour. This analysis was combined with the depth of cover over the pipes to develop a sewer failure risk component associated with erosion and pipe exposure. The visual inspections also identified locations where more detailed analysis may be needed.

Next Steps

This study summarizes the observed vulnerabilities as a snapshot in time. As a result, this vulnerability study will be incorporated into District's overall asset management program to allow for reassessment of conditions based on new data and an efficient use of resources to minimize the risk of vulnerable pipe segments. As the District collects and reviews additional data, the conditions, priorities and permitting needs identified in this study will be confirmed. By incorporating vulnerability into the District's Capital Improvement Plan (CIP) prioritization tool, details of specific improvements to minimize risk of vulnerable pipe segments will be developed in conjunction with the District's ongoing plans and priorities.

1.0 Introduction

1.1 SANITATION DISTRICT SYSTEM SUMMARY

The County of San Diego Sanitation District (District) performs public works functions to manage several wastewater systems within the County of San Diego and provides sewer service to nearly 36,000 customers in the unincorporated areas of the county. Wastewater from the communities of Alpine, East Otay Mesa, Lakeside, Spring Valley, and Winter Gardens, is conveyed through a network of collector pipes, trunk lines, and pump stations to the City of San Diego's Point Loma Treatment Plant for treatment and disposal. Wastewater from the rural communities of Julian, Pine Valley, and Campo is conveyed to nearby District-operated wastewater treatment plants for treatment and disposal. The District's sanitary sewer system consists of approximately 432 miles of sewer lines, 8,200 manholes, eight pump stations, and three wastewater treatment plants.

1.2 ASSET MANAGEMENT PROGRAM OVERVIEW

The District has embarked on an asset management program to better manage, improve, operate and maintain the sewer system. The District initially focused on improving data sources, especially information within the District's geographic information system (GIS). In 2017, the District initiated a multi-year effort to better assess and manage infrastructure. This program has multiple facets including implementing a new computer maintenance management system (CMMS), a system-wide closed-circuit television (CCTV) inspection program, and an improved capital improvement program (CIP). This vulnerability study will provide input to incorporate into the District's overall asset management program.

2.0 Identification of Vulnerable Crossings

2.1 DEFINITION OF A CROSSING

Wastewater conveyance systems are inherently vulnerable due to the nature of wastewater itself and the topographic constraints of San Diego County. Alignments along water bodies, through canyons, and across sensitive habitats are typical in San Diego as they can be the only feasible routes to allow gravity flows. The focus of this study was to assess vulnerabilities for a select set of pipelines in some of the most sensitive areas of the county – in locations that cross or lie adjacent to water bodies.

Assets included in the Analysis

The District identified 92 pipe segments to be included in this study, consisting of vulnerable water body crossings and pipelines adjacent to water bodies. 53 pipelines cross water bodies (52 are gravity pipelines and one pipe is a force main attached to a bridge crossing). In addition to the 53 crossings, 39 adjacent pipelines were also included to form a broader picture of vulnerabilities. The list of pipe segments is presented in Table 1 and depicted on Figure 1 through Figure 5. The following further defines the pipelines in each subset and how they were identified.

- **Pipeline Crossings Definition.** The *Enrollee's Guide to the SSO Database,* produced by the State Water Resources Control Board (SWRCB), defines a crossing as a sewer pipe crossing over or under a water body (SWRCB, August 2013). The Enrollee's Guide states "A pipeline parallel to a stream or creek should not be included unless the pipeline is conveying flow from one side of the water body to the other. A water body is any significant accumulation of water such as streams, rivers, ponds, lakes, reservoirs, wetlands, oceans or seas."
- Consistent with the Enrollee's Guide, crossings were identified by the District using in-house GIS data for its sewer collection system and available water body GIS data. The water body data consisted of the National Hydrography Dataset (NHD), produced by the United States Geological Survey (USGS), updated January 2018. The sewer pipe data is maintained by the District and was also updated in January 2018.
- **Adjacent Pipelines Definition.** Adjacent pipelines were identified by District staff via the same methodology as the pipe crossings – through a review of GIS data and aerial mapping. Pipelines that appeared to be vulnerable to high consequence sanitary sewer overflows (SSOs) were included.

Other Vulnerable Pipelines

The District recognizes that there may be additional pipelines (or other assets) within the District's system that may be vulnerable and warrant additional assessment. The District's entire collection system is being evaluated as part of an overall asset management program. The program has made significant strides in improving GIS data quality and expanding the CCTV inspection program. On-going efforts are aimed at improving the quality and usefulness of these data. As these systems continue to improve, the District will have better ways to identify and assess vulnerable pipelines. While this study is not intended to be comprehensive of all pipelines and their vulnerabilities, the District has discussed using this study as a basis for expanding vulnerability assessments if additional at-risk assets are identified.

2.2 SUMMARY OF IDENTIFIED PIPE SEGMENTS

Table 1 below provides a list of the vulnerable pipe segments that were identified for this study. Maps of the identified pipe segments are provided in Figure 1 through Figure 5.

Table 1 Identified Pipe Segments for Vulnerability Assessment

PIPE ID	WATERSHED	WATER BODY	CROSS/ADJACENT	DIAMETER	EXPOSED PIPE?
LS0905	Lower San Diego River	Los Coches Creek	Cross	10	
LS0844	Lower San Diego River	Los Coches Creek	Cross	8	
LS0843	Lower San Diego River	Los Coches Creek	Cross	8	
LS0842	Lower San Diego River	Los Coches Creek	Cross	8	
LS0841	Lower San Diego River	Los Coches Creek	Cross	8	
LS0840	Lower San Diego River	Los Coches Creek	Cross	8	
LS0839	Lower San Diego River	Los Coches Creek	Cross	8	
LS0838	Lower San Diego River	Los Coches Creek	Cross	8	
LS0832	Lower San Diego River	Los Coches Creek	Cross	8	
LS0831	Lower San Diego River	Los Coches Creek	Cross	8	
LS0829	Lower San Diego River	Los Coches Creek	Cross	8	
LS0828	Lower San Diego River	Los Coches Creek	Adjacent	8	
LS0827	Lower San Diego River	Los Coches Creek	Cross	8	
LS0826	Lower San Diego River	Los Coches Creek	Adjacent	10	
LS0822	Lower San Diego River	Los Coches Creek	Cross	8	
LS0806	Lower San Diego River	Los Coches Creek	Cross	8	
LS0805	Lower San Diego River	Los Coches Creek	Adjacent	8	
LS0802	Lower San Diego River	Los Coches Creek	Cross	8	
LS0801	Lower San Diego River	Los Coches Creek	Adjacent	10	
LS0798	Lower San Diego River	Los Coches Creek	Adjacent	12	
LS0452	Lower San Diego River	Los Coches Creek	Adjacent	15	
LS0451	Lower San Diego River	Los Coches Creek	Adjacent	15	
LS0550.05	Lower San Diego River	Los Coches Creek	Adjacent	18	
LS0550.04	Lower San Diego River	Los Coches Creek	Adjacent	18	
LS0550.03	Lower San Diego River	Los Coches Creek	Adjacent	18	
LS0550.02	Lower San Diego River	Los Coches Creek	Adjacent	18	
LS0550.01	Lower San Diego River	Los Coches Creek	Adjacent	18	
LS0446	Lower San Diego River	Los Coches Creek	Cross	12	
LS0432	Lower San Diego River	Los Coches Creek	Cross	8	

PIPE ID	WATERSHED	WATER BODY	CROSS/ADJACENT	DIAMETER	EXPOSED PIPE?
LS0422	Lower San Diego River	Los Coches Creek	Cross	8	Y
LS0419	Lower San Diego River	Los Coches Creek	Cross	18	
LS0416	Lower San Diego River	Los Coches Creek	Adjacent	18	
LS0402	Lower San Diego River	Los Coches Creek	Cross	8	
LS0393	Lower San Diego River	Los Coches Creek	Cross	18	Y
LS2473	Lower San Diego River	Los Coches Creek	Cross	8	Y
LS2472	Lower San Diego River	Los Coches Creek	Adjacent	10	Y
LS2391	Lower San Diego River	Los Coches Creek	Cross	8	
LS2307	Lower San Diego River	Los Coches Creek	Cross	15	
LS2239	Lower San Diego River	Los Coches Creek	Adjacent	8	
LS2237	Lower San Diego River	Los Coches Creek	Cross	21	
LS1849	Lower San Diego River	Los Coches Creek	Cross	12	
LS1503	Lower San Diego River	Los Coches Creek	Cross	8	Y
LS0253	San Vicente Creek	San Vicente Creek	Cross	10	
LS0038	San Vicente Creek	San Vicente Creek	Cross	6	Y
LS0127	Lower San Diego River	San Diego River	Cross	12	Y
LS0094	Lower San Diego River	San Diego River	Cross	24	
LS0078	Lower San Diego River	San Diego River	Cross	30	Y
LS0063	Lower San Diego River	San Diego River	Cross	27	Y
LS0043	Lower San Diego River	San Diego River	Adjacent	36	
LS0042	Lower San Diego River	San Diego River	Adjacent	36	
LS0019	Lower San Diego River	Forester Creek	Cross	42	
LS0018	Lower San Diego River	Forester Creek	Adjacent	33	
LS0004	Lower San Diego River	San Diego River	Adjacent	42	
SV1629	Lower Sweetwater River	San Diego 2nd Aqueduct	Adjacent	30	
SV1599-M	Lower Sweetwater River	Sweetwater River	Adjacent	8	
SV1627	Lower Sweetwater River	San Diego 2nd Aqueduct	Adjacent	30	
SV1589	Lower Sweetwater River	San Diego 2nd Aqueduct	Adjacent	30	
SV1517-M	Lower Sweetwater River	Sweetwater River	Adjacent	30	Y
SV1510-M	Lower Sweetwater River	Sweetwater River	Adjacent	24	Y
SV1508-M	Lower Sweetwater River	Sweetwater River	Adjacent	24	

PIPE ID	WATERSHED	WATER BODY	CROSS/ADJACENT	DIAMETER	EXPOSED PIPE?
SV1505	Lower Sweetwater River	Sweetwater River	Adjacent	24	
SV1347	Lower Sweetwater River	Sweetwater River	Adjacent	24	
SV1346	Lower Sweetwater River	Sweetwater River	Adjacent	30	
SV1345	Lower Sweetwater River	Sweetwater River	Adjacent	30	
SV1342	Lower Sweetwater River	Sweetwater River	Adjacent	36	
SV1173	Lower Sweetwater River	Sweetwater River	Cross	36	
SV1172	Lower Sweetwater River	Sweetwater River	Cross	36	
SV1043-M	Lower Sweetwater River	Sweetwater River	Adjacent	8	
SV0439	Lower Sweetwater River	Sweetwater River	Cross	8	
SV0438	Lower Sweetwater River	Sweetwater River	Cross	8	
SV0437	Lower Sweetwater River	Sweetwater River	Cross	8	
SV0435	Lower Sweetwater River	Sweetwater River	Cross	39	
SV0401	Lower Sweetwater River	Sweetwater River	Adjacent	8	
SV0400	Lower Sweetwater River	Sweetwater River	Cross	8	
SV0368	Lower Sweetwater River	Sweetwater River	Cross	42	
SV0367-M	Lower Sweetwater River	Sweetwater River	Adjacent	42	
SV0316	Lower Sweetwater River	Sweetwater River	Cross	30	
SV0015	Lower Sweetwater River	Sweetwater River	Adjacent	8	
SV0012-M	Lower Sweetwater River	Sweetwater River	Adjacent	54	
SV0006	Lower Sweetwater River	Sweetwater River	Adjacent	54	
SV0005	Lower Sweetwater River	Sweetwater River	Cross	54	
SV0004-M	Lower Sweetwater River	Sweetwater River	Cross	54	
SV0003-M	Lower Sweetwater River	Sweetwater River	Cross	54	
AL0309	Upper San Diego River	Alpine Creek	Cross	8	
AL0030	Upper San Diego River	Alpine Creek	Cross	12	Y
AL0006	Upper San Diego River	Alpine Creek	Cross	12	
JU0024-M	Upper San Diego River	Coleman Creek	Cross	8	
JU0016	Upper San Diego River	Coleman Creek	Cross	8	
JU0008-M	Upper San Diego River	Coleman Creek	Cross	8	
JU0003	Upper San Diego River	Coleman Creek	Cross	8	Y
SV7562	Lower Sweetwater River	NA	Adjacent	8	
SV7563	Lower Sweetwater River	NA	Adjacent	8	

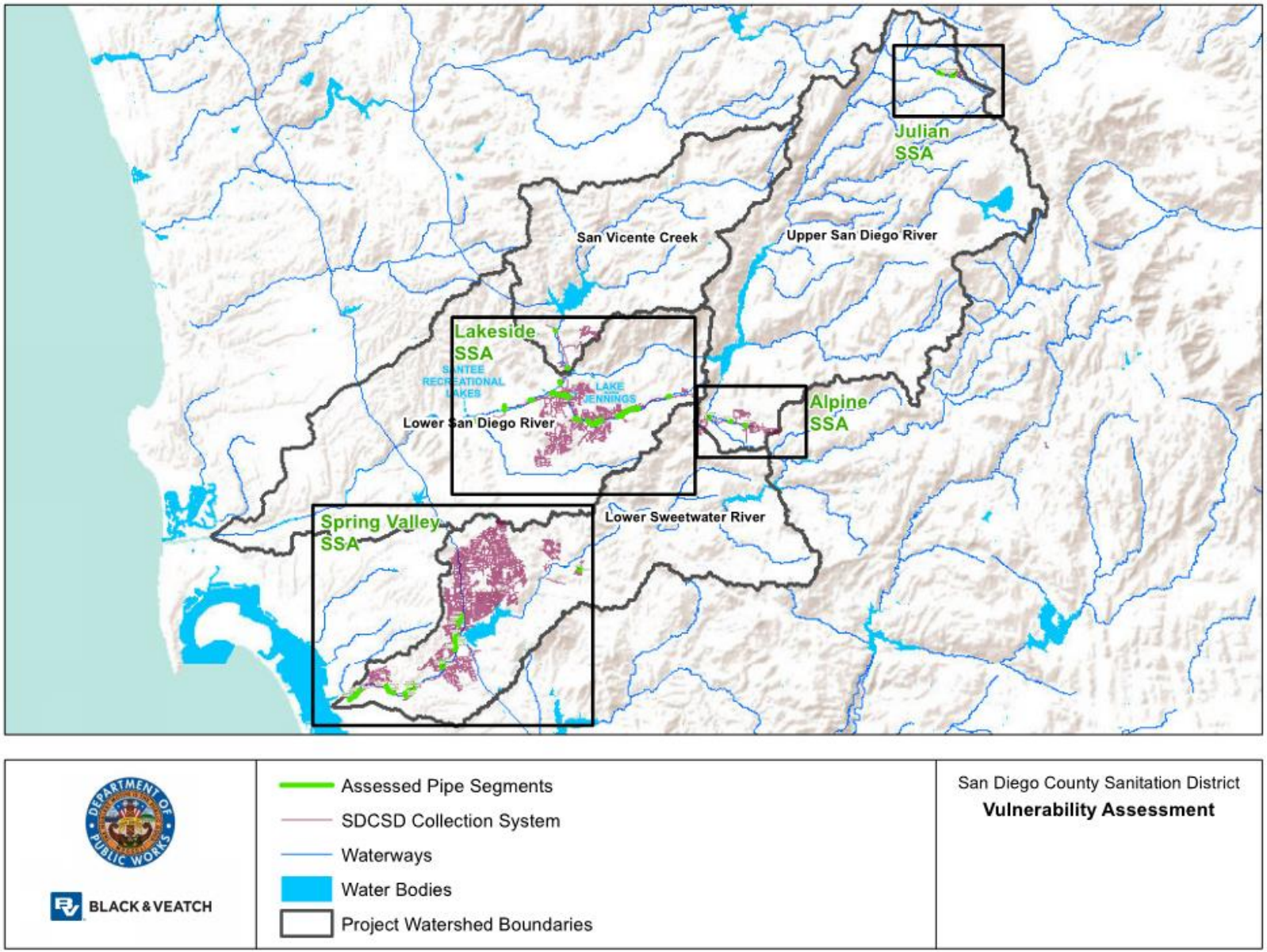

Figure 1 Vulnerable Pipe Segments - Key Map

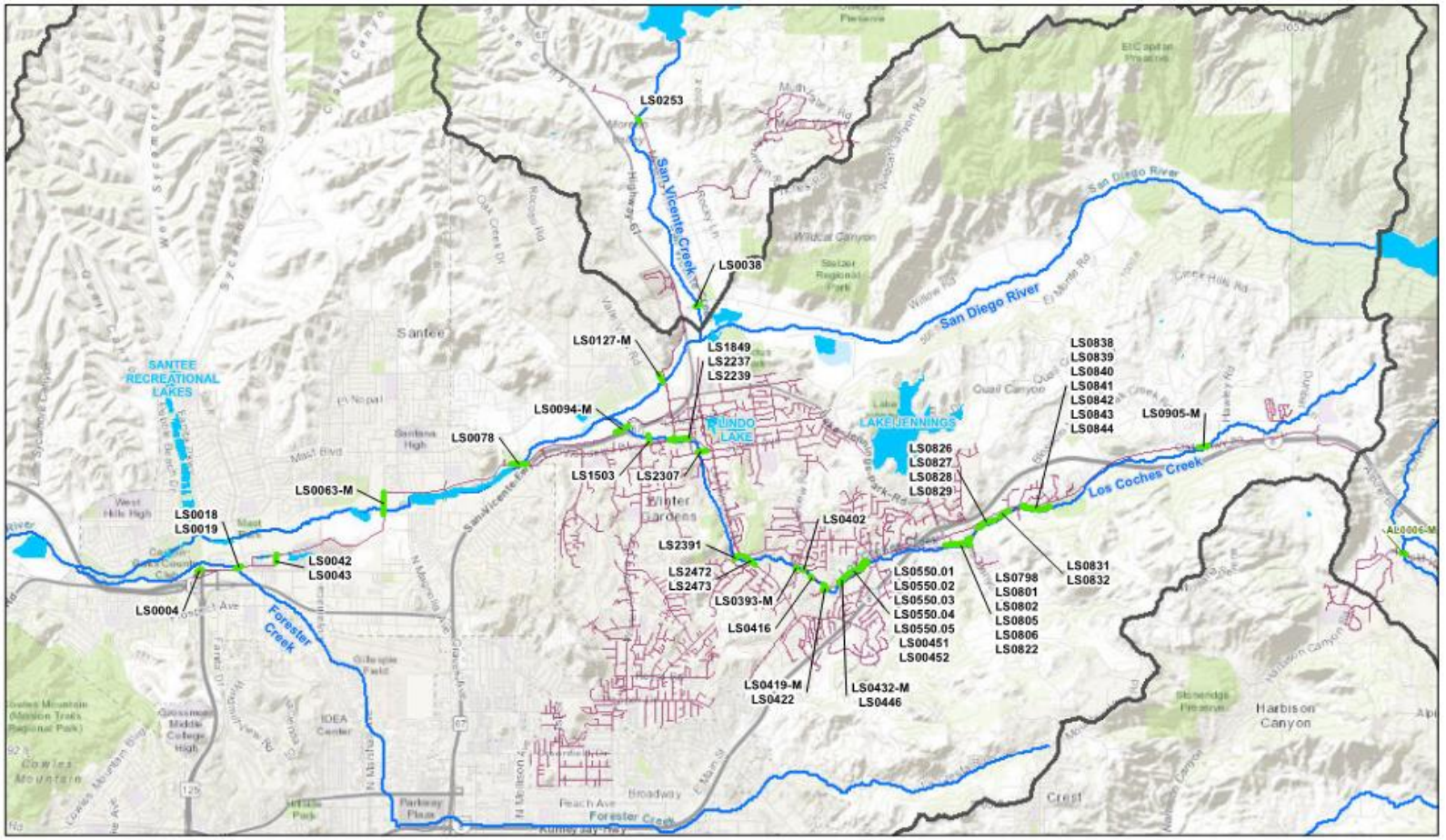

Figure 2 **Vulnerable Pipe Segments – Lakeside Service Area**

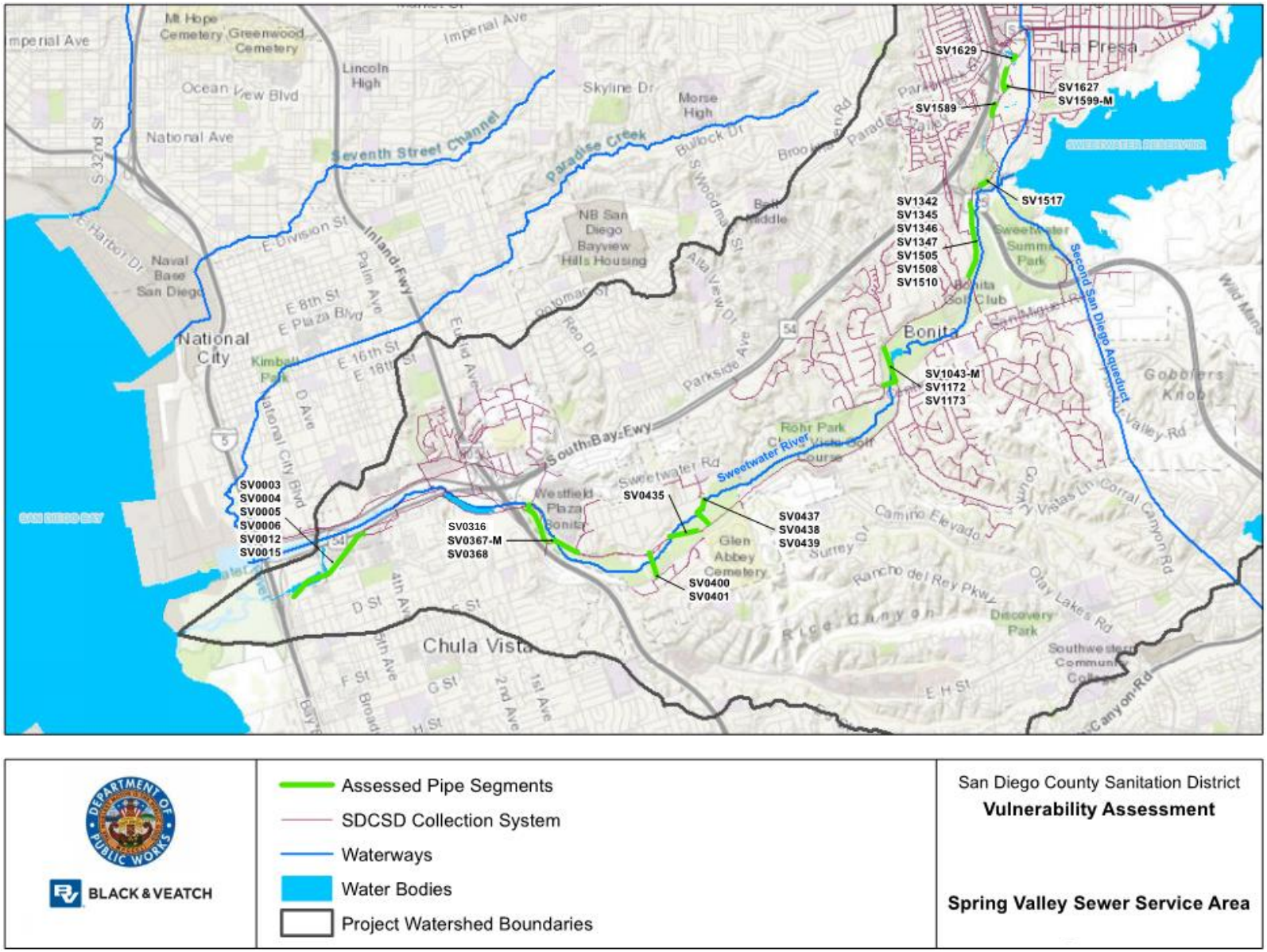

Figure 3 **Vulnerable Pipe Segments – Spring Valley Service Area**

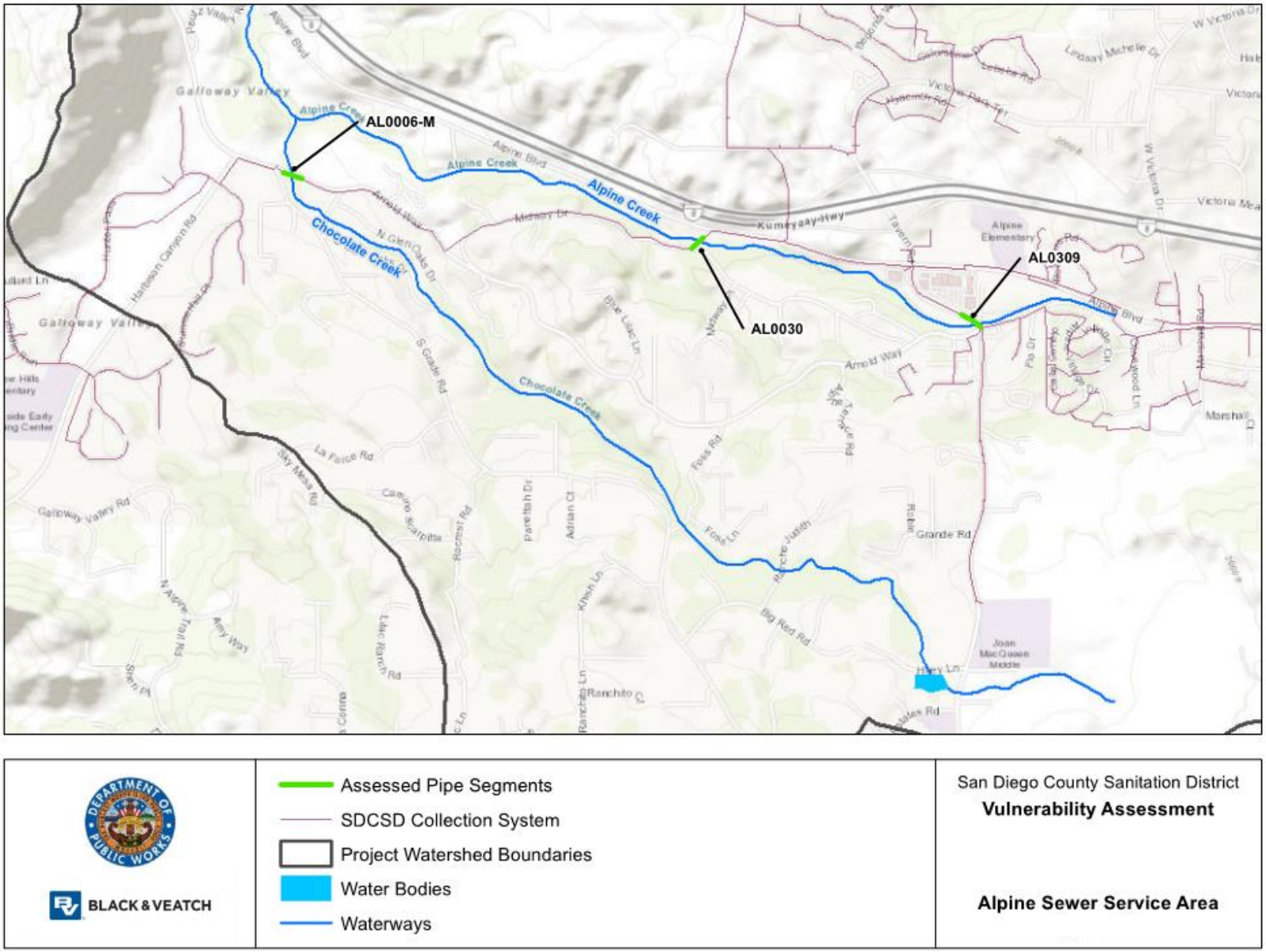

Figure 4 **Vulnerable Pipe Segments – Alpine Service Area**

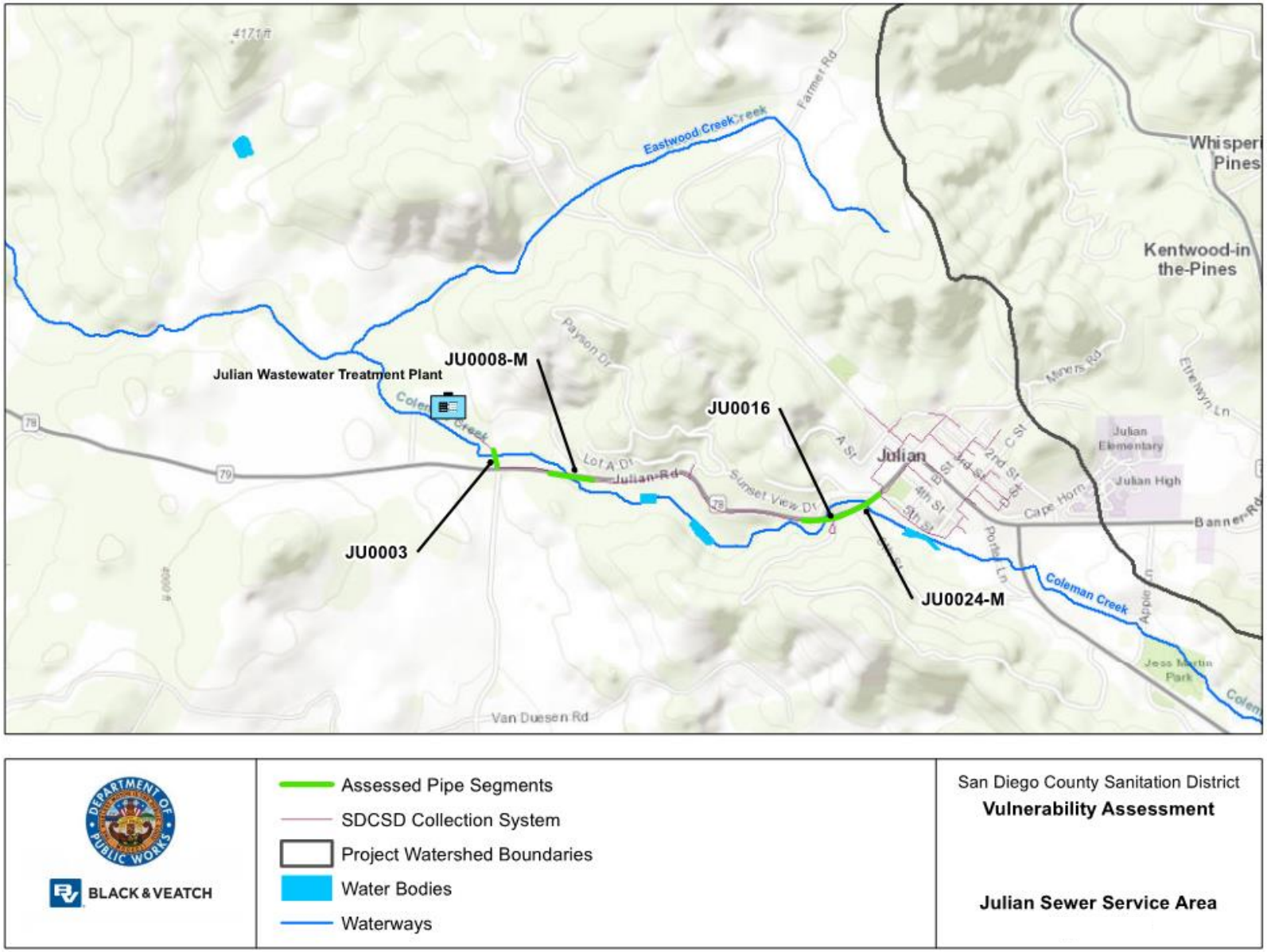

Figure 5 Vulnerable Pipe Segments – Julian Service Area

3.0 Data Collection and Review

3.1 SUMMARY OF AVAILABLE DATA

Table 2 below summarizes the available datasets utilized for this study.

Table 2 Data Layers for Vulnerability Assessment

DATA LAYER	TYPE	SOURCE	NOTES
Sanitary Sewer Collection System	Spatial	San Diego County Sanitation District (District) GIS Geodatabase (gbd)	Pipe, manhole, pump station, force main and treatment plant information. Updated January of 2018
Water Body Flowlines	Spatial	National Hydrography Dataset (NHD) information produced by the United States Geological Survey (USGS), Updated January 2018	Framework for identifying water-related entities such as industrial discharges, drinking water supplies, rivers and creeks.
100 Year Flood Elevations	Spatial	Federal Emergency Management Agency (FEMA) Flood Map Service Center Base Flood Elevation (BFE) dataset for San Diego County	Provides polyline data for 100-year flood projections showing flood elevations and reaches
Hydrological Spatial Data	Spatial	San Diego Geographical Information Source (SanGIS) hydrological shapefile data collected from a variety of federal, state and local sources	Data including lakes, lagoons, and watersheds
Geological Spatial Data	Spatial	San Diego Geographical Information Source (SanGIS) hydrological shapefile data collected from a variety of federal, state and local sources	Data including fault locations, near source shaking potential, liquefaction potential and soils
Ecological Spatial Data	Spatial	San Diego Geographical Information Source (SanGIS) hydrological shapefile data collected from a variety of federal, state and local sources	Data including environmentally sensitive area designations, and wetlands identification
Fire Hazard Severity Zones	Spatial	California Department of Forestry and Fire Protection (CAL FIRE) mapping of significant fire hazards	Designations based on fuels, terrain, weather and other relevant factors
Closed Circuit Television (CCTV) Condition Ratings	Tabular	SDCSD CCTV records	NASSCO condition data and ratings from inspections performed by Contractors, and non-NASSCO condition data and ratings from inspections performed internally by District Staff
As-Built Drawings	Spatial	SDCSD facilities data archives	
Wastewater Hydraulic Model Results	Tabular	SDCSD hydraulic model results from the 2013 Sewer Service Area (SSA) Master Plans performed by Atkins	Flow and depth over diameter ratio (d/D) hydraulic model results available for the Spring Valley, Lakeside and Alpine SSAs. No model results were available for the Julian SSA
Aerial and Basemap Imagery	Spatial	Google Earth aerial imagery and ArcGIS Online basemap imagery	Google Earth aerials and ArcGIS Online aerial, street, topographical and terrain imagery

3.1.1 Geospatial Data

The District's collection system is available as a geospatial layer which contains pipe, manhole, pump station, force main and treatment plant information. Available geospatial data layers from the District, SanGIS, and other publicly available sources were reviewed to identify key features of the vulnerable pipe segments. Prior to the site inspections, each pipe segment was reviewed using GoogleEarth to identify potential access restrictions. As shown in Figure 6, pipe segments with smart covers were identified. Geospatial data was incorporated into the risk assessment and prioritization task to identify vulnerabilities due to seismic risk, wildfire risk, and environmentally sensitive areas.

3.1.2 As-built Records

Available as-built record drawings of the vulnerable pipe segments were provided by the District and reviewed. As-built records contain key information on the depth of cover for pipe crossings and adjacent vulnerabilities, such as nearby gas lines.

3.1.3 CCTV Records and Condition Assessment

As discussed in Section 1.2, the District is currently performing CCTV inspections of their wastewater collection infrastructure. Where CCTV inspections had been performed, the resulting condition assessment data was used for risk assessment and prioritization of the pipe segment. Currently, 36 of the 92 identified pipe segments have available PACP condition scores.

3.1.4 Other Data Sources

The District also provided institutional knowledge from their maintenance and operation of the collection system. A list of pipes that are on a special maintenance program were identified. These segments require more routine cleaning and maintenance. The District also provided information regarding the causes of and responses to previous spills, which helped guide the risk assessment section of this report.

3.2 DATA GAPS

In recent years, the District has made significant efforts to develop a more robust and accessible database, particularly with respect to GIS. However, data gaps were identified during this assessment. Table 3 presents a summary of the data gaps observed from this study and recommended approaches to collecting the data.

Table 3 Data Gaps and Recommendations

DATA GAP	RECOMMENDED APPROACH
CCTV/Condition Assessment Data	Continue CCTV inspection program as part of Asset Management Program
Easement Information. The District maintains some digital easement data, generally for newer easements. Older easements include hardcopies in District files.	Continue to improve easement information management as part of overall asset management program.
Hydraulic model for Julian service area	Confirm hydraulic capacity for vulnerable pipe segments in Julian service area.
GIS attributes for collection system (IEs, manhole depths, rim elevations, material, siphons)	Continue to update master GIS database as new information is collected through various means.

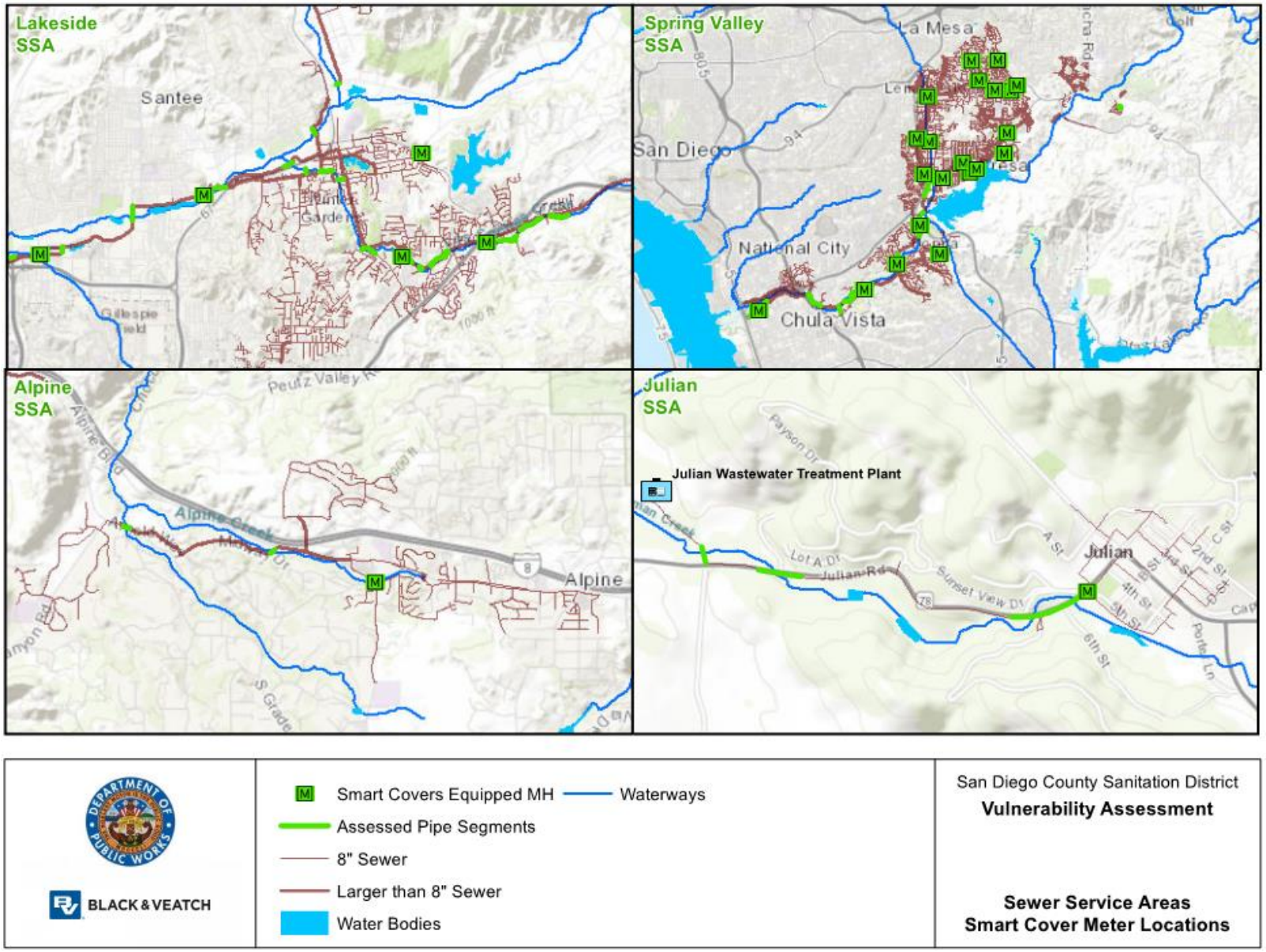

Figure 6 **Smart Cover Meter Locations**

4.0 Vulnerabilities

Based on a review of previous sewage spills in San Diego County, there is often not a single cause of a spill, but rather multiple variables that compound to trigger the event.

The following list summarizes vulnerabilities that could result in a sewage spill at a creek crossing. The most critical vulnerabilities are anticipated to include:

- **Natural Events.** Natural events can be wide ranging. The most typical for San Diego County include:
  - **Wet Weather Events.** Wet weather events, more specifically large storms, were considered the most likely natural event that could significantly impact sewer crossings. Large storms are infrequent in San Diego County but have significant precipitation intensity or durations which can stress watersheds. Large storm flows can scour streambanks and expose buried pipes and undermine exposed pipelines on supports. Large storm flows also typically result in debris transport, which can cause damage to exposed piping and piping supports. Debris transport can also result in damage to or congestion of stormwater infrastructure which increases potential for scour or other damage to streambanks. Identification of transportable debris which can cause damage is typically difficult to observe and more difficult to fix.
  - **Seismic.** Seismic events were considered possible, but a lower likelihood event than a wet weather event. The District does not have any pipelines crossing active faults, leaving increased near fault shaking and liquefaction of soils in the watershed as the most likely impacts. Pipeline fracture or separation could occur depending on the amount of ground deformation. While bulletproofing a sewer system against these rare events is difficult and typically not practical from a cost standpoint compared to the risk, these events were considered in the study.
  - **Wildfire.** Wildfires in themselves are unlikely to directly affect the pipes in this study as a majority are buried. Wildfires could affect the 13 exposed piping segments, and particularly a segment which has an adjacent natural gas pipeline. Wildfire impacts are more likely to indirectly affect risk through destruction of vegetation which stabilizes the watershed and increased potential for debris generation. Wildfire damage prior to wet weather events amplify the potential for scouring and debris related damage.
- **Vandalism.** Vandalism generally includes intentional damage to or misuse of exposed manholes and pipe segments. The most common example of vandalism the District observes is the removal of manhole lids and placement of unauthorized materials into the sewer.
- **Access Restrictions.** The inability to readily access, observe and maintain sewer crossings represents a major risk to the ability of the District to identify issues and act. Like wet weather, this vulnerability is considered one of the more impactful components related to risk and risk mitigation. Watershed crossings by their nature typically pose significant access constraints. Crossings are often located in remote or undeveloped landscapes, in natural crossings vegetation restricts access, and permitting and multi-jurisdictional requirements complicate access for maintenance and improvements.
- **Pipeline and Manhole Physical Vulnerabilities.** The age, material, and size of the pipeline are the predominant risk vulnerabilities. These factors are typically addressed as part of the risk assessment through a formalized LoF/Cof analysis.

- **Operations and Maintenance Vulnerabilities.** O&M activities are essential for proper management of the collection system. A lack of a formalized CMMS system, standard procedures, and CCTV programs create vulnerabilities. O&M activities also include remedying roots and clogs, over-capacity issues or other O&M issues.
- **Power, Telemetry and Instrumentation Risks.** This component is considered a less likely vulnerability since all but one pipeline are gravity fed and operate without power or active controls. The District operates a series of level sensors in its system to provide real-time monitoring of the system which can help spot potential problems and reduce response times.

5.0 Site Assessment

The field work for this study took place over a 6-day period, beginning on 7/24/2018 and concluding on 7/31/2018. Through the collaborative effort of Black & Veatch and District employees, 92 sites throughout Spring Valley, Lakeside, Alpine, and Julian—encompassing approximately 60 miles of San Diego County—were inspected.

In preparation for field work, Black & Veatch produced two items, the Safety and Health Preplanning Checklist (Checklist) and the Injury and Illness Prevention Plan (IIPP). Black & Veatch's procedure for Project Health and Safety Planning describes the Checklist as a requisite for all field work and site visits. The Checklist includes basic administrative information, an Emergency Action Plan (EAP), and a Job Hazard Analysis (JHA), all of which were reviewed and approved of by the Supervisor and Project Manager.

Black & Veatch prepared for field work by collecting data on the various sites and generating an efficient and coherent plan for action. The initial spreadsheet included pipe data, accessibility of the site, and any available GIS, CCTV, record drawing, and video data. This allowed Black & Veatch to gain preliminary understanding of the sites to be inspected. From there, a course of action was arranged based on assumptions regarding necessary time spent at each site as well as travel time between the sites. These assumed times were used to estimate the exact sites that would be visited each day over the 9-day period. Thereafter, schematics on Google Earth were constructed depicting the most efficient path for each day.

Due to the vulnerabilities inherent to wastewater conveyance systems, Black & Veatch considered potential risks while objectively inspecting each site, ultimately gathering sufficient data to move into the next phase of analysis. The field work was an integral phase for the project, and through analytic planning and observation, the appropriate information was readily collected.

5.1 DEVELOPMENT OF INSPECTION PLAN

Throughout the field work, two programs were used that allowed the team to electronically collect data on electronic devices which could be saved for further review. Data on manholes was gathered via Collector for ArcGIS, an interactive ArcGIS application that allows for the mobilization of information and collection of shareable data while in the field. Screenshots of the Collector app are shown in Figure 7. The second program used was Survey123, another mobilized application of ArcGIS designed for personalized data collection, wherein the team collected data on evidence of streambank erosion. Screenshots of the Survey123 app are shown in Figure 8. In preparation for field work, Black & Veatch adapted these programs to the needs of the study by developing the standardized surveys within the software that was used on site. Photo documentation was included in these surveys, as well as qualitative analysis of the manholes, pipes, and streambanks.

5.2 SUMMARY OF SITE DATA

Data collected from the field work are provided digitally to the District as Appendix A. Photos are provided digitally as Appendix D.

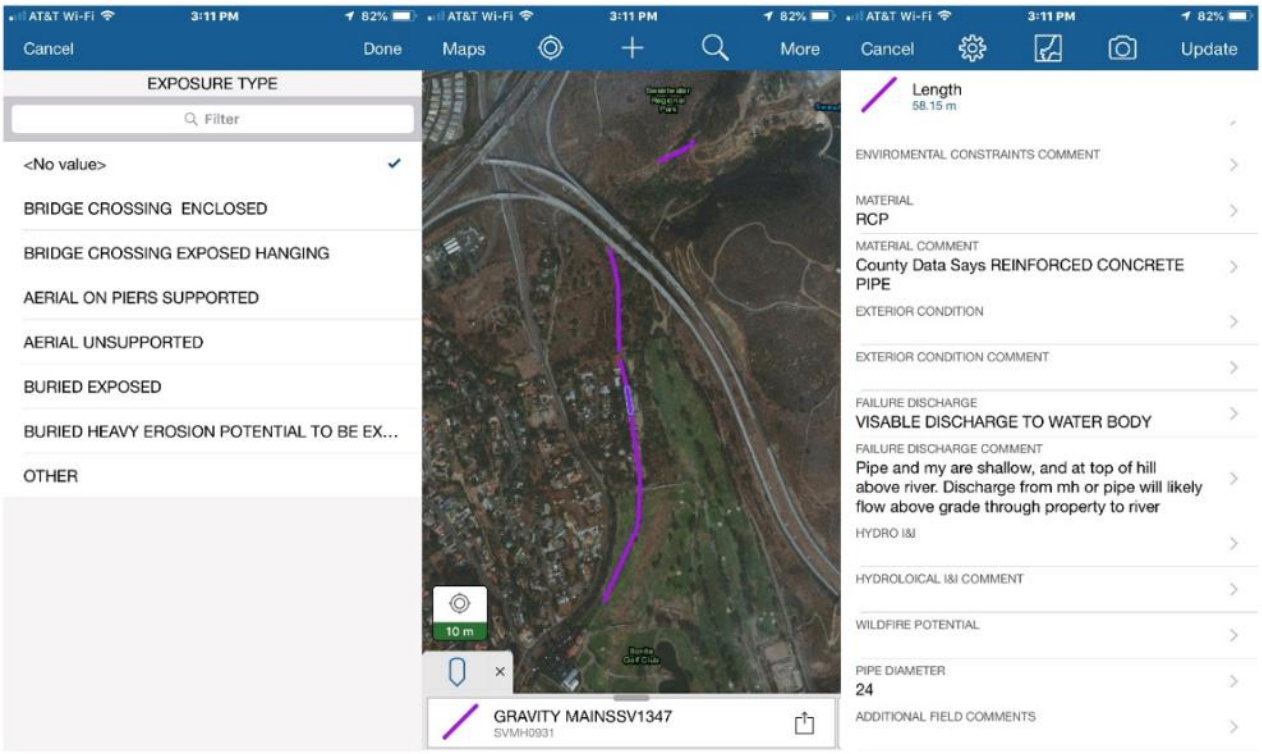

Figure 7 **Screenshots of ArcGIS Collector App**

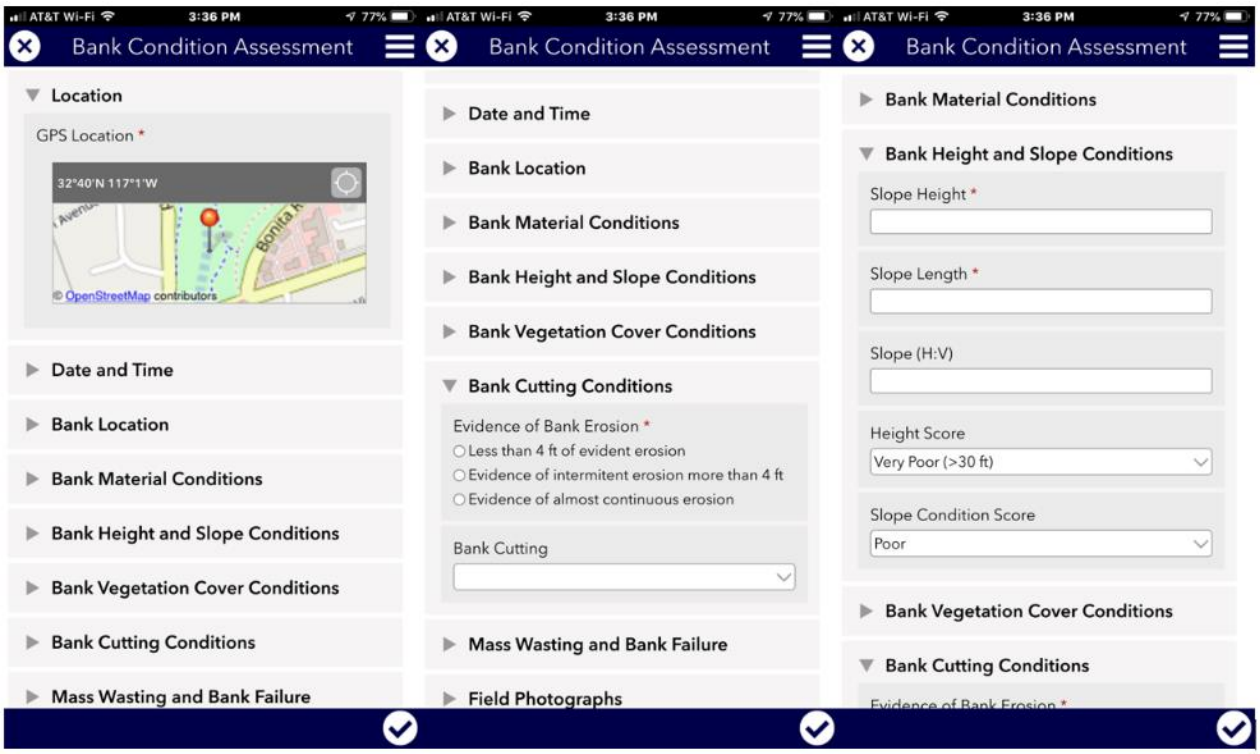

Figure 8 **Screenshots of Survey123 App**

6.0 Stream Erosion Evaluation

6.1 STREAM BED DEGRADATION AND BANK EROSION SEVERITY

The stream bed degradation and bank erosion severity was determined from field inspections based on average bank height, bank slope, bank material (e.g. rock, revetment, soil type), vegetation protection and visual evidence of stream degradation, bank erosion and scour. A bank condition scoring matrix was used to evaluate bank site conditions. This scoring matrix has been adapted from Johnson et. Al. (Johnson, P.A., G.L. Gleason and R.D. Hey, 1999), *Rapid assessment of channel stability in Vicinity of Road Crossings*, ASCE, Journal of Hydraulic Engineering Vol 125, No. 6. The aforementioned ASCE bank condition scoring matrix is a rapid screening level assessment technique and well suited for the initial vulnerability assessment and level of effort proposed within the scope of work.

6.1.1 Stream Bank Height

Stream bank height can be an indication of the flows that a stream has historically conveyed. Streams with high banks have conveyed flows greater than the base flow and have the potential to erode because of those high flows. The ranking used in the evaluation included four groupings where stream bank height was classified as:

- Good (< 6 ft)
- Fair (6 ft < h < 15 ft)
- Poor (> 15 ft)
- Very Poor (>30 ft)

6.1.2 Stream Bank Slope

Stream slope and stream height are closely related to determine the overall condition of the stream. Streams with banks with a more gradual slope are less likely to erode than streams with steeper slopes. The slopes were calculated by estimating the bank height and the horizontal distance from the stream bank base to top. The ranking used in the evaluation included three groupings where stream bank slope was classified as:

- Good (< 1.7 ft/ft)
- Fair (>1.7 ft/ft and < 2ft/ft)
- Poor (> 2 ft/ft)

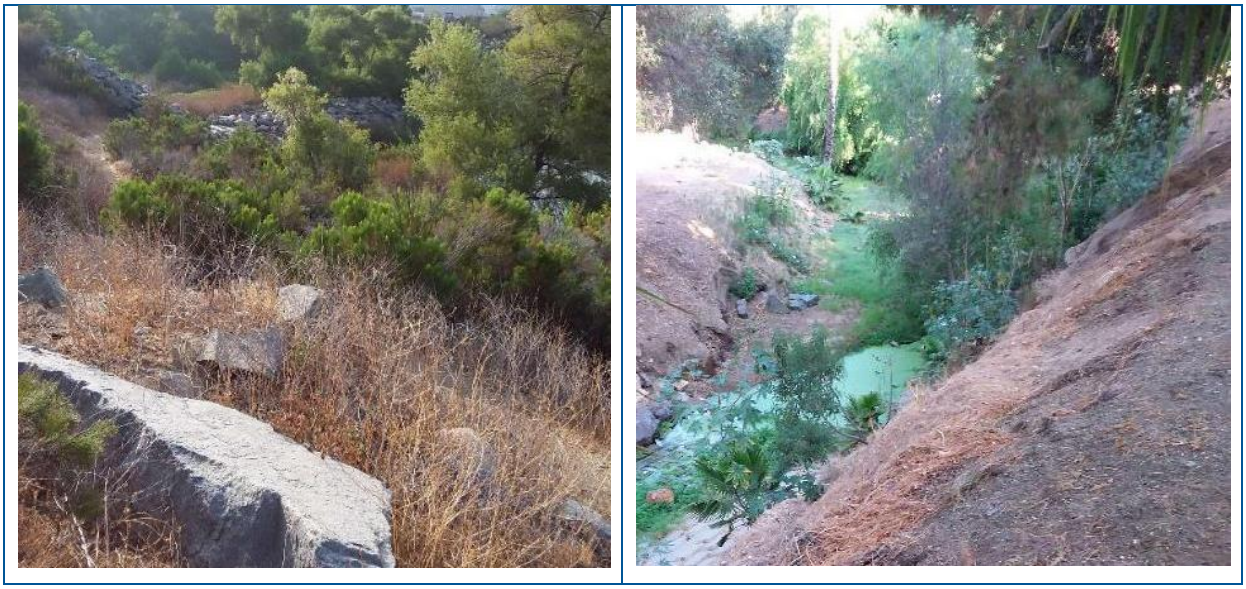

Figure 9 Examples of stream bank slopes classified as "good" (left) and "poor" (right)

6.1.3 Stream Bank Material

The erodibility of a stream bank is also dependent on the soil material. The ranking used in the evaluation included nine groupings where stream bank soil type was classified as:

Clay (Poor)	Sand (Good)	Rock (Poor)
Sandy Clay (Good)	Gravel (Good)	Riprap (not applicable)
Sandy Loam (Good)	Shale (Poor)	Wall (not applicable)

6.1.4 Woody Vegetation

The roots associated with woody vegetation can help hold stream banks together because of their root systems. The roots can help retard erosion and protect the stream bank from erosion. The fraction of woody vegetation at each site was estimated and categorized as a percentile ranging from zero to 100 percent in increments of 10 percent.

6.1.5 Understory Layer Development

The understory is a description of the amount of ground cover on the stream bank. Like the woody vegetation, increasing amounts of ground cover can help the stream bank adhesion and resist erosion from elevated flows. The understory was classified as:

- Well-developed understory layer
- Moderately developed understory layer
- Poorly developed or bare soil

Figure 10 **Examples of a well-developed understory layer (left) and poorly developed or bare soil (right)**

6.1.6 Root Exposure

The amount of root exposure is a good indication of the relative stability of the stream bank and if erosion has been occurring. The degree of root exposure was classified as:

- None
- Common
- Extensive

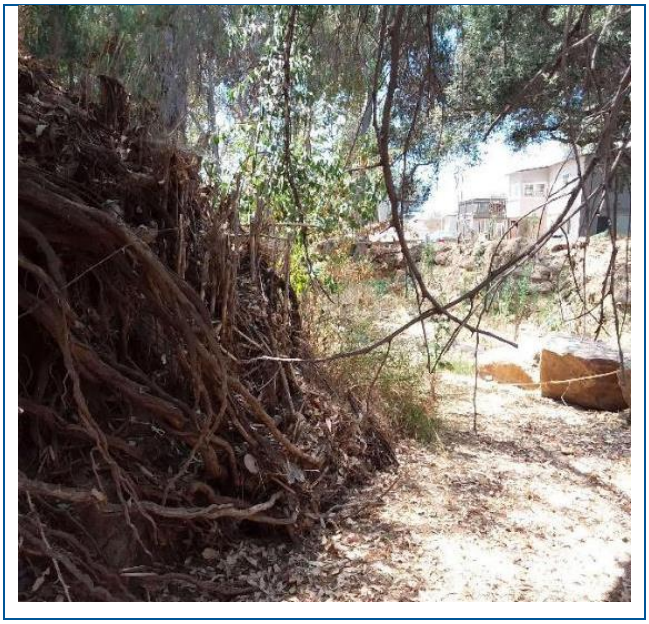

Figure 11 **Example of excessive root exposure due to stream bank erosion**

6.1.7 Tree Conditions

As stream banks fail, the soils that support the riparian trees can erode and can cause trees to begin to fall into the stream. The trees that were impacted by stream bank erosion were classified as:

- No trees leaning
- Some trees leaning
- Many trees leaning

Figure 12 Examples of trees leaning into a stream because of stream bank erosion

6.1.8 Bank Cutting

Stream bank cutting is a determination of the degree of stream bank incision and erosion. This indicates that the stream bank is not at equilibrium with the flows and is migrating outward. The degree of bank cutting was characterized as:

- Less than 4 ft of evident erosion
- Evidence of intermittent erosion more than 4 ft
- Evidence of almost continuous erosion

Figure 13 Example of significant stream bank cutting

6.1.9 Mass Wasting

The amount of stream bank material that has eroded and is in the stream channels is characterized as mass wasting. The stream bank mass wasting was characterized as:

- Minimal evidence of mass wasting
- Evidence of mass wasting, undercutting, and/or irregular channel width
- Evidence of extensive mass wasting, massive undercutting, and/or evidence of tension cracks

Figure 14 Example of significant stream bank mass wasting

6.2 SEWER FAILURE RISK

The sewer failure risk is based on a combination of the pipe's vertical distance with respect to the streambed invert and erosion potential. Stream bank heights were obtained from GIS based topographic data readily available through federal, state or local government agencies. Depth of cover for the pipes was based on as-built drawings provided by the District. Hydraulic modeling to evaluate long-term degradation or local scour was not performed at this time. The visual inspections also identified locations where more detailed analysis may be needed.

7.0 Risk Assessment and Prioritization

A risk-based prioritization was completed for the entire asset class of pipelines included in this analysis. The prioritization included a likelihood of failure (LoF) and consequence of failure (CoF) analysis. The purpose of this analysis was to categorize pipelines based on risk and to provide a tool to help prioritize pipeline, manhole, and other improvements (such as access improvements). The following summarizes these efforts.

7.1 PRIORITIZATION METHODOLOGY

LoF and CoF criteria were developed and presented to District staff on September 17, 2018, and is shown in Table 4 through Table 7; the resulting risk-based prioritization is shown in Appendix C. One important consideration was to align the results of this analysis with the risk-based prioritization Black & Veatch previously prepared for all of the District's pipelines. Although there were similarities and differences in the criteria, the results were calibrated such that any results from this study could be coordinated with other efforts occurring within the asset management program. Since all of the pipelines in this vulnerability assessment are adjacent to or crossing streams, the CoF is typically higher than many pipelines in the District's system. Therefore, the CoF scores in this study generally range in the 3.5 to 5.0 range instead of the full 1 to 5 range observed in the risk-based prioritization results for all the pipelines.

Table 4 Summary of Likelihood of Failure Criteria

SUB-CATEGORY	SUB-CATEGORY WEIGHT	OVERALL WEIGHT
LIKELIHOOD OF FAILURE: CONDITION CATEGORY		
Overall Pipeline Condition	60%	21.0%
Overall Manhole Condition	10%	3.5%
Pipeline Material	20%	7.0%
Pipeline/Supporting Infrastructure Age	10%	3.5%
LIKELIHOOD OF FAILURE: CAPACITY CATEGORY		
Lack of Capacity: Large Diameter (> 15")	100%	20.0%
Lack of Capacity: Small Diameter (≤ 15")		
LIKELIHOOD OF FAILURE: NATURAL IMPACTS CATEGORY		
Streambank Stability and Pipe Exposure	50%	10.0%
Flooding Damage Potential	20%	4.0%
Wildfire Damage Potential	15%	3.0%
Seismic Impact Zones	15%	3.0%
LIKELIHOOD OF FAILURE: MAINTENANCE CATEGORY		
Maintenance Access	100%	20.0%
Special Maintenance Pipe	ADD	--
Siphon	ADD	--
LIKELIHOOD OF FAILURE: SECURITY CATEGORY		
Security / Vandalism Potential and Evidence	100%	5.0%

Table 5 Definitions of Likelihood of Failure Criteria

SUB-CATEGORY	DEFINITION
LIKELIHOOD OF FAILURE: CONDITION CATEGORY	
Overall Pipeline Condition	• Where NASSCO CCTV Scoring is available, 1-5 scoring will be available and utilized. • Where NASSCO CCTV Scoring is not available, substitute the total LoF score of the pipe segment from the SDC Asset Management Year 1 Rehab Prioritization • Where exterior condition data is available increase score: - By 2 where structural or corrosion damage has been observed - By 1 where coating loss or damage has been observed (without corrosion or structural damage) • For pipes having a designation requiring "Special Maintenance", increase scores by 1
Overall Manhole Condition	Utilize B&V MH Condition Scoring 5 - Severe defects, failure imminent 4 - Significant defects, maintenance necessary. Ex: fractures, exposed reinforcing, major root intrusion 3 - Moderate defects, maintenance necessary soon. Ex: cracking, aggregate & reinforcement exposure, minor root intrusions 2 - Minimal defects 1 - Like New
Pipeline Material	Defective pipe types, poor application selection and/or corrosion resistance, rigid pipes subject to brittle failures, and iron or steel pipe with corrosion protection 5 - RPM (techite) **- LoF SCORE WILL DEFAULT TO 5 FOR ALL PIPES OF THIS MATERIAL** 4.5 - Cast Iron, Ductile Iron 4 - RCP 3 - VCP or unknown 2 - None 1 - PVC
Pipeline/ Supporting Infrastructure Age	Typical design life of 50-75 years 5 - >75 4 - 60-74 3 - 45-59 2 - 25-44 1- <25
LIKELIHOOD OF FAILURE: CAPACITY CATEGORY	
Lack of Capacity: Large Diameter (> 15")	Capacity deficient pipe leads to overflows during rainfall events. Desktop from model results: 5 - WWF d/D>0.92(surcharging), DWF>0.75 3 - WWF d/D 0.75-0.92, DWF d/D 0.50-0.74 1 - WWF d/D <0.75, DWF <0.50
Lack of Capacity: Small Diameter (< 15")	Capacity deficient pipe leads to overflows during rainfall events. Desktop from model results: 5 - WWF d/D>0.92(surcharging), DWF>0.5 3 - WWF d/D 0.75-0.92, DWF d/D 0.40-0.49 1 - WWF d/D <0.75, DWF <0.40

SUB-CATEGORY	DEFINITION
LIKELIHOOD OF FAILURE: NATURAL IMPACTS CATEGORY	
Streambank Stability and Pipe Exposure	Streambank stability assessment scoring per method prescribed in Johnson et. al, scaled to a 5 point scoring system. 5 = Severe = Score Range 11.2-12.8 4 = High = Score Range 9.4-11.2 3 = Intermediate = Score Range 7.6-9.4 2 = Low = Score Range 5.8-7.6 1 = Minor = Score Range 4-5.8 1 = No streambank associated with the location As-built drawings have been reviewed to assess the depth of cover of pipes crossing under streams: • Where as-built data is available for a crossing change the score: - Increase by 2if depth of cover is less than 2 feet and pipe is not encased - Increase by 1 if depth of cover is between 2 & 4 feet and pipe is not encased - Decrease by 2 if the crossing pipe is encased
Flooding Damage Potential	Potential for washout or damage to the pipe directly or indirectly during flood events and debris flow 5 - Pipe is exposed and in the flow path below the 100-year flood level, high potential for debris flow 4 - Manhole rim elevation(s) below the 100-year flood level, pipe supports in flow path, med potential for debris flow 3 - All other crossings 2 - All non-crossings
Wildfire Damage Potential	Per SanGIS Fire Hazard Severity Zones: 5 - Very high 4 - High 3 - Moderate 1 - All other Where pipe is exposed and within a Fire Hazard Severity Zone of moderate or above, increase to rating of 5
Seismic Impact Zones	Per USGS Data (from SanGIS) for Liquefaction: 5 – Within liquefiable layer 3 - Others
LIKELIHOOD OF FAILURE: MAINTENANCE CATEGORY	
Maintenance Access	General site accessibility 5 - Multiple barriers, including steep channel banks; within ESA 4 - Multiple barriers 3 - Heavy foliage, physical barrier 2 - Gate or fence 1 - No barriers to access; outside of ESA

SUB-CATEGORY	DEFINITION
	Large vehicle access 5 - No access 4 - Off-road or unmaintained 3 - Public ROW with major traffic control 1 - Road trail/maintained easement or public ROW with no major traffic control Personnel and equipment access 5 - No access 4 - Walking/difficult walking access only 3 - Challenging access 2 - Convenient access 1 - Fully accessible
Special Maintenance Pipe	If pipe is part of the District's Special Maintenance List • Add 1
Siphon	If pipe is a siphon • Add 2
LIKELIHOOD OF FAILURE: SECURITY CATEGORY	
Security / Vandalism Potential and Evidence	5 - Potential for vehicle contact 4 - Observed vandalism 3 - Plainly visible / theft potential 1 - Restricted access (fences, gates), bolted manhole covers

Table 6 Summary of Consequence of Failure Criteria

SUB-CATEGORY	SUB-CATEGORY WEIGHT	OVERALL WEIGHT
CONSEQUENCE OF FAILURE: SPILL MAGNITUDE & RESPONSE CATEGORY		
Pipe Size	40%	20.0%
Flow Monitoring	20%	10.0%
Access	20%	10.0%
Spill Mitigation/Capture	20%	10.0%
CONSEQUENCE OF FAILURE: IMPACT DUE TO RESPONSE CATEGORY		
Environmental Impacts	50%	12.5%
Social Impacts	50%	12.5%
CONSEQUENCE OF FAILURE: COST FACTORS CATEGORY		
Bury depth (if applicable)	30%	7.5%
Accessibility	30%	7.5%
Pipe Size/Length	30%	7.5%
Exposed Pipe Type (if applicable)	10%	2.5%

Table 7 Definitions of Consequence of Failure Criteria

SUB-CATEGORY	DEFINITION
CONSEQUENCE OF FAILURE: SPILL MAGNITUDE & RESPONSE CATEGORY	
Pipe Size	5.0 - 36" and above 4.5 - 24" and 30" 4.0 - 15" to 21" 3.5 - 10" to 12" 3.0 - 8" and smaller
Monitoring / Spill Detection	5 – No monitoring capabilities (remote and no downstream monitoring system) 4 – Can detect spill from visual or odor 2 – Smart cover downstream, sensoring, telemetry
Access	Reference LoF definitions and scoring 5.0 - LoF Access Score of 5 4.5 - LoF Access Score of 4 4.0 - LoF Access Score of 3 3.5 - LoF Access Score of 2 3.0 - LoF Access Score of 1
Spill Mitigation/ Capture	Ease of recovering spill volume, ability to bypass flows during repair 5 - Spill directly into waterway 4 - Spill into groundwater in proximity of waterway 1 - No transport waterway or waterbody present
CONSEQUENCE OF FAILURE: IMPACT DUE TO RESPONSE CATEGORY	
Environmental Impacts	5 - Entering an ESA required and/or disruptions to natural flow patterns required (buried pipes in perennial waterbodies (SD River, Sweetwater River)) 4 - Work in a waterbody that is not an ESA and not perennial 1 - No impacts to sensitive environments
Social Impacts	5 - Disruptions to beneficial/recreational use and/or proximity to schools, hospitals, etc. 3 - Social impacts unknown
CONSEQUENCE OF FAILURE: COST FACTORS CATEGORY	
Bury Depth	Bury Depth (if applicable) 5.0 - 20+ foot average depth 4.5 - 15-19 foot average depth 4.0 - 10-14 foot average depth 3.5 - 5-9 foot average depth 3.0 - <5 foot average depth (including above grade) Where no bury depth data is not available a score of 3 will be assumed
Accessibility	Reference CoF Spill Magnitude & Response: Access sub-category score
Pipe Size	Reference CoF Spill Magnitude & Response: Flow sub-category score
Exposed Pipe Type	Exposed Pipe Type (if applicable) 5.0 - On piers, above grade in an active waterway 4.5 - Inside bridge girder 4.0 - On piers, above grade over a drainage way (not normally wet, drains to larger waterway) 3.0 - All other exposure types

7.2 PRIORITIZATION RESULTS

As shown in Figure 15, the results of the risk assessment display relatively high CoF for all pipe segments with variable LoF. This is expected as all pipe segments in this study are inherently vulnerable due to their proximity to the water bodies.

Heat maps showing LoF scores are presented in Figure 16 through Figure 19. Heat maps showing CoF scores are presented in Figure 20 through Figure 23. The detailed scoring results are provided in Appendix C.

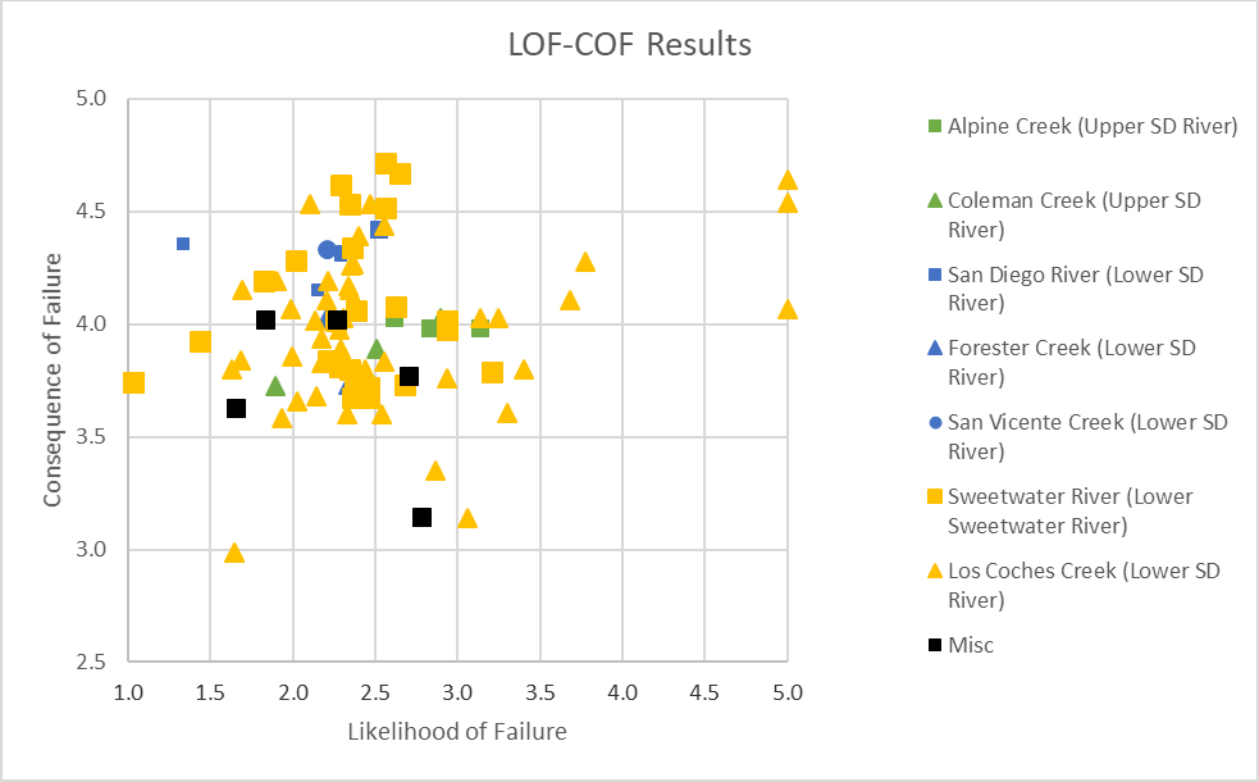

Figure 15 Chart of LoF-CoF Results

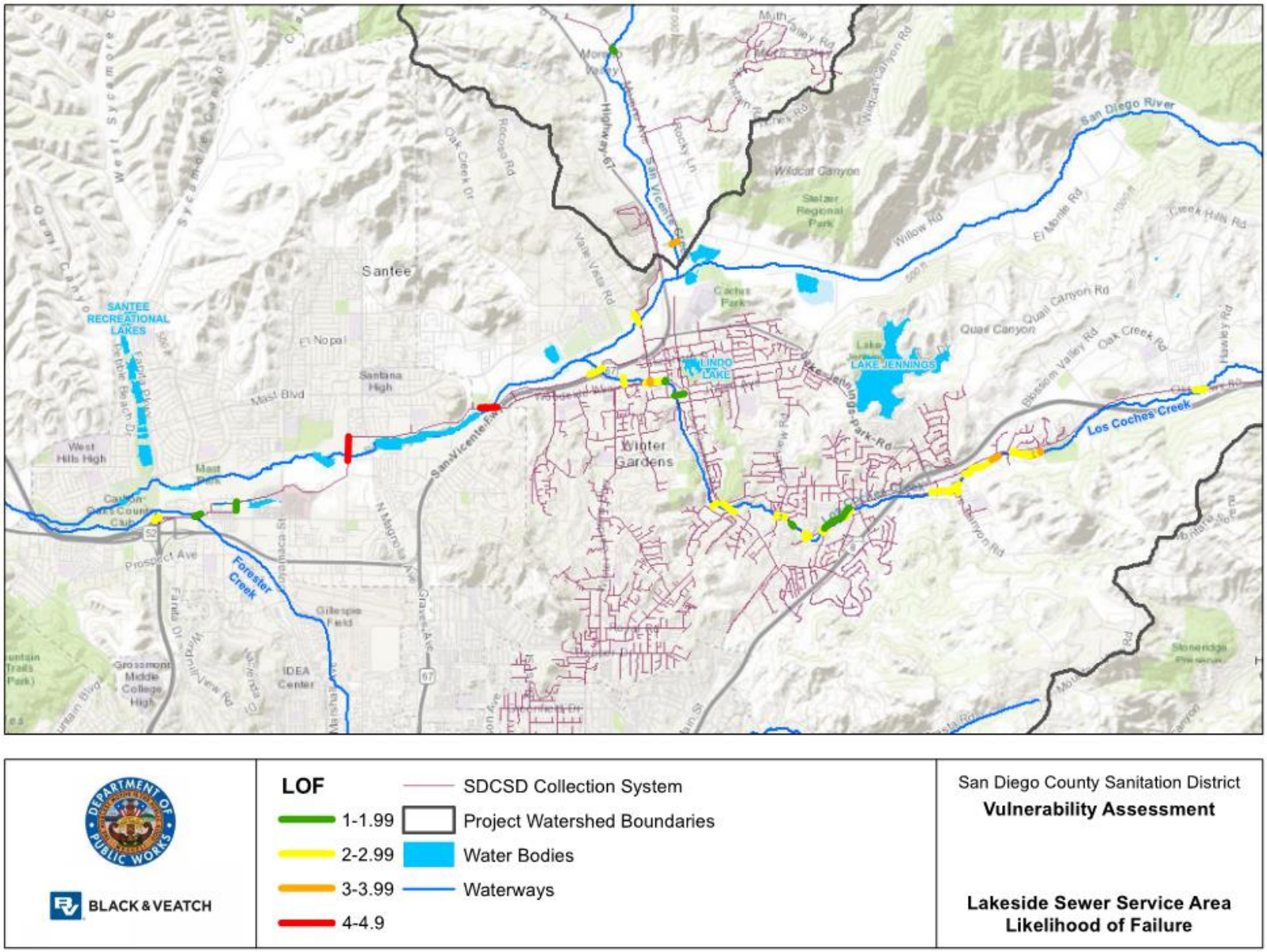

Figure 16 Likelihood of Failure Results – Lakeside

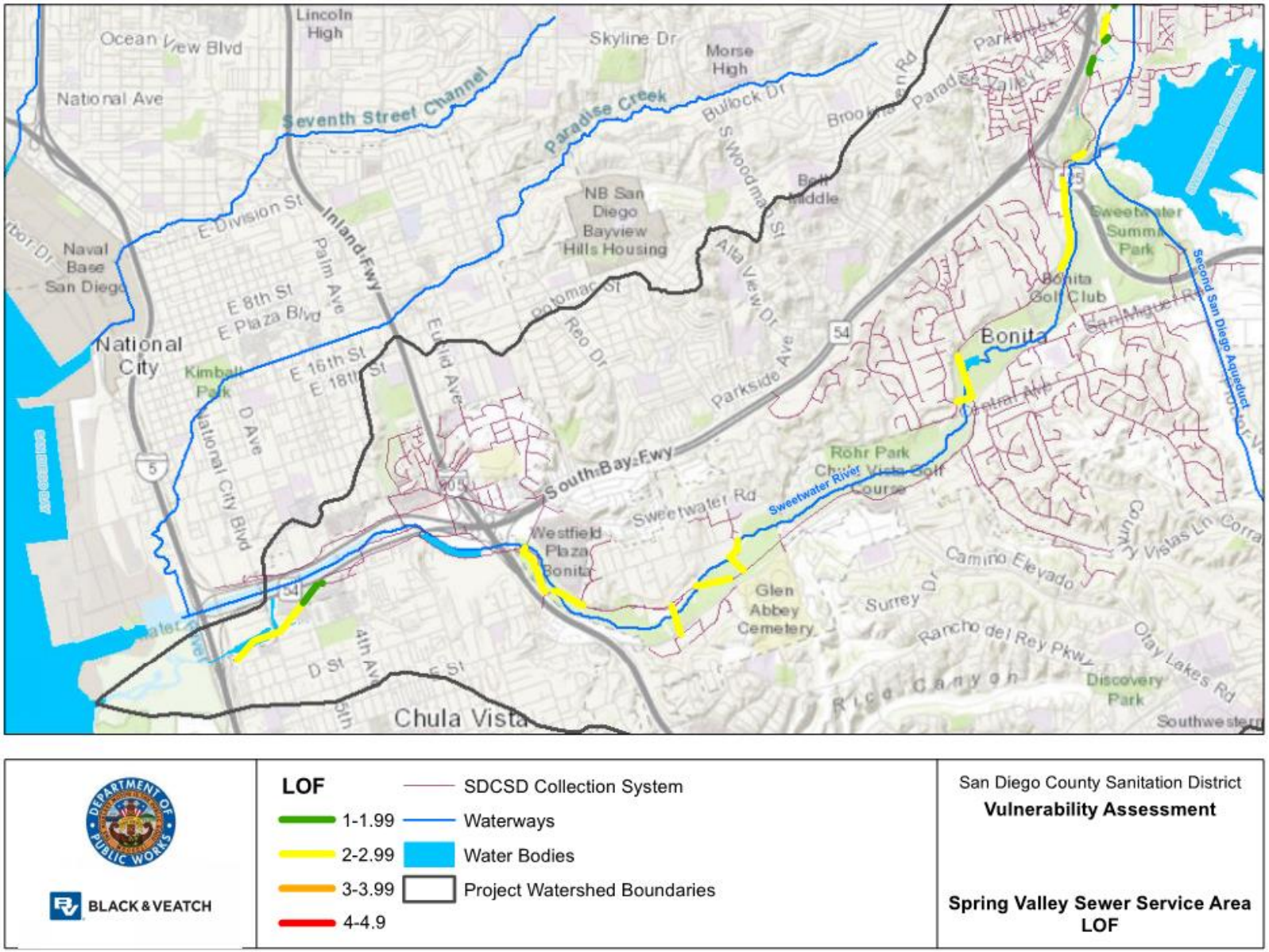

Figure 17 Likelihood of Failure Results – Spring Valley

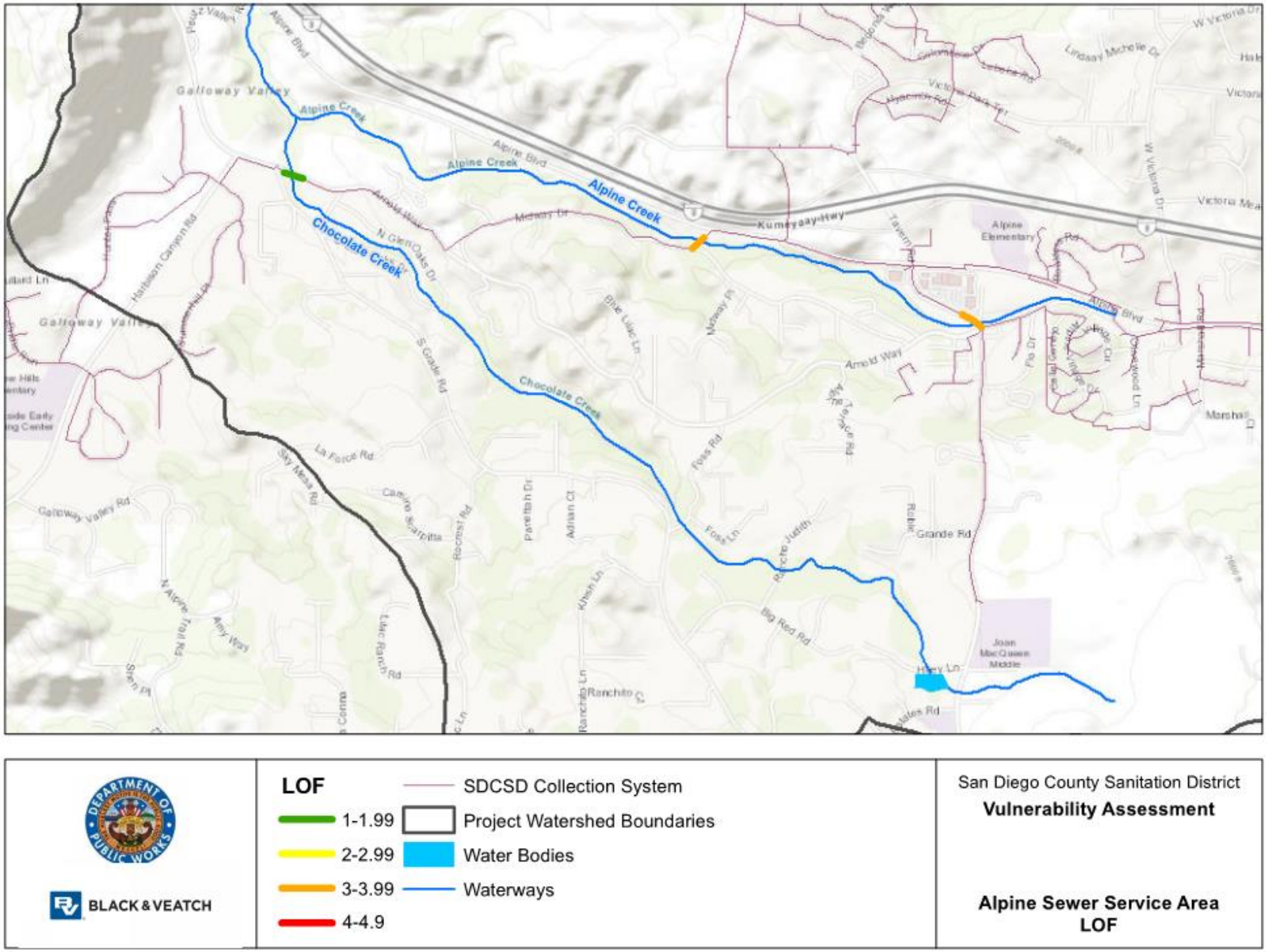

Figure 18 Likelihood of Failure Results - Alpine

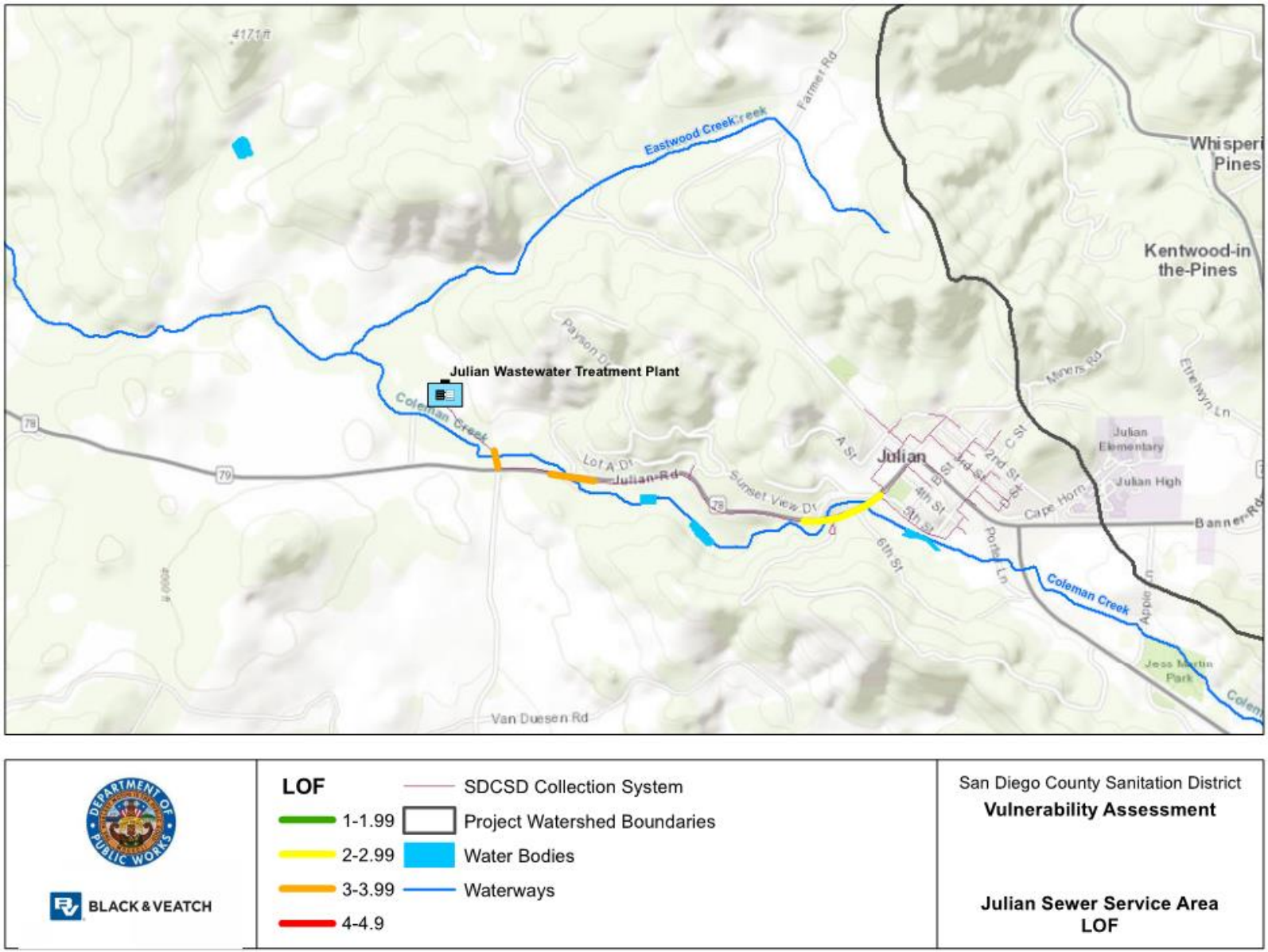

Figure 19 Likelihood of Failure Results - Julian

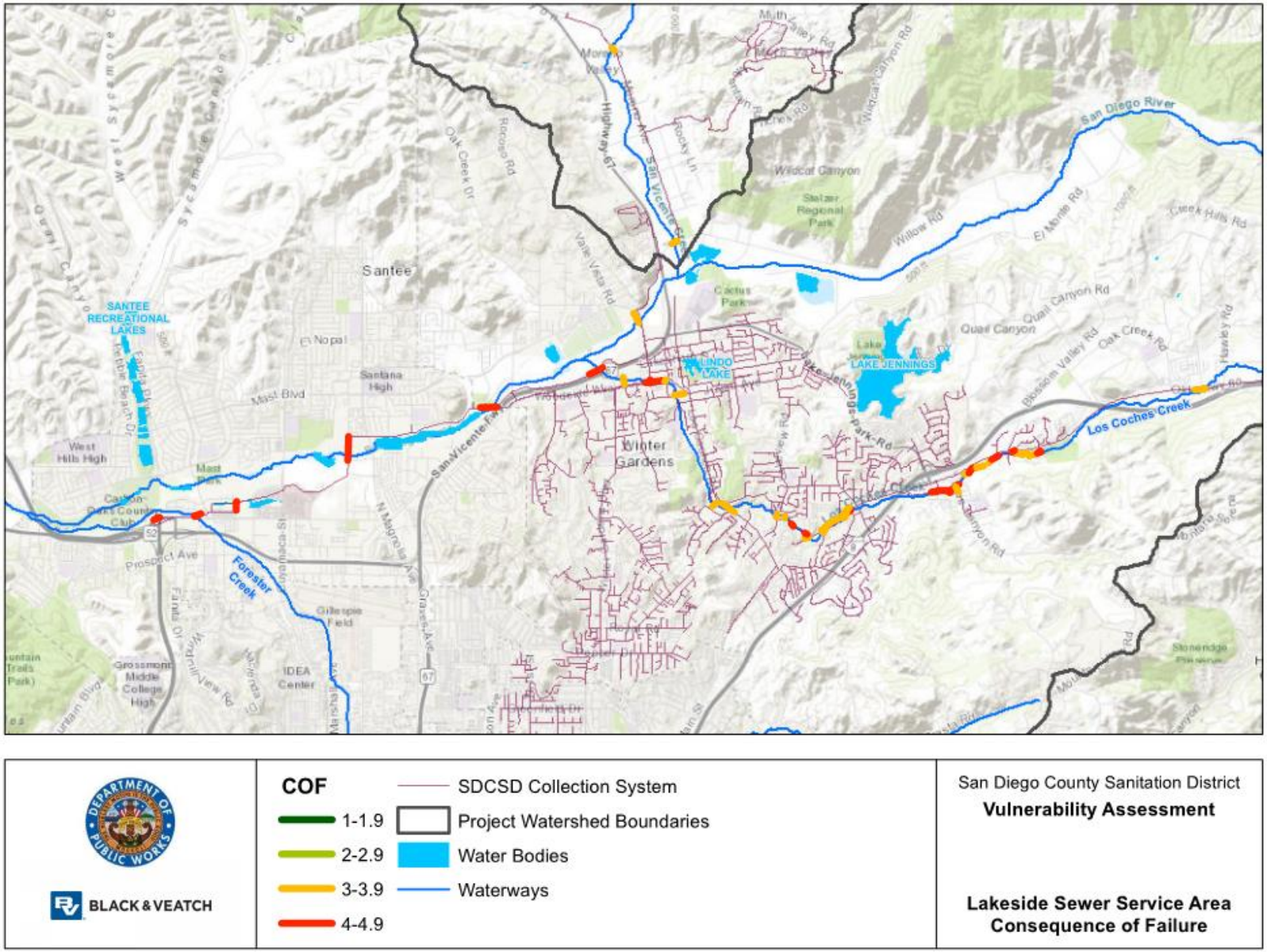

Figure 20 Consequence of Failure Results - Lakeside

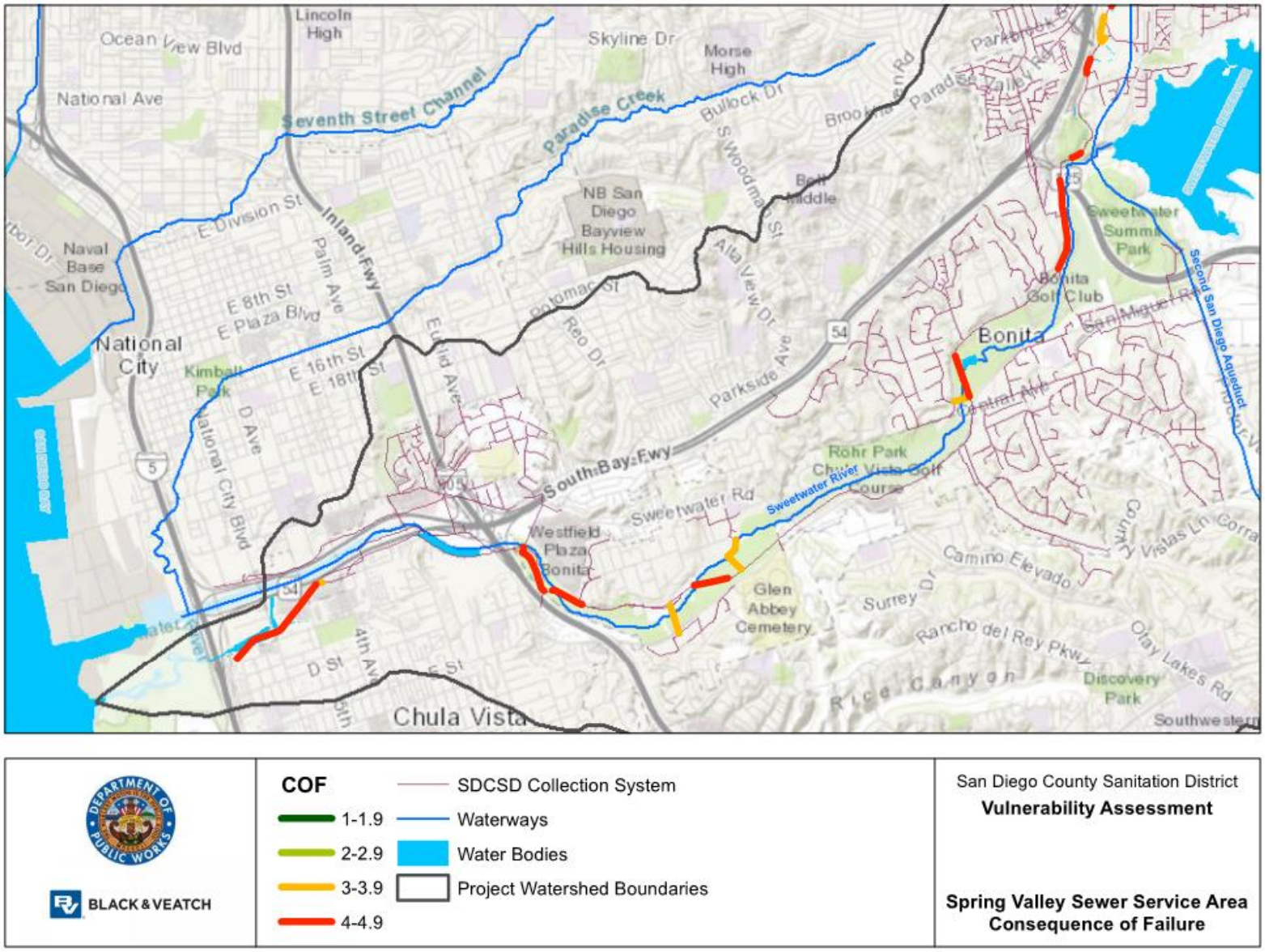

Figure 21 Consequence of Failure Results – Spring Valley

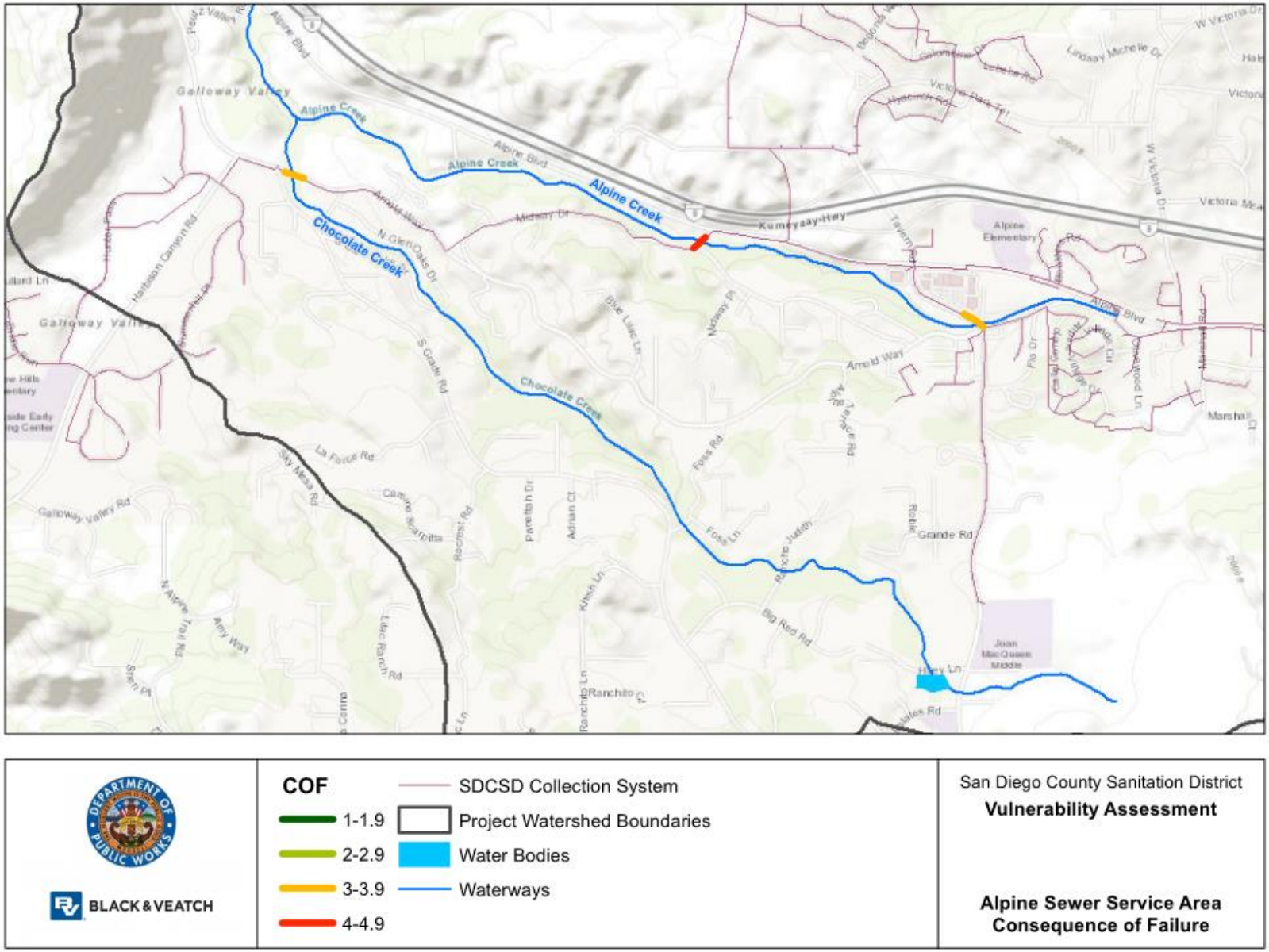

Figure 22 Consequence of Failure Results - Alpine

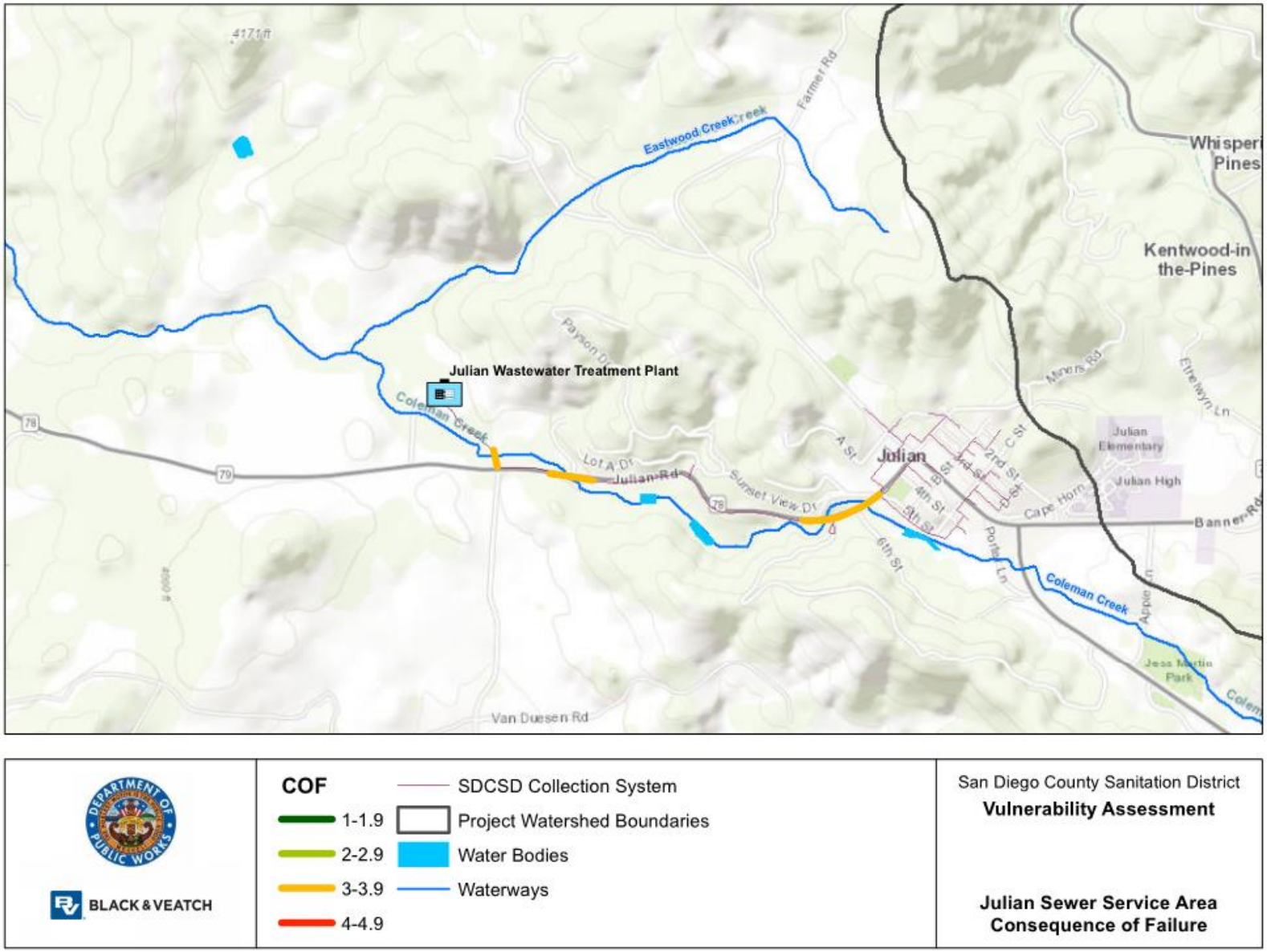

Figure 23 Consequence of Failure Results - Julian

7.3 DOWNSTREAM IMPACT SUMMARY

On February 10, 2010, the California Regional Water Quality Control Board, San Diego Region (RWQCB) adopted the Revised Total Maximum Daily Loads (TMDLs) for Indicator Bacteria Project I – Twenty Beaches and Creeks in the San Diego Region (Including Tecolote Creek) (Bacteria TMDL). The Bacteria TMDL lists impaired water bodies and provides concentration-based water quality targets. In response to the Bacteria TMDL, a cost-benefit analysis was developed to investigate alternative pathways to compliance. One scenario of the cost-benefit analysis and the focus of this report is the targeting of human-sources of bacteria and viruses. The human sources scenario attempted to estimate load contributions and costs of load reduction strategies for human-sources of bacteria and viruses, including leaking sanitary sewer pipes (mains and laterals).

The results of the human sources scenario concluded that the existing data were inadequate to characterize the role of sewer collection systems on human sources of bacteria load contributions. The extent to which exfiltration from sewer pipes impacts TMDL compliance is currently not quantifiable. Therefore, the extent of benefits from reduction of exfiltration from sewer pipes is also not quantifiable at this time. However, given the proximity of the vulnerable pipe segments to the San Diego River watershed water bodies, it can be assumed that exfiltration from the vulnerable pipe segments is more likely to have a direct impact to downstream water quality than pipes that are further removed from the water bodies.

Some of the pipe segments identified in this study are currently being study for exfiltration to help better characterize the load contribution from sewer pipes as part of Tentative Investigative Order R9-2018-0021. Results of exfiltration study can then be extrapolated to estimate a watershed-based load associated with sewer pipes and their proximity to receiving waters. These results can then be used to document the benefits realized from addressing the identified vulnerable pipe segments.

8.0 Summary and Next Steps

The study at this particular point and time is a snap shot of the known vulnerable segments and will evolve with the scheduled completion of the system condition assessment and development of the District's asset management program. Sanitary sewer infrastructure located within proximity to streams and water bodies is inherently vulnerable. Any spill or leakage from these vulnerable segments can rapidly diffuse through the environment. From a practical standpoint, aligning sewers in these environments is largely unavoidable as both sewer pipes and drainage pathways share the same physical constraint of gravity flow. However, with careful planning and management, these risks can be mitigated to a large extent.

This vulnerability assessment provides a framework for identifying and prioritizing risk on some of the most vulnerable segments of the County of San Diego Sanitation District (District) sewer collection system. The focus of this study included stream crossings and vulnerable adjacent pipelines. Available data sources were reviewed and used to identify 92 pipe segments for consideration. Vulnerabilities were defined, which led to the development of a desktop and field work plan to gather data. Field work was conducted to evaluate access, erosion, pipe and manhole condition, and other factors contributing to the vulnerability of the system. Criteria were then defined to establish a risk-based approach for assessing and prioritizing the risk of each segment.

In the larger context, the District is developing a comprehensive asset management program which includes a CMMS system, CCTV inspection program, and prioritization of CIP projects. This vulnerability study will be incorporated into District's overall asset management program to allow for reassessment of conditions based on new data and an efficient use of resources to minimize the risk of vulnerable pipe segments. As the District collects and reviews additional data, the conditions, priorities and permitting needs identified in this study will be confirmed. By incorporating vulnerability into the District's CIP prioritization tool, details of specific improvements to minimize risk of vulnerable pipe segments will be developed in conjunction with the District's ongoing plans and priorities.

Appendix A. Summary of Site Data

Digitally Provided

Appendix B. Erosion Assessment Results

Pipe ID	Streambank Assessment Score	Streambank Assessment Rating
LS0905	6.0	Low
LS0844	8.0	Intermediate
LS0843	6.6	Low
LS0842	6.6	Low
LS0841	7.4	Low
LS0840	8.2	Intermediate
LS0839	9.4	High
LS0838	6.2	Low
LS0832	9.4	High
LS0831	7.4	Low
LS0829	8.4	Intermediate
LS0828	N/A	N/A
LS0827	8.6	Intermediate
LS0826	N/A	N/A
LS0822	9.4	High
LS0806	7.0	Low
LS0805	N/A	N/A
LS0802	7.4	Low
LS0801	N/A	N/A
LS0798	N/A	N/A
LS0452	N/A	N/A
LS0451	N/A	N/A
LS0550.05	N/A	N/A
LS0550.04	N/A	N/A
LS0550.03	N/A	N/A
LS0550.02	N/A	N/A
LS0550.01	N/A	N/A
LS0446	7.0	Low
LS0432	7.0	Low
LS0422	6.8	Low
LS0419	6.8	Low
LS0416	6.0	Low
LS0402	8.8	Intermediate
LS0393	7.0	Low
LS2473	4.8	Minor
LS2472	N/A	N/A
LS2391	4.8	Minor
LS2307	8.2	Intermediate
LS2239	7.4	Low
LS2237	10.0	High
LS1849	8.2	Intermediate
LS1503	5.4	Minor
LS0253	7.4	Low
LS0038	7.0	Low
LS0127	8.6	Intermediate
LS0094	4.8	Minor

Pipe ID	Streambank Assessment Score	Streambank Assessment Rating
LS0078	7.2	Low
LS0063	8.4	Intermediate
LS0043	7.4	Low
LS0042	7.4	Low
LS0019	6.2	Low
LS0018	6.6	Low
LS0004	8.4	Intermediate
SV1629	9.6	High
SV1599-M	8.2	Intermediate
SV1627	10.4	High
SV1589	7.2	Low
SV1517-M	7.4	Low
SV1510-M	7.8	Intermediate
SV1508-M	6.2	Low
SV1505	9.0	Intermediate
SV1347	8.6	Intermediate
SV1346	10.4	High
SV1345	7.8	Intermediate
SV1342	9.4	High
SV1173	5.4	Minor
SV1172	4.8	Minor
SV1043-M	4.8	Minor
SV0439	N/A	N/A
SV0438	8.2	Intermediate
SV0437	7.8	Intermediate
SV0435	7.0	Low
SV0401	7.2	Low
SV0400	7.2	Low
SV0368	5.4	Minor
SV0367-M	N/A	N/A
SV0316	8.2	Intermediate
SV0015	9.2	Intermediate
SV0012-M	7.0	Low
SV0006	5.8	Low
SV0005	6.6	Low
SV0004-M	N/A	N/A
SV0003-M	N/A	N/A
AL0309	6.8	Low
AL0030	7.2	Low
AL0006	4.8	Minor
JU0024-M	7.0	Low
JU0016	7.2	Low
JU0008-M	7.8	Intermediate
JU0003	8.4	Intermediate
SV7562	8.2	Intermediate
SV7563	8.8	Intermediate

Appendix C. Risk Assessment Results

Likelihood of Failure Results

	LoF Scores																								
	Condition						35%	Capacity	20%	Maintenance					20%	Natural Impacts						20%	Security	5%	
	60%	ADD	ADD	10%	20%	10%		100%		100%			ADD	ADD		50%	ADD	SUBTRACT	20%	15%	15%		100%		
Pipe ID	Sewer Condition	*Sewer Condition: Exterior Condition*	Sewer Condition: Special Maintenance	MH Condition	Sewer Material	Sewer Age	Condition Category Score	Capacity	Capacity Category Score	*Access General*	Access Vehicle	Access Personnel	Special Maintenance	Siphon	Maintenance Category Score	Stream Stability	Stream Stability: Crossing Cover	Stream Stability: Crossing Encasement	*Flooding*	Wildfire	Seismic Impact	Nat Impact Category Score	Security	Security Category Score	Likelihood of Failure Total Score
LS0905	2.9	0.0	0.0	2.0	3.0	3.0	1.0	5.0	1.0	1.0	3.0	1.0	0.0	0.0	0.6	2.0	0.0	2.0	3.0	1.0	5.0	0.3	1.0	0.1	2.9
LS0844	3.8	0.0	0.0	2.0	3.0	3.0	1.2	5.0	1.0	4.0	5.0	3.0	0.0	0.0	1.0	3.0	0.0	2.0	3.0	5.0	3.0	0.5	1.0	0.1	3.7
LS0843	1.0	0.0	0.0	2.0	3.0	3.0	0.6	1.0	0.2	2.0	5.0	3.0	0.0	0.0	1.0	2.0	0.0	2.0	3.0	5.0	3.0	0.4	1.0	0.1	2.2
LS0842	4.0	0.0	0.0	2.0	3.0	3.0	1.2	1.0	0.2	2.0	5.0	4.0	0.0	0.0	1.0	2.0	1.0	0.0	3.0	5.0	3.0	0.7	1.0	0.1	3.1
LS0841	2.0	0.0	0.0	2.0	3.0	3.0	0.8	1.0	0.2	2.0	1.0	4.0	0.0	0.0	0.8	2.0	1.0	0.0	3.0	5.0	3.0	0.7	1.0	0.1	2.5
LS0840	2.1	0.0	0.0	2.0	3.0	3.0	0.8	1.0	0.2	2.0	5.0	4.0	0.0	0.0	1.0	3.0	1.0	0.0	3.0	5.0	3.0	0.8	1.0	0.1	2.8
LS0839	2.0	0.0	0.0	2.0	3.0	3.0	0.8	1.0	0.2	2.0	5.0	3.0	0.0	0.0	1.0	4.0	0.0	2.0	3.0	5.0	3.0	0.6	1.0	0.1	2.6
LS0838	1.0	0.0	0.0	2.0	3.0	3.0	0.6	1.0	0.2	4.0	5.0	4.0	0.0	0.0	1.0	2.0	0.0	2.0	3.0	5.0	3.0	0.4	1.0	0.1	2.2
LS0832	5.0	0.0	0.0	2.0	3.0	3.0	1.4	1.0	0.2	4.0	5.0	5.0	0.0	0.0	1.0	4.0	0.0	2.0	3.0	5.0	3.0	0.6	1.0	0.1	3.2
LS0831	1.8	0.0	0.0	2.0	3.0	3.0	0.8	1.0	0.2	3.0	4.0	3.0	0.0	0.0	0.8	2.0	0.0	2.0	3.0	5.0	3.0	0.4	1.0	0.1	2.2
LS0829	1.9	0.0	0.0	2.0	3.0	3.0	0.8	1.0	0.2	4.0	4.0	3.0	0.0	0.0	0.8	3.0	0.0	2.0	3.0	5.0	3.0	0.5	1.0	0.1	2.3
LS0828	3.8	0.0	0.0	2.0	3.0	3.0	1.2	1.0	0.2	3.0	3.0	2.0	0.0	0.0	0.6	0.0	0.0	0.0	2.0	5.0	3.0	0.3	1.0	0.1	2.3
LS0827	1.0	0.0	0.0	2.0	3.0	3.0	0.6	1.0	0.2	3.0	5.0	3.0	0.0	0.0	1.0	3.0	0.0	2.0	3.0	5.0	3.0	0.5	1.0	0.1	2.3
LS0826	3.2	0.0	0.0	2.0	3.0	3.0	1.0	1.0	0.2	3.0	3.0	2.0	0.0	0.0	0.6	0.0	0.0	0.0	2.0	5.0	3.0	0.3	1.0	0.1	2.2
LS0822	2.4	0.0	0.0	2.0	3.0	3.0	0.9	1.0	0.2	3.0	5.0	4.0	0.0	0.0	1.0	4.0	0.0	0.0	3.0	5.0	3.0	0.8	1.0	0.1	2.9
LS0806	3.0	0.0	0.0	2.0	3.0	3.0	1.0	1.0	0.2	1.0	1.0	1.0	0.0	0.0	0.2	2.0	0.0	0.0	3.0	5.0	3.0	0.6	1.0	0.1	2.0
LS0805	3.0	0.0	0.0	2.0	3.0	3.0	1.0	1.0	0.2	3.0	4.0	3.0	0.0	0.0	0.8	0.0	0.0	0.0	2.0	5.0	3.0	0.3	1.0	0.1	2.4
LS0802	1.0	0.0	0.0	2.0	3.0	1.0	0.5	1.0	0.2	4.0	3.0	3.0	0.0	0.0	0.8	2.0	0.0	0.0	3.0	5.0	3.0	0.6	1.0	0.1	2.1
LS0801	2.4	0.0	0.0	2.0	3.0	3.0	0.9	1.0	0.2	3.0	4.0	3.0	0.0	0.0	0.8	0.0	0.0	0.0	2.0	5.0	3.0	0.3	1.0	0.1	2.3
LS0798	4.2	0.0	0.0	2.0	3.0	3.0	1.3	1.0	0.2	3.0	4.0	3.0	0.0	0.0	0.8	0.0	0.0	0.0	2.0	5.0	3.0	0.3	1.0	0.1	2.6
LS0452	2.4	0.0	0.0	2.0	3.0	3.0	0.9	5.0	1.0	4.0	1.0	2.0	0.0	0.0	0.8	0.0	0.0	0.0	2.0	1.0	3.0	0.2	1.0	0.1	2.9
LS0451	2.4	0.0	0.0	2.0	3.0	3.0	0.9	5.0	1.0	4.0	1.0	2.0	0.0	0.0	0.8	0.0	0.0	0.0	2.0	1.0	3.0	0.2	1.0	0.1	2.9
LS0550.05	1.0	0.0	0.0	2.0	1.0	1.0	0.4	1.0	0.2	1.0	1.0	1.0	0.0	0.0	0.2	0.0	0.0	0.0	2.0	1.0	3.0	0.2	1.0	0.1	1.0
LS0550.04	1.0	0.0	0.0	2.0	1.0	1.0	0.4	1.0	0.2	1.0	3.0	1.0	0.0	0.0	0.6	0.0	0.0	0.0	2.0	1.0	3.0	0.2	1.0	0.1	1.4
LS0550.03	1.0	0.0	0.0	2.0	1.0	1.0	0.4	1.0	0.2	1.0	1.0	1.0	0.0	0.0	0.2	0.0	0.0	0.0	2.0	1.0	3.0	0.2	1.0	0.1	1.0
LS0550.02	1.0	0.0	0.0	2.0	1.0	1.0	0.4	1.0	0.2	1.0	1.0	1.0	0.0	0.0	0.2	0.0	0.0	0.0	2.0	1.0	3.0	0.2	1.0	0.1	1.0
LS0550.01	1.0	0.0	0.0	2.0	1.0	1.0	0.4	1.0	0.2	1.0	1.0	1.0	0.0	0.0	0.2	0.0	0.0	0.0	2.0	1.0	3.0	0.2	1.0	0.1	1.0
LS0446	3.2	0.0	0.0	2.0	3.0	3.0	1.0	5.0	1.0	1.0	1.0	1.0	0.0	0.0	0.2	2.0	0.0	2.0	3.0	1.0	3.0	0.2	1.0	0.1	2.5
LS0432	3.3	0.0	0.0	2.0	3.0	2.0	1.0	1.0	0.2	2.0	1.0	3.0	0.0	0.0	0.6	2.0	0.0	0.0	3.0	1.0	3.0	0.4	1.0	0.1	2.3
LS0422	2.8	0.0	0.0	2.0	1.0	1.0	0.8	1.0	0.2	1.0	3.0	1.0	0.0	0.0	0.6	2.0	0.0	0.0	3.0	1.0	3.0	0.4	3.0	0.2	2.1
LS0419	1.0	0.0	0.0	2.0	1.0	1.0	0.4	1.0	0.2	4.0	3.0	4.0	0.0	2.0	1.2	2.0	0.0	0.0	3.0	1.0	3.0	0.4	1.0	0.1	2.3
LS0416	1.0	0.0	0.0	2.0	1.0	1.0	0.4	1.0	0.2	2.0	4.0	3.0	0.0	0.0	0.8	2.0	0.0	0.0	2.0	1.0	3.0	0.4	1.0	0.1	1.8
LS0402	2.3	0.0	0.0	2.0	3.0	3.0	0.9	1.0	0.2	4.0	1.0	4.0	0.0	0.0	0.8	3.0	0.0	0.0	3.0	1.0	3.0	0.5	1.0	0.1	2.5
LS0393	3.2	0.0	0.0	2.0	4.5	3.0	1.2	3.0	0.6	1.0	1.0	1.0	0.0	0.0	0.2	2.0	0.0	0.0	3.0	1.0	3.0	0.4	3.0	0.2	2.6
LS2473	4.0	0.0	0.0	2.0	3.0	3.0	1.2	3.0	0.6	1.0	1.0	1.0	0.0	0.0	0.2	1.0	0.0	2.0	3.0	5.0	3.0	0.3	1.0	0.1	2.3
LS2472	3.2	0.0	0.0	2.0	3.0	3.0	1.0	5.0	1.0	1.0	1.0	1.0	0.0	0.0	0.2	0.0	0.0	0.0	2.0	5.0	5.0	0.4	1.0	0.1	2.7
LS2391	2.7	0.0	1.0	2.0	3.0	2.0	1.1	1.0	0.2	2.0	3.0	3.0	1.0	0.0	0.8	1.0	0.0	2.0	3.0	5.0	3.0	0.3	1.0	0.1	2.4
LS2307	2.4	0.0	0.0	2.0	3.0	3.0	0.9	1.0	0.2	1.0	1.0	1.0	0.0	0.0	0.2	3.0	0.0	0.0	3.0	3.0	5.0	0.7	1.0	0.1	2.0
LS2239	1.8	0.0	0.0	2.0	1.0	2.0	0.6	1.0	0.2	1.0	3.0	1.0	0.0	0.0	0.6	2.0	0.0	2.0	2.0	1.0	5.0	0.3	1.0	0.1	1.7
LS2237	2.1	0.0	0.0	2.0	3.0	2.0	0.8	1.0	0.2	1.0	3.0	1.0	0.0	0.0	0.6	4.0	0.0	0.0	3.0	1.0	5.0	0.7	1.0	0.1	2.3

	LoF Scores																								
	Condition						35%	Capacity	20%	Maintenance					20%	Natural Impacts						20%	Security	5%	
	60%	ADD	ADD	10%	20%	10%		100%		100%			ADD	ADD		50%	ADD	SUBTRACT	20%	15%	15%		100%		
Pipe ID	Sewer Condition	*Sewer Condition: Exterior Condition*	Sewer Condition: Special Maintenance	MH Condition	Sewer Material	Sewer Age	Condition Category Score	Capacity	Capacity Category Score	*Access General*	Access Vehicle	Access Personnel	Special Maintenance	Siphon	Maintenance Category Score	Stream Stability	Stream Stability: Crossing Cover	Stream Stability: Crossing Encasement	*Flooding*	Wildfire	Seismic Impact	Nat Impact Category Score	Security	Security Category Score	Likelihood of Failure Total Score
LS1849	2.4	0.0	0.0	2.0	3.0	3.0	0.9	5.0	1.0	1.0	3.0	1.0	0.0	0.0	0.6	3.0	0.0	0.0	3.0	1.0	5.0	0.6	1.0	0.1	3.1
LS1503	3.0	0.0	1.0	2.0	3.0	3.0	1.2	1.0	0.2	1.0	1.0	1.0	1.0	0.0	0.4	1.0	0.0	0.0	3.0	1.0	5.0	0.4	3.0	0.2	2.4
LS0253	1.2	0.0	0.0	1.0	1.0	1.0	0.4	1.0	0.2	2.0	1.0	4.0	0.0	0.0	0.8	2.0	0.0	2.0	4.0	5.0	5.0	0.5	1.0	0.1	1.9
LS0038	3.0	0.0	0.0	--	1.0	1.0	0.8	3.0	0.6	4.0	3.0	3.0	0.0	2.0	1.2	2.0	0.0	0.0	4.0	3.0	3.0	0.5	1.0	0.1	3.2
LS0127	2.2	0.0	0.0	2.0	1.0	1.0	0.6	3.0	0.6	1.0	1.0	1.0	0.0	0.0	0.2	3.0	0.0	0.0	3.0	1.0	5.0	0.6	3.0	0.2	2.2
LS0094	3.5	0.0	0.0	3.0	3.0	2.0	1.1	1.0	0.2	2.0	3.0	1.0	0.0	0.0	0.6	1.0	0.0	0.0	3.0	1.0	5.0	0.4	1.0	0.1	2.4
LS0078	2.1	0.0	0.0	3.0	5.0	2.0	1.0	5.0	1.0	2.0	3.0	1.0	0.0	0.0	0.6	2.0	0.0	0.0	5.0	5.0	5.0	0.7	3.0	0.2	5.0
LS0063	2.9	1.0	0.0	3.0	5.0	2.0	1.3	5.0	1.0	2.0	3.0	2.0	0.0	0.0	0.6	3.0	0.0	0.0	5.0	1.0	5.0	0.7	4.0	0.2	5.0
LS0043	1.0	0.0	0.0	2.0	1.0	1.0	0.4	3.0	0.6	1.0	1.0	1.0	0.0	0.0	0.2	2.0	0.0	0.0	2.0	1.0	5.0	0.5	1.0	0.1	1.7
LS0042	2.0	0.0	0.0	2.0	1.0	1.0	0.6	3.0	0.6	1.0	1.0	1.0	0.0	0.0	0.2	2.0	0.0	0.0	2.0	1.0	5.0	0.5	1.0	0.1	1.9
LS0019	1.0	0.0	0.0	2.0	1.0	1.0	0.4	1.0	0.2	2.0	1.0	1.0	0.0	0.0	0.4	2.0	0.0	2.0	3.0	1.0	5.0	0.3	1.0	0.1	1.3
LS0018	2.9	0.0	0.0	2.0	5.0	2.0	1.1	1.0	0.2	2.0	3.0	1.0	0.0	0.0	0.6	2.0	0.0	2.0	2.0	1.0	5.0	0.3	1.0	0.1	5.0
LS0004	2.8	0.0	0.0	2.0	3.0	1.0	0.9	1.0	0.2	1.0	3.0	1.0	0.0	0.0	0.6	3.0	0.0	2.0	2.0	1.0	5.0	0.4	1.0	0.1	2.1
SV1629	2.0	0.0	0.0	2.0	3.0	1.0	0.7	1.0	0.2	3.0	3.0	2.0	0.0	0.0	0.6	4.0	0.0	2.0	2.0	1.0	3.0	0.4	1.0	0.1	2.0
SV1599-M	2.6	0.0	0.0	2.0	3.0	1.0	0.9	1.0	0.2	1.0	1.0	1.0	0.0	0.0	0.2	3.0	0.0	2.0	2.0	3.0	3.0	0.4	1.0	0.1	1.7
SV1627	2.0	0.0	0.0	2.0	4.0	3.0	0.9	1.0	0.2	2.0	1.0	2.0	0.0	0.0	0.4	4.0	1.0	0.0	2.0	3.0	3.0	0.8	1.0	0.1	2.3
SV1589	2.0	0.0	0.0	2.0	3.0	1.0	0.7	1.0	0.2	2.0	3.0	2.0	0.0	0.0	0.6	2.0	0.0	2.0	2.0	3.0	3.0	0.3	1.0	0.1	1.8
SV1517-M	2.3	0.0	0.0	2.0	4.5	1.0	0.9	1.0	0.2	2.0	3.0	2.0	0.0	0.0	0.6	2.0	0.0	0.0	2.0	1.0	3.0	0.4	4.0	0.2	2.3
SV1510-M	2.0	0.0	0.0	2.0	3.0	1.0	0.7	1.0	0.2	2.0	3.0	2.0	0.0	0.0	0.6	3.0	0.0	0.0	2.0	1.0	5.0	0.6	4.0	0.2	2.3
SV1508-M	2.0	0.0	0.0	2.0	4.5	1.0	0.8	1.0	0.2	2.0	3.0	2.0	0.0	0.0	0.6	2.0	0.0	0.0	2.0	1.0	5.0	0.5	1.0	0.1	2.2
SV1505	2.1	0.0	0.0	2.0	3.0	1.0	0.7	1.0	0.2	1.0	1.0	3.0	0.0	0.0	0.6	3.0	0.0	0.0	2.0	3.0	5.0	0.6	1.0	0.1	2.2
SV1347	2.0	0.0	0.0	2.0	4.0	3.0	0.9	1.0	0.2	1.0	1.0	3.0	0.0	0.0	0.6	3.0	0.0	0.0	2.0	3.0	5.0	0.6	1.0	0.1	2.3
SV1346	2.5	0.0	0.0	2.0	4.0	3.0	1.0	1.0	0.2	2.0	1.0	1.0	0.0	0.0	0.4	4.0	0.0	0.0	2.0	3.0	5.0	0.7	1.0	0.1	2.4
SV1345	2.6	0.0	0.0	2.0	4.0	1.0	0.9	1.0	0.2	2.0	3.0	2.0	0.0	0.0	0.6	3.0	0.0	0.0	2.0	3.0	5.0	0.6	1.0	0.1	2.4
SV1342	2.5	0.0	0.0	2.0	4.0	1.0	0.9	1.0	0.2	2.0	3.0	2.0	0.0	0.0	0.6	4.0	0.0	0.0	2.0	3.0	5.0	0.7	1.0	0.1	2.5
SV1173	2.3	0.0	0.0	3.0	4.0	3.0	1.0	1.0	0.2	4.0	3.0	2.0	0.0	0.0	0.8	1.0	1.0	0.0	3.0	5.0	5.0	0.6	1.0	0.1	2.6
SV1172	2.3	0.0	0.0	3.0	4.0	3.0	1.0	1.0	0.2	2.0	3.0	3.0	0.0	0.0	0.6	1.0	0.0	0.0	3.0	5.0	5.0	0.5	1.0	0.1	2.3
SV1043-M	3.4	0.0	0.0	3.0	4.5	2.0	1.2	1.0	0.2	3.0	1.0	3.0	0.0	0.0	0.6	1.0	1.0	0.0	4.0	5.0	5.0	0.7	1.0	0.1	2.7
SV0439	3.0	0.0	0.0	2.0	3.0	3.0	1.0	1.0	0.2	3.0	3.0	3.0	0.0	0.0	0.6	1.0	1.0	0.0	3.0	1.0	5.0	0.5	1.0	0.1	2.4
SV0438	3.0	0.0	0.0	2.0	3.0	3.0	1.0	1.0	0.2	3.0	3.0	3.0	0.0	0.0	0.6	3.0	0.0	0.0	3.0	1.0	5.0	0.6	1.0	0.1	2.5
SV0437	3.0	0.0	0.0	2.0	3.0	3.0	1.0	1.0	0.2	1.0	3.0	2.0	0.0	0.0	0.6	3.0	0.0	0.0	3.0	1.0	5.0	0.6	1.0	0.1	2.5
SV0435	2.5	0.0	0.0	2.0	4.0	3.0	1.0	1.0	0.2	1.0	3.0	4.0	0.0	0.0	0.8	2.0	0.0	0.0	3.0	1.0	5.0	0.5	1.0	0.1	2.5
SV0401	2.3	0.0	1.0	2.0	3.0	3.0	1.1	1.0	0.2	3.0	3.0	3.0	1.0	0.0	0.8	2.0	0.0	2.0	2.0	1.0	5.0	0.3	1.0	0.1	2.4
SV0400	2.6	0.0	0.0	2.0	3.0	3.0	0.9	1.0	0.2	4.0	3.0	3.0	0.0	0.0	0.8	2.0	0.0	2.0	3.0	1.0	5.0	0.3	1.0	0.1	2.3
SV0368	2.0	0.0	0.0	2.0	4.0	3.0	0.9	1.0	0.2	5.0	3.0	4.0	0.0	0.0	1.0	1.0	0.0	0.0	4.0	1.0	5.0	0.4	1.0	0.1	2.6
SV0367-M	2.8	0.0	0.0	3.0	4.0	3.0	1.1	1.0	0.2	1.0	3.0	1.0	0.0	0.0	0.6	1.0	0.0	0.0	2.0	1.0	5.0	0.4	1.0	0.1	2.3
SV0316	2.8	0.0	0.0	3.0	4.5	2.0	1.1	1.0	0.2	1.0	3.0	2.0	0.0	0.0	0.6	3.0	0.0	0.0	4.0	1.0	5.0	0.6	1.0	0.1	2.6
SV0015	3.3	0.0	0.0	3.0	1.0	2.0	0.9	1.0	0.2	1.0	1.0	1.0	0.0	0.0	0.2	3.0	0.0	0.0	2.0	1.0	5.0	0.6	1.0	0.1	1.9
SV0012-M	2.0	0.0	0.0	3.0	4.0	3.0	0.9	1.0	0.2	1.0	1.0	1.0	0.0	0.0	0.2	2.0	0.0	0.0	2.0	1.0	5.0	0.5	1.0	0.1	1.8
SV0006	2.0	0.0	0.0	3.0	4.0	3.0	0.9	1.0	0.2	2.0	1.0	2.0	0.0	0.0	0.4	2.0	0.0	0.0	2.0	1.0	5.0	0.5	1.0	0.1	2.0
SV0005	1.8	0.0	0.0	3.0	4.0	3.0	0.9	1.0	0.2	2.0	3.0	3.0	0.0	0.0	0.6	2.0	0.0	0.0	3.0	1.0	5.0	0.5	1.0	0.1	2.2
SV0004-M	2.0	0.0	0.0	3.0	4.0	3.0	0.9	1.0	0.2	2.0	5.0	3.0	0.0	0.0	1.0	1.0	0.0	0.0	3.0	1.0	5.0	0.4	1.0	0.1	2.6

	LoF Scores																								
	Condition						35%	Capacity	20%	Maintenance					20%	Natural Impacts						20%	Security	5%	
	60%	ADD	ADD	10%	20%	10%		100%		100%			ADD	ADD		50%	ADD	SUBTRACT	20%	15%	15%		100%		
Pipe ID	Sewer Condition	*Sewer Condition: Exterior Condition*	Sewer Condition: Special Maintenance	MH Condition	Sewer Material	Sewer Age	Condition Category Score	Capacity	Capacity Category Score	*Access General*	Access Vehicle	Access Personnel	Special Maintenance	Siphon	Maintenance Category Score	Stream Stability	Stream Stability: Crossing Cover	Stream Stability: Crossing Encasement	*Flooding*	Wildfire	Seismic Impact	Nat Impact Category Score	Security	Security Category Score	Likelihood of Failure Total Score
SV0003-M	2.0	0.0	0.0	3.0	4.0	3.0	0.9	1.0	0.2	2.0	4.0	2.0	0.0	0.0	0.8	1.0	0.0	0.0	3.0	1.0	5.0	0.4	1.0	0.1	2.4
AL0309	3.8	0.0	1.0	2.0	3.0	3.0	1.4	3.0	0.6	1.0	3.0	1.0	1.0	0.0	0.8	2.0	0.0	0.0	3.0	5.0	3.0	0.6	1.0	0.1	3.4
AL0030	2.9	0.0	0.0	2.0	4.5	3.0	1.1	5.0	1.0	5.0	1.0	4.0	0.0	0.0	1.0	2.0	0.0	0.0	3.0	4.0	3.0	0.5	3.0	0.2	3.8
AL0006	2.9	0.0	0.0	2.0	3.0	3.0	1.0	1.0	0.2	1.0	1.0	1.0	0.0	0.0	0.2	1.0	0.0	2.0	3.0	1.0	5.0	0.2	1.0	0.1	1.6
JU0024-M	3.0	0.0	0.0	2.0	3.0	3.0	1.0	3.0	0.6	1.0	3.0	1.0	0.0	0.0	0.6	2.0	0.0	2.0	3.0	5.0	5.0	0.4	3.0	0.2	2.8
JU0016	3.4	0.0	0.0	2.0	3.0	2.0	1.1	3.0	0.6	1.0	3.0	1.0	0.0	0.0	0.6	2.0	0.0	0.0	3.0	5.0	3.0	0.6	1.0	0.1	2.9
JU0008-M	3.4	0.0	0.0	2.0	3.0	2.0	1.1	3.0	0.6	1.0	3.0	1.0	0.0	0.0	0.6	3.0	0.0	0.0	3.0	5.0	3.0	0.7	3.0	0.2	3.1
JU0003	3.4	0.0	0.0	2.0	3.0	2.0	1.1	3.0	0.6	3.0	3.0	4.0	0.0	0.0	0.8	3.0	0.0	0.0	5.0	5.0	5.0	0.8	1.0	0.1	3.3
SV7562	1.8	0.0	0.0	2.0	1.0	2.0	0.6	1.0	0.2	1.0	1.0	1.0	0.0	0.0	0.2	3.0	0.0	0.0	2.0	5.0	3.0	0.6	1.0	0.1	1.6
SV7563	1.8	0.0	0.0	2.0	1.0	2.0	0.6	1.0	0.2	1.0	1.0	1.0	0.0	0.0	0.2	3.0	0.0	0.0	2.0	5.0	3.0	0.6	1.0	0.1	1.6

Consequence of Failure Results

	CoF Scores													
	Spill Magnitude and Response				50%	Impacts due to Response		25%	Cost Factors				25%	
	40%	20%	20%	20%		50%	50%		30%	30%	30%	10%		
Pipe ID	Pipe Size	Monitoring	Access	*Spill Mitigation / Capture*	Spill Magnitude & Response Score	Environment Impacts	Social Impacts	Impact Due to Response Score	Bury Depth (If Applicable)	Access	Pipe Size	Exposed Pipe Type (If Applicable)	Cost Factors Category Score	Consequence of Failure Total Score
LS0905	3.0	4.0	4.0	4.0	1.8	4.0	5.0	1.1	3.0	4.0	3.0	1.0	0.8	3.8
LS0844	3.0	4.0	5.0	4.0	1.9	5.0	5.0	1.3	3.5	5.0	3.0	1.0	1.0	4.1
LS0843	3.0	4.0	5.0	4.0	1.9	5.0	5.0	1.3	3.5	5.0	3.0	1.0	1.0	4.1
LS0842	3.0	4.0	5.0	4.0	1.9	4.0	5.0	1.1	3.5	5.0	3.0	1.0	1.0	4.0
LS0841	3.0	4.0	4.5	4.0	1.9	4.0	5.0	1.1	3.5	4.5	3.0	1.0	0.9	3.9
LS0840	3.0	4.0	5.0	4.0	1.9	4.0	5.0	1.1	3.5	5.0	3.0	1.0	1.0	4.0
LS0839	3.0	4.0	5.0	4.0	1.9	4.0	5.0	1.1	4.0	5.0	3.0	1.0	1.0	4.0
LS0838	3.0	4.0	5.0	4.0	1.9	4.0	5.0	1.1	4.0	5.0	3.0	1.0	1.0	4.0
LS0832	3.0	4.0	5.0	4.0	1.9	4.0	5.0	1.1	4.0	5.0	3.0	1.0	1.0	4.0
LS0831	3.0	4.0	4.5	4.0	1.9	4.0	5.0	1.1	4.0	4.5	3.0	1.0	1.0	3.9
LS0829	3.0	4.0	4.5	4.0	1.9	4.0	5.0	1.1	3.5	4.5	3.0	1.0	0.9	3.9
LS0828	3.0	4.0	4.0	4.0	1.8	4.0	5.0	1.1	3.5	4.0	3.0	1.0	0.9	3.8
LS0827	3.0	4.0	5.0	4.0	1.9	4.0	5.0	1.1	4.0	5.0	3.0	1.0	1.0	4.0
LS0826	3.0	4.0	4.0	4.0	1.8	4.0	5.0	1.1	4.0	4.0	3.0	1.0	0.9	3.8
LS0822	3.0	4.0	5.0	4.0	1.9	4.0	5.0	1.1	4.0	5.0	3.0	1.0	1.0	4.0
LS0806	3.0	4.0	3.0	4.0	1.7	4.0	5.0	1.1	4.0	3.0	3.0	1.0	0.8	3.7
LS0805	3.0	4.0	4.5	4.0	1.9	5.0	5.0	1.3	4.0	4.5	3.0	1.0	1.0	4.1
LS0802	3.0	4.0	4.5	4.0	1.9	5.0	5.0	1.3	3.5	4.5	3.0	1.0	0.9	4.0
LS0801	3.0	4.0	4.5	4.0	1.9	5.0	5.0	1.3	3.5	4.5	3.0	1.0	0.9	4.0
LS0798	3.5	4.0	4.5	4.0	2.0	4.0	5.0	1.1	4.0	4.5	3.5	1.0	1.0	4.1
LS0452	4.0	2.0	4.5	4.0	1.9	4.0	5.0	1.1	4.0	4.5	4.0	1.0	1.0	4.0
LS0451	4.0	2.0	4.5	4.0	1.9	4.0	5.0	1.1	3.5	4.5	4.0	1.0	1.0	4.0
LS0550.05	4.0	2.0	3.0	4.0	1.7	4.0	5.0	1.1	4.0	3.0	4.0	1.0	0.9	3.7
LS0550.04	4.0	2.0	4.0	4.0	1.8	4.0	5.0	1.1	4.0	4.0	4.0	1.0	1.0	3.9
LS0550.03	4.0	2.0	3.0	4.0	1.7	4.0	5.0	1.1	4.0	3.0	4.0	1.0	0.9	3.7
LS0550.02	4.0	2.0	3.0	4.0	1.7	4.0	5.0	1.1	4.0	3.0	4.0	1.0	0.9	3.7
LS0550.01	4.0	2.0	3.0	4.0	1.7	4.0	5.0	1.1	4.0	3.0	4.0	1.0	0.9	3.7
LS0446	3.5	2.0	3.0	4.0	1.6	4.0	5.0	1.1	4.0	3.0	3.5	1.0	0.9	3.6
LS0432	3.0	2.0	4.0	4.0	1.6	4.0	5.0	1.1	3.5	4.0	3.0	1.0	0.9	3.6
LS0422	3.0	2.0	4.0	5.0	1.7	4.0	5.0	1.1	1.0	4.0	3.0	3.0	0.9	3.7
LS0419	4.0	2.0	4.5	4.0	1.9	4.0	5.0	1.1	4.0	4.5	4.0	1.0	1.0	4.0
LS0416	4.0	2.0	4.5	4.0	1.9	4.0	5.0	1.1	4.0	4.5	4.0	1.0	1.0	4.0
LS0402	3.0	2.0	4.5	4.0	1.7	4.0	5.0	1.1	3.5	4.5	3.0	1.0	0.9	3.7
LS0393	4.0	2.0	3.0	5.0	1.8	4.0	5.0	1.1	1.0	3.0	4.0	4.5	0.9	3.8
LS2473	3.0	4.0	3.0	5.0	1.8	4.0	5.0	1.1	1.0	3.0	3.0	4.5	0.8	3.7
LS2472	3.0	4.0	3.0	5.0	1.8	4.0	5.0	1.1	1.0	3.0	3.0	4.5	0.8	3.7
LS2391	3.0	4.0	4.0	4.0	1.8	4.0	5.0	1.1	3.5	4.0	3.0	1.0	0.9	3.8
LS2307	4.0	4.0	3.0	4.0	1.9	4.0	5.0	1.1	3.0	3.0	4.0	1.0	0.8	3.9
LS2239	3.0	4.0	4.0	4.0	1.8	4.0	5.0	1.1	4.0	4.0	3.0	1.0	0.9	3.8
LS2237	4.0	4.0	4.0	4.0	2.0	4.0	5.0	1.1	4.5	4.0	4.0	1.0	1.0	4.2

	CoF Scores													
	Spill Magnitude and Response				50%	Impacts due to Response		25%	Cost Factors				25%	
	40%	20%	20%	20%		50%	50%		30%	30%	30%	10%		
Pipe ID	Pipe Size	Monitoring	Access	*Spill Mitigation / Capture*	Spill Magnitude & Response Score	Environment Impacts	Social Impacts	Impact Due to Response Score	Bury Depth (If Applicable)	Access	Pipe Size	Exposed Pipe Type (If Applicable)	Cost Factors Category Score	Consequence of Failure Total Score
LS1849	3.5	4.0	4.0	4.0	1.9	4.0	5.0	1.1	4.5	4.0	3.5	1.0	1.0	4.0
LS1503	3.0	4.0	3.0	5.0	1.8	4.0	5.0	1.1	1.0	3.0	3.0	3.0	0.8	3.7
LS0253	3.0	4.0	4.5	4.0	1.9	4.0	3.0	0.9	4.5	4.5	3.0	1.0	1.0	3.7
LS0038	3.0	2.0	4.5	5.0	1.8	4.0	5.0	1.1	1.0	4.5	3.0	3.0	0.9	3.8
LS0127	3.5	4.0	3.0	5.0	1.9	4.0	5.0	1.1	1.0	3.0	3.5	3.0	0.8	3.8
LS0094	4.5	4.0	4.0	4.0	2.1	4.0	5.0	1.1	4.0	4.0	4.5	1.0	1.0	4.3
LS0078	4.5	4.0	4.0	5.0	2.2	5.0	5.0	1.3	1.0	4.0	4.5	5.0	1.1	4.5
LS0063	4.5	5.0	4.0	5.0	2.3	5.0	5.0	1.3	1.0	4.0	4.5	5.0	1.1	4.6
LS0043	5.0	2.0	3.0	4.0	1.9	5.0	5.0	1.3	4.0	3.0	5.0	1.0	1.0	4.2
LS0042	5.0	2.0	3.0	4.0	1.9	5.0	5.0	1.3	4.5	3.0	5.0	1.0	1.0	4.2
LS0019	5.0	4.0	3.5	4.0	2.2	4.0	5.0	1.1	4.5	3.5	5.0	1.0	1.1	4.4
LS0018	4.5	2.0	4.0	4.0	1.9	4.0	5.0	1.1	4.0	4.0	4.5	1.0	1.0	4.1
LS0004	5.0	4.0	4.0	4.0	2.2	5.0	5.0	1.3	4.0	4.0	5.0	1.0	1.1	4.5
SV1629	4.5	2.0	4.0	4.0	1.9	4.0	5.0	1.1	4.0	4.0	4.5	1.0	1.0	4.1
SV1599-M	3.0	2.0	3.0	4.0	1.5	5.0	5.0	1.3	4.5	3.0	3.0	1.0	0.9	3.6
SV1627	4.5	2.0	3.5	4.0	1.9	4.0	5.0	1.1	4.0	3.5	4.5	1.0	1.0	4.0
SV1589	4.5	2.0	4.0	4.0	1.9	5.0	5.0	1.3	4.0	4.0	4.5	1.0	1.0	4.2
SV1517-M	4.5	2.0	4.0	5.0	2.0	5.0	5.0	1.3	1.0	4.0	4.5	4.5	1.1	4.3
SV1510-M	4.5	2.0	4.0	5.0	2.0	5.0	5.0	1.3	1.0	4.0	4.5	4.0	1.1	4.3
SV1508-M	4.5	2.0	4.0	4.0	1.9	5.0	5.0	1.3	3.5	4.0	4.5	1.0	1.0	4.2
SV1505	4.5	2.0	4.0	4.0	1.9	5.0	5.0	1.3	4.0	4.0	4.5	1.0	1.0	4.2
SV1347	4.5	2.0	4.0	4.0	1.9	5.0	5.0	1.3	3.5	4.0	4.5	1.0	1.0	4.2
SV1346	4.5	4.0	3.5	4.0	2.1	5.0	5.0	1.3	3.5	3.5	4.5	1.0	1.0	4.3
SV1345	4.5	4.0	4.0	4.0	2.1	5.0	5.0	1.3	4.0	4.0	4.5	1.0	1.0	4.4
SV1342	5.0	4.0	4.0	4.0	2.2	5.0	5.0	1.3	4.0	4.0	5.0	1.0	1.1	4.5
SV1173	5.0	4.0	4.5	4.0	2.3	5.0	5.0	1.3	4.5	4.5	5.0	1.0	1.2	4.7
SV1172	5.0	4.0	4.0	4.0	2.2	5.0	5.0	1.3	4.0	4.0	5.0	1.0	1.1	4.5
SV1043-M	3.0	2.0	4.0	4.0	1.6	5.0	5.0	1.3	4.0	4.0	3.0	1.0	0.9	3.8
SV0439	3.0	4.0	4.0	4.0	1.8	5.0	3.0	1.0	3.5	4.0	3.0	1.0	0.9	3.7
SV0438	3.0	4.0	4.0	4.0	1.8	5.0	3.0	1.0	3.5	4.0	3.0	1.0	0.9	3.7
SV0437	3.0	4.0	4.0	4.0	1.8	5.0	3.0	1.0	4.0	4.0	3.0	1.0	0.9	3.7
SV0435	5.0	4.0	4.5	4.0	2.3	5.0	3.0	1.0	4.5	4.5	5.0	1.0	1.2	4.4
SV0401	3.0	4.0	4.0	4.0	1.8	5.0	3.0	1.0	4.0	4.0	3.0	1.0	0.9	3.7
SV0400	3.0	4.0	4.5	4.0	1.9	5.0	3.0	1.0	4.0	4.5	3.0	1.0	1.0	3.8
SV0368	5.0	4.0	5.0	4.0	2.3	5.0	5.0	1.3	4.0	5.0	5.0	1.0	1.2	4.7
SV0367-M	5.0	4.0	4.0	4.0	2.2	5.0	5.0	1.3	5.0	4.0	5.0	1.0	1.2	4.6
SV0316	4.5	4.0	4.0	4.0	2.1	5.0	5.0	1.3	4.5	4.0	4.5	1.0	1.1	4.4
SV0015	3.0	2.0	3.0	4.0	1.5	5.0	5.0	1.3	4.0	3.0	3.0	1.0	0.8	3.6
SV0012-M	5.0	2.0	3.0	4.0	1.9	5.0	5.0	1.3	4.5	3.0	5.0	1.0	1.0	4.2
SV0006	5.0	2.0	3.5	4.0	2.0	5.0	5.0	1.3	4.5	3.5	5.0	1.0	1.1	4.3
SV0005	5.0	2.0	4.0	4.0	2.0	5.0	5.0	1.3	4.0	4.0	5.0	1.0	1.1	4.3
SV0004-M	5.0	2.0	5.0	4.0	2.1	5.0	5.0	1.3	4.0	5.0	5.0	1.0	1.2	4.5

	CoF Scores													
	Spill Magnitude and Response				50%	Impacts due to Response		25%	Cost Factors				25%	
	40%	20%	20%	20%		50%	50%		30%	30%	30%	10%		
Pipe ID	Pipe Size	Monitoring	Access	*Spill Mitigation / Capture*	Spill Magnitude & Response Score	Environment Impacts	Social Impacts	Impact Due to Response Score	Bury Depth (If Applicable)	Access	Pipe Size	Exposed Pipe Type (If Applicable)	Cost Factors Category Score	Consequence of Failure Total Score
SV0003-M	5.0	2.0	4.5	4.0	2.1	5.0	5.0	1.3	3.0	4.5	5.0	1.0	1.0	4.3
AL0309	3.0	4.0	4.0	4.0	1.8	4.0	5.0	1.1	3.5	4.0	3.0	1.0	0.9	3.8
AL0030	3.5	4.0	5.0	5.0	2.1	4.0	5.0	1.1	1.0	5.0	3.5	4.0	1.1	4.3
AL0006	3.5	4.0	3.0	4.0	1.8	4.0	5.0	1.1	4.0	3.0	3.5	1.0	0.9	3.8
JU0024-M	3.0	2.0	4.0	4.0	1.6	4.0	3.0	0.9	1.0	4.0	3.0	1.0	0.7	3.1
JU0016	3.0	2.0	4.0	4.0	1.6	4.0	3.0	0.9	3.5	4.0	3.0	1.0	0.9	3.4
JU0008-M	3.0	2.0	4.0	4.0	1.6	4.0	3.0	0.9	1.0	4.0	3.0	1.0	0.7	3.1
JU0003	3.0	2.0	4.5	5.0	1.8	4.0	3.0	0.9	1.0	4.5	3.0	5.0	1.0	3.6
SV7562	3.0	4.0	3.0	1.0	1.4	1.0	5.0	0.8	4.0	3.0	3.0	1.0	0.8	3.0
SV7563	3.0	4.0	3.0	1.0	1.4	1.0	5.0	0.8	4.0	3.0	3.0	1.0	0.8	3.0

Appendix D. Site Photos

Digitally Provided