Section 4: Business Risk and Vulnerability Assessment

The City's WWCP preparation kicked off with a Business Risk and Vulnerability Assessment (BRVA) workshop series where City staff gathered to discuss their various systems, operational risks, potential modes of failure, and opportunities for improvement. A follow-up BRVA session was later held to capture Collection System Assets. City staff from operations and maintenance (O&M), engineering, and management were included in these conversations. This gathering of City stakeholders ensured a comprehensive analysis of the City's risks by discussing potential failures and their impact on the City's business plan. The BRVA creates a baseline for unit process and system performance, vulnerabilities, and failure modes based on input from stakeholders. Institutional knowledge is collected from City staff along with record data to review performance objectives and identify known functional failures and risks.

The BRVA outcomes prioritize needs using a relative risk score and profile to direct attention to the most critical systems. Unit processes are prioritized based on consequential ranks, asset vulnerabilities, organizational vulnerabilities, and opportunities for improvement.

4.1 BRVA Workshop Series

4.1.1 BRVA Approach

The BRVA approach is intended to bring City management, engineering, and O&M staff together to identify the nexus between business risk, capital improvements, and asset performance to identify the opportune area(s) to manage City assets most effectively. Each staffing outlet offers unique insight into vulnerabilities within the system. Providing an opportunity for each of these groups to openly discuss system concerns establishes a foundation for effective management of assets.

This high-level assessment directs attention to the most critical City wastewater facilities and systems based on consensus from workshop participants. Figure 4-1 illustrates a generic example of how BRVA outcomes are presented to prioritize decision making. System components are ranked from high to low risk based on a combination of the Consequence of Failure score and the Business Vulnerability score. The Consequence of Failure is a relative measure of the potential impact an agency will face when a unit process or asset experiences functional failure. Business Vulnerability addresses how an agency's business practices affect staff's ability to optimize the long-term operation and maintenance of a asset. These scores are generated using weighted metrics and then multiplied together to create the relative risk score.

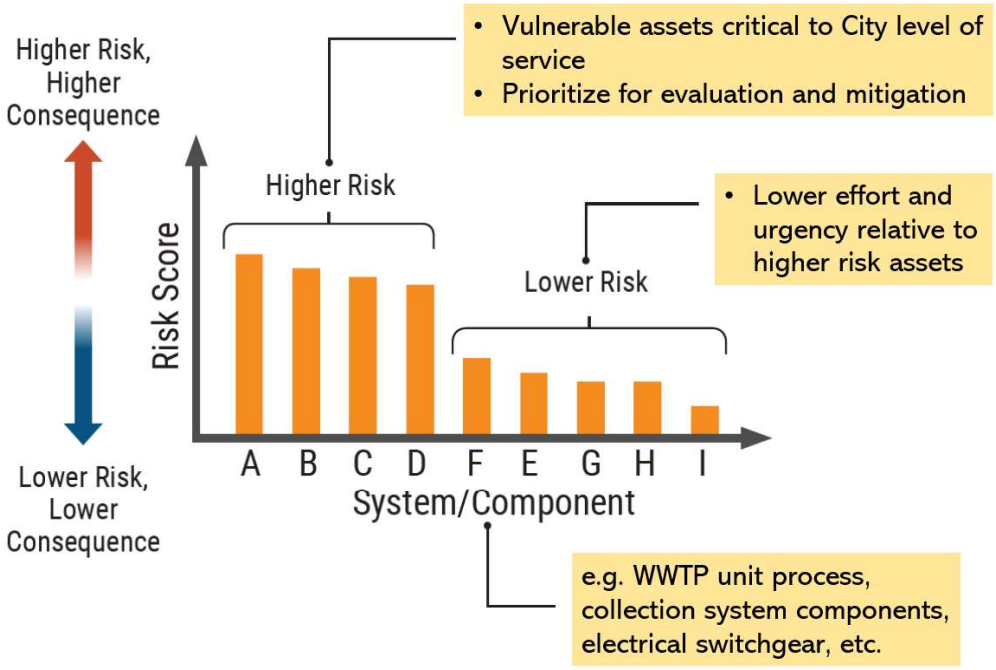

Figure 4-1: Example of Relative Risk Score and Profile

The BRVA workshops were designed to capture an objective opinion of the City's risk, based on a consequential and vulnerability risk assessment of the wastewater facilities, systems, and assets. This was completed by evaluating the desired function, ability to meet performance objectives, and existing O&M business processes for each system. While a complete profile of every asset is ideal for a comprehensive risk evaluation, for the purposes of this series, assets were allocated into major asset categories, and sub-system assets. The major asset categories is referred to herein as system unit processes, including systems within the WWTP and major systems of the collection system. These 17 major system unit processes are outlined below:

• **Grit Removal**	• Disinfection	• Electrical System
• **Pre-Aeration**	• Final Effluent Channel/Outfall	• Collection System Subbasins
• **Primary Clarification**	• Solids Stream	• Siphons Mains
• **Biofilter**	• Digestion	• Crosstown Pipeline &
• **Aeration**	• Biosolids Land Application	Central Bremerton Force Main

Organizing the City's wastewater assets into these unit processes was done based on a review of existing flow diagrams and schematics. From these 17 system unit processes, the assets are further broken down into 43 sub-system assets. A full list of all 43 assets is depicted in the results generated in Figure 4-3 and Figure 4-4.

There are four major elements of the BRVA:

1. The **first element** is to establish functional performance through general knowledge of the system by inquiring about the function of the system, performance criteria expected by the system, the key process indicators that the operator measures to meet system functional performance, and whether a failure event is evident to the operator.

2. The **second element** is to identify the impact of failure on safety, environment, service quality, public perception, and financial impact/fiscal sustainability.

3. The **third element** is to establish vulnerability of how the business operates, maintains and manages City facilities and systems. This is done by determining the condition of each unit processes relative to physical condition, the degree of potential safety risks, operating procedures, O&M training programs, management of change processes, and maintenance management systems.

4. The **fourth element** of the BRVA is to collaboratively identify improvement opportunities, from a high level. Business system improvements, including any O&M procedural improvements, replacement of critical assets, or re-engineering of the systems is considered to reduce the overall risk score. This element is the culmination of risk assessment and is completed at the end of all evaluations to generate the prioritize CIP program.

For each system and asset, the BRVA participants defined the system and assessed the consequence of failure and collective vulnerability of the system by carefully asking a series of strategic questions and applying the scoring approach defined in Section 6.5. The steps outlined in the following table describe the BRVA approach covered during the workshop series and align with the first three elements described above. The outcome of the asset evaluation is to identify business system improvements, as described by the fourth element above, and is completed after the workshop series.

Table 4-1: BRVA Workshop Steps (Elements 1 to 3)

Steps	Evaluation Criteria	Outcome
Define Asset Functional Attributes	- Functional Statement - Performance Objectives - Failure Modes and Detectability - Potential Improvement/ Mitigation	Compiled notes for each asset according to knowledge collected from City Staff
Assess Consequence of Failure	- Public/Staff health and Safety - Environmental and Regulatory Impact - Quality of Service/Continuity - Public Perception - Financial Impact/Fiscal Sustainability	Each criteria scored 1 to 5 Each criteria assigned a weighted multiplier
Assess Collective Business Vulnerability of Asset	- Work Execution Management - Asset Condition - Workforce Reliability & Training - Workface Safety Features & Culture - Process Resiliency - Engineering for maintenance Reliability & Asset Performance Tracking	Each criteria scored 1 to 5 Each criteria assigned a weighted multiplier

The following section provides a describes the evaluation criteria used to develop an arithmetic mean and determine the vulnerability rating for each unit process as it relates to the condition of each business element. This process establishes a uniform scoring metric to be used system wide prior to individual assets being discussed to maintain continuity and avoid initial bias.

Record documents were collected by KJ to generate a basic asset hierarchy of unit processes within the WWTP and collection system. Using this asset hierarchy, the framework and agendas for the BRVA workshop series were compiled and approved by the City. The BRVA leverages institutional knowledge through workshops and interviews with experienced O&M staff to determine and uncover reasonable system failure modes and effects, dominant failure mechanisms, operational targets, equipment history, system criticality, business vulnerabilities, likelihood of failure, and corrective actions. Various stakeholders from management and O&M from treatment, collections, electrical, and instrumentation and controls (I&C) were invited to all meetings allowing KJ to record institutional knowledge and notable areas of concern. Each staffing outlet offers unique insight into vulnerabilities within the system. Providing an opportunity for each of these groups to openly discuss system concerns establishes a foundation for effective management of assets. Attendance for these workshops included the following:

City Engineering: Ned Lever, William David, David Powell, and Cole Arthur

Wastewater O&M (WWTP and Pump Stations): Eric Burris, Kevin Golnik, Travis Olson, William Wendling, Dana Nystrom

Utility O&M (Collection System): Chance Berthiaume and Darrell Clauson

Facilitated by KJ Staff: Andrew Perez, Mackenzie Capaci, Gwen Gyldenege, Swati Maurya, Michael Lubovich, and Benjamin Schriber.

The BRVA workshop series agenda is outlined in Table 4-2 below:

Table 4-2: BRVA Workshop Agenda

10/17/2023	Service Levels, Corporate Risk Matrix Development	City's Vision & Mission, Agency Performance Objectives, Consequence of Failure Identification & Impact Scale, System Condition Scale, and BRVA Workshop Outline & Approval
10/18/2023	Workshop 1	Review Elements of the BRVA Tool, general flow path overview and initial concerns, Headworks, Grit Removal
10/19/2023	Workshop 2	Pre-aeration, Primary Clarification, Biofilters
10/25/2023	Workshop 3	Aeration, Secondary Clarification, Disinfection
10/26/2023	Workshop 4	Final Effluent Channel/Outfall, Solids Stream, Digestion
11/14/2023	Workshop 5	Biosolids Effluent, Electrical Systems, general overview of collections system (to be continued after future analysis)
09/24/2024	Workshop 6	Review Elements of the BRVA Tool, Collection System Subbasins
10/8/2024	Workshop 7	Remaining Subbasins, Siphons, Crosstown Pipeline & Central Bremerton Force Main

Not all staff referenced were in attendance for each workshop.

4.1.2 Levels of Service

The kickoff meeting focused on service levels and the development of a corporate risk matrix based on the City's goals and unique ability to manage and respond to different types of risks. KJ facilitated a conversation to develop a vision statement for Wastewater and Sewer Utility Operations that aligned with the established City Public Works and Utilities Mission.

Mission: Providing expert, efficient stewardship of Bremerton's infrastructure and natural resources; ensuring responsive and professional customer service.

Vision: To resiliently, reliably and efficiently stewards Bremerton's essential infrastructure and natural resources, while protecting public safety and the environment through innovative, sustainable, efficient, and cost-effective practices

Conducting risk analyses are inherently subjective, so the risk matrix serves as a tool to transform the subjective discussion into objective outcomes. The risk matrix helps achieve this by identifying functional failure, business impacts when failure occurs, and using the risk outcomes to streamline prioritization of City needs. City staff were given the opportunity to develop, refine, review and comment on the risk matrix before it was used during the BRVA workshops to confirm group consensus on the consequences and scoring criteria.

The risk matrix developed for the City is a 5 by 5 matrix that includes condition rating and probability of failure on the vertical access and various levels of consequence along the horizontal access. The risk matrix as shown in Figure 4-2 provides a color-coded illustration of the potential risk as it relates to the system condition rating and consequential criteria.

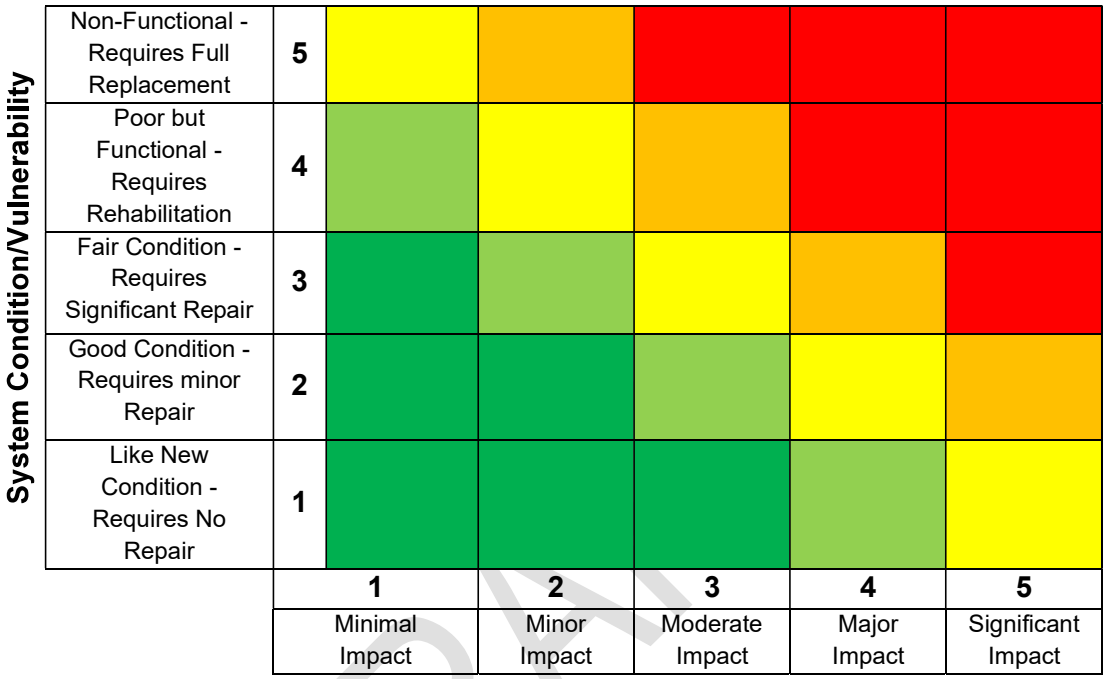

Figure 4-2: City Risk Matrix and Scoring

This matrix was used to develop the risk scores for the BRVA group workshops. In terms of the risk matrix anatomy, the red shaded sections indicate the exposure to risk is high as it relates to likelihood of a threat impacting the asset due to vulnerable condition and significant consequence of failure. The green shaded sections indicate assets in good condition with a low probability and/or minimal consequence of failure. Scoring descriptions and guidance are provided in the following sections. The system level consequential risk determined by the analysis is essentially the product of vulnerability and consequence that results from a failure event.

The service levels meeting, and subsequent workshop series was planned and implemented to gather key City staff in a single room with the purpose of collecting information on the current state of major assets to determine necessary improvements, while relating it to agreed upon parameters of operating conditions. The group focused on reviewing equipment conditions, maintenance practices, documentation, and staff concerns that characterize process reliability. Although each facility comes with unique challenges, including maintenance accessibility issues, asset age, design issues, and influent loading changes due to community water conservation measures, they all share common problems relative to reliable documentation control and a history of plant operations and maintenance practices.

4.1.3 Consequence of Failure/Criticality

The Consequence of Failure (CoF) addresses how the failure of an asset to meet its function will impact the ability of an agency to meet their mission, vision, and/or goals. It is a relative measure of the outcome when a unit process experiences functional failure and impedes intended engineered function of the unit process. These elements were based on the following categories: Public & Staff Health and Safety, Environmental and Regulatory Impact, Quality of Service and Continuity, Public Image/Perception, and Fiscal Impact. Each of these criteria are defined in Table 4-3 below:

Table 4-3: Consequence of Failure Definitions

Public & Staff Health and Safety	Relative impact a failure will have on the risk of accidents and injuries, and ability to create a safe working environment to protect the safety of life and property.
Environmental and Regulatory Impact	Relative impact a failure will have on the environment, as well as the potential legal implications based on existing environmental regulations and permit requirements with which the City will need to comply.
Quality of Service and Continuity	Relative impact a failure will have on the ability to maintain service levels after a disruptive event or disaster. Service continuity is important for ensuring that essential functions continue to operate.
Public Perception	Relative impact a failure will have on the collective opinion, attitude, and understanding that the residents of the City hold about their local government, its wastewater services, policies, and overall performance.
Financial Impact/Fiscal Sustainability	Relative impact a failure will have on available City funds and available financial resources necessary to support restoration efforts, including potential construction costs, bypassing, equipment/rentals, ongoing operational expenses (maintenance, utilities, staffing), and any permit violation fees.

The specific criteria and relative weight of these categories were reviewed with the City and structured around their business objectives. Table 4-4 displays the criticality scoring matrix developed with the City.

Table 4-4: Consequence of Failure (CoF) Scoring

Weight	Score: 1 Minimal Impact	Score: 2 Minor Impact	Score: 3 Moderate Impact	Score: 4 Major Impact	
30%	No injury or minor injury – contusions & lacerations, first aid, non-recordable or near miss	Minor to moderate Injury – contusions & lacerations w/out lost time - recorded	Moderate injury/lost time or restricted duty – OSHA triggered action	Major serious health issues (acute & chronic) & long-term injuries – disabling	
25%	No negative impacts on environment, public health, or regulatory compliance. 100% Permit Compliance.	No negative impacts on environment or public health; One-off Permit violation – No Action from DOE	No negative impacts on environment or public health; Multiple Permit violations within 6-12 months – No Action from DOE	Minor negative impact to the environment and/or public health Permit Violation – Action from DOE	Mod impac pu
15%	No impacts on service delivery or customers	Localized community impact / minor disruption.	Moderate localized long-term impact. Community short-term service disruption. Capacity limitations. Delays/Restrictions to developers (<6 months).	Community wide impacts with potential long-term service disruption. Capacity limitations. Delays/Restrictions to developers (>6 months).	Ser highly have Capa prov
10%	No Impact, odor complaint, or complaint to staff. No significant social media	Social media activity but no local media coverage. Response handled by staff. Potential complaints to City Council, but no action required.	Social media activity and maybe minor local media coverage. City Council may receive complaints to be responded to by staff.	Local media coverage with Board of Directors potentially involved in response. Potential long-term impact to community confidence in City.	Lead pos cove comm
20%	$100 < X < $10,000 Minor cost impacted that can be covered within an operational or CIP budget authorization	$10,000 < X < $25,000 Costs can be covered by reallocating authorized funding in operational or CIP budgets. Requires Director sign-off but does not need to go to Council.	$25,000 < X < $100,000 Non-emergency Requires City Manager sign-off, may require supplemental budget approval through Council.	$100,000 < X < $350,000 Emergency repair triggered. Requires Council to appropriate additional funding in an amount that affects the next FY CIP.	Em Requ addit that a mu

4.1.4 Business Vulnerability

Business Vulnerability (BV) addresses how an agency's business practices affect staff's ability to optimize the long-term operation and maintenance of an asset. This metric was based on six criteria including Work Execution Management (WEM), asset condition, workforce reliability and training, workforce safety features and culture, process resiliency, and engineering for maintenance reliability and asset performance tracking. This condition rates the various business systems and assets that support the operations, maintenance and engineering management that directly impact potential vulnerabilities within the system architecture. When the support systems and assets are in excellent condition, the vulnerability of the business is minimized. However, when the systems and assets are in poor condition, then the vulnerability of the business is greater. Each of these criteria are defined in Table 4-5 below:

Table 4-5: Business Vulnerability Criteria Definitions

Work Execution Management (WEM)	How efficient is the lifecycle of a work order; including identification of an issue, confirmation, documentation, resource planning, work execution, functional review, and close out?
Asset Condition	How functional is the asset in the current state? A measure of an asset's health and physical state at a given time is a key factor in determining how long an asset will remain useful and can help predict when it will need to be repaired, renewed, or replaced.
Workforce Reliability & Training	How functional is your staff resources, skills training, and knowledge transfer? A variety of activities that help employees and businesses develop and improve skills, and meet employment needs, including day-to-day skills training, mandatory trainings, documented training and materials, formal standard operating procedures (SOPs), abnormal operating procedures (AOPs), emergency response plans (ERPs), labor forecasting, knowledge transfer, etc.
Workforce Safety Features and Culture	How safe does your staff feel when working on or around assets? Appropriate safety policy and safety signs, labels, guarding, and clearances to help prevent injury, illness, or property damage.
Process Resiliency	How efficient and available are resources required to respond in the event of a failure or emergency event? The consistent ability of a defined process to produce the desired outcome with minimal errors, as outlined in the detailed steps and guidelines within the SOP, AOPs, and ERPs, essentially signifying how dependable and predictable the process is when followed accurately, even when under stress.

Engineering for Maintenance Reliability and Asset Performance Tracking	How intentional are engineering practices to improve the longevity and performance of physical assets by documenting system functions at the unit process level, leveraging a formal risk methodology, and using root cause analysis processes for key engineering tools which can 1) support O&M, 2) leverage reliability principles during the development of capital improvement strategies and design projects, and 3) formalize a management of change process?

The condition ratings listed in Table 4-6 for each business vulnerability criteria were used to develop the City's risk matrix.

Table 4-6: Business Vulnerability (BV) Scoring Criteria

eight	Score: 1 Excellent Condition	Score: 2 Good Condition	Score: 3 Fair Condition	Score: 4 Needs Attention
15%	No identification of failure	Non-Functional - Requires Full Replacement	No training	O&M do not feel safe conducting work. No safety equipment/protocols. Hazardous Environment. PPE Required.
20%	Not identified during routine inspection, but ability to be seen from O&M Long period of time prior to maintenance	Poor but Functional - Requires Rehabilitation	Minimal, undocumented training. Based on institutional knowledge	O&M do not feel safe conducting work. Non-functioning or failed safety equipment. Hazardous Environment. PPE Required.
10%	Not identified during routine inspection, but ability to be seen from O&M Mid-range response time to final execution	Fair Condition - Requires Significant Repair	Minimal, but documented training. Mostly based on institutional knowledge. Basic standard operating procedures (SOPs)	Controlled hazardous environmer PPE Required.
30%	Routine inspection/maintenance route. Mid-range response time to final execution	Good Condition - Requires Minor Repair	Required formal documented training protocols. SOPs, emergency response plans (ERPs)	O&M feels safe operating. PPE provided and known. Signage posted. Minimal, well controlled hazard.
20%	Routine inspection/maintenance route. Rapid response time to final execution	Like New Condition - Requires No Repair	Required formal documented training program. SOP, abnormal operating procedures (AOPs), ERPs exercised regularly. Validating relevancy.	O&M feels safe operating. No hazard.
5%	No identification of failure	Non-Functional - Requires Full Replacement	No training	O&M do not feel safe conducting work. No safety equipment/protocols. Hazardous Environment. PPE Required.

4.1.5 BRVA Key Observations

4.1.5.1 CoF/Criticality

Understanding the business impact of failures is essential in prioritizing how and where to act when emergencies or unexpected events occur. For example, is this piece of equipment or infrastructure *critical* to bring my process back online? CoF/Criticality is not a measurement of how well the piece of equipment or infrastructure is working, but instead evaluates the repercussions that would result from a potential failure and how that loss of function will impact the ability of the City to meets their mission, vision, and goals. These consequences are broken down below with observations made during the BRVA workshops:

4.1.5.1.1 Public & Staff Health and Safety:

Public and Staff Health and Safety measures the relative impact a failure of an asset will have on the risk of accidents and injuries, and the ability to create and maintain a safe working environment protecting the safety of life, property, and the environment. The health and safety of City staff, its residents, and its businesses is crucial to its overall success and is held paramount to other risk attributes. The most notable assets that presented concerns around the health and safety of staff and/or the public revealed during the BRVA include the whole electrical system and the anaerobic digesters. These assets and few others noted by City staff are described below:

- **Electrical System:** The electrical system has no known arc flash ratings and no signage indicating the last arc flash testing event, throughout the WWTP and collection system and select panels should be further evaluated if they fall under Class 1 Division 1 room classifications.

- **Anaerobic Digesters:** The anaerobic digesters present an inherent risk due to the nature of gas build up within them. If the dome were to rupture in any way, personnel working either on or around the digesters could be inundated and exposed to hazardous sludge and gases. Staff also discussed concerns around the explosion potential and boiler system being in poor condition, which could result in hydrogen sulfide gas not going through a proper safety system.

- **RAS System:** While not as likely, if the return activated sludge (RAS) system were to flood the basement, there could be improved measures installed to ensure staff safety from both the electrical and slip/trips/falls and potential inundation that could take place.

- **Odor Control Facilities:** There also should be secondary, redundant, or more frequently monitored ventilation in place around the odor control facilities at the WWTP and satellite facilities.

- **Primary Effluent System:** Pump removal for the Primary Effluent system is also extremely difficult and is a potential threat to staff safety since they do not have the ability to utilize a boom truck and use a forklift. Alternative methods for removal should

be evaluated to create a safer working environment for staff to preform maintenance on these pumps.

4.1.5.1.2 Environmental & Regulatory Impact:

The environmental and regulatory impact measures the relative effect a failure will have on the environment, as well as the potential legal implications based on existing environmental regulations and permit requirements that the City needs to comply with. The largest concerns to environmental impact are the electrical system doing down, since it was more than likely create an ongoing permit violation, a failure along any part of the Crosstown Pipeline or Central Bremerton Force Main could cause up to a 7-day beach closure, flooding in the streets, and impact to the Narrows. Similarly, a failure of the Port Washington Narrows siphon mains could discharge sewage into that body of water for a few days without notice.

4.1.5.1.3 Quality of Service & Continuity:

Quality of service and continuity measures the relative impact a failure will have on the ability to maintain service levels after a disruptive event or disaster. Service continuity is important for ensuring that essential functions continue to operate. From the risk assessment, the major assets identified as high consequence for this delivery were the Crosstown Pipeline and Central Bremerton Force Main, since these could impact the Navy shipyard operations by needing to temporarily redirect or bypass the Navy's sewer discharge to the City's system. Additionally, any bypass operation associated with the repair of the Crosstown Pipeline or CBFM, both of which pass through densely populated areas of Bremerton, could significantly impact the general public, vehicular traffic and Bremerton businesses due to the scale of bypass pumping operation.

4.1.5.1.4 Public Perception

Public Image is a measure of the relative impact a failure will have on the collective opinion, attitude, and understanding that the residents of the City hold about their local government, its wastewater services, policies, and overall performance. How the public views and trusts the City's system is vital to ensuring continued growth and investment into needed and desired projects. The City rated the Crosstown Pipeline and Central Bremerton Force Main and the Port Washington Narrows Siphon the most highly critical and publicized failures. The WWTP odor control at the headworks scrubber was also ranked highly, due to the WWTP's close proximity to a major highway, local businesses, and residential districts.

4.1.5.1.5 Financial Impact/Fiscal Sustainability

The financial impact/fiscal sustainability measures the relative effect a failure will have on available City funds and available financial resources necessary to support restoration efforts, including potential construction costs, bypassing, equipment/rentals, ongoing operational expenses (maintenance, utilities, staffing), and any permit violation fees.

In the event of a failure, the following systems were deemed of highest consequence, potentially exceeding $350,000 in rehabilitation:

- Crosstown Own Pipeline and Central Bremerton Force Main
- Port Narrows/Port Washington Narrows Siphon
- Electrical system
- Anaerobic digesters
- Oyster Bay Basin (OB-1, OB-2, OB-3)
- Primary clarifiers
- Primary sludge systems

The following systems fall within the potential $100,000 to $350,000 range for repairs:

- WWTP screening
- Aeration basins
- RAS/WAS systems
- Primary effluent
- Dewatering
- Lagoons

Major pieces of infrastructure like these will not only increase the cost of long-term repair but also the cost of emergency response services for potential bypassing and cleanup during the failure. It is vital to keep these under preventative maintenance inspection to avoid premature failure.

4.1.5.2 Business Vulnerability

The BV is measured by how well an agency's business practices affect their staff's ability to optimize the long-term operation and maintenance of all their assets. When discussing Business Vulnerability, it is important to understand how an organization functions; how well different departments communicate, where resources are sourced and allocated, and how performance metrics are determined and tracked for both. When assessing an O&M program, identifying the constraints placed on the O&M staff is a top priority. O&M constraints, which is often staff/resource limitations, can negatively impact how a facility is operated, maintained, and managed. City management must strive to achieve a delicate balance between risk, costs, and performance/compliance. Anything that constrains system functionality can significantly impact this delicate balance and should be addressed to prevent forcing O&M staff into a reactive state of operating and maintaining the facility. These constraints are largely exacerbated when there are not adequate business processes/practices in place, which are necessary to sustain system performance. Inadequate business processes/practices could leave the City vulnerable to increased exposure to business risk(s), threat likelihood(s) and/or system functional failure(s). Such business practices are listed below with observations made during the BRVA workshops:

4.1.5.2.1 Work Execution Management

The BRVA provided insight into how work is executed at City facilities. WEM is the lifecycle of a work order which includes the identification of an issue, confirmation, documentation, resource planning, work execution, functional review, and close out. It was discussed that O&M staff feel comfortable with the level of staff they have available to address major concerns, but with the personnel resources they have available and work order backlogs, their ability to ensure all

operational routine duties (ORDs) such as regular cleanings or equipment lubrications is limited. Most of the equipment at the WWTP and throughout the collection system is tied to SCADA and identification of failures is sufficiently relayed to staff, however hidden failures identified in the Crosstown Pipeline and all City Siphons could have major negative impacts on the ability to service the City. The thickening system and aerated grit system were identified as hidden failures that could take up to a week before staff may be made aware of a failure. The major concerns noted for WEM relate to long lead times for equipment and the inability to close out work orders. Providing more spare parts, resource pooling from nearby agencies, or staff increases may help alleviate this constraint.

4.1.5.2.2 Asset Condition

The asset condition is measure of an asset's health and physical state at a given time. It is a key factor in determining how long an asset will remain useful and can help predict when it will need to be repaired, renewed, or replaced. There was known rehabilitation needed for the anaerobic digesters, and the outfall was recently inspected with a diver who denoted visible separation. Most equipment within the WWTP was deemed in fair condition to good condition. The collection system is in worse condition since pump station piping, valves and equipment is constantly exposed to saltwater and there is a significant amount of aging gravity sewer piping, some installed as far back as the 1940s. Many wet wells have deteriorating concrete walls and liners. City staff will oftentimes perform ultrasonic pipe thickness testing of piping at the pump stations to ensure adequate wall thickness, since these pipes are continuously exposed to corrosive salt water. Notable observations from field inspections will be discussed in Sections 6 and 7.

4.1.5.2.3 Workforce Reliability & Training:

Workforce Reliability and Training is key to every asset management program because it connects the physical asset to the human asset. If one wants an asset to perform its expected function, then that asset must be operated and maintained correctly. This is only achieved by ensuring that comprehensive competency-based training is offered by the City. Workforce reliability and training is a measure of the variety of activities that help employees and businesses develop and improve skills, and meet employment needs. For example, this includes day-to-day skills training, mandatory trainings, documented training and materials, labor forecasting, knowledge transfer. Major concerns noted from the BRVA include training or knowledge of how to address issues that occur in the siphons. There is also limited personnel who have the knowledge to operate and troubleshoot the digesters. Staff also lacked confidence in their ability to address failures in the WWTP final effluent channel/outfall; stating they have the skillset to fix equipment, but not training on how to approach it, given its limited accessibility. There is only one certificated technician and two instrument technicians to maintain the electrical and controls system, and there is limited institutional knowledge on motor control center (MCC) and electrical layout and connections within the plant. Overall, most training is based on institutional knowledge transfer and there is limited to no formal training or emergency preparedness training plans for both the WWTP and the collection system.

4.1.5.2.4 Workforce Safety Features and Culture

The Workforce safety features and culture are a gauge for the appropriateness and effectiveness of the safety policies that are in place, including but not limited to, signage, labels, guarding, clearances, Safety Data Sheets, The City maintains strong safety policies and encourages staff to be accountable while performing work. The BRVA identified that while safety practices are in place, and that staff feel adequately safe while working, there are opportunities for greater implementation of physical safety controls (including but not limited to signage, striping, and guarding). Specifically, signage and striping around electrical hazards and appropriate clearances should be implemented. The BRVA also identified that working on much of the collection system and the WWTP outfall would require significant traffic control and hiring 3rd party services. The most impactful and urgent safety concern noted was about the need for arc flash testing throughout the WWTP and collection system.

4.1.5.2.5 Process Resiliency

Process Resiliency is a measure of the consistent ability of a defined process to produce the desired outcome with minimal errors. This is outlined in the detailed steps and guidelines within the standard operating procedure (SOP), essentially signifying how dependable and predictable the process is when followed accurately. The O&M staff stated they do not have a complete list of documented procedures for various major assets SOPs, limited abnormal operating plans (AOPs), and little to no emergency response plans (ERPs) documented. There should also be more standard procedures for routine and planned inspections for major assets at the WWTP, such as the Digesters, final effluent channel/outfall, thickening tanks, and chlorine contact basins. There are also asset reliability issues including lacking a robust spare parts program and instances where equipment that should be run in a lead-lag setting is not operated as such. This operational strategy impacts the reliability of equipment and may affect the rate of component level wear and tear. If certain assets are operated with equal run times, the anticipated timing for repairs or replacement may coincide, potentially leaving the City exposed to limited or no redundancy if a failure were to occur.

4.1.6 Engineering for Maintenance Reliability and Asset Performance

Maintenance reliability uses engineering practices to improve the reliability and performance of physical assets by documenting system functions at the unit process level, leveraging a formal risk methodology, and using root cause analysis processes for key engineering tools. These can support O&M, leverage reliability principles during the development of capital improvement strategies and design projects and formalize a management of change process. During staff interviews it was noted that O&M would like more tools available to them such as CCTV footage of underground pipes, specifically highly critical areas like the Crosstown Pipeline, WWTP channels, and siphons, and the ability to track this overtime. Additionally, a consistently updated hydraulic model of the system would allow City staff to determine what areas of the system might have capacity concerns as flows increase over time. For the siphons, and in particular the Port Washington Narrows Siphon, there was cathodic protection installed along the rock wall next to CE-1, but it has not been used in almost a decade: cathodic protection is vital in identifying and adequately preventing corrosion. For assets that have limited ability to be inspected, such as the siphons, utilizing the technology the City already has installed, should be

of a high priority. There is a need for a unifying framework for strategic asset management programming that allows the integration of capital improvement planning, longer term design planning, and annual budget planning activities across the various facilities and systems. A goal of this WWCP is to provide a strategic approach and framework to bridge organizational policies and business activities (e.g., Capital Improvement Projects [CIP] and Maintenance Projects [MP]) for sustaining the City's service level obligations.

4.1.6.1 BRVA Findings

The intent of the BRVA is to identify the most vulnerable unit processes that might impact the performance of the City's facilities and systems; systems that might put the City at risk regarding safety, public regulation, service, image, and economic categories. After the BRVA was completed, risk ranking for each unit process was calculated by taking the weighted arithmetic mean of the criticality scores and multiplying it by the arithmetic mean of the vulnerability scores. Figure 4-3 illustrates the preliminary risk scores for City assets.

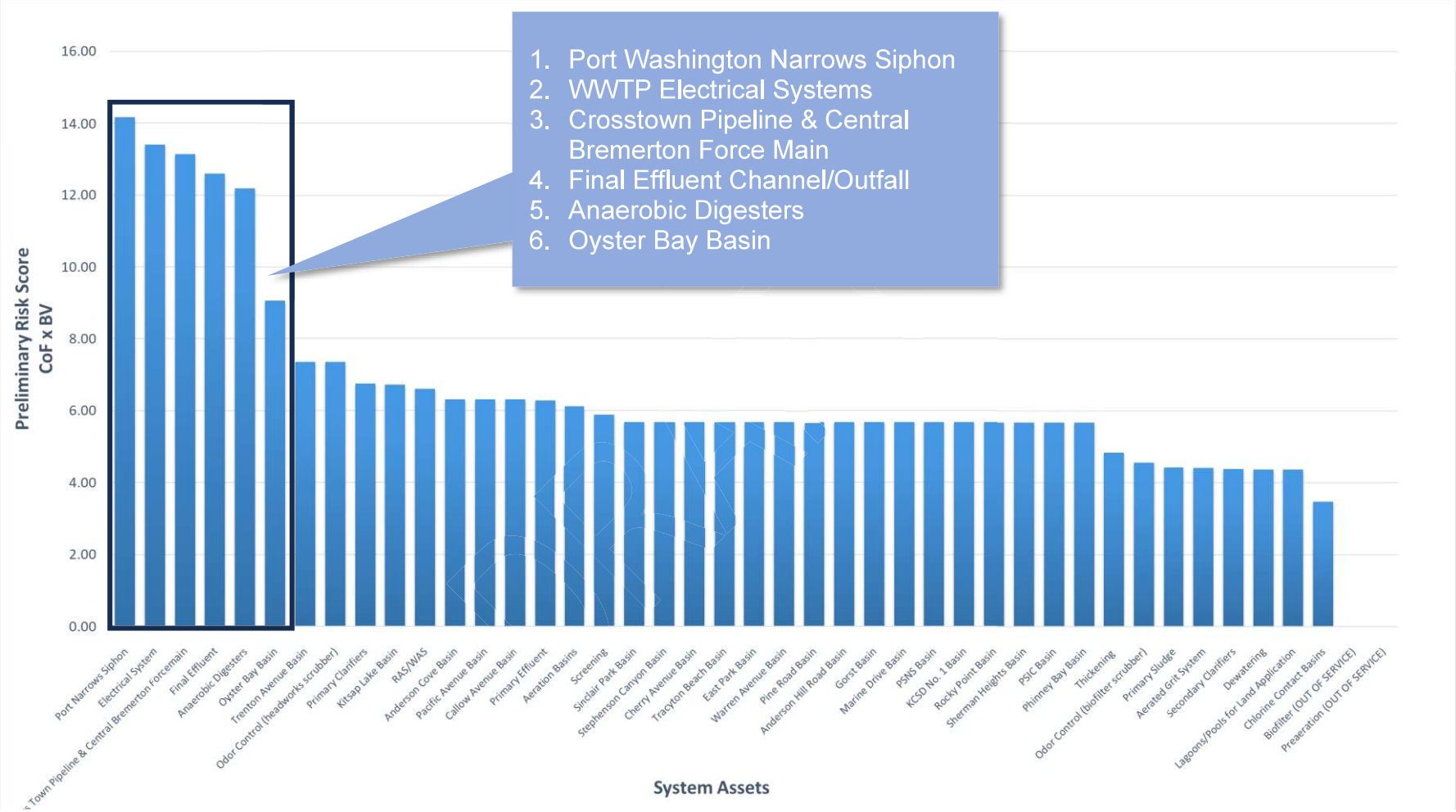

Figure 4-3: Preliminary Risk Score

Based on the feedback from City staff, the assets considered highly critical and in need of attention are listed below, with scores ranging from 14.2 to 9.1.

- Port Washington Narrows Siphon
- Electrical system
- Crosstown Pipeline
- Central Bremerton Force Main
- Final Effluent Channel/Outfall
- Anaerobic Digesters
- Oyster Bay Basin Collections System

Figure 4-4 illustrates the risk score results on a scatter plot for the 43 assets evaluated. Assets shown in the upper right red area indicate higher risks from a criticality and vulnerability perspective than those shown in the yellow or green areas. This data visually shows that 13 of the 43 assets are listed as either needing improvements or of high concern to the City, 21 are in fair condition or moderate concern to the City, and 7 are considered to be in good condition or little concern to the City, not including two which were denoted as “Out of Service” and they were not scored.

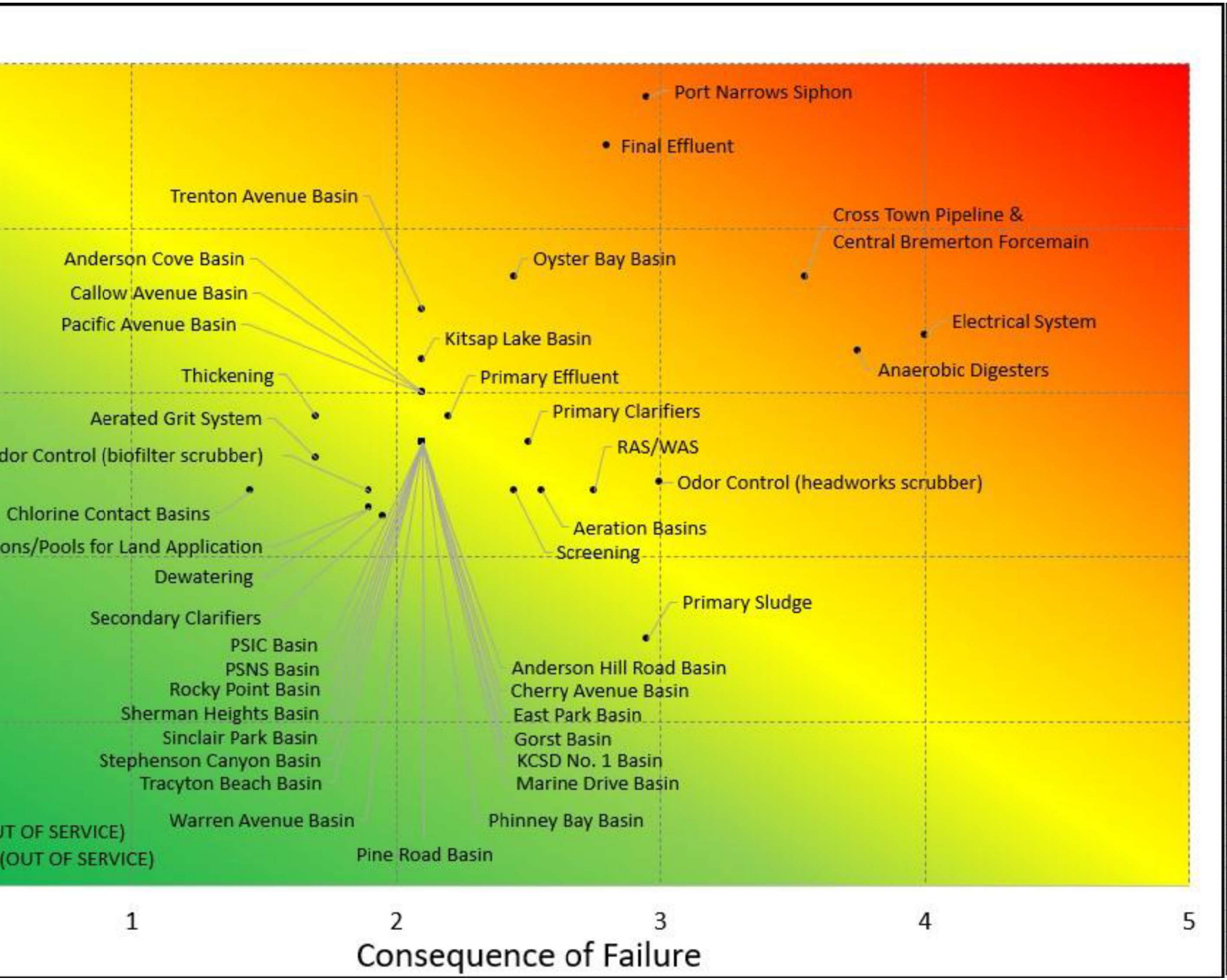

Figure 4-4: Preliminary Risk Score – BRVA Heat Map

4.1.7 Risk Score Validation & Calibration

Following the BRVA, both desktop and field evaluations were completed and further discussed in Sections 6 and 7. The field investigations confirmed many of the findings from the BRVA interviews however some asset scores were recalibrated to reflect existing conditions more accurately. Adjustments to the preliminary risk score are made where appropriate after these evaluations to achieve the final risk profile. Typically, these adjustments are done for Asset Condition and Workforce Safety Features and Culture, however some extenuating circumstances can lead to modifications to other scoring metrics as needed.

4.1.8 Likelihood of Failure

The estimated likelihood of failure is directly related to the condition evaluation. These estimates are a useful indicator of expected functional performance that may initiate root cause analyses, a tool to assist with proactive maintenance strategies, and in some cases life expectancies of fixed asset classes. The estimated probability of failure provides a convenient way to view the information from an alternative perspective. Although the probability of failure is a variable that is typically included with a risk analysis, we did not apply this variable to develop the initial risk score during the BRVA because we focused our analyses at a system level and not at the asset or component level. Probability of failure was implemented after the condition assessments, WWTP analysis, and collection system hydraulic modeling.