PACIFIC GAS AND ELECTRIC COMPANY

ATTACHMENT A

ADDITIONAL INFORMATION

QUESTION 1

RISK ASSESEMENT

A. Applicable to All Utilities

1. Risk Assessment Methods (New Request)

Pacific Gas and Electric Company, Southern California Gas Company, San Diego Gas and Electric Company, and Southwest Gas Company shall each provide a description of their distribution pipeline risk and consequence assessment methods, including all input variable definitions, data sources for inputs, equations or descriptions of equations sufficient to recreate them, and output variable definitions. A description of the defining characteristics of distribution pipelines subject to this analysis and of the distribution pipelines not subject to this analysis shall also be provided. Documents provided in other proceedings or data requests may be resubmitted to fulfill this requirement if they include the required information. If the complete document(s) constitute more than 10 pages, the utility shall also provide a one-page summary.

Response:

PG&E's Distribution Integrity Management Program (DIMP) provides a way to evaluate threats to the gas distribution system by risk ranking to prioritize mitigation activities. This information is used to develop appropriate mitigation plans to remediate or improve Company assets that may pose a threat to public safety or the efficient delivery of safe and reliable gas service. Integrity management at PG&E focuses on:

- Transporting natural gas in a safe, reliable, and efficient manner from transmission pressure facilities to distribution main facilities.
- Transporting natural gas in a safe, reliable, and efficient manner from distribution main facilities to distribution service lines, and ultimately customer connected equipment.
- Protecting the public, including customers, the general public, and their assets and property. Integrity management provides the tools and processes for risk ranking and prioritization, ensuring that PG&E focuses on identifying threats to its system and remediates them appropriately.

PG&E's Utility procedure TD-4850P-01, "Gas Distribution Integrity Management Program" describes PG&E's overarching framework to meet the requirements of Code of Federal Regulations (CFR) Title 46, Transportation, Part 192, Subpart P – Gas Distribution Pipeline Integrity Management (IM) (see Q.A.1 Appendix 01). Section 2.1 of this procedure states: "DIMP applies to all gas distribution facilities operated by the Company, including any feature of the distribution line system as defined in Utility Standard TD-4125S, "Maximum Allowable Operating Pressure Requirements."

The risk scoring methodology (data inputs, factors, weightings, and equations) for gas distribution assets are described Attachment N and its appendices (provided Q.A.1 Appendix 01), which are supplemental guidance documents to TD-4850P-01.

- Attachment N: Risk Algorithm, which provides an overview of the risk model.

- Attachment N, Appendix A, which describes the Likelihood of Failure (LoF) and Consequence of Failure (CoF) factor values.
- Attachment N, Appendix B, which describes the derivation of the LoF factor values.
- Attachment N, Appendix C, which describes the derivation of the CoF factor values.

Gas Distribution Integrity Management Program

SUMMARY

This utility procedure provides methods and implementation processes to ensure the safety of the gas distribution systems owned and operated by Pacific Gas and Electric Company (PG&E or Company) throughout the Company's service area and to meet the requirements of Code of Federal Regulations (CFR) Title 49, Transportation, Part 192—Transportation of Natural and Other Gas by Pipeline: Minimum Federal Safety Standards, Subpart P—Gas Distribution Pipeline Integrity Management (IM). This utility procedure also provides the overarching framework for the Company's distribution integrity management program (DIMP).

Level of Use: Informational Use

TARGET AUDIENCE

DIMP personnel

SAFETY

Performing this utility procedure will not raise the risk of a specific hazard to personnel, public, or equipment.

BEFORE YOU START

Review roles and requirements in Utility Standard TD-4850S, "Distribution Integrity Management Program Requirements and Responsibilities."

TABLE OF CONTENTS

PROCEDURE STEPS

1 Introduction

1.1 Distribution Integrity Management (IM) at PG&E

1. This utility procedure is the controlling document for the integrity management of PG&E's gas distribution system. Where there are discrepancies between this utility procedure and other supporting documents, this utility procedure will take precedence.

2. DIMP provides a way to evaluate threats to the gas distribution system by risk ranking to prioritize mitigation activities. This information is used to develop appropriate mitigation plans to remediate or improve Company assets that may pose a threat to public safety or the efficient delivery of safe and reliable gas service. Integrity management at PG&E focuses on:

    - Transporting natural gas in a safe, reliable, and efficient manner from transmission pressure facilities to distribution main facilities.

    - Transporting natural gas in a safe, reliable, and efficient manner from distribution main facilities to distribution service lines, and ultimately customer connected equipment.

    - Protecting the public, including customers, the general public, and their assets and property. Integrity management provides the tools and processes for risk ranking and prioritization, ensuring that PG&E focuses on identifying threats to its system and remediates them appropriately.

1.2 DIMP Cycle

1. PG&E strives to continuously improve the safety of its distribution system. As such, this utility procedure will be updated as part of PG&E's DIMP cycle to include additional process improvements, risk identification efforts, and mitigation actions, as indicated in Figure 1.

    a. The DIMP cycle includes one complete workflow iteration, not to exceed 5 calendar years from the previous cycle's end date.

Gas Distribution Integrity Management Program

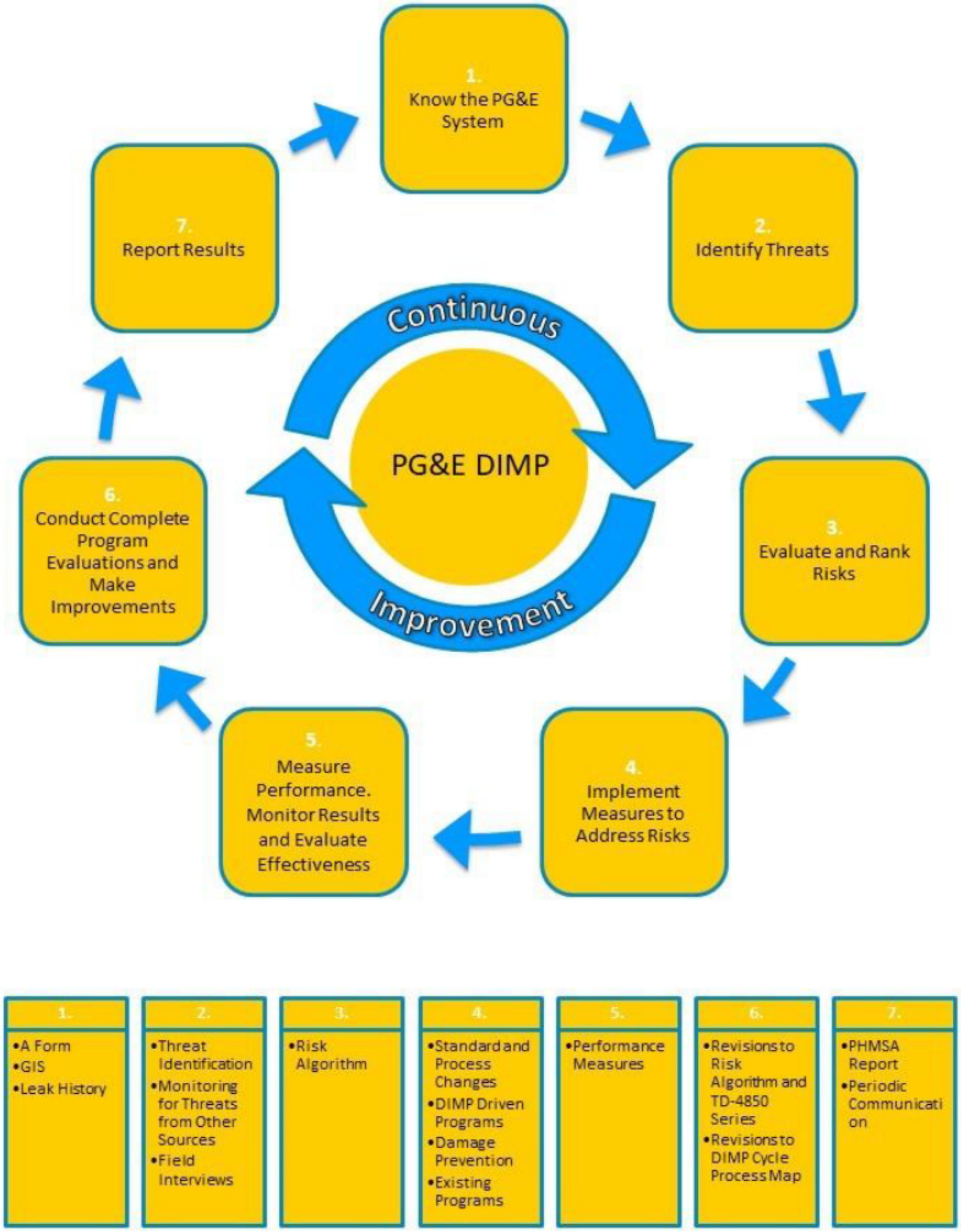


Figure 1. PG&E DIMP Cycle

1.2 (continued)

2. At the beginning of each DIMP cycle, a corrective action program notification (CAPN) is created to track progress and ensure records are retained for 10 years. The timeframe for the DIMP cycle should be stated within the CAP notification.

3. A CAP task is created for each element of the DIMP cycle. A description of each CAP task and the required deliverables must be included in the long text. To close a CAP task, the supporting documentation must be attached to the CAP task or described in the CAP task long text. Alternatively, if the files are too large, a path to where the data is stored is documented.

4. Before a CAP task is closed, a reviewer must evaluate if the work associated with the CAP task is complete by answering the following questions within the CAP task long text:

   - Has the work been completed?
   - Is all required documentation attached to the CAP task?
   - Are the steering committee (SC) meeting minutes, if required, attached to the CAP task?
   - Is the screenshot of the approved EDRS, if required, attached to the CAP task?

1.3 Supporting Documents

1. Attachments in the *DIMP Manual*.

   a. The *DIMP Manual* contains attachments related to this utility procedure. These attachments are supplementary documents that are intended to be living documents updated as required.

   b. The following attachments are included in the *DIMP Manual* and can be accessed through the DIMP SharePoint:

      - Attachment A, “Mitigation Activities”
      - Attachment B, “DIMP Cycle Process Map”
      - Attachment C, “DIMP Data Matrix”
      - Attachment E, “DIMP Steering Committee Charter”
      - Attachment F, “DIMP Documentation and Archives”
      - Attachment G, “Monitoring for New Threats”

1.3 (continued)

- Attachment H, "Threat Identification and Risk Evaluation"
- Attachment J, "Leak Repair Scrub Process"
- Attachment K, "Mitigation Analysis Process"
- Attachment L, "DIMP Field Review Process"
- Attachment M, "Performance Measure Reporting"
- Attachment N, "Risk Algorithm"

2. Related guidance documents

   a. Related guidance documents are PG&E documents that directly relate to or support DIMP. They are approved in accordance with the requirements for guidance documents.

1.4 Inclusion of the DIMP Cycle Results into Annual Asset Management Asset Family CAP

1. New threat information must be considered during the annual Asset Family Review process for potential input to the Loss of Containment Risk for distribution mains and services as well as customer connected equipment. Additionally, new threat information is considered during the annual Asset Family Review process for potential inclusion in the Asset Management Risk Register.

2 Covered Facilities

2.1 DIMP applies to all gas distribution facilities operated by the Company, including any feature of the distribution line system as defined in Utility Standard TD-4125S, "Maximum Allowable Operating Pressure Requirements."

3 Roles and Responsibilities

3.1 See Utility Standard TD-4850S for roles and responsibilities.

3.2 The DIMP organizational structure can be found by using PG&E's electronic organization chart, "Who's Who."

4 Knowledge of the System

4.1 Scope

1. This step describes how DIMP identifies, gathers, and analyzes system information that is used to identify threats to the system and to select appropriate mitigation actions.

4.2 Introduction

1. System knowledge is the core foundation of DIMP. This knowledge is used in identifying threats, analyzing risk, and implementing measures to address risk. This knowledge is based on an understanding of the system attributes, including materials, construction methods, operating and maintenance conditions, leaks, and other relevant environmental and operating factors.

4.3 Data Source Identification

1. DIMP mitigation and risk personnel review the data sources listed in Step 4.4 for inclusion in DIMP processes. Consideration is given to information gained from the data of past design, operations, and maintenance, as well as knowledge from the DIMP SC and subject matter experts (SMEs).

2. DIMP personnel review each data source by assessing the following information:

- Type of data (e.g., pipe diameter, material, pressure, location, environment)
- Format of data (paper or electronic)
- Use and relevance to risk model
- Frequency of update
- Completeness of data
- Quality of data

4.4 Data Sources

1. *DIMP Manual*, Attachment C, documents data sources available for use in threat identification, risk assessment, mitigation analysis (MA), programs and activities to address risk, and performance measurement.

2. Pipeline leak data is documented in SAP through the leak repair and inspection form (A-Form).

   a. The criteria used to scrub the data for use in risk assessments is documented in *DIMP Manual*, Attachment J. If the primary sources for required fields do not contain the data, secondary sources are identified to fill the missing data.

3. DIMP coordinates the collection of additional information to be used during MA. If additional information is needed, a plan is established to collect the required information.

4. The following methods are used to collect information from past design, operations, and maintenance practices:

4.4 (continued)

a. DIMP Field Review

(1) The DIMP field review consists of a series of comprehensive meetings during which threat categories are discussed with division personnel.

(2) A more detailed description of the DIMP field review process is included in *DIMP Manual*, Attachment L.

b. As-Built Plans

(1) DIMP reviews job files, as-builts, and gas service records (GSRs) to collect information on gas mains and service lines as appropriate to support mitigation analyses and activities.

c. Gas Distribution Geographic Information System (GD GIS)

(1) PG&E uses GD GIS to understand the characteristics and locations of its gas distribution facilities. GD GIS is continuously updated to reflect changes or corrections to the gas distribution facility data.

4.5 Pipeline Construction Data

1. As part of PG&E's DIMP program, DIMP uses information pertaining to all new and existing pipeline construction, including location, installation year, material type, diameter, footage, and job number. Company guidance documents describe the current procedures for design, construction, recording, and retention of newly installed, replaced, and repaired pipeline and pipeline facilities.

4.6 Missing Information

1. DIMP defines missing information as GD GIS main and service asset attributes that are needed for the risk assessment process (see Attachment H, Appendix B) but are recorded as unknown or missing in GD GIS (e.g., null values or a 01/01/1800 installation date).

a. Data from the Leak Repair, Inspection and Gas Quarterly Incident Report (A-Form) (Form TD-5100P-01-F01), which must be completed for leak repairs, or the Pipe Inspection Form (Form TD-5100-P-01-F03), which must be completed when a section of buried pipeline is exposed for non-leak reasons, may be used in the risk model in place of missing main or service attributes.

b. Where necessary, assumed values may be used in the risk model in place of missing main or service attributes. See Attachment N and its appendices for specific assumptions.

5 Threat Identification Process

5.1 Scope

1. This step outlines the process that DIMP uses to identify threats to the integrity of the gas distribution system.

5.2 Methodology

1. The threat identification process uses leak repair data, which is annually reviewed and scrubbed according to *DIMP Manual*, Attachment J. Data scrubbing is critical in producing consistent and actionable data. Leaks are reviewed and mapped to a sub-threat category, and the results are reviewed for quality and importance. The identified threats are approved by the DIMP SC.

2. Other threats are identified per *DIMP Manual*, Attachment G. Data sources reviewed include internal and external data sources to generate a list of items needing further evaluation for inclusion in the risk model. Near miss data (sometimes referred to as near hit data) is included in this review. The results of the evaluations are brought to the DIMP SC to ensure proper resolution of these items.

   a. Reference to near-miss data is a result of the 2017 CPUC audit findings of the DIMP Program, Task 4 (CAP 112780109).

3. DIMP personnel categorize threats into eight general categories to align with the requirements outlined in 49 CFR §192, Subpart P. All eight threat categories listed below are considered system-wide threats:

   - Corrosion
   - Natural forces
   - Excavation damage
   - Other outside force damage
   - Material, weld, or joint failure
   - Equipment failure
   - Incorrect operations
   - Other

4. PG&E defines sub-threats on facilities as a subcategory of one of the eight code-defined threats. These sub-threats are identified per *DIMP Manual*, Attachment H, "Threat Identification and Risk Evaluation," and are used by DIMP mitigation personnel for MA and to determine appropriate mitigation actions.

5.2 (continued)

5. DIMP defines interactive threats as two or more threats acting on a pipeline section that result in a higher likelihood of failure than the sum of the independent likelihoods of failure. Co-located or coexisting threats on a pipeline section do not necessarily result in an interaction (see *DIMP Manual*, Attachment N, “Appendix A”).

6 Risk Evaluation and Ranking of Threats

6.1 Scope

1. This step describes how DIMP personnel evaluate and rank risk. Threats to the distribution system are evaluated as part of the risk assessment process for PG&E’s distribution facilities.

6.2 Methodology

1. Through the risk evaluation and ranking process, DIMP personnel determine the relative importance of each threat and establishes a ranking of the risks posed to its distribution facilities, which are validated by the DIMP SC. The risk approach uses a risk algorithm to assign a risk score to each asset, which is further described in *DIMP Manual*, Attachment N, “Risk Algorithm,” and *DIMP Manual*, Attachment H, “Threat Identification and Risk Evaluation.”

6.3 Risk Model Review

1. Before initiating risk calculations and rankings, DIMP risk assessment personnel review the risk model with the DIMP SC. During this review, the team considers all lessons learned in the previous cycle with regard to the risk model. The team revises the risk model accordingly for the subsequent risk evaluation.

6.4 Determining Recommendations for MA

1. To determine recommendations for MA, per 49 CFR §192.1007(c), “Evaluate and rank risk.” DIMP risk assessment personnel subdivide the system into regions with similar characteristics (e.g., contiguous areas within a distribution pipeline consisting of mains, services, and other appurtenances; and areas with common materials or environmental factors), and for which similar actions likely would be effective in reducing risk.

2. DIMP risk assessment personnel review the risk results to determine the method to identify recommendations for MA.

6.5 Risk Assessment Results and Approval

1. The DIMP SC and DIMP Director review and approve the risk factors used in the calculation and the risk-ranking results. This validation also includes a comparison to previous cycles. Based on any changes from this review, the risk algorithm may be adjusted by DIMP risk assessment personnel. Once approved by the DIMP SC and DIMP Director, the risk evaluation results and MA recommendations are documented in a report for DIMP mitigation personnel.

7 Identify and Implement Measures to Address Risk

7.1 Scope

1. This step describes DIMP programs and activities to mitigate risk, including an effective leak management program, the MA process, and the process to update or create programs and activities.

7.2 Introduction

1. Risk can be managed or eliminated by reducing the number of leaks or by mitigating the consequence. DIMP risk assessment and mitigation personnel implement actions and develop risk management programs designed to reduce risks associated with identified threats to its gas distribution system.

7.3 Methodology

1. The areas recommended for MA are reviewed by DIMP mitigation personnel. DIMP mitigation personnel combine similar MA based on the type of risk identified.

2. During an MA, DIMP mitigation personnel may work with SMEs, field personnel, DIMP risk assessment personnel, or asset and program owners. The steps of an MA include data gathering, data analysis, geospatial analysis, and the development of mitigation activities. Each completed MA and its associated mitigation activities are approved by the DIMP SC, and the analysis must be approved by the positions noted in Utility Standard TD-4850S.

7.4 Current Programs

1. The following are descriptions of programs developed by PG&E before the formal DIMP rule implementation in 2011. These programs were developed as a result of other leak management and damage prevention requirements and needs identified internally by PG&E. These programs are reviewed during the MA process to determine if they can be used to implement mitigation activities without new program creation.

   a. Leak Management Program

      (1) One of PG&E’s key integrity management processes is its Leak Survey Program, as documented in Utility Standard TD-4110S, “Gas Leak Survey and Detection Program,” and its supplemental procedural documents. The objective of the program is to search for, detect, and evaluate gas leak indications to ensure the safety of the public and Company personnel, to assess the condition of the gas system, to comply with regulatory requirements, and to ensure that leak surveys are conducted at clearly mandated, regular intervals throughout the distribution systems.

7.4 (continued)

(2) The leak management team monitors metrics of leak management program.

b. Damage Prevention Program

(1) PG&E's Damage Prevention Program addresses the risk to PG&E's system associated with excavation damage. The key components of the program include:

- Public awareness: Educate excavators and the general public about pipeline safety and safe digging procedures.

- Locate and mark: Ensure PG&E facilities are accurately located prior to excavation damage.

- Damage investigation: Conduct thorough investigations of dig-ins to understand cause of damage.

(2) The damage prevention team monitors metrics and identifies and addresses trends.

c. Other programs

(1) PG&E has implemented other programs to address risks on its gas distribution system outside of the DIMP cycle. Mitigation activities can use the following existing programs to address risk identified through MA:

- Plastic Replacement Program: Replacement of high-risk pre-1985 plastic.

- Gas Pipeline Replacement Program (GPRP): Replacement of high-risk cast iron and pre-1941 steel.

- Copper Services Replacement Program (CSRP): Replacement of all copper service lines.

- District Regulator and Farm Taps Reliability Programs: Replacement of targeted large and small district regulator stations and farm taps.

- Cross Bore Program: Inspection of sewer mains and laterals for unintentional boring of gas facilities through sewers.

7.5 DIMP Mitigation Activities

1. Mitigation activities are developed as a result of analysis performed as part of DIMP. See *DIMP Manual*, Attachment A, for a complete list of these DIMP-driven programs and activities that address risk.

7.6 DIMP Engineering

1. Some mitigation activities are identified and managed by DIMP engineering personnel. While under the overall umbrella of DIMP, these mitigation measures are managed separately due to the following considerations:

   - Minimal activity and resources required
   - Risk reduction not realized in the near term
   - Efforts incorporated into existing projects

2. DIMP mitigation personnel are kept apprised of these activities through SME input and ongoing interaction between the teams. As these mitigation activities develop, they may be formally incorporated into DIMP for documentation and effectiveness tracking.

7.7 Mitigation Analysis

1. The list of areas for MA is reviewed by DIMP mitigation personnel. Each area is analyzed per *DIMP Manual*, Attachment K. MA documentation and mitigation activities are documented with a unique number to enable tracking. Areas with similar findings are combined into a single MA tracking number.

7.8 Determine mitigation activities

1. DIMP mitigation personnel consider all current and applicable mitigation activities and will first leverage those before developing new mitigation activities. During this review, DIMP mitigation personnel will identify new mitigation activities or changes to the program that would increase its effectiveness in reducing risk.

2. If, during their review, DIMP mitigation personnel are unable to identify current programs or activities designed to mitigate specific threats, the team will work to develop a new program or activity to mitigate risk.

3. The DIMP SC and DIMP Director will review and approve the MA and the associated mitigation activities.

8 Measure Performance and Monitor Results

8.1 Scope

1. PG&E has identified a number of performance metrics that will be measured, monitored, and used in the determination of mitigation effectiveness from an established baseline per 49 CFR §192.1007(e), "Measure performance, monitor results, and evaluate effectiveness."

8.2 Reporting Baseline

1. DIMP risk assessment personnel reviewed statistics and historical information on leak survey frequency and chose 2010 as the baseline year. In reviewing historical leak data, DIMP risk assessment personnel discovered that PG&E experienced a much higher than normal number of leaks in 2009.

2. This increase in repaired leaks was related to the implementation of a new leak survey training program and an accelerated leak survey of PG&E's gas distribution system.

3. Since 2009 leak data did not represent a typical year in terms of leak survey or number of leaks and PG&E had improved its implementation of a consistent leak grading policy in 2009, PG&E selected leak data from 2010 for its baseline.

4. Baseline data for excavation damage and all internally-driven programs and activities that address risk were set at 2010 to be consistent with the code-required leak data baseline.

8.3 Reportable and Collected Performance Measures

1. DIMP personnel submit performance measures on an annual basis per *DIMP Manual*, Attachment M. The number of hazardous leaks repaired, categorized by material, is also collected annually, but is not required to be reported.

8.4 Mitigation Analysis Baseline

1. A mitigation baseline is established for each threat identified from the performance data used in the MA analysis, measuring the effectiveness of mitigation activities. The mitigation baseline is the event count of the aggregate incident data.

8.5 Mitigation Performance Measures and Effectiveness Evaluation

1. Mitigation activities may have performance measures identified and defined in *DIMP Manual*, Attachment A. Mitigation activities are split between those activities that require field remediation and those that are data gathering or procedural. After the mitigation performance results have been obtained, they are compared to the number of incidents in the mitigation activity baseline. Attachment A has a complete list of all programs and activities developed as a result of DIMP analyses. The DIMP SC and the DIMP director are responsible to review and approve the results of the effectiveness evaluation of the completed mitigation activities at the completion of each DIMP cycle.

9 Program Evaluation and Continuous Improvement

9.1 Scope

1. DIMP is evaluated for continuous improvement per the program evaluation requirements outlined in 49 CFR §192.1007(f), "Periodic Evaluation and Improvement."

9.2 Cyclical Program Review and Document Revisions

1. PG&E performs a review of the completed DIMP every cycle, not exceeding five years, per 49 CFR §192.1007(f) to determine if the processes, activities, and programs are achieving the overall objectives of the program, to identify the types of improvements to be made, and to implement process changes as necessary. This review can be completed more often to incorporate program improvements resulting from DIMP lessons learned. This utility procedure and the following resources are reviewed to evaluate the effectiveness of programs and mitigation activities in reducing leaks and risks:

   - Utility Standard TD-4850S
   - *DIMP Manual*
   - Mitigation activities performance measures
   - Code-required performance measures

2. At the creation of the DIMP cycle CAP issue, include and assign to the asset family principal the review and update of Attachment B, "DIMP Cycle Process Map."

3. Route updated Attachment B, if applicable, via EDRS to DIMP leadership team (ELT) and DIMP Director for review and approval.

9.3 Lessons Learned

1. PG&E documents and tracks the lessons learned from previous DIMP cycles to facilitate updating this utility procedure and other resources (see Step 9.2). A CAP task is created in the DIMP cycle notification to track each of the following lessons learned:

- Previous Cycle – Risk Review
- Previous Cycle – Mitigation Review
- Current Cycle – Risk Collection
- Current Cycle – Mitigation Collection

2. A separate CAP issue is created as an extended evaluation of the lessons learned.

3. The DIMP SC is responsible for reviewing any DIMP Cycle Lessons Learned CAP issues and incorporating findings into the next DIMP cycle.

9.4 Regulatory Audits (as scheduled)

1. Corrective actions from external audits are documented and tracked through completion via CAP and the Enterprise Compliance Tracking System (ECTS) regulatory compliance tracking process.

10 Management of Change (Change Control)

10.1 Scope

1. This step describes how the management of change (MOC) process, as documented in Utility Standard TD-4014S, "Change Control (Management of Change)," applies to DIMP, including documentation requirements.

10.2 Activities Requiring MOC

1. The MOC process applies to the following DIMP changes:

a. Changes to this utility procedure.

(1) Changes made to this utility procedure are documented in the Revision Notes and the guidance document analysis (GDA), promoting continuous improvement to these documents. The current and superseded versions are stored in the Technical Information Library (TIL).

b. Changes to the *DIMP Manual*

10.2 (continued)

(1) Changes made to attachments in the *DIMP Manual* are documented in the Change Log sections located at the end of each attachment. Attachments associated with this utility procedure are intended to be living documents and are updated as required. The current versions of the attachments are found in the *DIMP Manual*. Once a new revision is created, the superseded revision is moved into the superseded folder.

c. Effectiveness evaluations

(1) An effectiveness evaluation is performed when changes to the process or criteria may affect the output of the risk model or mitigation activity. The reason for an effectiveness evaluation must be documented in the Change Log sections located at the end of each attachment. If the evaluation takes time to complete, it must be documented and tracked in the CAP. The following activities and *DIMP Manual* attachments are subject to effectiveness evaluations:

- The addition or removal of any *DIMP Manual* attachments
- Attachment A, “Mitigation Activities”
- Attachment H, “Threat Identification and Risk Evaluation”
- Attachment J, “Leak Repair Scrub Process”
- Attachment K, “Mitigation Analysis Process”
- Attachment N, “Risk Algorithm”

11 Internal DIMP Communication Plan

11.1 Scope

1. This step describes PG&E’s internal DIMP communication plan, which is designed to keep Gas Operations personnel and appropriate PG&E leadership informed about DIMP.

   a. All communications are logged and tracked as a CAP task created within the DIMP cycle notification.

11.2 Methodology

1. Communications are conducted per Table 1 to ensure that the appropriate individuals and authorities have all current information about the PG&E distribution pipeline system and distribution integrity management efforts. Table 1 outlines the details of the communication plan for a DIMP cycle. Communication is completed at the end of the DIMP cycle and is tracked through CAP.

Table 1. DIMP Communications

Communicator	Audience	DIMP Message
DIMP Director	Gas Operations Leadership Team	Status report providing a summary of the DIMP cycle findings and top risks identified
DIMP Risk Assessment, DIMP Engineering, or DIMP Mitigation	Transmission Integrity Management Program (TIMP)	Report any findings that may affect PG&E transmission facilities

2. Communication documentation is stored on local shared drives. See *DIMP Manual*, Attachment F, for more details.

12 Reports to Government Agencies

12.1 Scope

1. This step outlines PG&E's process for submitting reports to the Pipeline and Hazardous Materials Safety Administration (PHMSA) and to the California Public Utilities Commission (CPUC), in compliance with 49 CFR §192 and CPUC General Order (GO) No. 112-F, "State of California Rules Governing Design, Construction, Testing, Operation, and Maintenance of Gas Gathering, Transmission, and Distribution Piping Systems." A CAP Task is to be set up within the DIMP cycle notification that documents DIMP cycle results communicated to the CPUC.

12.2 PHMSA Gas Distribution Annual Report Form F7100.1-1 (PHMSA F 7100.1.1)

1. On an annual basis, PG&E completes PHMSA F 7100.1-1 per Utility Procedure TD-4413P-03, "Annual and Quarterly Reporting Requirements for Gas Incidents, Events and Activities," and submits the form through PHMSA's online portal no later than March 15 of each year. In addition, PG&E provides a copy of Form PHMSA F 7100.1-1 to the CPUC with a report outlining the major mitigation programs and accomplishments of the program during the previous year. Refer to *DIMP Manual*, Attachment M, for details on collecting the information required.

12.3 DIMP Plan Updates

1. Changes to the DIMP plan (this utility procedure and associated Utility Standard TD-4850S) will be communicated to the CPUC by the regulatory compliance organization. The DIMP Director will notify regulatory compliance regarding the reporting requirement.

13 Record Retention

13.1 Scope

1. This step describes PG&E's policy and procedures for retaining records and supporting documentation associated with DIMP.

13.2 Identified Records and Retention Timeframe

1. All records and other documentation that demonstrate compliance with the requirements of 49 CFR §192, Subpart P must be kept for a minimum of 10 years. DIMP will retain copies of records as necessary to comply with this requirement. These records include, but are not limited to, the following sources:

   - This utility procedure
   - The *DIMP Manual* and its attachments (includes historical versions of RMP-15, "Risk Management Program")
   - DIMP SC notes
   - DIMP field review meeting notes
   - System knowledge data
   - Results and process documentation for threat identification, risk analyses, mitigation analyses, and regulatory reporting
   - Performance measure data

13.3 Documentation Collection and Archiving Procedures

1. The master documents for DIMP will be located on PG&E shared drives, the TIL, and SharePoint. See *DIMP Manual*, Attachment F, for the locations of documentation associated with DIMP.

END of Instructions

DEFINITIONS

Distribution line: A pipeline other than a gathering or transmission line. A line is a distribution line if it meets **either** one of the following criteria:

1. Transports gas downstream of a distribution center whether in a main or service line.

2. Operates as a farm tap.

Effectiveness measurement: A metric that compares the mitigation baseline to the total number of repaired leaks for a period after mitigation activity is completed.

Excavation damage: Any impact that results in the need to repair or replace an underground facility due to a weakening, or the partial or complete destruction, of the facility. Excavation damage can include damage to protective coating, lateral support, cathodic protection, or the housing for the line device or facility.

Hazardous leak: A leak that represents an existing or potential hazard to persons or property, requiring immediate repair or continuous action until conditions are no longer hazardous. Classified as a Grade 1 leak by PG&E.

Interactive threats: Two or more threats acting on a pipeline section that result in a higher likelihood of failure than the sum of the independent likelihoods of failure. Co-located or coexisting threats on a pipeline section do not necessarily result in an interaction.

Main: A distribution line transporting gas that serves as a common source of supply for more than one service line.

Near miss (per GO No. 112-F): Unplanned or undesired events that adversely affect an operator's facilities or operations, but do not result in injury, illness, damage, release of gas, loss of gas service, over-pressurization of gas pipeline facilities, or in a reportable incident, but had the potential to do so. PG&E sometimes refers to near misses as near hits. Near miss events include, but are not limited to:

- A subsurface pipeline facility not marked or mismarked for excavation purposes.

- Excavation activity near a pipeline facility conducted without a valid Underground Service Alert ticket.

- The incorrect, or unintentional, operation of a valve or pressure regulator.

- An incorrectly mapped pipeline facility.

- Work activity in which a standard, procedure, or process approved by an Operator was correctly applied but the activity, nonetheless, resulted in creating a situation or condition where damages or injuries could have easily occurred.

Definitions (continued)

Risk: A measure of likelihood and consequence associated with a failure.

Service line: A distribution line that transports gas from a common source of supply to an individual customer, two adjacent or adjoining residential or small commercial customers, or to multiple residential or small commercial customers served through a meter header or manifold. A service line ends at the outlet of the customer meter or at the connection to a customer's piping (whichever is further downstream), or at the connection to customer piping if there is no meter. "Service line" is often colloquially shortened to "service."

Sub-threat: A sub-category of one of the eight code-defined threats.

Threat: A cause of failures. These fall under one of the eight code-defined threat categories: corrosion, natural forces, excavation damage, material, weld or joint failure, other outside force damage, equipment failure, incorrect operations, and other. Threats can be either current or potential for any given segment. Current and potential threats are defined as:

- A current threat is a threat currently impacting the segment of pipe being evaluated. For example, Aldyl-A cracking is a current threat to all Aldyl-A pipe segments regardless of whether that particular segment has cracked.
- A potential threat is a threat that may impact the segment being evaluated, or may impact it in the future. For example, flooding is a potential threat to all pipe in a flood plain even when there is no flood.

Transmission line: A pipeline, other than a gathering line, that meets **any** of the following criteria:

1. Transports gas from a transmission line, gathering line, or storage facility to any of the following:
    - Distribution center
    - Storage facility
    - Large-volume customer that is upstream of a distribution center
2. Operates at or above a hoop stress of 20% specified minimum yield strength (SMYS) or is upstream of a segment of pipe operating at or above a hoop stress of 20% SMYS.
3. Transports gas within a storage field.

IMPLEMENTATION RESPONSIBILITIES

DIMP Director will communicate the publication of this utility procedure to affected personnel.

GOVERNING DOCUMENT

Utility Standard TD-4850S, “Distribution Integrity Management Program Requirements and Responsibilities”

COMPLIANCE REQUIREMENT / REGULATORY COMMITMENT

Records and Information Management:

Information or records generated by this procedure must be managed in accordance with the Enterprise Records and Information (ERIM) Policy, Standards and Enterprise Records Retention Schedule (ERRS). Refer to GOV-7101S, “Enterprise Records and Information Management Standard,” and related standards. Management of records includes, but is not limited to:

- Integrity
- Storage
- Retention and Disposition
- Classification and Protection

Code of Federal Regulations, Title 49, Transportation, Part 192—Transportation of Natural and Other Gas by Pipeline: Minimum Federal Safety Standards, Subpart P—Gas Distribution Pipeline Integrity Management (IM)

Code of Federal Regulations Title 49, Transportation, Part 192—Transportation of Natural and Other Gas by Pipeline: Minimum Federal Safety Standards, Section (§) 192.1007(c), “Evaluate and rank risk”

Code of Federal Regulations Title 49, Transportation, Part 192—Transportation of Natural and Other Gas by Pipeline: Minimum Federal Safety Standards, Section (§) 192.1007(e), “Measure performance, monitor results, and evaluate effectiveness”

Code of Federal Regulations Title 49, Transportation, Part 192—Transportation of Natural and Other Gas by Pipeline: Minimum Federal Safety Standards, Section (§) 192.1007(f), “Periodic Evaluation and Improvement”

California Public Utilities Commission General Order No. 112-F, “State of California Rules Governing Design, Construction, Testing, Operation, and Maintenance of Gas Gathering, Transmission, and Distribution Piping Systems”

REFERENCE DOCUMENTS

Developmental References:

NA

Supplemental References:

California Public Utilities Commission General Order No. 112-F, "State of California Rules Governing Design, Construction, Testing, Operation, and Maintenance of Gas Gathering, Transmission, and Distribution Piping Systems."

DIMP Manual, Attachment A, "Mitigation Activities"

DIMP Manual, Attachment B, "DIMP Cycle Process Map"

DIMP Manual, Attachment C, "DIMP Data Matrix"

DIMP Manual, Attachment E, "DIMP Steering Committee Charter"

DIMP Manual, Attachment F, "DIMP Documentation and Archives"

DIMP Manual, Attachment G, "Monitoring for New Threats"

DIMP Manual, Attachment H, "Threat Identification and Risk Evaluation"

DIMP Manual, Attachment J, "Leak Repair Scrub Process"

DIMP Manual, Attachment K, "Mitigation Analysis Process"

DIMP Manual, Attachment L, "DIMP Field Review Process"

DIMP Manual, Attachment M, "Performance Measure Reporting"

DIMP Manual, Attachment N, "Risk Algorithm"

Utility Procedure TD-4413P-03, "Annual and Quarterly Reporting Requirements for Gas Incidents, Events and Activities"

Utility Standard TD-4110S, "Gas Leak Survey and Detection Program"

Utility Standard TD-4125S, "Maximum Allowable Operating Pressure Requirements"

APPENDICES

NA

ATTACHMENTS

NA

DOCUMENT RECISION

Utility Procedure TD-4850P-01, “Distribution Integrity Management Program,” Rev. 2, published 10/16/2019

DOCUMENT APPROVER

[redacted], Director, DIMP

DOCUMENT OWNER

[redacted] Supervising Engineer, Standards Engineering

DOCUMENT CONTACT

[redacted], Senior Engineer, DIMP

(Document contact may change after publication. To find the current document contact, see the Gas Standards and Procedures Responsibility List.)

REVISION NOTES

Where?	What Changed?
Revision 3b	
Step 1.4.1	Updated step to delete inclusion in the Asset Management Risk Register, and to add input to the Loss of Containment Risk for distribution mains and services.
Step 1.5	Deleted entire step on inclusion of the DIMP cycle program evaluation and improvements. Content that is still relevant was moved to Section 9.
Step 4.4.2	Deleted statement describing data retention in SAP.
Step 4.4.b.(1)	Updated step by deleting “relevant to” and by adding “as appropriate to support.”
Step 4.4.c.(1)	Added “GD GIS is continuously updated to reflect changes or corrections to the gas distribution facility data.”
Step 4.6	Added new step describing missing information.
Step 5.2.5	Deleted “For example, the interaction of pipe squeezing and slow crack growth is taken into account through the squeeze point factor for the material failure plastic crack sub-threat”
Step 6.2.2	Deleted entire step describing DIMP personnel monitoring new threats.
Step 7.3.2	Added “may.”
Step 7.4.1.a.(2)	Updated entire step.
Step 7.4.c.(1), first and second bullet points	• Deleted “Aldyl-A” and added “plastic” and “pre-1985 plastic. • Replaced “-1940” with “1941.”
Step 8.4.1	Replaced “risk” with “threat.”
Step 9.2.2, Step 9.2.3	Added new steps with content previously in Step 1.5. Split into two steps.
Step 9.3.2. Step 9.3.3	Added new steps about separating CAP issues and DIMP SC responsibility previously in Step 1.5.
Supplemental References	Deleted “known” in title of DIMP Manual, Attachment H.
Throughout	Adjusted pagination.
Revision 3a (Publication Date: 08/18/2021 Effective Date: 11/01/2021)	
Section 12.3	Deleted entire section. Current Section 12.4 becomes new Section 12.3.
Revision 3 (Publication Date: 12/16/2020 Effective Date: 01/01/2021)	
Section 1	• Added body of Attachment D into Step 1.2. • Revised cycle map. Removed register reference from Box 7 and added “Revisions to DIMP Cycle Process Map” to Box 6. • Eliminated reference to Attachment D in Step 1.3. • Removed references to Asset Management Risk Register in Step 1.4.
Section 8	• Added reference to Code of Federal Regulations Title 49, Transportation, Part 192—Transportation of Natural and Other Gas by Pipeline:

	Minimum Federal Safety Standards, Section (§) 192.1007(e), "Measure performance, monitor results, and evaluate effectiveness" in 8.1.1. Subsequently removed the bullet points because that list is directly in the code. • Removed list of performance measures in Step 8.3 and referred to Attachment M.
Where?	What Changed?
Section 9	• Removed bullet points in Step 9.1.1 since all items are already addressed in prior sections of the procedure or in later ones. • Moved "mitigation activities effectiveness" step to be merged with Step 8.5.1 "Mitigation performance measures" • Removed Step 9.5 "Program Administration (5 years)" and combined into Step 9.2. Specifically addressed that the procedure and all associated documents are reviewed cyclically, not to exceed 5 years. • Created a step for Lessons Learned in Step 9.2.2.
Table 1	• Updated DIMP organization name and updated the message that will be provided to align with the message to other organizations.
Section 11	• Changed "management" to "leadership" in Step 11.1.1. • Replaced "steering committees" with "steering committee."
Section 12	• Added reference to *DIMP Manual* Attachment M in Step 12.2.1
Section 13	• Removed Step 13.1 that referenced record retention schedule per corrective action program notification (CAPN) 119169158 - 2020 Safety and Enforcement Division (SED) Audit recommendations for DIMP.
Definitions	• Removed "Cause" definition. • Added "material, weld, and joint failure" to "Threat" definition.

PACIFIC GAS AND ELECTRIC COMPANY

GAS OPERATIONS
DISTRIBUTION INTEGRITY MANAGEMENT

Attachment N

Risk Algorithm

Rev. 5

Publication Date: July 31, 2020

Effective Date: July 31, 2020

Table of Contents

1.0 INTRODUCTION

Attachment N describes the RiskFinder risk algorithm and formulas used in the risk evaluation process for the DIMP cycle. Attachment N, Appendix A details the factor values and data filters used in the risk formulas. Attachment N, Appendix B details the derivation of the Likelihood of Failure (LoF) factors. Attachment N, Appendix C details the derivation of the Consequence of Failure (CoF) factors.

Refer to Attachment H for details about executing the risk evaluation process.

2.0 RISK METHODOLOGY

The RiskFinder model calculates quantitative risk values for individual features in four asset groups: Mains, Services (including belowground portions of risers), Above Ground Facilities (aboveground portions of risers, along with meter sets), and Regulator Stations (normally exposed equipment and piping). Mains and services are represented as segments with lengths, whereas above ground facilities (AGFs) and regulator stations are represented as dimensionless points. Farm tap services and regulators (i.e., those directly connected to transmission pipelines) are included as part of the services and regulator stations asset groups, respectively.

The model is delineated by sub-threats, which are sub-categorizations of the eight threat categories: Corrosion; Equipment Failure; Excavation Damage; Incorrect Operations; Material, Weld, or Joint Failure; Natural Forces; Other Outside Forces; and Other. This subcategorization improves analytical clarity because sub-threats represent distinct failure mechanisms within each threat category that may be masked at the broader threat category level. Not every sub-threat is applicable to every asset type. The sub-threat list and identification process are documented in Attachment H.

Each sub-threat LoF estimates the likelihood for a loss of gas containment event caused by that sub-threat. It may contain up to three types of factors that independently contribute to a sub-threat LoF, listed below:

- The District Baseline leak rate is specific to an asset type, sub-threat, and district. It estimates the likelihood of failure based on historical leaks to account for potentially unidentified likelihood factors that may be common to features in the district (e.g., environmental characteristics, construction practices, materials, or operating parameters).
- The Plat Baseline leak rate is specific to an asset type, sub-threat, and district. It estimates the likelihood of failure based on historical leaks to account for potentially unidentified likelihood factors that may be common to features in the plat (e.g., environmental characteristics, construction practices, materials, or operating parameters).
- Supplemental information may be used to derive factors to improve likelihood projections that may not be captured in the Baseline factors.

CoF estimates the safety-related impact of a loss of gas containment event. It includes the following factors:

- The Severity factor accounts for the variation in consequences for different threats due to the tendencies toward different failure modes. It has units of serious injuries or fatalities (SIFs) per 100,000 leaks. Per the PHMSA incident reporting instructions (Form PHMSA F 7100.1 (rev 10-2014)), a SIF includes: injuries sustained as a result of the incident and requiring hospital admission and at least one overnight stay, and fatalities at the time of the incident or within 30 days of the initial incident date due to injuries sustained as a result of the incident.
- The Migration factor is a unitless multiplier that accounts for the relative likelihoods that leaks in different types of environments will migrate and accumulate, resulting in serious consequences.
- The Pressure factor is a unitless multiplier that accounts for the relative likelihoods that leaks from assets with different pressures will result in serious consequences.
- The Population Density factor is a unitless multiplier that reflects the relative impact to human life based on local population densities and locations.
- The EFV factor is a unitless multiplier that reflects the likelihood of an EFV to operate. It reduces the consequence for service and aboveground facility (AGF) assets where an EFV exists upstream.

The general formulas for each component are described below. Attachment N, Appendix A describes the factor weightings, values and data filters used to calculate the LoF and CoF factors. Attachment N, Appendix B describes the rationale for each LoF Supplemental factor and weighting. Attachment N, Appendix C describes the rationale for each CoF factor.

2.1 Risk of Failure (RoF)

For all four asset types, each feature's total risk value is the sum of all applicable sub-threat RoF values:

$$\mathbf{RoF_{Total} = RoF_{SubThreat1} + \ldots + RoF_{SubThreat\_n}}$$

Each sub-threat risk value is expressed as:

$$\mathbf{RoF_{SubThreat\_n} = LoF * CoF}$$

2.2 Likelihood of Failure (LoF)

For each sub-threat and asset type, the unit likelihood of failure of a feature is calculated as the weighted sum of any following factor(s): District Baseline (DB), Plat Baseline (PB), and Supplemental factors. Each weighting reflects a factor's relative contribution to the sub-threat and asset type's LoF value, and all non-zero weightings sum to 1. To obtain the likelihood of failure per feature, the weighted sum of the factors is multiplied by the feature length (for main and service segments) or count (for AGF or regulator station points; the count is always 1 per feature). The calculated LoF has units of leak counts per year and is mathematically given as:

$$\mathbf{LoF = [(wt_{DB} * Baseline_{District}) + (wt_{PB} * Baseline_{Plat}) + (wt_{Supp} * Supp_{N})] * Feature\ Mileage}$$

or

$$\mathbf{LoF = [(wt_{DB} * Baseline_{District}) + (wt_{PB} * Baseline_{Plat}) + (wt_{Supp} * Supp_{N})] * Feature\ Count}$$

The likelihood factor types are defined below:

2.2.1 District Baseline (**Baseline**$_{\text{District}}$)

The District Baseline is the average annual leak rate for each district, asset type, and sub-threat combination. It is calculated by spatially counting the repaired leaks caused by a given sub-threat within a district, and dividing by the mileage or count of features applicable to the sub-threat and the number of years within the specified timeframe (may vary for each sub-threat and asset type):

$$\textbf{Baseline}_{\textbf{District}} = \frac{\textbf{Sub}-\textbf{Threat Leak Count}}{\textbf{Asset Mileage} * \textbf{Years}}$$

or

$$\textbf{Baseline}_{\textbf{District}} = \frac{\textbf{Sub}-\textbf{Threat Leak Count}}{\textbf{Asset Count} * \textbf{Years}}$$

Where:

Sub-threat leak count: the number of leaks that fall within the district for the defined sub-threat category over the specified time frame.

Asset Mileage: Applies to Mains and Services. Main mileage is the sum of main lengths within the district. Service mileage is the sum of service lengths within the district.

Asset Count: Applies to Above Ground Facilities and Regulator Stations. Since these asset types cannot be inventoried as lengths, the formula uses asset counts.

In Appendix A, the list of all threats, sub-threats and queries used to supply leak counts and asset lengths or counts can be found in the LoF tab.

The BaseDistrict models perform these calculations.

2.2.2 Plat Baseline (**Baseline**$_{\text{Plat}}$)

The Plat Baseline is the average annual leak rate for each plat, asset type, and sub-threat combination. It is calculated analogously to the District Baseline except at the plat level instead of the district level.

In Appendix A, the list of all threats, sub-threats and queries used to supply leak counts and asset lengths or counts can be found in the LoF tab.

The BasePlat models perform these calculations.

2.2.3 Supplemental (**Supp**$_{\text{N}}$)

Supplemental factors use modeling methods and data sources that vary by asset and sub-threat. They are developed to provide more precise modeling of LoF when justified by available data. Examples include an asset's specific leak history, proximity to seismic hazards, Jana Labs' Aldyl-A ranking, asset installation year, material type, FEMA flood zones, regions of unstable soil, and observations collected from Field Reviews. Leak counts and leak characteristics are processed by the Local Query Cache (LQC) scripts. All other data are processed by the FactorPrep models.

The category values and factor weightings are listed in the LOF tab of Appendix A, and are justified in Appendix B. The Supplemental factor calculations are performed by the LOF models.

2.3 Consequence of Failure (CoF)

For each applicable feature, the calculated CoF per sub-threat and asset type has units of SIFs per 100,000 leaks and is mathematically calculated as:

CoF = Severity × Migration × Pressure × PopDens × EFV

In Appendix A, the COF tab lists the factor values and queries for the CoF factors. The ROFCOF models perform these calculations. Brief descriptions of each factor are below, and detailed explanations are in Appendix C.

2.3.1 Severity factor

The Severity factor accounts for the variation in consequences for different threats due to the tendencies toward different failure modes. It has units of SIFs per 100,000 unmitigated leaks ("unmitigated" meaning not immediately shut off by an excess flow valve; see Excess Flow Valve factor below).

2.3.2 Migration factor

The Migration factor is a unitless multiplier that accounts for the relative likelihoods that leaks in different types of environments will migrate and accumulate, resulting in serious consequences. This factor assigns values based on whether the asset is buried or inside a structure, as opposed to aboveground or otherwise exposed.

2.3.3 Pressure factor

The Pressure factor is a unitless multiplier that accounts for the relative likelihoods that leaks from assets operating at different pressures will result in serious consequences. A leak in a higher pressure class asset results in a higher release rate and potentially greater impact. When pressure is not available, the pressure class is assumed to be high pressure (HP).

2.3.4 Population Density (PopDens) factor

The Population Density factor is a unitless multiplier that reflects the relative impact to human life based on local population densities and locations. It is based on and applied using 2010 United States Census Block data. Where an asset intersects multiple blocks, a block area-weighted average population density is used to determine the population class.

2.3.5 Excess Flow Valve (EFV) factor

The EFV factor reflects the likelihood of an EFV to operate. It has units of unmitigated leaks per leak. It reduces the consequence for service (including branch service) and AGF assets where an EFV exists upstream. EFVs are designed to shut off gas flow to services when high flow rates are experienced, so their likelihood to operate depends on asset failure modes.

3.0 RISK ANALYSIS PROCESS FLOW

The RiskFinder algorithm is housed within DNVGL's Uptime platform. Uptime is an ArcGIS add-on that processes risk calculations based on GIS data. DIMP's risk algorithm is executed through a series of Uptime analytical models and external processing scripts as shown below (**Figure 1**). Following the risk algorithm RoF calculations, "rollup" processes may be used to summarize the feature risk scores to broader levels (e.g., plats, districts, divisions, jobs) to assist with analysis of the risk results and determination of Mitigation Analysis recommendations per Attachment H.

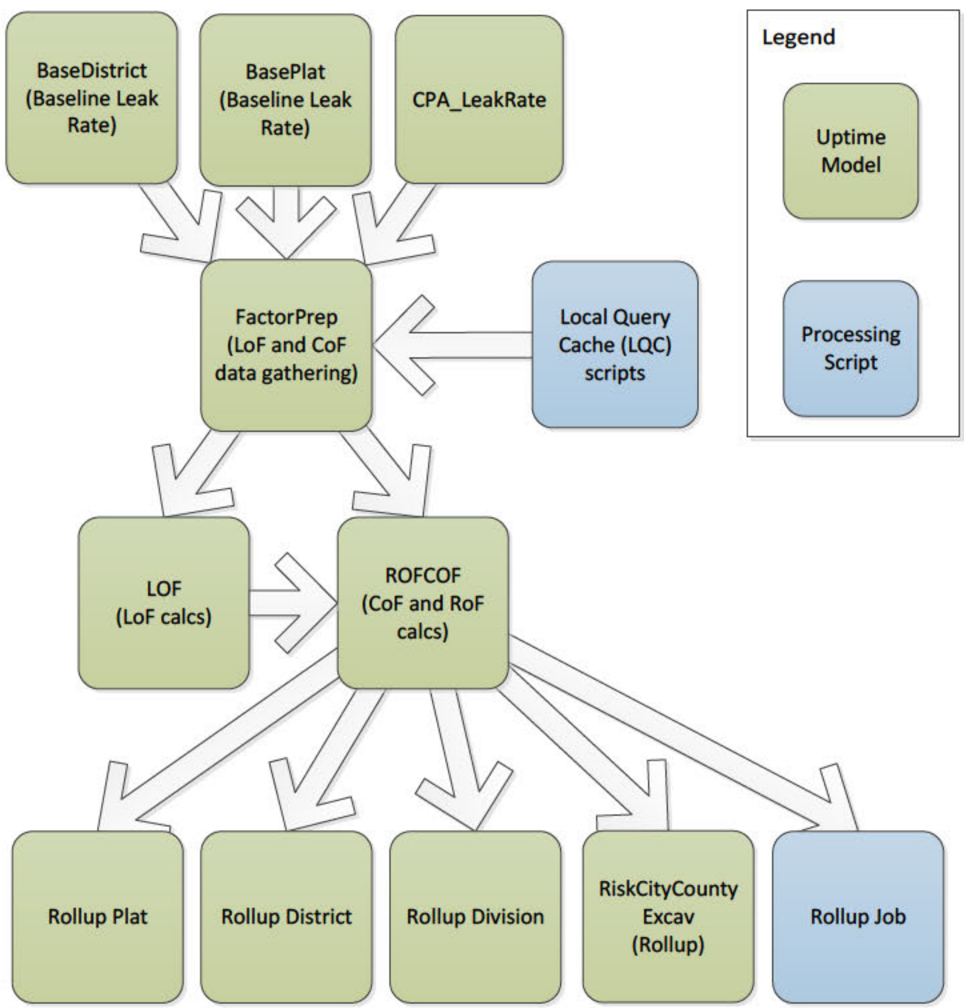


Figure 1: Risk analysis process flow diagram

4.0 RESULTS FEATURE CLASSES

The output feature classes from each analytical step are captured in the following table:

Table 1: Feature classes generated

Model(s) or Script	Results feature class
BaseDistrict	BaseDistrictMain, BaseDistrictService, BaseDistrictAGF, BaseDistrictRegStation
BasePlat	BasePlatMain, BasePlatService, BasePlatAGF, BasePlatRegStation
CPA_LeakRate	CPA_LeakRate
Local Query Cache scripts	OLSMainLQC, OLSServiceLQC, OLSMetersetLQC
FactorPrep	FactorPrepMain, FactorPrepService, FactorPrepAGF, FactorPrepRegStation
LOF	LOFMain, LOFService, LOFAGF, LOFRegStation
ROFCOF	ROFMain, ROFService, ROFAGF, ROFRegStation
RollupPlatMap, RollupDistrict, RollupDivision	RiskRegionSummary
RiskCityCountyExcav	RiskCityCountyExcav
Rollup Job	_JobRollup

For the FactorPrep, LoF, and RoF features classes, their GDGIS_GUID fields are linked to the original asset feature class's GlobalID field.

Attachment N - Change Log *Change control system based on process safety criteria identified in Utility Standard TD-4014S, Section 3*		
Change Owner (name/LAN ID): [redacted]		**Date:** 7/31/2020
Section	**What Changed and Why?**	**Desired Outcome**
2.0	Added statement to clarify that farm tap services and regulators are included as part of the Services and Regulator Stations asset groups, respectively.	Clarification only. No change to risk assessment process.
2.0	"Material/Weld" threat name changed to "Material, Weld, or Joint Failure" to align with PHMSA language.	No change to risk algorithm.
3.0	Added statement to clarify distinction between risk algorithm calculations and rollup operations.	Clarification only. No change to risk assessment process.
4.0	Added script and result for "Job Rollup", which was missing in previous version.	More complete documentation and awareness of this process.
Appendix A	Updated LOF factors and weighting for reasons described in Appendix B.	Improved risk modeling.
Appendix A	Updated COF factor values. Updated calculations with more recent PG&E leak data.	Minor improvements to risk modeling.
Appendix A	Renamed sub-threat "Pipe Dope" to "Seal Failure" to more broadly encompass other types of seal failures, which have similar consequence and remediation approaches (i.e., replacing "consumables", such as dope, grease, or other sealants). Addresses 2017 CPUC audit recommendations (see CAP 113822253 tasks 1 and 2).	Clarifying to reflect de facto processes. Negligible impact to risk assessment.
Appendix A	Renamed sub-threat (Equipment) "Malfunction" to "Miscellaneous" to more broadly encompass leaks that occur on valves and regulation equipment, but not necessarily due to a malfunction of the equipment. Addresses 2017 CPUC audit recommendations (see CAP 113822253 task 3).	Clarifying to reflect de facto processes. Negligible impact to risk assessment.
Appendix A	Added new sub-threat "Plastic Tee Cap Incorrect Operations" to enable more granular analysis of risk (i.e., separation of tee cap failures due to incorrect operations vs material/manufacturing issues).	Ability to parse risks based on different drivers, leading to more effective mitigations.
Appendix A	Split "Weld Failure" into three sub-threats: "Girth Weld Failure", "Longitudinal Weld Failure", and "Other Weld Failure" to enable more granular analysis of risk.	Ability to parse risks based on different drivers, leading to more effective mitigations.

Appendix A	Split "Plastic Material Failure" into two sub-threats: "Plastic Material Failure Body of Pipe" and "Plastic Material Failure Fitting" to enable more granular analysis of risk.	Ability to parse risks based on different drivers, leading to more effective mitigations.
Appendix B	Updated explanations for LOF factors and weightings to account for new data and insights. See Appendix B content for change descriptions and reasons.	Improved risk modeling.
Appendix C	Updated calculations with more recent PG&E leak data. Corrected Excel calculation formulas for severity values.	Minor improvements to risk modeling.

Hazard evaluation associated with this change: *Identify any Safety, Health, Environmental and Asset risks associated with the implementation of the change (Refer to Utility Procedure TD-4006P-01, "Process Hazard Analysis" for additional information)*:
No hazards have been identified with this change.

List other documents affected by the change:
None

Implementation Plan: *Identify how changes are communicated and executed:*

1. [redacted] to send email to all DIMP personnel upon routing of document for approval in EDRS, alerting them of change.
2. [redacted]) to upload Attachment N to the DIMP Sharepoint and move previous version to superseded file in the DIMP SharePoint, upon EDRS document approval by Director.
3. Changes to document are effective as of the Director approval date.
4. No training is required for this change.

How will Effectiveness Evaluation be conducted?
At the end of the 2020 DIMP Cycle, results of risk assessment will be evaluated, and any adverse effect of change will be documented in the DIMP Cycle CAP – Lessons Learned.

Document Reviewer/Approver	LAN ID	Electronic Signature	Date
Director: Mike Kerans	MEKJ	EDRS: 2020-48126	7/31/2020

Threat	Sub-Threat	Applicable Asset Type	LOF District Baseline weighting	LOF District Baseline timeframe (yrs)	LOF Plat Baseline weighting	LOF Plat Baseline timeframe (yrs)	**Baseline | OLS:** Leak attribute query		**Baseline:** Asset attribute query [additional condition: InstalledCompletionDate excludes analysis year]	LOF Supp 1 weighting	LOF Supp 1 factor	LOF Supp 2 weighting	LOF Supp 2 factor	LOF Supp 3 weighting	LOF Supp 3 factor	LOF Supp 4 weighting	LOF Supp 4 factor
Corrosion	Atmospheric	Main	-	-	1.00	5	Leak.SubThreatCalc = 'AtmosphericCorrosion'	Leak.AssetGroupCalc = 'Main'	Total length where DistributionMain.MaterialDESC <>	-	-	-	-	-	-	-	-
Corrosion	Atmospheric	Service	-	-	1.00	5		Leak.AssetGroupCalc = 'Service'	Total length where Service.Materia DESC <> Plastic'	-	-	-	-	-	-	-	-
Corrosion	Atmospheric	Above Ground Facility	-	-	0.50	5		Leak.AssetGroupCalc = 'Riser'	Total Count	0.5	Point Leak History Leak rates for categories based on count of historical sub-threat leaks on AGF point: 1. 1 or more 0.0049296 2. None: 0.0002959	-	-	-	-	-	-
Corrosion	Atmospheric	Reg Station	-	-	1.00	5		Leak.AssetGroupCalc = 'Regulator'	Total Count	-	-	-	-	-	-	-	-
Corrosion	External	Main	-	-	-	-	Leak.SubThreatCalc = 'ExternalCorrosion'	Leak.AssetGroupCalc = 'Main'	Total length where DistributionMain.MaterialDESC <> Plastic'	0.40	External corrosion leak rate per CPA Leak rate (leaks/mi-yr) per CPA based on spatial intersection. - Default cases: If a main does not intersect a CPA polygon or if the total CPA steel main length is less than 0.1 m le the LOF formula will use the District Baseline leak rate and this Supplemental factor's weighting. If a main intersects multiple CPA polygons the maximum value will be used.	0.35	Coating and CP status Leak rate determined by combination of attributes based on GUID relationship: (DistributionMainCalc.CPProtectionType or GPRPdata.CATH_PROT or FieldReviewMains.Subthreat) (DistributionMainCalc.CoatingTypeDesc or GPRPdata.Coating or Leak.CoatingType) 1. Unprotected Bare: 0.9273 2. Protected/Unknown Bare: 0.4496 3. Unprotected Coated/Unknown: 0.1170 4. Protected/Unknown Coated/Unknown: 0.0433 - Default cases: "Unknown" covered in cases 2 3 and 4 above. Assumes "Unknown" CP or coating statuses are "Protected" or "Coated" respectively.	0.05	Age Leak rates from formula based on attribute: Leak rate per mile-yr = -0.00242 64* Year of Insta ledcompletiondate 4.78636 - Default cases: Uses maximum formula value (0.1247) for years before 1925 (includes unknown installation year of 1800) and use minumum formula value (0.006043) for years after 1974.	0.20	Segment Leak History Leak rates for categories based on count of historical sub-threat leaks on segment: 1. 2 or more: 0.32586 2. 1: 0.15299 3. None: 0.03740
Corrosion	External	Service	-	-	-	-		Leak.AssetGroupCalc = 'Service'	Total length where Service.Materia DESC <> Plastic'	0.50	External corrosion leak rate per CPA Leak rate (leaks/mi-yr) per CPA based on spatial intersection. - Default cases: If a service does not intersect a CPA polygon or if the total CPA steel service length is less than 0.1 mile the LOF formula wi l use the District Base ine leak rate and this Supplemental factor's weighting. If a service intersects multiple CPA polygons the maximum value will be used.	0.50	Segment Leak History Leak rates for categories based on count of historical sub-threat leaks on segment: 1. 2 or more: 0.608 2. 1: 0.150 3. None: 0.019	-	-	-	-
Corrosion	Internal	Main	1.00	5	-	-	Leak.SubThreatCalc = 'InternalCorrosion'	Leak.AssetGroupCalc = 'Main'	Total length where DistributionMain.MaterialDESC <>	-	-	-	-	-	-	-	-
Corrosion	Internal	Service	1.00	5	-	-		Leak.AssetGroupCalc = 'Service'	Total length where Service.Materia DESC <> Plastic'	-	-	-	-	-	-	-	-
Corrosion	Internal	Above Ground Facility	1.00	5	-	-		Leak.AssetGroupCalc = 'Riser'	Total Count	-	-	-	-	-	-	-	-
Corrosion	Internal	Reg Station	1.00	5	-	-		Leak.AssetGroupCalc = 'Regulator'	Total Count	-	-	-	-	-	-	-	-
Equipment Failure	Miscellaneous	Main	0.50	5	-	-	Leak.SubThreatCalc = 'EquipmentMisc'	Leak.AssetGroupCalc = 'Main'	Total Length	0.50	Segment Leak History Leak rates for categories based on count of historical sub-threat leaks on segment: 1. 1 or more: 0.004546 2. None: 0.000282	-	-	-	-	-	-
Equipment Failure	Miscellaneous	Service	0.50	5	-	-		Leak.AssetGroupCalc = 'Service'	Total Length	0.50	Segment Leak History Leak rates for categories based on count of historical sub-threat leaks on segment: 1. 1 or more: 0.06564 2. None: 0.00250	-	-	-	-	-	-
Equipment Failure	Miscellaneous	Above Ground Facility	1.00	5	-	-		Leak.AssetGroupCalc = 'Riser'	Total Count	-	-	-	-	-	-	-	-
Equipment Failure	Miscellaneous	Reg Station	1.00	5	-	-		Leak.AssetGroupCalc = 'Regulator'	Total Count	-	-	-	-	-	-	-	-
Equipment Failure	Seal Failure	Main	0.50	5	-	-	Leak.SubThreatCalc = 'SealFailure'	Leak.AssetGroupCalc = 'Main'	Total Length	0.50	Segment Leak History Leak rates for categories based on count of historical sub-threat leaks on segment: 1. 1 or more: 0.081470 2. None: 0.014889	-	-	-	-	-	-
Equipment Failure	Seal Failure	Service	0.50	5	-	-		Leak.AssetGroupCalc = 'Service'	Total Length	0.50	Segment Leak History Leak rates for categories based on count of historical sub-threat leaks on segment: 1. 1 or more: 0.1408 2. None: 0.0035	-	-	-	-	-	-
Equipment Failure	Seal Failure	Above Ground Facility	0.50	5	-	-		Leak.AssetGroupCalc = 'Riser'	Total Count	0.50	Point Leak History Leak rates for categories based on count of historical sub-threat leaks on segment: 1. 1 or more: 0.0108090 2. None: 0.0055121	-	-	-	-	-	-
Equipment Failure	Seal Failure	Reg Station	0.50	5	-	-		Leak.AssetGroupCalc = 'Regulator'	Total Count	0.50	Point Leak History Leak rates for categories based on count of historical sub-threat leaks on segment: 1. 1 or more: 0.02133333 2. None: 0.01643363	-	-	-	-	-	-
Excavation Damage	Excavation Damage	Main	0.30	5	-	-	Leak.SubThreatCalc = 'ExcavationDamage'	Leak.AssetGroupCalc = 'Main'	Total Length	0.70	Segment Leak History Depth of Cover Material Leak rates for categories based on leak history depth of cover and material: 1. Shallow depth (<19in & >0in): 0.01494 2. Excavation Leaks >0: 0.01136 3. Plastic: 0.006381 4. Metal or Unknown: 0.002093 - Default case: Covered in case 4 above.	-	-	-	-	-	-
Excavation Damage	Excavation Damage	Service	0.30	5	-	-		Leak.AssetGroupCalc = 'Service'	Total Length	0.70	Segment Leak History Depth of Cover Material Leak rates for categories based on leak history depth of cover and material: 1. Plastic & Sha low Depth (< 8in & >0in): 0.1356 2. Plastic & Excavation Leaks >0: 0.07914 3.Plastic: 0.02018 4.Metal or Unknown: 0 001791 - Default case: Covered in case 4 above.	-	-	-	-	-	-
Incorrect Operation	Construction Defect	Main	0.15	5	0.15	5	Leak.SubThreatCalc in ('MetConstrDef' 'PlasConstrDef')	Leak.AssetGroupCalc = 'Main'	Total Length	0.70	Segment Leak History Material Installation Date Leak rates for categories based on segment leak history material and insta lation year: 1. (Metal or Unknown) Install Year <1943: 0.02417 2. (Metal or Unknown) Install Year >1942 & ConstrDefLk>0 : 0.02233 3. (Metal or Unknown) Install Year >1942: 0.00751 4. Plastic Install Year <1976: 0.02362 5. Plastic Install Year >1975 & Construction Defect Leaks >0: 0.01733 6. Else: 0.004714	-	-	-	-	-	-
Incorrect Operation	Construction Defect	Service	0.15	5	0.15	5		Leak.AssetGroupCalc = 'Service'	Total Length	0.70	Segment Leak History Material Installation Date Leak rates for categories based on segment leak history material and insta lation year: 1. Construction Defect Leaks >0: 0.045327 2. Plastic Install Year <1995: 0.012364 3. Plastic Install Year >1994: 0.008791 4. Metal or Unknown: 0.001672 - Default case: Covered in case 4 above.	-	-	-	-	-	-
Incorrect Operation	Construction Defect	Above Ground Facility	0.50	5	0.50	5		Leak.AssetGroupCalc = 'Riser'	Total Count	-	-	-	-	-	-	-	-
Incorrect Operation	Construction Defect	Reg Station	0.50	5	0.50	5		Leak.AssetGroupCalc = 'Regulator'	Total Count	-	-	-	-	-	-	-	-
Incorrect Operation	Crossbore	Main	-	-	0.10	5	Leak.SubThreatCalc = 'Xbore'	Leak.AssetGroupCalc = 'Main'	Total Length	0.90	Crossbore Review Material Installation Date Service Count Like ihood based on Legacy Crossbore Review (DistributionMain.DistMain_XB_Class) Material Installation Date and Count of Services: 1. Class 1 (DistMain_XB_Class = 1 and Installation Date before 1/ /2017): 3E-6 * (Count of Service Locations) / (2 * (Segment Mileage)) 2. Class 2 (GDGIS Material = Plastic and (Installation Date after 12/31/1984 or 1/1/1800) : 2E-7 * (Count of Service Locations) / (2 * (Segment M leage)) 3. Class 3 (All other mains): 7E-8 * (Count of Service Locations) / (2 * (Segment Mileage)) - Default case: Covered in case 3 above	-	-	-	-	-	-
Incorrect Operation	Crossbore	Service	-	-	0.10	5		Leak.AssetGroupCalc = 'Service'	Total Length	0.90	Crossbore Review Insta lation Date Installation Method Like ihood based on Legacy Crossbore Review (Service.Srv_XB_Class) Insta lation Date and Installation Method: 1. Class 1 (Srv_XB_Class = 1 and Installation Date before 1/1/2017) : 1E-5 / (Segment M leage) 2. Class 2 (GDGIS Material = Plastic and JOINTTRENCHINDICATOR = "N"): 6E-7 / (Segment Mileage) 3. Class 3 (All other services): 1E-7 / (Segment Mileage) - Default case: Covered in case 3 above	-	-	-	-	-	-

Threat	Sub-Threat	Applicable Asset Type	LOF District Baseline weighting	LOF District Baseline timeframe (yrs)	LOF Plat Baseline weighting	LOF Plat Baseline timeframe (yrs)	**Baseline | OLS:** Leak attribute query		**Baseline:** Asset attribute query [additional condition: InstalledCompletionDate excludes analysis year]	LOF Supp 1 weighting	LOF Supp 1 factor	LOF Supp 2 weighting	LOF Supp 2 factor	LOF Supp 3 weighting	LOF Supp 3 factor	LOF Supp 4 weighting	LOF Supp 4 factor
Incorrect Operation	Fusion Failure	Main	**0.15**	5	**0.15**	5	Leak.SubThreatCalc = 'Fusion'	Leak.AssetGroupCalc = 'Main'	Total length where DistributionMain.MaterialDESC = Plastic'	**0.70**	Installation Date Like ihood based on installation year: 1. Install Year <1983: 0.0075041 2. Install Year >1982: 0.0008133	-	-	-	-	-	-
Incorrect Operation	Fusion Failure	Service	**0.15**	5	**0.15**	5		Leak.AssetGroupCalc = 'Service'	Total length where Service.Materia DESC = 'Plastic'	**0.70**	Installation Date 1. Install Year >1983: 0.000050 2. Else: 0.000488	-	-	-	-	-	-
Incorrect Operation	Incorrect Operations	Main	**0.50**	5	**0.50**	5	Leak.SubThreatCalc = 'IncorrectOperations'	Leak.AssetGroupCalc = 'Main'	Total Length	-	-	-	-	-	-	-	-
Incorrect Operation	Incorrect Operations	Service	**0.50**	5	**0.50**	5		Leak.AssetGroupCalc = 'Service'	Total Length	-	-	-	-	-	-	-	-
Incorrect Operation	Incorrect Operations	Above Ground Facility	**0.50**	5	**0.50**	5		Leak.AssetGroupCalc = 'Riser'	Total Count	-	-	-	-	-	-	-	-
Incorrect Operation	Incorrect Operations	Reg Station	**0.50**	5	**0.50**	5		Leak.AssetGroupCalc = 'Regulator'	Total Count	-	-	-	-	-	-	-	-
Incorrect Operation	Other Weld Failure	Main	**0.15**	5	**0.15**	5	Leak.SubThreatCalc = MetWeldOther'	Leak.AssetGroupCalc = 'Main'	Total length where DistributionMain.MaterialDESC <> Plastic'	**0.70**	Interacting Sub-Threat Leak History Insta lation Date Like ihood based on Construction Defect leak history Install Year 1) Construction Defect Leaks >0: 0.0094890 2) Install Year <1949: 0.0074605 3) Install Year >1948: 0.0024364	-	-	-	-	-	-
Incorrect Operation	Other Weld Failure	Service	**0.50**	5	**0.50**	5		Leak.AssetGroupCalc = 'Service'	Total length where Service.Materia DESC <> Plastic'	-		-	-	-	-	-	-
Incorrect Operation	Other Weld Failure	Above Ground Facility	**0.50**	5	**0.50**	5		Leak.AssetGroupCalc = 'Riser'	Total Count	-	-						
Incorrect Operation	Other Weld Failure	Reg Station	**0.50**	5	**0.50**	5		Leak.AssetGroupCalc = 'Regulator'	Total Count	-	-	-	-	-	-	-	-
Incorrect Operation	Girth Weld Failure	Main	**0.15**	5	**0.15**	5	Leak.SubThreatCalc = 'GirthWeld'	Leak.AssetGroupCalc = 'Main'	Total length where DistributionMain.MaterialDESC <> Plastic'	**0.7**	Installation Date 1. Install Year <1948: 0.00409290 2. Install Year >1947: 0.00208 60	-	-	-	-	-	-
Incorrect Operation	Girth Weld Failure	Service	**0.50**	5	**0.50**	5		Leak.AssetGroupCalc = 'Service'	Total length where Service.Materia DESC <> Plastic'	-	-	-	-	-	-	-	-
Incorrect Operation	Plastic Tee Cap Incorrect Operations	Service	**0.15**	5	**0.15**	5	Leak.SubThreatCalc = 'PlasIncOpTeeCap'	Leak.AssetGroupCalc = 'Service'	Total length where Service.Materia DESC = Plastic'	**0.7**	Installation Date Segment Leak History 1. Plastic Incorrect Operations Tee Cap Leaks >0: 0.1917 2. Install Year >1997: 0.0045 3. Install Year <1998: 0.0213	-	-	-	-	-	-
Material Weld or Joint Failure	Longitudinal Weld Failure	Main	**0.30**	5	-	5	Leak.SubThreatCalc = Longitudinal Weld'	Leak.AssetGroupCalc = 'Main'	Total length where DistributionMain.MaterialDESC <> Plastic'	**0.7**	Installation Date 1. Install Year <1951 or missing: 0.000633 2. Install Year >1950: 0.000152	-	-	-	-	-	-
Material Weld or Joint Failure	Longitudinal Weld Failure	Service	**1.00**	5	-	5		Leak.AssetGroupCalc = 'Service'	Total length where Service.Materia DESC <> Plastic'	-	-	-	-	-	-	-	-
Material Weld or Joint Failure	Compression Coupling	Main	**1.00**	5	-	-	Leak.SubThreatCalc = 'CompresCoupl'	Leak.AssetGroupCalc = 'Main'	Total Length	-	-	-	-	-	-	-	-
Material Weld or Joint Failure	Compression Coupling	Service	**0.30**	5	-	-		Leak.AssetGroupCalc = 'Service'	Total Length	**0.7**	Material Installation Date Installation Method 1. Plastic & Insta l Year <1981: 0.0023229 2. Plastic & Insta l Year >1980 & Inserted: 0.0018158 3. Plastic & Insta l Year >1980 : 0.0006787 4. Metal: 0.0001141	-	-	-	-	-	-
Material Weld or Joint Failure	Compression Coupling	Above Ground Facility	**1.00**	5	-	-		Leak.AssetGroupCalc = 'Riser'	Total Count	-	-	-	-	-	-	-	-
Material Weld or Joint Failure	Compression Coupling	Reg Station	**1.00**	5	-	-		Leak.AssetGroupCalc = 'Regulator'	Total Count	-	-	-	-	-	-	-	-
Material Weld or Joint Failure	Metallic Material Failure	Main	**1.00**	5	-	-	Leak.SubThreatCalc = 'MetMatFail'	Leak.AssetGroupCalc = 'Main'	Total length where DistributionMain.MaterialDESC <> Plastic'	-	-	-	-	-	-	-	-
Material Weld or Joint Failure	Metallic Material Failure	Service	**1.00**	5	-	-		Leak.AssetGroupCalc = 'Service'	Total length where Service.Materia DESC <> Plastic'	-	-	-	-	-	-	-	-
Material Weld or Joint Failure	Metallic Material Failure	Above Ground Facility	**1.00**	5	-	-		Leak.AssetGroupCalc = 'Riser'	Total Count	-	-	-	-	-	-	-	-
Material Weld or Joint Failure	Metallic Material Failure	Reg Station	**1.00**	5	-	-		Leak.AssetGroupCalc = 'Regulator'	Total Count	-	-	-	-	-	-	-	-
Material Weld or Joint Failure	Plastic Material Failure Fitting	Main	**0.30**	5	-	-	Leak.SubThreatCalc = 'PlasMatFailFitting'	Leak.AssetGroupCalc = 'Main'	Total length where DistributionMain.MaterialDESC = Plastic'	**0.70**	Installation Date 1. Install Year >1986: 0.00066540 2. Install Year >1975: 0.00293350 3. Install Year <1976: 0.00790220	-	-	-	-	-	-
Material Weld or Joint Failure	Plastic Material Failure Fitting	Service	**0.30**	5	-	-		Leak.AssetGroupCalc = 'Service'	Total length where Service.Materia DESC = 'Plastic'	**0.70**	Installation Date Segment Leak History 1. Plastic Material Failure Fitting Leaks >0: 0.06045 2. Install Year <1987: 0.00526 3. Install Year >1986: 0.00158	-	-	-	-	-	-
Material Weld or Joint Failure	Plastic Material Failure Fitting	Above Ground Facility	**1.00**	5	-	-		Leak.AssetGroupCalc = 'Riser'	Total Count	-	-	-	-	-	-	-	-
Material Weld or Joint Failure	Plastic Material Failure Fitting	Reg Station	**1.00**	5	-	-		Leak.AssetGroupCalc = 'Regulator'	Total Count	-	-	-	-	-	-	-	-
Material Weld or Joint Failure	Plastic Material Failure Body of Pipe	Main	**0.30**	5	-	-	Leak.SubThreatCalc = 'PlasMatFai BOP'	Leak.AssetGroupCalc = 'Main'	Total length where DistributionMain.MaterialDESC = Plastic'	**0.70**	Jana Rank Squeeze Points Segment Leak History 1. Jana >4 & Plastic Material Failure Body of Pipe Leaks >0: 0.0647 2. Jana >4 & Squeeze >0: 0 0080 3. Jana >4: 0.0050 4. Jana <=4 & Plastic Material Failure Body of Pipe Leaks >0: 0.0430 5. Else: 0.0005	-	-	-	-	-	-
Material Weld or Joint Failure	Plastic Material Failure Body of Pipe	Service	**0.30**	5	-	-		Leak.AssetGroupCalc = 'Service'	Total length where Service.Materia DESC = Plastic'	**0.70**	Installation Date Squeeze Points Segment Leak History 1. Install Year < 1985 & Plastic Material Failure Body of Pipe >0: 0.04558 2. Install Year < 1985 & Squeeze >0: 0.00333 3. Install Year < 1985: 0.00117 4. Install Year > 1984: 0.000 6	-	-	-	-	-	-
Material Weld or Joint Failure	Plastic Tee Cap Material Failure	Service	**0.30**	5	-	-	Leak.SubThreatCalc = 'PlasMatFailTeeCap'	Leak.AssetGroupCalc = 'Service'	Total length where Service.Materia DESC = 'Plastic'	**0.70**	Installation Date Segment Leak History 1. Plastic Material Failure Tee Cap Leaks >0: 0.14014 2. Install Year < 1998: 0.016 0 3. Install Year > 1997: 0.00202	-	-	-	-	-	-
Natural Forces	Earth Movement	Main	-	-	**0.20**	15		Leak.AssetGroupCalc = 'Main'	Total Length	**0.20**	Landslide Leak rates for categories based on attribute Landslide.LS_Hazard: 1. Hazard Level 1: 0.0010995 2. Hazard Level 2: 0.0015163 3. Hazard Level 3: 0.0024608 4. Hazard Level 4: 0.0034053 5. Hazard Level 5: 0.0043498 - Default case: 0.00 0995	**0.2**	Fault Creep Leak rates for categories based on attribute GPAT_Mains_RF.GPAT_HazardCategory_FaultCreep: 1. "HL1": 0.0037 2. "HL2": 0.0174 3. "HL3": 0.0225 - Default case: 0.0010 (Earth Movement system average)	**0.4**	Segment Leak History Leak rates for categories based on count of historical sub-threat leaks on segment: 1. 1 or more: 0.006936 2. None: 0.0006 0	-	-
Natural Forces	Earth Movement	Service	-	-	**0.20**	15	Leak.SubThreatCalc =	Leak.AssetGroupCalc = 'Service'	Total Length	**0.30**	Landslide Leak rates for categories based on attribute Landslide.LS_Hazard: 1. Hazard Level 1: 0.0012915 2. Hazard Level 2: 0.0019504 3. Hazard Level 3: 0.00249 8 4. Hazard Level 4: 0.0030332 5. Hazard Level 5: 0.0035746 - Default case: 0.0012915	**0.5**	Segment Leak History Leak rates for categories based on count of historical sub-threat leaks on segment: 1. 1 or more: 0.006654 2. None: 0.000598	-	-	-	-

Threat	Sub-Threat	Applicable Asset Type	LOF District Baseline weighting	LOF District Baseline timeframe (yrs)	LOF Plat Baseline weighting	LOF Plat Baseline timeframe (yrs)	Baseline | OLS: Leak attribute query		Baseline: Asset attribute query [additional condition: InstalledCompletionDate excludes analysis year]	LOF Supp 1 weighting	LOF Supp 1 factor	LOF Supp 2 weighting	LOF Supp 2 factor	LOF Supp 3 weighting	LOF Supp 3 factor	LOF Supp 4 weighting	LOF Supp 4 factor
Natural Forces	Earth Movement	Above Ground Facility	-	-	0.30	15	'EarthMovement'	Leak.AssetGroupCalc = 'Riser'	Total Count	0.70	Landslide Leak rates for categories based on attribute Landslide.LS_Hazard: 1. Hazard Level 1: 0.00000230 2. Hazard Level 2 :0.00000230 3. Hazard Level 3: 0.00000291 4. Hazard Level 4: 0.00000394 5. Hazard Level 5 :0.00000394 - Default case: 0.00000230	-	-	-	-	-	-
Natural Forces	Earth Movement	Reg Station	-	-	0.10	15		Leak.AssetGroupCalc = 'Regulator'	Total Count	0.90	Landslide Leak rates for categories based on attribute Landslide.LS_Hazard: 1. Hazard Levels 1-5: 0.00002348 - Default case: 0.00002348	-	-	-	-	-	-
Natural Forces	Earthquake	Main	-	-	-	-	Leak.SubThreatCalc = 'Earthquake'	Leak.AssetGroupCalc = 'Main'	Total Length	0.5	Fault Intersection Leak rates for categories based on spatial intersect with Faults_Buffers: 1. Yes: 0.00020990 2. No: 0	0.5	PGA / Liquefaction Factor Leak rates for categories based on PGA and Liquefaction hazard value: 1. (PGA 0.1*LIQ_Hazard) >=0.8: 0.00020990 2. Else: 0	-	-	-	-
Natural Forces	Earthquake	Service	-	-	-	-		Leak.AssetGroupCalc = 'Service'	Total Length	0.5	Fault Intersection Leak rates for categories based on spatial intersect with Faults_Buffers: 1. Yes: 0.00052572 2. No: 0	0.5	PGA / Liquefaction Factor Leak rates for categories based on PGA and Liquefaction hazard value: 1. (PGA 0.1*LIQ_Hazard) >=0.8: 0.00052572 2. Else: 0	-	-	-	-
Natural Forces	Earthquake	Above Ground Facility	-	-	-	-		Leak.AssetGroupCalc = 'Riser'	Total Count	0.5	Fault Intersection Leak rates for categories based on spatial intersect with Faults_Buffers: 1. Yes: 0.00001476 2. No: 0	0.5	PGA / Liquefaction Factor Leak rates for categories based on PGA and Liquefaction hazard value: 1. (PGA 0.1*LIQ_Hazard) >=0.8: 0.00001476 2. Else: 0	-	-	-	-
Natural Forces	Earthquake	Reg Station	-	-	-	-		Leak.AssetGroupCalc = 'Regulator'	Total Count	0.5	Fault Intersection Leak rates for categories based on spatial intersect with Faults_Buffers: 1. Yes: 0.00021364 2. No: 0	0.5	PGA / Liquefaction Factor Leak rates for categories based on PGA and Liquefaction hazard value: 1. (PGA 0.1*LIQ_Hazard) >=0.8: 0.00021364 2. Else: 0	-	-	-	-
Natural Forces	Flooding	Main	-	-	-	15	Leak.SubThreatCalc = 'Flood'	Leak.AssetGroupCalc = 'Main'	Total Length	1.0	Flood Zone Leak rates for categories based on attribute FEMAFlood.FloodZoneOccurenceand DIMP_WaterCrossings: 1. If North Valley or North Bay divisions see lookup DIMP_WaterCrossings else In 00-yr flood zone: 0.00021772 2. Else: 0	-	-	-	-	-	-
Natural Forces	Flooding	Service	-	-	0.50	15		Leak.AssetGroupCalc = 'Service'	Total Length	0.50	Flood Zone Leak rates for categories based on attribute FEMAFLood.FloodZoneOccurence: 1. In 100-yr flood zone: 0.00037014 2. Else: 0	-	-	-	-	-	-
Natural Forces	Flooding	Above Ground Facility	-	-	0.50	15		Leak.AssetGroupCalc = 'Riser'	Total Count	0.50	Flood Zone Leak rates for categories based on attribute FEMAFLood.FloodZoneOccurence: 1. In 100-yr flood zone: 0.00000238 2. Else: 0	-	-	-	-	-	-
Natural Forces	Flooding	Reg Station	-	-	0.50	15		Leak.AssetGroupCalc = 'Regulator'	Total Count	0.50	Flood Zone Leak rates for categories based on attribute FEMAFLood.FloodZoneOccurence: 1. In 100-yr flood zone: 0.00006880 2. Else: 0	-	-	-	-	-	-
Natural Forces	Lightning	Main	-	-	1.00	5	Leak.SubThreatCalc = 'Lightning'	Leak.AssetGroupCalc = 'Main'	Total Length	-	-	-	-	-	-	-	-
Natural Forces	Lightning	Service	-	-	1.00	5		Leak.AssetGroupCalc = 'Service'	Total Length	-	-	-	-	-	-	-	-
Natural Forces	Lightning	Above Ground Facility	-	-	1.00	5		Leak.AssetGroupCalc = 'Riser'	Total Count	-	-	-	-	-	-	-	-
Natural Forces	Lightning	Reg Station	-	-	1.00	5		Leak.AssetGroupCalc = 'Regulator'	Total Count	-	-	-	-	-	-	-	-
Natural Forces	Other	Main	-	-	1.00	5	Leak.SubThreatCalc = 'OtherNF'	Leak.AssetGroupCalc = 'Main'	Total Length	-	-	-	-	-	-	-	-
Natural Forces	Other	Service	-	-	1.00	5		Leak.AssetGroupCalc = 'Service'	Total Length	-	-	-	-	-	-	-	-
Natural Forces	Other	Above Ground Facility	-	-	1.00	5		Leak.AssetGroupCalc = 'Riser'	Total Count	-	-	-	-	-	-	-	-
Natural Forces	Other	Reg Station	-	-	1.00	5		Leak.AssetGroupCalc = 'Regulator'	Total Count	-	-	-	-	-	-	-	-
Natural Forces	Root Damage	Main	-	-	1.00	10	Leak.SubThreatCalc = 'Roots'	Leak.AssetGroupCalc = 'Main'	Total Length	-	-	-	-	-	-	-	-
Natural Forces	Root Damage	Service	-	-	1.00	10		Leak.AssetGroupCalc = 'Service'	Total Length	-	-	-	-	-	-	-	-
Natural Forces	Tsunami	Main	-	-	-	-	Leak.SubThreatCalc = 'Tsunami'	Leak.AssetGroupCalc = 'Main'	Total Length	1.00	Potential Tsunami Inundation Area Leak rates for categories based on spatial intersect with tsunami_inundation_area: 1. Yes: 0.00000077 2. No: 0	-	-	-	-	-	-
Natural Forces	Tsunami	Service	-	-	-	-		Leak.AssetGroupCalc = 'Service'	Total Length	1.00	Potential Tsunami Inundation Area Leak rates for categories based on spatial intersect with tsunami_inundation_area: 1. Yes: 0.00000077 2. No: 0	-	-	-	-	-	-
Natural Forces	Tsunami	Above Ground Facility	-	-	-	-		Leak.AssetGroupCalc = 'Riser'	Total Count	1.00	Potential Tsunami Inundation Area Leak rates for categories based on spatial intersect with tsunami_inundation_area: 1. Yes: 0.00000077 2. No: 0	-	-	-	-	-	-
Natural Forces	Tsunami	Reg Station	-	-	-	-		Leak.AssetGroupCalc = 'Regulator'	Total Count	1.00	Potential Tsunami Inundation Area Leak rates for categories based on spatial intersect with tsunami_inundation_area: 1. Yes: 0.00000077 2. No: 0	-	-	-	-	-	-
Other Outside Forces	Electrical Faci ities	Main	0.333	10	0.333	10	Leak.SubThreatCalc = 'Electrica Damage'	Leak.AssetGroupCalc = 'Main'	Total Length	0.333	Material Leak rates for categories based on Materia Desc: 1. Plastic or Unknown: 0.0001957 2. Metallic: 0 - Default case: covered in case 1 above.	-	-	-	-	-	-
Other Outside Forces	Electrical Faci ities	Service	0.25	10	0.25	10		Leak.AssetGroupCalc = 'Service'	Total Length	0.25	Joint Trench Leak rates for categories based on attribute Service.JOINTTRENCHINDICATOR: 1. Y or UNK: 0.00038649 2. N: 0.00004109 - Default case: covered in case 1 above.	0.25	Material Leak rates for categories based on MaterialDesc: 1. Plastic or Unknown: 0.00024856 2. Metallic: 0 - Default case: covered in case 1 above.	-	-	-	-
Other Outside Forces	Electrical Faci ities	Above Ground Facility	1.00	10	-	-		Leak.AssetGroupCalc = 'Riser'	Total Count	-	-	-	-	-	-	-	-
Other Outside Forces	Electrical Faci ities	Reg Station	1.00	10	-	-		Leak.AssetGroupCalc = 'Regulator'	Total Count	-	-	-	-	-	-	-	-
Other Outside Forces	Fire or Explosion	Main	1.00	10	-	-	Leak.SubThreatCalc = 'FireExplosion'	Leak.AssetGroupCalc = 'Main'	Total Length	-	-	-	-	-	-	-	-
Other Outside Forces	Fire or Explosion	Service	1.00	10	-	-		Leak.AssetGroupCalc = 'Service'	Total Length	-	-	-	-	-	-	-	-
Other Outside Forces	Fire or Explosion	Above Ground Facility	0.90	10	-	-		Leak.AssetGroupCalc = 'Riser'	Total Count	0.10	High Fire Threat Areas Leak rates for categories based on HighFireThreatDist.CPUC Tier: 1. "1" "2" or "3": 0.006 2. Else: 0	-	-	-	-	-	-
Other Outside Forces	Fire or Explosion	Reg Station	1.00	10	-	-		Leak.AssetGroupCalc = 'Regulator'	Total Count	-	-	-	-	-	-	-	-
Other Outside Forces	Rodent	Main	1.00	10	-	-	Leak.SubThreatCalc =	Leak.AssetGroupCalc = 'Main'	Total Length	-	-	-	-	-	-	-	-
Other Outside Forces	Rodent	Service	1.00	10	-	-		Leak.AssetGroupCalc = 'Service'	Total Length	-	-	-	-	-	-	-	-

Threat	Sub-Threat	Applicable Asset Type	LOF District Baseline weighting	LOF District Baseline timeframe (yrs)	LOF Plat Baseline weighting	LOF Plat Baseline timeframe (yrs)	Baseline | OLS: Leak attribute query		Baseline: Asset attribute query [additional condition: InstalledCompletionDate excludes analysis year]	LOF Supp 1 weighting	LOF Supp 1 factor	LOF Supp 2 weighting	LOF Supp 2 factor	LOF Supp 3 weighting	LOF Supp 3 factor	LOF Supp 4 weighting	LOF Supp 4 factor
Other Outside Forces	Rodent	Above Ground Facility	1.00	10	-	-	'Rodent'	Leak.AssetGroupCalc = 'Riser'	Total Count	-	-	-	-	-	-	-	-
Other Outside Forces	Rodent	Reg Station	1.00	10	-	-		Leak.AssetGroupCalc = 'Regulator'	Total Count	-	-	-	-	-	-	-	-
Other Outside Forces	Previously Damaged	Main	1.00	10	-	-	Leak.SubThreatCalc = 'PrevDmgAG'	Leak.AssetGroupCalc = 'Main'	Total Length	-	-	-	-	-	-	-	-
Other Outside Forces	Previously Damaged	Service	1.00	10	-	-		Leak.AssetGroupCalc = 'Service'	Total Length	-	-	-	-	-	-	-	-
Other Outside Forces	Previously Damaged	Above Ground Facility	1.00	10	-	-		Leak.AssetGroupCalc = 'Riser'	Total Count	-	-	-	-	-	-	-	-
Other Outside Forces	Previously Damaged	Reg Station	1.00	10	-	-		Leak.AssetGroupCalc = 'Regulator'	Total Count	-	-	-	-	-	-	-	-
Other Outside Forces	Third Party	Main	1.00	10	-	-	Leak.SubThreatCalc = '3rdParty'	Leak.AssetGroupCalc = 'Main'	Total Length	-	-	-	-	-	-	-	-
Other Outside Forces	Third Party	Service	1.00	10	-	-		Leak.AssetGroupCalc = 'Service'	Total Length	-	-	-	-	-	-	-	-
Other Outside Forces	Third Party	Above Ground Facility	1.00	10	-	-		Leak.AssetGroupCalc = 'Riser'	Total Count	-	-	-	-	-	-	-	-
Other Outside Forces	Third Party	Reg Station	1.00	10	-	-		Leak.AssetGroupCalc = 'Regulator'	Total Count	-	-	-	-	-	-	-	-
Other Outside Forces	Vehicle	Main	1.00	10	-	-	Leak.SubThreatCalc = 'Vehicle'	Leak.AssetGroupCalc = 'Main'	Total Length	-	-	-	-	-	-	-	-
Other Outside Forces	Vehicle	Service	1.00	10	-	-		Leak.AssetGroupCalc = 'Service'	Total Length	-	-	-	-	-	-	-	-
Other Outside Forces	Vehicle	Above Ground Facility	-	-	-	-		Leak.AssetGroupCalc = 'Riser'	Total Count	0.50	Customer Class Leak rates for categories based on ServiceLocation.CurbMeterIndicator and Meterset Cust_Class_Cd: 1. ServiceLocation.CurbMeterIndicator = "Y": 0 2. Meter.Cust_Class_Cd = "COM/IND": 6.106E-5 3. Else: 1.057E-5	0.5	Population Density Leak rates for categories based on ServiceLocation.CurbMeterIndicator and spatial intersect with CensusBlock: 1. ServiceLocation.CurbMeterIndicator = "Y": 0 2. Pop Density Low (People per sq mile ≤ 5 000): 1.949E-5 3. Pop Density High (People per sq mile >9 000): 1.022E-5 4. Pop Density Medium (5 000 < people per sq mile ≤ 9 000): 0.696E-5	-	-	-	-
Other Outside Forces	Vehicle	Reg Station	-	-	-	-		Leak.AssetGroupCalc = 'Regulator'	Total Count	1.0	Vaults Leak rates for categories based on RegulatorStation.VAULTGUID and RegulatorStation.NUMBEROFVAULTS: 1. VAULTGUID is not null OR NUMBEROFVAULTS >0: 0 2. Else: 0.00010145	-	-	-	-	-	-
Other Outside Forces	Vandalism	Main	1.00	10	-	-	Leak.SubThreatCalc = 'Vandalism'	Leak.AssetGroupCalc = 'Main'	Total Length	-	-	-	-	-	-	-	-
Other Outside Forces	Vandalism	Service	1.00	10	-	-		Leak.AssetGroupCalc = 'Service'	Total Length	-	-	-	-	-	-	-	-
Other Outside Forces	Vandalism	Above Ground Facility	1.00	10	-	-		Leak.AssetGroupCalc = 'Riser'	Total Count	-	-	-	-	-	-	-	-
Other Outside Forces	Vandalism	Reg Station	1.00	10	-	-		Leak.AssetGroupCalc = 'Regulator'	Total Count	-	-	-	-	-	-	-	-
Other	Other	Main	1.00	5	-	-	Leak.SubThreatCalc = 'Other - Other'	Leak.AssetGroupCalc = 'Main'	Total Length	-	-	-	-	-	-	-	-
Other	Other	Service	1.00	5	-	-		Leak.AssetGroupCalc = 'Service'	Total Length	-	-	-	-	-	-	-	-
Other	Other	Above Ground Facility	1.00	5	-	-		Leak.AssetGroupCalc = 'Riser'	Total Count	-	-	-	-	-	-	-	-
Other	Other	Reg Station	1.00	5	-	-		Leak.AssetGroupCalc = 'Regulator'	Total Count	-	-	-	-	-	-	-	-

Severity
(see LoF pages for applicable asset types per sub-threat)

Sub-Threat	Severity Class	Factor Value
Corrosion - Atmospheric	Medium	3.1
Corrosion - External	Medium	3.1
Corrosion - Internal	Medium	3.1
Equipment - Miscellaneous	Low	0.1
Equipment - Seal Failure	Low	0.1
Excavation Damage - Excavation Damage	High	19.9
Incorrect Operation - Crossbore	High	19.9
Incorrect Operation - Incorrect Operations	High	19.9
Incorrect Operation - Construction Defect	High	19.9
Incorrect Operation - Other Weld Fa lure	High	19.9
Incorrect Operation - Girth Weld Failure	High	19.9
Incorrect Operation - Plastic Tee Cap	High	19.9
Incorrect Operation - Fusion Fa lure	High	19.9
Material/Weld Fail - Longitudinal Weld Failure	Medium	3.1
Material/Weld Fail - Metallic Material Failure	Medium	3.1
Material/Weld Fail - Plastic Material Failure Fitting	Medium	3.1
Material/Weld Fail - Plastic Material Failure BOP	Medium	3.1
Material/Weld Fail - Compression Coupling	Medium	3.1
Material/Weld Fail - Plastic Tee Cap Failure	Medium	3.1
Natural Forces - Earthquake	High	19.9
Natural Forces - Earth Movement	High	19.9
Natural Forces - Flooding	High	19.9
Natural Forces - Lightning	High	19.9
Natural Forces - Other	High	19.9
Natural Forces - Root Damage	High	19.9
Natural Forces - Tsunami	High	19.9
Other Outside Force - Fire or Explosion	High	19.9
Other Outside Force - Rodent	High	19.9
Other Outside Force - Previously damaged	High	19.9
Other Outside Force - Electrical Facilities	High	19.9
Other Outside Force -Third Party	High	19.9
Other Outside Force -Vehicle	High	19.9
Other Outside Force -Vandalism	High	19.9
Other - Other	High	19.9

Population Density
(appl cable to all asset types)

Population Density	Feature class and query (if applicable)	Factor Value
High: Special impact location[1]	- VendorPublicAssembly.CONFIRMEDSTATUS_Desc <> 'Confirmed Non-PA' - LeakSurveyPolygon.LEAKSURVEYTYPE_Desc in ('Church' 'Hospital' 'Licensed Day Care' Electric Substation' 'Other Public Assembly' 'School' 'Public Gathering (ie Park)') OR LeakSurveyPolygon.LEAKSURVEYFREQUENCY_Desc in ('Annual Leak Survey' 'Quarter-Annual Leak Survey' 'Semi-Annual Leak Survey') - Meterset.CURR_TRANS_CD= 'S' AND Meterset.SP_TYPE_DESCR in ('Gas-Mtr Com-Complex' 'Gas-Mtr-Com-Lg-Standrd/Elvated' 'Gas-Mtr-Com-Lg-Standrd' 'Gas-Mtr-Ind-Lg-Standrd/Elvated' 'Gas-Mtr-Ind-Lg-Standrd' 'Gas-Mtr-Res-Complex' 'Gas-Mtr-Ind-Complex') - Railway (Landbase) - BARTRail	1.73
High: People per sq mile > 9 000[2]	- CensusBlock.Population - CensusBlock.Shape.area	1.73
Medium: 5 000 < people per sq mile ≤ 9 000[2]		0.93
Low: People per sq mile ≤ 5 000[2]		0.27
Unknown (Default)	*n/a*	1.73

[1] Applies to risk objects within 100 feet of these locations.
[2] Applies to risk objects spatially intersecting these locations.

Migration and Accumulation
(applicable to noted asset types)

Characteristic	Feature class and query (if applicable)	Factor Value
Aboveground/Exposed	- All Above Ground Facilities (except inside structure) - All Reg Stations - Mains that intersect PipeExposure	0.31
Buried/Inside	- All Services - All Mains (except those that intersect PipeExposure) - Above Ground Facilities that are inside structure[3] - Above Ground Facilities that are within 100 feet of encroachments: SAPOtherCWDetail.DriverCodeDesc LIKE '%Overbuild%' OR SAPOtherCWDetail.DriverCodeDesc LIKE '%Encroachment%' OR upper(FieldReview<asset>.Issue_Description) LIKE '%VERBUILD%'	1.69

[3] Meterset.CURR_TRANS_CD= 'S' AND
(Meterset.MTR_LOC_CD like '_A-'
OR Meterset.MTR_LOC_CD like '_U-'
OR Meterset.MTR_LOC_CD like '_Y_'
OR Meterset.MTR_LOC_CD like '__K'
OR Meterset.MTR_LOC_CD like '_AC'
OR Meterset.MTR_LOC_CD like '_AE'
OR Meterset.MTR_LOC_CD like '_AG'
OR Meterset.MTR_LOC_CD like '_AM'
OR Meterset.MTR_LOC_CD like '_AN'
OR Meterset.MTR_LOC_CD like '_AP'
OR Meterset.MTR_LOC_CD like '_AQ'
OR Meterset.MTR_LOC_CD like '_AT'
OR Meterset.MTR_LOC_CD like '_AU'
OR Meterset.MTR_LOC_CD like '_AV'
OR Meterset.MTR_LOC_CD like '_UC'
OR Meterset.MTR_LOC_CD like '_UE'
OR Meterset.MTR_LOC_CD like '_UG'
OR Meterset.MTR_LOC_CD like '_UM'
OR Meterset.MTR_LOC_CD like '_UN'
OR Meterset.MTR_LOC_CD like '_UP'
OR Meterset.MTR_LOC_CD like '_UQ'
OR Meterset.MTR_LOC_CD like '_UT'
OR Meterset.MTR_LOC_CD like '_UU'
OR Meterset.MTR_LOC_CD like '_UV')

Pressure
(applicable to all asset types)

Pressure Classification	Feature class and query (if applicable)	Factor Value
High Pressure	- Main: DistributionMainCalc.PressureClassification = 'HP' - Service and Above Ground Facility: Service.PressureClassification = 'HP' (for AGF assets join by ServiceID) - Regulator Station: RegStation.PressureClassification = 'HP'	1.13
Semi-High Pressure	- Main: DistributionMainCalc.PressureClassification = 'SHP' - Service and Above Ground Facility: Service.PressureClassification = 'SHP' (for AGF assets join by ServiceID) - Regulator Station: RegStation.PressureClassification = 'SHP'	0.93
Low Pressure	- Main: DistributionMainCalc.PressureClassification = 'LP' - Service and Above Ground Facility: Service.PressureClassification = 'LP' (for AGF assets join by ServiceID) - Regulator Station: RegStation.PressureClassification = 'LP'	0.87
Unknown (Default)	*n/a*	1.13

EFV
(applicable to Services and Above Ground Facilities - see LoF pages for appl cable asset types per sub-threat)

Sub Threat	Severity Class	Factor Value	
		EFV[4]	No EFV
Corrosion - Atmospheric	Medium	0.57	1.00
Corrosion - External	Medium	0.57	1.00
Corrosion - Internal	Medium	0.57	1.00
Equipment - Miscellaneous	Low	0.81	1.00
Equipment - Seal Failure	Low	0.81	1.00
Excavation Damage - Excavation Damage	High	0.37	1.00
Incorrect Operation - Crossbore	High	0.37	1.00
Incorrect Operation - Incorrect Operations	High	0.37	1.00
Incorrect Operation - Construction Defect	High	0.37	1.00
Incorrect Operation - Other Weld Failure	High	0.37	1.00
Incorrect Operation - Girth Weld Failure	High	0.37	1.00
Incorrect Operation - Plastic Tee Cap	High	1.00	1.00
Incorrect Operation - Fusion Failure	High	0.37	1.00
Material/Weld Fail - Longitudinal Weld Failure	Medium	0.57	1.00
Material/Weld Fail - Metallic Material Failure	Medium	0.57	1.00
Material/Weld Fail - Plastic Material Failure Fitting	Medium	0.57	1.00
Material/Weld Fail - Plastic Material Failure BOP	Medium	0.57	1.00
Material/Weld Fail - Compression Coupling	Medium	0.57	1.00
Material/Weld Fail - Plastic Tee Cap Failure	Medium	1.00	1.00
Natural Forces - Earthquake	High	0.37	1.00
Natural Forces - Earth Movement	High	0.37	1.00
Natural Forces - Flooding	High	0.37	1.00
Natural Forces - Lightning	High	0.37	1.00
Natural Forces - Other	High	0.37	1.00
Natural Forces - Root Damage	High	0.37	1.00
Natural Forces - Tsunami	High	0.37	1.00
Other Outside Force - Fire or Explosion	High	0.37	1.00
Other Outside Force - Rodent	High	0.37	1.00
Other Outside Force - Previously damaged	High	0.37	1.00
Other Outside Force - Electrical Facilities	High	0.37	1.00
Other Outside Force -Third Party	High	0.37	1.00
Other Outside Force -Vehicle	High	0.37	1.00
Other Outside Force -Vandalism	High	0.37	1.00
Other - Other	High	0.37	1.00

[4] Applies to all Service segments and Above Ground Facilities downstream of an EFV feature.

TOPIC	Likelihood of Failure (LoF) Model	ATTACHMENT N REVISION	5
ENGINEERS	[redacted], [redacted]	PUBLICATION DATE	7/31/2020
SUMMARY	Description and background for sub-threat LoF model, factors, and parameters.	EFFECTIVE DATE	7/31/2020

Contents

Explanation of Sub-Threat Supplemental Factor and Weighting Values

Corrosion, Atmospheric Corrosion: Main/Service/Reg

Explanation for Supplemental Factors:

No supplemental factors are used for this combination.

Explanation for Weightings:

The plat baseline factor is given 100% weight because atmospheric corrosion is assumed to affect above ground assets at a more localized level than the District.

References/Data Sources:

No supplemental factors are used for this combination. For information about the baseline factors, refer to Attachment N.

Corrosion, Atmospheric Corrosion: AGF

Explanation for Supplemental Factors:

- **Point Leak History:** A supplemental factor accounting for point leak history was included in the model, as this factor was found to be significantly correlated with sub-threat leak rate based on decision tree (partition) analysis. Points are classified as having either no past leaks, or 1 or more past leaks. The factor leak rate values for each classification were derived by determining the average annual leak rate over a five-year period (2015-2019) for points classified using pre-2015 leak history.

Explanation for Weightings:

Weightings are distributed uniformly to the plat baseline and point leak history factor. The district baseline is not used because LoF is assumed not to correlate at the district-level for this sub-threat.

References/Data Sources:

- Partition Analysis for Point Leak History Factor:
  \\rcnas01-smb\riskmgmtprd-fs01\DIMP_2020\02. DIMP Compliance\03. Risk Evaluation\1. Research\JMP AGF Atmos Corr Pt Leak Hist.doc

Corrosion, External Corrosion: Main

Explanation for Supplemental Factors:

- **CPA Leak Rate:** The factor “CPA leak rate” provides a more accurate reflection of metallic performance than the District leak rate. The factor value is the annual average leak rate of each CPA based on 9 years of external corrosion leaks, including active leaks (those that occurred on pipe segments that are still in the system) and inactive leaks (those that occurred on pipe segments that have since been removed or replaced). The leak rates are normalized by miles of steel main in each CPA:

$$LOF_{CPALeakRate,CPAi} = \frac{\#\ of\ Leaks_{ExternalCorrosion,Main,2011-2019,CPAi}}{Miles_{SteelMain,CPAi} \times 9\ Years}$$

- 9 years (2011-2019) of leak data was selected to maximize the leak data population without having to account for accelerated leak survey performed in 2009-2010 in the normalization calculations.
- To reduce the influence of small populations, leak rates are only used from CPAs with at least 0.1 mile of steel main. If the steel main population is below 0.1 mile, the District baseline leak rate will be used. This cutoff was chosen after a review of CPA leak rates, which showed a natural break in leak counts when a CPA contained at least 0.1 mile of steel main.
- Note that the GDGIS CPA boundaries are currently geographical and have not been field verified as electrically accurate. This is being addressed in the multi-year Enhanced CP Survey effort led by Corrosion Engineering.

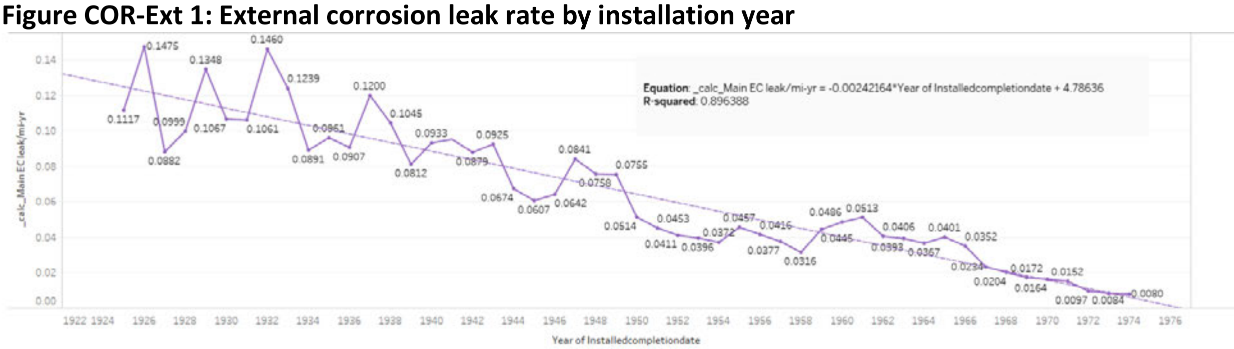
- **Coating and CP Status:** The factor "Coating and CP status" has four combinations of CP (protected or unprotected) and Coating (coated or bare). The input attributes use data from GPRP, GDGIS, and leak repairs. The factor values were calculated by associating active external corrosion leaks repaired between 2011-2019 with main features and dividing the count of leaks by the length of steel in each of the four categories:

$$LOF_{CP+Coating,Category\ i} = \frac{\#\ of\ Leaks_{ExternalCorrosion,Main,2011-2019,Category\ i}}{Miles_{SteelMain,Category\ i} \times 9\ Years}$$

  - The factor values are applied to features in the corresponding categories, which are determined using GDGIS and GPRP data for cathodic protection and coating status, leak data for bare locations, and Field Review for unprotected locations. In cases of conflicting data, the more conservative value is applied.

- **Age:** The factor "Age" models the relationship between external corrosion leak rate and installation year. This factor is a simple linear regression applicable to steel installed from 1925-1974, derived using active main external corrosion leaks repaired from 2011-2019 (see Figure 1).

Figure COR-Ext 1: External corrosion leak rate by installation year



- **Segment Leak History:** A supplemental factor accounting for segment leak history was included in the model, as this factor was found to be significantly correlated with sub-threat leak rate based on decision tree (partition) analysis. Segments are classified as having 2 or more past leaks, 1 past leak, or no past leaks. The factor leak rate values for each classification were derived by determining the average annual leak rate over a five-year period (2015-2019) for segments classified using pre-2015 leak history.

Explanation for Weightings:

- District Baseline leak rate: 0.0
  This weighting is zero because the District-level baseline leak rate will be used as a backup for the CPA leak rate.
- Plat Baseline leak rate: 0.0
  The Plat Baseline is not used because LoF is assumed not to correlate at the plat-level for this sub-threat.
- Segment Leak History: 0.2
  This weighting is 0.2 because there is strong confidence that segment-specific leak history represents the likelihood of a future external corrosion leak.
- CPA leak rate: 0.4
  Given the importance of cathodic protection for steel pipe, there is most confidence that the CPA-specific leak rates are representative of the likelihood for a future external corrosion leak.
- CP + Coating: 0.35
  There is higher confidence that the simplified combinations of cathodic protection status and coating status are correlated with external corrosion leaks. During a meeting with Corrosion Engineering, it was discussed that locations with bare and unprotected pipe would have a significantly higher likelihood of leaking and this factor should be weighted higher. Additionally, GDGIS now reflects the local corrosion maps in identifying these locations. Therefore, the confidence in this factor is higher.
- Age: 0.05
  This weighting is 0.05 because the correlation between installation year and leak rate is moderate.

References/Data Sources:

- Tableau analysis:
  \\rcnas01-smb\riskmgmtprd-fs01\DIMP_2020\02. DIMP Compliance\03. Risk Evaluation\1. Research\Corrosion LoF\Corrosion LOF 2020.twb
  - Source data:
    \\rcnas01-smb\riskmgmtprd-fs01\DIMP_2020\02. DIMP Compliance\03. Risk Evaluation\1. Research\Corrosion LoF
- Partition Analysis for Segment Leak History Factor:
  \\rcnas01-smb\riskmgmtprd-fs01\DIMP_2020\02. DIMP Compliance\03. Risk Evaluation\1. Research\JMP Main Ext Corr Seg Leak Hist.doc

Corrosion, External Corrosion: Service

Explanation for Supplemental Factors:

Current supplemental factors:

- **CPA Leak Rate:** The factor "CPA leak rate" provides a more accurate reflection of the steel's performance than the previously used District leak rate. The factor value is the annual average leak rate of each CPA based on 9 years of active and inactive external corrosion leak data (2011-2019), normalized by miles of steel services in each CPA:

$$LOF_{CPALeakRate,CPAi} = \frac{\#\ of\ Leaks_{ExternalCorrosion,Service,2011-2019,CPAi}}{Miles_{SteelServices,CPAi} \times 9\ Years}$$

  - 9 years of leak data was selected to maximize the leak data population without having to account for accelerated leak survey performed in 2009-2010 in the normalization calculations.
  - To reduce the influence of small populations, leak rates are only being used from CPAs with at least 0.1 mile of steel services. If the steel service population is below 0.1 mile, the District baseline leak rate will be used. This cutoff was chosen after a review of CPA leak rates, which showed a natural break in leak counts when a CPA contained at least 0.1 mile of steel services.
  - Note that the GDGIS CPA boundaries are currently geographical and have not been field verified as electrically accurate. This is being addressed in the multi-year Enhanced CP Survey effort led by Corrosion Engineering.
- **Segment Leak History:** A supplemental factor accounting for segment leak history was included in the model, as this factor was found to be significantly correlated with sub-threat leak rate based on decision tree (partition) analysis. Segments are classified as having 2 or more past leaks, 1 past leak, or no past leaks. The factor leak rate values for each classification were derived by determining the average annual leak rate over a five-year period (2015-2019) for segments classified using pre-2015 leak history.

Explanation for Weightings:

- District Baseline leak rate: 0.00
  This weighting is zero because the District-level baseline leak rate will be used as a backup for the CPA leak rate.
- Plat Baseline leak rate: 0.0
  The Plat Baseline is not used because LoF is assumed not to correlate at the plat-level for this sub-threat.
- Segment Leak History: 0.50
  This weighting is 0.50 because there is strong confidence that segment-specific leak history represents the likelihood of a future external corrosion leak.
- CPA leak rate: 0.50
  This weighting is 0.50 because it has the most confidence that the leak rates are representative of the likelihood for a future external corrosion leak.

References/Data Sources:

- Partition Analysis for Segment Leak History Factor:
  \\rcnas01-smb\riskmgmtprd-fs01\DIMP_2020\02. DIMP Compliance\03. Risk Evaluation\1. Research\JMP Service Ext Corr Seg Leak Hist.doc

Corrosion, Internal Corrosion: Main/Service/AGF/Reg

Explanation for Supplemental Factors:

No supplemental factors are used for this combination.

Explanation for Weightings:

The district baseline is given 100% weight. This is based on an assumption of greater geographical randomness in the absence of data or reason to justify more specific factors.

References/Data Sources:
No supplemental factors are used for this combination. For information about the baseline factors, refer to Attachment N.

Equipment Failure, Miscellaneous: Main/Service

Explanation for Supplemental Factors:

- **Segment Leak History:** A supplemental factor accounting for segment leak history was included in the model, as this factor was found to be significantly correlated with sub-threat leak rate based on decision tree (partition) analysis. Segments are classified as having either no past leaks, or 1 or more past leaks. The factor leak rate values for each classification were derived by determining the average annual leak rate over a five-year period (2015-2019) for segments classified using pre-2015 leak history.

Explanation for Weightings:

- Weightings are distributed uniformly to the district baseline and segment leak history factor. The Plat Baseline is not used because LoF is assumed not to correlate at the plat-level for this sub-threat.

References/Data Sources:

- Partition Analysis for Segment Leak History Factor – Main: \\rcnas01-smb\riskmgmtprd-fs01\DIMP_2020\02. DIMP Compliance\03. Risk Evaluation\1. Research\JMP Main Equip Misc Seg Leak Hist.doc
- Partition Analysis for Segment Leak History Factor – Service: \\rcnas01-smb\riskmgmtprd-fs01\DIMP_2020\02. DIMP Compliance\03. Risk Evaluation\1. Research\JMP Service Equip Misc Seg Leak Hist.doc

Equipment Failure, Miscellaneous: AGF/Reg

Explanation for Supplemental Factors:
No supplemental factors are used for this combination.

Explanation for Weightings:
The district baseline is given 100% weight. This is based on an assumption of greater geographical randomness in the absence of data or reason to justify more specific factors.

References/Data Sources:
No supplemental factors are used for this combination. For information about the baseline factors, refer to Attachment N.

Equipment Failure, Seal Failure: Main/Service/AGF/Reg

Explanation for Supplemental Factors:

- **Segment/Point Leak History:** A supplemental factor accounting for segment/point leak history was included in the model, as this factor was found to be significantly correlated with sub-threat leak rate based on decision tree (partition) analysis. Segments/points are classified as having either no past leaks, or 1 or more past leaks. The factor leak rate values for each classification were derived by determining the average annual leak rate over a five-year period (2015-2019) for segments/points classified using pre-2015 leak history.

Explanation for Weightings:

- Weightings are distributed uniformly to the district baseline and segment/point leak history factor. The Plat Baseline is not used because LoF is assumed not to correlate at the plat-level for this sub-threat.

References/Data Sources:

- Partition Analysis for Segment Leak History Factor – Main: \\rcnas01-smb\riskmgmtprd-fs01\DIMP_2020\02. DIMP Compliance\03. Risk Evaluation\1. Research\JMP Main Seal Fail Seg Leak Hist.doc
- Partition Analysis for Segment Leak History Factor – Service: \\rcnas01-smb\riskmgmtprd-fs01\DIMP_2020\02. DIMP Compliance\03. Risk Evaluation\1. Research\JMP Service Seal Fail Seg Leak Hist.doc
- Partition Analysis for Segment Leak History Factor – AGF: \\rcnas01-smb\riskmgmtprd-fs01\DIMP_2020\02. DIMP Compliance\03. Risk Evaluation\1. Research\JMP AGF Seal Fail Pt Leak Hist.doc
- Partition Analysis for Segment Leak History Factor – Regulator Station: \\rcnas01-smb\riskmgmtprd-fs01\DIMP_2020\02. DIMP Compliance\03. Risk Evaluation\1. Research\JMP Reg Seal Fail Pt Leak Hist.doc

Excavation Damage, Excavation Damage: Main

Explanation for Supplemental Factors:

Leak History, Depth of Cover, Material: Supplemental factors accounting for (in order of decreasing leak rate) (1) depth of cover, (2) segment excavation leak history, (3) and material (plastic or metal) is included in the model, as those factors showed a statistically significant correlation with excavation leak rate. The groupings were determined by a decision tree analysis. The factor leak rate values for each grouping were derived by determining the average annual number of leaks over the five-year period (2015-2019) and dividing by the miles of main for that factor. Mains that have leaked in the past have higher likelihoods of future leaks. The higher leak rate for segments damaged by excavation in the past could be due to continued excavation exposure in the same area, due to difficult to locate, or being shallow. Metal pipe has a lower leak rate compared to plastic pipe and this is reasonable since metal is more easily located and more durable and resilient.

  - The shallow factor was based on analysis of leak rates and cover depth. The cut-off for shallow cover depth (<19 inches) was determined by finding a natural break in the leak rate by cover depth data. The values are applied using SAP leak repair data, as well as field review data, to identify segments at shallow depths.
  - Past leak experience was determined by grouping those segments that had a leak prior to 2015 versus those that did not and including this grouping in the decision tree analysis described above.

Explanation for Weightings:

- The supplemental factor is given the higher weighting of 70% as it had a significant correlation to leak rate.
- The district baseline factor is given a lower weighting of 30% to account for geographical effects and inactive leaks (those that occurred on pipe segments that have since been removed or replaced).

References/Data Sources:

Excavation Factor Value Analysis: \\rcnas01-smb\riskmgmtprd-fs01:\DIMP_2020\02. DIMP Compliance\03. Risk Evaluation\1. Research\JMP Main Excev Partition.doc

Excavation Damage, Excavation Damage: Service

Explanation for Supplemental Factors:

Leak History, Depth of Cover, Material: Supplemental factors accounting for (1) depth of cover segment, (2) segment excavation leak history , (3) and material (metal or plastic) is included in the model, as those factors showed a significant statistical correlation with excavation leak rate. Shallow services and services that have leaked in the past have higher likelihoods of future leaks. The higher leak rate for segments damaged by excavation in the past could be due to continued excavation exposure opportunity in the same area, due to difficult to locate, or being shallow.

Metal pipe has a lower leak rate compared to plastic pipe and this is reasonable since metal is more easily located and more durable and resilient.

- The groupings were determined by a decision tree analysis. The factor leak rate values for each grouping were derived by determining the average annual number of leaks over the five-year period (2015-2019) and dividing by the miles of service for that factor.
    - The shallow factor was based on analysis of leak rates and cover depth. The cut-off for shallow cover depth (<18 inches) was determined by finding a natural break in the leak rate by cover depth data. The values are applied using SAP leak repair data, as well as field review data, to identify segments at shallow depths.
    - Past leak experience was determined by grouping those segments that had a leak prior to 2015 versus those that did not.

Explanation for Weightings:

- The supplemental factor is given the higher weighting of 70% as it had a significant correlation to leak rate.
- The district baseline factor is given a lower weighting of 30% to account for geographical effects and inactive leaks (those that occurred on segments that have since been removed or replaced).

References/Data Sources:

- Excavation Factor Value Analysis: \\rcnas01-smb\riskmgmtprd-fs01:\DIMP_2020\02. DIMP Compliance\03. Risk Evaluation\1. Research\JMP Service Excav Partition.doc

Incorrect Operations, Construction Defect: Main/Service

Explanation for Supplemental Factors:

- **Leak History, Material, Installation Year:** Supplemental factors accounting for (1) segment construction defect leak history, (2) material (metal or plastic), and (3) installation year areincluded in the model, as those factors showed a significant statistical correlation with sub threat leak rate. The groupings were determined by a decision tree analysis. The factor leak rate values for each grouping were derived by determining the average annual number of leaks over the five-year period (2015-2019) and dividing by the miles of main or service for that factor.
    - Past leak experience was determined by grouping those segments that had a leak prior to 2015 versus those that did not. Segments with historic leaks have a higher likelihood of future leaks, indicating that the effects of poor construction continue for some time.
    - For mains, older plastic (pre-1976) has a higher leak rate; which is likely due to the sensitivity of Aldyl-A to construction practices (e.g. rocky backfill or stress). Older metal (<1943) also has a higher leak rate compared to newer metal, which is reasonable as construction practices have improved over time. The material and install year factor were also found to interact (i.e. they are not independent).
    - For services, plastic has a higher leak rate compared to metal, and plastic older than 1995 has a higher leak rate compared to newer plastic.

Explanation for Weightings:

- A higher weighting of 70% was given to the supplemental factors due to significant statistical correlation to leak rate.
- 15% is given to district base and 15% to plat base to allow for geographical effects and inactive leaks, and potential correlations with work centers and specific jobs.

References/Data Sources:

- Decision Tree Analysis for Main Supplemental Factor: \\rcnas01-smb\riskmgmtprd-fs01\DIMP_2020\02. DIMP Compliance\03. Risk Evaluation\1. Research\JMP Main ConstrDef Partition.doc
- Decision Tree Analysis for Service Supplemental Factor: \\rcnas01-smb\riskmgmtprd-fs01\DIMP_2020\02. DIMP Compliance\03. Risk Evaluation\1. Research\JMP Service ConstrDef Partition.doc

Incorrect Operations, Construction Defect: AGF/Reg

Explanation for Supplemental Factors:

No supplemental factors are used for this combination.

Explanation for Weightings:

Weightings are distributed with 50% to the district baseline factor and 50% to the plat baseline factor to account for the possibility of correlations to both work centers (districts as proxy) and specific jobs (plats as proxy).

References/Data Sources:
No supplemental factors are used for this combination. For information about the baseline factors, refer to Attachment N.

Incorrect Operations, Crossbore: Main/Service

Explanation for Supplemental Factors:

- **Crossbore Review, Material, Installation Date, Installation Method, Service Count:** This model estimates the likelihood of a leak due to a crossbore in terms of leaks per mile per year (leaks/mile-year) based on asset characteristics as categorized below.

  The below leak rates per parcel per year have been estimated for different categories of assets (see References/Data Sources for data and calculation details):

Table INC-Xbore 1: Legacy Crossbore Location Class Criteria as Applied to GDGIS Main Segments

Class	Criteria	Per Parcel Leak Rate [leaks/parcel-year]
1	DistMain_XB_Class[1] = 1 and Installation Date before 1/1/2017	**3 X 10 -6**
2	Material = Plastic and (Installation Date after 12/31/1984 or 1/1/1800 (Unknown))	**2 X 10 -7**
3	All other mains	**7 X 10 -8**

[1]Legacy Crossbore Class 1 main segments, where records reviewed indicated horizontal directional drilling (HDD) was performed; these are identified during GDGIS data preparation for DIMP (see reference documents below).

Table INC-Xbore 2: Legacy Crossbore Location Class Criteria as Applied to GDGIS Service Segments

Class	Criteria	Per Parcel Leak Rate [leaks/parcel-year]
1	Srv_XB_Class[1] = 1 and Installation Date before 1/1/2017	**1 X 10 -5**
2	Material = Plastic and JOINTTRENCHINDICATOR = "N"	**6 X 10 -7**
3	All other services	**1 X 10 -7**

[1]Legacy Crossbore Class 1 service segments, where records reviewed indicated installation as part of the copper service replacement program (CSRP) or where records reviewed indicate horizontal directional drilling (HDD) was performed; these are identified during GDGIS data preparation for DIMP (see reference documents below).

The DIMP risk model requires LOF factor values to be in terms of leaks per mile-year, so the values for the supplemental factor (SME_Xbore) will be calculated for each segment dynamically, using the associated service locations (risers) and segment lengths to convert from the estimated leaks per parcel-year (leaks/parcel-year) to estimated leaks per mile-year (leaks/mile-year) for each segment:

For main segments:

$$\mathrm{SME_{Xbore}} = \frac{Per\ Parcel\ Leak\ Rate_{ClassN} * \frac{Count\ of\ Downstream\ Service\ Locations}{2}}{Length\ of\ Segment}$$

For service segments:

$$\mathrm{SME_{Xbore}} = \frac{Per\ Parcel\ Leak\ Rate_{ClassN} * 1\ [Parcel]}{Length\ of\ Segment}$$

Assumptions:

The above methodology relies on the following assumptions:

- Each main segment has an equal number of parcels on both sides of street.
- For mains, the count of service locations downstream of the main represents the number of parcels (and therefore sewer lateral crossings).
- A gas main only interacts with sewer laterals on one side of the street. Therefore, the number of sewer laterals (as estimated by the number of gas services fed from a given gas main segment) should be divided by two to capture the crossings on one side of a street and is incorporated in the facility length factor.
- For services, one sewer main crossing per gas service segment.
- No new Class 1 segments have been created in 2017 and later, since the implementation of crossbore prevention practices such as post-HDD inspections.

Explanation for Weightings:

- The Plat Baseline has a weighting of 10% because LoF is assumed to be correlated at the plat-level, and this correlation is assumed to have more influence on LoF than the district baseline.
- The supplemental factor has 90% of the weighting due to the small baseline datasets and rarity of crossbores.

References/Data Sources:

- Crossbore Estimated Leak Rates: \\rcnas01-smb\riskmgmtprd-fs01\DIMP_2020\02. DIMP Compliance\03. Risk Evaluation\1. Research\Crossbore factor\Crossbore Estimated Leak Rates.pdf
- GDGIS Data (including downstream service location and crossbore class 1 identification): \\rcnas01-smb\riskmgmtprd-fs01\DIMP_2020\01. System Knowledge\02. Processed Data\RiskFinder\RF GDGIS\RiskFinder GDGIS 2020-01-15.gdb
- GDGIS Data Preparation for DIMP (including Crossbore Class 1 identification): \\rcnas01-smb\riskmgmtprd-fs01\DIMP_2020\01. System Knowledge\02. Processed Data\RiskFinder\RF GDGIS\Documentation

Incorrect Operations, Fusion Failure: Main/Service

Explanation for Supplemental Factors:

- **Installation Year:** An installation year factor is included in the model, as it showed a significant statistical correlation to fusion leak rate. The factor leak rate values, in leaks/ mile – year, are derived by determining the average annual number of leaks over a five year period (2015-2019) for each factor and dividing by the miles of main or service for that factor, with a decision tree analysis determining the significant groupings (cutoff years). Older pipe was found to have a higher leak rate compared to newer which could be due to fusion construction practices and materials improving over time.

Explanation for Weightings:

- A higher weighting of 70% was given to the supplemental factor due to significant statistical correlation to leak rate.
- 15% is given to district base and 15% to plat base to allow for geographical effects and inactive leaks, and potential correlations with work centers and specific jobs.

References/Data Sources:

- Decision Tree Analysis for Main Supplemental Factor: \\rcnas01-smb\riskmgmtprd-fs01\DIMP_2020\02. DIMP Compliance\03. Risk Evaluation\1. Research\JMP Main Fusion Partition.doc
- Decision Tree Analysis for Service Supplemental Factor: \\rcnas01-smb\riskmgmtprd-fs01\DIMP_2020\02. DIMP Compliance\03. Risk Evaluation\1. Research\JMP Service PlasFusion Partition.doc

Incorrect Operations, Incorrect Operations: Main/Service/AGF/Reg

Explanation for Supplemental Factors: .

No supplemental factors are used for this combination.

Explanation for Weightings:

Weightings are distributed with 50% to the district baseline factor and 50% to the plat baseline factor to account for the possibility of correlations to both work centers (districts as proxy) and specific jobs (plats as proxy).

References/Data Sources:

No supplemental factors are used for this combination. For information about the baseline factors, refer to Attachment N.

Incorrect Operations, Other Weld Failure: Main

Explanation for Supplemental Factors:

- **Interacting Sub-Threats, Leak History, Installation Year:** A supplemental factor for the interaction of past construction defect leaks with weld failure leaks, and for Install Year were found to be statistically significant. The past leak experience factor values were determined by grouping those segments that had a leak prior to 2015 versus those that did not. The factor leak rate values, in leaks/mile-year, are derived by determining the average annual number of leaks over a five year period (2015-2019) for each factor and dividing by the miles of main or service for that factor, with a decision tree analysis determining the significant groupings. The group that had past construction defect leaks were found to have a higher weld leak rate (leaks/mile-year) compared to the group that did not have past leaks. This is reasonable since construction practices may result in increased weld failures. Pipe older than 1949 was found to have a higher leak rate compared to newer pipe.

Explanation for Weightings:

- A weighting of 70% was assigned to the supplemental factor, which showed statistical significance.
- Weightings of 15% each were assigned to the plat and district baseline factors to account for the possibility of correlations to both work centers (districts as proxy) and specific jobs (plats as proxy).

References/Data Sources:

- Decision Tree Analysis for Supplemental Factor: \\rcnas01-smb\riskmgmtprd-fs01\DIMP_2020\02. DIMP Compliance\03. Risk Evaluation\1. Research\JMP Main Weld Partition.doc

Incorrect Operations, Other Weld Failure: Service/AGF/Reg

Explanation for Supplemental Factors:

No supplemental factors are used for this combination.

Explanation for Weightings:

Weightings are distributed with 50% to the district baseline factor and 50% to the plat baseline factor to account for the possibility of correlations to both work centers (districts as proxy) and specific jobs (plats as proxy).

References/Data Sources:

No supplemental factors are used for this combination. For information about the baseline factors, refer to Attachment N.

Incorrect Operations, Girth Weld Failure: Main

Explanation for Supplemental Factors:

- **Installation Year:** The factor leak rate values, in leaks/mile-year, are derived by determining the average annual number of leaks over a five year period (2015-2019) for each factor and dividing by the miles of main or service for that factor, with a decision tree analysis determining the significant groupings. Pipe older than 1948 was found to have a higher leak rate compared to newer pipe.

Explanation for Weightings:

- A weighting of 70% was assigned to the supplemental factor, which showed statistical significance.
- Weightings of 15% each were assigned to the plat and district baseline factors to account for the possibility of correlations to both work centers (districts as proxy) and specific jobs (plats as proxy).

References/Data Sources:

- Decision Tree Analysis for Supplemental Factor: \\rcnas01-smb\riskmgmtprd-fs01\DIMP_2020\02. DIMP Compliance\03. Risk Evaluation\1. Research\JMP Main GirthWeld Partition.doc

Incorrect Operations, Girth Weld Failure: Service

Explanation for Supplemental Factors:
No supplemental factors are used for this combination.

Explanation for Weightings:
Weightings are distributed with 50% to the district baseline factor and 50% to the plat baseline factor to account for the possibility of correlations to both work centers (districts as proxy) and specific jobs (plats as proxy).

References/Data Sources:
No supplemental factors are used for this combination. For information about the baseline factors, refer to Attachment N.

Incorrect Operations, Plastic Tee Cap Failure: Service

Explanation for Supplemental Factors:
Installation Year, Leak History: The factor leak rate values, in leaks/mile-year, are derived by determining the average annual number of leaks over a five-year period (2015-2019) for each factor and dividing by the miles of main or service for that factor, with a decision tree analysis determining the significant groupings. These tee cap leaks were classified at leak repair with a cause of construction defect or incorrect operations; this difference in leak cause distinguishes them from Plastic Material Failure Tee Cap The older tees (installed/manufactured before 1996) are assumed to be failing due to workmanship (e.g. the use of a wrench), combined with interaction with poor material. They are made of Calcon Polyacetal material. The newer caps are made of polyethylene (PE) material which is more resilient to cracking when over-tightened. **Explanation for Weightings:**

- The supplemental factor was assigned a 70% weighting, as this has a statistically significant correlation with leak rate.
- District baseline was given a 30% weighting to account for geographical effects and inactive leaks.

References/Data Sources:

- Decision Tree Analysis: \\rcnas01-smb\riskmgmtprd-fs01\DIMP_2020\02. DIMP Compliance\03. Risk Evaluation\1. Research\JMP Service PlasInsOp TeeCap Partition.doc

Material Failure, Compression Coupling: Main/AGF/ Reg

Explanation for Supplemental Factors:

No supplemental factors are used for this combination.

Explanation for Weightings:

The district baseline is given 100% weight. This is based on an assumption of greater geographical randomness in the absence of data or reason to justify more specific factors.

References/Data Sources:

No supplemental factors are used for this combination. For information about the baseline factors, refer to Attachment N.

Material Failure, Compression Coupling: Service

Explanation for Supplemental Factors:

- **Installation Year, Material, Inserted plastic:** The factor leak rate values, in leaks/mile-year, are derived by determining the average annual number of leaks over a five year period (2015-2019) for each factor and dividing by the miles of main or service for that factor, with a decision tree analysis determining the significant groupings. Plastic pipe has a higher leak rate than metal; plastic pipe older than 1981 was found to have a higher leak rate compared to newer pipe; and inserted newer plastic pipe has a higher leak rate compared to non-inserted. This is reasonable due to improvement in couplings over time, and damage can be caused during the plastic insertion process that can cause the coupling / pipe seal to leak.

Explanation for Weightings:

- A weighting of 70% was assigned to the supplemental factor, which showed statistical significance.
- Weightings of 30% each were assigned to the district baseline factors to account for the possibility of correlations to larger geographic districts.

References/Data Sources:

- Decision Tree Analysis for Supplemental Factor: \\rcnas01-smb\riskmgmtprd-fs01\DIMP_2020\02. DIMP Compliance\03. Risk Evaluation\1. Research\JMP Service ComprCoupling Partition.doc

Material Failure, Metallic Material Failure: Main/Service/AGF/Reg

Explanation for Supplemental Factors:

No supplemental factors are used for this combination.

Explanation for Weightings:

The district baseline is given 100% weight. This is based on an assumption of greater geographical randomness in the absence of data or reason to justify more specific factors.

References/Data Sources:

No supplemental factors are used for this combination. For information about the baseline factors, refer to Attachment N.

Material Failure, Plastic Material Failure Body of Pipe: Main

Explanation for Supplemental Factors:

- **Aldyl A Jana Rank, Squeeze Points, Segment Leak History**: Supplemental factors accounting for (1) Aldyl A Jana rank, (2) squeeze points, and (3) segment leak history are used in the model. The factor leak rate values, in leaks/ mile – year, are derived by determining the average annual number of leaks over a five year period (2015-2019) for each factor and dividing by the miles of main or service for that factor, with a decision tree analysis determining the significant groupings.
    - Past leak condition was determined by grouping those segments that had a leak prior to 2015 versus those that did not.
    - Squeezed main segments are defined as any segment that had been repaired prior to 2015 with a repair code likely to result in the pipe being squeezed (See Attachment J Appendix A for repair codes used). It is known that older Aldyl A (higher Jana ranking) that is squeezed can initiate slow crack growth, so the higher leak rate is reasonable.
    - The Aldyl A Jana rank data was updated using the V1.1 Jana calculator as shown in the documentation.

Explanation for Weightings:

- The supplemental factors are given a 70% weighting as these factors have significant statistical correlation with leak rate.
- District baseline was given a 30% weighting to account for geographical effects and inactive leaks.

References/Data Sources:

- Decision Tree Analysis: \\rcnas01-smb\riskmgmtprd-fs01\DIMP_2020\02. DIMP Compliance\03. Risk Evaluation\1. Research\JMP Main PlasMatFailBOP Partition.doc
- Jana Aldyl-A Rank Updates: \\rcnas01-smb\riskmgmtprd-fs01\DIMP_2020\02. DIMP Compliance\03. Risk Evaluation\1. Research\Jana\JanaUpdate.xlsx
- Jana Aldyl A Rank Calculator (J-DIMP) Documentation: \\rcnas01-smb\riskmgmtprd-fs01\DIMP_2019\02. DIMP Compliance\03. Risk Evaluation\Known Threats\1. Research\JanaUpdate\JDIMP Risk Ranking of PG&Es Aldyl Plastic Gas Distribution Pipeline Assets.pdf

Material Failure, Plastic Material Failure Body of Pipe: Service

Explanation for Supplemental Factors:

- **Installation Date, Squeeze Points, Segment Leak History**: Supplemental factors for (1) construction year of the service (before vs after 1985), (2) squeeze points, and (3) segment leak history was included in the model. The factor leak rate values, in leaks/ mile – year, are derived by determining the average annual number of leaks over a five year period (2015-2019) for each factor and dividing by the miles of main or service for that factor, with a decision tree analysis determining the significant groupings. It is reasonable that older pipe has a higher leak rate as materials tend to degrade with time and older plastic materials (particularly Aldly A) have known problems.

- Past leak condition was determined by grouping those segments that had a leak prior of this type to 2015 versus those that did not.
- Squeezed segments were defined as any segment that had been repaired prior to 2015, using the repair codes likely to result in squeezing of the pipe (see Attachment J Appendix A for repair codes used).

Explanation for Weightings:

- The supplemental factor was assigned a 70% weighting, as this has a statistically significant correlation with leak rate.
- District baseline was given a 30% weighting to account for geographical effects and inactive leaks.

References/Data Sources:

- Decision Tree Analysis: \\rcnas01-smb\riskmgmtprd-fs01\DIMP_2020\02. DIMP Compliance\03. Risk Evaluation\1. Research\JMP Service PlasMatFailBOP Partition.doc

Material Failure, Plastic Material Failure Fitting: Main/Service

Explanation for Supplemental Factors:

- **Installation Year, Segment Leak History**: Supplemental factors accounting for (1) construction year (for both main and service), and (2) segment leak history for service only, are used in the model. The factor leak rate values, in leaks/ mile – year, are derived by determining the average annual number of leaks over a five year period (2015-2019) for each factor and dividing by the miles of main or service for that factor, with a decision tree analysis determining the significant groupings. Past leak condition was determined by grouping those segments that had a leak prior to 2015 versus those that did not.

Explanation for Weightings:

- The supplemental factor was given a 70% weighting as these factors have significant statistical correlation with leak rate.
- District baseline was given a 30% weighting to account for geographical effects and inactive leaks.

References/Data Sources:

- Decision Tree Analysis for Main Supplemental Factor: \\rcnas01-smb\riskmgmtprd-fs01\DIMP_2020\02. DIMP Compliance\03. Risk Evaluation\1. Research\JMP Main PlasMatFailFitting Partition.doc
- Decision Tree Analysis for Service Supplemental Factor: \\rcnas01-smb\riskmgmtprd-fs01\DIMP_2020\02. DIMP Compliance\03. Risk Evaluation\1.

Research\JMP Service PlasMatFailFitting Partition.doc

Material Failure, Plastic Material Failure Fitting: AGF/Reg

Explanation for Supplemental Factors:

No supplemental factors are used for this combination. Regulator stations assets were added for this sub threat as a small number of leaks have occurred in the past. Plastic leaks on a regulator station are rare and may involve tubing and other unusual situations.

Explanation for Weightings:

The district baseline is given 100% weight. This is based on an assumption of greater geographical randomness in the absence of data or reason to justify more specific factors.

References/Data Sources:

No supplemental factors are used for this combination.

Material Failure, Plastic Tee Cap Failure: Service

Explanation for Supplemental Factors:

- **Installation Date, Leak History**: Supplemental factors for (1) construction year of the service, and (2) segment leak history was included in the model. The factor leak rate values, in leaks/ mile – year, are derived by determining the average annual number of leaks over a five year period (2015-2019) for each factor and dividing by the miles of main or service for that factor, with a decision tree analysis determining the significant groupings. These tee cap leaks were assigned a cause of largely material defect, plastic cracking or plastic embrittlement, at leak repair, this difference in leak cause distinguishes them from Incorrect Operations Plastic Tee Cap
    - Past leak condition was determined by grouping those segments that had a leak prior to 2015 versus those that did not.
    - The older tees (installed/manufactured before 1996) are assumed to be failing due to poor material. They are made of Calcon Polyacetal material. The newer caps are made of polyethylene (PE) material which is more resilient to cracking.
    - For the segment leak history factor, repaired caps tend to leak again due to the following reasons:
        - They are older and the coupon may fail over time by shrinking
        - Tee and cap threads not compatible
        - The use of a wrong replacement cap
        - Cross threaded during replacement
        - Using a wrong O-ring and poor use of grease

Explanation for Weightings:

- The supplemental factor was assigned a 70% weighting, as this has a statistically significant correlation with leak rate.
- District baseline was given a 30% weighting to account for geographical effects and inactive leaks.

References/Data Sources:

- Decision Tree Analysis: \\rcnas01-smb\riskmgmtprd-fs01\DIMP_2020\02. DIMP Compliance\03. Risk Evaluation\1. Research\JMP Service PlasMatFailTcap Partition.doc

Natural Forces, Earth Movement: Main

Explanation for Supplemental Factors:

The Earth Movement sub-threat has two geologically based supplemental factors, "Landslide" and "Fault Creep." These geologically base factors are in addition to historical leak based data at both the plat level, "Plat Baseline," and "Segment Leak History".

- **Landslide:** this factor accounts for movement of rock, debris, or earth down a slope**.** .The landslide "susceptibility" of earth due to precipitation or seismic events incorporates elevation rate of change, soil characteristics, and historical events. The Transmission Integrity Management Program Geohazard map layer, Landslide Susceptibility Geodatabase, dated 7/24/2018, is used to categorize distribution assets into five susceptibility levels ranging from "low" to "known or high". This file is appended annually with new observed locations (known) of earth movement, supplied by the distribution patrol program. This data is used to determine the supplemental factor values due to landslide for mains, services, above ground facilities, and regulator stations.
    - Basing the likelihood of failure upon known leak history, the leak data used in the calculation is taken from DIMP processed, snapped leak data to perform spatial analysis. For Earth Movement, leak history is attributed with the spatial coincident land slide susceptibility hazard value to sum the number of leaks present within the different susceptibility categories. Because of the limited number of PG&E leaks caused by Earth Movement per year, the entire date range available is included within the calculation, 48 years (1971 through 2019).
    - The quantity of mains, services, and regulator stations considered in their respective calculation is taken from a "snapshot" of GDGIS data, dated 1/15/2020. Follow the same process as the leak data geospatial attribution, each segment of main, service, and regulator station is also attributed, with the coincident landslide susceptible category in order to build a total population of each asset.
    - Assumptions:
        - The system performance reacts in a similar manner over the 48 year period of leaks, exposed to earth movement stresses (time dependent interactive threats are neglected).
        - The system populations today are relatively the same and any increases in size have made supplemental factors more conservative.
        - Landslide susceptibility accurately captures the propensity for leaks due to "earth movement."
        - Limited leak data can be reasonably applied to the entire system of assets.
        - Soil saturation (with water) is neglected when seismic landslide susceptibility is evaluated.

- It is reasonable that prior history of earth movement on a specific segment / piece of equipment dictates that reoccurrence is more probable than a location with no prior history.

- **Fault Creep:** Slow moving aseismic movement (slip) along fault lines that occur near the surface of the earth's crust. This movement occurs between seismic events and is not meant to characterize slip immediately after seismic events. The fault creep geohazard data is pre-processed to categorize mains into three hazard classes (Hazard level I – low, Hazard level II – medium, and Hazard level III – High) based on four attributes: fault creep rate, degree of pipeline pinning (or networking), the main to fault crossing angle, and material. Currently, this factor specifically targets mains within the Hayward Fault zone of uncertainty only.
  - The supplemental factors assigned to the three hazard level categories assumes that earth movement leaks within the Hayward fault zone of uncertainty can be caused by either creep and / or slow-moving land slide activity because of the complexity of the geology along the Hayward fault. Following the same methodology used for landslide, both assets and leaks are agglomerated to arrive at explicit supplemental factor values for each hazard level over the available leak data period, 30 years (1989-2019).
  - Mains only within the Hayward Fault zone of uncertainty are assigned a fault creep hazard level, the remaining mains outside the zone (system wide) are assigned the average earth movement leak rate.
  - Assumptions:
    - Most earth movement leaks that occur within the Hayward fault zone of uncertainty can be attributed to fault creep.

Table NAF-EarthMovement 1: Natural Forces, Earth Movement, Landslide, Main Supplemental Factor

Landslide Susceptibility (1-5)	Leak Count	Asset Population (mi)	No. Years	Supplemental Factor $\frac{\textbf{Leak Count}}{\textbf{Population} \times \textbf{No.Years}}$
Low (1)	1684	31907.40	48	1.0995E-03
Low-Moderate (2)	173	2377.03	48	1.5163E-03
Moderate (3)	266	6266.48	48	8.8434E-04*
Moderate-High (4)	76	2499.46	48	6.3347E-04*
Known or High (5)	55	263.42	48	4.3498E-03

NOTE: In cases when the risk evaluation does not attribute a landslide susceptibility category (asset exists outside of a susceptibility polygon) the least conservative supplemental factor is assigned, 1.099536E-03. *In the case where the relative size of polygons and asset population contained within them, used in the LoF derivation, skew the supplemental factor beyond intuition, the two susceptibilities are modified. In this case the LoF values for Moderate (3) and Moderate-High (4) are interpolated between Known of High (5) and Low-Moderate (2) as follows, assuming even splits:(3) = (4.3498E-03 – 1.51625E-03)*(1/3) + 1.5163E-03, (3) = 2.4608E-03 and (4) = (4.3498E-03 – 1.51625E-03)*(2/3) + 1.51625E-03, (4) = 3.4053E-03

Table NAF-EarthMovement 2: Natural Forces, Earth Movement, Fault Creep, Main Supplemental Factor

Hazard Level	Leak Count	Population (mi)	No. Years	Supplemental Factor – System Average Leak Rate $\frac{\boldsymbol{Leak\ Count}}{\boldsymbol{Population \times No.Years}}$
I	3	27.22	30	3.7E-03
II	19	36.34	30	1.74E-02
III	6	8.92	30	2.25E-02

Table NAF-EarthMovement 3: Natural Forces, Earth Movement, System Average

Asset	Leak Count	Population (mi)	No. Years	Supplemental Factor – System Average Leak Rate $\frac{\boldsymbol{Leak\ Count}}{\boldsymbol{Population \times No.Years}}$
Mains	2156	43387.32	48	1.0E-03

- **Segment Leak History:** A supplemental factor accounting for segment leak history was included in the model, as this factor was found to be significantly correlated with sub-threat leak rate based on decision tree (partition) analysis. Segments are classified as having either no past leaks, or 1 or more past leaks. The factor leak rate values for each classification were derived by determining the average annual leak rate over a five-year period (2015-2019) for segments classified using pre-2015 leak history.

Explanation for Weightings:

Compared to the overall leaks on mains within a district, the earth movement threat is a localized geotechnical hazard (block level magnitude) and therefore more heavily weighted toward the segment's geospatial location, with the anticipation that re-occurring events at the location of that segment are more likely to occur. There are no changes in the weightings from 2019. An equal weighting approach is used between Plat Baseline (general geographic area), Landslide (smaller geographic area), and Fault Creep. Segment Leak History (smallest defined area) is assigned a slightly higher weighting with the expectation that locations that have leaked in the past due to earth movement are more likely to leak again.

References/Data Sources:

- Landslide geodatabase:
  \\rcnas01-smb\riskmgmtprd-fs01\DIMP_Programs\Natural Forces\Patrol Data\Production\LS_Patrol Database\LS_Patrol Database_2020.gdb
- Processed geocoded leak database:
  \\rcnas01-smb\riskmgmtprd-fs01\DIMP_2020\01. System Knowledge\02. Processed Data\RiskFinder\RF Leaks\Results.gdb
- GDGIS 1/15/2020 "snapshot":
  \\rcnas01-smb\riskmgmtprd-fs01\DIMP_2020\01. System Knowledge\02. Processed Data\RiskFinder\RF GDGIS\RiskFinder GDGIS 2020-01-15.gdb
- Partition Analysis for Segment Leak History Factor:
  \\rcnas01-smb\riskmgmtprd-fs01\DIMP_2020\02. DIMP Compliance\03. Risk Evaluation\1. Research\JMP Main Earth Move Seg Leak Hist.doc
- Fault Creep geodatabase:
  \\rcnas01-smb\riskmgmtprd-fs01\DIMP_2020\01. System Knowledge\02. Processed Data\Natural Forces\RiskFinder\GPAT 2020 Results.gdb

Natural Forces, Earth Movement: Service

Explanation for Supplemental Factors:

- **Landslide:** See explanation of landslide susceptibility factor under Natural Forces: Earth Movement, Main.

Table NAF-EarthMovement 5: Natural Forces, Earth Movement, Service Supplemental Factor

Landslide Susceptibility (1-5)	Leak Count	Population (mi)	No. Years	Supplemental Factor $\frac{\textit{Leak Count}}{\textit{Population} \times \textit{No.Years}}$
Low (1)	3349	54024.81	48	1.2915E-03
Low-Moderate (2)	354	3781.28	48	1.9504E-03
Moderate (3)	569	7723.84	48	1.5350E-03*
Moderate-High (4)	206	2792.02	48	1.5371E-03*
Known or High (5)	47	273.92	48	3.5746E-03

NOTE: In cases when the risk evaluation does not attribute a landslide susceptibility category (asset exists outside of a susceptibility polygon) the least conservative supplemental factor is assigned, **1.291459E-03**. *In the case where the relative size of polygons and asset population contained within them, used in the LoF derivation, skew the supplemental factor beyond intuition, the two susceptibilities are modified. In this case the LoF values for Moderate (3) and Moderate-High (4) are interpolated between Known of High (5) and Low-Moderate (2) as follows, assuming even splits:
(3) = (3.5746E-03 – 1.95040E-03)*(1/3) + 1.95040E-03, (3) = 2.4918E-03 and (4) = (3.5746E-03 – 1.95040E-03)*(2/3) + 1.95040E-03, (4) = 3.0332E-03

- **Segment Leak History:** A supplemental factor accounting for segment leak history was included in the model, as this factor was found to be significantly correlated with sub-threat leak rate based on decision tree (partition) analysis. Segments are classified as having either no past leaks, or 1 or more past leaks. The factor leak rate values for each classification were derived by determining the average annual leak rate over a five-year period (2015-2019) for segments classified using pre-2015 leak history.

Explanation for Weightings:
Compared to the overall leaks on services within in a district, the earth movement threat is a localized geotechnical hazard (block level magnitude) and therefore more heavily weighted toward the segment's geospatial location, with the anticipation that re-occurring events at the location of that segment are more likely. Both Segment Leak History and Supplemental factors capture spatial attributes more accurately than the overall plat baseline leak score for this specific sub-threat and hence receive a combined 80% weighting. These weightings are unchanged from 2019.

References/Data Sources:

- Landslide geodatabase: \\rcnas01-smb\riskmgmtprd-fs01\DIMP_Programs\Natural Forces\Patrol Data\Production\LS_Patrol Database\LS_Patrol Database_2020.gdb
- Processed geocoded leak database: \\rcnas01-smb\riskmgmtprd-fs01\DIMP_2020\01. System Knowledge\02. Processed Data\RiskFinder\RF Leaks\Results.gdb
- GDGIS 1/15/2020 "snapshot:" \\rcnas01-smb\riskmgmtprd-fs01\DIMP_2020\01. System Knowledge\02. Processed Data\RiskFinder\RF GDGIS\RiskFinder GDGIS 2020-01-15.gdb
- Partition Analysis for Segment Leak History Factor: \\rcnas01-smb\riskmgmtprd-fs01\DIMP_2020\02. DIMP Compliance\03. Risk Evaluation\1. Research\JMP Service Earth Move Seg Leak Hist.doc

Natural Forces, Earth Movement: Reg Station

Explanation for Supplemental Factors:

- **Landslide:** See explanation under Natural Forces, Earth Movement, Main.

Table NAF-EarthMovement 7: Natural Forces, Earth Movement, Regulator Station Supplemental Factor

Landslide Susceptibility (1-5)	Leak Count	Population (count)	No. Years	Supplemental Factor $\frac{\textit{Leak Count}}{\textit{Population} \times \textit{No. Years}}$
Low (1)	5	4437	487	2.348E-05
Low-Moderate (2)	0	236	48	0*
Moderate (3)	0	481	48	0*

Moderate-High (4)	0	92	48	0*
Known or High (5)	0	43	48	0*

*Because of a very limited number of regulator station leaks documented within areas of landslide susceptibility, the only calculated value (2.348E-05) is used as default, for all the susceptibilities: Low(1), Low-Moderate (2), Moderate(3), Moderate-High(4), and Known or High(5) . In cases when the risk evaluation does not attribute a landslide susceptibility category (asset exists outside of a susceptibility polygon) the same supplemental factor is assigned, 2.348E-05. This general approach is being used across all stations since very few leaks on stations are reported as cause "earth movement."

Explanation for Weightings:

Compared to the overall leaks on regulator stations within in a district, the earth movement threat is a localized geotechnical hazard (block level magnitude) and therefore more heavily weighted toward the stations' geospatial locations, with the anticipation that re-occurring events are more likely at those locations that have leaked before. Because of limited leak data, 90% weighting is given to the supplemental factor. With the general approach being used for the supplemental factor, it is believed to be more conservative than relying heavily on the baseline value. This approach is unchanged from 2019.

References/Data Sources:

- Landslide geodatabase: \\rcnas01-smb\riskmgmtprd-fs01\DIMP_Programs\Natural Forces\Patrol Data\Production\LS_Patrol Database\LS_Patrol Database_2020.gdb
- Processed geocoded leak database: \\rcnas01-smb\riskmgmtprd-fs01\DIMP_2020\01. System Knowledge\02. Processed Data\RiskFinder\RF Leaks\Results.gdb
- GDGIS 1/15/2020 "snapshot:" \\rcnas01-smb\riskmgmtprd-fs01\DIMP_2020\01. System Knowledge\02. Processed Data\RiskFinder\RF GDGIS\RiskFinder GDGIS 2020-01-15.gdb

Natural Forces, Earth Movement: AGF

Explanation for Supplemental Factors:

- **Landslide:** Similar to both mains and services, the leak and asset attribution to landslide susceptibility is also carried out for above ground facilities (see explanation under Natural Forces, Earth Movement, Main).

Table NAF-EarthMovement 9: Natural Forces, Earth Movement, AGF Supplemental Factor

Landslide Susceptibility (1-5)	Leak Count	Population (count)	No. Years	Supplemental Factor $\frac{Leak\ Count}{Population \times No.Years}$
Low (1)	425	3805933	48	2.33E-06*
Low-Moderate (2)	22	243105	48	1.89E-06*

Moderate (3)	**62**	**443830**	**48**	**2.91E-06**
Moderate-High (4)	**24**	**121912**	**48**	**4.10E-06***
Known or High (5)	**1**	**10202**	**48**	**2.04E-06***

NOTE: In cases when the risk evaluation does not attribute a landslide susceptibility category (asset exists outside of a susceptibility polygon) the least conservative supplemental factor is assigned, 2.2999290E-06 (see below).

* In the case where the relative size of polygons and asset population contained within them, used in the LoF derivation, skew the supplemental factor beyond intuition, the two susceptibilities are agglomerated:

(2 - "Low-Moderate") + (1 – "Low"): 447 Leaks | 4,049,038 (count) | 48 years = 2.30E-06 leaks/(count*yr)

(4 - "Moderate-High") + (5 – Known or High): 25 Leaks | 132,114 (count) | 48 years = 3.94E-06

Explanation for Weightings:
Compared to the overall leaks on AGF within in a district, the earth movement threat is a localized geotechnical hazard (block level magnitude) and therefore more heavily weighted toward the equipment's geospatial location, with the anticipation that events at the location of the equipment is more likely to occur. Because of limited leak data, the weighting is higher for the supplemental factor. This approach is unchanged from 2019.

References/Data Sources:

- Landslide geodatabase:
  \\rcnas01-smb\riskmgmtprd-fs01\DIMP_Programs\Natural Forces\Patrol Data\Production\LS_Patrol Database\LS_Patrol Database_2020.gdb
- Processed geocoded leak database:
  \\rcnas01-smb\riskmgmtprd-fs01\DIMP_2020\01. System Knowledge\02. Processed Data\RiskFinder\RF Leaks\Results.gdb
- GDGIS 1/15/2020 "snapshot:"
  \\rcnas01-smb\riskmgmtprd-fs01\DIMP_2020\01. System Knowledge\02. Processed Data\RiskFinder\RF GDGIS\RiskFinder GDGIS 2020-01-15.gdb

Natural Forces, Earthquake: Main/Service/AGF/Reg

Explanation for Supplemental Factors:

- **Fault Crossing:** The number of recorded leaks at PG&E caused by earthquakes is very limited, requiring an "asset perspective" approach, which bases the likelihood of failure upon known leak causing events and the number of leaks caused during those events. The most significant events within the PG&E gas service territory, in recent history, are the Ridgecrest earthquake (M7.1, 2019), the Napa earthquake (M6.0, 2014), and the Loma Prieta earthquake (M6.9, 1989). There are several geotechnical characteristics used in two conditions s applied to all four asset types: mains, services, above ground facilities, and regulator stations. The first condition evaluated is the asset's proximity to a fault's "zone of influence." Those assets that lie within the zone are deemed more likely to be damaged during a seismic event because of their proximity to active fault traces. Only fault zones with an age (time period) description by the USGS as "historic" and "holcenic" are considered active and in scope. The second supplemental factor is a combination of USGS data sets: liquefaction susceptibility and the peak ground acceleration (pga) calculated to have a 10% exceedance in 50 years (10in50).

- The quantity of mains, services, and regulator stations considered in their respective calculation is taken from a "snapshot" of GDGIS data, dated 1/15/2020. Similar to the leak data geospatial attribution, each segment of main, service, and regulator station is also attributed, using a clipping method, with the coincident landslide susceptible category in order to build a total population of each asset.
- Assumptions:
  - Future performance of the distribution system will be similar to Ridgecrest, Napa, and Loma Prieta earthquakes.
  - Future significant earthquake events will be of similar magnitude.
  - Leak repair data: leak causes were accurately documented as "earthquake" at the time of the events.
  - The known faults within the USGS database of both historic and holcenic time periods are accurate and complete.
  - Limited leak data can be reasonably applied to the entire system of assets.

Table NAF-Earthquake 11: Natural Forces, Earthquake, Mains, Services, AGF, and Reg Stn Supplemental Factors

Asset	Likelihood of Asset Exposure to Event (events / yr.) [A]	Likelihood of Asset to Leak (leaks / event) [B]	Length or Count of Asset (mi. or count) [C]	Earthquake Factor $\frac{A \times B}{C}$
Mains	0.094	2	895.76	2.0990E-04
Services	0.094	4	715.21	5.2572E-04
AGF	0.094	5	31841	1.476E-05
Reg. Stn.	0.094	0.1	44	2.1364E-04

The following describes the existing leak database and major assumptions for the above table:

- Main: 3 Significant system wide events that occurred within 32 years of each other (Loma Prieta {1987}, Napa {2014}, Ridgecrest {2019}), (0.094), 2 leak (max) per event (based on historical leak rates from both Napa and Ridgecrest events), main length = 895.76 miles within fault zones.
- Service: 3 Significant system wide events that occurred within 32 years of each other (Loma Prieta {1987}, & Napa {2014}, Ridgecrest {2019}), (0.094), 4 *leaks (max) per event (based on historical leak rates from both Napa and Ridgecrest events)*, service length = 715.21 miles within fault zones.

- AGF: 3 Significant system wide events that occurred within 32 years of each other (Loma Prieta {1987}, & Napa {2014}, Ridgecrest {2019}), (0.094), 5 *leaks (max) per event (based on assumed/ known sensitivity to meterset – structure relationship)*. 31841 meters lie within fault zones.
- Reg. Stn.: 3 Significant system wide events that occurred within 32 years of each other (Loma Prieta {1987}, & Napa {2014}, Ridgecrest {2019}), (0.094), *0.01 leaks (max) per event (based on assumed)*. 44 stations lie within fault zones

“Based on assumed” are those where limited asset leak data is known for both events and have been estimated as reasonable.

Explanation for Weightings:

The earthquake sub-threat is split into two conditions that are evaluated for each feature, both location within a fault zone of influence as well as a combined scoring of the USGA liquefaction susceptibility and 10in50 PGA. If the feature falls within a fault zone, it is assigned 50% of the earthquake factor (see above). Additionally, if the summed score between the liquefaction susceptibility value and the pga value is larger than 0.5, the feature is assigned 50% of the earthquake factor. Features may have both conditions met and are considered independent from each other. It is anticipated that those assets that are within proximity to seismic faults will be exposed to greater ground accelerations, greater ground velocities, and ultimately greater ground displacements, including possible surface rupture. Also, assets need not be near a fault to be susceptible to high pga and liquefaction phenomena during a seismic event.

References/Data Sources:

- Fault zones: \\rcnas01-smb\riskmgmtprd-fs01\DIMP_2020\03. DIMP Activities\01. Projects\Natural Forces\Buffered Faults\04. Results\Results.gdb
- Processed geocoded leak database: \\rcnas01-smb\riskmgmtprd-fs01\DIMP_2020\01. System Knowledge\02. Processed Data\RiskFinder\RF Leaks\Results.gdb
- GDGIS 1/15/2020 “snapshot:” \\rcnas01-smb\riskmgmtprd-fs01\DIMP_2020\01. System Knowledge\02. Processed Data\RiskFinder\RF GDGIS\RiskFinder GDGIS 2020-01-15.gdb

Natural Forces, Flooding: Main/Service/AGF/Reg

Explanation for Supplemental Factors:

- **Flood Zone:** The number of recorded leaks at PG&E caused by flooding is very limited, requiring an “asset perspective” approach. This approach is based upon the likelihood of failure upon known leak causing events and the number of leaks caused during those events. Unlike the threat of earthquakes, the impact of flooding events tends to be localized with limited impact to distribution assets. The specific geospatial data used to determine the supplemental factor due to flooding for mains, services, above ground facilities, and regulator stations is the National Flood Insurance Program “100-year flood maps.” These maps developed since the 1960’s illustrate areas that have a 1-percent annual exceedance probability of flooding. Unfortunately, these maps do not illustrate areas that flood at greater frequencies than 1:100 years. The 100-year flood map is used to identify assets at risk, but not used as the basis of frequency of asset exposure. Leak data with the cause flooding dictates a more conservative approach than using a simple 1:100-year frequency for the frequency of flooding events.

- The quantity of mains, services, above ground facilities, and regulator stations considered in their respective calculation is taken from a "snapshot" of GDGIS data, dated 1/15/2020. The asset's geospatial attribution, using a clipping method, with the coincident 100-year flood zone feature class is conducted in order to build a total population of each asset. Additionally, an in-progress effort is taking place to identify main water crossings, so a combined data set of specific crossings for North Valley and North Bay Divisions, in addition to the remainder of the system that lies within flood zones, are identified for the Flood Zone supplemental factor.

Table NAF-Flooding 13: Natural Forces, Flooding, Mains, Services, AGF, and Reg. Stn Supplemental Factors

Asset	Likelihood of Asset Exposure to Event* (events / yr.) [A]	Likelihood of Asset to Leak* (leaks / event) [B]	Length or Count of Asset (mi. or count) [C]	Supplemental Factor $\frac{A X B}{C}$
Mains	2.15	0.3	2962.51	2.1772E-04
Services	2.15	0.5	2904.30	3.7014E-04
AGF	2.15	0.2	180743	2.38E-06
Reg. Stn.	2.15	0.02	625	6.880E-05

The following describes the existing leak database and major assumptions for the above table:

- Review of current leak data reveals 43 leaks due to flooding over a 20-year period (2000-2019). It is assumed that leaks due to flooding are Natural Force related leaks and the true number is most likely less than 43 leaks attributed to natural flooding but provides a conservative approach to flood frequency.
- The 43 leaks cited are limited to mains and services, yet all asset types are assumed to have the same probability of being exposed to flooding.
- **Main**: Historical leak data indicates that approximately one in three flood events results in damage to main or ~ 0.3 (13/43).
- **Service**: Historical leak data indicates that approximately one in every two flood events results in damage to service or ~0.5 (22/432).
- **AGF**: Historic leak data indicates that approximately one in every five flood events results in damage to above ground facilities or ~0.2 (8/43).
- **Reg. Stn.**: Historic leak data indicates that approximately one in every fifty flood events results in damage to a regulator station or ~0.02 (1/43).

Explanation for Weightings:

It is anticipated that those assets that are within proximity to water ways that have been exposed to past flood events are likely to be exposed again.

For mains, operator and industry events indicate that the risk to mains during flooding is limited to those at water crossings where fluid velocity can cause scour, undermining, or susceptibility to debris strikesBecause of limited leak data and knowledge that water courses are small and narrow compared to plat area, baseline weighting has been changed to 0% and transitioned fully (100%) supplemental factor.

For service, AGF, and stations the threat of flooding is broad, as compared to main, where standing water may cause debris strikes or structure movement. Therefore, a significant weighting is based on the assets' plat leak history and proximity to flood plains, yielding a 50% weighting to plat baseline and 50% weighting to Supplemental factors (within 100 year flood zones).

References/Data Sources:

- 100-Year Flood: \\ffShare01-NAS\RiskMgmt\DIMP_2017\1. System Knowledge\1. Raw Data\Natural Forces\Floods\100YrFlood.shp
- Processed geocoded leak database: \\rcnas01-smb\riskmgmtprd-fs01\DIMP_2020\01. System Knowledge\02. Processed Data\RiskFinder\RF Leaks\Results.gdb
- GDGIS 1/15/2020 "snapshot:" \\rcnas01-smb\riskmgmtprd-fs01\DIMP_2020\01. System Knowledge\02. Processed Data\RiskFinder\RF GDGIS\RiskFinder GDGIS 2020-01-15.gdb

Natural Forces, Lightning, Main/Service/AGF/Reg

Explanation for Supplemental Factors:

No supplemental factors are used for the lightning sub-threat.

Explanation for Weightings:

Due to the unique characteristics of lightning strikes, it is understood that lightning striking an asset or an exterior object connected to an asset more than once is highly unlikely. It is also understood that certain districts are more prone to lightning strikes due to their unique orographic effects on weather systems. Therefore, plat baseline values are weighted 100% and district baseline values are considered too large of an area to capture specific topography where lightning strikes are more common. All assets are considered to have the same probability of damage due to lightning.

References/Data Sources:

No supplemental factors are used for this sub-threat. For information about the baseline factors, refer to Attachment N.

Natural Forces, Other: Main/Service/AGF/Reg

Explanation for Supplemental Factors:

No supplemental factors are used for the Natural Force "Other" sub-threat.

Explanation for Weightings:

Due to the random variability in Natural Force events categorized as "other," 100% weighting is applied to plat baseline, with the assumption that "other" natural force leaks are rather localized. For information regarding baseline factors, refer to Attachment N.

References/Data Sources:
No supplemental factors are used for this sub-threat. For information about the baseline factors, refer to Attachment N.

Natural Forces, Root Damage: Main/Service

Explanation for Supplemental Factors:
No supplemental factors are used for the Natural Force sub-threat, "Root Damage."

Explanation for Weightings:
It has been observed there is little to no difference in leak rates due to root damage from district to district. Tree root damage tends to fall into two cases:

1. Isolated to a single tree incidence where a single tree species is relatively isolated from other trees and the single tree's proximity to nearby assets causes multiple leaks over time, or
2. A row / cluster of the same species of trees is in proximity to assets where the chances of a specific interaction mechanism may be repeated by neighboring trees.

Because of limited leak data, the baseline factor is weighted 100%. Further, root damage is assumed to be local in nature, given housing tract design along with similar demographics /vegetation; thus, plat baseline is favored over district.

References/Data Sources:
No supplemental factors are used for this sub-threat. For information regarding baseline and OLS factors, refer to Attachment N.

Natural Forces, Tsunami, Main/Service/AGF/Reg

Explanation for Supplemental Factors:

There are no recorded leaks at PG&E with the attributed cause due to a tsunami, requiring a unique approach.

The tsunami sub threat is based upon a feature class developed for the California Emergency Management Agency (CALEMA) by the California Geological Survey (CGS) in partnership with the University of Southern California (USC) in 2009, known as the "Tsunami Inundation," in order to identify distribution assets threatened by this specific hazard.

Statistical data taken from the NGDC/WDS Global Historical Tsunami Database, 2100 BC to Present: https://data.nodc.noaa.gov/cgi-bin/iso?id=gov.noaa.ngdc.mgg.hazards:G02151

In order to bridge the relationship between historical tsunami events and likelihood of impact to gas distribution assets, the assumption was made that events significant enough to cause loss of life also have capacity to damage or cause failure to both below and above ground assets.

Tsunami Event$_{\text{Loss of Life}}$ = Event$_{\text{Failure of asset}}$

Considering the historical data, the historical account of tsunamis to impact the North & Central America West coast: $\frac{174\ Events}{2019-1806} = \frac{0.817\ Events}{yr}$

Specifically evaluating the fraction of tsunamis, worldwide, that result in a least 1 fatality (from year 365 to 2019):

$$\frac{253\ Events_{Deaths}}{2676\ Events_{Total}} = \frac{(0.0945\ Events_{Death})}{Events_{Total}}$$

Finally, including the total mileage of the North and Central America Western coast lines, 9200 miles, considering the fraction of California coastline (840/9200):

$$\frac{.817\ Events_{Total}}{yr} * \frac{(0.0945\ Events_{Death})}{Events_{Total}} * \frac{1}{9200\ mi} = \frac{8.392 * 10^{-6} Events}{mi * yr}$$

$$\frac{8.392 * 10^{-6} Events}{mi * yr} * \frac{840\ CA\ mi}{9200\ Americas\ mi} = \frac{7.7 * \ 10^{-7} Events}{mi * yr}$$

The application of this threat to assets assumes any assets within the linear distance along the coastline, within the inundation zone is at risk.

Explanation for Weightings:
Since there is no leak history for Tsunami, baseline factors do not apply , and only those assets within the tsunami inundation feature class are assigned the supplemental factor of 7.7E-7. (weighting of 1). Because the expected impact is catastrophic, all four asset classes are treated the same. Failure modes range from submersion, debris strikes, and soil/material deposition/removal that all asset types would be significantly impacted, affecting asset performance.

References/Data Sources:

- Tsunami Inundation Area Data Source (NOAA): https://data.nodc.noaa.gov/cgi-bin/iso?id=gov.noaa.ngdc.mgg.hazards:G02151
- Tsunami Inundation Area Shapefile: \\ffshare01-nas\riskmgmt\DIMP_2018\01. System Knowledge\01. Raw Data\Natural Forces\Tsunami\01. Data\tsunami_inundation_area.shp

Other Outside Forces, Electrical Facilities: Main

Explanation for Supplemental Factors:

- **Material:** A supplemental factor accounting for material (plastic vs metallic) was included in the model, as this factor was found to be significantly correlated with sub-threat leak rate based on decision tree (partition) analysis. The factor leak rate values for each classification were derived by determining the average annual leak rate over a ten-year period (2010-2019) for each classification.

Explanation for Weightings:

Weightings are distributed uniformly to the district baseline, plat baseline, and material factors. Both district and plat baseline factors are used to account for the possibility of correlations to both work centers (districts as proxy) and specific jobs (plats as proxy). For information about the baseline factors, refer to Attachment N.

References/Data Sources:

- Partition Analysis for Material Factor: \\rcnas01-smb\riskmgmtprd-fs01\DIMP_2020\02. DIMP Compliance\03. Risk Evaluation\1. Research\JMP Main Elec Fac Material.doc

Other Outside Forces, Electrical Facilities: Service

Explanation for Supplemental Factors:

- **Joint Trench:** A supplemental factor accounting for joint trench installation was included in the model, as this factor was found to be significantly correlated with sub-threat leak rate based on decision tree (partition) analysis. The factor leak rate values for each classification were derived by determining the average annual leak rate over a ten-year period (20010-2019) for each classification.
- **Material:** A supplemental factor accounting for material (plastic vs metallic) was included in the model, as this factor was found to be significantly correlated with sub-threat leak rate based on decision tree (partition) analysis. The factor leak rate values for each classification were derived by determining the average annual leak rate over a ten-year period (20010-2019) for each classification.

Explanation for Weightings:

Weightings are distributed uniformly to the district baseline, plat baseline, joint trench, and material factors. Both district and plat baseline factors are used to account for the possibility of correlations to both work centers (districts as proxy) and specific jobs (plats as proxy). For information about the baseline factors, refer to Attachment N.

References/Data Sources:

- Partition Analysis for Joint Trench Factor: \\rcnas01-smb\riskmgmtprd-fs01\DIMP_2020\02. DIMP Compliance\03. Risk Evaluation\1. Research\JMP Service Elec Fac JointTrench.doc
- Partition Analysis for Material Factor: \\rcnas01-smb\riskmgmtprd-fs01\DIMP_2020\02. DIMP Compliance\03. Risk Evaluation\1. Research\JMP Service Elec Fac Material.doc

Other Outside Forces, Electrical Facilities: AGF/Reg

Explanation for Supplemental Factors:

No supplemental factors are used for this combination.

Explanation for Weightings:
The district baseline is given 100% weight. This is based on an assumption of greater geographical randomness in the absence of data or reason to justify more specific factors.

References/Data Sources:
No supplemental factors are used for this combination. For information about the baseline factor, refer to Attachment N.

Other Outside Forces, Fire or Explosion: AGF

Explanation for Supplemental Factors:

- **High Fire Threat District:** High Fire Threat District from the CPUC Fire-Threat Map is used as a factor.
  - For AGF assets in areas of "Zone 1 - High Hazard Zones", "Tier 2 - Elevated", or "Tier 3 - Extreme", a factor value of 0.006 is given. This value is based on the number of structures destroyed per year, divided by the total number of AGF features in those areas. This is based on the conservative assumptions that all structures destroyed (1) involve AGF leaks; (2) were located in the "Zone 1", "Tier 2", or "Tier 3" areas; and (3) were in PG&E service territory. The number of structures destroyed is taken from CAL FIRE yearly fire damage summary.

$$LOF_{FireThreat} = \frac{\#\ of\ StructureDestroyed_{CAL\ FIRE\ 1989-2016}}{\#\ Years_{CAL\ FIRE\ 1989-2016} \times \#\ AGF\ features_{1,2,3\ Fire\ Threat\ Areas}}$$

$$LOF_{FireThreat} = \frac{21{,}880\ Structures\ Destroyed}{28\ Years \times 136{,}946_{1,2,3\ Fire\ Threat\ Areas}}$$

$$LOF_{FireThreat} = 0.006 \frac{Leaks}{Count * Year}$$

  - For AGF assets not in the above areas, a factor value of zero is assumed.

Explanation for Weightings:

- The high fire threat district factor is given a weight of 0.1 because, although it is based on useful historical data, details are limited, so significant conservative assumptions had to be made to apply it to PG&E.
- The remaining weight (0.9) is attributed to district baseline based on an assumption of greater geographical randomness in the absence of data or reason to justify more specific factors.

References/Data Sources:

- CAL FIRE Yearly Fire Damage Summary (8/1/2018): \\rcnas01-smb\riskmgmtprd-fs01\DIMP_2019\02. DIMP Compliance\03. Risk Evaluation\Known Threats\1. Research\Fire threat data\CalFire_yearly_summary-2016.pdf

- CPUC Fire-Threat Map Data (2018): \\rcnas01-smb\riskmgmtprd-fs01\DIMP_2020\01. System Knowledge\01. Raw Data\Fire\LBGIS_HighFireThreatDist_2018.gdb\HighFireThreatDist
- GDGIS ServiceLocation (Above Ground Facilities; 1/15/2020): \\rcnas01-smb\riskmgmtprd-fs01\DIMP_2020\01. System Knowledge\02. Processed Data\RiskFinder\RF GDGIS\RiskFinder GDGIS 2020-01-15.gdb\Reference_ServiceLocation

Other Outside Forces, Fire or Explosion: Main/Service/Reg

Explanation for Supplemental Factors:
No supplemental factors are used for this combination.

Explanation for Weightings:
The district baseline is given 100% weight. This is based on an assumption of greater geographical randomness in the absence of data or reason to justify more specific factors.

References/Data Sources:
No supplemental factors are used for this combination. For information about the baseline factor, refer to Attachment N.

Other Outside Forces, Rodent: Main/Service/AGF/Reg

Explanation for Supplemental Factors:
No supplemental factors are used for this combination.

Explanation for Weightings:
The district baseline is given 100% weight. This is based on an assumption of greater geographical randomness in the absence of data or reason to justify more specific factors.

References/Data Sources:
No supplemental factors are used for this combination. For information about the baseline factors, refer to Attachment N.

Other Outside Forces, Previously Damaged: Main/Service/AGF/Reg

Explanation for Supplemental Factors:
No supplemental factors are used for this combination.

Explanation for Weightings:
The district baseline is given 100% weight. This is based on an assumption of greater geographical randomness in the absence of data or reason to justify more specific factors.

References/Data Sources:
No supplemental factors are used for this combination. For information about the baseline factors, refer to Attachment N.

Other Outside Forces, Third Party: Main/Service/AGF/Reg

Explanation for Supplemental Factors:
No supplemental factors are used for this combination.

Explanation for Weightings:
The district baseline is given 100% weight. This is based on an assumption of greater geographical randomness in the absence of data or reason to justify more specific factors.

References/Data Sources:
No supplemental factors are used for this combination. For information about the baseline factors, refer to Attachment N.

Other Outside Forces, Vehicle: AGF

Explanation for Supplemental Factors:

- **Customer Class:** A supplemental factor accounting for customer class from Meter InfoBase (MIB) was included in the model, as this factor was found to be significantly correlated with sub-threat leak rate based on decision tree (partition) analysis. The factor leak rate values for each classification were derived by determining the average annual leak rate over a ten-year period (2010-2019) for each classification.
- **Population Density**: A supplemental factor accounting for population density was included in the model, as this factor was determined to be significant through relative risk and chi-square analyses. The factor leak rate values for each classification were derived by determining the average annual leak rate over a ten-year period (2010-2019) for each classification.

Explanation for Weightings:
Weightings are distributed uniformly to the two supplemental factors. The district and plat baselines are not used because LoF is assumed not to correlate at the district- and plat-level for this sub-threat.

References/Data Sources:

- Partition Analysis for Customer Class Factor: \\rcnas01-smb\riskmgmtprd-fs01\DIMP_2020\02. DIMP Compliance\03. Risk Evaluation\1. Research\JMP AGF Vehicle CustClassCd.doc
- Customer Class, Determination of Significance: \\ffshare01-nas\riskmgmt\DIMP_2018\03. DIMP Activities\05. DIMP Teams\06. Threat Teams\06. Other Outside Forces\Issues\vehicle\Myles Everett_24092018_VehicleLeaksRelativeCalculation.docx
- Partition Analysis for Population Density Factor: \\rcnas01-smb\riskmgmtprd-fs01\DIMP_2020\02. DIMP Compliance\03. Risk Evaluation\1. Research\JMP AGF Vehicle PopDens.doc
- Population Density, Determination of Significance: \\ffshare01-nas\riskmgmt\DIMP_2018\03. DIMP Activities\05. DIMP Teams\06. Threat Teams\06. Other Outside Forces\Issues\vehicle\Myles Everett_27112018_VehicleLeaksPopulationClassRelativeRiskCalculation.docx

Other Outside Forces, Vehicle: Reg

Explanation for Supplemental Factors:

- **Vaults**: It is assumed that station features within vaults are not susceptible to vehicle impacts, and therefore LoF is zero. The leak rate for all other features is determined as the average annual leak rate over a ten-year period (2010-2019) for all those features.

Explanation for Weightings:
The vault factor is given 100% weight. The district and plat baselines are not used because LoF is assumed not to correlate at the district- and plat-level for this sub-threat.

References/Data Sources:
- Vault Factor Value Calculation: \\rcnas01-smb\riskmgmtprd-fs01\DIMP_2020\02. DIMP Compliance\03. Risk Evaluation\1. Research\OOF\Reg Station Vehicle.xlsx

Other Outside Forces, Vehicle: Main/Service

Explanation for Supplemental Factors:
No supplemental factors are used for this combination.

Explanation for Weightings:
The district baseline is given 100% weight. This is based on an assumption of greater geographical randomness in the absence of data or reason to justify more specific factors.

References/Data Sources:

No supplemental factors are used for this combination. For information about the baseline factors, refer to Attachment N.

Other Outside Forces, Vandalism: Main/Service/AGF/Reg

Explanation for Supplemental Factors:
No supplemental factors are used for this combination.

Explanation for Weightings:
The district baseline is given 100% weight. This is based on an assumption of greater geographical randomness in the absence of data or reason to justify more specific factors.

References/Data Sources:
No supplemental factors are used for this combination. For information about the baseline factors, refer to Attachment N.

Other, Other: Main/Service/AGF/Reg

Explanation for Supplemental Factors:
No supplemental factors are used for this combination.

Explanation for Weightings:
The district baseline is given 100% weight. This is based on an assumption of greater geographical randomness in the absence of data or reason to justify more specific factors.

References/Data Sources:
No supplemental factors are used for this combination. For information about the baseline factors, refer to Attachment N.

Cross-Factor Calibration (Relative Comparison)

Supplemental factor values were compared to ensure that they were appropriate relative to each other. The following steps were taken to perform this calibration:

1. For a given asset type, list each supplemental factor category with its value.
2. Sort all supplemental factor categories by value.
3. Review and verify whether the values for each category are in appropriate relative position (by orders of magnitude). Remember to consider both category population (denominator) as well as expected leak rate (numerator) when determining whether a value is appropriate (e.g., a category value may seem “high” but may be appropriate if the category population is small).

The steps above are iterated until values for each category are determined to be in appropriate relative position (by orders of magnitude). The tables below show the final iteration with the final factor values for the 2020 Risk Assessment.

Table Calibration 1: Main Supplemental Factor Category Values Comparison

Category	Value (Leaks/mile-year)	Order of Magnitude
COR Ext, CPA leak rate, max (continuous values)	2.22E+00	0
COR Ext, Coating & CP, Unprotected + Bare	9.27E-01	-1
COR Ext, Coating & CP, Protected/Unk + Bare	4.50E-01	-1
COR Ext, Segment Leak History, 2+	3.26E-01	-1
COR Ext, Segment Leak History, 1	1.53E-01	-1
COR Ext, Age, Install year < 1925	1.25E-01	-1
COR Ext, Coating & CP, Unprotected + Coated/Unk	1.17E-01	-1
EQP Seal Failure, Segment Leak History, 1+	8.15E-02	-2
MAT Plastic Mat Fail BOP, Jana/Squeeze/History, Jana >4 & Leak>0	6.47E-02	-2
COR Ext, Age, Install Year = 1950	6.42E-02	-2
COR Ext, Coating & CP, Protected/Unk + Coated/Unk	4.33E-02	-2
MAT Plastic Mat Fail BOP, Jana/Squeeze/History, Jana 0 to 4 & Leak>0	4.30E-02	-2
COR Ext, Segment Leak History, 0	3.74E-02	-2
INC Construction, History/Material/Install, Metal <1943	2.42E-02	-2
INC Construction, History/Material/Install, Plastic <1976	2.36E-02	-2
NAF Earth Move, Fault Creep, HAZ3	2.25E-02	-2
INC Construction, History/Material/Install, Metal,>1942 & 1+ leaks	2.23E-02	-2
NAF Earth Move, Fault Creep, HAZ2	1.74E-02	-2
INC Construction, History/Material/Install, Plastic >1975 & 1+ Leaks	1.73E-02	-2
EXC Excavation, History/Depth/Material, Shallow	1.49E-02	-2
EQP Seal Failure, Segment Leak History, 0	1.49E-02	-2
EXC Excavation, History/Depth/Material, 1+ leaks	1.14E-02	-2
INC Other Weld, Interacting Leak History, ConstrDef >0	9.49E-03	-3
MAT Plastic Mat Fail BOP, Jana/Squeeze/History, Jana >4 & Squeeze	8.00E-03	-3
MAT Plastic Mat Fail Fit, Installation Year, <1976	7.90E-03	-3
INC Construction, History/Material/Install, Metal >1942	7.51E-03	-3
INC Fusion, Installation Year, <1983	7.50E-03	-3
INC Other Weld, Interacting Leak History, Install Year < 1949	7.46E-03	-3
NAF Earth Move, Segment Leak History, 1+	6.94E-03	-3
EXC Excavation, History/Depth/Material, Plastic	6.38E-03	-3
COR Ext, Age Install Year > 1974	6.04E-03	-3
MAT Plastic Mat Fail BOP, Jana/Squeeze/History, Jana >4 & No Squeeze	5.00E-03	-3
INC Construction, History/Material/Install, Plastic >1975 & 0 Leaks	4.71E-03	-3
EQP Miscellaneous, Segment Leak History, 1+	4.55E-03	-3
NAF Earth Move, Landslide Susceptibility, 5	4.35E-03	-3
COR Ext, CPA leak rate, non-zero min (continuous values)	4.19E-03	-3

Category	Value (Leaks/mile-year)	Order of Magnitude
INC Girth Weld, Installation Year, <1948	4.09E-03	-3
NAF Earth Move, Fault Creep, HAZ1	3.70E-03	-3
NAF Earth Move, Landslide Susceptibility, 4	3.41E-03	-3
MAT Plastic Mat Fail Fit, Installation Year, >1975	2.93E-03	-3
EQP Miscellaneous, Segment Leak History, 0	2.82E-03	-3
NAF Earth Move, Landslide Susceptibility, 3	2.46E-03	-3
INC Other Weld, Interacting Leak History, Install Year > 1948	2.44E-03	-3
EXC Excavation, History/Depth/Material, Metal	2.09E-03	-3
INC Girth Weld, Installation Year, >1947	2.08E-03	-3
NAF Earth Move, Landslide Susceptibility, 2	1.52E-03	-3
NAF Earth Move, Landslide Susceptibility, 1	1.10E-03	-3
NAF Earth Move, Fault Creep, No	1.00E-03	-3
INC Fusion, Installation Year, >1982	8.13E-04	-4
MAT Plastic Mat Fail Fit, Installation Year, >1986	6.65E-04	-4
MAT Longitudinal Weld, Installation Year, <1951	6.33E-04	-4
NAF Earth Move, Segment Leak History, 0	6.10E-04	-4
MAT Plastic Mat Fail BOP, Jana/Squeeze/History, Jana 0 to 4 & Leak=0	5.00E-04	-4
NAF Flood, Flood Zone/Water Crossing, Yes	2.18E-04	-4
NAF Earthquake, Fault Crossing, Yes	2.10E-04	-4
NAF Earthquake, PGA/Liquefaction, PGA+0.1*LIQ_HAZ >=0.8	2.10E-04	-4
OOF Elec Fac, Material, Plastic/Unk	1.96E-04	-4
MAT Longitudinal Weld, Installation Year, >1950	1.52E-04	-4
INC Crossbore, Class/Install, Class 1 <2017 (for 0.25 miles, 20 services)	1.20E-04	-4
INC Crossbore, Class/Install, Plastic >1984 (for 0.25 miles, 20 services)	8.00E-06	-6
INC Crossbore, Class/Install, All other (for 0.25 miles, 20 services)	2.80E-06	-6
NAF Tsunami, Tsunami Area, Yes	7.70E-07	-7
NAF Earthquake, Fault Crossing, No	0.00E+00	n/a
NAF Earthquake, PGA/Liquefaction, PGA+0.1*LIQ_HAZ <0.8	0.00E+00	n/a
NAF Flood, Flood Zone/Water Crossing, No	0.00E+00	n/a
NAF Tsunami, Tsunami Area, No	0.00E+00	n/a
OOF Elec Fac, Material, Metallic	0.00E+00	n/a

Table Calibration 2: Service Supplemental Factor Category Values Comparison

Category	Value (Leaks/mile-year)	Order of Magnitude
COR Ext, CPA leak rate, max (continuous values)	4.97E+00	0
COR Ext, Segment Leak History, 2+	6.08E-01	-1
INC Plastic Tee Cap, Install Date/Segment Leak History, 1+ leaks	1.92E-01	-1
COR Ext, Segment Leak History, 1	1.50E-01	-1
EQP Seal Fail, Segment Leak History, 1+	1.41E-01	-1
MAT Plastic Tee Cap, Install Date/Segment Leak History, 1+ leaks	1.40E-01	-1
EXC Excavation, History/Depth/Material, Plastic Shallow	1.36E-01	-1
EXC Excavation, History/Depth/Material, Plastic 1+ leaks	7.91E-02	-2
EQP Misc, Segment Leak History, 1+	6.56E-02	-2
MAT Plastic Mat Fail Fitting, Install/Squeeze/History, 1+ leaks	6.05E-02	-2
MAT Plastic Mat Fail BOP, Install/Squeeze/History, <1985 & Leaks > 0	4.56E-02	-2
INC Construction, History/Material/Install, 1+ leaks	4.53E-02	-2
INC Plastic Tee Cap, Install Year < 1998	2.13E-02	-2
EXC Excavation, History/Depth/Material, Plastic 0 leaks	2.02E-02	-2
COR Ext, Segment Leak History, 0	1.90E-02	-2
MAT Plastic Tee Cap, Install Year < 1998	1.63E-02	-2
INC Construction, History/Material/Install, Plastic <1995	1.24E-02	-2
INC Construction, History/Material/Install, Plastic >1994	8.79E-03	-3
NAF Earth Move, Segment Leak History, 1+	6.65E-03	-3
MAT Plastic Mat Fail Fitting, Install/Squeeze/History, <1987	5.26E-03	-3
COR Ext, CPA leak rate, non-zero min (continuous values)	4.75E-03	-3
INC Plastic Tee Cap, Install Year > 1997	4.50E-03	-3
NAF Earth Move, Landslide Susceptibility, 5	3.57E-03	-3
EQP Seal Fail, Segment Leak History, 0	3.50E-03	-3
MAT Plastic Mat Fail BOP, Install/Squeeze/History, <1985 & Sqz >0	3.33E-03	-3
NAF Earth Move, Landslide Susceptibility, 4	3.03E-03	-3
EQP Misc, Segment Leak History, 0	2.50E-03	-3
NAF Earth Move, Landslide Susceptibility, 3	2.49E-03	-3
MAT Comp Coupling, Material/Install/Method, Install <1981	2.32E-03	-3
MAT Plastic Tee Cap, Install Year > 1997	2.02E-03	-3
NAF Earth Move, Landslide Susceptibility, 2	1.95E-03	-3
MAT Comp Coup, Matl/Inst/Method, Plastic & Inst >1980 & Inserted	1.82E-03	-3
EXC Excavation, History/Depth/Material, Metal	1.79E-03	-3
INC Construction, History/Material/Install, Metal	1.67E-03	-3
MAT Plastic Mat Fail Fitting, Install/Squeeze/History, >1986	1.58E-03	-3
NAF Earth Move, Landslide Susceptibility, 1	1.29E-03	-3
MAT Plastic Mat Fail BOP, Install/Squeeze/History, <1985 & no sqz	1.17E-03	-3

Category	Value (Leaks/mile-year)	Order of Magnitude
MAT Comp Coupling, Material/Install/Method, Plastic & Install >1980	6.79E-04	-4
NAF Earth Move, Segment Leak History, 0	5.98E-04	-4
INC Crossbore, Class/Install, Class 1 <2017 (for 0.018 miles)	5.56E-04	-4
NAF Earthquake, Fault Crossing, Yes	5.26E-04	-4
NAF Earthquake, PGA/Liquefaction, PGA+0.1*LIQ_HAZ >=0.8	5.26E-04	-4
INC Fusion, Installation Year, <1984	4.88E-04	-4
OOF Elec Fac, Joint Trench, Yes or Unk	3.86E-04	-4
NAF Flood, Flood Zone, Yes	3.70E-04	-4
OOF Elec Fac, Material, Plastic/Unk	2.49E-04	-4
MAT Plastic Mat Fail BOP, Install/Squeeze/History, >1984	1.60E-04	-4
MAT Comp Coupling, Material/Install/Method, Metal	1.14E-04	-4
INC Fusion, Installation Year, >1983	5.00E-05	-5
OOF Elec Fac, Joint Trench, No	4.11E-05	-5
INC Crossbore, Class/Install, Plastic non-Joint Trench (for 0.018 miles)	3.33E-05	-5
INC Crossbore, Class/Install, All other (for 0.018 miles)	5.56E-06	-6
NAF Tsunami, Tsunami Area, Yes	7.70E-07	-7
NAF Earthquake, Fault Crossing, No	0.00E+00	n/a
NAF Earthquake, PGA/Liquefaction, PGA+0.1*LIQ_HAZ <0.8	0.00E+00	n/a
NAF Flood, Flood Zone, No	0.00E+00	n/a
NAF Tsunami, Tsunami Area, No	0.00E+00	n/a
OOF Elec Fac, Material, Metallic	0.00E+00	n/a

Table Calibration 3: Above Ground Facility Supplemental Factor Category Values Comparison

Category	Value (Leaks/count)	Order of Magnitude
EQP Seal Failure, Point Leak History, 1+	1.08E-02	-2
OOF Fire, High Fire Threat Dist, 1 2 or 3	6.00E-03	-3
EQP Seal Failure, Point Leak History, 0	5.51E-03	-3
COR Atmos, Point Leak History, 1+	4.93E-03	-3
COR Atmos, Point Leak History, 0	2.96E-04	-4
OOF Vehicle, Cust Class, COM/IND	6.11E-05	-5
OOF Vehicle, PopDens, Low	1.95E-05	-5
NAF Earthquake, PGA/Liquefaction, PGA+0.1*LIQ_HAZ >=0.8	1.48E-05	-5
NAF Earthquake, Fault Crossing, Yes	1.48E-05	-5
OOF Vehicle, Cust Class, Other	1.06E-05	-5
OOF Vehicle, PopDens, High	1.02E-05	-5
OOF Vehicle, PopDens, Medium	6.96E-06	-6
NAF Earth Move, Landslide Susceptibility, 5	3.94E-06	-6
NAF Earth Move, Landslide Susceptibility, 4	3.94E-06	-6
NAF Earth Move, Landslide Susceptibility, 3	2.91E-06	-6
NAF Flood, Flood Zone, Yes	2.38E-06	-6
NAF Earth Move, Landslide Susceptibility, 1	2.30E-06	-6
NAF Earth Move, Landslide Susceptibility, 2	2.30E-06	-6
NAF Tsunami, Tsunami Area, Yes	7.70E-07	-7
NAF Earthquake, PGA/Liquefaction, PGA+0.1*LIQ_HAZ <0.8	0.00E+00	n/a
NAF Earthquake, Fault Crossing, No	0.00E+00	n/a
NAF Flood, Flood Zone, No	0.00E+00	n/a
NAF Tsunami, Tsunami Area, No	0.00E+00	n/a
OOF Fire, High Fire Threat Dist, Else	0.00E+00	n/a
OOF Vehicle, Cust Class, Curb Meter	0.00E+00	n/a
OOF Vehicle, PopDens, Curb Meter	0.00E+00	n/a

Table Calibration 4: Regulator Station Supplemental Factor Category Values Comparison

Category	Value (Leaks/count)	Order of Magnitude
EQP Seal Failure, Point Leak History, 1+	2.13E-02	-2
EQP Seal Failure, Point Leak History, 0	1.64E-02	-2
NAF Earthquake, PGA/Liquefaction, PGA+0.1*LIQ_HAZ >=0.8	3.62E-04	-4
NAF Earthquake, Fault Crossing, Yes	3.62E-04	-4
NAF Flood, Flood Zone, Yes	1.47E-04	-4
OOF Vehicle, Vaults, No	1.01E-04	-4
NAF Earth Move, Landslide Susceptibility, 5	3.97E-05	-5
NAF Earth Move, Landslide Susceptibility, 1	3.97E-05	-5
NAF Earth Move, Landslide Susceptibility, 2	3.97E-05	-5
NAF Earth Move, Landslide Susceptibility, 3	3.97E-05	-5
NAF Earth Move, Landslide Susceptibility, 4	3.97E-05	-5
NAF Tsunami, Tsunami Area, Yes	7.70E-07	-7
NAF Earthquake, PGA/Liquefaction, PGA+0.1*LIQ_HAZ <0.8	0.00E+00	n/a
NAF Earthquake, Fault Crossing, No	0.00E+00	n/a
NAF Flood, Flood Zone, No	0.00E+00	n/a
NAF Tsunami, Tsunami Area, No	0.00E+00	n/a
OOF Vehicle, Vaults, Yes	0.00E+00	n/a

TOPIC	Consequence of Failure (CoF) Model	ATTACHMENT N REVISION	5
ENGINEERS	[redacted]	PUBLICATION DATE	7/31/2020
SUMMARY	Description and background for sub-threat CoF model, factors, and parameters.	EFFECTIVE DATE	7/31/2020

Explanation of CoF Factor Values

Severity

Explanation of Factor:

The Severity factor accounts for the variation in consequences for different threats due to the tendencies toward different failure modes. It has units of SIFs per 100,000 unmitigated leaks ("unmitigated" meaning not immediately shut off by an excess flow valve; see Excess Flow Valve factor below). Per the PHMSA incident reporting instructions (Form PHMSA F 7100.1 (rev 10-2014)), a SIF includes: injuries sustained as a result of the incident and requiring hospital admission and at least one overnight stay, and fatalities at the time of the incident or within 30 days of the initial incident date due to injuries sustained as a result of the incident. The threats have been grouped into three severity classes, according to the historical rate of injuries and fatalities per leak based on nationwide PHMSA report data:

Table 1: SIFs per Leak by Threat Based on Nationwide PHMSA Report Data (Report Years 1999-2018*)

Severity Class	Threat	Leaks**	SIFs	SIFs per 100,000 Unmitigated Leaks**
High	Other Outside Forces	455,686	240	52.7
	Incorrect Operation	363,552	146	40.2
	Natural Forces	491,118	136	27.7
	Excavation Damage	1,847,012	331	17.9
	Other	2,524,151	280	11.1
Medium	Material, Weld, or Joint Failure	1,057,921	72	6.8
	Corrosion	2,715,680	46	1.7
Low	Equipment	3,302,020	4	0.1

*Data from Report Years 1999-2018 was used as 2019 data was not yet available from the PHMSA website as of March 30, 2020, which was when this analysis was completed in preparation for the 2020 Risk Assessment.

**Because PHMSA annual report instructions require the exclusion of leaks repaired by tightening, lubricating, or adjusting (TLA), the reported leak counts have been adjusted to estimate the inclusion of such leaks. The adjustment uses TLA percentages from 2009-2018 PG&E gas distribution leak repairs as approximations for nationwide percentages. All reported leaks are assumed to be "unmitigated."

The factor values for each class will be based on the nationwide historical rates of SIFs per leak for each severity class:

Table 2: Severity Class Factor Values (SIFs per 100,000 Leaks by Severity Class)

Severity Class	Leaks*	SIFs	SIFs per 100,000 Unmitigated Leaks*
High	5,681,518	1,133	19.9
Medium	3,773,601	118	3.1
Low	3,302,020	4	0.1

*The reported leak counts have been adjusted to estimate the inclusion of TLA leaks.

References/Data Sources:

- PHMSA SIFs per Leak Analysis: \\rcnas01-smb\riskmgmtprd-fs01\DIMP_2020\02. DIMP Compliance\03. Risk Evaluation\3. Documentation\CoF\PHMSA SIFsPerLeak Analysis 2020-03.xlsx

Migration

Explanation of Factor:

The Migration factor is a unitless multiplier that accounts for the relative likelihoods that leaks in different types of environments will migrate and accumulate, resulting in serious consequences. This factor takes into account whether the asset is buried or inside a structure, as opposed to aboveground or otherwise exposed.

The factor values are based on historical rates of PG&E repaired leaks that were determined to be hazardous (Grade 1) for each class. The rates for each class are rescaled to make the midpoint between the maximum and minimum values equal to 1, while preserving proportionality between the values; this is done by dividing all values by the midpoint value.

Table 3: Migration Classes with Hazardous Leak Rates and Factor Values

Migration Class	Rate of Hazardous (Grade 1) Leaks	Rescaled Factor Value
Aboveground/Exposed	0.10	0.31
Buried/Inside	0.54	1.69

Based on leaks repaired in years 2000-2019.

Assumptions:

- Each leak repair record accurately recorded the location of the leak at the time of the repair.
- The composition of PG&E's system is effectively similar (with regards to consequence factors) to the composition of the entirety of distribution systems reporting to PHMSA nationwide. (This assumption is necessary to apply the adjustment factors derived from PG&E leak data to the Severity factor derived from nationwide PHMSA data.)

References/Data Sources:

- PG&E Repaired Leaks Analysis: \\rcnas01-smb\riskmgmtprd-fs01\DIMP_2020\02. DIMP Compliance\03. Risk Evaluation\3. Documentation\CoF\Leaks Analysis for CoF 2020-03.twb

Pressure

Explanation of Factor:

The Pressure factor is a unitless multiplier that accounts for the relative likelihoods that leaks from assets operating at different pressures will result in serious consequences. A leak in a higher pressure class asset results in a higher release rate and potentially greater impact. When pressure is not available, the pressure class is assumed to be high pressure (HP).

The factor values are based on historical rates of PG&E repaired leaks that were determined to be hazardous for each class. The rates for each class are rescaled to make the midpoint between the maximum and minimum values equal to 1, while preserving proportionality between the values; this is done by dividing all values by the midpoint value.

Table 4: Pressure Classes with Hazardous Leak Rates and Factor Values

Pressure Class	Rate of Hazardous Leaks	Rescaled Factor Value
High Pressure (HP; greater than 25 psig)	0.56	1.13
Semi-High Pressure (SHP; greater than 12 in. water column, but not more than 25 psig)	0.46	0.93
Low Pressure (LP; less than or equal to 12 in.-w.c.)	0.43	0.87

Based on leaks repaired in years 1999-2018.

Assumptions:

- Each leak repair record accurately recorded the location of the leak and pressure class of the asset at the time of the repair.
- The composition of PG&E's system is effectively similar (with regards to consequence factors) to the composition of the entirety of distribution systems reporting to PHMSA nationwide. (This assumption is necessary to apply the adjustment factors derived from PG&E leak data to the Severity factor derived from nationwide PHMSA data.)

References/Data Sources:

- PG&E Repaired Leaks Analysis: \\rcnas01-smb\riskmgmtprd-fs01\DIMP_2020\02. DIMP Compliance\03. Risk Evaluation\3. Documentation\CoF\Leaks Analysis for CoF 2020-03.twb

Population Density

Explanation of Factor:

The Population Density factor is a unitless multiplier that reflects the relative impact to human life based on local population densities and locations. It is based on and applied using 2010 United States Census Block data.

The factor values are based on the median population density (people per square mile by census block) represented by each population density class. The densities for each class are rescaled to make the midpoint between the maximum and minimum values equal to 1, while preserving proportionality between the values.

Table 5: Population Density Classes with Median Population Densities and Factor Values

Population Density Class	Median Population Density (rounded to nearest thousand)	Rescaled Factor Value
High Density (people per square mile > 9,000)*	13,000	1.73
Medium Density (5,000 < ppsqmi ≤ 9,000)	7,000	0.93
Low Density (ppsqmi ≤ 5,000)	2,000	0.27

*Assets within 100 feet of special impact locations are included in the "High Density" class. Special impact locations are public assembly locations, business districts, high risk customer meters, and railways.

Where an asset intersects multiple blocks, a block area-weighted average population density is used to determine the population class.

References/Data Sources:

- Census Data Analysis: \\ffshare01-nas\riskmgmt\DIMP_2018\02. DIMP Compliance\03. Risk Evaluation\Known Threats\2. Documentation\CoF\PGE population analysis.twb

Excess Flow Valve (EFV)

Explanation of Factor:

The EFV factor reflects the likelihood of an EFV to operate. It has units of unmitigated leaks per leak. It reduces the consequence for service (including branch service) and AGF assets where an EFV exists upstream. EFVs are designed to shut off gas flow to services when high flow rates are experienced, so their likelihood to operate depends on asset failure modes. To determine factor values, failure modes are assumed to correlate with the severity classes delineated for the severity factor (see Severity Factor section above). Factor values will be based on the historical rate of EFV not operated per EFV existing for each Severity class.

Table 6: Severity Classes with EFV Non-Operation Rate and Factor Values

Severity Class	EFV Non-Operation Rate	Factor Value [Unmitigated Leaks / Leak]
High	37%	0.37
Medium	57%	0.57
Low	81%	0.81

Based on leaks repaired in years 1999-2018.

For an AGF or service feature where an EFV does not exist upstream, the factor value will be 1. Also, for main and regulator station features, the factor value will be 1.

Assumptions:

- Each leak repair record accurately recorded the location of the leak at the time of the repair.
- Each relevant leak repair record accurately recorded whether an EFV existed at the time of the repair.
- The composition of PG&E's system is effectively similar (with regards to consequence factors) to the composition of the entirety of distribution systems reporting to PHMSA nationwide. (This assumption is necessary to apply the adjustment factors derived from PG&E leak data to the Severity factor derived from nationwide PHMSA data.)

References/Data Sources:

- PG&E Repaired Leaks Analysis: \\rcnas01-smb\riskmgmtprd-fs01\DIMP_2020\02. DIMP Compliance\03. Risk Evaluation\3. Documentation\CoF\Leaks Analysis for CoF 2020-03.twb

QUESTION 2

U.S. DEPARTMENT OF TRANSPORTATION PIPELINE AND HAZARDOUS MATERIALS SAFETY ADMINISTRATION (PHMSA) ANNUAL REPORT OF GAS DISTRIBUTION 2021

NOTICE: This report is required by 49 CFR Part 191. Failure to report may result in a civil penalty OMB No. 2137-0629 as provided in 49 USC 60122.

OMB NO: 2137-0629
EXPIRATION DATE: 5/31/2024

		Initial Date Submitted:	03/01/2022
U.S. Department of Transportation Pipeline and Hazardous Materials Safety Administration	**ANNUAL REPORT FOR CALENDAR YEAR 2021 GAS DISTRIBUTION SYSTEM**	**Report Submission Type**	INITIAL
		Date Submitted:	

A federal agency may not conduct or sponsor, and a person is not required to respond to, nor shall a person be subject to a penalty for failure to comply with a collection of information subject to the requirements of the Paperwork Reduction Act unless that collection of information displays a current valid OMB Control Number. The OMB Control Number for this information collection is 2137-0629. Public reporting for this collection of information is estimated to be approximately 16 hours per response, including the time for reviewing instructions, gathering the data needed, and completing and reviewing the collection of information. All responses to this collection of information are mandatory. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden to: Information Collection Clearance Officer, PHMSA, Office of Pipeline Safety (PHP-30) 1200 New Jersey Avenue, SE, Washington, D.C. 20590.

Important: *Please read the separate instructions for completing this form before you begin. They clarify the information requested and provide specific examples. If you do not have a copy of the instructions, you can obtain one from the PHMSA Pipeline Safety Community Web Page at http://www.phmsa.dot.gov/pipeline/library/forms.*

PART A - OPERATOR INFORMATION	**(DOT use only)**		**20220542-45515**

1. Name of Operator	PACIFIC GAS & ELECTRIC CO
2. LOCATION OF OFFICE (WHERE ADDITIONAL INFORMATION MAY BE OBTAINED)	
2a. Street Address	6111 BOLLINGER CANYON RD #4430H
2b. City and County	SAN RAMON
2c. State	CA
2d. Zip Code	94583
3. OPERATOR'S 5 DIGIT IDENTIFICATION NUMBER	15007
4. HEADQUARTERS NAME & ADDRESS	
4a. Street Address	PG&E - GAS OPERATIONS, REGULATORY COMPLIANCE
4b. City and County	SAN RAMON
4c. State	CA
4d. Zip Code	94583
5. STATE IN WHICH SYSTEM OPERATES	CA
6. **THIS REPORT PERTAINS TO THE FOLLOWING COMMODITY GROUP** *(Select Commodity Group based on the predominant gas carried and complete the report for that Commodity Group. File a separate report for each Commodity Group included in this OPID.)*	
Natural Gas	
7. **THIS REPORT PERTAINS TO THE FOLLOWING TYPE OF OPERATOR** *(Select Type of Operator based on the structure of the company included in this OPID for which this report is being submitted.)*:	
Investor Owned	

PART B - SYSTEM DESCRIPTION

1.GENERAL

	STEEL				PLASTIC	CAST/ WROUGHT IRON	DUCTILE IRON	COPPE R	OTHER	RECONDITION ED CAST IRON	SYSTEM TOTAL
	UNPROTECTED		CATHODICALLY PROTECTED								
	BARE	COATED	BARE	COATED							
MILES OF MAIN	1.37	232.05	24.71	19420.65	24042.76	53.5	0	0	0	0	43775.04
NO. OF SERVICES	7	7465	284	1138986	2502696	31	0	76	0	0	3649545

2.MILES OF MAINS IN SYSTEM AT END OF YEAR

MATERIAL	UNKNOWN	2" OR LESS	OVER 2" THRU 4"	OVER 4" THRU 8"	OVER 8" THRU 12"	OVER 12"	SYSTEM TOTALS
STEEL	15.32	12656.04	5042.42	1688.76	162.63	113.60	19678.77
DUCTILE IRON	0	0	0	0	0	0	0
COPPER	0	0	0	0	0	0	0
CAST/WROUGHT IRON	.45	30.79	17.94	4.25	.07	0	53.5
PLASTIC PVC	0	0	0	0	0	0	0
PLASTIC PE	3.83	18593.41	4447.11	998.36	.05	0	24042.76
PLASTIC ABS	0	0	0	0	0	0	0
PLASTIC OTHER	0	0	0	0	0	0	0
OTHER	0	0	0	0	0	0	0
RECONDITIONED CAST IRON	0	0	0	0	0	0	0
TOTAL	19.6	31280.24	9507.47	2691.37	162.75	113.6	43775.03

Describe Other Material:

3.NUMBER OF SERVICES IN SYSTEM AT END OF YEAR — **AVERAGE SERVICE LENGTH: 49.7**

MATERIAL	UNKNOWN	1" OR LESS	OVER 1" THRU 2"	OVER 2" THRU 4"	OVER 4" THRU 8"	OVER 8"	SYSTEM TOTALS
STEEL	23276	1073876	48614	856	71	49	1146742
DUCTILE IRON	0	0	0	0	0	0	0
COPPER	0	76	0	0	0	0	76
CAST/WROUGHT IRON	0	27	4	0	0	0	31
PLASTIC PVC	0	0	0	0	0	0	0
PLASTIC PE	21114	2435741	44592	1182	58	9	2502696
PLASTIC ABS	0	0	0	0	0	0	0
PLASTIC OTHER	0	0	0	0	0	0	0
OTHER	0	0	0	0	0	0	0
RECONDITIONED CAST IRON	0	0	0	0	0	0	0
TOTAL	44390	3509720	93210	2038	129	58	3649545

Describe Other Material:

4.MILES OF MAIN AND NUMBER OF SERVICES BY DECADE OF INSTALLATION

NOTICE: This report is required by 49 CFR Part 191. Failure to report may result in a civil penalty OMB No. 2137-0629 as provided in 49 USC 60122.

OMB NO: 2137-0629
EXPIRATION DATE: 5/31/2024

	UNKNOWN	PRE-1940	1940-1949	1950-1959	1960-1969	1970-1979	1980-1989	1990-1999	2000-2009	2010-2019	2020-2029	TOTAL
MILES OF MAIN	253.59	1362.14	3013.43	6131.69	6571.79	6142.24	5923.92	5582	5282.10	2822.64	689.52	43775.06
NUMBER OF SERVICES	450552	24371	97570	367009	344169	461086	478491	513552	487948	349418	75377	3649543

PART C - TOTAL LEAKS AND HAZARDOUS LEAKS ELIMINATED/REPAIRED DURING THE YEAR

CAUSE OF LEAK	MAINS		SERVICES	
	TOTAL	HAZARDOUS	TOTAL	HAZARDOUS
CORROSION FAILURE	1324	320	2614	1972
NATURAL FORCE DAMAGE	72	42	423	275
EXCAVATION DAMAGE	196	190	1392	1362
OTHER OUTSIDE FORCE DAMAGE	14	13	223	206
PIPE, WELD OR JOINT FAILURE	101	62	1578	879
EQUIPMENT FAILURE	322	190	2832	628
INCORRECT OPERATIONS	503	206	2555	1480
OTHER CAUSE	83	46	9929	1435

NUMBER OF KNOWN SYSTEM LEAKS AT END OF YEAR SCHEDULED FOR REPAIR : **1**
NUMBER OF HAZARDOUS LEAKS INVOLVING A MECHANICAL JOINT FAILURE : 618

PART D - EXCAVATION DAMAGE

1. TOTAL NUMBER OF EXCAVATION DAMAGES BY APPARENT ROOT CAUSE: 1629

a. One-Call Notification Practices Not Sufficient: 751

b. Locating Practices Not Sufficient: 157

c. Excavation Practices Not Sufficient: 688

d. Other: 33

2. NUMBER OF EXCAVATION TICKETS : 1673545

PART E - EXCESS FLOW VALUE (EFV) AND SERVICE VALVE DATA

Total Number Of Services with EFV Installed During Year: 20761

Estimated Number Of Services with EFV In the System At End Of Year: 415381

* Total Number of Manual Service Line Shut-off Valves Installed During Year: 2332

* Estimated Number of Services with Manual Service Line Shut-off Valves Installed in the System at End of Year: 97628

**These questions were added to the report in 2017.*

PART F - LEAKS ON FEDERAL LAND

TOTAL NUMBER OF LEAKS ON FEDERAL LAND REPAIRED OR SCHEDULED TO REPAIR: 28

PART G-PERCENT OF UNACCOUNTED FOR GAS

UNACCOUNTED FOR GAS AS A PERCENT OF TOTAL CONSUMPTION FOR THE 12 MONTHS ENDING JUNE 30 OF THE REPORTING YEAR.

[(PURCHASED GAS + PRODUCED GAS) MINUS (CUSTOMER USE + COMPANY USE + APPROPRIATE ADJUSTMENTS)] DIVIDED BY (CUSTOMER USE + COMPANY USE + APPROPRIATE ADJUSTMENTS) TIMES 100 EQUALS PERCENT UNACCOUNTED FOR.

FOR YEAR ENDING 6/30: .81%

PART H - ADDITIONAL INFORMATION

PART I - PREPARER

Susie Richmond,Mgr. Gas Ops Compliance (Preparer's Name and Title)	(925) 786-0267 (Area Code and Telephone Number)
Susie.Richmond@pge.com (Preparer's email address)	(Area Code and Facsimile Number)