PACIFIC GAS AND ELECTRIC COMPANY
RSE LITE TOOL DOCUMENTATION AND USER GUIDE

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1 Introduction and Purpose

The RSE Lite tool was created to estimate the Risk Spend Efficiency (RSE) of a proposed program given the program characteristics such as scope, cost, effectiveness, benefit length, etc. This tool uses existing baseline data (Tranche Exposure, Likelihood and Consequence of a Risk Event) for a specified risk event or a Cross Cutting Factor, computed from the Enterprise Risk Model (ERM) and focuses on calculating a risk reduction and RSE on a program by program basis. In this document, the terms Baseline and Test Year (TY) Baseline are used interchangeably. For the 2023 GRC, program risk reduction is calculated relative to the TY Baseline. In other use cases, it may be appropriate to use the Baseline instead. For more details on baseline risk scores and RSE calculation methodology, please read the ERM Documentation and User Guide[1].

This RSE Lite Tool Documentation and User Guide assumes that a reader is familiar with the terminology and methodology explained in the ERM Documentation and User Guide and explains the information specific to the RSE Lite tool, which implements a simplified risk reduction and RSE calculation so that the effects of adjusting program characteristics can be quickly estimated.

2 RSE Lite Methodology

The RSE Lite tool requires as an input the yearly Likelihood of Risk Event (LoRE), Consequence of Risk Event (CoRE), and Tranche Exposure. This LoRE and CoRE represent the baseline risk, which is the risk score assuming that the control programs are in place (controls are programs that are in place that reduce the risk from an Inherent case to the Baseline case). This has implications when calculating risk reductions for controls and mitigations. Consistent with the 2018 S-MAP Revised Lexicon[2], mitigations are programs that further reduce risk from the baseline risk score in the presence of the program, while controls are programs that would increase risk from the baseline risk score in the absence of the program.

This section is structured so that the reader can follow the flow of information in the RSE calculation procedure from Program Inputs (Section 2.1) to the RSE calculation (Section 2.5). However, the reader may also find it useful to follow the narrative in the Outputs (Section 3.4), which starts from the RSE calculation (Section 2.5), the highest, most aggregated level and follow how this uses the most granular level of information provided in Program Inputs (Section 2.1).

2.1 Program Inputs

To estimate the risk reduction of a program, the following user input is required. User inputs are described in more detail in Section 3.2.

[1] See "Risk Modeling WP-1 PGE Enterprise Risk Model Documentation and User Guide"
[2] See D.18-12-014, p.16

1. Program scope describing how much of the tranche exposure is affected by the program in each year.

2. Program Cost and how the cost is allocated to specific Tranches within the Risk Event to get Program Cost by Tranche.

3. The risk reduction impact of the program, characterized by
    a. Effectiveness as a percentage reduction of specific driver/sub-driver frequencies and/or percentage reduction of the consequence of specific attributes for the program scope specified.

       For mitigations the effectiveness is expressed as a reduction relative to the baseline.

       For controls the effectiveness can be expressed in two ways: 1) work unit based: as an expected number of risk events reduced per work unit 2) exposure unit based: as a reduction relative to the inherent risk, i.e. the risk without the control program being evaluated.

    b. Benefit length, i.e. the number of years that the risk reduction of the program persists, once the program is implemented.

    c. Effectiveness degradation rate or method, describing how the effectiveness degrades over the benefit length.

2.2 Tranche-level Average Effectiveness

The program effectiveness input is with respect to the program scope applied, and the program scope can often be a subset of the tranche exposure. Thus, the effectiveness input needs to be adjusted (or normalized) to be the effectiveness that can be applied to the tranche-level risk score. We term this tranche-level average effectiveness. For example, if the program scope is 30% of the tranche exposure and effectiveness input is 40% to the program scope, then the tranche-level effectiveness is 30%*40% = 12% on average for the tranche.

The program effectiveness input is also for the first year of the program implemented. If the program is implemented or performed on a specific program scope in year *y0* and program benefit lasts *n* years, then the program effectiveness needs to be extrapolated using the specified effectiveness degradation rate or method for the years *y0+1*, …, *y0+n-1*.

Specifically, given the program inputs (i.e., scope, effectiveness, benefit length, effectiveness degradation rate), the RSE Lite tool computes average effectiveness of the program as a percentage of tranche risk score for an applicable sub-driver or attribute that the program mitigates.[3]

$AvgEff(y, Tranche, \cdot)$ is the tranche-level effectiveness accounting for the program scope, benefit life, and degradation as applicable:

[3] When the program effectiveness is different by outcomes, this calculation is done at the tranche-outcome level.

(1) $AvgEff_{y0}(y, Tranche, \cdot) = \frac{ProgramExposure_{y0}(y)}{Exposure(y)} Eff(Tranche, \cdot) DegradationFactor(y - y0)$

Where

(2) $DegradationFactor(k) = \begin{cases} 0, & if\ k \geq BenefitLife \\ DF_{m,k}, & if\ k < BenefitLife\ and\ DegradationMethod = m \end{cases}$

Where $DegradationFactor$ is Effectiveness Degradation Rate, and Degradation Method is the Effectiveness Degradation Method as input by the user and described in Section 3.2.4.

For Mitigation programs, the $AvgEff_{y0}(y, Tranche, \cdot)$ is used directly to compute risk reduction without further conversion. For Control programs whose exposure unit is not expressed as 'Work unit', the effectiveness input is in terms of effectiveness from Inherent Risk (i.e, risk with the control program removed from baseline), thus $AvgEff_{y0}(y, Tranche, \cdot)$ is converted to the Effectiveness relative to the Baseline Risk using the following formula before being multiplied to Baseline Risk in Section 2.3:

(3) $AvgEff_{y0}(y, Tranche, \cdot) \leftarrow \frac{AvgEff_{y0}(y, Tranche, \cdot)}{1 - AvgEff_{y0}(y, Tranche, \cdot)}$

2.3 Tranche-level Risk Reduction

Once the tranche-level average effectiveness is obtained, the tranche-level risk reduction in each year for an applicable sub-driver or attribute can be calculated as a product of 1) the average effectiveness value of the program to the tranche risk score and 2) tranche risk score. These risk reduction values are then aggregated. Specifically, the risk reduction for year *y* for a preventive program[4] implemented in year *y0* is calculated as:

(4) $Frequency\ Risk\ Reduction_{y0}(y, Tranche) = Exposure(y, Tranche) \times \sum_{outcome}[(\sum_{subdriver} LoRE\ Reduction\ (y, Tranche, Outcome, subdriver)) \times CoRE(y, Tranche, Outcome)]$

Where

(5) $LoRE\ Reduction(y, Tranche, Outcome, subdriver) = AvgEff_{y0}(y, Tranche, Outcome, subdriver) \times LoRE(y, Tranche, Outcome, subdriver)$

The risk reduction for year y for a protective program[5] implemented in year *y0* is calculated as:

(6) $Consequence\ Risk\ Reduction_{y0}(y, Tranche) = Exposure(y, Tranche) \times \sum_{Outcome}[LoRE(y, Tranche, Outcome) \times \sum_{Attribute} CoRE\ Reduction(y, Tranche, Outcome, Attribute)]$

Where

[4] A preventive program is a program that reduces the likelihood of a risk event

[5] A protective program is a program that reduces the consequence of a risk event.

(7) $$CoRE\ Reduction(y, Tranche, Outcome, Attribute) = \left(AvgEff_{y0}(y, Tranche, Outcome, Attribute) \times CoRE(y, Tranche, Outcome, Attribute)\right)$$

Note that the direct multiplication of the program effectiveness to the CoRE value is a simplification of the ERM model methodology. The ERM methodology applies the program effectiveness to the simulated natural unit of the consequence, applies the MAVF scaling function to calculate the simulated CoRE values, and finally averages the CoRE values to compute the Risk Score.

Tranche-level Risk Reduction from a mitigation program for each year is then calculated as in equation (8). For a control program, the last term in equation (8) is added instead of subtracted.

(8) $$\begin{aligned} Risk\ Reduction_{y0}(y, Tranche) &= Frequency\ Risk\ Reduction_{y0}(y, Tranche) + \\ &Consequence\ Risk\ Reduction_{y0}(y, Tranche) \\ &-Exposure(y, Tranche) \\ &\times \sum_{outcome} \Bigg[\sum_{subdriver} \Big(AvgEff_{y0}(y, Tranche, Outcome, subdriver) \\ &\times LoRE(y, Tranche, Outcome, subdriver)\Big) \\ &\times \sum_{Attribute} \big(AvgEff_{y0}(y, Tranche, Outcome, Attribute) \\ &\times CoRE(y, Tranche, Outcome)\big)\Bigg] \times \frac{Exposure(y,\ Tranche)}{ProgramExposure_{y0}(y,\ Tranche)} \end{aligned}$$

Note that most programs either reduce likelihood or consequence of a risk event, not both. When that is true, programs have zero as the last term above, and one of the first two terms will also be zero.

2.4 NPV OF RISK REDUCTION

The Net Present Value (NPV) of Tranche Risk Reduction for a program implemented in *y0* is calculated as:

(9) $$\begin{aligned} &NPV\ Risk\ Reduction_{y0}(\ Tranche) \\ &= \sum_{y0 \le y < y_0 + Benefit\ life} \left(\frac{1}{(1+r)^{y-y0}} \times Risk\ Reduction_{y0}(y, Tranche)\right) \end{aligned}$$

where *r* is a discount rate consistent across all risks and the Benefit Life is as specified per program.

NPV Risk Reduction from a program is then aggregated over applicable tranches:

(10) $$NPV\ Risk\ Reduction_{y0} = \sum_{Tranche} NPV\ Risk\ Reduction_{y0}(Tranche)$$

2.5 RSE

The Risk Spend Efficiency (RSE) of program implemented in year *y0* is calculated as the ratio of the net present value of annual risk reduction to the net present value of the costs, as follows:

(11) $$RSE_{y0} = \frac{NPV\ Risk\ Reduction_{y0}}{NPV\ (Cost_{y0})}$$

The RSE of program implemented over the GRC period (i.e., 2023-2026) is also calculated in the RSE lite tool as:

(12) $$RSE_{2023-2026} = \frac{\sum_{y0=2023}^{2026} NPV\ Risk\ Reduction_{y0}}{\sum_{y0=2023}^{2026} NPV\ (Cost_{y0})}$$

2.6 Caveats and Limitations

As mentioned the Risk Reduction Methodology section 2.3 of this Document and Portfolio-level Analysis Section 4.2.1 in the ERM Documentation and User Guide, the RSE Lite Tool will not produce the same RSEs as the Enterprise Risk model because the RSE Lite Tool:

1. Simplifies consequence mitigation calculation by computing CoRE reduction, not Natural Unit reduction.
2. Does not consider diminished risk reduction when a program **interacts** with other programs (different program mitigates risk on the same exposure). Thus, the risk reduction and RSE values here are for comparing programs against one another and should not be used to calculate the risk reduction of a portfolio of programs[6].
3. Does not consider diminished risk reduction when a program **overlaps** itself in time (same program mitigates risk on the same exposure)[7]

3 RSE Lite User Guide

This section of the document describes how the methodology described in Section 2 has been implemented, and serves as a User Guide as to how the information flows between PG&E's Enterprise Risk Model (ERM) and the RSE Lite Tool to calculate marginal risk reduction and Risk Spend Efficiency Values.

[6] For more information on scope overlap between programs, see Section 4.2.1. of the "Risk Modeling WP-1 PGE Enterprise Risk Model Documentation and User Guide"

[7] For more information on the scope overlap within a program, see the same reference as in footnote 6.

3.1 TOOL ARCHITECTURE

The RSE Input File and RSE Lite Tool are both components of PG&E's risk quantification process, as shown in Figure 1 below, replicated from the ERM Documentation and User Guide.

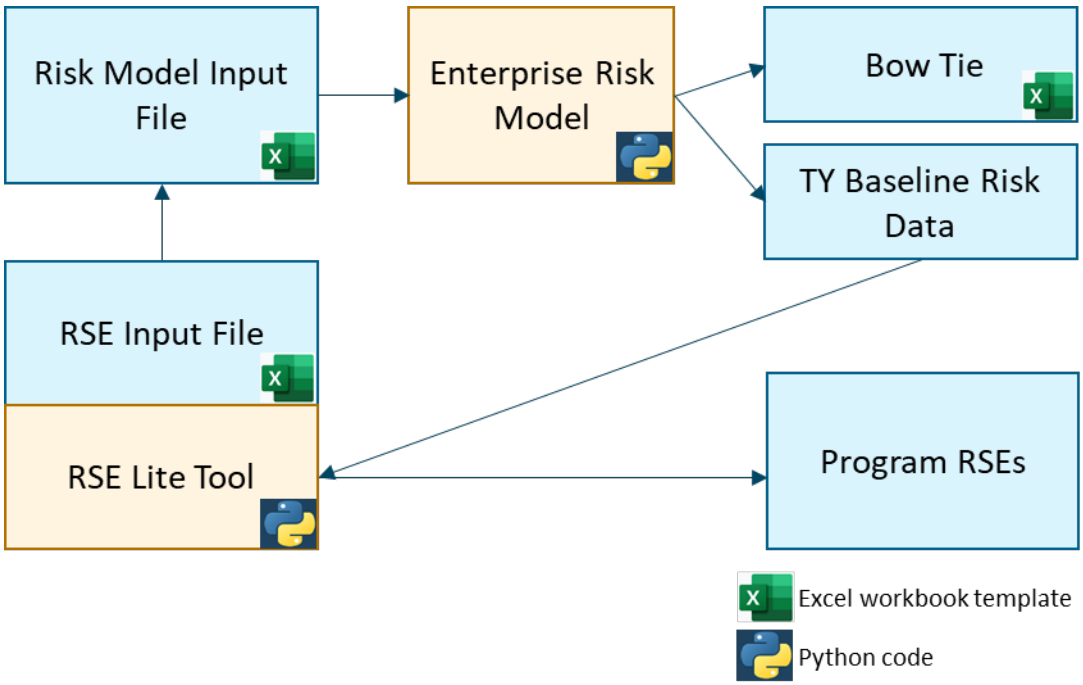


Figure 1: Enterprise Risk Model Architecture

The RSE Input File contains the input formation needed to run the RSE Lite Tool. Each RSE Input File contains the Controls and Mitigations that serve to maintain or reduce risk levels for a particular Risk Event or Cross Cutting Factor. Program definition includes program scope, cost, effectiveness, and benefit length that affect relevant bow-tie elements.

The RSE Lite Tool also relies on ERM model output (aka TY Baseline Risk Data[8]) for Tranche exposure, Test Year Baseline LoRE, and Test Year Baseline CoRE values to calculate the program risk reduction.

In general, the RSE Input file follows a similar convention for cell formatting as the Risk Model Input File:

Description	**Format**
Input cell - user input required	
Error checking cell - formula that should not be touched	
Analysis cell - formula that should not be touched	

3.2 INPUTS

The first five tabs in the RSE Input File are where the user provides inputs that characterize the Mitigation and Control programs. The tabs numbered 1- through 4- are parsed by the RSE Lite Tool Python code to perform the risk reduction and RSE calculation as described in Section 2. In addition,

[8] TY Baseline Risk Data files are available for each Risk Event for which RSEs are calculated.

there may be as many additional informational tabs as needed to support the information in these five tabs.

The following subsections detail inputs provided by the user in each of the named tabs.

3.2.1 Tab Summary of Programs

This tab provides the user and reviewer a high-level view of the programs that affect a Risk Event or Cross-Cutting Factor.

Each row in the table contains a high-level summary of the Control and Mitigation programs. The first three columns (Program ID, Program, and Mitigation or Control) is used to identify the programs in later tabs, so it is important that the program names in this tab must match identically the program names in the other tabs.

3.2.2 Tab 1-Program Exposure

The table *TableExposure* in this tab allows the user to specify the program scope.

Program ID: Unique identifier for the Program; this is a lookup via formula from the Summary of Programs tab.

Type: Whether the program is a Mitigation or Control; this is a lookup via formula from the Summary of Programs tab.[9]

Program: Input the program name exactly as written in the Summary of Programs tab.

Risk (for Cross Cutter Only): For Cross Cutting programs, the programs need to be mapped to a particular Risk Event. Each program mapped to a particular Risk Event needs to have its own row.

Tranche: the tranche that the program affects
If the program affects all tranches, leave as blank
If the program affects a few tranches, either

1. list each tranche in a separate line with the same program name, or
2. use the keyword "- All" to specify aggregate tranches. More detail on how to specify aggregate tranches in Section 3.2.2.1

Program Exposure YYYY: Specify the program exposure for year YYYY in the units as specified in the Unit for Program Exposure column.

Unit for Program Exposure: The dropdown provides three options:
1. Exposure unit
2. % of tranche exposure
3. Work unit

Choose "Exposure unit" to indicate that the program exposure entries are in the same units as the tranche exposure, "% of tranche exposure" if the program exposure entries are expressed as percentage of the tranche exposure, and "Work unit" if the program is a control and the

[9] A control program is occasionally termed 'Compliance Control'. This is handled identically in calculations to a 'Control' program.

program exposure entries indicate the number of assets to be worked on. Note: If “Work unit” is selected, the effectiveness values specified in Tab 3 or 4 are interpreted differently and a slightly modified methodology is used to calculate the risk reduction from the program. This methodology is described in Section 3.2.2.2.

Risk Exposure Unit: An optional text field for the user to specify the risk exposure unit as modeled in the ERM. *For informational purposes only.*

Work Units YYYY: For some programs, work units are specified in the GRC filing, and these may differ from the risk exposure units used in the ERM. An example of this is for the Vegetation Management program for the Failure of Electric Distribution Overhead Assets risk (DOVHD). The risk exposure units are in miles while the work units are by the number of trees being managed by the program. *For informational purposes only.*

For some Control programs, the user may choose to use work units as the Unit for Program Exposure. In this case, the Program Exposure YYYY columns will have the same values as the Work Units YYYY and a different methodology is used to calculate the risk reduction from the program. This methodology is described in Section 3.2.2.2.

Unit for work units: An optional text field for the user to specify the work unit. *For informational purposes only.*

Explanation of relationship between different units: An optional text field for the user to describe the relationship between the different units if the connection is not obvious. *For reference only.*

Other Note: An optional text field for the user to provide any other information. *For informational purposes only.*

Flag for modeler: A validation cell that throws a flag if the Unit for Program Exposure is specified as “% of tranche exposure”, but the value in the Program Exposure YYYY cells are greater than 1.

Risk ID: Used by the model to filter and sort Cross-Cutting Factor programs by Risk Event. References the Risk (for Cross Cutter Only) column. If this column is empty, the value defaults to the Risk Event Risk ID.

3.2.2.1 Specifying aggregate Tranches

To group tranches, "- All" text will serve as a wildcard to use all the tranches that begin with the text before the "-" character. Note that a space is preferred around the "-" character for readability, but not necessary.

The Unit for Program Exposure for aggregated tranches can be in any of the options provided to the user. If **“**% of tranche exposure” is selected, the same percentage is used across all the tranches within the aggregated tranche. Otherwise, the value provided is allocated to each of the tranches within the aggregated tranche proportional to the tranche exposure.

Illustrative examples using simplified wildfire tranches as listed below.

Tranche	Exposure (miles)
HFTD - Distribution - A	50

HFTD - Distribution - B	75
HFTD - Distribution - C	100
Non-HFTD - Distribution	5000
HFTD – Transmission – Tier 1 – Voltage Class 1	20
HFTD – Transmission – Tier 1 – Voltage Class 2	40
HFTD - Transmission - Tier 2 - Voltage Class1	45
HFTD - Transmission - Tier 2 - Voltage Class2	50
Non-HFTD - Transmission - Voltage Class1	2000
Non-HFTD - Transmission - Voltage Class2	4000

Given the list of tranches above, different levels of aggregated tranches can be specified:

HFTD - All: applies the program to all HFTD tranches.
HFTD - Distribution - All: applies the program to tranches that start with "HFTD - Distribution"
HFTD - Transmission - All: apples the program to tranches that start with "HFTD - Transmission"
HFTD - Transmission - Tier 2 - All: applies the program to tranches that start with "HFTD - Distribution - Tier 2"

Example 1: Specifying aggregate Tranche Exposure as "% of tranche exposure"

In the 1-Program Exposure tab:

Program	Tranche	Program Exposure 2020	Unit for Program Exposure
Program A	HFTD – Distribution – All	15%	% of tranche exposure

In the RSE Lite Tool, the Program Exposure is expanded to

Program	Tranche	Program Exposure (miles)
Program A	HFTD - Distribution – A	15% * 50 = 7.5
Program A	HFTD - Distribution – B	15% * 75 = 11.25
Program A	HFTD - Distribution – C	15% * 100 = 15

Example 2: Specifying aggregate Tranche Exposure as "Exposure unit"

In the 1-Program Exposure tab:

Program	Tranche	Program Exposure 2020	Unit for Program Exposure
Program A	HFTD – Distribution – All	50	Exposure unit

In the RSE Lite Tool, the Program Exposure is expanded to

Program	Tranche	Program Exposure (miles)
Program A	HFTD - Distribution - A	50 * 50/225 = 11.1
Program A	HFTD - Distribution - B	50 * 75/225 = 16.7
Program A	HFTD - Distribution - C	50 * 100/225 = 22.2

The Tool will allocate the total Program Exposure by the relative percentage of the tranche exposure.
The same methodology applies if the Unit for Program Exposure selected is "work unit".

3.2.2.2 Methodology for program exposure specified as Work Units

As mentioned in the methodology in Section 2.1, the RSE Lite tool allows the user to specify the Program Exposure for Control programs in Work Units and interpret effectiveness input as an expected number of risk events reduced per work unit. In order words, it is the probability of having a risk event when one unit of work is not performed, multiplied by the probability of preventing the risk event when one unit of work is performed. Then, instead of calculating the LoRE reduction per Unit Tranche Exposure directly, the subdriver-level Frequency reduction is first calculated as:

(13) $$Frequency\ Reduction\ (y, Subdriver,\ Tranche, Outcome) =$$

$$WorkUnits(Tranche) \times Effectivenes(y, Subdriver)$$

$$\times \frac{BaselineFrequency\ (y, Subdriver, Tranche, Outcome)}{\sum_{applicable\ Subdrivers} \sum_{Outcome} BaselineFrequency\ (y, Subdriver, Tranche, Outcome)}$$

This frequency reduction is then converted to the LoRE reduction per Unit Tranche Exposure using the following equation:

(14) $$Lore\ Reduction(y, Tranche, Outcome) = \sum_{Subdriver} \frac{Frequency\ Reduction\ (Subdriver, Tranche, Outcome, Year)}{Exposure(Tranche)}$$

Beyond this point, the same calculation as in Section 2.3 follows.

3.2.3 Tab 2-Program Cost

There are two tables in this tab. The first table, *TableProgSpend*, allows the user to specify the costs by program.

Program ID: Unique identifier for the Program; this is a lookup via formula from the Summary of Programs tab.

Type: Whether the program is a Mitigation or Control; this is a lookup via formula from the Summary of Programs tab.

Program: Input the program name exactly as written in the Summary of Programs tab.

MAT (optional): This allows the user to further disaggregate the program costs into Maintenance Activity Type (MAT) level, if preferred. The user can use this column as informational to indicate what MAT codes are related to this program. Alternately, the user can use different rows to specify costs related to different MAT codes for the same program.

Independent of how the MAT column is used, the RSE Lite Tool will calculate the Risk Spend Efficiency based on the total program cost.

CapEx USD YYYY: The annual capital expenditures for the program, a user input. To account for all costs associated with capital investments subject to cost-of-service ratemaking (i.e., depreciation, income taxes, property tax, insurance, incremental expenses and return on equity over the life of an asset), a Present Value of Revenue Requirement (PVRR) multiplier is applied in the RSE Lite Tool based on user selections in later columns. The PVRR multiplier methodology is

described in Section 3.2.3.1 of this Document as well as Section 1.6.2 of the ERM documentation and User Guide.

OpEx USD YYYY: The annual expense expenditures for the program, a user input.

Asset Type: The asset type for the capital expenditures.

Generic Capital PVRR Multiplier: The PVRR multiplier based on default assumptions based on the Asset Type selection, not including incremental operation and maintenance (O&M) costs, as described in in Section 3.2.3.1. If Asset Type is "Custom", this cell will be blank.

Custom Capital PVRR Multiplier: A user-defined PVRR multiplier, not including incremental O&M costs. Assumptions made to arrive at this multiplier should be justified in a separate reference tab. The Asset Type should be specified as "Custom" for this value to be used.

Generic Lifetime Incremental O&M PVRR Multiplier: The incremental O&M cost associated with the capital expenditure based on default assumptions and the Asset Type selection as described in in Section 3.2.3.1.

Custom Lifetime Incremental O&M PVRR Multiplier (optional; specify if 0): A user-defined Lifetime Incremental O&M PVRR Multiplier. Assumptions made to arrive at this multiplier should be justified in a separate reference tab if applicable. Some capital expenditures do not result in incremental O&M.

Lifetime Incremental O&M PVRR Multiplier: If a Custom Lifetime Incremental O&M PVRR Multiplier is specified, that value is used, otherwise use the Generic Lifetime Incremental O&M PVRR Multiplier.

PVRR multiplier: The present value of revenue requirement multiplier to the net present value (NPV) of capital expenditure, representing the revenue requirement of a capital investment (O&M, depreciation, return on equity, etc.) over the lifetime of the asset. The PVRR multiplier is the sum of the Capital PVRR Multiplier and the Lifetime Incremental O&M PVRR Multiplier. If Asset Type is "Custom", then the Capital PVRR Multiplier equals the Custom Capital PVRR Multiplier, otherwise the Capital PVRR Multiplier equals the Generic Capital PVRR Multiplier.

Notes: An optional text field for the user to provide any other information. *For informational purposes only.*

The second table, *TableTranchSpend*, allows the user to specify the allocation of the total program costs to program cost by tranche. Note that for Cross Cutting Factor programs, the costs are not allocated by Risk and therefore this table is intentionally left blank.

Program ID: Unique identifier for the Program; this is a lookup via formula from the Summary of Programs tab.

Type: Whether the program is a Mitigation or Control; this is a lookup via formula from the Summary of Programs tab.

Program: Input the program name exactly as written in the Summary of Programs tab.

MAT (optional): If MAT is specified in *TableProgSpend*, then the costs can be allocated by MAT and by tranche.

Allocation method: There are two cost allocation methods supported by the RSE Lite Tool:
1. Prorate by Program Exposure, which prorates the costs to applicable tranches affected by the program based on the program scope.
2. % of Total cost, where the user will specify the percentages to be allocated to the applicable program tranches in the columns to the right.
For more detail on the allocation methodologies, see Section 3.2.3.2.

Tranche: Specify only if Allocation method is "% of Total cost". There should be a row for each applicable tranche for a program, with as many tranches as specified in Tab 1-Program Exposure.

Spend USD YYYY: The annual percentage of the total cost allocated to the tranche specified in the row. Note that this percentage will apply to both capital and expense expenditures.

3.2.3.1 Treatment of Capital Costs

As mentioned in the ERM documentation, the Present Value of Revenue Requirement (PVRR) multiplier accounts for the revenue requirements associated with capital investments. These include insurance, depreciation, income taxes, property tax, return on equity, and any incremental (or decremental) operation and maintenance (O&M) costs. In the calculation of RSEs for the 2023 GRC, PG&E has made a first effort to incorporate the Revenue Requirement associated with the capital investment through a simple PVRR multiplier, obtained mostly using generic assumptions. PG&E expects that this can be further refined and improved over time.

The PVRR multiplier is the sum of two components: the Capital PVRR Multiplier, and the O&M PVRR Multiplier.

The Generic Capital PVRR Multiplier is calculated using standard assumptions[10] of federal, state and property tax rates, rate of return, and asset book depreciation life values for several asset groups. Some examples of asset groups include buildings, computer software, gas meters, electric distribution assets, gas distribution, and gas transmission & storage.

If desired, a Custom Capital PVRR Multiplier may be calculated by the user for the specific program if different assumptions other than the standard assumptions are warranted.

The Generic Lifetime O&M PVRR Multiplier is derived from 2016 to 2020 recorded expenses as a percentage of gross book value for each asset group. The average annual O&M for each asset group was estimated based on the average over the 2016 to 2020 recorded O&M costs for LOB asset group:

(15) $Average\ annual\ O\&M =$

$$M = Average\ over\ 2016 - 2020\ \left[\frac{\text{O\&M cost by LOB asset group}}{\text{Gross book value by LOB asset group}}\right]$$

Using the 2016 - 2020 average O&M% reflects the present value of the annual O&M incurred at any point in the lifetime of the asset. This is because the expenses recorded in the data do not tie to a

[10] PG&E's Charge 2020 tool was used to calculate the Generic Capital PVRR Multiplier for PG&E's 2023 GRC.

particular asset, which does not give us information on the age of the asset when the expenses were incurred.

The Generic Lifetime O&M PVRR Multiplier is the net present value of the annual O&M escalated at inflation over the book life of the asset

(16)

$$\text{Generic Lifetime O\&M PVRR Multiplier} = NPV_{discount\ factor}\left[M, \ldots, M * (1 + inflation)^{BookLife\ -1}\right]$$

Where the book life is consistent with on standard assumptions made by PG&E's Economic Analysis department.[11]

If the user has information on the incremental costs of O&M of the specific program, for example from a vendor quote, then a Custom Lifetime O&M PVRR Multiplier can be provided.

If it can be assumed that there is no increase in O&M from the capital investment under the program, for example replacing an existing asset with a new asset with the same type[12], the Custom Lifetime O&M PVRR Multiplier can be set to zero. It is important to note that these O&M costs are incremental to what is already being paid for O&M in these asset classes. In some cases, the incremental O&M can set to be negative, when an asset is being replaced with different asset type with lower lifetime O&M costs.

3.2.3.2 Cost Allocation methods

The following examples illustrate how costs are allocated for the two cost allocation methods "prorate by Program Exposure" or "% of Total Cost".

If the cost allocation option "prorate by Program Exposure" is chosen then the total program cost will be allocated based on the program exposure, (e.g., miles for wildfire risk). This cost allocation works for Program Exposures expressed in exposure units or work units.

Example1 (cost allocation option = "prorate by Program Exposure"):

- Inputs:
  - Total program cost: $100M
  - Program Exposure:
    - tranche 1: 100 miles
    - tranche 2: 300 miles
  - Cost Allocation option: "prorate by Program Exposure"
- Calculations:
  - Cost allocation factor:
    - tranche 1: 100/400 = 25%
    - tranche 2: 300/400 = 75%
  - final cost by tranche:
    - tranche 1: 25% * $100M = $25M
    - tranche 2: 75% * $100M = $75M

[11] For the purposes of this analysis, the inflation rate used was 3.0%, and the discount factor used was 7.0%. The book life of each asset group based on the Charge 2020 tool.

[12] We can assume no incremental O&M in this case since the O&M would be the same for a like-for-like asset replacement.

If the cost allocation option "'% of Total Cost (specify to the right)" is chosen then the total program cost will be allocated based on the percentages provided by the user, regardless of the Program Exposure provided. This option is utilized when costs do not scale with the risk exposure units, e.g. for Spillway Remediation Program in the Large Uncontrolled Water Release Risk Event.

Example 2 (cost allocation option = "% of Total Cost (specify to the right)"):

- Inputs:
  - Total program cost: $100M
  - Program Exposure:
    tranche 1: 100%
    tranche 2: 100%
  - Cost Allocation option: "prorate by Program Exposure"
  - In this case, we know the specific cost on a Tranche level:
    Tranche 1: $40M
    Tranche 2: $60M
    Thus, % of Total cost allocation factors would be specified as:
    Tranche 1: 40/100 = 40%
    Tranche 2: 60/100 = 60%

Note that in Example 2, if the option "prorate by program exposure" had been chosen then the cost allocation factor will be erroneously calculated as:

tranche 1: 1/2 = 50%
tranche 2: 1/2 = 50%

3.2.4 Tab 3-Eff – Frequency Programs

There are three tables in this tab. The first table, *TableFreqPrograms*, allows the user to specify the remaining program characteristics by tranche, driver, sub-driver, and outcome.

Program ID: Unique identifier for the Program; this is a lookup via formula from the Summary of Programs tab.

Type: Whether the program is a Mitigation or Control; this is a lookup via formula from the Summary of Programs tab.

Program: Input the program name exactly as written in the Summary of Programs tab.

Risk (for Cross Cutter Only): For Cross Cutting programs, the programs need to be mapped to a particular Risk Event. Each program mapped to a particular Risk Event needs to have its own row.

Tranche: If blank, the Tool will apply the program to the applicable tranches as specified in tab 1-Program Exposure. Specify tranches here ONLY IF the program effectiveness differs by tranche. If specified for one tranche, there should be as many rows as needed for all the applicable tranches.

Driver: If the program applies to all the drivers of a Risk Event, leave blank. Otherwise, specify the applicable drivers for the program. If specified, there should be as many rows as needed for all the applicable drivers.

Subdriver: If the program applies to all the Subdrivers within a Driver, then leave this as blank. Otherwise, specify the applicable subdrivers for the program. If specified, there should be as many rows as needed for all the applicable drivers, and the Driver column must also be filled in.

Outcome: If the program applies to all the outcomes of a Risk Event, leave blank. Otherwise, specify the applicable outcomes for the program. If specified for one outcome, there should be as many rows as needed for all the applicable outcomes.

Does this use qualitative measure?: Select TRUE if the program effectiveness is quantified using the Qualitative Methodology. Otherwise, select FALSE. The Qualitative Methodology is described in more detail in Section 3.2.6.

Effectiveness – Quantitative: If Does this use qualitative measure? Is set to FALSE, then this cell should contain the program effectiveness as a percentage. Otherwise, the value entered in this cell will be ignored.

For program Type Mitigation, this percentage would be the percent risk reduction from the Baseline Risk.

For program Type Control, this percentage would be the percent risk reduction from the Inherent Risk. The effectiveness for controls will be converted to effectiveness relative to Baseline Risk in the RSE Lite Tool as described in the methodology in Section 2.

Category: This is for computing the program effectiveness using the Qualitative Methodology. Select the program category that best matches the program.

Risk driver primarily due to… This is for computing the program effectiveness using the Qualitative Methodology. Select the option that best matches the drivers affected by the program.

Explanation of Program Category and Risk Driver type: A required text field for the user to justify the selections made for program Category and Risk driver type.

Effectiveness Cap (Ec): The maximum effectiveness of the program based on the selections made for program Category and Risk driver type.

Maturity Factor (Mf): This is the discount factor on the Effectiveness Cap based on the user responses to the Maturity Factor questionnaire, described in more detail in Section 3.2.6.2. This value is required for Controls, but not for Mitigations. This is because a maturity assessment cannot be performed for programs that have not yet been implemented.

To populate this cell, a separate tab named “Maturity Factor – <PRG#>” needs to be created for each of the Controls. The formula in this cell searches for a tab with <PRG#> matching the last 4 digits of the Control Program ID in that row, and pulls the Maturity Factor from that tab.

Effectiveness (Ec*Mf): If Does this use qualitative measure? Is set to TRUE, this is the Effectiveness – Quantitative value. Otherwise, this is the Qualitative program effectiveness as the product of Effectiveness Cap and Maturity Factor. For Mitigation programs, the Maturity Factor defaults to 1, since a maturity assessment cannot be performed for programs that have not yet been implemented.

Benefit length (yrs): The (integer) number of years that the program benefits last beyond the implementation of the program in year YYYY. For example, a program implemented in 2021 with a 5-year benefit length would have risk reduction benefits for 2021 through 2025.

Effectiveness degradation rate: Specify the degradation rate based on the methodology described in Effectiveness degradation method.

Effectiveness degradation method: There are currently two types of supported degradation methods:

1. Esc: where $DF_{esc,k} = (1 - \mathrm{degR})^{\mathrm{k}}$ for k in years 1,…, Benefit length
2. Linear: where $DF_{linear,k} = 1 - degR * k$ for k in years 1,…, Benefit length

Explanation of Benefit Length: A required text field for the user to justify the Benefit length.

Same benefit set across program?: a validation cell that shows TRUE if the benefit length and degradation method are the same for all rows with the same Program.

Risk ID: Used by the model to filter and sort Cross Cutting Factor programs by Risk Event. References the Risk (for Cross Cutter Only) column. If this column is empty, the value defaults to the Risk Event Risk ID.

The second table *TableQualFreqEff* to the right of *TableFreqPrograms* is a reference table for the Qualitative Program Effectiveness Cap, described in more detail in Appendix 3.2.6.1.

The third table *TableFreqMapping* to the right of *TableQualFreqEff* is used in the Risk Model Input File for the Risk Event for data entry purposes. This table will be populated by the RSE Lite Tool when running the rse_input_automation.py script to import the inputs from the RSE Input File to the Risk Model Input File.

3.2.5 Tab 4-Eff – Conseq Programs

There are three tables in this tab. The first table, *TableConseqPrograms*, allows the user to specify the remaining program characteristics by tranche, outcome, and subattribute.

Program ID: Unique identifier for the Program; this is a lookup via formula from the Summary of Programs tab.

Type: Whether the program is a Mitigation or Control; this is a lookup via formula from the Summary of Programs tab.

Program: Input the program name exactly as written in the Summary of Programs tab.

Risk (for Cross Cutter Only): For Cross Cutting programs, the programs need to be mapped to a particular Risk Event. Each program mapped to a particular Risk Event needs to have its own row.

Tranche: If blank, the Tool will apply the program to the applicable tranches as specified in tab 1-Program Exposure. Specify tranches here ONLY IF the program effectiveness differs by tranche. If specified for one tranche, there should be as many rows as needed for all the applicable tranches.

Outcome: If the program applies to all the outcomes of a Risk Event, leave blank. Otherwise, specify the applicable outcomes for the program. If specified for one outcome, there should be as many rows as needed for all the applicable outcomes.

Attribute: If the program applies to all the MAVF Attributes[13] of a Risk Event Outcome, leave blank. Otherwise, specify the applicable attribute for the program. If specified, there should be as many rows as needed for all the applicable attributes.

Does this use qualitative measure?: Select TRUE if the program effectiveness is quantified using the Qualitative Methodology. Otherwise, select FALSE. The Qualitative Methodology is described in more detail in Section 3.2.6.

Effectiveness – Quantitative: If Does this use qualitative measure? Is set to FALSE, then this cell should contain the program effectiveness as a percentage. Otherwise, the value entered in this cell will be ignored.

For program Type Mitigation, this percentage would be the percent risk reduction from the Baseline Risk.

For program Type Control, this percentage would be the percent risk reduction from the Inherent Risk. The effectiveness for controls will be converted to effectiveness relative to Baseline Risk in the RSE Lite Tool as described in the methodology in Section 2.

Category: This is for computing the program effectiveness using the Qualitative Methodology. Select the program category that best matches the program.

Consequence develops… This is for computing the program effectiveness using the Qualitative Methodology. Select the option that best matches the how the consequences of the Risk Event or Cross Cutting Factor develops. More detail is provided in Section 3.2.6.1.

Explanation of Program Category and Consequence type: A required text field for the user to justify the selections made for program Category and Consequence type.

Effectiveness Cap (Ec): The maximum effectiveness of the program based on the selections made for program Category and Risk driver type.

Maturity Factor (Mf): This is the discount factor on the Effectiveness Cap based on the user responses to the Maturity Factor questionnaire, described in more detail in Section 3.2.6.2. This value is required for Controls, but not for Mitigations. This is because a maturity assessment cannot be performed for programs that have not yet been implemented.

To populate this cell, a separate tab named "Maturity Factor – <PRG#>" needs to be created for each of the Controls. The formula in this cell searches for a tab with <PRG#> matching the last 4 digits of the Control Program ID in that row, and pulls the Maturity Factor from that tab.

Effectiveness (Ec*Mf): If Does this use qualitative measure? Is set to TRUE, this is the Effectiveness – Quantitative value. Otherwise, this is the Qualitative program effectiveness as

[13] Details of the four Attributes of PG&E's Multi-Attribute Value Function: Safety, Electric Reliability, Gas Reliability, and Financial, can be found in Section 1.2 of the ERM Documentation

the product of Effectiveness Cap and Maturity Factor. For Mitigation programs, the Maturity Factor defaults to 1, since a maturity assessment cannot be performed for programs that have not yet been implemented.

Benefit length (yrs): The (integer) number of years that the program benefits last beyond the implementation of the program in year YYYY. For example, a program implemented in 2021 with a 5-year benefit length would have risk reduction benefits for 2021 through 2025.

Effectiveness degradation rate: Specify the degradation rate based on the methodology described in Effectiveness degradation method.

Effectiveness degradation method: There are currently two types of supported degradation methods:

3. Esc: where $DF_{esc,k} = (1 - \mathrm{degR})^{\mathrm{k}}$ for k in years 1,…, Benefit length
4. Linear: where $DF_{linear,k} = 1 - degR * k$ for k in years 1,…, Benefit length

Explanation of Benefit Length: A required text field for the user to justify the Benefit length.

Same benefit set across program?: a validation cell that shows TRUE if the benefit length and degradation method are the same for all rows with the same Program.

Risk ID: Used by the model to filter and sort Cross Cutting Factor programs by Risk Event. References the Risk (for Cross Cutter Only) column. If this column is empty, the value defaults to the Risk Event Risk ID.

The second table *TableQualConseqEff* to the right of *TableConseqPrograms* is a reference table for the Qualitative Program Effectiveness Cap, described in more detail in Appendix 3.2.6.1.

The third table *TableConseqMapping* to the right of *TableQualConseqEff* is used in the Risk Model Input File for the Risk Event for data entry purposes. This table will be populated by the RSE Lite Tool when running the rse_input_automation.py script to import the inputs from the RSE Input File to the Risk Model Input File.

3.2.6 Qualitative Mitigation and Control Effectiveness Assessment (Optional)

If a quantitative data or SME judgement is not available, a user can choose a qualitative method of program effectiveness. The qualitative method that PG&E developed as a last resort to use starts with an Effectiveness Cap, E_c, which describes the maximum effectiveness the Program can achieve for the specific Category and Driver or Consequence.

For a Control Program, the Effectiveness Cap is discounted by the Program Maturity Factor, M_f. This Maturity Factor includes consideration of staffing levels, ownership of the Program, records management, and other process related factors that are considered as important for control program in achieving its maximum effectiveness. The Maturity Factor is the product of 1 minus the individual discounts related to each of the questions related to maturity of the Control Program.

$$(17) M_f = \prod_i (1 - M_i)$$

Where M_f is the credit for each response to Question *i*.

Finally, Program Effectiveness, P_e, is then calculated as a product of all the variables calculated and applied to the relevant driver or consequence selected for the Effectiveness Cap. Program Effectiveness is represented as a percentage rounded up to the nearest whole number to avoid false precision. Note that M_f is 1 for mitigations where the discount factor is not considered relevant.

(18) $P_e = E_c M_f$

3.2.6.1 Program Effectiveness Cap (E_c)

Table 1 describes the Effectiveness Caps for programs that result in a reduction of Driver frequency. Each row is a Category of program arranged in the order of the most effective type of program first to the least effective type of program. Each column describes the primary Driver that the Program addresses. The intersection of the Category row and the Driver Type column is the Effectiveness Cap.

Table 1: Effectiveness Cap (E_c) for programs affecting Driver frequency

Program Description		***Risk Driver is Primarily Due to….***			
CATEGORY	**DESCRIPTION**	**HUMAN ERROR**	**FUNCTIONAL FAILURE**	**MALICIOUS/ NEGLIGENT ACTION**	**NATURAL FORCE**
Elimination	Risk exposure is fully removed by implementing control or mitigation as long as program remains in place.	90%	90%	90%	90%
Engineered barrier	Program represents a barrier (e.g., physical, software) installed between the Risk Driver and Risk Event.	90%	75%	50%	50%
Substitution	Program implements a more effective tool or methodology to prevent risk exposure.	75%	50%	50%	0%
Administrative Barrier	Program implements human work practices and behaviors that reduce risk exposure.	30%	0%	0%	0%
Distance Gap	Program establishes an open boundary between Risk Driver and Risk Event.	20%	0%	0%	15%
Detect / Notify / Respond	Program introduces visibility or early detection of risk event or leading indicators which leads to prompt intervention or recovery.	10%	10%	25%	10%
Minor or Preventative Maintenance	Program repairs minor degradations identified through	0%	25%	5%	5%

	another process or on a preventative basis.				
Not Applicable	Program does not address exposure of the subject tranche or does not address the subject risk driver.	0%	0%	0%	0%

Table 2 describes the Effectiveness Caps for programs that result in a reduction on the impact of a Consequence. Each row is a Category of program arranged in the order of the most effective type of program first to the least effective type of program. Each column describes how the Consequence of the Risk event manifests. A "gradually" developing consequence development generally means there is sufficient time to attempt an evacuation or an opportunity to prevent customer impacts from a reliability event (e.g., rerouting gas or power). All other consequence developments should be considered prompt.

Table 2: Effectiveness cap (E_c) for programs modifying Consequences of the Risk Event

Program Description		Risk Event Consequences happen…	
CATEGORY	**DESCRIPTION**	**RAPIDLY**	**GRADUALLY**
Replacement	Program is in place such that impacts of consequences are able to be reduced through use of another mechanism (e.g., re-routing power).	90%	100%
Engineered Barrier	Barrier (physical or software) installed between the Risk Event and impacts.	50%	75%
Automated Response	Program implements a mechanism such that automated detection and response reduces the impacts of the consequence.	25%	50%
Manual Response	Program implements a mechanism such that an automated or manual detection method prompts a manual response to the consequence.	10%	25%
Not Applicable	Program does not address exposure of the subject tranche, or does not address the subject risk driver, or has no impact on consequences.	0%	0%

Some illustrative examples of Program categories, Driver types and Consequence Types are described in Appendix A.1.

3.2.6.2 Program Maturity Factor M_f

Table 3 provides a questionnaire for determining the Maturity Factor. The Maturity Factor reduces the Effectiveness Cap to account for process-related issues that may undermine the effectiveness of a Control program. The percentages provided in each square represents the Maturity Factor percentage discount, M_i, used in Equation 1. Note the input template attached to this guidance automatically calculates the percentage discounts based on responses selected.

Table 3: Program Maturity Discount Factors (M_f) for Program process maturity

Questions		Responses		
		A	B	C
1	Are there accountable control owners to oversee the end-to-end process?	**(0%)** One or more control owners in an organization	**(10%)** Multiple control owners across organization	**(15%)** No designated control owners
2	Is staffing sufficient for executing the control?	**(0%)** Staffing is sufficient	**(10%)** Openings exist but control is maintained by current staffing	**(15%)** Staffing is insufficient to effectively implement control
3	Is training mandated for process owners implementing the control?	**(0%)** Training is accredited and directly applicable	**(10%)** Training is not accredited or not directly applicable	**(15%)** Training is generic or does not exist
4	Are there open Internal Audit (IA) High Risk Findings?	**(0%)** No, all IA High Risk Findings are closed	**(3%)** IA High Risk Findings are open and corrective actions are in progress	**(5%)** IA High Risk Findings are still under investigation
5	Are there non-conformances or violations (NC&V)?	**(0%)** NC&Vs are closed and no negative trend has been identified	**(3%)** NC&Vs are open and no negative trend has been identified	**(5%)** NC&Vs are open and trending is negative
6	Is a skillset mandated for the control owner?	**(0%)** Control owner has a defined skillset filled by current owner	**(3%)** Control owner does not meet defined skillset or is interim	**(5%)** Skillset is generic or irrelevant
7	Is a skillset mandated for personnel executing the control?	**(0%)** Personnel meet and have a defined skillset	**(3%)** Personnel do not meet defined skillset or are interim	**(5%)** Skillset is generic or irrelevant
8	Is there guidance on the control?	**(0%)** Guidance documents are up to date	**(3%)** Guidance documents exist but updates or	**(5%)**

			corrections are needed	Guidance documents are inadequate or aren't used
9	Are records in a template format and retained?	**(0%)** Templates are effective and retained per Enterprise Records & Information Management (ERIM) standards	**(3%)** Deficiencies have been identified with templates or retention	**(5%)** Templates don't exist or are used inconsistently or ineffectively
10	Is the control assessed by a qualified internal party?	**(0%)** Independent internal assessment is performed at an appropriate interval	**(3%)** Internal assessments are performed but lack independence or effectiveness	**(5%)** Control is not assessed or assessment items are not addressed.
11	Is the control assessed against the desired objectives and inherent risk?	**(0%)** Control is assessed and open items are addressed	**(3%)** Control is assessed but deficiencies are not timely addressed	**(5%)** Control is generically assessed or not assessed
12	Is data from the control tracked and trended?	**(0%)** Data is effective and validated and helps drive implementation	**(3%)** Data is collected but is not validated or inconsistently implemented	**(5%)** Data is not collected or is not relevant to control objective
13	Are metrics directly related to the control and reported to leadership at an appropriate interval?	**(0%)** Metrics are reported to leadership and help inform decision-making	**(3%)** Metrics do not reach the appropriate level of leadership or inconsistently inform decision-making	**(5%)** Metrics are not reported or are ineffective for decision-making purposes

Some illustrative examples of program maturity factor selections are described in Appendix A.2.

3.3 Running The Model

To run the RSE Lite Tool with the inputs provided in the RSE Lite File, provide the following input on the RSE Lite tab of the RSE Lite File:

Risk Data File Folder: This is the file path to the folder containing both the Risk Data File and the rse_lite.exe executable file.

Risk Data File Name: This is the name (with file extension) of the Risk data file that contains the Test Year Baseline Risk data. This data file is an output of the Enterprise Risk Model.

Risk Data File Path: This File path is generated via Excel formula and read in by the RSE Lite script.

RSE Lite exe path: This File path is generated via Excel formula and read in by the RSE Lite script.

NPV year: The year to calculate the net present value of costs and risk reduction. *This cell is populated by EORM quant and should not be changed unless the user receives clearance to do so.*

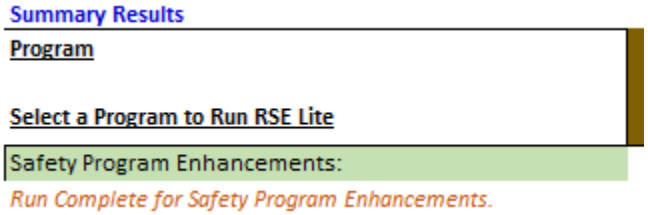
Discount rate: The discount rate used to calculate net present value of costs and risk reduction. *This cell is populated by EORM Quant and should not be changed unless the user receives clearance to do so.*

Aggregation years: The years over which the Program RSEs would be aggregated[14]. Enter the start year in the first cell and the end year (inclusive) in the second cell. The third cell will automatically populate with the aggregation period. *This cell is populated by EORM Quant and should not be changed unless the user receives clearance to do so.*

3.3.1 Running for a single program on the RSE Lite tab.

This functionality is used to quickly assess different configurations of program characteristics such as exposure, cost, effectiveness, etc. Additionally, a single program run can be used to diagnose input issues.

Select a program from the drop-down menu in cell B12:



Once selected, click the "RUN" button to call the rse_lite.exe file.

The orange text under the program selection will provide status updates for the Tool run.

3.3.2 Running for multiple programs on the RSE Results tab

To run for multiple programs at once, use the RSE Results tab. Once program inputs are finalized, the batch run function can be used to produce a report of annual RSEs at the program level.

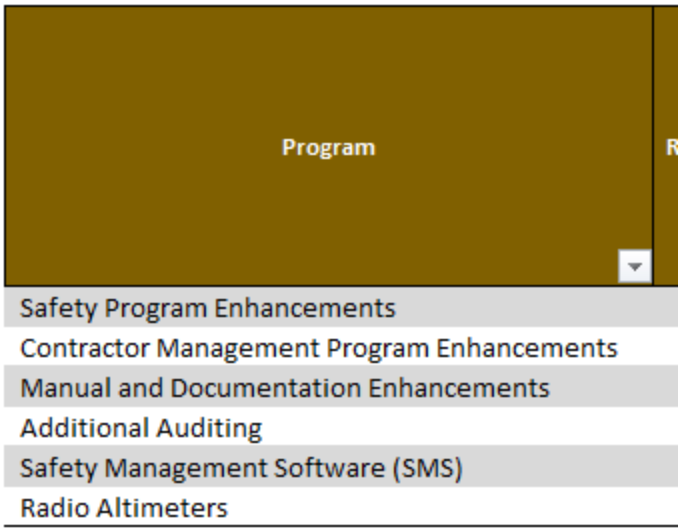
Copy the names of the programs to be run in batch into the Program column of the table exactly as written in the Summary of Programs tab.

Click "Start Batch Run".

The orange text above the table will provide status updates for the Tool run.

[14] For PG&E's 2023 GRC, the Aggregation years was the GRC period 2023-2026

Batch Run Complete 06/08 16:13 with v2.3.2 and risk data file SS_AVATN_20210421_20210421101007_TYBaselinePr oposed_rselite.xlsx.



3.3.3 Process for calculating Cross Cutting Factor program RSEs

The process to calculate Cross Cutting Factor (CCF) program RSEs require more coordination between the CCF and Line of Business (LOB) teams that manage the Risk Events. This is to ensure that CCF effects are properly modeled in the Risk Event, and the CCF program effects on the risks are accurately captured. Calculating CCF program RSEs also rely on the Test Year Baseline data from the Risk Events that they affect, and thus the program RSE calculations typically occur only after the Risk Event bowties have been finalized.

First, the CCF and LOB teams work together to produce a Cross Cutter Mapping Table[15] that maps the Cross Cutters to the risks. Then, the CCF and LOB teams coordinate to find likelihood or consequence data that support the inclusion of CCFs into the LOB Risk Event bowtie.[16]

If there are CCF programs that mitigate LoRE or CoRE of a Risk Event, then CCs will coordinate with LOBs to fill out a CCF RSE Input Template with the program characteristics. Once the CCF program inputs are specified and all TY Baseline Risk Data for applicable risks are available, the TY Baseline Risk Data for CCF can be created by running a python script. The TY Baseline Risk Data is then used to run the RSE lite in the RSE Input template of the CCF.

[15] See Attachment B of Chapter 2 of PG&E's 2023 GRC Opening Testimony for a current Cross Cutter Mapping table.

[16] The different ways Cross Cutting Factors show up in the Risk Event bowtie is detailed in the Risk Modeling WP-1.

3.4 OUTPUTS

3.4.1 Tab RSE Results

The RSE Results tab shows summary results for all the programs specified during the batch run as described in the procedure in Section 3.3.2. There are two tables in this tab – *TableAllRSEs* and *TableRSEbatch.* The NPV parameters are specified in the RSE Lite tab. See Section 3.3 for more information.

3.4.1.1 TableAllRSEs

The *TableAllRSEs* table shows program level summary results.

Program	NPV Risk Reduction - 2020	NPV Risk Reduction - 2021	NPV Risk Reduction - 2022	NPV Risk Reduction - 2023	NPV Risk Reduction - 2024	NPV Risk Reduction - 2025	NPV Risk Reduction - 2026	NPV Risk Reduction - 2023-2026 Total	Risk Spend Eff - 2020	Risk Spend Eff - 2021	Risk Spend Eff - 2022	Risk Spend Eff - 2023	Risk Spend Eff - 2024	Risk Spend Eff - 2025	Risk Spend Eff - 2026	Risk Spend Eff - 2023-2026 Total	NPV Capital Cost with PVRR ($M) - 2023-2026	NPV Expense Cost ($M) - 2023-2026	NPV Cost ($M) - 2023-2026	NPV Freq Reduction 2023-2026
Safety Program Enhancements		16.45	15.37	19.08	17.83	16.67	15.58	69.16		35.50	34.80	45.30	44.42	43.54	42.69	44.04	-	1.57	1.57	8.92
Contractor Management Program Enhancements		13.22	12.35	16.57	15.48	14.47	13.52	60.04		28.52	27.96	39.33	38.56	37.80	37.06	38.23	-	1.57	1.57	11.05
Manual and Documentation Enhancements		12.07	11.28	13.43	12.55	11.73	10.96	48.66		72.27	144.29	180.19	176.65	173.19	169.79	175.16	-	0.28	0.28	8.92
Additional Auditing		13.25	12.38	16.61	15.52	14.51	13.56	60.19		139.39	136.64	192.21	188.44	184.75	172.50	184.71	-	0.33	0.33	11.08
Safety Management Software (SMS)		11.79	11.02	13.09	12.23	11.43	10.68	47.44		210.63	206.49	257.26	252.22	247.27	230.88	247.22	-	0.19	0.19	8.69
Radio Altimeters		0.01	0.01	0.01	0.01	0.01	0.01	0.04		inf	inf	inf	inf	inf	inf	inf	-	-	-	0.01

- NPV Risk Reduction – YYYY is the net present value of the risk reduction from the program implemented in year YYYY. It is detailed in Equation (10) of Section 2.4. This is the numerator for the Risk Spend Eff – YYYY.

  Note that the risk reduction calculated for years prior to the TY Baseline year may be underestimated, since the TY Baseline LoRE or CoRE would already contain the risk reduction from this program[17]. For example, in the 2023 GRC the TY Baseline score for 2021 and 2022 already include the risk reduction[18] from the program implemented in 2021. The NPV Risk Reduction for 2021 is then reducing risk from the TY Baseline score, which is a lower score than the Baseline score.

- NPV Risk Reduction – 2023-2026 Total is the sum of NPV Risk Reduction for the years in the aggregation period, i.e. the GRC period 2023-2026, of the program risk reduction in Equation (10) of Section 2.4. This is the numerator of the Risk Spend Eff – 2023-2026 Total.

- Risk Spend Eff – YYYY is the RSE of the program implemented in year YYYY, calculated as the ratio of the net present value of annual risk reduction to the net present value of the costs as detailed in Equation (11) of Section 2.5.

- Risk Spend Eff – 2023-2026 Total is the RSE of program implemented over the aggregation period, i.e. the GRC period 2023-2026 as detailed in Equation (12) of Section 2.5. It is calculated as the ratio of NPV Risk Reduction – 2023-2026 Total to NPV Cost ($M) 2023-2026.

[17] See Figure 1-7 of the ERM Model Documentation and User Guide (Risk Modeling WP-1) for an illustration of the Baseline, TY Baseline, and Mitigated Score.

[18] Since this risk reduction is calculated using the ERM, this would be the allocated portfolio-level risk reduction. For more detail, see Section 4.2.1 of the ERM Model Documentation and User Guide (Risk Modeling WP-1)

- NPV Capital Cost with PVRR ($M) 2023-2026 is the net present value of the capital costs incurred over the aggregation period, i.e. the GRC period 2023-2026, including the PVRR multiplier as described in Section 3.2.3.1.

- NPV Expense Cost ($M) 2023-2026 is the net present value of the expense costs incurred over the aggregation period, i.e. the GRC period 2023-2026.

- NPV Cost ($M) 2023-2026 is the sum of NPV Capital Cost with PVRR ($M) 2023-2026 and NPV Expense Cost 2023-2026. This is the denominator to Risk Spend Eff – 2023-2026 Total.

- NPV Freq Reduction 2023-2026 is the net present value of the number of events avoided over the aggregation period, i.e. the GRC period 2023-2026.

3.4.1.2 TableRSEbatch

The *TableRSEbatch* table shows program outputs by tranche (or for Cross Cutting Factor programs, by Risk Event). This table may be to the right of *TableAllRSEs* in the RSE Results tab. If a warning in the *RunMessage* range reads "Batch output table does not exist in RSE Results tab. Writing detailed run table to TableRSE in RSE Lite tab", then this table would be written to the *Summary Results by Tranche* in the RSE Lite tab. See a screenshot of part of the table below.

TableRSEbatch

Program	Index	2021 Program Risk Reduction NPV	2022 Program Risk Reduction NPV	2023 Program Risk Reduction NPV	2024 Program Risk Reduction NPV	2025 Program Risk Reduction NPV	2026 Program Risk Reduction NPV	2023-2026 Program Freq Reduction NPV	2023-2026 Program Freq Risk Reduction NPV	2023-2026 Program Conseq Risk Reduction NPV	2023-2026 Program Risk Reduction NPV	2021 Program RSE	2022 Program RSE	2023 Program RSE	2024 Program RSE	2025 Program RSE	2026 Program RSE	2023-2026 Program RSE	CapEx USD 2021	CapEx USD 2022	CapEx USD 2023	CapEx USD 2024	CapEx USD 2025	CapEx USD 2026	PVRR Multiplier	2023-2026 Capital Cost NPV with PVRR	OpEx USD 2021	OpEx USD 2022	OpEx USD 2023	OpEx USD 2024	OpEx USD 2025	OpEx USD 2026	2023-2026 Expense Cost NPV
Safety Program Enhancements	Fixed Win	0.046096	0.043076	0.053937	0.050408	0.04711	0.044028	0.025197	0.134682	0.074249	0.195483	2.610879	2.559445	3.361854	3.295935	3.231309	3.16795	3.268127	0	0	0	0	0	0	0	0	17655.17	18008.27	18368.44	18735.8	19110.52	19492.73	59815.07
Safety Program Enhancements	Helicopter	11.47703	10.72532	13.50032	12.61712	11.7917	11.02028	6.536704	34.40332	17.88542	48.92941	144.9329	142.0793	187.6067	183.9282	180.3217	176.786	182.3763	0	0	0	0	0	0	0	0	79188.61	80772.38	82387.83	84035.59	85716.3	87430.62	268288.2
Safety Program Enhancements	Helicopter	2.130375	1.99084	2.505918	2.34198	2.188766	2.045576	1.280682	6.402623	3.318879	9.082239	11.19697	10.97652	14.49368	14.20949	13.93087	13.65771	14.0896	0	0	0	0	0	0	0	0	190263.5	194068.8	197950.2	201909.2	205947.4	210066.3	644606
Safety Program Enhancements	Helicopter	0.179129	0.16739	0.209929	0.196195	0.18336	0.171364	0.051806	0.569233	0.248538	0.760847	27.63984	27.09461	35.64588	34.94694	34.2617	33.58991	34.65208	0	0	0	0	0	0	0	0	6480.812	6610.428	6742.637	6877.49	7015.039	7155.34	21956.76
Safety Program Enhancements	Helicopter	0.107057	0.100042	0.128337	0.119941	0.112094	0.104761	0.024697	0.330694	0.167509	0.465134	7.5277	7.379234	9.930363	9.73565	9.544755	9.357603	9.653508	0	0	0	0	0	0	0	0	14221.77	14506.21	14796.33	15092.26	15394.1	15701.99	48182.86
Safety Program Enhancements	Helicopter	2.512379	2.347778	2.683353	2.507807	2.343745	2.190415	0.997775	6.732184	3.666354	9.72532	16.13705	15.81902	18.96636	18.59447	18.22987	17.87243	18.43759	0	0	0	0	0	0	0	0	155690.1	158803.9	161980	165219.6	168524	171894.5	527472.5

- Program is the name of the program

- Index is either the tranche name (for Risk RSE Input files) or the Risk Event Risk ID (for Cross Cutting Factor programs). The Risk Event corresponding to the Risk ID can be referenced in the Data & Validation tab.

- YYYY Program Risk Reduction NPV is the net present value of the tranche- or Risk-level risk reduction from the program implemented in year YYYY. The equation for NPV risk reduction is detailed in Section 2.4. This is the numerator for the YYYY - Risk Spend Eff.

- The quantity NPV Risk Reduction – YYYY in *TableAllRSEs* is the sum over tranche for each program in this column.

- 2023-2026 Program Freq Reduction NPV is the net present value of the number of events avoided over the aggregation period, i.e. the GRC period 2023-2026. The NPV Freq Reduction 2023-2026 in *TableAllRSEs* is the sum over tranche for each program in this column.

- 2023-2026 Program Freq Risk Reduction NPV is the net present value of the tranche- or Risk-level Frequency Risk Reduction over the aggregation period, i.e. the GRC period 2023-2026. The

Frequency Risk reduction is calculated at the tranche- and year- level as described in Equation (4) of Section 2.3.

- 2023-2026 Program Conseq Risk Reduction NPV is the net present value of the Consequence Risk Reduction over the aggregation period, i.e. the GRC period 2023-2026. The Consequence Risk reduction is calculated at the tranche- and year- level as described in Equation (6) of Section 2.3.

- 2023-2026 Program Risk Reduction NPV is the net present value of the tranche- or Risk-level Risk Reduction over the aggregation period, i.e. the GRC period 2023-2026. The Frequency Risk reduction is calculated at the tranche- and year- level as described in Equation (8) of Section 2.3. 2023-2026 Program Risk Reduction NPV is the numerator for the 2023-2026 Program RSE calculation.

- YYYY Program RSE is the tranche- or Risk-level RSE of the program implemented in year YYYY, calculated as the ratio of the tranche- or Risk-level YYYY Program Risk Reduction NPV to the sum of the net present value of CapEX USD YYYY with PVRR and the net present value of OpEx USD YYYY.

- 2023-2026 Program RSE is the tranche- or Risk-level RSE of the program implemented over the aggregation period, i.e. the GRC period 2023-2026. It is calculated as the ratio 2023-2026 Program Risk Reduction NPV to the sum of the 2023-2026 Capital Cost NPV with PVRR and the 2023-2026 Expense Cost NPV.

- CapEx USD YYYY is the nominal tranche- or Risk-level capital cost of the program implemented in year YYYY.

- PVRR Multiplier is the present value of revenue requirement multiplier to the net present value (NPV) of capital expenditure, representing the revenue requirement of a capital investment (O&M, depreciation, return on equity, etc.) over the lifetime of the asset. For more detail on the PVRR Multiplier calculation, see Section 3.2.3.1.

- 2023-2026 Capital Cost NPV with PVRR is the net present value of the tranche- or Risk-level capital costs incurred over the aggregation period, i.e. the GRC period 2023-2026, including the PVRR Multiplier. It is one of the terms of the denominator for 2023-2026 Program RSE.

- OpEx USD YYYY is the tranche- or Risk-level nominal expense cost of the program implemented in year YYYY.

- 2023-2026 Expense Cost NPV is the tranche- or Risk-level expense costs incurred over the aggregation period, i.e. the GRC period 2023-2026. It is one of the terms of the denominator for 2023-2026 Program RSE.

3.4.1.3 TableProgramRR

The batch run function also produces a table of program risk reduction by Risk, tranche and year. This

table may be to the right of *TableRSEbatch* in the RSE Results tab. If a warning in the *RunMessage* range reads "Batch output table does not exist in RSE Results tab. Writing detailed run table to TableProgramRR in RSE Lite tab", then this table would be written to the *Program Risk Reduction* table in the RSE Lite tab. See a screenshot of part of the table below.

Program Risk Reduction

Program	Risk ID	Tranche	Year	Discount Factor	2021 Program Freq Reduction	2021 Program Freq Risk Reduction	2021 Program Conseq Risk Reduction	2021 Program Risk Reduction
Safety Program E	AVATN	Fixed Wing - Pat	2021	1	0.00685967	0.0318489	0.01743149	0.0460955
Safety Program E	AVATN	Fixed Wing - Pat	2022	0.9345794	0	0	0	0
Safety Program E	AVATN	Fixed Wing - Pat	2023	0.8734387	0	0	0	0
Safety Program E	AVATN	Fixed Wing - Pat	2024	0.8162979	0	0	0	0
Safety Program E	AVATN	Fixed Wing - Pat	2025	0.7628952	0	0	0	0
Safety Program E	AVATN	Fixed Wing - Pat	2026	0.7129862	0	0	0	0
Safety Program E	AVATN	Helicopter - Carg	2021	1	1.8164473	8.48478772	3.84072507	11.477034
Safety Program E	AVATN	Helicopter - Carg	2022	0.9345794	0	0	0	0
Safety Program E	AVATN	Helicopter - Carg	2023	0.8734387	0	0	0	0
Safety Program E	AVATN	Helicopter - Carg	2024	0.8162979	0	0	0	0
Safety Program E	AVATN	Helicopter - Carg	2025	0.7628952	0	0	0	0
Safety Program E	AVATN	Helicopter - Carg	2026	0.7129862	0	0	0	0

- Program is the name of the program

- Risk ID is the Risk Event Risk ID (for Cross Cutting Factor programs). The Risk Event corresponding to the Risk ID can be referenced in the Data & Validation tab.

- Tranche is the tranche that the program affects

- Year is the year that the risk reduction occurs from the implementation of the Program in year YYYY.

- Discount factor is the net present value (NPV) discount factor given the discount rate and NPV year provided in the RSE Lite tab, and described in Section 3.3.

- YYYY Program Freq Reduction is the Tranche-level Frequency Reduction in Year for the program implemented in YYYY. The Frequency reduction is calculated as the product of the Tranche exposure and the LoRE reduction at the tranche- and year-level (i.e. as described in Equation (5) of Section 2.3).

- YYYY Program Freq Risk Reduction is the Tranche-level Frequency Risk Reduction in Year for the program implemented in YYYY. The Frequency Risk reduction is calculated at the tranche- and year-

level as described in Equation (4) of Section 2.3.

- YYYY Program Conseq Risk Reduction is the Consequence Risk Reduction in Year for the program implemented in YYYY. The Consequence Risk reduction is calculated at the tranche- and year-level as described in Equation (6) of Section 2.3.

- YYYY Program Risk Reduction is the Total Risk Reduction in Year for the program implemented in YYYY. The Consequence Risk reduction is calculated at the tranche- and year-level as described in Equation (8) of Section 2.3.

- YYYY Program Risk Reduction NPV is the net present value is the Total Risk Reduction in Year for the program implemented in YYYY. It is the product of the Discount factor and the YYYY Program Risk Reduction

- 2023-2026 Program Freq Reduction is the (undiscounted) sum of YYYY Program Freq Reduction over the aggregation period, i.e. the GRC period 2023-2026.

- 2023-2026 Program Freq Reduction NPV is the sumproduct of Discount factor and the YYYY Program Freq Reduction over the aggregation period, i.e. the GRC period 2023-2026.

- 2023-2026 Program Freq Risk Reduction is the (undiscounted) sum of YYYY Program Freq Risk Reduction over the aggregation period, i.e. the GRC period 2023-2026.

- 2023-2026 Program Freq Risk Reduction NPV is the sumproduct of Discount factor and the YYYY Program Freq Risk Reduction over the aggregation period, i.e. the GRC period 2023-2026.

- 2023-2026 Program Conseq Risk Reduction is the (undiscounted) sum of YYYY Program Conseq Risk Reduction over the aggregation period, i.e. the GRC period 2023-2026.

- 2023-2026 Program Conseq Risk Reduction NPV is the sumproduct of Discount factor and the YYYY Program Conseq Reduction over the aggregation period, i.e. the GRC period 2023-2026.

- 2023-2026 Program Risk Reduction is the (undiscounted) sum of YYYY Program Risk Reduction over the aggregation period, i.e. the GRC period 2023-2026.

- 2023-2026 Program Risk Reduction NPV is the sumproduct of Discount factor and the YYYY Program Risk Reduction over the aggregation period, i.e. the GRC period 2023-2026.

3.4.2 Tab RSE Lite

The RSE Results tab shows summary and detailed results for a single program after running the procedure described in Section 3.3.1. The NPV parameters are specified in the RSE Lite tab. See Section 3.3 for more information.

3.4.2.1 Summary Results Table

The *Summary Results* table in the RSE Lite tab shows program level summary results for a single program. For more explanation of the columns, see the description for *TableAllRSEs* in Section 3.4.1.1.

Summary Results

Program Select a Program to Run RSE Lite	NPV Risk Reduction - 2020	NPV Risk Reduction - 2021	NPV Risk Reduction - 2022	NPV Risk Reduction - 2023	NPV Risk Reduction - 2024	NPV Risk Reduction - 2025	NPV Risk Reduction - 2026	NPV Risk Reduction - 2023-2026 Total	Risk Spend Eff - 2020	Risk Spend Eff - 2021	Risk Spend Eff - 2022	Risk Spend Eff - 2023	Risk Spend Eff - 2024	Risk Spend Eff - 2025	Risk Spend Eff - 2026	Risk Spend Eff - 2023-2026 Total	NPV Capital Cost with PVRR ($M) - 2023-2026	NPV Expense Cost ($M) - 2023-2026	NPV Cost ($M) - 2023-2026	NPV Freq Reduction - 2023-2026
Safety Program Enhancements:	-	17.40	16.26	19.09	17.84	16.67	15.58	69.17	-	37.54	36.81	45.31	44.42	43.55	42.70	44.05	0	1.570321386	1.570321386	8.916860502

Program outputs by tranche (or for Cross Cutting Factors, by Risk Event) can be viewed for a single program in the *Summary Results by Tranche* table in the RSE Lite tab. For more explanation of the columns, see the description for *TableRSEbatch* in Section 3.4.1.2.

Summary Results by Tranche

index	2021 Program Risk Reduction NPV	2022 Program Risk Reduction NPV	2023 Program Risk Reduction NPV	2024 Program Risk Reduction NPV	2025 Program Risk Reduction NPV	2026 Program Risk Reduction NPV	2023-2026 Program Freq Reduction NPV	2023-2026 Program Freq Risk Reduction NPV	2023-2026 Program Conseq Risk Reduction NPV	2023-2026 Program Risk Reduction NPV	2021 Program RSE
Fixed Wing - Patrol or Inspection	0.0	0.0	0.1	0.1	0.0	0.0	0	0	0	0	3
Helicopter - Cargo or Lift	12.2	11.4	13.5	12.6	11.8	11.0	7	34	18	49	154
Helicopter - Human External Cargo	2.3	2.1	2.5	2.3	2.2	2.0	1	6	3	9	12
Helicopter - Insulator Wash	0.2	0.2	0.2	0.2	0.2	0.2	0	1	0	1	29
Helicopter - Passenger Ferry	0.1	0.1	0.1	0.1	0.1	0.1	0	0	0	0	8
Helicopter - Patrol or Inspection	2.6	2.4	2.7	2.5	2.3	2.2	1	7	4	10	16
Aggregated	17.4	16.3	19.1	17.8	16.7	15.6	9	49	25	69	38

More granular information can be found for a single program can be found in the remaining tables in the RSE Lite tab.

3.4.2.2 Program Risk Reduction Table

The *Program Risk Reduction* table details the risk reduction by Tranche (or for Cross Cutting Factors, by Risk Event) and by year of program benefit life for each program implementation year. For more explanation of the columns, see the description for *TableProgramRR* in Section 3.4.1.3.

Program Risk Reduction

Program	Risk ID	Tranche	Year	Discount Factor	2021 Program Freq Reduction	2021 Program Freq Risk Reduction	2021 Program Conseq Risk Reduction	2021 Program Risk Reduction
Safety Program I	AVATN	Fixed Wing - Pat	2021	1	0.00685967	0.0318489	0.01743149	0.0460955
Safety Program I	AVATN	Fixed Wing - Pat	2022	0.9345794	0	0	0	0
Safety Program I	AVATN	Fixed Wing - Pat	2023	0.8734387	0	0	0	0
Safety Program I	AVATN	Fixed Wing - Pat	2024	0.8162979	0	0	0	0
Safety Program I	AVATN	Fixed Wing - Pat	2025	0.7628952	0	0	0	0
Safety Program I	AVATN	Fixed Wing - Pat	2026	0.7129862	0	0	0	0
Safety Program I	AVATN	Helicopter - Carg	2021	1	1.8164473	8.48478772	3.84072507	11.477034
Safety Program I	AVATN	Helicopter - Carg	2022	0.9345794	0	0	0	0
Safety Program I	AVATN	Helicopter - Carg	2023	0.8734387	0	0	0	0
Safety Program I	AVATN	Helicopter - Carg	2024	0.8162979	0	0	0	0
Safety Program I	AVATN	Helicopter - Carg	2025	0.7628952	0	0	0	0
Safety Program I	AVATN	Helicopter - Carg	2026	0.7129862	0	0	0	0

3.4.2.3 Risk Reduction per Unit Program Exposure Table

The *Risk Reduction per Unit Program Exposure* table breaks out the risk reduction calculation in the *Program Risk Reduction* table by the LoRE and CoRE reduction components at the tranche, outcome, and year level.

Risk Reduction per Unit Program Exposure

Freq Risk Reduction = LoRE Reduction x CoRE, Conseq Risk Reduction = LoRE x CoRE Reduction, Risk Reduction = Freq Risk Reduction + Conseq Risk Reduction +- LoRE Reduction x CoRE Reduction

Risk ID	Tranche	Outcome	Year	CoRE	Electric Reliability CoRE	Financial CoRE	Safety CoRE	LoRE Reduction per Unit Tranche Exposure 2021	LoRE Reduction per Unit Tranche Exposure 2022	LoRE Reduction per Unit Tranche Exposure 2023	LoRE Reduction per Unit Tranche Exposure 2024	LoRE Reduction per Unit Tranche Exposure 2025	LoRE Reduction per Unit Tranche Exposure 2026	CoRE Reduction per Unit Tranche Exposure 2021	CoRE Reduction per Unit Tranche Exposure 2022
AVATN	Fixed Wing - Patrol	Aggregate	2021	4.6433567	0.00086669	0.002813	4.639676908	7.405E-06	0	0	0	0	0	0.4643357	0
AVATN	Fixed Wing - Patrol	Aggregate	2022	4.64335449	0.00086669	0.002811	4.639676908	0	7.405E-06	0	0	0	0	0	0.4643354
AVATN	Fixed Wing - Patrol	Aggregate	2023	5.34617025	0.000963	0.003123	5.342084031	0	0	8.513E-06	0	0	0	0	0
AVATN	Fixed Wing - Patrol	Aggregate	2024	5.34617025	0.000963	0.003123	5.342084031	0	0	0	8.513E-06	0	0	0	0
AVATN	Fixed Wing - Patrol	Aggregate	2025	5.34617025	0.000963	0.003123	5.342084031	0	0	0	0	8.513E-06	0	0	0
AVATN	Fixed Wing - Patrol	Aggregate	2026	5.34617025	0.000963	0.003123	5.342084031	0	0	0	0	0	8.513E-06	0	0

- Risk ID is the Risk Event Risk ID (for Cross Cutting Factor programs). The Risk Event corresponding to the Risk ID can be referenced in the Data & Validation tab.

- Tranche is the tranche that the program affects.

- Outcome is the outcome associated with the risk event.

- Year is the year that the risk reduction occurs from the implementation of the program in year YYYY.

- CoRE is the pre-mitigation consequence of the risk event associated with the Tranche, Outcome, and Year. It is the sum of the Electric (or Gas) Reliability CoRE, Financial CoRE, and Safety CoRE.

- Electric (or Gas) Reliability CoRE is the pre-mitigation CoRE associated with electric or gas reliability, calculated using the multi-attribute value function (MAVF)[19].

- Financial CoRE is the pre-mitigation CoRE associated with financial losses, excluding utility shareholder financial interests, calculated using the multi-attribute value function (MAVF).

- Safety CoRE is the pre-mitigation CoRE associated with serious injury or fatality, calculated using the multi-attribute value function (MAVF).

- LoRE Reduction per Unit Tranche Exposure YYYY is the LoRE reduction at the tranche- and outcome-level for the Year from the implementation of the program in year YYYY. It is the sum over all subdrivers of the quantity calculated in Equation (5) of Section 2.3.

- CoRE Reduction per Unit Tranche Exposure YYYY is the CoRE reduction at the tranche- and outcome-level for the Year from the implementation of the program in year YYYY. It is the sum over all attributes of the quantity calculated in Equation (7) of Section 2.3.

- LoRE is the pre-mitigation likelihood of the risk event associated with the Tranche, Outcome, and Year.

- Freq Risk Reduction per Unit Tranche Exposure YYYY is the Tranche- and Outcome-level Frequency Risk Reduction in Year for the program implemented in YYYY. The Frequency Risk reduction is calculated as LoRE Reduction per Unit Tranche Exposure YYYY multiplied by the CoRE.

- Conseq Risk Reduction per Unit Tranche Exposure YYYY is the Tranche- and Outcome-level Consequence Risk Reduction in Year for the program implemented in YYYY. The Consequence Risk reduction is calculated as CoRE Reduction per Unit Tranche Exposure YYYY multiplied by the LoRE.

- Risk Reduction per Unit Tranche Exposure YYYY is the Tranche- and Outcome-level Risk Reduction in Year for the program implemented in YYYY. This quantity is calculated on the tranche- and year-level as described in (8) of Section 2.3.

3.4.2.4 LoRE Reduction per unit of work each year, by Tranche, Outcome, Driver, Subdriver and Year

The *LoRE Reduction per unit of work each year, by Tranche, Outcome, Driver, Subdriver and Year* provides more granular information on the LoRE reduction components.

[19] For more information on the MAVF, see

LoRE Reduction per unit of work each year, by Tranche, Outcome, Driver,Subdriver and Year.

Purely based on effectiveness, regardless of program exposure.

Index	Risk ID	Tranche	Outcome	Driver	Subdriver	Year	LoRE	Tranche Exposure	Freq	Yr	Type	Adjusted Effectiveness	Effectiveness Life	Effectiveness Degradation Rate	Effectiveness Degradation Method	2021 Tranche Average Effectiveness	LoRE Reduction per Unit Tranche Exposure 2021
Safety Pro	AVATN	Fixed Wing -	Aviation In	Equipment Fa	Aggregated	2021	4.5297E-06	935.0033	0.004235285	2021	Mitigation	0.1	1	0	esc	0.1	4.5297E-07
Safety Pro	AVATN	Fixed Wing -	Aviation In	Equipment Fa	Aggregated	2022	4.5297E-06	935.0033	0.004235285	2022	Mitigation	0.1	1	0	esc	0	0
Safety Pro	AVATN	Fixed Wing -	Aviation In	Equipment Fa	Aggregated	2023	8.28477E-06	935.0033	0.007746291	2023	Mitigation	0.1	1	0	esc	0	0
Safety Pro	AVATN	Fixed Wing -	Aviation In	Equipment Fa	Aggregated	2024	8.28477E-06	935.0033	0.007746291	2024	Mitigation	0.1	1	0	esc	0	0
Safety Pro	AVATN	Fixed Wing -	Aviation In	Equipment Fa	Aggregated	2025	8.28477E-06	935.0033	0.007746291	2025	Mitigation	0.1	1	0	esc	0	0
Safety Pro	AVATN	Fixed Wing -	Aviation In	Equipment Fa	Aggregated	2026	8.28477E-06	935.0033	0.007746291	2026	Mitigation	0.1	1	0	esc	0	0

- Index is a reference column used by the RSE calculation code

- Risk ID is the Risk Event Risk ID (for Cross Cutting Factor programs). The Risk Event corresponding to the Risk ID can be referenced in the Data & Validation tab.

- Tranche is the tranche that the program affects.

- Outcome is the outcome associated with the risk event.

- Driver is the risk event driver affected by the program.

- Subdriver is the risk event subdriver affected by the program.

- Year is the year that the risk reduction occurs from the implementation of the program in year YYYY.

- LoRE is the pre-mitigation likelihood of the risk event per unit exposure associated with the Tranche, Outcome, Driver, Subdriver and Year.

- Tranche Exposure is the risk exposure (in exposure units specified in the Risk Input File) of the Tranche

- Freq is the annual frequency of the risk event for the Tranche, Outcome, Driver, Subdriver and Year. It is calculated as LoRE * Tranche Exposure

- Yr is the numerical form of Year, used by the RSE calculation code. It is output here for debugging purposes.

- Type is the program type, i.e. whether it is a Mitigation or Control

- Adjusted Effectiveness is the effectiveness of the program in reducing risk per unit exposure on the Tranche, Outcome, Driver, Subdriver and Year level. The effectiveness as input by the user in Tab 3-Eff (see Section 3.2.4) is adjusted for the program exposure and the annual degradation.

- Effectiveness Life is the (integer) number of years that the program benefits last beyond the implementation of the program in year YYYY. This is the same as the Benefit length (yrs) specified in

Tab 3-Eff (see Section 3.2.4).

- Effectiveness Degradation Rate is the degradation rate based specified in Tab 3-Eff (see Section 3.2.4).

- Effectiveness degradation method is the effectiveness degradation method specified in Tab 3-Eff (see Section 3.2.4).

- YYYY Tranche Average Effectiveness is the Adjusted Effectiveness at the Tranche, Outcome, Driver, Subdriver and Year level for the program implemented in YYYY.

- LoRE Reduction per Unit Tranche Exposure YYYY is the LoRE reduction at the Tranche, Outcome, Driver, Subdriver and Year level for the program implemented in YYYY. It is calculated as the product of YYYY Tranche Average Effectiveness and LoRE, as detailed in Equation (5) of Section 2.3.

3.4.2.5 CoRE Reduction per unit of work each year, by Tranche, Outcome, Driver and Attribute

The *CoRE Reduction per unit of work each year, by Tranche, Outcome, Driver and Attribute* provides more granular information on the CoRE reduction components.

CoRE Reduction per unit of work each year, by Tranche, Outcome, Driver and Attribute.
Purely based on effectiveness, regardless of program exposure.

Index	Risk ID	Tranche	Outcome	Year	Attribute	CoRE	Tranche Exposure	Yr	Type	Adjusted Effectiveness	Effectiveness Life	Effectiveness Degradation Rate	Effectiveness Degradation Method	2021 Tranche Average Effectiveness	CoRE Reduction per Unit Tranche Exposure 2021	2022 Tranche Average Effectiveness
Safety Pro	AVATN	Fixed Wing -	Aviation In	2021	Financial	0.001388	935.0033	2021	Mitigation	0.1	1	0	esc	0.1	0.000138782	0
Safety Pro	AVATN	Fixed Wing -	Aviation In	2021	Safety	4.639243	935.0033	2021	Mitigation	0.1	1	0	esc	0.1	0.463924284	0
Safety Pro	AVATN	Fixed Wing -	Aviation In	2022	Financial	0.001387	935.0033	2022	Mitigation	0.1	1	0	esc	0	0	0.1
Safety Pro	AVATN	Fixed Wing -	Aviation In	2022	Safety	4.638809	935.0033	2022	Mitigation	0.1	1	0	esc	0	0	0.1
Safety Pro	AVATN	Fixed Wing -	Aviation In	2023	Financial	0.001541	935.0033	2023	Mitigation	0.1	1	0	esc	0	0	0
Safety Pro	AVATN	Fixed Wing -	Aviation In	2023	Safety	5.341042	935.0033	2023	Mitigation	0.1	1	0	esc	0	0	0
Safety Pro	AVATN	Fixed Wing -	Aviation In	2024	Financial	0.001541	935.0033	2024	Mitigation	0.1	1	0	esc	0	0	0
Safety Pro	AVATN	Fixed Wing -	Aviation In	2024	Safety	5.341042	935.0033	2024	Mitigation	0.1	1	0	esc	0	0	0
Safety Pro	AVATN	Fixed Wing -	Aviation In	2025	Financial	0.001541	935.0033	2025	Mitigation	0.1	1	0	esc	0	0	0
Safety Pro	AVATN	Fixed Wing -	Aviation In	2025	Safety	5.341042	935.0033	2025	Mitigation	0.1	1	0	esc	0	0	0
Safety Pro	AVATN	Fixed Wing -	Aviation In	2026	Financial	0.001541	935.0033	2026	Mitigation	0.1	1	0	esc	0	0	0
Safety Pro	AVATN	Fixed Wing -	Aviation In	2026	Safety	5.341042	935.0033	2026	Mitigation	0.1	1	0	esc	0	0	0

- Index is a reference column used by the RSE calculation code

- Risk ID is the Risk Event Risk ID (for Cross Cutting Factor programs). The Risk Event corresponding to the Risk ID can be referenced in the Data & Validation tab.

- Tranche is the tranche that the program affects.

- Outcome is the outcome associated with the risk event.

- Year is the year that the risk reduction occurs from the implementation of the program in year YYYY.

- Attribute is the applicable MAVF attribute (Safety, Electric Reliability, Gas Reliability, Financial) that is affected by the program.

- CoRE is the pre-mitigation consequence of the risk event per unit exposure associated with the Tranche, Outcome, Attribute and Year.

- Tranche Exposure is the risk exposure (in exposure units specified in the Risk Input File) of the Tranche

- Yr is the numerical form of Year, used by the RSE calculation code. It is output here for debugging purposes.

- Type is the program type, i.e. whether it is a Mitigation or Control

- Adjusted Effectiveness is the effectiveness of the program in reducing risk per unit exposure on the Tranche, Outcome, Driver, Subdriver and Year level. The effectiveness as input by the user in Tab 4-Eff (see Section 3.2.5) is adjusted for the program exposure and the annual degradation.

- Effectiveness Life is the (integer) number of years that the program benefits last beyond the implementation of the program in year YYYY. This is the same as the Benefit length (yrs) specified in Tab 4-Eff (see Section 3.2.5).

- Effectiveness Degradation Rate is the degradation rate based specified in Tab 4-Eff (see Section 3.2.5).

- Effectiveness degradation method is the effectiveness degradation method specified in Tab 4-Eff (see Section 3.2.5).

- YYYY Tranche Average Effectiveness is the Adjusted Effectiveness at the Tranche, Outcome, Driver, Subdriver and Year level for the program implemented in YYYY.

- CoRE Reduction per Unit Tranche Exposure YYYY is the CoRE reduction at the Tranche, Outcome, Attribute and Year level for the program implemented in YYYY. It is calculated as the product of YYYY Tranche Average Effectiveness and CoRE, as detailed in Equation (7) of Section 2.3.

APPENDIX

A. QUALITATIVE METHODOLOGY DETAILS

A.1. EFFECTIVENESS CAP EXAMPLES

Driver Program Category

- Elimination
    - Undergrounding a line eliminates the potential for a downed wire due to vegetation incursion.

    - Decommissioning and removing a dam eliminates the potential for dam failure.
    - Removing a gas line in an area eliminates the potential for a dig-in.
- Engineered barrier
    - A firewall is installed in a network system to prevent intrusion.
    - A cover is placed over a switch to prevent accidental manipulation.
    - A chain link fence is installed to prevent intrusion.
    - A diode is installed to prevent outside parties from manipulating electronic controls.
- Substitution
    - A tool used by personnel is replaced to allow work to be performed safer and easier.
    - A second pump is installed to ensure flow is able to be maintained.
    - A backup valve is installed to ensure flow can be stopped in an emergency.
    - Critical equipment is moved to a more secure location to prevent physical attack.
- Administrative Barrier
    - Employees are mandated to use circle/slash in a procedure to prevent errors when performing a procedure that could lead to a risk event.
    - Three-way communication is utilized to ensure communication is clearly understood during a high risk evolution.
- Distance Gap
    - Tape is placed on a floor to demonstrate a safe area for personnel to stand away from a hazard.
    - Vegetation is cleared to a certain distance to prevent contact with power lines.
- Detect / Notify / Respond
    - Inspections are performed and resulting issues identified are promptly addressed.
    - An automated system alerts an operator to take action to prevent a risk event from occurring.
    - Security cameras are installed and monitored to identify and respond to intruders.
- Minor or Preventative Maintenance
    - Regular testing and maintenance is performed on critical equipment to ensure reliability.
    - Chain link fencing is regularly tensioned and rust and other degradations are addressed.
    - Equipment is serviced or replaced at Original Equipment Manufacturer (OEM) recommended intervals.

Risk Driver Attribute

- Human Error
    - Operator error leads to overpressurization of a gas line.
    - Excessive and unmonitored pumping leads to overtopping of a dam.
- Functional Failure
    - A pump fails to start either by manual action from an operator or expected automated response.
    - A valve operator fails to open a valve either by manual action from an operator or expected automated response.
    - Software crashes.
- Malicious / Negligent Action

- A drunk driver runs into a pole.
- A nation-state attacker sabotages critical infrastructure.
- A cyber attacker installs ransomware on internal systems.
- A contractor digs into a buried gas line.

- Natural Force
  - Sudden rains on snowpack leads to flooding.
  - High winds.
  - Flow accelerated corrosion and cracking.
  - Thermal cycling.

Consequence Program Attribute

- Replacement
  - Power or gas is rerouted so that an outage is momentary or undetectable.
  - Control systems are relocated outside of the flood zone to allow operators to safely control equipment during an event.
- Engineered Barrier
  - A seawall is installed so that a tsunami does not incur on critical equipment.
  - An infected system is isolated to prevent spread of a computer virus.
- Automated Response
  - An automated system detects a sudden loss of gas pressure and closes the supply valve to the affected line.
  - A turbine overspeed is detected and forces the turbine to trip.
- Manual Response
  - SCADA system detects high flows and triggers an alarm to prompt operators to take action.
  - A member of the public alerts authorities to a downed wire.

Risk Event Consequence Development

- Rapid
  - People living within 30 minutes of the flood zone after a dam failure may not have adequate time to evacuate after a dam failure.
  - A dig in results in unexpected rupture and ignition of a gas line.
- Gradual
  - A wildfire develops away from a population center and people in threat are able to be evacuated prior to the wildfire approaching.
  - Insufficient power is forecasted by the CalISO and warnings are able to be issued to alert the populace to potential outages.

A.2. Maturity Factor Response Explanations

1. *Are there accountable control owners to oversee the end to end process?*
   a. *One or more control owners in an organization*. Centralized accountable owners have full visibility to the process required to fully execute the control.
   b. *Multiple control owners across organization*. Decentralized owners or overlapping responsibilities can result in gaps in process ownership.

c. *No designated control owners.* Control is executed by staff, but owners have either departed or are not designated so ownership and oversight is unclear or nonexistent.

2. *Is staffing sufficient for executing the control?*
   a. *Staffing is sufficient.* Control is being executed by current staff, and while openings may exist, it does not strain the execution of the control.
   b. *Openings exist but control is maintained by current staffing.* Control is being executed by current staff, but gaps in staffing result in current staff taking on a number of additional responsibilities which may not be sustainable or may lead to errors.
   c. *Staffing is insufficient to effectively implement control.* Control is still being executed, but personnel executing the control have to assume numerous roles, are strained, and may often miss deadlines or perform insufficiently due to excessive loading.
3. *Is training mandated for process owners implementing the control?*
   a. *Training is accredited and directly applicable.* Owners of the control have been trained to execute the specific control and the training itself has been validated as effective or applicable.
   b. *Training is not accredited or not directly applicable.* Owners of the control have been trained, but the control is covered only briefly or in part, or the training has not been reviewed for effectiveness or applicability.
   c. *Training is generic or does not exist.* Owners of the control have not been trained for executing the control and rely upon passed down knowledge or learning through execution of the control.
4. *Are there open Internal Audit (IA) High Risk Findings?*
   a. *No, all IA High Risk Findings are closed.* IA High Risk Findings have been resolved or have not been found. This option may be selected if IA does not evaluate the program, but follow up should be performed to ensure IA has had the opportunity to audit the program.
   b. *IA High Risk Findings are open and corrective actions are in progress.* IA High Risk Findings are open but on track to timely resolution.
   c. *IA High Risk Findings are still under investigation.* IA High Risk Findings have recently been discovered or have not been investigated to determine closure path.
5. *Are there non-conformances or violations (NC&V)?*
   a. *NC&Vs are closed and no negative trend has been identified.* NC&Vs have been investigated and resolved. Further, NC&Vs are trended and have not been found to indicate a gap in the control. This option may be selected if the control does not receive regulatory oversight.
   b. *NC&Vs are open and no negative trend has been identified.* NC&Vs are being addressed but open issues still require resolution to close identified gaps in execution of the control. Further, NC&Vs are trended and have not been found to indicate further gaps in the control exist.
   c. *NC&Vs are open and trending is negative.* NC&Vs are open and are not being addressed to resolution. Further, trending of NC&Vs is not being performed or are indicative of gaps in execution of the control.
6. *Is a skillset mandated for the control owner?*

a. *Control owner has a defined skillset filled by current owner.* Owner(s) of the control meet expectations necessary to provide ownership and oversight of the control.
b. *Control owner does not meet defined skillset or is interim.* Owner(s) of the control do not meet expectations for providing ownership or oversight of the control or have been temporarily elevated to the position until the position can be filled.
c. *Skillset is generic or irrelevant.* Necessary skillset for owner(s) of the control has not been defined or there are no control owners.

7. *Is a skillset mandated for personnel executing the control?*
    a. *Personnel meet and have a defined skillset.* Personnel executing the control meet expectations necessary to be relevant subject matter experts (SMEs) for implementing the control.
    b. *Personnel do not meet defined skillset or are interim.* Personnel executing the control do not meet expectations necessary to be considered SMEs for implementing the control or may be temporarily filling roles to ensure the control is able to be executed.
    c. *Skillset is generic or irrelevant.* Necessary skillset for personnel executing the control has not been defined.
8. *Is there guidance on the control?*
    a. *Guidance documents are up to date.* Guidance documents are used to implement the control and are able to be consistently followed by personnel executing the control.
    b. *Guidance documents exist but updates or corrections are needed.* Guidance documents are used to implement the control and able to be followed to execute the control, however they cannot be consistently followed for full implementation, are out of date, or have known gaps or workarounds.
    c. *Guidance documents are inadequate or aren't used.* Guidance documents are not used to implement the control, do not exist, or are inadequate and unable to be followed.
9. *Are records in a template format and retained?*
    a. *Templates are effective and retained per Enterprise Records & Information Management (ERIM) standards.* Templates are used for collecting data from the control which allows for appropriate follow-up and trending. The templates are then stored per company standards to ensure appropriate recordkeeping.
    b. *Deficiencies have been identified with templates or retention.* Templates are used but require rework for effective implementation and trending of control. The templates are inconsistently stored or ERIM assessment of retention methods have found deficiencies.
    c. *Templates don't exist or are used inconsistently or ineffectively.* Data collected through implementation of control is inconsistently documented and issues may not be easily identified for remediation.
10. *Is the control assessed by a qualified internal party?*
    a. *Independent internal assessment is performed at an appropriate level.* An independent party with the implementing organization assesses the effectiveness of the control. For example, departments providing quality verification or Compliance Maturity Controls Testing.
    b. *Internal assessments are performed but lack independence or effectiveness.* Personnel performing the control or control owners regularly evaluate the control to ensure completeness of the control.

c. *Control is not assessed or assessment items are not addressed.* Control is performed without internal assessment, or assessments are performed but issues identified are not investigated and addressed.

11. *Is the control assessed against the desired objectives and inherent risk?*
    a. *Control is assessed and open items are addressed.* Assessments performed on this control are directed towards ensuring control's effectiveness and do not roll up the control with other programs such that the control is indistinguishable.
    b. *Control is assessed but deficiencies are not timely addressed.* Assessment is performed as described, but issues identified are not clearly tracked to resolution.
    c. *Control is generically assessed or not assessed.* Assessment rolls up control into several other programs and does not directly address goals of the control, or control is not assessed internally.
12. *Is data from the control tracked and trended?*
    a. *Data is effective and validated and helps drive implementation.* Data is collected and clearly usable for purposes of the control. Further, data is regularly reviewed to ensure it is trended and issues identified are addressed.
    b. *Data is collected but is not validated or inconsistently implemented.* Data is collected but gaps in collection have been identified or review and validation is performed inconsistently. The data is still clearly usable for the intended purposes of the control.
    c. *Data is not collected or is not relevant to control objective.* Data collection is inconsistent or issues identified don't often reach resolution. No trending or reviews are performed.
13. *Are metrics directly related to the control and reported to leadership at an appropriate interval?*
    a. *Metrics are reported to leadership and inform decision-making.* Metrics are clear and comprehensive and reported to leadership directly to allow leadership action prior to degradation of risk and control.
    b. *Metrics do not reach the appropriate level of leadership or inconsistently inform decision*-making. Metrics are not clearly visible to a level of leadership that can remediate issues with the control or risk.
    c. *Metrics are not reported or are ineffective for decision*-making purposes. No metrics exist for the control or are rolled up such that no visibility for the risk or control is achievable.