# St. Louis County CSAH 4 (Rice Lake Road) Risk Assessment Summary

January 12, 2024

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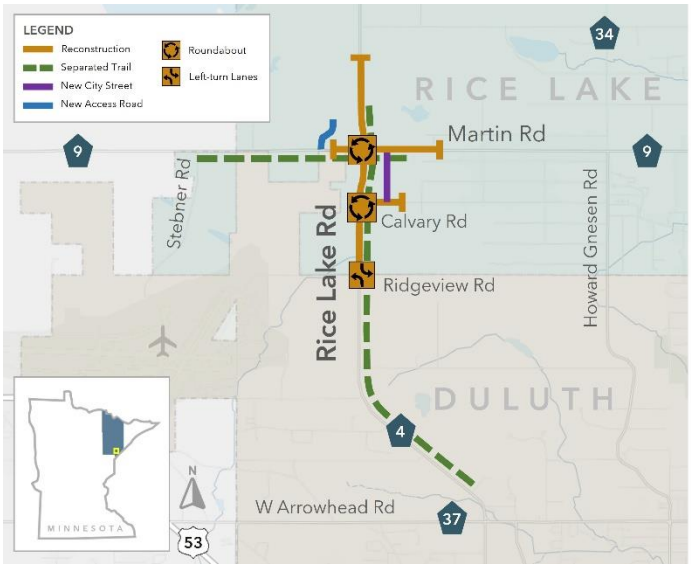
## Project Overview

Rice Lake Rd (CSAH 4) is a regionally significant roadway that serves the newly founded City of Rice Lake, acts as a key commuter and truck route for the Duluth metro area and connects to the communities of the East Iron Range which is a nationally strategic mining area. This project will support private investments in commercial and residential development to grow local jobs that are connected to places of community and while improving traffic capacity and operations of the Rice Lake Rd corridor. As a result, the new Rice Lake Rd will function as the downtown center of Rice Lake.




## Purpose

The purpose of a risk management assessment is to identify potential risk, analyze the potential for the risk to occur and the cost and schedule impact if the risk occurs. Once the issues are identified, the team determines the best way to avoid, minimize or mitigate the risk and assign someone on the project team to monitor the issue.

Project risk management is the process for conducting risk management planning, identification, analysis, responses, monitoring, and controlling the project. The objectives of project risk management are to increase the probability and impact of positive events and decrease the probability and impact of negative events. Project issue management includes utilizing the outputs from the risk management planning.

## Process

The project management team conducted a process to identify risks, analyze qualitative impacts of the risk and analyze the quantitative impacts of the risk. The process started by emailing a risk assessment information packet and a worksheet for each PMT member to complete to identify and share their input on the probability and magnitude of the potential risk. See attachment A Risk Packet for the overview and instructions that were provided to PMT members.

Following are the steps taken to complete the risk assessment.

July and August, Bolton & Menk prepared the risk assessment packet and a risk register spreadsheet for the external Project Management Team to complete. On August 14, the packet was reviewed and finalized with the project manager. On August 17, the email with instructions and the risk assessment packet was sent to project partners on the external Project Management Team including representatives of Rice Lake, Duluth, and several departments within St. Louis County. They were given three weeks to complete the table and return it to the project team who compiled the results into one table.

On September 11, the project team reviewed the compiled list of initial risks identified by project partners and finalized it. The next step was to draft potential mitigation strategies. On October 2, the project team reviewed and discussed mitigation strategies.

1. Qualitative
    a. Assess and combine probability of occurrence and impact
    b. Rank and categorize risks; distinguish which ones are high priority
    c. Identify which risks require responses in the near future, which ones need additional analysis, and which low-priority risks to keep on a watch list
    d. Assign rating
2. Quantitative
    a. Numerically analyze effect of identified risks on overall project objectives.
    b. Gather and analyze information about how likely a risk is
    c. Quantify risk impacts on project objectives like cost and schedule

## Results

The greatest risk to the project is not receiving sufficient grant funding and construction costs coming in higher than estimated. Both of these impacts would have a significant schedule impact of up to a year to give the county time to assess the situation and determine the next steps to take. The issue of construction costs being higher than estimated could be due to several factors such as material costs, or worker shortages, which will be monitored and tracked as the project completes design, engineering and preparing construction bid documents.

The risk register analyzes the cost impacts under several scenarios:

| | Scenario | Description | Cost impact |
|---|---|---|---|
| **1** | Weighted probability | Likelihood of risk occurring, and the likely cost impact considered | $2.4 million |
| **2** | Moderate | All identified risks occur at a likely cost estimate | $6.9 million |
| **3** | Worst case | All identified risks occur at the maximum cost | $10.1 million |

Many of these risks have a low probability of happening and the risk register has identified strategies to avoid or mitigate as well as assigned a staff person to monitor the risk. As the project progresses and risks are resolved or closed out, the risk register will be updated, included the estimated cost impact.

## Monitoring and Tracking

The next steps are to monitor, track and manage risk over as the project progresses. The project management team has identified management strategies and assigned an owner to take responsibility for a specific risk. The risk management team identities one of the four ways to address a negative risk.

1. **Avoid**: You can avoid a threat by making changes to the project itself to prevent the risk from impacting it.
2. **Transfer**: You transfer a threat to a third party. In this case, the risk is still present, but another party will have ownership and responsibility of it (like insurance).
3. **Mitigate**: You mitigate a threat by taking steps to lessen either the likelihood that it will happen or the impact it will have on project objectives. Taking action to prevent or reduce the probability of an event is typically more effective than fixing a problem after it occurs. If it is not possible to reduce or prevent a risk, developing a response to mitigate the impact may be helpful. In this case, the risk still occurs, but using the risk response will decrease the severity of its impact.
4. **Accept**: You accept a threat by deciding not to take any action. This approach leaves the team to address the risk if it becomes real, typically through a contingency reserve.

Every-other month, the project team members that have been assigned a risk will be asked to provide a status update on any activities related to that risk. When a risk has been retired, the potential cost of that risk will be removed from the tracker.

## Attachment 1:  Risk Packet

# Risk Management Summary

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# Risk Identification

Risk identification determines what might happen that could affect the objectives of the project. It produces a deliverable — the project risk register – that documents the risks and their characteristics. The risk register is subsequently amended by the qualitative or quantitative risk analysis, risk response, and risk monitoring processes. Risk identification is an iterative process because new risks may become known as the project progresses through its life cycle, previously-identified risks may drop out, and other risks may be updated.

### *"Risk" Includes Threats and Opportunities*

There are two sides to risk: threats and opportunities.

Projects in design have the greatest potential for opportunities because the project is still open to changes. Risk reduction and avoidance are opportunities, as are value analyses, constructability reviews, and innovations in design, construction methods, and materials.

Once a project enters construction, the project objectives (scope, time, and cost) are fixed contractually, so opportunities to save money and time are fewer. Any changes must be made using a Supplemental Agreement (SA) and only a negative SA such as one resulting from a Value Engineering Change Proposal by the contractor would still afford an opportunity to save money and time. Otherwise, SAs add cost and/or time to the project. So, the risk management focus during construction is on reducing or eliminating risks.

## Identifying Project Risks

When risk management is initially applied to a project, the project risk manager convenes the PRMT to identify and assess risks.

> Including causes or effects in a risk register can obscure genuine risks, which may not receive the appropriate degree of attention they deserve. One way to clearly separate risks from their causes and effects is to use a description with required elements to provide a three-part structured "risk statement": "If xxxxx (cause) occurs, then xxxxx (risk event) may happen, which will harm our xxxx (consequence)."As a result of *<definite cause>*, *<uncertain event>* may occur, which would lead to *<effect on objective(s)>*."
>
> Examples include:
>
> - "If we use an unfamiliar technology (a definite requirement), then unexpected design problems may occur (an uncertain risk), which would result in overspending on the project (an effect on the budget objective)."
> - "If we commit to a project design we have never utilized (fact = cause), then we may misunderstand the requirements (uncertainty = risk), resulting in a project which does not meet the performance criteria (contingent possibility = effect on objective)."

At the risk identification stage, the impacts on cost and time are not analyzed – that happens in the qualitative risk analysis (Chapter 4) or quantitative risk analysis (Chapter 5) processes.

The team members identify the potential risks (threats and opportunities) using any combination of:

- Brainstorming,
- Challenging of assumptions,
- Looking for "newness" (e.g. new materials, technology, or processes),
- Their knowledge of the project or similar projects,
- Consultation with others who have significant knowledge of the project or its environment,
- Consultation with others who have significant knowledge of similar projects, and
- The experience of project stakeholders or others in the organization.

When the team identifies risks, it should include descriptions of:

- What may happen or not go according to plan,
- What the impacts to the project objectives would be should the risk arise,
- What the assumptions and current status are that support the assessment of the risk,
- What action, if any, has been taken to respond to the risk, and
- What further options might be available for responding to the risk?

The information is entered into the risk register. Each risk is assigned to a member of the PRMT who becomes its Risk Owner. The risk register is reviewed and updated throughout the project.

The project manager, at his/her option, may elicit initial risk registers from the functional units and consolidate the contributions into a single project risk register. Alternatively, the project risk register may be developed during a PRMT meeting.[1]

**MITIGATING RISKS AT JOB SITES**

Access to all areas of a project site may not be possible before construction. This makes it difficult to determine environmentally sensitive areas or subsurface information. The team needs to recognize this uncertainty address it in the construction phase.

Some options for addressing the risks from unknown conditions:

1. Plan for the scope of the risk and consider different payment mechanisms, like change orders, to mitigate it.

2. Provide language in the Special Provisions for the contractor to provide access to the job site for the Department's personnel as a first order of work.

3. Provide language in the Special Provisions for the contractor to hold off on ordering materials whose quantity may be impacted by this new information.

4. Provide resources for design personnel to perform a timely design/assessment using the new information.

## 3-3 Examples of Risk Statements

**TABLE 4 – EXAMPLE RISK STATEMENTS**

| | Risk Statement |
|---|---|
| **Design** | If the survey is inaccurate or incomplete, then the project's design may have to be revised. |
| | A design change that is outside the parameters contemplated in the Environmental Document triggers a supplemental EIR which causes a delay due to the public comment period. |
| **Environmental** | Potential lawsuits may challenge the environmental report, delaying the start of construction or threatening loss of funding. |
| | Nesting birds, protected from harassment under the Migratory Bird Treaty Act, may delay construction during the nesting season. |
| **R/W** | Due to the complex nature of the staging, additional right of way or construction easements may be required to complete the work as contemplated, resulting in additional cost to the project. |
| | Due to the large number of parcels and businesses, the condemnation process may have to be used to acquire R/W, which could delay start of construction by up to one year, increasing construction costs. |
| **Construction** | Hazardous materials encountered during construction will require an on-site storage area and potential additional costs to dispose. |
| | Unanticipated buried man-made objects uncovered during construction require removal and disposal, resulting in additional costs. |

## 3-4 Entering Data into the Risk Register

At this stage, complete the information in the following risk register columns:

| Column | Contents |
|---|---|
| **Risk Name** | Provide a title for the risk that can be used to refer to it. You will expand upon this in the risk description. |
| **Status** | Select "Active" or "Retired." A risk is retired when it has no further possibility of impacting the project. |
| **Description** | Write a complete description of the event and its potential impacts on the project if this risk were to occur. See Section 3-2 for the structure of the risk statement. |
| **Probability** | The likelihood that the risk event will happen. |
| **Impact** | If the risk event does occur, what will the effect be (positive or negative) on cost, time, scope and/or quality? |
| **Response Type** | Select how the PM or PMRT has chosen to respond to the risk: Avoid, accept, mitigate, transfer, exploit, enhance or share. See chapter 7 for definitions of risk response strategies. |
| **Response Action** | List how the risk will be dealt with. |
| **Responsible Person** | Enter the name of the PRMT member responsible for this risk. |
| **Residual probability/impact** | If the risk action is followed, how has the probability/impact changed? |
| **Contingency** | How much time or dollars need to be set aside for this risk on the project? This amount should be carried into TPCE or schedule as extra. For major/moderate projects, this amount may be calculated using a Monte Carlo simulation. For smaller projects, the PRM or PM may simply do research on material costs, for example, and input an estimate. |
| **Last Updated** | Enter the date the risk was created. |
| **Next Review Date** | Enter the date when the risk register will be updated again. |

# Risk Checklists

Risk checklists are a tool for risk identification that can be used at the earliest stages of risk identification to learn from past projects and past team member experience. The list helps Estimators to better understand the required contingency and helps Managers to more effectively control scope growth throughout the project development process. The use of a risk checklist is the final step of risk identification to ensure that common project risks are not overlooked.

**What is it?**
Risk checklists are a historic list of risks identified or realized on past projects. Risk checklists are meant to be shared between Estimators and discipline groups on all projects.

**Why use it?**
The benefit of maintaining risk checklists is to capture corporate knowledge within a state highway agency and ensure that common risks are not overlooked in the estimating or risk management process. Risk checklists are simple to maintain if the agency has a central estimating or risk management function. Risk checklists can also be maintained by individual Estimators or Project Managers.

**What does it do?**
Risk checklists serve as a final step in the risk identification process to ensure that common risks are not overlooked.

**When to use it?**
Risk checklists should be used only after the team has identified risks on its own (e.g., through an examination of scope and estimating assumptions, the brainstorming of issues and concerns, or the creation of a red flag list). Risk checklists should not be used as the first step in risk identification because they may not contain important project-specific risks. If a project team relies too heavily on a risk checklist, it could easily overlook project-specific risks, and the risks may not be phased correctly for the unique aspects of the project.

**How to use it?**
A risk checklist should be reviewed at the start of a project and potentially several more times throughout the project. The list should be reviewed by a project team, and the risks that may have impacts should be documented and added to the risk register and possibly marked for quantitative analysis.

**Example**
California DOT has developed a sample list of risks in its Project Risk Management Handbook. This sample list of risks can be used as the basis for creating a list of red flag items for an individual project. The Caltrans list is quite comprehensive, and any single project's list of risks should not include all of these elements.

**Caltrans Sample Risk List (Caltrans 2007)**

**Technical Risks**

- Design incomplete
- Right-of-Way analysis in error
- Environmental analysis incomplete or in error
- Unexpected geotechnical issues
- Change requests because of errors
- Inaccurate assumptions on technical issues in planning stage
- Surveys late and/or surveys in error
- Materials/geotechnical/foundation in error
- Structural designs incomplete or in error
- Hazardous waste site analysis incomplete or in error
- Need for design exceptions
- Consultant design not up to Department standards
- Context sensitive solutions
- Fact sheet requirements (exceptions to standards)

**External Risks**

- Landowners unwilling to sell
- Priorities change on existing program
- Inconsistent cost, time, scope, and quality objectives
- Local communities pose objections
- Funding changes for fiscal year
- Political factors change
- Stakeholders request late changes
- New stakeholders emerge and demand new work
- Influential stakeholders request additional needs to serve their own commercial purposes
- Threat of lawsuits
- Stakeholders choose time and/or cost over quality

**Environmental Risks**

- Permits or agency actions delayed or take longer than expected
- New information required for permits
- Environmental regulations change
- Water quality regulation changes
- Reviewing agency requires higher-level review than assumed
- Lack of specialized staff (biology, anthropology, archeology, etc.)
- Historic site, endangered species, wetlands present
- EIS required
- Controversy on environmental grounds expected
- Environmental analysis on new alignments is required
- Formal NEPA/404 consultation is required
- Formal Section 7 consultation is required Section 106 issues expected

- Project in an area of high sensitivity for paleontology
- Section 4(f) resources affected
- Project in the Coastal Zone
- Project on a Scenic Highway
- Project near a Wild and Scenic River
- Project in a floodplain or a regulatory floodway
- Project does not conform to the state implementation plan for air quality at the program and plan level
- Water quality issues
- Negative community impacts expected
- Hazardous waste preliminary site investigation required
- Growth inducement issues
- Cumulative impact issues
- Pressure to compress the environmental schedule

**Organizational Risks**

- Inexperienced staff assigned
- Losing critical staff at crucial point of the project
- Insufficient time to plan
- Unanticipated project manger workload
- Internal "red tape" causes delay getting approvals, decisions
- Functional units not available, overloaded
- Lack of understanding of complex internal funding procedures
- Not enough time to plan
- Priorities change on existing program
- New priority project inserted into program
- Inconsistent cost, time, scope and quality objectives

**Project Management Risks**

- Project purpose and need is poorly defined
- Project scope definition is poor or incomplete
- Project scope, schedule, objectives, cost, and deliverables are not clearly defined or understood
- No control over staff priorities
- Too many projects
- Consultant or contractor delays
- Estimating and/or scheduling errors
- Unplanned work that must be accommodated
- Communication breakdown with project team
- Pressure to deliver project on an accelerated schedule
- Lack of coordination/communication
- Lack of upper management support
- Change in key staffing throughout the project
- Inexperienced workforce/inadequate staff/resource availability
- Local agency issues

- Public awareness/support
- Agreements

**Right-of-Way Risks**

- Utility relocation may not happen in time
- Freeway agreements
- Railroad involvement
- Objections to Right-of-Way appraisal takes more time and/or money

**Construction Risks**

- Inaccurate contract time estimates
- Permit work windows
- Utility
- Surveys
- Buried man-made objects/unidentified hazardous waste

**Regulatory Risks**

- Water quality regulations change
- New permits or new information required
- Reviewing agency requires higher-level review than assumed

**Sample Risk Checklist from the Minnesota DOT:**

**No. of lanes**

- Traffic volumes
- Level of Service LOS analysis
- Lane continuity
- High-occupancy vehicle, single-occupancy vehicle, etc.
- Policies, purpose, and need

**Access**

- Functional classification of roadways
- Traffic volumes
- Traffic movements
- Traffic forecasts
- Right-of-way impacts
- Environmental issues
- Existing interchange/conditions
- Municipal land use planning
- Design speed/engineering standards
- Access category
- Bike/Pedestrian
- Crash data

**Horizontal**

- Right-of-Way impacts
- Environmental issues
- Soils
- Utilities
- Existing conditions
- Topography
- Pavement condition
- Staging/Detour
- Municipal community planning
- Design speed
- Enforcement issues
- Engineering standards
- Park & Ride
- HOV/Transit elements

**Vertical**

- Design speed/engineering standards
- Soils – rock, muck, water
- Utilities
- Topography
- Bridges
- Municipal community planning
- Noise
- Adjacent land use
- Drainage
- Airports

**Bridge**

- Cross section – mainline
- Cross section – cross street
- Profiles
- Skew
- Type selection
- Aesthetics
- Bike/Pedestrian trails
- Airport location
- Lighting & signing
- Soils/Foundations
- Waterway analysis
- Bridge clearance (overlays)
- Utilities
- Staging/Detour
- Bridge approach costs
- Temps and shoo fly

**Retaining walls**

- Type
- Cross sections
- Aesthetics
- Drainage
- Right-of-Way impacts
- Utilities
- Soils/Foundations

**Traffic**

- Design speed
- Functional classification
- Roadway type
- Access locations
- Traffic movements
- Traffic volumes
- LOS analysis
- Signal warrant analysis
- Crash data
- Safety systems
- Lighting warrants
- Signing
- Striping determination
- Airports
- Foundation analysis

**WRE**

- Alignments
- Profiles
- Cross sections
- Drainage areas
- Existing conditions
- Impervious areas
- Banking
- Waterway analysis
- DNR
- Corps
- Watersheds/WCA/BWSR
- NPDES/PCA/MS4
- City/County coordination
- Right-of-Way impacts
- Soils
- Drinking water areas
- Airports

- Ponding

**Pavement**

- Soils
- Cross sections
- Traffic volumes
- Vehicle classification
- Profiles
- Water table
- Drainage
- Pavement selection
- Shoulder use
- Traffic staging/control
- Dynamic shoulders
- Transit shoulders
- Pavement condition

**Utilities**

- As-builts (Mn/DOT and city)
- Surveys
- Gopher 1
- Aerial photography
- R/W maps
- Plats
- Site plans
- Coordinate with city/county
- Permits
- Alignments
- Profiles
- Cross sections
- Drainage elements
- Retaining walls
- Noise walls
- Bridges
- Construction staging

**Railroad**

- Aerial photos
- Alignments
- Profiles
- Cross sections
- Drainage
- Retaining walls
- Noise walls
- Bridges

- R/W maps
- Plats
- Railroad office coordination
- Construction staging

**Earthwork**

- Alignments
- Profiles
- Soil borings
- Intersections
- Drainage elements
- Subsurface drains
- Foundation analysis
- Contaminated soils – remediation

**Noise walls**

- Alignments
- Profiles
- Land use maps
- Traffic volumes
- LOS
- Traffic classifications
- Utilities
- R/W impacts
- Municipal consent
- Historic property review
- Drainage elements
- Airports
- Aesthetics
- Wall type
- Foundation analysis

**Maintenance**

- Maintenance elements/issues
- Drain tile
- Anti-icing
- HOV bypass
- Snow storage
- Snow control

**Transportation Management System**

- TMS, ITS, IVHS elements

**Construction**

- Innovative construction services
- Detours
- Staking
- Extraordinary enforcement
- Extraordinary public relations
- Seasonal impacts
- Vibration and noise

**Surveys**

- Survey

**Tips**

This method is only truly useful when the project team members think about every item on the list as a jumping off point for further risks. Each item must be thought about in detail to ensure that the risk is truly a project risk. The thought process should be documented in order to build on this in future discussions of the risks.

**Resources**

Caltrans Office of Statewide Project Management Improvement (2007). Project Risk Management Handbook: Threats and Opportunities, 2nd ed., May 2007, Caltrans, Sacramento, CA. http://www.dot.ca.gov/hq/projmgmt/guidance_prmhb.htm.

Molenaar, K. R. (2005). "Programmatic Cost Risk Analysis for Highway MegaProjects," Journal of Construction Engineering and Management, Vol. 131, No. 3.

# Qualitative Risk Analysis

Qualitative risk analysis includes methods for prioritizing the identified risks for further action, such as risk response. The PRMT can improve the project's performance effectively by focusing on high-priority risks.

Team members revisit qualitative risk analysis during the project's lifecycle. When the team repeats qualitative analysis for individual risks, trends may emerge in the results. These trends can indicate the need for more or less risk management action on particular risks or even show whether a risk mitigation plan is working.

## Risk Assessment

Qualitative risk analysis for all projects levels (minor, moderate, major and mega) assigns a Probability and an Impact to each risk in the risk register. The Overall Rating will automatically calculate and determine where the greatest effort should be focused in responding to the risks. They facilitate structured risk response action and resource allocation.

The three ratings for projects are:

- "High" – First priority for risk response.
- "Medium" – Risk response as time and resources permit.
- "Low" – No risk response required at this time.

Qualitative risk analysis includes methods for prioritizing the identified risks for further action, such as risk response. The PRMT can improve the project's performance effectively by focusing on high-priority risks.

Team members revisit qualitative risk analysis during the project's lifecycle. When the team repeats qualitative analysis for individual risks, trends may emerge in the results. These trends can indicate the need for more or less risk management action on particular risks or even show whether a risk mitigation plan is working.

Qualitative risk analysis for Moderate projects assesses the priority of identified risks using their probability of occurring and the corresponding impact on project objectives if the risks occur.

## Probability and Impact Ratings for Projects

Table 5 lists an example of definitions of risk probability and impact ratings. The cost impact ratings may be easier to apply if expressed in terms of dollars. The ratings for the project serve as a consistent frame of reference for the PRMT in assessing the risks during the life of the project.

The table is intended as a guide – the PRMT may define dollar and time ranges as appropriate for the project. The impacts are to the overall project. Schedule delay applies to risks that are on the critical path (the longest path). During the Planning and Design phase, delay impacts to the letting date may be of primary interest. During construction, delays impact project completion.

**TABLE 5 –DEFINITIONS OF IMPACT AND PROBABILITY RATINGS**

| Rating --> | Very Low | Low | Moderate | High | Very High |
|---|---|---|---|---|---|
| **Cost Impact of Threat (CO + COS)** | Insignificant cost increase | <5% cost increase | 5-10% cost increase | 10-20% cost increase | >20% cost increase |
| **Cost Impact of Opportunity** | Insignificant cost | <1% cost decrease | 1-3% cost decrease | 3-5% cost decrease | >5% cost decrease |
| **Schedule Impact of** | Insignificant slippage | <1 month slippage | 1-3 months slippage | 3-6 months slippage | >6 months slippage |
| **Schedule Impact of Opportunity** | Insignificant improvement | <1 month improvement | 1-2 months improvement | 2-3 months improvement | >3 months improvement |
| **Probability** | 1–9% | 10–19% | 20–39% | 40–59% | 60–99% |

## Performing Qualitative Risk Analysis

The PRMT assesses each identified risk in turn and assesses:

- The rating for the probability of the risk occurring, and
- The rating of cost and time impact of each risk, should it occur.

For a particular impact, the combination of the probability rating of the risk occurring and the impact rating positions the risk into one of the three colored zones in the risk matrix. The color of the zone indicates the priority of the risk for risk response: red zone signifies high importance, yellow is medium importance, and green is low importance.

For example, a risk having a "Moderate" probability and a "High" impact falls into the red zone. Its impact score is 3 x 8 =24.

## 5-3 Entering Assessments into the Risk Register

The qualitative risk analysis of each risk is entered into the risk register.

| Column | Contents |
|---|---|
| **Probability** | Select the probability level from the drop-down list. |
| **Cost Impact** | Select the cost impact level from the drop-down list. |
| **Time Impact** | Select the time impact level from the drop-down list. |

The "Cost Score" is equal to the Probability number times the Cost Impact number. The "Time Score" is equal to the Probability number times the Time Impact number. The risks in a colored zone may be further prioritized for risk response according to their Cost and Time Scores. The higher the score, the higher the priority for risk response and monitoring. Other columns in the risk register will be completed or updated by the risk response process in Chapter 7.

# Quantitative Risk Analysis – Level 3

Level 3 will require expertise and possibly training.
Please see the SSC for guidance.

Quantitative risk analysis is a way of numerically estimating the probability that a project will meet its cost and time objectives. Quantitative analysis is based on a simultaneous evaluation of the impact of all identified and quantified risks, using Monte Carlo simulation by *@Risk*, *Crystal Ball, Acumen or Primavera Risk Analysis* software. The result is a probability distribution of the project's cost and completion date based on the identified risks in the project.

Quantitative risk analysis simulation starts with the model of the project and either its project schedule or its cost estimate, depending on the objective. The degree of uncertainty in each schedule activity and each line-item cost element is represented by a probability distribution. The probability distribution is usually specified by determining the optimistic, the most likely, and the pessimistic values for the activity or cost element. This is typically called the "3-point estimate." The three points are estimated by the project team or other subject matter experts who focus on the schedule or cost elements one at a time.

Specialized simulation software runs (iterates) the project schedule or cost estimate model many times, drawing duration or cost values for each iteration at random from the probability distribution derived from the 3-point estimates for each element. The software produces a probability distribution of possible completion dates and project costs. From this distribution, it is possible to answer such questions as:

- How likely is the current plan to come in on schedule or on budget?
- How much contingency reserve of time or money is needed to provide a sufficient degree of confidence?

Which activities or line-item cost elements contribute the most to the possibility of overrunning schedule or cost targets can be determined by performing sensitivity analysis with the software.

## Quantifying the Risks

The project risk manager leads the PRMT in quantifying cost and schedule risks.

- The probability of the risk occurring is expressed by two values: "Low" and "High" that cover the range.
- Three-point estimates are used for cost and schedule impacts. The three-point estimate consists of determining the "Low" (optimistic), "High" (pessimistic) and "Most Likely" values for the cost and time. The most likely value may be omitted if it cannot be established credibly.

The cost impacts include direct costs only; they exclude any cost of delay (determined from the output of a schedule risk analysis – see "Schedule Risk Analysis" on page 25). Schedule impacts are expressed in days of potential delay due to the risk. Some risks may not have both cost and schedule impacts.

Potential project delivery schedule delays can impact the letting date and construction duration. The cost of potential delay to the letting date may be a risk item in the risk register.

## Entering Quantifications into the Risk Register

The qualitative risk analysis of each risk is entered into the following columns of the risk register.

| Column(s) | Contents |
|---|---|
| **Probability** | Enter the "Low" to "High" values. |
| **Cost Impact** | If there is a cost impact, enter a "Low" and "High" cost. If there is reason for a credible "Most Likely" cost, enter it; otherwise, leave this entry blank.<br>If no cost impact, leave these cells blank. |
| **Time Impact** | If there is a time impact, enter a "Low" and "High" time in days. If there is reason for a credible "Most Likely" time, enter it; otherwise, leave this entry blank.<br>If there is no time impact, leave these cells blank. |

"Probable Cost" is calculated from the average value of the Probability range multiplied by the average value of the Cost Impact range.
"Probable Time" is calculated from the average value of the Probability range multiplied by the average value of the Time Impact range.

The risks are prioritized for risk response in descending order of their "Probable Cost" and/or "Probable Time".

# Risk Response

Risk response is the process of developing strategic options, and determining actions, to enhance opportunities and reduce threats to the project's objectives. A project team member is assigned to take responsibility for each risk response. This process ensures that each risk requiring a response has an owner monitoring the responses, although the owner may delegate implementation of a response to someone else.

## Risk Response Strategies

| For Threats | For Opportunities |
|---|---|
| ***Avoid.*** Risk can be avoided by removing the cause of the risk or executing the project in a different way while still aiming to achieve project objectives. Not all risks can be avoided or eliminated, and for others, this approach may be too expensive or time-consuming. However, this should be the first strategy considered. | ***Exploit***. The aim is to ensure that the opportunity is realized. This strategy seeks to eliminate the uncertainty associated with a particular upside risk by making the opportunity definitely happen. Exploit is an aggressive response strategy, best reserved for those "golden opportunities" having high probability and impacts. |
| ***Transfer.*** Transferring risk involves finding another party who is willing to take responsibility for its management, and who will bear the liability of the risk should it occur. The aim is to ensure that the risk is owned and managed by the party best able to deal with it effectively. Risk transfer usually involves payment of a premium, and the cost-effectiveness of this must be considered when deciding whether to adopt a transfer strategy. | ***Share***. Allocate risk ownership of an opportunity to another party who is best able to maximize its probability of occurrence and increase the potential benefits if it does occur. Transferring threats and sharing opportunities are similar in that a third party is used. Those to whom threats are transferred take on the liability and those to whom opportunities are allocated should be allowed to share in the potential benefits. |
| ***Mitigate.*** Risk mitigation reduces the probability and/or impact of an adverse risk event to an acceptable threshold. Taking early action to reduce the probability and/or impact of a risk is often more effective than trying to repair the damage after the risk has occurred. Risk mitigation may require resources or time and thus presents a tradeoff between doing nothing versus the cost of mitigating the risk. | ***Enhance***. This response aims to modify the "size" of the positive risk. The opportunity is enhanced by increasing its probability and/or impact, thereby maximizing benefits realized for the project. If the probability can be increased to 100 percent, this is effectively an exploit response. |

***Acceptance.*** This strategy is adopted when it is not possible or practical to respond to the risk by the other strategies, or a response is not warranted by the importance of the risk. When the project manager and the project team decide to accept a risk, they are agreeing to address the risk if and when it occurs. A contingency plan, workaround plan and/or contingency reserve may be developed for that eventuality.

## 7-2 Examples of Risk Responses

Table 6 repeats the example risk statements from Table 4 and shows a risk response for each.

**TABLE 6 –EXAMPLE RISK RESPONSES**

| | Risk Statement | Risk Response |
|---|---|---|
| **Design** | Inaccuracies or incomplete information in the survey file could lead to rework of the design. | Mitigate: Work with Surveys to verify that the survey file is accurate and complete. Perform additional surveys as needed. |
| | A design change that is outside of the parameters contemplated in the Environmental Document triggers a supplemental EIS[2] which causes a delay due to the public comment period. | Avoid: Monitor design changes against ED to avoid reassessment of ED unless the opportunity outweighs the threat. |
| **Environmental** | Potential lawsuits may challenge the environmental report, delaying the start of construction or threatening loss of funding. | Mitigate: Address concerns of stakeholders and public during environmental process. Schedule additional public outreach. |
| | Nesting birds, protected from harassment under the Migratory Bird Treaty Act, may delay construction during the nesting season. | Mitigate: Schedule contract work to avoid the nesting season or remove nesting habitat before starting work. |
| **R/W** | Due to the complex nature of the staging, additional right of way or construction easements may be required to complete the work as contemplated, resulting in additional cost to the project. | Mitigate: Re-sequence the work to enable ROW Certification. |
| | Due to the large number of parcels and businesses, the condemnation process may have to be used to acquire R/W, which could delay start of construction by up to one year, increasing construction costs and extending the time for COS. | Mitigate: Work with Right-of-Way and Project Management to prioritize work and secure additional right-of-way resources to reduce impact. |
| **Construction** | Hazardous materials encountered during construction will require an on-site storage area and potential additional costs to dispose. | Accept: Ensure storage space will be available. |
| | Unanticipated buried man-made objects uncovered during construction require removal and disposal resulting in additional costs. | Accept: Include a Supplemental Work item to cover this risk. |

## 7-3 Responding to Risks

Following identification and analysis of project risks, the PRMT takes action to improve the odds in favor of project success. Ultimately, it is not possible to eliminate all threats or take advantage of all opportunities – but they will be documented to provide awareness that they exist and have been identified. Successful risk response will change the risk profile through the project life cycle, and risk exposure will diminish.

Risk response involves:

- The PRMT determining which risks warrant a response and identifying which strategy is best for each risk.
- Assigning an action to the Risk Owner to identify options for reducing the probability or impacts of each risk. The Risk Owner takes the lead and can involve experts available to the project.
- Evaluating each option for potential reduction in the risk and cost of implementing the option.
- Selecting the best option for the project.
- Requesting additional contingency, if needed.
- Assigning an action to the Risk Owner to execute the selected response action. The Risk Owner is the lead and may assign specific tasks to other resources to have the response implemented and documented.

If the PRMT judges that a risk should be accepted, it may assign an action to the Risk Owner to prepare a contingency plan if deemed necessary.

### A RISK PERSPECTIVE CAN ENHANCE DECISIONS

When considering risk mitigation methodology, it is important to recognize the impacts of the decision. The impact of responding to a risk may make sense in the short term (e.g. Saves design costs, allows team to meet schedule), but the impact of the risk needs to be taken as a whole.

For example, the impact of just a few unknown conditions can affect the construction schedule to the point where an environmental work window requires the project to be suspended. It is important to recognize how much of an impact there would be in making a decision. While the direct cost of resolving the unknown condition may be less than the cost of a site visit, the overall impact of the change may be a significant delay to the contract if not recognized.

## Entering Risk Responses into the Risk Register

The risk response action for each risk is entered into the "Response Actions" column of the risk register. Risk responses are options and actions that enhance opportunities or reduce threats. The PMRT, PRM, PM or project team decide upon the response action to risks listed in the risk register. The response action is then assigned to one person, the person responsible for executing and monitoring the risk response that is chosen. Planned risk responses must be appropriate to the significance of the risk, cost effective in meeting the challenge, realistic within the project context

and agreed upon by all parties involved, and owned by a single person. Risk responses must also be timely.[3]

[3] Project Management Institute. *A Guide to the Project Management Body of Knowledge (PMBOK Guide) – Fourth Edition*

## Attachment 2:  Risk Register as of Jan. 31, 2024